Preface

Special Issue on Changing Economic Issues of Natural Resources

The ever-evolving paradigm that governs the intricate intertwining of economic dynamics and natural resources serves to underscore an overriding truth: the bedrock of the economic edifice remains inextricably intertwined with these resources, even as the specter of the digital revolution casts its considerable shadow over the immediate future. It is in the crucible of these interactions that all economic enterprises find their moorings, tied to the fundamental pillars that constitute the natural resource endowment. This resource endowment encompasses a range of indispensably vital components, including the mineral deposits that underpin industrial processes, the vast aquifers and reservoirs that support agricultural and industrial endeavors, the fertile expanse of arable land that serves as the cradle of food production, and the encompassing atmospheric layers that intricately shape climatic dynamics. A broader intellectual exploration beckons, however, as the paradigm of space, construed in its geographical guise, emerges as the central fulcrum orchestrating a grand ballet of both human migratory patterns and the transit routes traversed by commodified goods.

The annals of temporal progression have witnessed a profound shift in the epistemological lens through which natural resources are valued and perceived. In previous epochs, an entrenched perspective heralded the conspicuous rise of nations endowed with an abundance of raw materials, thereby weaving a narrative that exalted the virtues inherent in these resource-rich domains. Implicit in this elucidation was the proposition that the abundant availability of economically viable raw materials provided these nations with a formidable competitive advantage, thereby creating a favorable ecosystem in which the parsimonious production of consumable goods proliferated, ushering in robust export trajectories and bringing about an improvement in the balance of trade. The inexorable progression of temporal epochs, however, ushered in a countervailing perspective that unfolded like a tapestry of emergent wisdom. This viewpoint accentuated the latent economic inefficiency inherent in the unmediated production and export of unprocessed commodities, a paradigm inextricably intertwined with the intricate allocation of vast reservoirs of capital. The implicit vulnerability of the production domain to the vagaries of oscillating demand dynamics and the erratic vicissitudes of price trends served as a poignant undercurrent to this evolving narrative. Universal in its resonance, an emerging mandate augurs the need to elevate the ambitious enterprise of global resource exploration and its wise stewardship to the pinnacle of the exalted tapestry of global economic deliberation.

Thus, the grand tapestry of economic thought unfolds in response to the evolving tides of time, echoing the complex reverberations generated by the ongoing interplay between human society and the finite endowments of our planet. This intricate dialectic resonates as a testament to the perpetuity of transformation, transcending epochs and reshaping the contours of epistemic paradigms. Within this narrative lies an unmistakable testament to the enduring symbiosis between the bounty of Earth's resources and the relentless march of human endeavor. As the inexorable cadence of temporal progression continues, the inexhaustible dialogue between the realms of resource utilization and economic advancement continues unabated, etching its imprint on the annals of scientific discourse and influencing the arc of human progress.

Henceforth, the intricate and ever-evolving dialectical interplay that exists between the realms of economic dynamics and the reservoirs of nature's bounty persists, traversing the epochs and paradigms of perceptual evolution. Within this continuous and dynamic interplay, one finds the unassailable and perpetual indispensability of natural resources to the very fabric that weaves the intricate tapestry of a nation's economic narrative. This axiom, steadfast and unwavering, stands as a resolute sentinel, a foundational postulate that retains its tenacity amidst the relentless momentum of the inexorable digital metamorphosis that is engulfing contemporary society.

Natural resources, which constitute the fundamental substratum upon which the edifice of human existence and economic enterprise resolutely stands, occupy an inherently pivotal nexus within the grand tapestry of planetary dynamics. The intricate choreography orchestrated between the availability of these resources and the undulating course of economic progression has crystallized into an epochal dilemma that tightly embraces both the robust redoubts of well-established developed economies and the nascent domains of their burgeoning developing counterparts. Indeed, the palpable and foreboding specter of resource depletion, analogous to an impending storm gathering on the distant horizon, casts an inauspicious and ominous shadow over the trajectory of economic progress, rendering it an enterprise fraught with challenges and uncertainties.

The fundamental importance of natural resources, as both substrate and catalyst for human livelihoods and economic growth, precipitates their central positioning within the broader context of global dynamics. This pivotal juncture, where the realms of anthropogenic aspiration intersect with the intricate rhythms of environmental endowment, assumes a prominent role in shaping the trajectory of planetary evolution. The orchestration of resource availability is intimately intertwined with the ebb and flow of economic progress, a dance performed on a stage defined by the nuanced interplay of demand, extraction, use, and conservation.

In the fluid expanse of the global economic theater, this dynamic interplay unfolds as a compelling spectacle that has captured the attention not only of the established stalwarts of the advanced economies, but also of the emerging aspirants to prosperity. The economies that have ascended to the pinnacle of development find themselves in a perpetual dance of balance, maneuvering to extract maximum benefit from their resource endowments while mitigating the environmental and social consequences of resource depletion. At the same time, their developing counterparts strive to use their latent resource potential as a catalyst for accelerated growth, while treading carefully on the precipice of environmental integrity and sustainable growth.

Over the course of time, this interplay between resource availability and economic growth has driven the two into a symbiotic embrace, continually reshaping the contours of global development paradigms. The looming specter of resource depletion, like a gathering storm, testifies to the delicate balance that must be maintained to ensure the longevity of economic trajectories. It is in this interstice that the intricate choreography of resource management, economic progress, and environmental stewardship unfolds-a grand narrative that continues to unfold across the eons, an essential chapter in the unfolding story of humanity's quest for progress and sustainability.

As nations and economies traverse this intricate topography of resource management, the gravity of their endeavor cannot be understated. They are charged with the solemn responsibility of balancing the scales of prosperity with the integrity of ecosystems to ensure a sustainable legacy for generations to come. This nuanced responsibility requires the cultivation of a global ethos characterized by cooperation, knowledge sharing, and mutual benefit. The dynamic interaction between governments, institutions, industry and civil society catalyzes the emergence of a harmonious symphony of progress and environmental stewardship.

The imperative to optimize resources and cultivate sustainable use strategies is an enduring testament to the profound symbiotic interdependence between the burgeoning realm of human prosperity and the bountiful resources endowed by our planetary home. Embedded in this imperative is the recognition that optimal resource stewardship is the key to a harmonious coalescence between human progress and the preservation of Earth's intrinsic vitality.

The multiple challenges converging around the precipice of resource depletion are akin to a clarion call, resounding with the potential to trigger a cascade of detrimental effects. The stark consequences of unmitigated inaction and the harboring of suboptimal resource utilization strategies cast an unsettling shadow over the precipice of economic trajectory. The specter of economic stagnation looms, a consequence borne of the inability to wisely manage the finite resources that underpin human progress. At the same time, this misalignment threatens to exacerbate existing social inequalities, which are often perpetuated by resource scarcity. It is a stark reminder that the noble pursuit of human well-being remains tenuous in the face of resource mismanagement, as vulnerable populations are disproportionately exposed to the effects of scarcity.

The dynamic interplay between the finite offerings of our natural environment and the surging tide of economic growth creates a nuanced duality marked by a convergence of escalating emissions and accentuated depletion of these invaluable resources. At the epicenter of this complex equation is the central role that natural resources play in the crucible of the production process-an engine that propels the chariot of economic progress forward. Underlying this intricate symbiotic dance, however, is an undeniable truth: the inherent exhaustibility that shrouds natural resources, compounded by the relentless march of time that heralds the manifestation of diminishing returns on the inputs that underpin the realm of economic progress.

Viewed through a broader prism, the ramifications of resource-intensive practices transcend the confines of mere economic calculus and affect the very foundation of sustainable development. The crux of this intricate matter lies in the acumen to recognize that while the immediate economic utility of natural resources may satisfy pressing human needs, their transformative transformation into a diverse array of goods and services produces a multifaceted increase in their socio-economic value within the intricate fabric of society. This metamorphic transformation of raw natural essence into utilitarian commodities serves as the cornerstone for the perpetuation of economic vitality, echoing as the lifeblood coursing through the veins of progress.

At the zenith of this labyrinthine progression is the shining beacon of rational responses to external stimuli, a beacon that stimulates the ascent of economic sectors in an unceasing, cyclical fashion. This self-reinforcing amplification of economic activity produces a heightened vitality that reverberates through the very sinews of economic endeavor. This amplification, like the crescendo of a resonant melody, unfolds as a glorious tapestry of productive engagement that spans the diverse realms of economic sectors. Ultimately, this symphonic crescendo culminates in the catalytic emergence of economies of scale, heralding a harmonious symphony that orchestrates the melodious serenade of reduced unit costs of production-a refrain that echoes as an ode to the intricate dance between the innate resources of the natural world and the symphony of sustainable economic growth.

In summative resonance, the intricately choreographed ballet between the realm of natural resources and the symphonic overture of economic growth unfolds like an opulent tapestry-a masterpiece meticulously woven with threads of intricate interconnectedness and multifaceted mutual influence. The narrative woven here traverses dimensions beyond the mere juxtaposition of finite resource availability and the burgeoning economic fabric, echoing a clarion call for a harmonious equilibrium achieved through conscientious stewardship. As we navigate the winding trajectory toward the hallowed shores of sustainable development, the ongoing intricate dance endures as a testament to the profound synergy woven through the embrace of human ingenuity and the priceless treasures bequeathed to us by the munificence of nature's endowment. This narrative stands as an enduring affirmation of humanity's ability to navigate the delicate balance between growth and stewardship that is inscribed in the very heartbeat of our journey toward a thriving, sustainable future.

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Territorial Inequalities of Medicinal Waters, as Natural Healing Factors, in Hungary

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Abstract: The geographical occurrence of natural medicinal factors and their use in medical tourism, show differences in different countries and nations. The hydrogeological situation of Hungary is unique in Europe, thanks to the outstanding quantity and quality of medicinal waters. This natural healing factor provides the basis of the country's medical tourism and plays a prominent role in the spa treatment of musculoskeletal issues for patients. Due to the increasing value of health and the tourist importance of medicinal waters, the development of spa towns with a view to the sustainability of natural healing factors is becoming more and more important, for which it is important to reduce territorial inequalities. Accordingly, our research aims to map the territorial inequalities of Hungarian medicinal waters using the polarization and distribution indicators of territorial research. From our results, we concluded that the territorial inequality and concentration of medicinal waters, are relatively low in Hungary, which indicates a small territorial inequality. Among the country's NUTS3 areas, the counties of the Northern and Southern Great Plains region, Zala, Vas, and Heves County and Budapest, are the most developed, in terms of medicinal waters. On the one hand, these results provide guidelines for spa town decision-makers regarding the need to equalize territorial inequalities in the area of natural healing waters. On the other hand, our results can assist with the planning of further development of settlements along with the development of spa treatments, based on the local medicinal water. In addition, our results also highlight the need for further research on the topic, to ensure the optimal and sustainable use of medicinal waters, as well as to meet the needs of the public and the various service providers.

Keywords: medical tourism; medicinal water; natural healing factor; territorial inequality

1 Introduction

Only 0.6% of the Earth's water resources are groundwater resources [29, 43, 76]. The underground aquifer formations of different ages and properties resulted in diverse types of groundwater resources. In the use of underground water resources, the provision of drinking water [77], agricultural and industrial utilization (e.g., geothermal energy), and spa treatment (tourism and health care) are prominent in the world, in which the use of thermal and mineral waters plays a prominent role. [1, 11, 16, 26, 28, 53, 75]. The processing of the literature on the international data of thermal, mineral and medicinal plants is briefly summarized below. The occurrence of thermal waters exist in several countries (Japan, Israel, Iceland, New Zealand), but in Europe (France, Italy, Hungary, Spain, Germany, Austria, Romania, Czech Republic) availability is particularly outstanding [7] [20]. There are 480 thermal and mineral springs in Italy [30], more than 1000 in Turkey [66], and 8500 in Romania [54]. In terms of the natural healing factors, Germany ranks first in Europe [80], but thermal and mineral waters can also be found in Switzerland [17] and the Czech Republic [61]. In addition to the countries famous for their significant number of natural healing factors, these natural features also form the basis of medical tourism in other countries. Slovakia is also relatively rich in thermal and mineral waters, whose spa tourism, according to Matlovičová et al., is based on the services of 31 spas located in the country's 21 spa towns [50]. According to the Tourism Organization of Serbia (TOS), Serbia has more than 1,000 thermal and mineral water sources, as well as many other natural healing factors (healing muds and healing gases), thanks to its geographical features [78]. In Vojvodina alone, 73 hydrothermal drillings were carried out until the end of 1998, the number of which continued to increase at a slower rate after that [44], with nature conservation and sustainable tourism aspects increasingly in mind nowadays [68]. This rate is 75% in several European countries, and more than 95% in Hungary [67, 73].

Based on the research of MUNTEANU et al. [55], the health use of natural medicinal agents has spread in many areas of the world. This is mainly manifested in the medicinal use of mineral and thermal waters in the Middle East, Southeast Europe, Asia, South America and North Africa. In the Middle East and North Africa, the recreational use of beach climate therapy is most typical, but medicinal use also appears in several countries (Israel, Tunisia, Turkey) [2] [69]. In Asia, spiritual, religious and recreational use is the most widespread in the spirit of holistic thinking [65], and in America the use of thermal and mineral waters can be linked to ancient sacred cults, which became part of the tourism system with the development of the wellness spa movement [66]. In many countries of Europe (Germany, France, the Czech Republic, Austria, Romania, Hungary) and in recent decades in America, the possibilities offered by spas have been integrated into the range of health services [33] [46].

In Hungary, underground aquifer formations of different ages and features resulted in diverse types of underground water resources [45]. As a result, there is a wide range of opportunities for the use of water measured in international terms [51].

Hungary's hydrogeological properties are well-known worldwide, thanks to which it has an outstanding amount and quality of natural healing factors, including thermal and mineral water reserves. The use of this water resource is wide-ranging, but it is most prominent in medical tourism [39], during the use of certified medicinal waters for medicinal purposes [36].

The name of medicinal water in Hungary is regulated by EüM decree 74/1999. (XII. 25) [5]. The scope of the decree covers both the producers of medicinal water and those engaged in health service activities using this natural healing factor.

To be declared a medicinal water, mineral water has fulfilled several requirements. In addition to bacteriological, hydrogeological and public health tests, a medical study required, which clearly proves the healing effect of the water for external or internal use. The purpose of classification as medicinal water is that the thermal mineral water intended to be used as medicinal water by 74/1999. (XII. 25.) Based on one EüM decree, it must be proven to be medicinal water and thus, be chemically and bacteriologically flawless. In Hungary, the classification as medicinal water was previously authorized by the National General Administration of Spas and Spas (OGYFI), then by the National Office of the Chief Medical Officer (OTH), and currently by the Government Office of the Capital City of Budapest, if the necessary criteria are met. During the procedure, it is necessary to carry out a comparative or follow-up medical examination, which significantly confirms the healing effect of the given water in the case of the examined disease [20, 37, 60]. From a medical point of view, the declaration as medicinal water is effective if the tested pathological symptom parameters show a significantly favorable result in at least 51% compared to the control group, and based on these results, on the recommendation of the competent Professional College, the tested water is declared as medicinal water [22, 60, 63]. In Europe, Hungary has the strictest process for declaring medicinal water [8].

74/1999. (XII. 25.) based on the wording of the EüM decree, we call those natural mineral waters that have a proven and verified medicinal effect "medicinal water". Medicinal waters can be classified into seven main groups according to their composition and are suitable for the treatment of different types of diseases (Table 1).

Table 1
Types and areas of use of medicinal waters in Hungary

The type of medicinal water (based on composition)	Disease or group of diseases
Salt water (calcium chloride, magnesium chloride)	- Gynecological diseases - Urological diseases - Dermatological inflammatory diseases
Carbonated (sour) **waters**	Cardiovascular diseases
Alkaline or calcareous waters (sodium bicarbonate, calcium bicarbonate, magnesium bicarbonate)	Musculoskeletal and rheumatological symptoms
Iron waters	Gynecological chronic inflammations
Iodine, bromine waters	- Hypothyroidism - Stress; sleep disorder - Peripheral joint diseases - Gynecological inflammations - Urological inflammations
Sulphate, sulphide (sulfur) **waters**	Dermatological symptoms
Radioactive waters	- Inflammatory rheumatological diseases - Hormonal diseases - Metabolic diseases

Source: [17]

The effectiveness of domestic medicinal waters is supported by numerous international and domestic publications in a meta-analysis [9], as well as in additional publications [6] [10]. Based on the research results of the past decades, it became possible to determine the applicability of domestic medicinal waters according to their chemical composition according to different diseases and disease groups [21] [31]. Based on several decades of empirical and evidence-based medicine (EBM) balneological research results, which are increasing nowadays, it can be concluded that domestic medicinal waters and other natural healing factors are a therapeutic option for many chronic health problems. Most of the medicinal waters are of outstanding importance in the treatment of locomotor diseases and are available in many settlements in Hungary.

In Hungary, the primary field of application of medicinal water treatments, or balneotherapy, is the treatment of musculoskeletal diseases, which, in addition to health care, also forms the basis of medical tourism. Thanks to this, the situation of our country is well known, according to which our country has an absolute advantage compared to other countries and a comparative advantage compared to the countries of the European Union in terms of tourism based on medicinal water [71].

The multifactorial system of medical tourism has a complex effect on social and economic processes, in which context it fits well into the diverse world of social geography. Accordingly, we consider it essential to emphasize the definition of regional differences in natural healing factors, including medicinal waters as health products [12, 62, 74]. Reducing growing regional inequalities in health and medical tourism can be an important part of the planning of spa town developments and the cooperation of those involved [4, 13, 14, 23, 38, 72]. In the globalized offer of medical tourism, Hungary can have a competitive advantage if it can provide special tourist services using medicinal waters as natural healing factors [49]. This is especially relevant in the period after the COVID-19 pandemic [24] [41].

Our research aims to explore and define the territorial inequalities of medicinal waters as natural healing factors in Hungary to promote the development of spa towns.

2 Materials and Methods

To achieve our research goal, we used the Hungarian database of natural healing factors for our secondary research. The examined data were collected and processed from the 2019 National Public Health and Medical Officer Service (ÁNTSZ) database. We included this year's data in our analysis because after the COVID-19 pandemic [18], which also appeared in Hungary in March 2020, due to the changes in medical tourism, only significantly distorted data are available to spa medical data, which could have significantly influenced our research results. We examined the data on medicinal waters in Hungary at the NUTS3 division level (territorial middle level), so the sample of the analysis consists of 20 areas (Budapest and 19 counties) [1].

The data analysis, we used the extent-ratio, the extent of dispersion, the relative extent and the dual indicator (Éltető – Frigyes index) to measure territorial polarization. And the Gini index, the Hirschman – Herfindahl index and the Hoover index to measure the deviation of the territorial distributions was used [27] [32]. The relationship between the Gini index and the Hoover index was depicted using the Lorenz curve [24] [31].

Among the measures of regional polarization, the extent-ratio is used to determine the number of times the difference between the two extreme values of the medicinal waters examined per area: $K = X_{max} / X_{min}$ [29]. As a second polarization indicator, we use the extent of dispersion, which determines the difference between the largest and smallest value of the investigated natural healing factor: $R = x_{max} - x_{min}$ [33]. In our studies, this indicator shows the biggest differences in the number of medicinal waters by area. The relative extent is already suitable for a more detailed comparison of the data series, so in our research we use this indicator to determine how the average of the medicinal water number in the examined area compares to the difference between the largest and smallest values of the same factors: $Q = \frac{X_{max} - X_{min}}{\overline{X}}$ [29]. As a fourth polarization indicator, we use the Éltető – Frigyes index [15]. With this indicator, we examine the development and supply of medicinal waters in the examined areas (as the ratio of the average of the values above the average of the entire distribution and the average of the values below the average of the entire distribution): $D = \frac{\overline{X_m}}{\overline{X_a}}$ [26] [30]

Based on the literature, several methods are available for the more complex measurement of regional research, which are described in various aspects by foreign [46, 10, 9] and domestic authors [14, 29, 31]. To measure the deviation of territorial distributions, we first use the Gini index, which is one of the most frequently used territorial index. It is primarily used to examine income inequalities [24], but its use is increasingly spreading during health inequality studies as well: $G = \frac{\Sigma_{i=1}^{n} \Sigma_{i=1}^{n} |y_i - y_j|}{2 * \bar{y} * n^2}$ [8, 14, 16, 29, 33]. In our research, we use this indicator to determine the average difference in the number of medicinal waters per area, that is, the difference in their territorial distribution. When applying the Gini index, researchers accept a value of around 0.4 as a relatively significant inequality. Using another indicator for measuring territorial distributions, the Hoover index, we examine what percentage of the medicinal waters would need to be regrouped between the territories for the distribution to be the same: $h = \frac{\Sigma_{i=1}^{n} |x_i - f_i|}{2}$ [14, 23, 33]. The relationship between the Gini index and the Hoover index can be clearly illustrated using the Lorenz curve, which also helps describe inequality [24] [31].

In the present research, the Lorenz curve illustrates medicinal waters' proportion (inequality) per territorial unit. In the figures, the blue line indicates the cumulative distribution of the ratio of medicinal water as a medicinal tourism characteristic in increasing order (Lorenz curve), and the arrow indicates the maximum vertical distance between the Lorenz curve and the diagonal (largest difference), which corresponds to the Hoover index. The ratio of the area between the diagonal and the Lorenz curve to the area of the half square gives the Gini index. The Hirschman – Herfindahl index is used to measure the sectoral concentration in our study, which is based on the concept of the distribution ratio and shows the degree of concentration of a given neutral characteristic between territorial units: $HI = \sum_{i=1}^{n}(x_i / \Sigma x_i)^2$ [33]. With this index, we examine the differences in the territorial distribution of medicinal waters in Hungary. The indicator compares the distribution of the examined factors to a completely uniform one, a value above 0.6 indicates a strong concentration [29].

3 Results

The data of the Hungarian medicinal waters examined in our research (270) were collected from the ÁNTSZ database at the settlement level, and we generated a database aggregated at the district level and then at the regional level. Our results show that the number of registered medicinal waters varies between 0 and 20 in the districts of Hungary. This result is illustrated on a map in Figure 1.

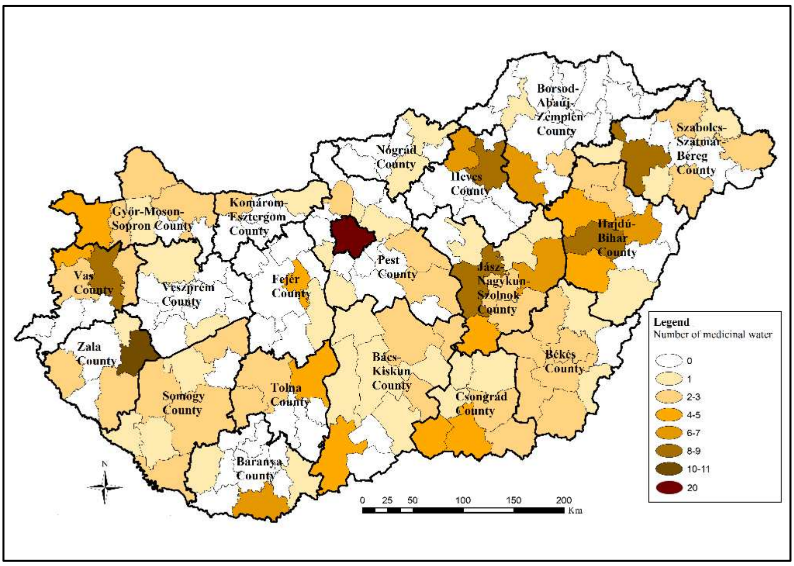

Figure 1
Number of medicinal waters in Hungary in 2019
Source: Based on ÁNTSZ 2019, own calculation and editing

Based on the settlement data of the ÁNTSZ, we determined the number of medicinal waters at the regional average level, based on which data we performed the territorial calculations (Figure 2).

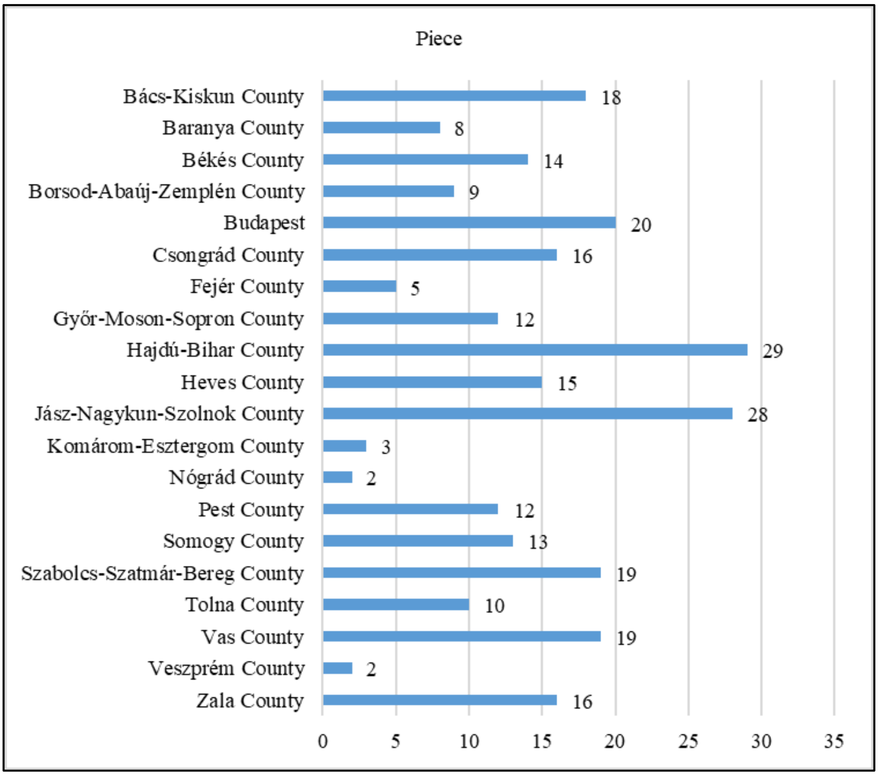

Figure 2

Number of medicinal waters in Hungary's NUTS areas

Source: Based on ÁNTSZ 2019, own calculation and editing

Based on the data, we found that the number of medicinal waters in Hungary is the fewest in Veszprém and Nógrád County (two each), and the most in Hajdú-Bihar (29) and Jász-Nagykun-Szolnok (28) County.

3.1 Territorial Water Inequalities

Territorial differences (inequality, development, concentration) of medicinal waters were examined with the help of metrics of territorial polarization and indices showing differences in territorial distributions at the regional average level in Hungary.

3.1.1 Examination Results of Territorial Polarization

To examine territorial polarization, we used the methods of extent-ratio, dispersion extent, relative extent, and the Éltető – Frigyes index (dual indicator).

Calculating the extent-ratio: *K = 29/2 = 14.5,* was obtained. This result shows a fourteen-and-a-half times difference between the areas with the most (29) and the least (two) medicinal water.

As a result of the examination of the extent of the dispersion: *R = 29 – 2 = 27* was obtained, with which we were able to determine the significant difference in the number of medicinal water elements of the territorial unit with the highest (29) and lowest (two) medicinal water numbers.

When calculating the relative extent: The result was *Q = (29-2)/13.5 = 2*, which shows a two-fold difference between the average (13.5) number of medicinal waters in the area with the most (29) and the least (two) medicinal waters.

After that, one of the most commonly used metrics, the Éltetlő – Frigyes index (dual indicator), was calculated based on the data in Table 2.

Table 2

Éltető – Frigyes index of medicinal waters

	Undeveloped areas										**Developed areas**												
NUTS3 areas	Nógrád County	Veszprém County	Komárom-Esztergom County	Fejér megye County	Baranya County	Borsod-Abaúj-Zemplén County	Tolna County	Győr-Moson-Sopron County	Pest County	Somogy County	Békés County	Heves County	Csongrád County	Zala County	Bács-Kiskun County	Szabolcs-Szatmár-Bereg County	Vas County	Budapest	Jász-Nagykun-Szolnok County	Hajdú-Bihar County	**Below-average average**	**Above-average average**	**Average**
pcs	2	2	3	5	8	9	10	12	12	13	14	15	16	16	18	19	19	20	28	29	**7.6**	**19.4**	**13.5**

Source: Based on ÁNTSZ 2019, own calculation and editing

The result of the Éltető – Frigyes index of the medicinal waters is *D = 19.4/7.9 = 2.5*, which value shows a difference of two and a half times between the medicinal water supply of the territorial units. Based on these data, we determined the developed and underdeveloped areas of Hungary in terms of medicinal water supply (Figure 2).

Based on the data, we determined that in Hungary, on average, there are 13.5 medicinal waters in one area. Budapest and nine counties have an above-average medicinal water number, which is why we assessed this as a developed regional average level. Among the developed areas, Hajdú-Bihar County (29 units) and Jász-Nagykun-Szolnok County (28 units) stand out. Ten counties lag behind the national average, in terms of the number of medicinal waters. The fewest medicinal waters are found in Nógrád and Veszprém County (two each). The areas with an above-average medicinal water number are located in the eastern and central parts of the country, as well as in Heves, Zala, Vas County, and Budapest.

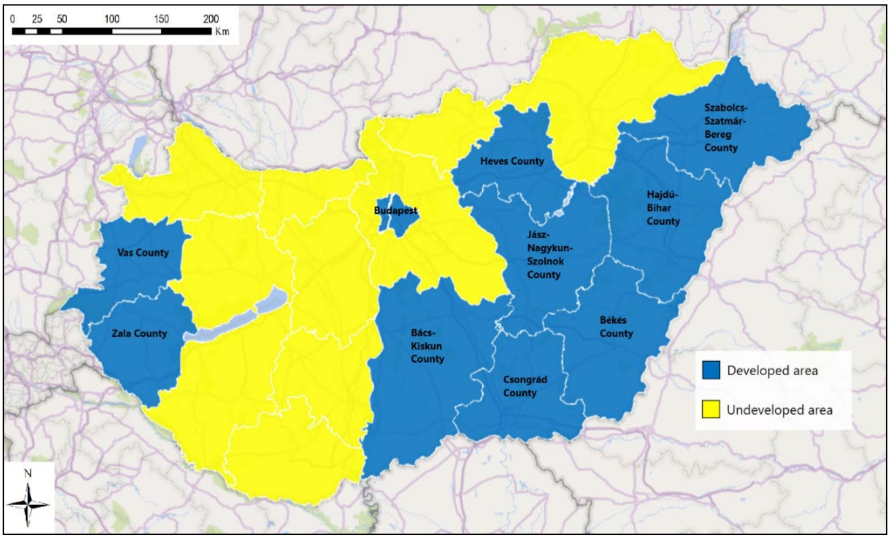

Figure 2
In terms of medicinal waters, developed and underdeveloped areas in Hungary
Source: Based on ÁNTSZ 2019, own calculation and editing

While the location of the areas with below-average (underdeveloped regional average) medicinal water numbers is typical for the western and northern parts of the country, with the exception of Zala, Vas, Heves, Szabolcs-Szatmár-Bereg County and Budapest.

3.1.1 Examination Results of Territorial Distributions

The Gini index, the Hoover index, and the Hirschman – Herfindahl index were used to analyze the territorial distributions, that is, the concentration and the combinations of the Gini index and the Hoover index were also plotted on the Lorenz curve.

Examining the Gini index of medicinal waters, we found a difference in the territorial distribution of the medicinal factor:

$G = \frac{\Sigma_{i=1}^{n}\Sigma_{i=1}^{n}|y_i - y_j|}{2* \bar{y} *n^2} = \frac{1666}{2*13,5*400} = \frac{1666}{10800} = 0.15$. This means that the average difference between the medicinal waters at the average domestic level is 0.15. This result shows significant regional equality for medicinal waters. The data are also illustrated using the Lorenz curve (Figure 3).

In the figure, the blue line indicates the cumulative distribution of the ratio of medicinal waters in ascending order, and the arrow indicates the maximum difference between the Lorenz curve and the diagonal (0.15). Since the Lorenz curve is close to the diagonal, we conclude that the result shows significant territorial equality.

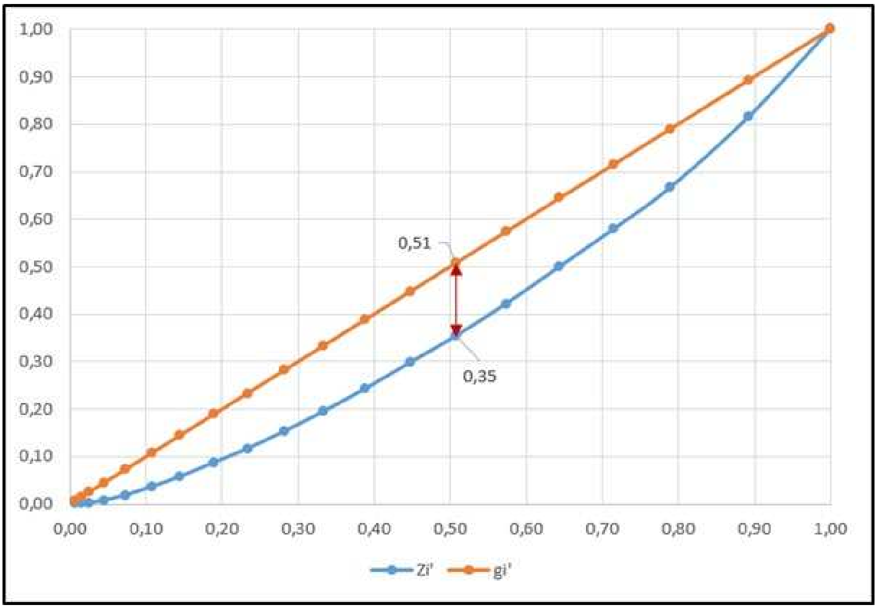

Figure 3

The Lorenz curve of Hungarian medicinal waters

Source: Based on ÁNTSZ 2019, own calculation and editing

Analyzing the data further, using the Hoover index, we examined what percentage of Hungarian medicinal waters would need to be regrouped between areas to ensure that their territorial distribution is the same with the number of musculoskeletal diseases registered in the country and the medicinal water treatment utilization. Calculated with the musculoskeletal disease number:

$h = \frac{\Sigma_{i=1}^{n}|x_i - f_i|}{2} = 53/2 = 26.5$, and the Hoover index of medicinal waters: $h = \frac{\Sigma_{i=1}^{n}|x_i - f_i|}{2} = 36/2 = 18.0,$ calculated with the medicinal water treatment utilization. Based on the results obtained in this way, we conclude that in the case of medicinal waters, the territorial distribution would be the same in the case of regrouping with the number of musculoskeletal diseases at 26.5%, and the medicinal water treatment utilization at 18.0%.

The territorial concentration of the medicinal waters was also examined using the Hirschman – Herfindahl index. As a result: $HI = \Sigma_{i=1}^{n}(x_i/\Sigma x_i)^2 = (0.007^2 + 0.007^2 + 0.011^2 + 0.019^2 + 0.030^2 + 0.033^2 + 0.037^2 + 0.044^2 + 0.044^2 + 0.048^2 + 0.052^2 + 0.056^2 + 0.059^2 + 0.059^2 + 0.067^2 + 0.070^2 + 0.070^2 + 0.074^2 + 0.104^2 + 0.107^2) = 0.065$. This value indicates a relatively low concentration of medicinal water and therefore a small regional inequality.

The results of our research are summarized in Table 3.

Table 3
Territorial indices of medicinal waters

Extent-ratio (K)	Extent of dispersion (R)	Relative extent (Q)	Dual indicator (D) (Éltető-Frigyes index)	Gini index (G)	Hirschman-Herfindahl index (HI)	Hoover index (h) (%)	
						Musculosceletal disorders number	Number of medicinal water treatment utilization
14,5	27,0	2,0	2,5	0,15	0,065	26,5	18,0

Based on medium-level studies of medicinal waters as natural healing factors in Hungary, it can be concluded that they show relatively low (small) regional inequality and concentration. In other words, Hungary's medicinal water supply is relatively uniform from a territorial point of view.

Conclusions

Our study aimed to map the territorial inequalities of Hungarian medicinal waters, as natural healing factors and to present the obtained results, to promote the tourism and health industry development, for Spa towns.

Thanks to its significant hydrogeological features, Hungary is in a privileged position, in Europe, thanks to the quantitative and quality indicators of its medicinal waters. This natural healing factor, is not only prominent in its natural geography but also has a significant social and economic role as a result of its use in medical tourism and health care. Environmental and nature conservation efforts that have become increasingly important in recent years [39], as well as the tourism [37] and health changes caused by the COVID-19 pandemic, also justify the fact that the field tests of this unique natural healing factor are carried out in Hungary. We did all this to promote the planning of tourism and health developments [40] related to medicinal water, which is becoming necessary in spa towns.

In our research, we used the extent-ratio, extent of dispersion, relative extent and the Éltető – Frigyes index (dual indicator) methods to examine territorial polarization [15, 29, 33], while we used the Gini index, the Lorenz curve, the Hoover index and the Hirschman – Herfindahl index to measure the deviation of the territorial distributions [16, 23, 29, 33].

Based on he calculated regional average results, we have come to the overall conclusion that Hungarian medicinal waters show relatively low (small) regional inequality and concentration. According to this, the country's medical water supply as a whole is relatively uniform from a territorial point of view. According to the results of the most informative and reliable indicator, the Éltető – Frigyes index, i.e., the dual indicator, nine counties of Hungary and Budapest can be called developed areas, in terms of medicinal water supply. Among the developed areas, Hajdú-Bihar County (29 units) and Jász-Nagykun-Szolnok County (28 units) stand out. However, we consider it important to point out that the aggregated data are not sufficient in themselves and provide adequate guidelines for the planning of spa town developments. It is necessary to pay special attention to the partial results, which draw attention to the peripheral areas that are underdeveloped in terms of medicinal water supply. Also, further research is needed in the fields of tourism and healthcare, in order to reveal populations, service providers and based on this information, develop the optimal and sustainable use of medicinal water, in addition to the realization of the interests in supply and demand.

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Natural Resources: Can the Oil and Gas Industry Continue to Support Further Economic Development?

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Abstract: Oil and gas have been the main contributor to the economic development in the Middle East, North Africa and various other regions. In the face of increased concerns regarding the use of oil and gas, there is a need to understand whether relying on these natural resources, for further economic development, is sustainable, or not. By reviewing the existing literature and providing a descriptive analysis of the oil and gas market, the aim of this paper is to explain the existing problems for the future of the oil and gas industry. After the introduction and the methodology, there is a literature review section, the analysis of oil and gas market in the world, and then the examination of the recent sanctions on oil and gas and their economic impacts. Finally, the authors discuss the main problems related to oil and gas. A major finding found, as a result of our study, is that due to the volatile market prices, high sensitivity to external factors, transition to renewable energy resources, possible damages to demand and the underdevelopment of non-energy sectors and human capital, the non-renewable, resource-based, natural sustainable development, is not possible to achieve in the near future. Our conclusion is that while non-renewable energy resources have been the driver of economic growth in many countries, the problems related to their usage and many external factors that can lead to a decrease in demand for oil and gas, means that it will not be possible to achieve sustainable development through the oil and gas industry, in the future.

Keywords: economic growth; export; gas market; GDP; natural resources; oil and gas sector

1 Introduction

Natural resources are different types of materials that exist in the lands of the country which have their own value in the international market. The existence of natural resources within the country can have both positive and negative impacts on the economy. Historically, natural resources have always been regarded as a blessing for a country as the government can export its natural resources to generate government revenue [1]. However, it has become clear that the impact of natural resources on the economy depends on many different economic and political factors existing in the country [2]. The exploitation, production, and supply of natural resources should be done in a way that will benefit the whole population of the country including future generations.

As a result of the negative impact of non-renewable energy resources on the environment and the expected depletion of these resources in the future, it is needed to move to renewable energy resources from non-renewable ones to be able to fulfill the energy demand when trying to achieve sustainable development. While the move of renewable energy resources is on the agenda of the world and many governments, it is not clear how this strategy will affect the development of resource-rich countries. Even if the world is trying to transform its energy use from non-renewable to renewable energy sources, there will still be a need for oil and gas as the transformation process and development of necessary technology itself needs oil and gas as a source of energy [3].

Oil and gas market faces many different challenges which risk the development of countries and companies that have oil and gas-based economies [4]. Coal and gas energy assists in development when its share is small, while over-consumption hampers development [5]. This paper will elaborate on different features of the oil and gas market, ongoing trends in the world, and the structure of the economies of oil and gas-supplying countries to understand whether these countries will be able to continue to grow economically by using their natural resources.

There are growing concerns regarding the compatibility of the oil and gas industry in a sustainable future [6]. Sustainability is a critical issue for resource-rich countries [7]. Many oil and gas-rich countries became high-income economies as they generated high levels of export revenues. The reason behind this development and increased demand for oil and gas has been the fact that the development of the current industrial world needs fuel to generate energy for its processes [8]. However, this brings questions regarding the sustainability of resource-based economic development.

Non-renewable energy resource use is not relevant to the concept of sustainable development as it can lead to the depletion of resources that are currently existing and damage the environment which will affect the living standards of the population negatively. In the case of oil and gas-rich countries, even if one disregards the negative environmental impact, the depletion of resources is likely to cause a drop in the economic growth rate. There is a need to clarify the impact of this depletion in the near future and understand if it is possible to avoid the potential decrease in economic growth rate when oil and gas resources are still available.

This paper aims to identify the possibilities for natural resources to further support economic growth in the case of oil and gas. In this paper authors re-evaluated the idea that the state of the business cycle can be determined based on the co-movements of macroeconomic indicators. The importance of our paper that the literature review lacks such a study which examines the problems related to oil and gas from sustainable development perspective. Firstly, a review of the existing literature on the economic growth trends in oil and gas-rich countries will be provided. By examining the existing literature, the aim is to present comprehensive evidence and analysis of the impact of oil and gas resources on economic development. The paper continues with a review of the oil and gas market where supply, demand, and price dynamics in the international market are discussed. As a next step, the analysis of sanctions on oil and gas and their economic implications are provided. Finally, the authors discuses the problems related to oil and gas and their implications for oil and gas exporter countries.

The generation of huge government revenues, from the export of oil and gas and the improper use of the generated revenue, is a risk for future generations, as they will not be able to benefit from the same resources, as the current generations. This study criticizes the current policies of governments and draws attention to the importance of sustainability in the oil and gas sectors.

2 Methodology of Research

This study is based primarily on international and next on bibliography and databases, founded on the descriptive-analytical exploration of concrete economic, social and technological factors, which could be seen in the background of this complex relationship. In addition, a mention should be made, that one of the authors worked several years in this sector. Therefore, the on-site, personal experiences of the author have also contributed to the results of this work.

3 Literature Review

Natural resources are one of the main determinants of the economic growth rate [9]. By exporting the natural resources existing in their lands, countries get enormous sums of money to build their economies. In contrast to this argument, it can be found that there is a negative correlation between the economic growth rate, measured by per capita GDP growth rate and natural resource exports of the country, measured by the ratio of natural resource exports to GDP [1]. The economy needs to heavily use its natural resources to be able to achieve economic growth, in the case of a low level of innovation rate [10]. However, the author also mentions the importance of investing the returns from the use of natural resources, to support the innovation of the economy. Then, the question arises why resource-rich countries around the world are not the leaders of innovation. Other authors attempted to answer this question by providing social, political, and economic explanations [1]. While social explanation focuses on the idea that the high-level development of the industry in countries which does not have natural resources is related to the need for this development as there are no other source of exports exist, political explanation focuses on the fact that the revenue from natural resources is not effectively invested in other sectors of the economy but captured by high-level governmental officials instead. An author supports the political claims by mentioning the importance of the characteristics of governance in economic development [12]. The Author mentions that it is not natural resources that causes a lower level of economic growth for resource abundant countries, compared to others but the governments which do not manage the return on natural resources to support the economy as a whole.

As an economic explanation, a paper presents the theory of Dutch disease [1]. The literature on 'Dutch disease' in developing and emerging countries is rich [14]. Dutch disease theory suggests the idea that when a specific sector in the economy generates a high level of export revenue and causes an appreciation of the national currency, other sectors of the economy face a decrease in exports as these products are more expensive in the international market [13] [14]. Also, the investment within the country also flows to the booming sector of the economy which again constitutes to the lack of attention to other sectors of the economy. According to publicly available data, the existence of natural resources can affect the economy both in positive and negative ways and can lead to the net zero impact at the end [15]. Natural resources are not expected to be depleted in the near future, but due to the lack of availability and increasing costs of exploitation, the prices will jump substantially which will negatively affect the economic growth of the countries which have based their economies on natural resources [16]. The existing research suggests that the profitability of the non-renewable energy resources will decrease in the future because of the fact that the highest quality and easily accessible portion of these resources has started to be extracted first [17]. As the difficulty of accessibility increases, the costs related to the exploitation will increase which will result in lower profits from non-renewable natural resources. It is not possible to achieve sustainable economic growth only through the export of exploited natural resources [18].

There is a need to strengthen an economy through different types of investments either to different sectors of the economy or to the physical and human capital. The lack of quality in the human capital is among the reasons for poorer economic growth in resource-rich countries as governments fail to address the diversification in the skills of the labor force [1]. Economies should at least be able to process the natural resources extracted to some degree instead of just exporting the raw natural resources [18]. In this way, the country will be able to add value and differentiate its products in the international market and contribute to the domestic economy also by decreasing the dependence on imports of processed natural resources which is already existing in the country.

It is not possible to achieve sustainable development by basing the economic growth on non-renewable energy resources because they will deplete at some point in the future [19]. Considering the attempts to switch from non-renewable energy resources to renewable energy resources because of many different reasons including the negative environmental impact of oil and gas and the fact that they will deplete in the future, the demand for the non-renewable natural resources is likely to decrease in the coming years. According to publicly research results, it is possible to achieve sustainable economic growth through the use of renewable energy resources instead of using non-renewable energy resources and harming the environment [20]. According to other authors, the usage of non-renewable energy resources is associated with a statistically significant economic growth in all European countries [8]. Considering the fact that non-renewable energy resources are the main type of fuel used in manufacturing in Europe, the study is proof that resource-rich, especially oil and gas rich countries can benefit from these resources more if they also develop manufacturing sectors of their economies. These countries can even generate higher profitability ratios from manufacturing as there will be much lower costs of energy compared to European countries.

3.1 The Review of the Oil and Gas Markets

Oil and gas are the most commonly used natural resources in the world currently. Non-renewable energy resources, in general, including oil and gas, do not need advanced technologies to generate energy, which make them the easiest option to be used for industry. From Figure 1 below, it is easy to understand that the energy use per capita has always been increasing since the 1970s on average in the World while the pattern is fluctuating for the OECD average [21]. However, the average energy use per capita is higher in OECD countries compared to the world average due to the higher levels of industrialization and more developed infrastructure that is in need for energy in OECD countries. Also, the graph on the bottom of Figure 1 shows that more than 80% of the energy consumption of OECD members and overall world is generated from fossil fuels, while there has been a decrease since 1972. This shows that the world is still dependent on non-renewable energy resources, as the main source of energy, which is not sustainable.

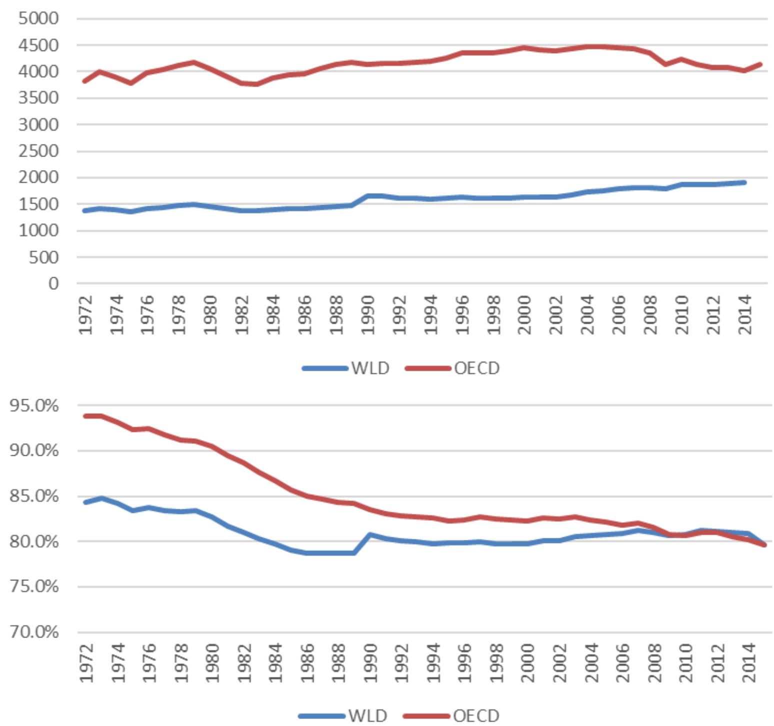

Figure 1

Energy consumption per capita as kg equivalent of oil and fossil fuel energy consumption as a percentage of total energy consumption for world and OECD

Source: [21]

The United States of America, Saudi Arabia, and Russia lead the production of crude oil in 2021 as these three countries together accounted for 42.5% of the total production [22]. The United States, Russia, Iran, China, and Qatar have been the main producers of natural gas in 2020 [23]. Many countries generated high levels of government revenue from oil and gas exports including Arab countries, Iran, North African countries and others. Oil and gas market has an oligopolistic structure and the members of the oligopoly are able to manipulate prices by affecting the supply. The Organization of Petroleum Exporting Countries (OPEC) includes main oil rich countries over the world which are able to increase and decrease supply of oil to manipulate the market. More than 80% of proven oil reserves in the world is located in OPEC countries [24]. The power of OPEC is one of the factors that contributes to the volatility of oil prices [25]. Figure 2 represents the weekly price of crude oil over the period between January 1996 and April 2022 [26].

The ups and downs of oil prices are easily observable in Figure 2 which means that crude oil prices are highly volatile. Therefore, heavy dependence on oil and gas can lead to the booms and busts in the economy of countries that have these resources.

Volatility of crude oil prices is an economical problem for both importers and exporters of these natural resources [27]. The extremes of crude oil and gas prices shown in Figure 2 and Figure 3, show that there will be periods, when resource abundant countries, will receive huge amounts of foreign exchange inflow and periods when the amount of this inflow will be substantially lower [28].

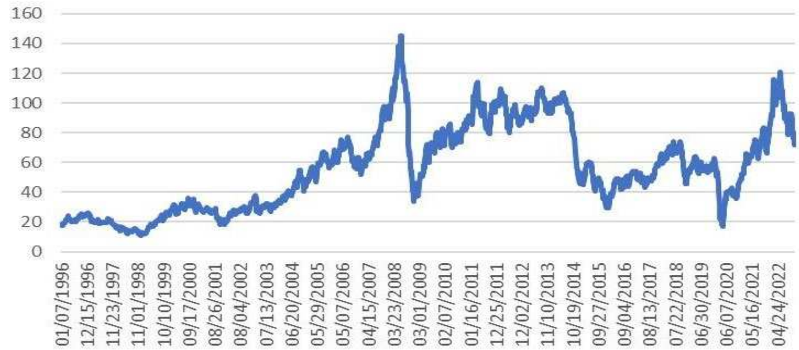

Figure 2
Weekly crude oil price between 1996 and 2022 (USD)
Source: [28]

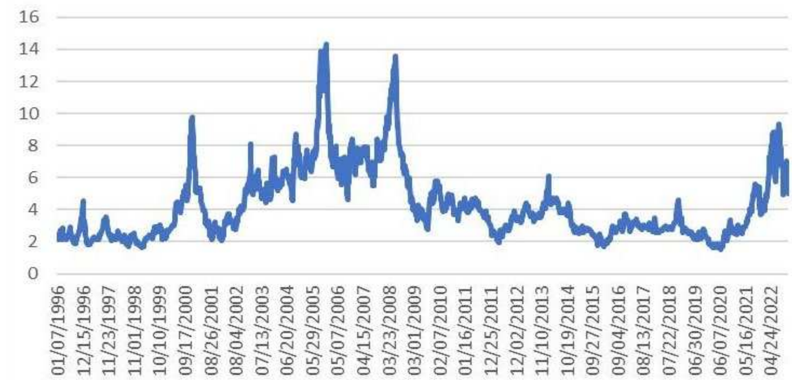

Figure 3
Weekly gas price between 1996 and 2022 (USD)
Source: [21]

Europe has faced extreme hikes in gas prices as a result of the political instabilities which led to the decrease in the supply of oil and gas from Russia. The International Energy Agency (IEA) predicts that while demand for gas will continue to decrease in Europe, it will continue to increase gradually in Asia [29]. Figure 4 represents the oil rents as a percent of GDP for the five main oil supplier countries based on the data extracted from databank of [21]. Figure 4 shows the fact that the USA and

Canada have a lower share of oil revenues as a percent of their GDP. This is because the USA and Canada have a more diversified economy, with a developed industry, which is also in need of oil, as a fuel. Therefore, oil is not exported, but used mostly within the country.

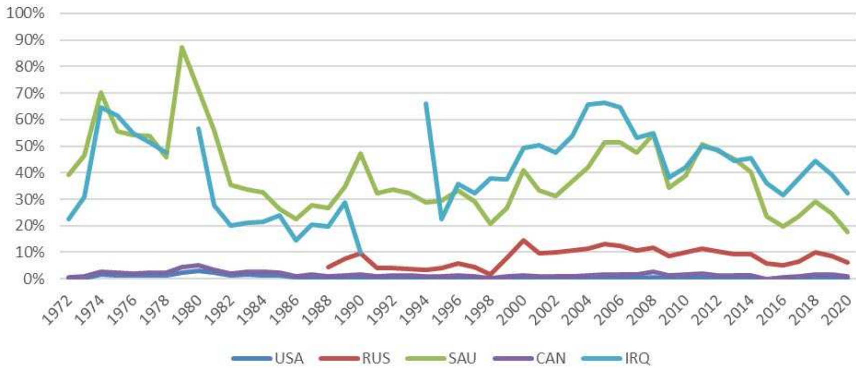

Figure 4

Oil rents as a percentage of GDP for the USA, Russia, Saudi Arabia, Canada, and Iraq

Source: [21]

However, for Saudi Arabia, Iraq, and Russia, oil revenues contribute significantly to GDP, as oil is mainly exported. The asymmetric impact of oil supply and demand shocks is significant in Pakistan [30]. According to publicly available data, while the USA was the main crude oil producer country, Saudi Arabia was the main oil exporter country in 2021 [31]. Iraq produces more than 4 million barrels of oil per day [32]. The case is similar for natural gas revenue as developed countries have lower levels of revenue from natural gas as a percent of GDP because of the lower level of exports and more diversified economy. However, overall, oil contributes GDP more in resource rich countries compared to natural gas.

3.2 Oil and Gas as a Driver of Economic Development

The reason for oil and gas rich countries' economic growth was the use of oil and gas as an energy input in the industry and manufacturing [33]. While it is observed that oil and gas rich countries faced with high levels of GDP growth rates, improvements in infrastructure, and increased inflow of foreign direct investment (FDI), but instead of a direct effect on economic growth, oil and gas revenues should be used for the development of economy as a whole by investments in different sectors which will lead economic diversification [34].

The diversification level of an economy can be understood from the structure of its export's portfolio. The trends of fuel exports, high-technology exports, and manufactured exports of the country for four developing oil exporting countries are represented in Figure 5 [21].

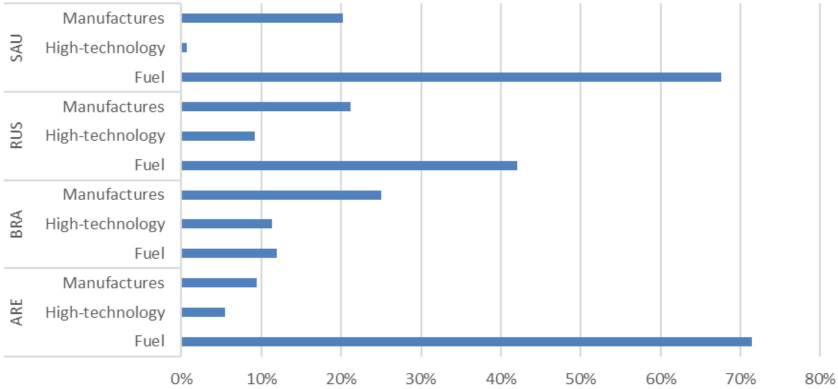

Figure 5

Fuel exports as a percentage of total merchandise exports, manufacturing exports as a percentage of total exports, and high-technology exports as a percentage of manufacturing exports for Saudi Arabia, Russia, Brazil, and United Arab Emirates

Source: [21]

As represented in Figure 5, for all four countries, most of the exports of the country is fuel exports. Only a small portion of the exports are manufactured exports, while high technology exports are the smallest part of manufacturing exports. In the case of Brazil, the share of manufactured goods and high technology products are decreasing in the export portfolio of Brazil while the share of fuel exports is increasing according to World Development Indicators [21]. It is a sign of the start of natural resource dependency of the economy and needs to be addressed. The beginning of oil production in the country affected the other sectors of economy negatively and non-oil and agricultural exports of Ghana decreased because of the stronger foreign exchange rate which makes goods and services more expensive in the international market compared to before [35]. Another author mentions the fact that while oil revenues have contributed to the economic development of the Arab world since now, the region failed to improve its non-oil sector which also causes employment issues for the population [36].

According to publicly empirical analysis for the period between 1997 and 2015 reveals the fact that there is a positive correlation between oil prices and GDP growth rate for the Caspian Sea region [37]. This finding has two main implications:

- Oil rich countries' economic growth rate will depend on the supply and demand dynamics in the market.
- Considering the fact that oil prices are highly volatile, the economy of these countries will also be highly volatile.

Other authors impact of oil prices on GDP depends on the level of growth rate and in the case of South Africa, the higher oil prices lead to lower GDP growth rates [38]. The Markow chain method is important because this allows to analyze the unobservable variable in greater detail. Other author mentions the fact that since Ghana's oil resources were found and crude oil production started, the economy started to grow and the currency of Ghana started to appreciate based on the empirical data analysis [35]. However, for the case of Nigeria, the existence of oil and gas causes an attraction of FDI which also brings new technology to the country [34]. The main issue here is to be able to attract FDI and consequently, new technology, to also non-oil sectors of the economy. Another research study provides a clear picture of the relationship among biomass consumption, oil prices, and GDP growth, providing useful insights for policymakers, government, decision-makers, and energy sectors to consolidate the energy system in South Asian countries.

3.3 Recent Sanctions on Oil and Gas and Their Economic Impact

The ongoing war in Ukraine brought many economic challenges with itself. To prevent the aggressive behavior of the Russian government in Europe, different countries adopted sanctions towards Russia. This opened up discussions on the possible impact of sanctions on the global economy. As oil and gas exports are one of the main sources of government revenue for Russia, USA and European countries put limits on the number of Russian imports, mainly oil, gas, and coal imports [39]. However, the sanctions are not likely to affect only the Russian economy as market prices for oil, gas, and coal should also be expected to increase because of the sanctions.

The sales of goods and services between different countries or between businesses from different countries is international trade. Because of the many different participants involved, international trade can be explained by network theory which explains international trade as a creation and maintenance of connection with the representatives of different countries in the world market [40].

It is important for sanctions to have three important characteristics to be successful according to the network theory [41]:

- First, the applicant of the sanction should have more information than the party which receives the sanction. When applied to the case of energy sanctions on Russia, it is not clear if this information asymmetry exists. Because the fuel market, especially oil and gas, have many strong participants and almost all information regarding the reserves, production level, price level and others are easily accessible, it is not possible to have a big information asymmetry in the case of energy sanctions.
- The second important feature is the length of the sanctions. When sanctions are applied for a longer period of time, the receiver party will be able to adjust its policy accordingly which will decrease the benefits of sanctions for the applicant. The possible length of sanctions applied to the Russian economy may depend on many different factors considering the fact that the war is still

ongoing. If the sanctions on Russia are not removed at the right time, the European population will continue to suffer from extreme high energy prices while Russia will already start to fulfill demand from other parts of the market.

- The final feature is that it is better to have unilateral sanctions instead of multilateral which means that sanctions are better when they are applied by a unit party to avoid any miscommunication within the network. Sanctions on Russia are done by many different parties separately as the limits on energy imports from Russia are different for different countries.

One of the important features of international trade is the participants' possibilities to increase their power when explained by network theory [42]. In the case of the oil and gas market, the sanction on Russia caused an increase in the level of prices for fuel. This is because of the fact that the manufacturing industry all over the world is still in need of fuel as a source of energy despite the commitment from the world to switch to renewable energy sources. The limit on fuel imports from Russia decreases the supply of oil which moves the market price for fuel to an upper level. Therefore, the international market for fuel gives the possibility to its participants to increase their power in case of sanctions.

Another issue is the fact that while sanctions are imposed by the applicants to make some countries change the direction of their policy, it can also make the sanctioned country's economy even stronger. In the case of Russia, the war with Ukraine is not the only case that country is sanctioned. Russia has faced import sanctions throughout history by the USA and Europe. While the aim of these sanctions is to decrease the power and competitiveness of the sanctioned country in the market, this country will also try to find effective policies to prevent the negative impact on its economy [43]. Russia already sells its oil for lower than market prices to keep its competitiveness in the market, but to avoid the loss of revenue, the country will need to advance its production processes for the future. These advancements means that, in case of need, the next sanctions package in the future will not be effective. Russia is also expanding its relationships with other countries, which is another threat according to the network theory of international relations as Russia will be more independent of the USA and Europe to sustain its economic growth.

Overall, all types of sanctions are likely to decrease the economic development of the global economy. In the case of sanctions in the fuel market, the negative impact on economic development is more significant because of the impact of them on the whole industry as a source of energy. According to publicly available forecasted, a decrease of 3% in GDP growth rate in 2022 and further 0.5% in 2023 compared to 2021 which is highly impacted by the existing sanctions on Russian non-renewable energy resources [44].

3.4 Problems Related to Oil and Gas

One of the main problems in the oil and gas market is the heavy dependence of the supply, demand, and consequently, price patterns on political issues [33]. The war between Russia and Ukraine is a good example of how politics can affect the oil market. While Russia faced low demand, other oil and gas rich countries needed to supply more than before. Both of the situations are not easily manageable. While it can seem like extreme high oil prices are good for oil and gas producers, as explained in the beginning of the paper, it is actually not the case. While direct oil and gas revenue may increase, it can affect the overall economy negatively because of the appreciation of currency and lower foreign demand and investment for other sectors of the economy.

Uncertainty in oil and gas prices is one of the main problems faced by both supply and demand sides. As discussed in the beginning of the paper, oil and gas prices are highly volatile and a number of factors can lead to the increase and decrease in oil prices. Therefore, it is not secure to base the development of the economy on the oil and gas sector only. A good example is the case of Azerbaijan for 2015. One main reason for the devaluation of the Azerbaijani Manat, was the decrease in oil revenue [45]. While the export of Azerbaijani oil decreased, the issue was magnified by the decreasing oil prices. The government lost its foreign exchange reserves, to keep the exchange rate fixed, which was not successful. The economy faced high inflation and decrease in the purchasing power of the population.

While oil and gas are effective sources of energy and very popular in the international market, oil and gas reserves will be depleted in the future and they are non-renewable. The production of oil from high-quality oil reserves has already decreased because of the depletion and switching to other low-quality oil reserves are not effective. There are two main reasons [46]:

- The first, extracting oil from low-quality oil reserves is costly because of the technology and time needed.
- The second is the fact that switching to low-quality oil reserves will harm the environment even more than current damage.

Another literature mentions the need for investment in the Middle-East to avoid shortage in the supply of oil in the near future [47]. However, the author also mentions that even if the investments are made the oil reserves will be depleted soon but it is not possible to mention an exact date as Middle-Eastern countries do not provide clear information about their oil reserves.

The negative impact of fossil fuels on the environment and its contribution to global warming and climate change started frequent discussion and implementation of policies to switch to renewable energy resources. More than half of the CO_2 emissions are stemming from energy use [48]. Consumers are also becoming more aware about environmental issues and environmental impact of the suppliers also affecting their purchasing decisions. To keep up with the customers' expectations and protect their competitiveness in the market, businesses also try to decrease their negative environmental impact. Decreasing the usage of fossil fuels as a source of energy and using renewable energy is an important step to achieve this goal. However, the process of switching to renewable energy resources is not straightforward from both technological and policy perspectives. The transition process should be fair to all parties of the society considering the fact that living and employment conditions of many people will be affected [49]. Despite the challenges, the transition is on the agenda and it has already started to happen… gradually.

Figure 6 shows the dynamics of renewable energy consumption as a percentage of total energy consumption for OECD countries [21]. While the numbers are still small, it has increased over the time and further increase will happen. Consequently, the demand for oil and gas as a source of energy will decrease which is a threat for countries that base their economies on oil and gas production and export.

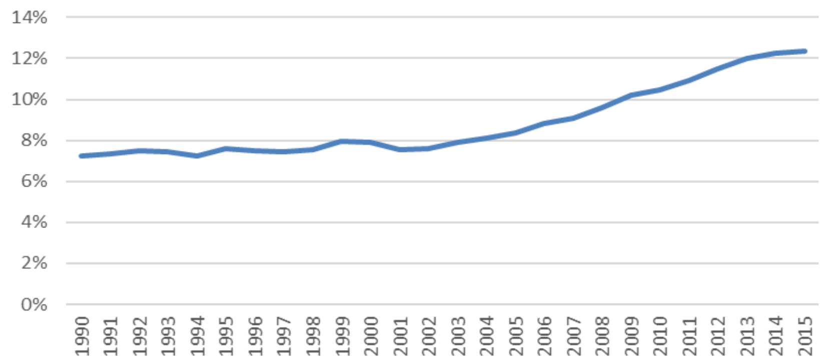

Figure 6

Renewable energy consumption as a percentage of total energy consumption for OECD countries

Source: [21]

As a result of the negative environmental impact of fossil fuels, the world is urged to adopt the usage of renewable energy sources. However, the development of technology that decreases or removes the pollution and emissions from fossil fuel usage can create the possibility to continue the usage of oil and gas without any harm to the environment. The problem related to this solution is about the costly nature of developing this technology. However, even if the necessary technologies are adopted, there is no guarantee that the emissions will be stored properly [33].

According to publicly available forecasted, next problem is related to the possible decrease in world GDP for 2022 and 2023 [44]. The lower level of income for the world population means a lower level of energy use because of many different reasons both directly and indirectly. To exemplify the indirect effects, lower income level means that people will have less money to spend on goods and services they were consuming before and this will decrease production. Lower level of production will lead to the decreased demand for energy and in turn, lower demand for oil and gas.

Changing the strategies and policies based on the demands of society is not an easy and costly process. While the society demands for social responsibility from oil and gas producers and suppliers, it is a challenging process to decide and implement strategies to align with the society's expectations. Oil and gas businesses need to adjust their strategy in a way that they will be able to operate in the future [50]. The dependence of the economy on the oil and gas sector also has its implications for human resources [51] [52]. Oil and gas sector does not create enough jobs directly which means that basing the economy only on this sector may lead to unemployment [36]. The human resources working in the oil and gas industry mostly are not high-quality human capital [1]. Therefore, there is a need for the development of other sectors of the economy and improvements in the human capital accordingly.

Overall, the generation of huge government revenue from the exportation of oil and gas and improper use of the generated revenue is a risk for future generations as they will not be able to benefit from the same resources as current generations do. The governments of oil and gas rich countries should invest the money generated from the oil and gas sector properly to make future generations able to benefit from them too. However, as oil and gas will be depleted in the future and non-oil sectors of oil rich countries are not well developed, future generations will suffer for employment and purchasing power in the international market.

Conclusions

Natural resources, especially oil and gas, have been the main contributors of economic development for a number of countries. The analysis done in this work showed that the export portfolio of the main oil and gas exporter countries, is mainly based on the oil and gas industry, while other sectors of the economy remain underdeveloped. Oil rents constitute a considerable part of GDP in these countries and if we consider the indirect impact of the oil and gas industry on GDP, it will become even larger. While most of the benefit from natural resource revenues can be generated through the effective investment policies of the government to diversify the economy, most resource rich countries failed to adopt this strategy.

The review of the oil and gas market presented in this study shows that the main oil exporters countries do not have diversified export portfolios. Oil and gas markets face high levels of price volatility. The market is also highly responsive to geopolitics. As supplier and demand countries of oil and gas have different political strategies, the sanctions on oil and gas are frequently used as an attempt to impact political behavior. This, in turn, affects the demand, supply, and price level. As oil and gas are the main source of energy for industrial production, changes in supply and demand affects the global economy significantly.

In addition to the high volatility of oil and gas prices, the fact that these resources will be depleted sometime in the future, means that even if there is a demand in the market, current resource rich countries will not be able to meet the demand. Therefore, the revenue from oil and gas will disappear, at some point in the future.

The negative impact of oil and gas on the environment causes increasing concerns regarding the use of them as a source of energy. To be able to achieve sustainable development, the world is trying to switch from non-renewable to renewable energy sources to decrease the negative impact on the environment and to ensure that the consistent growth will also continue in the future for the next generations. The technology to decrease the emissions, from oil and gas usage, is costly and difficult to ensure 100% quality, which makes it almost impossible to eliminate the emissions from their use.

The world economy is highly vulnerable to many different external factors. The Covid-19 pandemic and resulting lockdowns, caused a huge decline in consumption and people started to save. The war between Russia and Ukraine also had a similar effect. Therefore, it is not possible to estimate the future income level and consequently, future demand for oil and gas. All these possible scenarios lead to the similar conclusion, that future generations, in oil and gas rich countries, will not be able to benefit from these resources.

To conclude, while non-renewable energy resources have been the driver of economic growth in many countries, the problems related to their usage and many external factors that can lead to a decrease in demand for oil and gas means that it will not be possible to achieve sustainable development through the oil and gas industry in the future.

Consequently, instead, Governments should develop policies to use the oil and gas revenues in an effective way, that will lead to improvements for all sectors of the economy and the development of local Human Capital. In this way, the future generations will benefit from current, extensive government revenues derived from oil and gas.

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The Influence of Land Utilization and Urbanization, on Environmental Decay in G-20 Countries: Novel Implications for Sustainable Urban Growth

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Abstract: The declining quality of utilized land is due to tectonic forces and exogenic procession, which creates an alarming situation, globally. This research investigates land utilization and greenhouse gas emissions in G-20 countries from 1990 to 2019. The reason behind the data sample from 1990 to 2019 is the availability of data and synchronization of variables for the analytical process. The annual data is deprived of the World Development Indicator. This study contributes to determining the dynamic relationship among total greenhouse gases, land utilization, urban development, economic development, and agricultural land by employing advanced techniques, FMOLS, DOLS and VECM. The conducting analysis tests the long-run relationship's robustness and causal trend after checking cross-sectional dependency and integration level. The Kao corroborated the presence of cointegration while long-run relationship authenticated by FMOLS and DOLS. The VEC model revealed that total greenhouse gases are unidirectionally related to land utilization, urban development and agricultural land. This research is valuable for researchers, agronomists, soil scientists, environmentalists, government, and policymakers seeking the enhancement of environmental quality, reduction of greenhouse gas emissions, reductions in soil erosion and improvement of green production methods that target sustainable development goals.

Keywords: Land Utilization; Urban Development; Total Greenhouse Gases; sustainable development; G20 countries

1 Introduction

Globally, cereal lands declined 50% its productivity due to soil, water and wind erosion. According to a thoroughgoing guesstimate, soil erosion takes US$400 billion for recovering the loss of 75 billion tons of fertile soil [1]. The agronomists and soil scientists considered a US$70 per person loss globally [2] [3]. In addition, the land cover changed and faced degradation due to greenhouse gas emissions. The member countries of G-20 are a presented fragmented picture on the Environmental Performance Index (EPI) map [4]. The environmental performance index report of Y-2021 declared that the highest performer in degradation of environment from G20 countries is UK and India along with the EU as a whole. The high rating of GHG emissions category is attained by India, the UK and France. France joined the UK and India in the last two years to increase GHG emissions. Global warming and GHG emissions have expanded rapidly, and worldly the countries are trying to attain a zero-carbon economy. The G20 countries were established a Green Finance Study Group (GFSG) who tracks the institutions and markets barriers to green finance. The GFSG stream is divided into five subgroups, i.e., green bonds experts & green institutional investors, by seeking the help of the Organization for Economic Cooperation and Development (OECD) [5]. The OECD, with the collaboration of GFSG has established a vast system to mobilize private capital for green financing. The structural policies and systematic approach were adopted by Italy and introduced GFSG in 2021 for restructuring their financial work stream with the help of OECD. The indexing process is unsure about the increasing and decreasing GHG emissions [6]. However, there is still room to shape the sustainable environment, introduce strategies of recovery packages, and many more policies are under discussion. Energy production and consumption comes from undeveloped and unsustainable methods in virtually 11 members, of the G20 countries.

The major contributors of unsustainable energy methods in G20 are Turkey (Rank: 172, EPI Score: 26.30), Mexico (Rank: 73, EPI Score: 45.50), India (Rank: 180, EPI Score: 18.90), South Africa (Rank: 116, EPI Score:37.20), Indonesia (Rank: 164, EPI Score: 28.20), Turkey (Rank:172, EPI Score: 26.30), and the United States (Rank: 43, EPI Score:51.10). The figure-1 is presenting the whole environmental situation of G20 countries, which displayed the toxic and unsustainable area by red color. Land utilization is essential due to its strong link with agronomic productivity, food security, quality of life and environmental sustainability [7] [8]. Land degradation and food production decay can be masked by the adaptation of advanced technology and input restoration [9] [10]. The use and abuse of pesticides directly influence land performance and land degradation [11]. Insecticides, fungicides, herbicides, rodents, molluscicides, nematicides, plant growth regulators and others are good to use in minor quantities. Excessive use degrades the land and soil quality and affects beneficial soil microorganisms with human health as slow poison [12] [13]. Land is a non-renewable resource at a human time scale. Some human-based activities like reducing effective rooting path influence land quality adversely and these activities are irreversible [14].

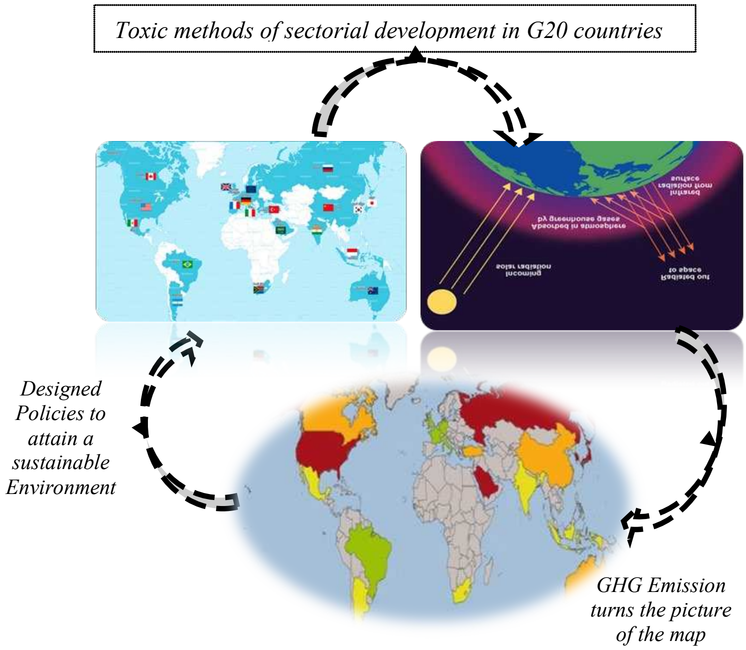

Figure 1
The impact of Greenhouse gases on G-20 Countries

The innovatory and distinctive fragment of this research is to explore the influential capability of different sectors of development on greenhouse gases emission. The excessive use of land in G20 countries has worsened environmental sustainability, which creates an alarming situation toward food security and ecological sustainability. The World Business Council for Sustainable Development (WBCSD) also considered reducing the fertility of the land and increasing environmental pollution. The agronomists, environmentalists and economists are working on sustainable development of cultivated land. This research attempts to fill the gap and collaborate to solve this global issue, i.e., optimization of land productivity with environmental sustainability. The determinants are sectored as dependent, independent and control variables. Total greenhouse gases emission is performing as dependent variables as well as the leading authorities of environmental deterioration. Land utilization and urban development is representative of variables' independence. Land utilization is a key to people's productive land and living standard of people while urban development is the commentating factor of population, projections, and facilitation of urban areas [10] [11] [15] [16]. Economic development and the

Crop Production Index are listed as control variables. The panel data of G20 countries are approached from 1990 to 2018 for determining the relationship among variables. The G20 countries have a mixture of developed, emerging, and developing economies; that's why this research will be unique and exciting. It's easy to present an individual country, but it's a hectic task to increase the level of other members equivalently as a group [17]. This research also enlightened the way of thinking and visualization by enhancing a broad view. The focused groups of countries have gone through divergent environmental, economic, and social phases, so this research can be used the other countries on the globe that have the same situation. The casual relationship and trending behavior of variables toward the environment are measured using FMOLS, DOLS and VECM techniques. Furthermore, this research provides comprehensive suggestions to boost the quality of the environment in G20 countries.

2 Literature Review

Land and soil aren't non-renewable or replaceable resources, but 95% of global food production with ecosystem services like biomass production, contaminants filtration, mass transfer and circulating energy between spheres are on its credit [18] [19]. The intensive toxic change in climate, resources depletion, and the rapid growth of population, dietary patterns, and productive agronomic land has become the reason for unprecedented stresses and shocks in the global food system [19] [20]. Kang et al., [20] determined a significant relationship between land degradation, climate variation and human activities by utilizing the Normalized Difference Vegetation Index (NDVI) and Net Primary Productivity (NPP) which are based on the Euclidean distance method. The findings of this research flourish the quantitative relationship between climate change and human activities by generating Land Degradation and Development Index (LDDI). Human activities are dominantly influenced by land degradation as compared to climate changes (temperature & precipitation) [6] [21]. The production of land is part of the daily use of every human being. On one side, land degradation due to the overuse of pesticides is poisoning; on the other side, land infertility becomes the reason for food shortages. The health of the soil and productive land is as important for human beings as its production. The persistent decline in terrestrial ecosystem productivity features vegetation degradation, water loss, soil erosion and desertification [5], but almost 3.2 billion in urban development & populated areas are influenced globally. This approximation discovered that human activities degrade 30% globally and 40% land of developing countries [22]. The greenhouse effect and ecosystem carelessness are lost \$6.3 trillion, and 73% of dry lands are affected by the deprivation process. Agro-pastoral areas in G20 countries have been targeted at a large scale as well as the forestlands and grasslands are shortened. This research has screened peat land degradation and development in

Peninsular Malaysia and the islands of Sumatra and Borneo and covered the western half of insular Southeast Asia, and calculated the global contribution of CO_2 emission by land utilization. The research data has protected the period from 1990 to 2008. The facts and figures are derived from satellite pictures of high-resolution Landsat (30 m spatial resolution) and Satellite Pour l'Observation de la Terre (SPOT; 10–20 m). Peat swamp forestry ecosystems have observed dramatic reduction and degradation by land cover changes since 1990. Shockingly, within 20 years, almost 5.1 million hectares of peat land have been deforested, and the remaining forests have been logged selectively in bulk quantity.

The secondary growth of unmanaged habitats had doubled in size within no time, and the proliferation of peat land and industrial plantation comprised a quarter of total land (0.3 Mha-2.3 Mha; 2% -15%). According to conservative estimation, the minimum carbon emission in the atmosphere is 1.5Gt from 1990 due to changes in land utilization. The yearly quota of peat land research areas is at least 81Mt of carbon emission per year, equal to 300 Mt of CO_2 emissions owing to peat land alone. This figurative conclusion has indicated that peat land degradation and development have been endangering in insular Southeast Asia over the last two decades. Furthermore, the survival of Southeast Asian peat-swamp forest ecosystems has also resulted in significant global carbon emissions, creating a constant source of carbon dioxide [23]. A comprehensive research work of an Indian city named Ahmedabad has enlightened the way to assess land utilization efficiency and offered [24] a more nuanced view of land consumption patterns in the public and private sectors [25]. This research also focused on how sub-optimal land development patterns emerge in a rapidly growing city. The factors selected to determine the relationship and development variations are public streets, building footprints, and public & remote open areas. The inefficiency of land use with less land in the public domain and more used as private open spaces (mainly as margins and setbacks) is that the output of analytical procession comes from excessive fragmentation. To enhance the efficiency of land, Indian cities should rationalize their development policies and adopt output-based strategies.

3 Data Screening and Analytical Methods

3.1 Data Screening

The research data is gathered from the World Development Indicator (WDI) from 1990 through 2019 for G-20 countries. The scalariform of variables and their identifiers total greenhouse gas emissions (TGE), land under cereal production (LU), Urbanization population (UD), economic development (ED), and Agricultural Land (AL) which are presented in table-1 with auxiliary details.

The variables are prismatically performed their roles in the analytical process, e.g., dependent (TGE), independent (LU & UD) and control variables (GDP & AL). In addition, the data sheets are used for analysis after the natural log to circumlocution the defalcation of data like heteroskedasticity and non-linear modeling.

Table 1

Variable Description

Symbol	Variables	Unit of Measurement
TGE	Total Greenhouse Gases Emissions	Total greenhouse gas emissions (kt of CO_2 equivalent)
LU	Land Utilization	Land under cereal production (hectares)
UD	Urban Development	Urban population
ED	Economic Development	GDP per capita (current US$)
AL	Agricultural Land	Percentage of Land Area
Research data is extracted from the World Bank (2022)		

3.2 Analytical Methods

This analytical process attempts to identify the nexus among total greenhouse gases (TGE), land utilization (LU), urban development (UD), economic development (ED), and Agricultural Land (AL). The flowchart of analytical procession and variables are presented in figure 2. The analysis will undergo into four sections: firstly, The Pesaran CD test is employed to govern the cross-sectional dependent or independent variables. Secondly, the unit root test is used in conjunction with the Pesaran CD test [44]. Thirdly, the cointegration relation is determined by employing the Kao test. Fourthly, the FMOLS and DOLS are used to evaluate long-run relationships, whilst the VECM is utilized to determine Granger Causality in the long and short run.

3.2.1 Cross-Section Dependence Test

The Pesaran CD test is used to ensure that the unit root test produces accurate results. The equational structure of the panel model for the Pesaran CD is presented as follows:

$$y_{it} = \alpha_i + \beta_{it} Z_{it} + u_{it}$$

In the Pesaran Cross-sectional Dependency equation, $i = 1,2, \ldots, N$ is the subscript of each land utilizing G-20 countries individually for time dimensions $t = 1,2, \ldots, T$. The parameter of α_i is archetypal of the constant evaluation of y_{it} causal variables β_{it} is used as a vector parameter, and the error term is denoted by u_{it} . The equational form of the null hypothesis is $H_0 = \gamma_{ij} = \gamma_{ji} = cor.(\mu_{it}, \mu_{jt}) = 0 \ for \ i \neq j$ which confirms no cross-sectional dependency while alternative hypothesis equational form is $H_a = \gamma_{ij} = \gamma_{ji} \neq 0 \ for \ i \neq j$ against the null hypothesis. The j[th] term is representative of autocorrelation coefficient. Previous literature witnessed divergent tests implementation as Friedman [26] and Breusch-Pagan LM [27]. Compared to Friedman [26] and Breusch-Pagan LM [27], the small data sample is more appropriately measured by the Pesaran CD test. The unit root test is checked stability and stationarity of selected series if the unit root test has existed in time series and it confirmed non-stationarity in data.

3.2.2 Unit-Root Test

The stationarity of the data series is checked by employing the ADF test for level and first difference [19]. The least-square method-based unit-root test for the individual intercept and the fundamental structured of ADF, PP [28], LLC & IPS [29] based on below mentioned equations as:

$$ADF: \Delta y_t = \alpha_0 + \alpha y_{t-1} + \sum_{i=1}^{p} \beta_j \Delta y_{t-i} + \varepsilon_t$$

$$PP: \Delta y_t = (p-1) y_{t-1} + \varepsilon_t$$

$$LLC: \Delta y_{it} = \emptyset_i y_{i,t-1} + z'_{it}\gamma_i + \sum_{j=1}^{p} \theta_{ij} \Delta y_{i,t-j} + \mu_{it}$$

$$IPS: \Delta y_{it} = \emptyset_i y_{i,t-1} + z'_{it}\gamma_i + \sum_{j=1}^{p_i} p_{i,j} \Delta y_{i,t-j} + \varepsilon_{it}$$

In above mentioned equations, the Δy_t is changing determinator of dependent variable concerning time.

The constant is denominated by α_0 and α is the coefficient of the preceding value. In the Phillips & Perron [28] the first difference operator is nominated with Δ while y_t for high order of autocorrelation and y_{t-1} for endogeneity concerning time. The equational structure of the Levin-Lin-Chu test is based on two parts; 1) a standard autoregressive parameter is shared by all panels. Because the parameter $\emptyset_i y_{i,t-1} + z'_{it}\gamma_i$ is likely to be plagued by serial correlation, 2) $\sum_{j=1}^{p} \theta_{ij} \Delta y_{i,t-j}$is addressed the LLC augment model. This supplementary element of the model is employed to increase the dependent variable's lag.

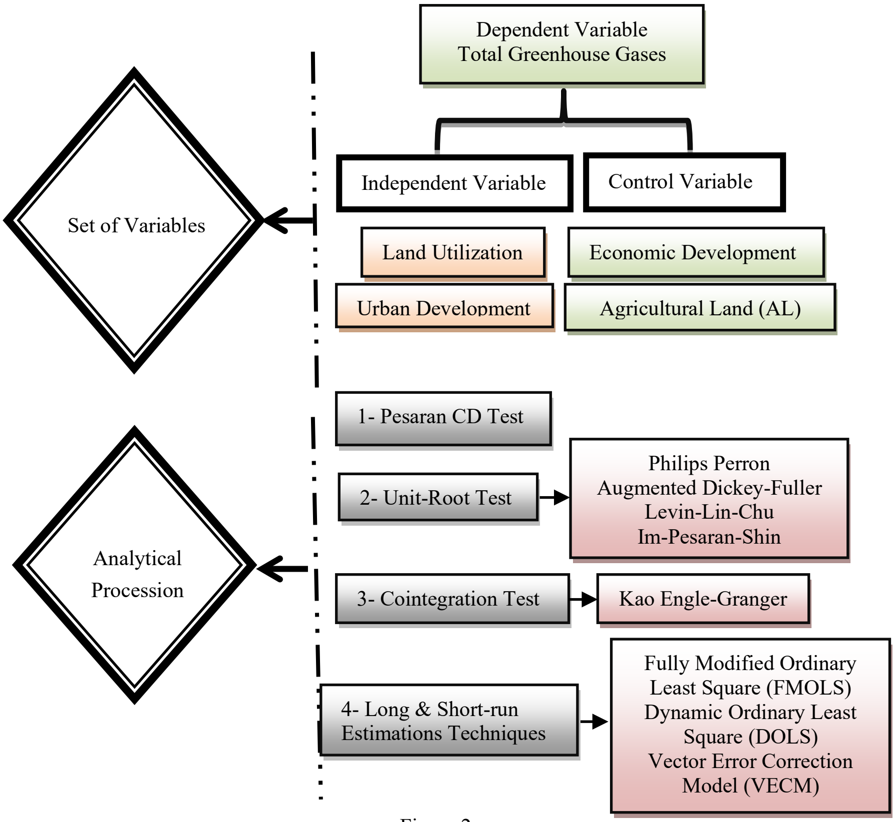

Figure 2
Flowchart of Variables and Analytical Techniques

The IPS test eliminates serial correlation and relaxes the premise of a shared autoregressive parameter, it is acceptable to shorten the data period. Furthermore, IPS does not require a balanced dataset. The equational part $\left(\overset{N,T}{N(panel\ size), T(Sample)}\right) = N^{-1}\sum_{i=1}^{N} t_i(N,T)$ is representative of no serial correlation without using any lag option.

3.2.3 Cointegration Test

The Kao Engle-Granger based cointegration test is selected to check the cointegration relation of variables. The cross-section specific intercepts and homogeneous coefficients are the fundamentals of the Kao cointegration on the first stage regressor [30].

$$y_{it} = \alpha_i + \beta x_{it} + \varepsilon_{it}$$
$$y_{it} = y_{it-1} + u_{i,t}$$
$$x_{it} = x_{it-1} + \varepsilon_{it}$$

$$Covariance: w_{it} = \begin{bmatrix} u_{it} \\ \varepsilon_{it} \end{bmatrix} \text{ is estimated as } \hat{\Sigma} = \begin{bmatrix} \hat{\sigma}_u^2 & \hat{\sigma}_{u\varepsilon} \\ \hat{\sigma}_{u\varepsilon} & \hat{\sigma}_\varepsilon^2 \end{bmatrix} = \frac{1}{NT}\sum_{i=1}^{N}\sum_{t=1}^{T} w_{it} w_{it}'$$

$$= \frac{1}{N}\sum_{i=1}^{N}\left[\frac{1}{T}\sum_{t=1}^{T}(w_{it}w_{it}') + \frac{1}{T}\sum_{\tau=1}^{\infty}\mathrm{K}\left(\tau/_b\right)\sum_{t=\tau+1}^{T}(w_{it}w_{it-\tau}' + w_{it-\tau}w_{it}') \atop k = kernel\ nominator, b = bandwidth\right]$$

The heterogeneity and homogeneity are presented in equation as α_i and β_i. The trend coefficients are displayed as γ_i to zero. Kernel is the parameter of Long-run covariance estimation.

3.2.4 Fully-Modified & Dynamic Ordinary Least Square

The application of the cointegration equation has included the FMOLS, and DOLS approaches to check the long-run relationship among variables. The modification of autocorrelation and residual non-normality is possible under impartial conditions. The primary purpose of FMOLS was to measure parameters because the OLS term only deals with asymptotical biases [31] [32]. The implication of FMOLS and DOLS methods resolves the endogeneity issue and removes small samples' biases or provides accurate results without biases. The FMOLS facilitates the extension of the OLS panel setting and dynamic heterogeneity [33]. The FMOLS estimator is as follows:

$$\beta_{FMOLS} = \left[\sum_{i=1}^{N}\sum_{t=1}^{T} X_{it}X_{it}'\right]^{-1}\left(\sum_{i=1}^{N}\sum_{t=1}^{T} X_{it}\bar{y}_{it}^{+} - \gamma_{12}^{+'}\right)$$
$$Cointegrated\ variables: X_{it}, Y_{it}$$

The modified dependent variables are shown as $\bar{y}_{it}^{+}$ and $\bar{y}_{it}^{+} = (y_{it} - \bar{y}_{it}) - \hat{w}_{12}\Omega_{22}^{-1}\Delta_{22}$ and corrected serial correlation, Ω, Δ is long-run estimators. The DOLS method is a parametric economic method for determining the long-run relationship among coefficients [34]. The equational presentation of the DOLS model is as follows:

$$DOLS: y_t = a + bX_t + \sum_{i=-k}^{i=k} \emptyset_i \Delta X_{t+i} + \varepsilon_t$$

The long-term elasticity is captured by b; $\emptyset$ leads lag differences of I (1) regressor. Moreover, the endogeneity, autocorrelation and non-normal residuals adjustment is assisted by coefficients as nuisance parameters [35].

3.2.5 Vector Error Correction Model (VECM) Granger Causality

After confirming the cointegration relationship, VECM can investigate the causation direction of factors. The VECM modeling framework within a system of EC model used in this study is as follows:

$$\begin{bmatrix} \Delta lnTGO_t \\ \Delta lnLU_t \\ \Delta lnUD_t \\ \Delta lnED_t \\ \Delta lnCPI_t \end{bmatrix} = \begin{bmatrix} \theta_1 \\ \theta_2 \\ \theta_3 \\ \theta_4 \\ \theta_5 \end{bmatrix} + \begin{bmatrix} d_{11m} d_{12m} d_{13m} d_{14m} \\ d_{21m} d_{22m} d_{23m} d_{24m} \\ d_{31m} d_{32m} d_{33m} d_{34m} \\ d_{41m} d_{42m} d_{43m} d_{44m} \\ d_{51m} d_{52m} d_{53m} d_{54m} \end{bmatrix} \text{X} \begin{bmatrix} \Delta lnCO_{2t-1} \\ \Delta lnLU_{t-1} \\ \Delta lnUD_{t-1} \\ \Delta lnED_{t-1} \\ \Delta lnCPI_{t-1} \end{bmatrix} + \cdots +$$

$$\begin{bmatrix} d_{11n} d_{12n} d_{13n} d_{14n} \\ d_{21n} d_{22n} d_{23n} d_{24n} \\ d_{31n} d_{32n} d_{33n} d_{34n} \\ d_{41n} d_{42n} d_{43n} d_{44n} \\ d_{51n} d_{52n} d_{53n} d_{54n} \end{bmatrix} \text{X} \begin{bmatrix} \Delta lnTGO_{t-1} \\ \Delta lnLU_{t-1} \\ \Delta lnUD_{t-1} \\ \Delta lnED_{t-1} \\ \Delta lnCPI_{t-1} \end{bmatrix} + \begin{bmatrix} \lambda_1 \\ \lambda_2 \\ \lambda_3 \\ \lambda_4 \\ \lambda_5 \end{bmatrix} (ECM_{t-1}) + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \\ \varepsilon_{5t} \end{bmatrix}$$

In the above model, coefficients $\lambda_1 - \lambda_7$ are representative of error correction terms, $\varepsilon_{1t} - \varepsilon_{7t}$ denoted homoscedastic disturbance term, ECM_{t-1} displays the long-term equilibrium and the speed of adjustment from the short-term equilibrium to the long-term equilibrium. It is possible to determine the short-term causation and its direction using the Wald test's first difference statistics [19] [36].

4 Empirical Results

The cross-section dependence test is the first data check test for analytical purposes and processing specific econometric methodology. As the name of this test mentioned, checking the cross-sectional independence of panel data is implied. The results of the residuals CD are presented in Table 2, which is evidence of positive significance at the 1% level in Breusch-Pagan LM, Pesaran Scaled LM, and Pesaran CD tests. The significance of the cross-section dependence tests declares the presence of cross-sectional dependency in selected data series [37-39].

Table 2
Residuals Cross-Section Dependency Test

CSD Tests	Pesaran's test	Probability
Breusch-Pagan LM Test	2231.54*	0.000
Pesaran Scaled LM Test	104.729*	0.000
Pesaran CD Test	12.942*	0.000

*Note: * is presenting a 1% level of significance.*

The results of four divergent panel unit root tests (PURTs) are presented in Table 2. The compilation of results is based on the integration level $Z_{it} \sim I(0) or Z_{it} \sim I(1)$ of data series for an individual intercept at the level and first difference [37]. The total greenhouse gases (TGE) are significant 1% level under four PURTs and integrated at first difference. The integration of urban development is confirmed at 1% under the first difference, while 2 (PP & LLC) methods supported level integration at 1% and 5%. The crop production index is significant at 1% under the first difference, while Phillip Perron of level-integration also shows significance at 1%. The economic development and land utilization are integrated at first difference under 4-panel unit-root tests at a 1% significance level.

Table 3
The Unit Root Test based on Individual Intercept Variables

Variables	Level				First Difference			
	ADF	PP	LLC	IPS	ADF	PP	LLC	IPS
TGE	34.314	41.211	-1.069	2.647	164.945*	301.618*	-6.844*	-9.309*
	0.723	0.417	0.142	0.996	0.000	0.000	0.000	0.000
LU	50.167	66.938*	-0.957	-0.964	273.415*	452.297*	-12.157*	-15.146*
	0.130	0.005	0.169	0.168	0.000	0.000	0.000	0.000
UD	44.167	219.202*	-3.103*	0.681	62.211**	52.843***	-3.683*	-2.135**
	0.300	0.000	0.001	0.752	0.014	0.084	0.000	0.016
ED	30.422	21.384	-2.952*	0.448	186.091*	240.314*	-11.090*	-10.646*
	0.863	0.993	0.002	0.673	0.000	0.000	0.000	0.000
AL	30.111	80.273*	-1.293***	2.012	173.056*	292.646*	-10.807*	-11.013*
	0.872	0.000	0.098	0.978	0.000	0.000	0.000	0.000

*Note: *, ** is presenting 1% and 5% level of significance.*

The Kao Engle–Granger-based cointegration test is significant at a 1% level. As per the Kao Engle-Granger based cointegration test, the outputs are acquired in five consecutive statistics named modified Dickey-Fuller, Dickey-Fuller, augmented Dickey-Fuller, unadjusted Dickey-Fuller, and unadjusted modified Dickey-Fuller. The significance of all five at the 1% level authorized the cointegration relation among variables. The collective results of cointegration tests are inveterate that total greenhouse gases (TGE), land utilization (LU), urban development (UD), economic development (ED), and agricultural land (AL) are moving toward a long-run equilibrium relationship altogether.

Table 4
Kao Engle–Granger-Based Cointegration Test

Tests	Statistic	p-value
Modified Dickey-Fuller	3.200*	0.001
Dickey-Fuller	3.966*	0.000
Augmented Dickey-Fuller	4.058*	0.000
Unadjusted modified Dickey-Fuller	3.103*	0.001
Unadjusted Dickey-Fuller	3.791*	0.000

*Note: *, ** is presenting 1% and 5% level of significance.*

The FMOLS is employed to determine the long-run elasticity of the panel. Table 5 consists of the results of FMOLS which confirmed the significance of the complete set of variables (LU, UD, ED & AL) at a 1% level. Land utilization shows a negative significance, while the rest of the four variables are positively significant. The FMOLS tackles simultaneity bias, non-exogeneity, and serial correlation problems. It obtains asymptotically efficient consistent estimates in data series [7] [14]. The cinematography of FMOLS results declares variables' positive or negative contribution to greenhouse gas emissions. The increase in land utilization with a percentage of -0.185 can decrease by 1% greenhouse gas emissions. The negative sign of the land utilization coefficient is an indication of a reduction in greenhouse gas emissions. In contrast, the positive sign of UD, ED, and AL confirm the positive contribution or enhancing behavior toward greenhouse gas emission. The negative contribution of land utilization is logical and considerable because the land is involved in both kinds of projections, i.e., environmentally friendly or unfriendly. An increase in UD 0.799%, ED 0.071% and AL 0.263% contributes a 1% increase in GHG individually. The positive and significant behavior of variables is the vibrant signal of positive contribution to greenhouse gases emission. The contribution of variables can be categorized as per their contribution [37] [40]. The DOLS is generally used to robust check the small sample, cross-check Ordinary Least Square (OLS) & the Fully Modified Ordinary Least Square (FMOLS), and control endogeneity biases. Table 5 also contained the results of DOLS in the last three columns [8]. The DOLS test's results present the increasing effect of independent variables and their impact on greenhouse gas emissions. The results of DOLS confirmed the significance of all variables except land utilization. Urban development and economic development are positively significant at 10% and 1% orderly, assuring their role in increasing greenhouse gas emissions. The agricultural land is negatively significant at the 5% level. Thus, the economic development contribution to greenhouse gases emission is comparatively low [7] [8].

Table 5
The Estimated FMOLS and DOLS

Regressors	Fully Modified OLS			Dynamic OLS		
	Coefficient	t-Statistic	Prob.	Coefficient	t-Statistic	Prob.
LU	-0.185*	-10.098	0.000	0.130	1.649	0.101
UD	0.799*	674.510	0.000	0.487***	1.925	0.056
ED	0.071*	7.952	0.000	0.246*	6.522	0.000
AL	0.263*	98.683	0.000	-2.019**	-2.061	0.040

*Note: *,**,*** is presenting 1% ,5% and 10% level of significance*

The confirmation of cointegration among variables is completed by the fundamental assumption to run VECM. The VECM results are displayed in table 6, and asterisks are placed on the top of coefficients to declare their significant levels. The causal relationship among variables is determined by applying VECM, which is presented in Figure 3. All variables' error correction term is significant, confirming a long-run relationship among the selected set of variables. Total greenhouse gases emission, urban development, and crop production index are significant and negative, while the rest of the two variables (LU & ED) are positively significant [7]. The ECt-1 term is positive and significant for TGE, ED, and AL at 1%, 1% & 10% orderly, while LU and UD are positively insignificant. All variables' short-run casual relationships are determined first and second to check the accurate and precise directional connection. The total greenhouse gas emission has a positive and unidirectional relationship with urban growth, $TGE \rightarrow UD$ at 1% level. Land utilization and agricultural land both are negatively significant at 5% and showing a unidirectional relationship with TGE as $LU \rightarrow TGE$ & $AL \rightarrow TGE$. Instead of a relationship directory of dependent and independent variables, the independent variables also show their association with their counterparts [19][40], as land utilization and economic development, are negatively related to each other $LU \rightarrow ED$ at 5% level. Economic development and agricultural land are negatively and bi-directionally related to each other, at a 1% level of significance$ED \rightarrow AL$. Agricultural land has confirmed the negative and significant unidirectional relationship between land utilization and urban development at a 10% level as $AL \rightarrow LU$ &$AL \rightarrow UD$. Agricultural land indeed broadened due to the expansion of economic development [41]. The metropolitan areas are generally developed regions due to more luxurious facilities that directly relate to energy consumption.

Table 6
Estimation of VECM Granger Causality

Dependent Variables	D (TGE)	D(LU)	D(UD)	D(ED)	D(AL)
EC_{t-1}	0.005*	0.003	0.000	0.017*	0.001***
D(TGE(-1))	0.030	0.046	-0.001	0.023	-0.025
D(TGE(-2))	0.072	-0.028	0.010*	0.108	-0.015

D(LU (-1))	-0.045**	-0.182*	0.000	-0.189**	-0.012
D(LU (-2))	-0.024	-0.126*	-0.002	-0.183**	-0.007
D(UD(-1))	0.591	-0.433	0.906*	0.124	-0.165
D(UD(-2))	0.251	-0.122	0.035	-0.970	0.348
D(ED(-1))	0.005	0.013	0.001	0.161*	-0.003*
D(ED(-2))	-0.017	-0.016	0.000	-0.079***	0.000
D(AL(-1))	0.032	-0.164	0.005**	0.100	0.071
D(AL(-2))	-0.279**	-0.447***	-0.012***	-0.464*	0.146*

*Note: *,**,*** is presenting 1% , 5% and 10% level of significance.*

The instantaneous results of VECM are presented in Table 7. The variables with the derivative sign display Granger causality in short-run effects. The last value with the caption "All" represents the ECT term, which confirmed Granger causality in the long run [19]. Urban development and agricultural land are significant at 1% and 5%, while the positive insignificance of land utilization and economic development is observed. The individual results of land utilization and economic development are positively insignificant, while all chi square pooled results are significant, at a 1% level.

Table 7

VEC Granger Causality/Block Exogeneity Wald Tests

Excluded	**Chi-sq**	**df**	**Prob.**
D(LU)	6.040	2	0.049
D(UD)	18.387*	2	0.000
D(ED)	2.145	2	0.342
D(AL)	6.621**	2	0.037
All	32.600*	8	0.000

*Note: *,**, *** is presenting 1%, 5% and 10% level of significance orderly.*

5 Discussion of Findings

This research confirmed that the G20 countries attributed divergent challenges to green technological development, environmental efficiency, and sufficient environmental administration in individual member countries. Land utilization and agricultural land utilize less than average techniques that deteriorate the balances and environmentally friendly development. The G20 countries should boost up their managerial sufficiency and technology advancement by introducing dual-wheel driving [8]. The results of this study have exposed remarkable changes in environmental sustainability regarding land utilization of G-20 countries from 1990 to 2019. The results of this research masterpiece revealed the long-run relationship among selected variables by employing the Kao cointegration technique [42] [43].

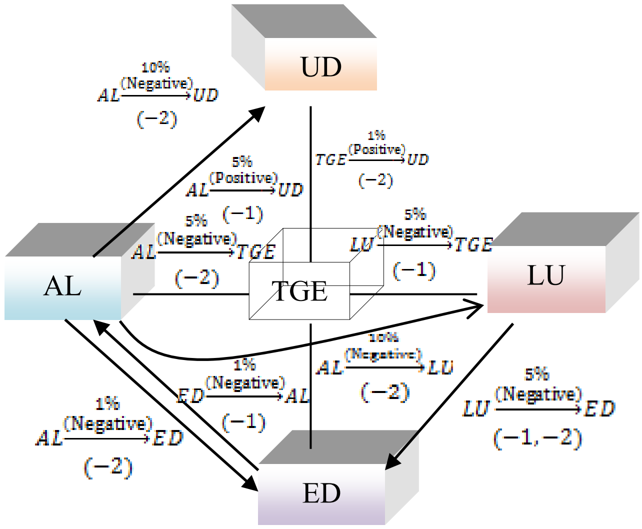

Figure-3
Causal Relationship among Variables

The results of the Granger Causality test have declared that UD and AL are the cause of environmental degradation and authorize their contribution with positive significance. The directional relationship among variables confirmed a positive unidirectional relationship between total greenhouse gases (TGE), with urban development (UD) and a negative unidirectional relationship between land utilization (LU) and agricultural land (AL). Urban development becomes the reason for many toxic emissions, land erosion, and disturbance of ecology conservation Halton. In contrast, land utilization or agricultural land is less toxic but more environmentally friendly. There are two key reasons to suspect that the GHG emission figures reported in this research have been calculated conservatively. First, it should be remembered that increasing urban development in degraded cereal-producing areas was thought to increase carbon emissions [1] [14].

This is because more transportation and fuel-burning emissions result from the rapid growth and development of the metropolitan regions [22] [23]. Second, land use is more vulnerable to fire due to ecological degradation and most land cover changes. As a result, GHG emissions caused by fire are inextricably related to environmental damage. These emissions, however, were not included in this study [2] [20] [44]. The individual governments of the G20 countries should implement the policies of laypeople and agencies to put an eye on the good practices of environmental protection. The developing and emerging members of the G20 should focus more on ecologically friendly growth projects.

Concluding Remarks and Implications

This research is conducted to determine the dynamic relationship between total greenhouse gases, land utilization, urban development, economic development and agricultural land by employing FMOLS, DOLS and VECM. The analysis process initiated by checking the cross-dependency and integration level of the data series i.e., at the level $Z_{it} \sim I(0)$ and first difference $Z_{it} \sim I(1)$. The results of the integration check revealed that cointegration is feasible to be applied. The Kao cointegration, FMOLS, and DOLS tests are employed to determine the long-run relationship among variables, while the VECM explores the directional relationship and speed of adjustment from the short to long-run period. Greenhouse gas emissions of the G20 countries were mainly caused by urban development, economic development, and agricultural land, while land utilization reduced greenhouse gas emissions. Technical products and heterogeneity of G20 nations are evident in greenhouse gases emission. The occupation of the global map by G20 countries is recognized as leading countries, so they have more room for environment quality optimization.

The green technology promotion in the production and consumption of energy can work more quickly because this research is indicated that the urban development sector is neglected more. All countries' research and development sectors should promote clean technology for all sectors of the economy to minimize greenhouse gas emissions. This is a more concerning part of the implication when countries will introduce clean technology simultaneously.

In future research work, different countries or groups of countries, can be explored, as well as expanding the discussion of environmental sustainability. In future research, the study can be divided into three leading groups of countries, as catching-up countries (chasers), leading countries (technology leaders) and best practice countries (best practitioners).

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Agricultural Route Efficiencies, based on Data Envelopment Analysis (DEA)

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Abstract: Agriculture is one of our most critical industries, since it provides food. The large size of the agricultural land implies that the treatment of the land must be performed efficiently by mechanization - ground, aircraft or drone (agricultural aircraft are used in this research). Land processing should be done in multiple routes to treat all plots due to the limited capacity of the aircraft. One set of routes needed for treatment of all plots on one agricultural land forms one processing plan. Suppose that we have several different processing plans generated intuitively or by using an exact or heuristics algorithm, the research question is which one to choose to efficiently treat the agricultural land divided into plots. We propose application of Data Envelopment Analysis (DEA) method for selecting efficient processing plans and selecting and scheduling the efficient routes within a plan, to ensure sustainability of the land treated. The first goal of this paper is to select a relatively efficient processing plan (from the predetermined set of plans) using the Data Envelopment Analysis (DEA) approach and to analyze relatively inefficient ones. The second goal of the application of DEA method is the selection of efficient routes within one efficient processing plan. Input and output variables are selected based on the analyzed problem's specific characteristics and the previously published research. As a result, relatively efficient plans and routes are selected, and relatively inefficient ones are further analyzed to improve their performance by changing the inputs and/or outputs.

Keywords: agricultural land processing; route planning; efficiency evaluation; Data envelopment analysis

1 Introduction

Making agriculture more sustainable is a required aspect of every business activity related to that sector. The agriculture production consists of several conflicting resources [1] and the quality of the arable land decreases, and the human population increases; thus, many landscapes will be transformed into agricultural land.

The existing and future arable surface must be processed effectively and efficiently in order to be utilized and preserved for future use. Problems of evaluation and analysis of efficiency in the agriculture sector are often solved. Data Envelopment Analysis (DEA) is a commonly used technique for efficiency analysis [2]. DEA is suitable for the evaluation of agricultural production since it is a complex system with multiple inputs and outputs [3]. This research aims to select efficient routes and processing plans for agricultural land treatment using the DEA method. The motivation for this study arises after solving the vehicle routing problem in the treatment of agricultural land (agricultural land divided into plots) using agricultural aviation [4]. In order to solve the formulated problem, authors applied the exact or heuristics methods and the application of these method(s) resulted in processing plans. The processing plan represents a set of routes that an agricultural aircraft executes for treatment [4]. The greedy-based constructive heuristics developed by Andric Gusavac et al. [4] for solving large-scale problems can produce several production plans in multiple runs. The main issue is which of those plans is the most efficient regarding the multiple criteria. Furthermore, management could be faced with the problem of selecting and scheduling the land treatment routes within one processing plan. Therefore, to ensure the treated agricultural land's sustainability, we proposed the DEA method for selecting efficient processing plans and selecting and scheduling the efficient routes within a plan.

Main contribution of this paper is enabling the application of decision-making in the solving of the routing problem based on more than one criterion. Given that it is possible to obtain multiple set of routes (processing plans) for a certain dimension of the routing problem, the DEA method has proven to be extremely useful, because its application, based on several criteria, leads to the selection of efficient processing plans from a set of generated (exactly or by heuristics) plans. It is recognized that in a set of routes, efficient routes can also be identified, and ineffective ones can be analyzed to achieve their efficiency.

This paper is structured as follows: the DEA method is presented briefly in the second chapter, followed by the third chapter, where a detailed explanation of the problem is given. The proposed problem in this chapter is divided into two levels and solved consecutively. Concluding remarks and future research proposals are given in the last chapter of the paper.

2 Literature Review

The development of DEA method for evaluating efficiency made it possible to include, at the same time, multiple inputs, or multiple outputs into the analysis. The basic DEA model, defined in [2] was first used to measure the efficiency of non-profit sector. Today, DEA methods, either alone or in combination with other methods, is often applied to other areas, with diverse production inputs and outputs

[5][6]. Authors Andrić Gušavac and Savić [7] give a detailed review of the application of DEA method in agricultural land processing. Most of the papers presented in [7] examine technical efficiency and co-efficiency, and the lack of studies dealing with route efficiency in agriculture can be noticed.

Papers related to the problems of evaluation and comparative analysis of agricultural efficiency are commonly dealing with the efficiency assessment of bus transportation [8-11] and air routes performance [12]. The DEA method has been used since the early 1990s to compare outcomes in public transport areas [8]. In their research, the authors Singh et al. [8] assess the efficiency of the bus routes to determine efficient and inefficient routes using the DEA method. Performance evaluation of electric trolley bus routes is researched in [13]. Authors in [14] aim to show and test a developed model for determining the optimal transport route among alternatives, where the solution is a green route obtained by using DEA method.

For the DEA method to be well applied, it is necessary to perform a good selection of the Decision-Making Unit (DMU) and input and output criteria (performance indicators). Literature review where input and output variables for the evaluation of the DMU in the analyzed published papers are shown in Table 1.

Table 1
Review of the application of DEA in the evaluation of route efficiency

References	**Inputs**	**Outputs**
[13]	Fleet size. Man-hours, Electricity	Number of vehicle-km Trips
[14]	Transport costs, External costs Transport time	Given distance of transport route
[8]	Bus route length	Population along the bus route, Social priority points
[10]	Phase 1 inputs: Route length, Number of stops, Bus overlapping, Route directness, Metro overlapping Phase 2 inputs: Peak operation speed, Off-peak operation speed	Intermediate outputs: Residential coverage, Bus connectivity, Employment coverage, Metro connectivity Phase 2 outputs: Annual average daily ridership
[11]	Fuel cost per bus per day, Labor cost per bus per day, Operating expenses	Profit and Average passengers per bus per day, Emission metric
[9]	Route distance, Number of buses, Fuel consumption	Unlinked passenger trips
	Distance, Travel time, Service, Frequency, Deviation from shortest distance, Stops per km	Unlinked passenger trips

Most published research of routes performance for airlines consider companies as DMUs and not routes; therefore, in these cases insight into the various operation route problems may be lost. Not many published papers deal with air routes efficiency, this topic is analyzed in paper by authors Shao and Sun [12]. For this research, it is important to outline the analysis of routes in air transport, so the input and output variables used in the analysis in this paper dealing with airline routes are presented in Table 2.

Table 2

Selected input and output variables for air transport

References	Inputs	Outputs
[12]	Input of allocation stage: Number of flights Inter-phase measures: Available seats, Available tonnage	Passenger transport function output: Passenger throughput Freight transport function output: Mail and cargo throughput

Route length is most often used as input factor in public urban transport in the literature [8-10], as well as fuel costs [9] [11] [15] [16].

3 Materials and Methods

DEA [2] was first introduced for measuring the relative efficiency of non-profit organizations. These organizations are called Decision-Making Units (DMUs) and whose performance depends on multiple inputs and outputs. Application areas of the DEA method are later expanded to a wide range of areas.

DEA determines the efficiency rate of each DMU$_k$ (k=1,...,m).It is important to notice that the efficiency of each decision-making unit (DMU) is measured in relation to the other decision units so the obtained efficiency measure is relative. Every unit produces s outputs, while consuming n inputs, where the values of inputs x_{jk}, (j=1,...,n) and outputs y_{rk} (r=1,...,s) for each DMU$_k$ are given. An output-oriented DEA model is used in this research to determine the relative efficiency of each processing plan and each route, assuming constant returns-to-scale (CRS) [17]:

$$\min h_k = \sum_{j=1}^{n} v_j x_{jk} \tag{1}$$

subject to:

$$\sum_{r=1}^{s} u_r y_{rk} = 1 \tag{2}$$

$$\sum_{j=1}^{n} v_j x_{jp} - \sum_{r=1}^{s} u_r y_{rp} \geq 0,\ p = 1,...,k,...,m \tag{3}$$

$$v_j \geq \varepsilon,\ j = 1,...,n \tag{4}$$

$$u_r \geq \varepsilon,\ r = 1,...,s \tag{5}$$

where: $v_j,\ j = 1,...,n$, weights assigned to j^{th} input; $u_r,\ r = 1,...,s$, weights assigned to r^{th} output and h_k is relative efficiency score of DMU$_k$.

In order to perform mutual comparison of all relatively efficient units, a modified DEA model can be used. This model, proposed by Andersen and Petersen [18] enables the ranking of relatively efficient units, i.e., assessment of super-efficiency. Modification of the primary model implies that, from the set of constraints given by relation (3) in model (1-5), those constraints that correspond to DMU$_k$ are omitted. The form of these constrains is now:

$$\sum_{j=1}^{n} v_j x_{jp} - \sum_{r=1}^{s} u_r y_{rp} \geq 0,\ p = 1,...,m, p \neq k \tag{6}$$

These modified output-oriented DEA models enable the ranking of the efficient units similarly as inefficient based on an efficiency index greater or equal to 1.

The formulated model is solved using DEA Solver software [19] and at the end, analysis and results interpretation is performed.

4 Processing Plan and Route Efficiency Analysis using DEA Method

Let us suppose we have one agricultural land divided into plots and that one agricultural operation of chemical treatment must be processed on all the plots. Multiple routes have to be generated because an agricultural aircraft cannot treat all the plots in only one route due to the predefined capacity. The set of routes needed for all plots treatment forms one processing plan. The different processing plans can be generated intuitively or by using an exact or heuristics algorithm for solving the vehicle routing problem. For example, a specific cost minimization vehicle routing problem for aircraft processing of land agricultural land divided into plots is formulated by [4]. The performance measures for each plan can be calculated based on the obtained solution. In the real-world application, the decision-maker needs to determine the order of routes performing and make their schedule. This problem is, by definition, classified as a combinatorial problem that is difficult to solve. It became even more difficult in the presence of several input and output performance indicators. Furthermore, we already mentioned that special heuristics proposed in [4] could produce multiple processing plans by varying parameters in multiple runs. Those plans differ from the multiple criteria perspectives, such as performance indicators of total route length or total capacity usage. Thus, the necessity for criteria balancing and plans comparison arose.

Therefore, two research questions arise. The first research question: considering the possibility to generate multiple processing plans for one agricultural land, which processing plans from the observing set are relatively efficient based on multiple input and output criteria? The second research question: what is the relative efficiency of routes from one processing plan covering all plots? The answers to those questions are found by using the DEA method. Based on the previously stated, the efficiency evaluation by the DEA method is carried out through two steps, preceded by the preparation of the data and followed by the application of the obtained solution. The procedure of addressing the afore stated problem is presented in Figure 1.

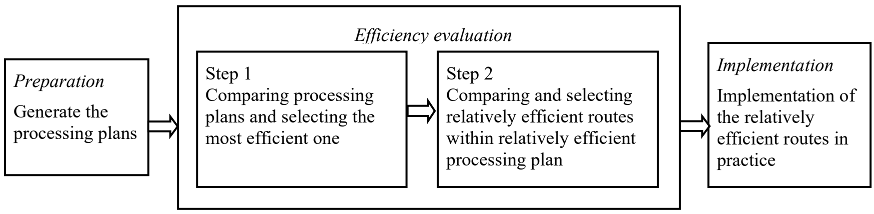

Figure 1
Procedure of processing plans and routes efficiency evolution in agriculture

For the first phase, the preparation of the data, the results (processing plans obtained by exact or heuristics methods) from the study conducted in [4] are used. These processing plans represent a set of routes that an agricultural aircraft executes for treatment. This phase is not in the focus of this paper; thus, a more detailed explanation of this step can be seen in [4].

Efficiency evaluation is conducted through two steps (Figure 1) When the processing plans are prepared, the first step in the application of the DEA method is to compare multiple plans that address the same problem and determine relatively efficient plans. In research presented in this paper, we used processing plans obtained in [4]. The full ranking of the relatively efficient plans can also be determined by applying the super-efficiency DEA model. In this way, the most efficient plan can be selected from a set of several solutions (relatively efficient processing plans), and it can be applied in practice in the last implementation phase. Relatively inefficient processing plans can be analyzed to perceive the necessary changes to values of inputs and/or outputs that need to be made for these plans to become relatively efficient as well. The next step is to compare the routes within one efficient plan using the DEA method (note: the DEA method can be applied for route selection to any processing plan from step 1). It is now possible to select relatively efficient routes that are part of a single plan, thus selecting the routes to be performed first in practice. After that, relatively inefficient routes can be analyzed to single out inputs and/or outputs of these routes whose values could be changed, and the relative inefficient routes could become relatively efficient.

For Step 1 in the proposed procedure of DEA application, the selected DMUs are processing plans, and in step 2, proposed DMUs are individual routes. The selection of input and output variables for the evaluation of the DMUs in each step is based on specifics of the problem itself and literature review where inputs and outputs in the analyzed published papers are shown in Table 1.

4.1. Selection of Relatively Efficient Processing plans

4.1.1 Input and Output Selection and Data Generation

In order to compare processing plans (processing plans are selected as DMUs) and select the relatively efficient ones for the application of DEA method, inputs proposed [7] are: (1) Total available capacity of all aircraft (in liters) - input 1; (2) Total cost of treatment of all plots (in monetary units) - input 2.

The aircraft (fuel tank) capacity is important because it determines the total length of flight. Total cost of treatment of all plots is the sum of total cost of aircraft flying throughout all the routes (for each route: from the airfield to the first plot in a route, flying between all plots in the routes, from the last plot in a route to the airfield and the cost of treatment of each plot).

Output variables that are proposed in this paper are:

(1) Total used capacity of all aircraft (in liters) - output 1
(2) Percentage share of effective flight in the total distance travelled [%] - output 2.

The total used capacity of all aircraft is calculated as the sum of individual capacities of all engaged aircraft, and the percentage share of effective flight in the total distance travelled is calculated as the sum of effective flight in each route in the processing plan. Effective flight is the flight of an aircraft that adds value, meaning that this part of the flight is only the part when the aircraft is flying over the plot and executing treatment. Input and output variables are selected based on the characteristics of the analyzed problem and based on the previous published research [9].

A total of 19 processing plans are generated by heuristics presented in the paper by Andric Gusavac et al. [4]. Each run of heuristics solves the instance with 100 plots and a maximum of 21 available aircraft. The number of plots to be treated is selected as a constant input parameter, and the parameter that varies is the number of aircraft used for plots treatment. As a result, obtained processing plans are considered as DMUs and their efficiency is evaluated in Step 1 (Figure 1).

Descriptive statistics for input data for the numerical example solved by the DEA method is shown in Table 3. Input 1 is obtained as the sum of the capacity of each available aircraft. The total cost of treating all plots represents the costs of treating all routes within the processing plan. The total used capacity of all aircraft is the sum of the capacity of each engaged aircraft, and the percentage share of effective flight in the total distance travelled is the sum of effective flight in each route plan. Effective flight is the flight over the plots when the aircraft is processing the plots and does not include the inter plot flight and flight between the airfield and the plots.

Table 3
Descriptive statistics for processing plans

	Input 1	**Input 2**	**Output 1**	**Output 2**
Average	6273.68	17171.20	4065.79	57.57
Max	8100.00	18357.00	4750.00	60.02
Min	4300.00	16461.10	3600.00	53.82
St Dev	1115.01	438.81	319.15	1.41
Correlation				
Input 1	1	0.3636	0.06144	-0.3652
Input 2		1	0.87089	-0.9994
Output 1			1	-0.8753
Output 2				1

4.1.2 Results Discussion

Software tool DEA-Solver-LV 8.0 [19] is used for solving the described example and the obtained values – the relative efficiency of processing plans is presented in Figure 2.

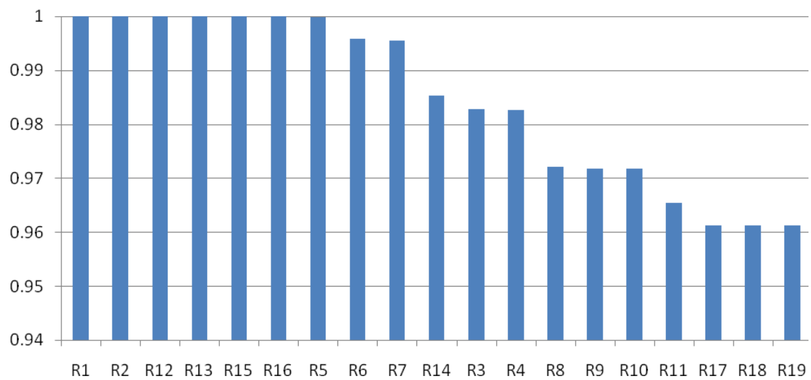

Figure 2
Relative efficiency of processing plans

Based on the obtained relative efficiency of the processing plans, it is possible to identify which inputs and/or outputs of relatively inefficient processing plans need to be reduced and/or increased for these plans to become relatively efficient. These possible changes for inputs and outputs are given in Table 4.

Table 4
Projection for input and output parameters for processing plans

DMU	Input 1		Input 2		Output 1		Output 2	
	Parameter	Projection	Parameter	Projection	Parameter	Projection	Parameter	Projection
R1	4300	4300.0	17203.9	17203.9	4300	4300.0	57.43	57.4
R2	4650	4650.0	16461.1	16461.1	3600	3600.0	60.02	60.0
R3	4900	4900.0	16950.3	16950.3	3900	3967.8	58.29	59.3
R4	5100	5100.0	16950.3	16950.3	3900	3969.3	58.29	59.3
R5	5250	5250.0	17133.1	17133.1	4250	4250.5	57.67	57.7
R6	5500	5500.0	17118.3	17118.3	4200	4217.4	57.72	57.9
R7	5700	5700.0	17118.3	17118.3	4200	4218.9	57.72	58.0
R8	5850	5850.0	17156.8	17156.8	4000	4114.4	57.59	59.2
R9	6100	6077.6	17156.8	17156.8	4000	4116.1	57.59	59.3
R10	6300	6077.6	17156.8	17156.8	4000	4116.1	57.59	59.3
R11	6450	5227.9	16919.5	16919.5	3700	3832.8	58.39	60.5
R12	6700	6700.0	17156.4	17156.4	4300	4300.0	57.59	57.6
R13	6900	6700.0	17156.4	17156.4	4300	4300.0	57.59	57.6
R14	7050	5506.6	16858.1	16858.1	3850	3906.9	58.61	59.5
R15	7300	7300.0	18357.0	18357.0	4750	4750.0	53.82	53.8
R16	7500	7500.0	18357.0	18357.0	4750	4750.0	53.82	53.8
R17	7650	5415.0	17014.3	17014.3	3750	3900.9	58.07	60.4
R18	7900	5415.0	17014.3	17014.3	3750	3900.9	58.07	60.4
R19	8100	5415.0	17014.3	17014.3	3750	3900.9	58.07	60.4

It is interesting to notice that only input 1 needs to be reduced so the relatively inefficient processing plans become relatively efficient. The reduction is from 0.37-3.53% for the processing plans R9, R10 and R13, and greater reduction needs to be done for processing plans R11, R14 and R17-R19, where the reduction is from 18.9-33.1%.

For the six relatively efficient DMUs (R1, R2, R12, R13, R15 and R16) no changes for the parameters' values are needed and the difference between the real and the projection value is zero. In order to make relatively inefficient DMUs efficient, it is possible to influence the real values of these parameters (output 1 and 2) and change them to the values given in Table 4 (increase to the projection values). These changes for outputs 1 and 2 are at maximum 4.0%.

Input 2 (total treatment cost of all plots within one treatment plan) does not need to be changed to make the treatment plan relatively efficient, and input 1 (available capacity of all aircraft) can only be reduced for eight relatively inefficient plans (out of 13) for these plans to become relatively efficient. Outputs have a much greater impact, as expected, given that an output-oriented DEA model is applied.

4.2. Ranking of the Relatively Efficient Processing Plans based on Super-Efficiency

As can be seen in Figure 2, six of 19 processing plans have an efficiency index equal to 1. This is the result of a flexible choice of weighting factors in the DEA method that favored aircraft capacity utilization as an output parameter. Using a DEA model for super-efficiency assessment (given in Section 2), the analysis was re-done to rank efficient DMUs (Figure 4).

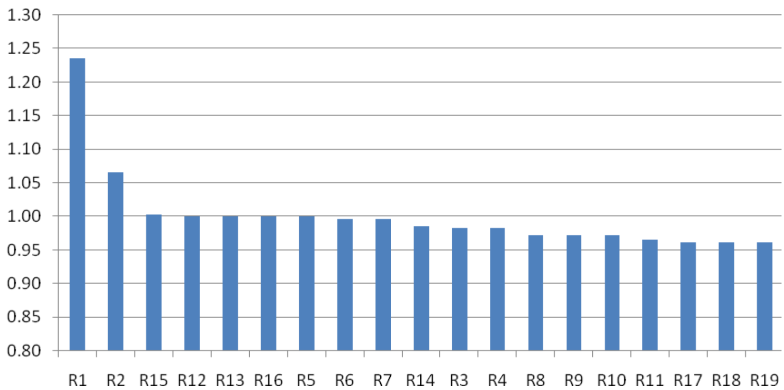

Figure 4
Super efficiency of processing plans

Figure 4 shows that two plans R1 and R2 have a super-efficiency index higher than 1 and processing plan R1 stands out in relation to other plans. The first-ranked plan R1 was singled out as the best solution, considering that real and relevant data were used for experiments in the analysis and the data from this processing plan will be used in further analysis to select relatively efficient routes within one processing plan.

4.3. Selection of Relatively Efficient Routes within One Processing Plan

4.3.1 Input and Output Selection and Data Generation

Now, when one super-efficient processing plan is selected, it is necessary to compare the routes within that one plan and to select relatively efficient routes. For the next phase of DEA application, the first ranking processing plan R1 is chosen–

it is an example, with 100 plots and 21 available aircraft. For detailed explanation of the processing plan structure see [4].

When a set of routes which need to be performed in order to finish a treatment of the land is determined, DEA is applied, and relatively efficient routes are selected. In order to process the whole agricultural land with chemical treatment, it is necessary to perform all the routes within one processing plan. The question that arises here is which routes should be performed first. The answer could be found in routes efficiency evaluation.

In the approach proposed here for the evaluation of route efficiency within one processing plan, the classical output-oriented CCR DEA model is used, and the proposed input and output variables for the application of the DEA method are given below:

- Input variables: Input 1 - Aircraft capacity (in liters)
  Input 2 - Total cost of plot treatment in the route (in monetary units)

- Output variables: Output 1 - Total treated surface area of all plots in the Route [acre]
  Output 2 - Percentage share of effective flight in the Total distance travelled [%]

Aircraft capacity represents the total available capacity of the aircraft fuel tank. It comprises the total distance of one aircraft flight. Total cost of treatment in the route comprises of the total cost of flying the aircraft from and to the airport, the cost of the realized flight between all plots in the route, and the cost of flying over each plot in the route during its treatment.

Table 5

Descriptive statistics for routes within processing plan

	Input 1	**Input 2**	**Output 1**	**Output 2**
Average	204.76	819.23	47.05	56.12
Max	250.00	1400.20	95.00	70.30
Min	150.00	307.30	16.00	43.05
St Dev	40.55	289.41	20.83	6.94
Correlation				
Input 1	1	-0.3348	-0.4401	-0.5001
Input 2		1	0.96809	0.53487
Output 1			1	0.71107
Output 2				1

The total treated surface area of plots in the route represents the total sum of the surface area of all plots in the considered route. In order to treat all plots in one route, the aircraft must fly from the airport to the first plot in the route, fly between each plot in the route and fly from the last plot in the route to the airport. Only the part of the flight related to plot treatment in the route is effective flight and this is the reason that Percentage share of effective flight in the total distance travelled is chosen as output 2. Descriptive statistics (maximum and minimum values, average values and standard deviation) and correlation analysis are shown in Table 5. The example was solved for an instance of the following dimensions: 21 aircraft and 100 plots. The obtained solution - the processing plan includes 21 routes that cover (treat) all the plots.

4.3.2 Results Discussion

Software tool DEA-Solver-LV 8.0 [19] is used for solving the described example and the obtained values – relative efficiency of routes in one processing plan are presented in Figure 4.

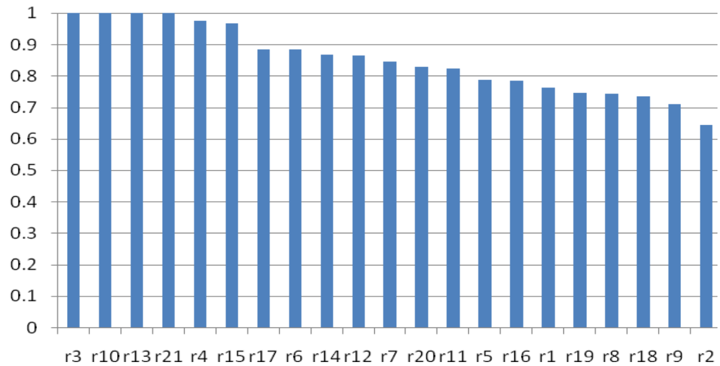

Figure 4

Relative efficiency of routes

Based on obtained results, four routes are relatively efficient and 17 are relatively inefficient. These results can be used for efficient scheduling, where the relatively efficient routes can be scheduled first in practice, and for the inefficient routes some further analysis can be done. It is possible to identify which inputs and/or outputs of relatively inefficient routes need to be reduced and/or increased as these routes could become relatively efficient. These possible changes i.e., projections are shown in detail in Table 6.

Table 6

Projection for input and output parameters for routes

DMU	Input 1		Input 2		Output 1		Output 2	
	Parameter	Projection	Parameter	Projection	Parameter	Projection	Parameter	Projection
R1	250	169.9	1054.3	1054.3	56	73.3	53.1	69.5
R2	250	195.2	604.0	604	26	40.4	43.0	66.9
R3	200	200.0	447.1	447.1	29	29.0	64.9	64.9

R4	150	150.0	1085.0	1085	71	74.0	65.4	66.7
R5	250	184.6	815.0	815	44	55.8	53.9	68.4
R6	200	200.0	346.1	346.1	17	19.6	49.1	55.6
R7	150	150.0	1151.4	1151.4	66	79.2	57.3	67.8
R8	250	189.0	733.2	733.2	37	49.8	50.5	67.9
R9	200	197.2	552.6	552.6	26	36.6	47.0	66.3
R10	150	150.0	692.2	692.2	43	43.0	62.1	62.1
R11	250	193.2	649.7	649.7	36	43.7	55.4	67.3
R12	200	171.3	1032.9	1032.9	62	71.7	60.0	69.4
R13	200	200.0	307.3	307.3	16	16.0	52.1	52.1
R14	250	186.7	775.9	775.9	46	52.9	59.3	68.2
R15	150	150.0	1400.2	1351.3	92	95.0	65.7	70.3
R16	250	170.6	1044.3	1044.3	57	72.5	54.6	69.5
R17	200	186.5	779.8	779.8	47	53.2	60.3	68.2
R18	150	150.0	830.1	830.1	39	53.9	47.0	63.8
R19	250	184.2	822.2	822.2	42	56.3	51.0	68.4

For plans that are relatively efficient, the changes are zero. Projection data for routes' inputs and outputs can help when choosing which route can be realized first in practice and which inputs and outputs can be changed for those routes that are relatively inefficient to become relatively efficient. For routes with an efficiency index less than 1, one can increase the index affecting specific inputs and/or outputs. In this way these routes can become relatively efficient and as such be applied in practice in land treatment.

DEA method provides not only answers regarding the relative efficiency of DMUs, but answers regarding the possible value changes in the input data, which can be used for achieving relative efficiency of relative inefficient DMUs. These possible changes are given in DEA solver report named projection analysis and, in the route selection case, the smallest average change of input and output variables is for the total available capacity of the aircraft input parameter. If the value for this variable is decreased (on average) for 11.36%, then the relatively inefficient routes would become relatively efficient. However, the capacity of the aircraft cannot be reduced by a certain percentage, because the capacity is predetermined, but it is possible to use aircraft with lower capacity. As for other inputs and outputs, the average change for Input 2 is extremely small (about 0.2%), while the average change for outputs is almost 20%. It is possible that these larger average changes are a consequence of the larger distance between the plots, so that the aircraft, in fact, does not have enough fuel capacity to finish the treatment of larger number of plots in one route. The proposal for overcoming this problem is to group the plots of agricultural land into groups and the aircraft would then consume less fuel on a flight that is not effective, and which involves "idling", i.e., flight between plots to be treated. In this case, the maximum area of grouped plots should certainly be considered, so as not to get into a situation where the plane cannot process a new and larger (grouped) plot in one flight. Another proposal for future research is to analyze solutions when larger capacity aircraft are involved in solving a given problem.

The influence of different parameters related to various processing plans and routes within one plan is analyzed from the aspect of relative efficiency. It is interesting that the average changes in output 1 for routes that are not relatively efficient are almost 20%, and almost 20% is the change in output 2. These parameters indicate that the distances of plots are far from the airfield and that the aircraft spends a large part of the flight on a flight that is not effective. The proposal for overcoming this situation is the introduction of another airfield or moving the existing one closer to the plots that need to be treated.

Conclusions

This paper examined a specific problem concerning the selection of relatively efficient processing plans and routes involved in Agriculture. The studied problem consists of application of DEA method on the predetermined set of processing plans and its application on the determined set of routes. The solution to the formulated problem is a relatively efficient processing plan and relatively efficient routes within the plan. The method used for the solution process is DEA method, and according to our knowledge and the analysis of the published research, DEA method has not yet been applied to the formulated problem. DEA is an effective and very useful tool for evaluating performance in a wide range of areas that can help management facilitate this process and focus on key Agriculture competencies, as it is shown in this paper, for the route efficiency problem.

The practical benefits of the research presented in this paper, comprises of selection and ranking of relatively efficient processing plans and selection and scheduling of relatively efficient routes. Relatively inefficient plans and routes can be further analyzed to determine the efficient projection of the input and output parameters.

The application of the proposed approach supports sustainable and responsible planning of the agricultural resources' usage. Reducing the emission of harmful gases that directly affect the reduction of the carbon footprint is achieved by applying the obtained solutions, which is of exceptional environmental importance.

Future research can be in evaluation of the efficiency of routes, where it is possible to apply modified DEA models, that would enable, for some of the inputs (e.g., aircraft capacity) to be exogenously fixed. Some inputs or outputs could be included in the efficiency analysis, e.g., the time of treatment of parcels. Introducing restrictions on the significance of certain inputs and outputs is also an interesting directions for future work.

Given the actuality of the application of Unmanned Aerial Vehicles (UAV) in Agriculture, it is very interesting to apply the proposed approach to the problems that are solved by the application of UAVs, in precision agriculture. In that case, the presented approach should be modified and applied in precise Agriculture to drone route efficiencies.

Negative impacts on the environment, such as the emission of harmful gases, can be included when applying the DEA methods, as one of the outputs that would be treated as an unwanted output. In this way, the negative impact of the treatment of agricultural land would be reduced and the efficiency of the processing plans and the routes themselves would be checked both from the point of view of the speed and efficiency of the land treatment (economic effect) and from the point of view of the impact on the environment (ecological effect).

The extensive literature review shows that the use of the DEA method, in agriculture has revealed, an increasing trend in the past decade, due to most developed papers having with practical implications. A big part of this paper presented a practical application, suggesting that the adoption of the DEA method, is widely used in agriculture.

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Analysis of Primary Energy Consumption, for the European Union Member States

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Abstract: The purpose of the article is to analyse the primary energy consumption of the EU member states and examine the relationship between renewable energy and non-renewable energy sources. The study is based on the production, import, export and gross energy consumption of the EU countries' primary energy carriers. The quantitative and percentage distribution of these variables was examined for the years 2010 and 2020. The correlation matrix of the countries was prepared on the basis of the data series of gross energy consumption from 2010 to 2020. Correlation values between renewable energy and non-renewable energy were collected from these result matrices. These values tabulated, made it possible to compare the countries in the correlation of renewable and non-renewable gross energy consumption. The results show that the EU countries have realized that in order to protect the climate, their energy strategy needed to be based on renewables. Renewable energies should replace the coal-fired power plants, that are the most responsible for greenhouse gas emissions. There are already significant changes in oil consumption of some EU countries, which is indicated by the spread of electric transport. Gas will remain the dominant fossil energy source in the future, due to the relatively low price and various technological advantages. Opinions on nuclear technology are divided, but the undeniable advantage is that specific greenhouse gas emissions, are extremely low.

Keywords: correlation; fossil energy; primary energy consumption; renewables

1 Introduction

In recent decades, world economic growth was significant due to the low cost of natural resources used for production and transportation. [1] With the growth of the world's population, energy consumption is significantly increasing mainly in the fast-growing Asian and African regions. In addition to the growing production and the change in lifestyles - especially in developed countries – also the energy demand increases. [2] In addition, the world's energy use is expected to increase by about 50% between 2018-2050. [3] [4]

The improvement of energy efficiency reduces the growing demand for energy; however, renewable energy has become a key issue in partially replace fossil energy. [5] [6] The role of renewable energy is significant even if the renewables are often available in smaller quantities, the production cannot be regulated and some of them depend on the weather conditions. The gross domestic product, population, labor, as well as greenhouse gas emissions growth, have a positive relationship with energy consumption. [7]

2 World Energy Outlook

Due to the Russian-Ukrainian war, the world is in the middle of a global energy crisis of unprecedented depth. Global energy markets are feeling the strain of the war since Russia is a major player in global energy markets. The world's energy consumption increased by 16.5% during the period between 2010 and 2021, from 505799 PJ up to 589354 PJ. However, between 2019 and 2021 the consumption of fossil fuels was unchanged.

Oil, coal and gas are still dominant in the world's energy consumption. Among fossil fuels, crude oil consumption was still the most significant in 2021 (184213 PJ), followed by coal consumption (160104 PJ) and natural gas consumption (145349 PJ). The fossils account for 82.5 % of energy consumption in the year 2021. (Figure 1)

The importance of non-fossil fuels is much smaller in the world. Nuclear energy accounted only for 4.3% (25313 PJ), hydro energy for 6.8% (40260 PJ) and renewables for 5.8% (34115 PJ) in total energy consumption. [8]

However, the renewables consumption increased by 345% (from 7659 PJ up to 34115 PJ) between 2010 and 2021. The use of energy and its growth rate is very uneven on Earth. In the year 2021, the largest energy users are China (26.5%), the USA (15.6%), India (6.7%), Russia (5.3%) and Japan (3.0%)

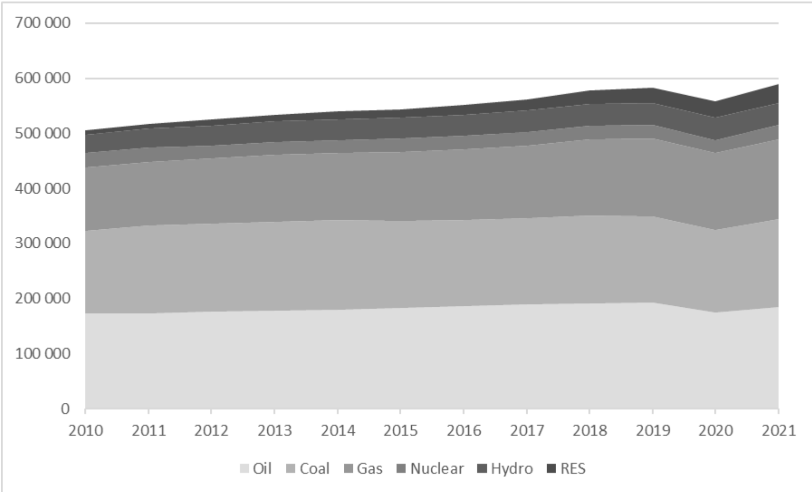

Figure 1
The development of the world's energy consumption, (PJ)

Primary energy grew by 31000 PJ in 2021, the largest increase in history and more than reversing the sharp decline that happened in 2020. However, between 2019 and 2021 renewable energy increased by 8000 PJ. According to forecasts, the primary energy intensity improves by 2.4% per year over the period to 2030. Growth in primary energy in the year 2021 was driven by emerging economies, which grew by 13000 PJ, with China expanding by 10000 PJ [9]. According to the forecast the primary energy supply will peak in 2036 at 643000 PJ, about 9% higher than at present, and then it will decline by around 3% by the year 2050.

3 Energy Situation in the European Union

The European Union has different energy sources as solid fossil fuels, natural gas, oil and petroleum, nuclear energy and renewable energy (such as hydro, wind and solar energy). The fossil-fuel share in primary energy consumption has decreased from over 90% to 70%, mainly due to reduced coal consumption for three decades, The primary energy production of the European Union amounted to 23994 PJ in 2021, which means a 17% drop compared to the year 2010. In the EU, coal accounted for 16%, oil for 4%, natural gas for 7%, renewables for 41% and nuclear energy for 32% of the primary energy production in 2021. The composition of primary energy production varies widely among the countries. Renewable energy is the only source of primary production in Malta and the main source in some EU countries with shares of over 95 % in Cyprus, Latvia and Portugal. Nuclear energy is the significant energy source from total national energy production in France (75%), Belgium (63%) and Slovakia (60%). Solid fuels are the dominant sources in

Poland (71%), Estonia (58%) and the Czech Republic (45%). Natural gas has an important role in energy production in the Netherlands with a share of 63% and in Ireland with 47%. Crude oil is the main source of primary production in Denmark (45%).

The energy available in the European Union comes from energy produced in the EU countries and from energy imported from third countries. As a result of the decline in domestic production, the EU had to rely increasingly on primary energy imports to meet the demand. The EU consumed 51249 PJ import energy, meanwhile, it exported 17262 PJ of energy in 2021. The EU is the world's largest energy importer, 58% of all energy was imported. There are several EU member states which depend, to a great extent, on specific suppliers, which makes them vulnerable.

Russia has been the largest importer of crude oil and natural gas for the EU as well as the main supplier of solid fuel. About 30% of crude oil, 43% of natural gas and 54% of solid fossil fuel (mostly coal) imports come from Russia. The Russia-Ukraine war in 2022 created a crucial economic crisis that led the European Union to take drastic economic sanctions against Russia considering that some countries such as Belgium, Hungary and Greece still rely heavily on energy imports from Russia.

The energy dependency rate of a country is the proportion of energy it imports divided by the county's total consumption. It is expressed as a percentage and it reflects how much an economy depends on other countries to meet its energy needs. In 2021, the EU produced about 42% of its own energy and 58% was imported. The import dependency of the EU member states is very wide-ranging. The import energy dependency of Malta, Cyprus and Luxembourg was over 90%, but Estonia's dependency rate stood only at 10% in 2021.

Gross inland energy consumption, sometimes it is abbreviated as gross inland consumption. The terms mean the overall supply of energy for all activities on the territory of the country, excluding international maritime bunkers. It measures the energy inputs to the economy. The gross energy consumption of the European Union decreased by 9.1% from 64464 PJ to 58578 PJ between 2010 and 2021. Fossil fuels are dominant in the European Union's gross energy consumption, the fossils account for 68.7% of energy consumption. Oil and petroleum represented 32.8% (19200 PJ), natural gas 24.3% (14242 PJ), and coal products 11.6% (6794 PJ) in consumption in 2021. The importance of non-fossil fuels is also significant in the European Union. Nuclear energy accounted for 13.3% (7815 PJ) in total energy consumption in the year 2021. (Figure 2).

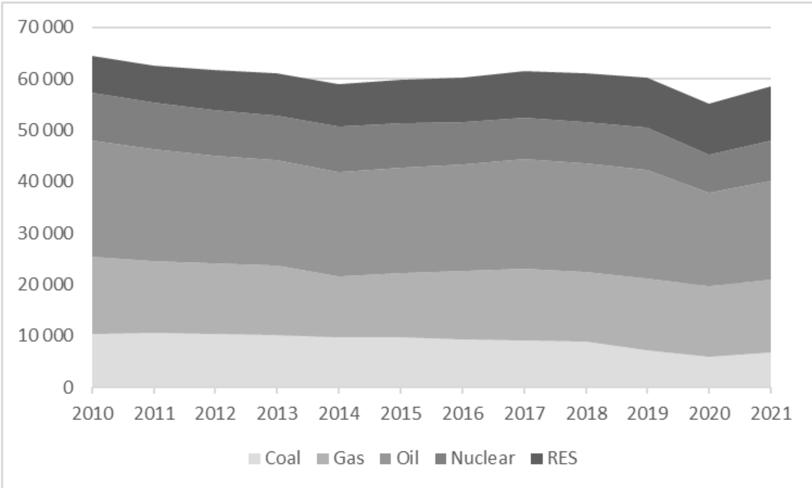

Figure 2
The development of the European Union's Gross Inland Consumption (PJ)

The EU's renewable energy consumption without hydropower reached 10526 PJ in 2021 with a share of 18% of the total. Biomass has the largest share with 44%, followed by hydropower (14%), wind power (12%), biogas (9%), biodiesel (5%), municipal waste (5%), solar PV (4%), geothermal energy (3%), solar energy (2%). In the EU, renewables represent 20.6% of electricity, 7.1% of transport and 18.1% of heating and cooling in 2021.

3.1 The Role of Renewables in the European Union's Energy Policy

The potential for renewable energy resources is enormous because they can exponentially exceed the world's energy demand; therefore, these types of resources will have a significant share in the future global energy portfolio. [10] In the future biomass can be considered the best option and has the largest potential, which meets these requirements and could insure fuel supply. [11] [12] A number of renewable energy technologies are available at different stages of the development cycle. Hydropower and bioenergy are the main sources of energy worldwide. Other options are technically proven and available on commercial terms, still occupying only a fraction of their potential markets. [13-15]

Hydropower, wind, solar and biomass energy are even more expensive than fossil-based power generation. However, due to steadily declining reserves of fossils and rising energy prices, it is increasingly worthwhile to switch to renewable energy sources. [16] [17] Renewable energy growth around the world continued to be driven by a combination of targeted public policy and advances in energy technologies. The policy support for renewable energy focused primarily on power generation, with support for renewable technologies lagging in the heating and cooling as well as transport sectors. [18]

The utilization of renewable energy sources has an increasing role in the EU's climate and energy policy. By using more renewables to meet its energy needs, the European Union lowers its dependence on imported fossil fuels and makes its energy production more sustainable. Influenced by economic and environmental interests the European Union committed itself to increase the utilization of renewable energy sources at the end of the 1990s. The Energy Policy White Paper issued by the European Commission initiated a common Renewable Energy Strategy and set up an Action Plan in 1997. The indicative objective was a 12% share of the contribution by renewable sources of energy and the European Union's gross inland energy consumption by 2010. [19] Recognizing the growing dependence on imports, the European Commission defined the objectives of energy policy in the Green Paper in 2006. Three key energy policy objectives were identified: improved competitiveness, security of supply, and protection of the environment. [20] The Directive 2009/28/EC established an overall policy for the production and promotion of energy from renewable sources in the EU. The directive set a binding target of 20% final energy consumption from renewable sources by 2020 – to be achieved through the attainment of individual national targets. Each EU country must have shown what actions they would intend to take to meet their renewables targets (including sectorial targets for electricity, heating and cooling, and transport). The countries must also ensure that at least 10% of their transport fuels come from renewable sources by 2020. Table 1 shows where the EU countries are in terms of the evolution of the use of renewable energy in the final energy consumption. It should be noted that gross inland energy consumption, which is the subject of the study, should not be confused with final energy consumption.

Table 1

The development of the share of renewable energy in the final energy consumption and the 2020 targets

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2020 target
	%											%
EU27 from 2020	14.4	14.5	16.0	16.7	17.4	17.8	18.0	18.4	19.1	19.9	22.1	20.0
Belgium	6.0	6.3	7.1	7.7	8.0	8.1	8.7	9.1	9.5	9.9	13.0	13.0
Bulgaria	13.9	14.2	15.8	18.9	18.0	18.3	18.8	18.7	20.6	21.5	23.3	16.0
Czechia	10.5	10.9	12.8	13.9	15.1	15.1	14.9	14.8	15.1	16.2	17.3	13.0
Denmark	21.9	23.4	25.5	27.2	29.3	30.5	31.7	34.4	35.2	37.0	31.7	30.0
Germany	11.7	12.5	13.5	13.8	14.4	14.9	14.9	15.5	16.7	17.3	19.3	18.0
Estonia	24.6	25.5	25.6	25.4	26.1	29.0	29.2	29.5	30.0	31.7	30.1	25.0
Ireland	5.8	6.6	7.0	7.5	8.5	9.1	9.2	10.5	10.9	12.0	16.2	16.0
Greece*	10.1	11.2	13.7	15.3	15.7	15.7	15.4	17.3	18.0	19.6	21.7	18.0

Spain	13.8	13.2	14.2	15.1	15.9	16.2	17.0	17.1	17.0	17.9	21.2	20.0
France	12.7	10.8	13.2	13.9	14.4	14.8	15.5	15.8	16.4	17.2	19.1	23.0
Croatia	25.1	25.4	26.8	28.0	27.8	29.0	28.3	27.3	28.0	28.5	31.0	20.0
Italy	13.0	12.9	15.4	16.7	17.1	17.5	17.4	18.3	17.8	18.2	20.4	17.0
Cyprus	6.2	6.2	7.1	8.4	9.1	9.9	9.8	10.5	13.9	13.8	16.9	13.0
Latvia	30.4	33.5	35.7	37.0	38.6	37.5	37.1	39.0	40.0	40.9	42.1	40.0
Lithuania	19.6	19.9	21.4	22.7	23.6	25.7	25.6	26.0	24.7	25.5	26.8	23.0
Luxembourg	2.9	2.9	3.1	3.5	4.5	5.0	5.4	6.2	8.9	7.0	11.7	11.0
Hungary	12.7	14.0	15.5	16.2	14.6	14.5	14.4	13.6	12.5	12.6	13.9	13.0
Malta	1.0	1.8	2.9	3.8	4.7	5.1	6.2	7.2	7.9	8.2	10.7	10.0
Netherlands	3.9	4.5	4.7	4.7	5.4	5.7	5.8	6.5	7.4	8.9	14.0	14.0
Austria	31.2	31.6	32.7	32.7	33.6	33.5	33.4	33.1	33.8	33.8	36.5	34.0
Poland	9.3	10.3	11.0	11.5	11.6	11.9	11.4	11.1	14.9	15.4	16.1	15.0
Portugal	24.1	24.6	24.6	25.7	29.5	30.5	30.9	30.6	30.2	30.6	34.0	31.0
Romania	22.8	21.7	22.8	23.9	24.8	24.8	25.0	24.5	23.9	24.3	24.5	24.0
Slovenia	21.1	20.9	21.6	23.2	22.5	22.9	22.0	21.7	21.4	22.0	25.0	25.0
Slovakia	9.1	10.3	10.5	10.1	11.7	12.9	12.0	11.5	11.9	16.9	17.3	14.0
Finland	32.2	32.5	34.2	36.6	38.6	39.2	38.9	40.9	41.2	42.7	43.8	38.0
Sweden	46.1	47.6	49.4	50.2	51.2	52.2	52.6	53.4	53.9	55.8	60.1	49.0

*(provisional)

Source: Eurostat database (2021)

The European Council set even more ambitious goals by increasing commitments by 2030. The aim was to promote the EU to achieve a more competitive, secure and sustainable energy system. The EU countries agreed on a new renewable energy target of at least 27% of the EU's final energy consumption, a 40% cut in greenhouse gas emissions compared to 1990 levels.

The European Commission aimed to increase between 55% and 75% the proportion of renewables in gross final energy consumption by 2050. This along with energy efficiency is considered critical in any model that could be adopted. [21]

The development of renewable energy is important from the viewpoint of lowering the cost of imported energy, borne by Central European countries. In addition, it would help to achieve the aim of reducing CO2 emissions. [22] Many illusions are related to the widespread use of renewable energy resources. A further reduction of bioenergy consumption can be achieved by faster electrification of heat needs and increased energy efficiency compared to RePowerEU by 2030. In order to achieve the goal, solar energy capacity must be significantly increased by 2030. [23]

The EU policy on energy aims to ensure the security of energy supply in the member states, to promote energy efficiency and energy saving, as well as to increase the share of renewable energy. Solidarity among the member states is fundamental. However, each country is responsible for its own energy security. The spread of renewables may be impeded by the availability of fossil resources within a country.

[24] The factors that provide the framework for countries are as follows different international obligations, differences in planning/licensing cultures, public awareness concerning renewables and/or technical differences. [25] [26]

The climate policy of the EU, the high fossil fuel prices and efforts to reduce energy import dependency on Russia to reduce fossil fuel demand, despite increasing consumption of coal in the current crisis.

Having revised the Renewable Energy Directive 2018/2001/EU the member states established a new binding renewable energy target for 2030. They will ensure that the share of energy from renewable sources in the Union's gross final consumption of energy of at least 32%, with a clause for a possible upwards revision by 2023. In July 2022, the European Commission presented Europe's new 2030 climate targets. The goal is to increase the present target to at least 40% renewable energy sources in the energy mix by 2030.

The Russian-Ukrainian war that broke out in 2022 created a new energy situation. The European Commission published the REPowerEU plan to reduce the EU's dependence on Russian gas and oil before 2030. Part of the plan is to raise the energy efficiency target from 9% to 14% by 2030 and to increase the share of renewable energy sources in the EU's energy structure. The REPowerEU plan also supports the European Commission's request to increase in the directive to 45% by 2030. Figure 3 shows the evolution of renewable energy targets. [27]

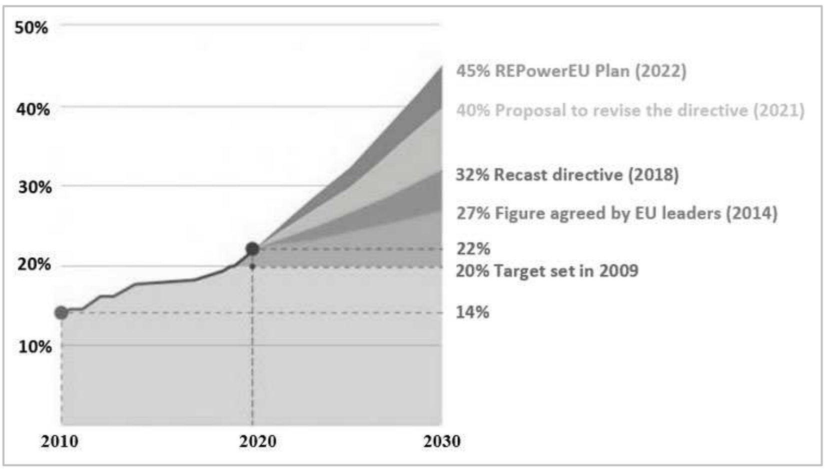

Figure 3
Evolution of renewable energy targets

Besides, the REPowerEU plan would increase total renewable energy capacity to 1236 GW by 2030, compared to the "Towards 55%!" with 1067 GW planned for 2030.

4 Material and Method

In energy statistics, the ability to separate primary and secondary energy is very important. In order to avoid double counting, it is essential to be able to separate new energy entering the system, (primary) and the energy that is transformed within the system (secondary). Primary energy can be defined as the energy that's extracted directly from natural resources, such as crude oil, hard coal and natural gas or is produced from primary commodities. Secondary energy is energy produced by converting the primary energy, such as electricity, refined automotive fuel or hydrogen. [28] Primary energy sources are very important for all sectors of the economy and global production and population have been rapidly growing. [29]

In the article, we analysed the gross inland energy consumption of the European Union countries. The gross inland energy consumption represents the quantity of energy necessary to satisfy the inland consumption of the geographical entity. In the narrow sense, it represents the sum of primary energy production and net import (import-export). In the broad sense, it is supplemented with recovered products, variations of stocks, bunkers and direct use. The diagram of energy flow can be illustrated by the Sankey diagram (Figure 4), where the direction of flow is shown by the arrows and the width of the arrows is shown proportionally to the flow quantity.

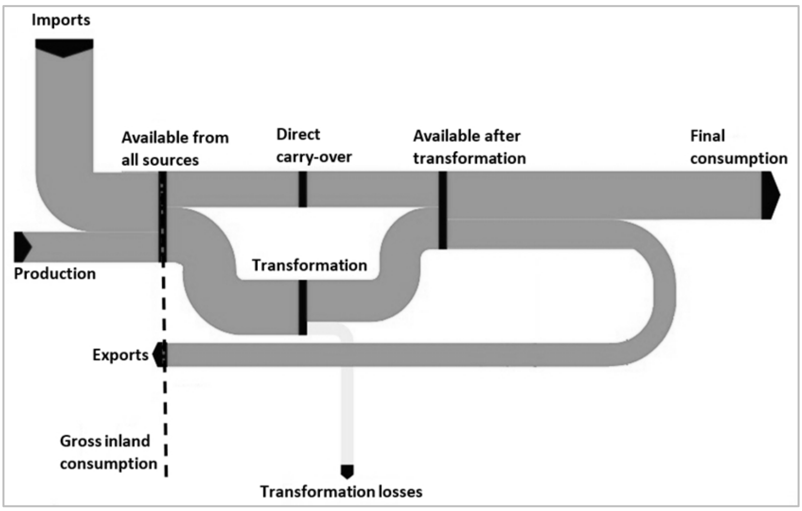

Figure 4
Simplified Sankey diagram for energy flow

The data of analysis come from the database of the European Commission Eurostat and the International Renewable Energy Agency (IRENA) regarding the period between 2010 and 2020. The main unit for energies is joules, or rather petajoules (PJ) according to the International System of Units (SI). In the article, we use the petajoule, as a unit of energy.

In the study, we used comparative time series analysis. The purpose of the article was to analyse the gross inland energy consumption of the EU countries and to examine the relationship between renewable energy and non-renewable energy sources. In the course of the analysis, we tried to determine which non-renewable energy carrier was replaced by the renewables in the EU member states. The replacement of energy sources with each other was analysed by correlation matrix and it was evaluated at 1% and 5% significance levels. The evaluation happened by using IBM SPSS Statistics 25.

To test the significance of the correlation coefficient, we formulate the hypothesis H0: ρ = 0. Our decision is based on a correlation coefficient (r) calculated in a sample with n elements. The rejection of H0 depends on the magnitude of the coefficient r and the magnitude of the degree of freedom f (f = n-2).

To calculate the significance, we use the t-distribution statistic. The formula is:

$$t = r \cdot \sqrt{\frac{n-2}{1-r^2}} \tag{1}$$

Using the statistical table of the result of the equation and the distribution of the t-distributed variable, we can determine whether our result is significant and, if so, to what extent.

If |t| > table, we reject H0 and say that the population correlation coefficient is different from 0. So, if the absolute value of our obtained result is greater than the number in the table corresponding to the given degree of freedom and significance level (usually 0.95), then we can reject the null hypothesis with 95% certainty.

The positive sign of r refers to the linear proportionality of the renewable and the primary energy associated with it, while the negative sign refers to its inverse proportionality. In this case, the inverse relationship is used to analyse the replacement between renewable and non-renewable energies. The closer to one the absolute value of r is, the stronger the relationship.

5 Results

5.1 Primary Production of EU-27

Among the EU member states France has been the leader in primary energy production for a long time. France's primary energy production amounted to 5065 PJ, which was an 11% decrease from 2010. Nuclear was the main source of energy production, accounting for 76% of total primary production, while renewables had a share of 23% in 2020. France was followed in the ranking by Germany. Between 2010 and 2020, Germany's primary energy production decreased by 27% to reach 3923 PJ. Renewables was accounting for around 50%

of total primary production in 2020, however, this rate was only 25% in 2010. Coal was the second highest contributor with 25%, while nuclear had an 18% share and oil had a 3% share**.** Poland was the third member state in the ranking. Poland's primary energy production was 2381 PJ in 2020, which represents a 15% decrease compared to 2010. Poland is Europe's largest coal producer. Black and brown coal were the main sources of energy production, accounting for 70% of total primary production, while the share of renewables was 23% in 2020. The Netherlands is also an important primary energy producer in the EU. However, Dutch primary energy production fell dramatically. The country's primary energy production was 2947 PJ in 2010, then it decreased to 1105 PJ by 2020. Gas remained the main source of energy production, accounting for 65% of the total in 2020. The share of renewables was 27% in the primary energy production mix. (Figure 5) The values of some countries are significantly higher than the values of the other countries, so for better visualization, they are shown separately on the right side of the figure.

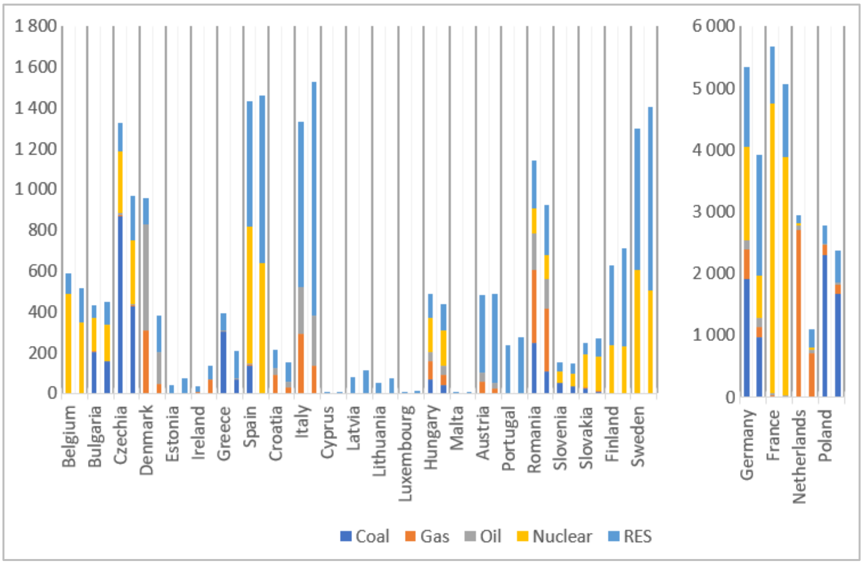

Figure 5

Primary energy production of EU-27 in 2010 and 2020 (PJ)

5.2 Energy Imports of the EU-27

Germany has been one of the largest energy importers in the European Union. Germany's import energy consumption was 10,231 PJ in 2010, then it decreased by 14% to 8809 PJ for the year 2020. Oil was dominant in energy imports in Germany with a share of 57%, while gas had a share of 32% and the share of coal was 10%. The country's import energy dependency was 63.7%. The Netherlands was the second largest importer among the member states. Between 2010 and 2020 the

Dutch total energy imports decreased by 5.5% and reached 6873 PJ. In the case of the Netherlands, oil was by far the largest imported energy product with a share of 81%. Besides, the Dutch gas import was significant (16% of the total energy imports). The import energy dependency of the Netherlands was 63.7%. Italy was also a very important energy importer in the EU. Italy's import energy consumption was 7336 PJ in 2010 and 5347 PJ in 2020, it means a 27% drop during the 10-year period. In Italy's import energy mix the share of oil was 52%, while gas had a share of 43%. In international comparison, Italy's 73.5% import energy dependency rate was high. France's energy imports decreased significantly between 2010 and 2020, from 6745 PJ to 5212 PJ. The two dominant import products of France were oil (62.3%) and gas (32.4%) in 2020. The French import energy dependence can be considered low (44%) among EU countries. Spain also should be mentioned as an important energy importer of the EU. In 2020, Spain's import energy consumption amounted to 4506 PJ, while in 2010 the energy imports were 5087 PJ. The Spanish import energy mix is based on oil with a share of 70% and the share of gas was 26% in 2020. The import energy dependence of Spain reached 67% for year 2020. (Figure 6)

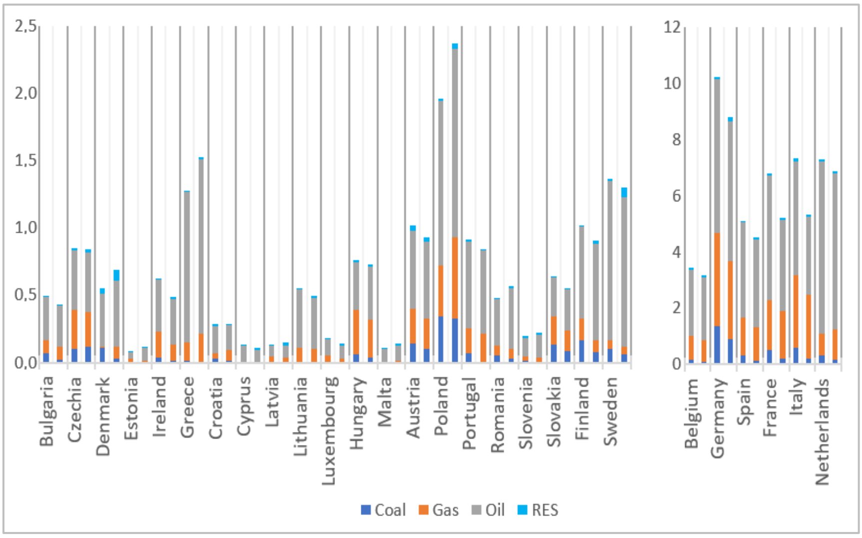

Figure 6
Energy imports of EU-27 in 2010 and 2020 (PJ)

5.3 Energy Exports of the EU-27

As can be seen in Figure 7 the Netherlands was by far the largest energy exporter among the EU member states. The Netherlands's energy export amounted to 6095 PJ in 2010, then it decreased by 26.5% to 4478 PJ in 2020. Oil was by far the largest exported energy product of the Dutch with a share of 87%. Oil was followed by gas accounting for 11% of energy exports. Belgium was one of the countries, in the European Union, that could increase energy exports. Belgium increased its energy exports from 1160 PJ to 1278 PJ during the period 2010-2020. Oil accounted for 89% and gas for 10% of total exports in 2020. Spain was the third largest exporter among the EU member states in 2020. In addition, Spain's energy exports nearly doubled between 2010 (591 PJ) and 2020 (1159 PJ). Oil was by far the most important energy product with a share of 84%, followed by Res with 7% and coal with 4.5%. Germany has been one of the significant energy exporters in the EU. The German energy exports amounted to 1110 PJ in 2020, compared to 1612 PJ in 2010. In the German export energy mix, oil represents 83%, while the 11.5% share of renewables can be considered significant. Italy's energy export was 1278 PJ in 2010 but fell to 1033 PJ in 2020. Italian energy exports were concentrated on oil, with oil accounting for 96% of the total. France should also be mentioned as a major energy exporter. French energy exports also decreased from 1092 PJ to 878 PJ during the period 2010-2020. In France's energy exports, oil and gas were dominant, with a share of 62% and 35% respectively. (Figure 7)

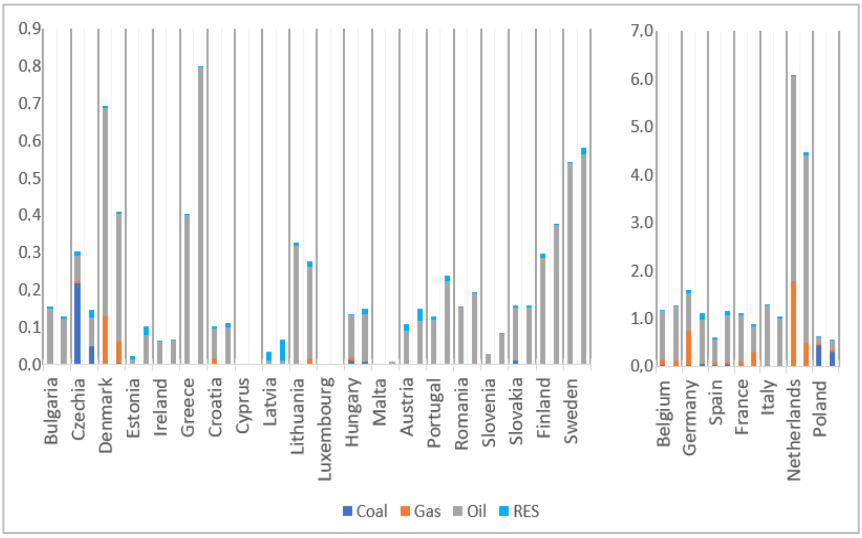

Figure 7

Energy exports of EU-27 in 2010 and 2020 (PJ)

5.4 Gross Inland Energy Consumption of the EU-27

Germany has been the largest economy in the European Union and also the most significant energy consumer. Germany reduced its gross energy consumption by 16% during the period 2010-2020 and reached 11818 PJ. Germany's energy consumption has been based on fossil energy. Oil accounted for 35%, gas for 26% and coal for 16% of total energy consumption in 2020. However, renewable energy use increased significantly between 2010 and 2020 from 9% to 17%. German nuclear energy consumption fell from 11% to 6% during the 10-year period. France also reduced its energy consumption by 17% from 1350 PJ to 9449 PJ over the ten years (compared to the 2010 level). In French energy consumption, nuclear energy dominated with a share of 41% in 2020. Oil represented 29%, gas had a 16% share and renewable energy had a 13% share in gross energy consumption. France was followed by Italy in the energy consumption ranking. Italy's inland energy consumption was 5763 Mtoe in 2020, compared to 7202 PJ in 2010. In the energy consumption of Italy, the share of gas was 42%, while oil had a share of 33%. The share of renewables reached 21% by 2020, compared with 13% in 2010. Spain was the fourth largest energy consumer among the EU member states. The gross energy consumption of Spain fell to 4646 PJ in 2020 from 5464 PJ in 2010. Spain's energy consumption is based on oil, which accounts for 41% of the total. Natural gas accounted for 25%, the nuclear energy for 14% of total energy consumption. In the case of Spain, the share of renewables in gross energy consumption also increased significantly and reached 17% by 2020. Unlike the previous countries, Poland did not reduce its energy consumption between 2010 and 2020. Poland's energy consumption remained at the level of 4217 PJ by 2020. Coal was dominant in the gross inland energy consumption with a share of 41%, 29% came from oil, 17% from natural gas and 13% from renewable energy. (Figure 8)

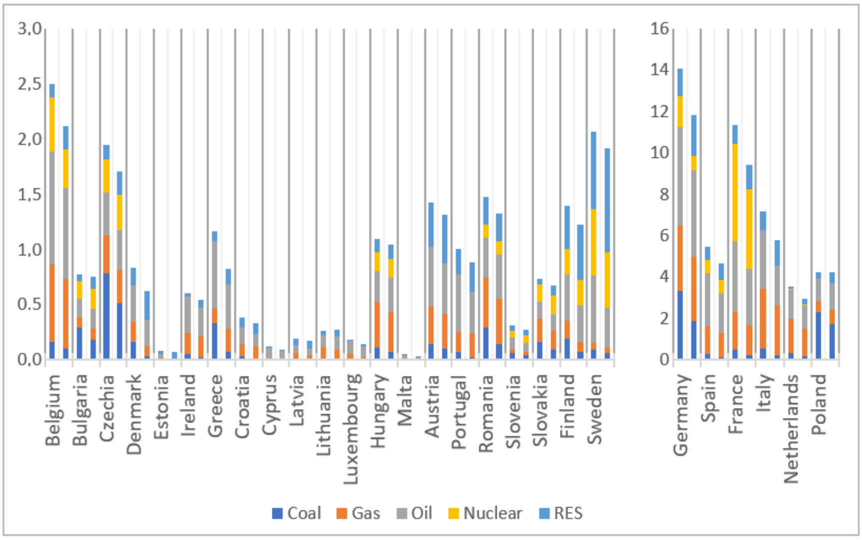

Figure 8

Gross Inland Energy Consumption of EU-27 in 2010 and 2020 (PJ)

5.5 Evaluation of the Relationship between Non-Renewable Energy and Renewable Energy based on Correlation Analysis

The study covered the years 2010-2020 (n = 11). The calculation of the r values of the correlation matrix f = 9 degrees of freedom (f = n-2), in addition to the student t table value, was determined at the 5% and 1% two-tailed significance levels, based on the following formulae:

$$r_{1,2} = \pm \sqrt[2]{\frac{t^2}{t^2+f^2}} \tag{2}$$

$$t_{0,95}(f = 9) = 2.262 \rightarrow r_{1,2} = \pm 0.6020 \tag{3}$$

$$t_{0,99}(f = 9) = 3.250 \rightarrow r_{1,2} = \pm 0.7348 \tag{4}$$

Based on equations, the positive correlation at the 5% significance level occurs at values r > 0.6020, and the negative correlation at r < -0.6020. At the 1% significance levels, these values are r > 0.7348 and r < -0.7348, respectively.

Table 2 shows the correlation values between the countries' renewable and non-renewable gross energy consumption.

Table 2

Correlation values between the countries' renewable and non-renewable gross energy consumption

	Coal	Gas	Oil	Nuclear
1. Belgium	-0.9074**	0.0398	-0.6948**	-0.4100
2. Bulgaria	-0.8837**	0.1980	0.7504**	0.5874*
3. Czechia	-0.9290**	-0.2352	0.0922	-0.0098
4. Denmark	-0.9526**	-0.8913**	-0.6287*	
5. Germany	-0.7824**	0.2804	-0.5375*	-0.9378**
6. Estonia	-0.8394**	-0.8024**	-0.9581**	
7. Ireland	-0.8229**	0.4163	-0.1077	
8. Greece	-0.9132**	0.5851*	-0.7941**	
9. Spain	-0.4559	-0.3626	-0.6798**	-0.5304*
10. France	-0.6973**	-0.1607	-0.7851**	-0.7768**
11. Croatia	-0.5074	-0.1418	-0.4529	
12. Italy	-0.8555**	-0.4503	-0.8608**	
13. Cyprus	0.5240*		-0.4196	
14. Latvia	-0.7542**	-0.7073**	0.5131	
15. Lithuania	-0.7793**	-0.8841**	0.8933**	
16. Luxembourg	-0.9055**	-0.8627**	-0.4356	
17. Hungary	-0.0964	-0.4409	-0.4604	-0.1828
18. Malta		0.9433**	-0.9385**	

19.	Netherlands	-0.7152**	-0.2523	-0.7663**	0.1656
20.	Austria	-0.6369*	-0.3127	-0.3354	
21.	Poland	-0.8525**	0.9242**	0.7296**	
22.	Portugal	-0.3962	0.3464	-0.3692	
23.	Romania	-0.7641**	-0.7920**	0.4011	-0.7568**
24.	Slovenia	-0.2652	-0.3189	-0.3725	-0.0445
25.	Slovakia	-0.9361**	-0.4263	0.4288	0.1440
26.	Finland	-0.8551**	-0.8427**	-0.6851**	-0.4109
27.	Sweden	-0.8538**	-0.2412	-0.9099**	-0.2993

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Table 2 shows that coal is negatively correlated with renewable energy at 1% significance in gross energy consumption in the case of Denmark (-0.9526), Slovakia (-0.9361), Czechia (-0.9290), Greece (-0.9132), Belgium (-0.9074), Luxembourg (-0.9055), Bulgaria (-0.8837), Italy (-0.8555), Finland (-0.8551), Sweden (-0.8538), Poland (-0.8525), Estonia (-0.8394), Ireland (-0.8229), Germany (-0.7824), Lithuania (-0.7793), Romania (-0.7641) and Latvia (-0.7542). Coal is negatively correlated with renewable energy at 5% significance in gross energy consumption in the case of the Netherlands (-0.7152), France (-0.6973) and Austria (-0.6369). The gas is negatively correlated with renewable energy at a 1% significance, in gross energy consumption, in the case of Denmark (-0.8913), Lithuania (-0.8841), Luxembourg (-0.8627), Finland (-0.8427), Estonia (-0.8024), Romania (-0.7920). The gas is negatively correlated with renewable energy at 5% significance in gross energy consumption in the case of Latvia (-0.7073). Gas is positively correlated with renewable energy at a 1% significance in gross energy consumption in the case of Malta (0.9433) and Poland (0.9242). Oil is negatively correlated with renewable energy at 1% significance in gross energy consumption in the case of Estonia (-0.9581), Malta (-0.9385), Sweden (-0.9099), Italy (-0.8608), Greece (-0.7941), France (-0.7851) and Netherlands (-0.7663). Oil is negatively correlated with renewable energy at 5% significance in gross energy consumption in the case of Belgium (-0.6948), Finland (-0.6851), Spain (-0.6798) and Denmark (-0.6287). Oil is positively correlated with renewable energy at a 1% significance in gross energy consumption in the case of Lithuania (0.8933) and Bulgaria (0.7504). Oil is positively correlated with renewable energy at a 5% significance in gross energy consumption in the case of Poland (0.7296). Nuclear energy is negatively correlated with renewable energy at 1% significance in gross energy consumption in the case of Germany (-0.9378), France (-0.7768) and Romania (-0.7568).

The correlation analysis shows which fossil energy carrier(s) each country focuses on replacing, when using renewable energy. Most countries are trying to replace coal. This is the fossil energy carrier that typically produces the most carbon dioxide emissions. Efforts must be made to replace coal as quickly as possible, even at the cost of temporarily consuming additional gas. With the parallel use of gas and renewable energy sources, the European Union can achieve the largest emission reduction in the fastest way possible. By 2050, EU can achieve the goal of climate neutrality, while producing the lowest possible aggregate emissions, during the transition period. [30]

Conclusions

The structure of energy production of the EU member states was different due to the differences in natural endowments. The increasingly strict climate protection commitments and the countries' energy independence efforts are all moving the energy consumption mixes of the EU countries, in the direction of renewable energy. This are clearly shown by the changes in the composition of the countries' energy production, import, export and energy consumption between 2010 and 2020. Apart from a few countries, the changes all point in the direction of increased renewable energy use. This is clearly demonstrated by the growth of renewable energies and the increasing weight of their share in the countries' energy consumption mix. Correlation analysis shows that renewable energies replaced fossil energies. In most EU countries coal was replaced by renewable energies. Coal is the most climate-burdening fossil energy carrier with the highest specific carbon dioxide emissions. The replacement of gas and oil is a much slower process than that of coal, since gas is an important element for heating and electricity production, while oil plays a major role in transportation. In the case of nuclear energy, the negative correlation value was due to rapidly growing renewable energies. E.g., in Germany, the shutdown of nuclear power plant blocks, as a result of the Fukushima disaster, was also a contribution.

Decarbonisation is an important part of the EU's climate policy. One way to reduce carbon dioxide emissions is to reduce energy consumption. The gross energy consumption of the European Union decreased by 9.1%, from 64464 PJ to 58578 PJ, between 2010 and 2021. It is important to note that further increasing the efficient use of energy significantly contributes to the reduction of energy consumption. Another option for reducing carbon dioxide emissions is to increase the share of renewables, which the EU has set at 20% by 2020 compared to 12% in 2010. This target value differs from country to country depending on the resources and geopolitical situation.

EU member states are divided in terms of how they want to achieve climate goals. One group of countries is anti-nuclear, led by Germany and the other group is in favour of nuclear energy, led by France. It is important to point out that the EC's proposal presented at the end of January 2022, which can classify energy production using natural gas and nuclear energy as sustainable, is favourable for both groups. According to the EC's proposal, all of this would last until the security of supply can be ensured by using renewable energy sources. Europe is extremely polarized when it comes to energy, however, practically every country is counting on either natural gas or nuclear energy, or both, for the medium term. [31]

Acknowledgement

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A Bibliometric Survey on Sustainable Finance: Research Patterns and Trends

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Abstract: The changing socio-economic environment for development, has redefined many aspects of development. It has changed the word "development", to "sustainable development", so the source of the finance, has also changed "finance" to "sustainable finance". The purpose of this study is to investigate trends and literature development of sustainable finance, that is an emergent issue in research. For analysis of trends and literature development of sustainable finance, this is a Bibliometric analysis, and has been conducted from the Scopus database. For analysis VOSviewer Bibliometric tools has been used to measure the different Bibliometric dimensions of sustainable finance. In the analysis, authors have examined the top most cited authors, thematic structures, top publishing journals, country-wise Bibliographic couplings and trends of the publication trends of sustainable finance. In this study, it has been found that there is widespread interdisciplinary research, for sustainable finance, but the specific and confined research of sustainable finance, is limited to the growth in publications trends that infer sustainable finance as an emerging concern of researchers and different stakeholders.

Keywords: Sustainable Finance; Sustainable Development; Green Finance

1 Introduction

Sustainable finance and green finance are transposable terms used in different reports and studies, but the sustainable finance word, is more holistic than green finance, because sustainable finance is an evolution of green finance [1]. Green finance has been defined by International Finance Corporations [2] as "financing of investments that provide environmental benefits" further [3] UNFCC(2018) has given a wider and more conclusive definition as, *"local, national or transnational financing-drawn from public, private and alternative sources of financing-that seeks to support mitigation and adaption actions that will address climate change"* both definitions have some differences, but both of the terms have concern is to provide suitable financing instrument [4] for sustainable environment and climate change [5]. To provide sufficient funds for clean and green environment, financial system of different economy provides climate finance, Green finance and sustainable finance, where climate provide mitigation, as well as adoption funding, green finance promotes better biodiversity and protection [6], but sustainable finance has wider scope to extend of application and implementation of environmental social governance, in nutshell climate finance, green finance are subset of sustainable finance [7].

Sustainable finance is systematic, and an organized management of financial resource, for those economic activities, which are involved in sustainable projects [8]. In spite of environmental issues and strict environmental social governance, Sustainable Finance play pivotal role in economic growth of any society [9]. In era of the sustainable development, sustainable finance has emerged as key factor for inclusive growth and development, as well as mobilization of financial resources [10]. Policy makers and other stakeholders have great concern because sustainable finance helps for inclusive growth and profitable growth in equity return of organization [11]. 0n the basis of different literature discussion sustainable finance is one of the emerging issues for researcher and new paradigm in area of financing sources of fund [12]. In the existing literature, there is so much on green finance, environment and sustainable development are widely available but organized Bibliometric analysis for exclusive for sustainable finance are not available or they very limited. This limited research penetration of sustainable finance is a crucial research gap, because as global economy moving towards sustainable development, then the role sustainable finance has a dynamic role and is a strong catalyst for sustainable development, so sustainable finance research cannot be avoided. The objective of this study, is to explore the different dimensions of sustainable finance, in the existing literature and find out the variables of sustainable finance and further analyze the developments in the area of sustainable finance. To fulfil the objective of this research, the following are the research questions that need to be answered:

RQ1 What is the literature development status of sustainable finance?

RQ2 What is different themes and subthemes in area of sustainable finance?

RQ3 How much of the sustainable finance literature is diverse?

The study has been organized in six parts. The first part explores the introduction, the second, discusses background of sustainable finance, the third, discuss methodology, the fourth part presents findings and interpretations, the fifth part highlights conclusion and last, sixth part, discuss the works limitations and future scope of studies.

2 Background of Sustainable Finance

The history of sustainable finance is not new, it dates to before to the industrial revolution, in banking sector. In the 15th and 16th centuries, Italian banks started to give loans to those firms and businesses that were not involved directly and indirectly in any war or unethical practices [13]. The concept of that time period was different, but the objective was still the same, like the peaceful existence of society and the environment. In the present era, sustainable finance has emerged from the 1991 Earth Summit in Rio de Janeiro, in this summit the United Nations Environment Program Finance Initiative (UNEP FI) [14] made the alliances with banks and financial institutions to promote sustainable development [15] and further define the dimension of sustainable finance. To help in investor guidance and evaluation of the sustainable instrument, in 1992, the Dow Jones Sustainability World Index was launched [16]. Global level monitoring and reporting of sustainable development activities was challenge, so the Global Reporting Initiative (GRI) was started, as collaborating institute of the UNEP in 2002 [17] and further in 2015, sustainable development and source of sustainable finance added the Millennium development goal [18]. In 2008, the World Bank launched the first green bond and in India, Yes Bank, launched the Green Infrastructure Bond, in 2015. After 2015, many green bonds and various sustainable finance instrument emerged in different development projects [19].

Although numerous components of the system are concerned with sustainability, financial implications are critical to any organization's longevity. Finance, in a larger perspective, encompasses a series of levels, actions and agents, including educators, employers and government agencies [20]. [21] According to Haigh (2012c, pp. 88-90), sustainable finance can signify the environment and society in which the financial system operates, seems to be in excellent shape [22]. Further, this excellent condition of financial systems can yield a more sustainable society.

3 Methodology

The Author has adopted Bibliometric methodology to identify evolution of research progress in area of sustainable finance. Bibliometric is a quantitative tool used to analyze the existing literature development and provide conclusive research patterns [23]. The Bibliometric is an important tool in the identification corpus of literature, in specific areas of research for consolidated out looks [24]. Through Bibliometric analysis, researchers seek patterns of intellectual development of a research area, publication, citation, top authors, top-cited papers and several other trends and patterns [25].

3.1 Selection of Manuscript and Data Analysis

Figure 1 highlights the process of document navigation and provides a short list of documents concerning “sustainable finance”, in Scopus source data base of Elsevier Ltd. The first step search “sustainable finance”, found 356 documents then the second step documents, limited only to social sciences, business management & economics documents, found 301 documents. Steps 3 documents were limited to only research articles, finding 201 documents in the English language, then the analysis of 201 research articles, for this bibliometric analysis, has been conducted by VOSviewer software.

3.2 Result Analysis

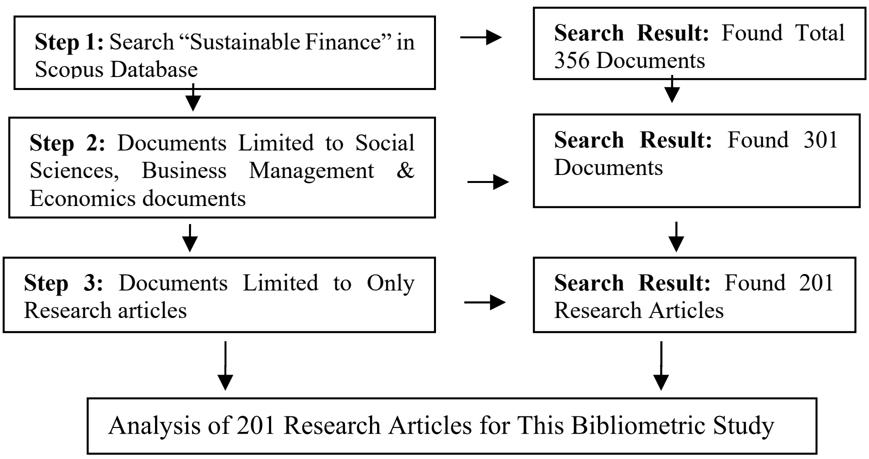

Figure 1
Process of Short-listing process of documents

4 Findings and Interpretation

Table 1
Contains the result of comparing in pairs with the final result

Authors	Title	Source title	Citations
Yip A. W. H., Bocken N. M. P (2018)	Sustainable business model archetypes for the banking industry	Journal of Cleaner Production	104
Fatemi A. M., Fooladi I. J. (2013)	Sustainable finance: A new paradigm	Global Finance Journal	45
Galaz V., Crona B., Dauriach A., Scholtens B., Steffen W. (2018)	Finance and the Earth system – Exploring the links between financial actors and non-linear changes in the climate system	Global Environmental Change	43
Drempetic S., Klein C., Zwergel B. (2020)	The Influence of Firm Size on the ESG Score: Corporate Sustainability Ratings Under Review	Journal of Business Ethics	41
Pueyo A. (2018)	What constrains renewable energy investment in Sub-Saharan Africa? A comparison of Kenya and Ghana	World Development	40
Carolina Rezende de Carvalho Ferreira M., Amorim Sobreiro V., Kimura H., Luiz de Moraes Barboza F. (2016)	A systematic review of literature about finance and sustainability	Journal of Sustainable Finance and Investment	36
Zhan C., de Jong M. (2018)	Financing eco cities and low carbon cities: The case of Shenzhen International Low Carbon City	Journal of Cleaner Production	28
Flammer C. (2021)	Corporate green bonds	Journal of Financial Economics	27
Mengze H., Wei L. (2015)	A comparative study on environment credit risk management of commercial banks in the Asia-Pacific Region	Business Strategy and the Environment	27
Kakabadse N. K., Kakabadse A. P., Summers N. (2007)	Effectiveness of Private Finance Initiatives (PFI): Study of private financing for the provision of capital assets for schools	Public Administration and Development	27
Missbach A. (2011)	The Equator Principles: Drawing the line for socially	Development	26

	responsible banks? An interim review from an NGO perspective		
Pham L., Luu Duc Huynh T. (2020)	How does investor attention influence the green bond market?	Finance Research Letters	25

Source: with help of VOSviewer Complied by Authors

4.1 Top Cited Articles and Literature Development

Table 1 highlights the top 10 cited articles, related to sustainable finance out of those top 10 articles, Yip & Bocken, 2018 is highest impact article, with total citations of 104. [26] Yip & Bocken, 2018 have adopted wider concept of the sustainable finance and investigated antecedents and consequences of banking industry to provide finance for sustainable development projects .due to wider concept of article got better citation in comparison to other research paper. Despite older article [27] Fatemi & Fooladi (2013) have only 45 citations, because it was confined with only sustainable finance, however, this article is most relevant and impactful for the area of sustainable finance. [28] Galaz, Crona, Dauriach, Scholtens & Steffen (2018) has proposed the importance of the financial actors that play crucial role in sustainable development and climate change and [29] Drempetic, Klein & Zwergel (2020) tried to explore new areas like corporate sustainable and responsible investments for environmental, social and corporate governance (ESG) scores, of the firms. This study has given quantifications, for the sustainable investments of the firms. However, these studies address the problem and concept of sustainable finance and investment but, [30] Pueyo (2018) attracted scholarly attention on different constrains of implementation of the policy related to sustainable finance. [31] Ferreira, Sobreiro, Kimura & Moraes (2016) is a remarkable study, in the area of finance and sustainability, it conducted a systematic review of literature for descriptive analysis, concept of finance and sustainability [32]. Zhan, & Jong (2018) proposed an empirical investigation on financing of sustainable development and the role of the financial vehicles in sustainable urban development, further [33] Flammer (2021) emphasized the corporate green bonds and tried to incorporate the response of investors sentiment towards green bond and the performance of those companies that adopted sustainable finance. [34] Mengze & Wei (2015) has given insights to the environment credit risk and bank performance; moreover, this study was constrained to environment economics. [35] Kakabadse, Kakabadse & Summers (2007) tried to evaluate new dimensions and the impact of private finance initiatives in sustainable finance. Other impactful studies [36] Missbach (2011) examined the role of banks in sustainable finance and further tried to assimilate sustainable finance with social catalysts and investor points of view [37] Pham & Huynh (2020) emphasized how investor attention can impact the returns and volatility. Further, that investor attention can help to develop information in financial market to promote sustainable investment [38]. This section part our work concerned the overall insights of literature development and top cited articles.

4.2 Thematic Structure of Sustainable Finance

After deletion of the duplications of key words, such as, green bonds or green bond, the authors have selected suitable keywords, according for the best fit in the study. In analysis of co-occurrences, we found four clusters that where first in red, second cluster in green, third in blue and fourth in yellow.

4.2.1 First Cluster: Governance Policies for Sustainable Finance

In this section, 11 items have been found and most them are related to governance issues and policy implementation, for the sustainable finance in economy. In Figure 2, the red nodes, co-occurrence of keywords like financial system, corporate governance and government policy economic growth, indicating that for better implementation of the sustainable finance, these key areas of research need to be integrated. For regulatory aspects, [39] Bengo, Boni, & Sancino (2022) in their research, have emphasized that implementation of policies of sustainable development, must have comprehensive and integrated frameworks, with proper checks and balances, further [40] Stawska & Jabłońska (2022) incorporated some these keywords and tried to measure inclusive growth with sustainable finance theory.

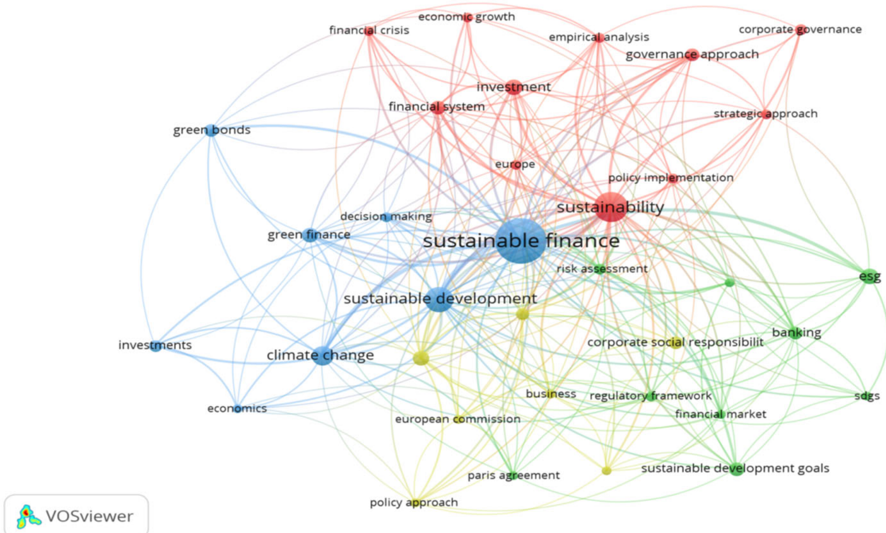

Figure 2

Co- Occurrences

Source: with help of VOSviewer Complied by Authors

4.2.2 Second Cluster: Financial System and Sustainable Development

In Figure 2, the green color nodes, cluster 2, has 9 items and most of the keywords are related to financial system and sustainable development. Banking, sustainable developments (SDGs), environment social governance (ESG) and financial market are intensive penetrated keywords of this segment. In this cluster of keywords, researchers tried to explore and investigate role of financial system in sustainable development in society. [41] Shobande & Enemona (2021) concluded in study that financial system plays crucial role in mobilization of financial resources for sustainable development. In other dimension [42] Straub (2021) has highlighted sustainable finance as lucrative financial avenue for sustainable development as well as their stakeholders.

4.2.3 Third Cluster: Financial Instruments and Sustainable Finance

The third cluster has 8 items of keywords that are highlighted blue. Analysis of this cluster is more important than other clusters, because in this cluster has the existence of keywords, sustainable finance. In this cluster climate change, decision making, economics, green bonds, green finance investments and sustainable finance are major keywords and sustainable finance is most interlinked keyword of the cluster. This cluster highlights those innovative financial instruments that have been emerged over time, in area of sustainable finance. Research area Green bonds, is greatly interlinked with sustainable finance because it has great potential to fulfil the Paris agreement goal for climate change and improve sustainable investment of finance [43] and investment in green bonds has emerged as most preferable for investors and other side researchers', have also taken great interest in this area, with integration of green bonds and sustainable finance [44].

4.2.4 Fourth Cluster: Social Economy for Sustainable Finance

Initially, the policy of sustainable development has emerged in European countries and they are the torch bearers for the creating organized legal framework in financial system, because European countries have focused on 'social economy' [45]. In Figure 2, the light yellow color, highlights cluster 4, with seven items and most of them are keywords that are related to policy provisions and policymaker's entities, those have significant contribution in social economy. This cluster is narrower than other clusters, which indicates the significant gap related to the evaluation of sustainable finance polices and policy makers [46].

4.3 Top Leading Journals in Publishing Sustainable Finance

In the research area of 'sustainable finance', many journals are publishing articles, through the analysis of the top publishing journals, as presented in Table 2. It has been found 'Journal of Cleaner Production' is a top publishing journal with 70 documents, with the highest citation. 'Journal of Cleaner Production' is top leading journal is area of sustainable finance and it has a great margin lead, with the second most publishing journal 'Business strategy and the Environment', however, the journal 'Business strategy and the Environment' is an emerging journal in the area of sustainable development.

Table 2
Top Leading Journals of Sustainable Finance

Sources	**Documents**	**Citations**	**Total Link Strength**
Journal of Cleaner Production	70	2230	755
Business strategy and the Environment	18	759	486
International Journal of Production Economics	10	245	266
Technological forecasting and social change	16	484	251
Journal of Sustainable Finance and Investment	20	150	112
Ecological Economics	7	309	100
Energy Economics	6	558	56
Resources Policy	6	34	34
Resources, Conservation And Recycling		5	230
Marine Policy	6	136	3

"International Journal of Production Economics" and Technological Forecasting and Social Change" are also leading journals in the area of sustainable finance further, if one does analysis of the top 5th journal 'Journal of Sustainable Finance and Investment' it is one of the journals which decided to publish papers in the more specific area of Sustainable Finance. Other journals publish interdisciplinary papers with integration of the sustainable finance, so that is the basic reason that 'Journal of Sustainable Finance and Investment' is lagging behind the other journals At the same time the 'Journal of cleaner Production' is leading journal because in the manuscript of the this journal, there is great diversity and integration of the differences in research areas with sustainable finance, like environment engineering with sustainable finance, bio-circular economies with sustainable finance, etc. The remaining 5 journals are also of quality and high reputation journals, but their influence in area of sustainable finance is limited.

4.4 Analysis of Top Cited Authors

To discover the impact, author and researcher citation analysis is one of the better techniques when checking influence in a specific area of research [47]. Top cited authors of sustainable finance, are presented in Figure 2. In the analysis process, research has ignored documents with author more than 25 and further imposed, 2 more filter 1st minimum 3 documents and 10 citations… as result, found only 5 authors in two clusters. Cluster 1 is highlighted in red node and 2 cluster is represented in green. In cluster 1 there are 3 authors Agyabeng, Baach and Di Vaio. And in 2 cluster, only 2 authors, Lim and Tseng, for a total of 5 authors in both clusters, Tseng is highest influential author with 5 documents and 111 citations, Di Vaio is 2nd highest cited author, with 3 documents and 99 citations, the 3rd most cited author is Baah, with 3 documents and 49 citations, the 4th most cited author is Agyabeng Mensah, having 3 citations and 47 citations and the 5th most cited author is Lim, having 3 documents and 42 citations. Overall, the top author citations indicate that research of sustainable finance, is still very limited.

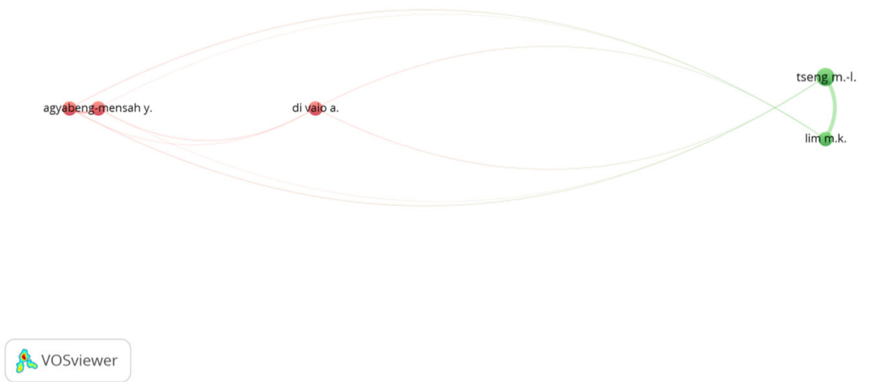

Figure 2
Top cited author

Source: with help of VOSviewer Complied by Authors

4.4.1 Country Wise Bibliographic Coupling of Sustainable Finance

To analyze the penetration for the country related research of sustainable finance, there has been a bibliographic coupling of sustainable finance conducted.

Figure 3 represents the bibliographic coupling of sustainable finance; here one basis of documents and citation total top 17 countries have been used for analysis. A filter was used to find out some influential countries. In scrutiny process, those documents have more than 25 co-authors were ignored and secondly those countries have minimum 10 documents and 100 citations were included and 17 countries. In the results, there are 3 clusters with cluster 1 in red color, cluster 2 in green and cluster 3 in blue.

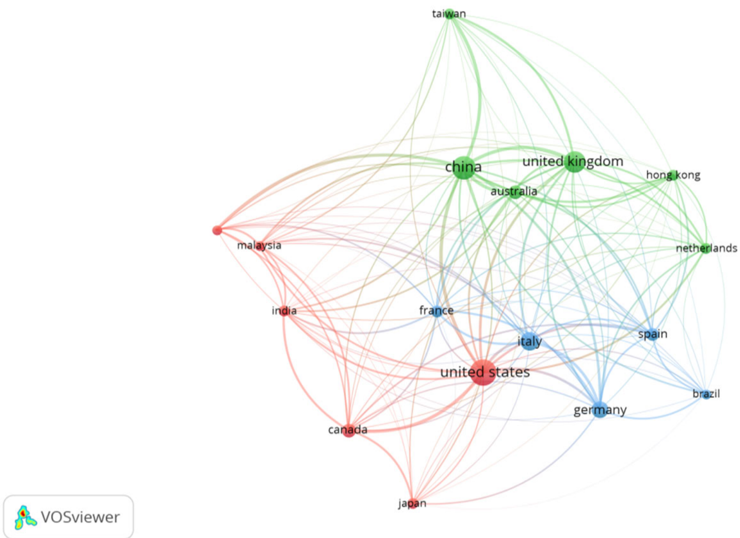

Figure 3
Country wise Bibliographic coupling of Sustainable finance
Source: with help of VOSviewer Complied by Authors

Table 3 represents the statistical data of bibliographic coupling of sustainable finance, which has been graphically represented, in Figure 4.

Table 3
Country Wise Bibliographic Coupling

Name of Country	Cluster	Documents	Citations
Canada	1	18	682
India	1	12	429
Japan	1	11	772
Malaysia	1	10	119
United State America	1	66	1,695
Pakistan	1	10	280
Australia	2	17	574
China	2	52	1,335
Hong-Kong	2	11	336
Taiwan	2	11	276
United Kingdom	2	42	812
Netherlands	2	12	742
Brazil	3	10	320
France	3	14	286
Germany	3	27	578
Italy	3	32	620
Spain	3	16	876

Source: with help of VOSviewer Complied by Authors

According to Table 3, the United States has highest intellectual contributions, with numbers of documents and citations and China has second highest documents and Citations. On the lower side, Malaysia is lowest among 17 countries. In the dimension of the research influence, Spain has highest, because with only 16 documents, it has 876 citations.

4.4.2 Trends of Sustainable Finance in Publication

Figure 4, depicts the chronological development of the literature of sustainable finance, according to Figure 4, the first articles was published in 2004 and in 2006 there were 0 papers, but from 2004 to 2017, growth in publications was not consistent however, after 2017 to 2021 publication of sustainable finance has steadily grown, because in 2017 there was 4 papers and 2021 total published articles are 88. The reason behind the dramatic growth of publications, is due to the different regulatory changes and adoptions of the sustainable finance mechanisms by different stakeholders. This has increased the research interest among researcher around the world. Over the entire period, growth in publications is an indicator for better future prospects for research in the area of sustainable finance however there is still much to do in the area of sustainable finance.

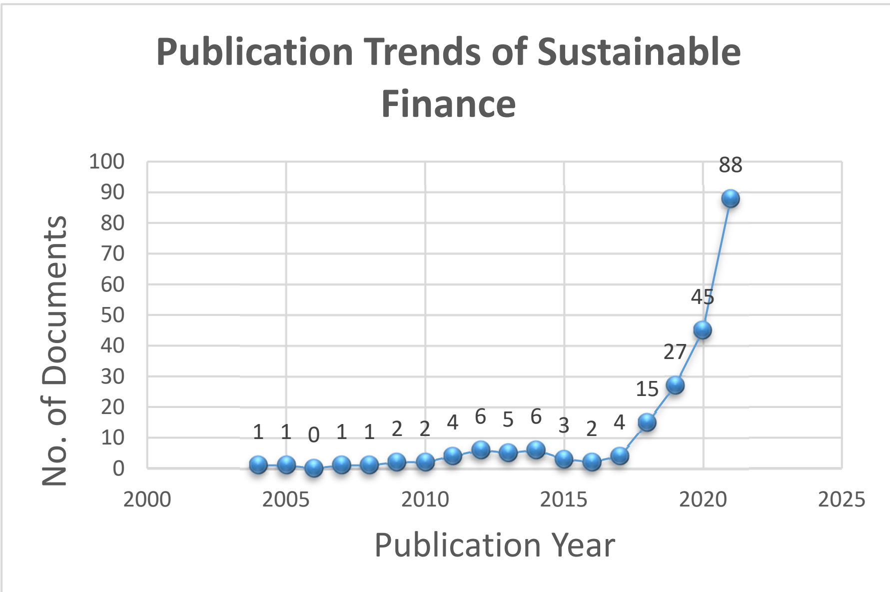

Figure 4
Country wise Bibliographic coupling of Sustainable finance

Source: With help of MS Office EXCEL, Complied by Authors

Conclusions

Societal concerns for sustainability and sustainable development, has raised issues in sustainable finance [48]. Over the last couple decades, growth in the publication of manuscripts for sustainable finance, depicts an emerging area of research. Bibliometric analysis and discussion of the sustainability of finance, indicates many research possibilities for regulatory institutions and researchers. In the area of sustainable finance, there is still a large research gap and this gap, is an opportunity for research in the area of sustainability and finance. In this bibliometric analysis, it was found that the literature of sustainable finance is not limited to the area of finance, because it is diverse and there is assimilation of other interdisciplinary areas, such as, environmental engineering, sustainable development and economic growth, however, the exclusive research concerning sustainable finance, has limited intellectual contributions.

Limitations and Future Scope of Research

In this work, the authors have taken data from the Scopus database, so for better and more intensive analysis, other databases like web of sciences, Lens, Pubmed, etc., can be integrate for a more holistic coverage of the research area. In the process of searches using only the 'sustainable finance' keyword, the authors have found a limited number of papers, so for a comprehensive study with 'sustainable finance' and some other included keywords, may give some new dimensions for the future researcher. This study has included only the "articles" category of documents, but in future research, inclusion of chapters in edited books and conference proceedings, could yield new research insights, for the area of Sustainable Finance.

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Generational Change in Family Farms and the Situation of Arable Land, as a Factor of Production, in Hungary

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Abstract: Family farms have been the cornerstone of rural society for centuries in Hungary. They provide significant contributions to the rural population and strengthen social and cultural traditions. From an agricultural point of view, Hungary has excellent potential, both because of its climate and its location. This is why agriculture has been the country's key sector for centuries. Even today, it still plays a significant role, but in terms of competitiveness and development, it falls short of the level that could be expected regarding to its capabilities. According to the 2020 agricultural census in Hungary, 216,000 farms are managed on nearly 4.922 million hectares. A substantial proportion of these farms are family farms and a significant share of the land as a natural resource is owned by them. My study – based on secondary research – deals with a major problem in Hungarian agriculture: Generational Change. In Hungary, there is currently, no tradition of farm transfer, but the issue of generational change, is becoming an increasingly pressing problem, for the Hungarian agricultural economy. In parallel, I analyze statistical data on the relationship of family farms with arable land, one of the most important and limited natural resources of the sector. The results show, that it is essential for the long-term survival of family farms, that the land owned and used by the farm, remains in the same hands and is not fragmented. Successful generational change is therefore, also crucial for land use. Measures taken in the past and in the period ahead (e.g., targeted support under the Common Agricultural Policy Strategic Plan 2023-2027 or Act CXLIII of 2021) can help to ensure a successful generational transition and the preservation of land.

Keywords: generational change; family farm; arable land

1 Introduction

Family businesses are key players in the economies of both developed and developing countries. They contribute significantly to GDP and play an important role in employment.

Family farms, which are enterprises in the agricultural sector, have been a cornerstone of rural society for centuries. They make a major contribution to rural population retention, play a key role in employment and reinforce social and cultural traditions [1]. Despite this, the number of family farms is decreasing across Europe. The reasons are complex.

Farmers are struggling to cope with the problems of climate change, that of low viability, changing farm and agricultural holding structures and finally, successful generational change. Problems with farm viability and the lack of innovative farming practices often play a key role in succession decisions, preventing older farmers from passing on the farm [2-4].

In addition, data from the 2010 General Agricultural Census (GAC) already pointed out that the proportion of older farmers is much higher than that of young farmers, i.e., the number of young farmers entering the sector cannot replace the number of older farmers leaving it. The lack of sufficient replacement could threaten the survival of farms [5].

There is currently no tradition of farm transfer in Hungary, but the issue of generational change is becoming an increasingly pressing problem for Hungarian agriculture. For years, professional organizations have been calling for creating better conditions to support successful generational change. As a result, the Act CXXIII of 2020 on Family Farming [6] came into effect on 1st January 2021.

The primary aim was to simplify the new forms of agricultural production that would be created under this law, which is increase the competitiveness of farmers and promote generational change.

2 Family Farms

Consequently, we will review the past and present situation and the future challenges of family farming.

2.1 Family Farms in the 2nd Half of the 20th Century

After the Second World War, nationalization and collectivization of agriculture began in Hungary. Following the establishment of agricultural cooperatives, backyard farms were created.

Between 1957 and 1959, the political leadership sought to reorganize the cooperatives that had been dissolved during the revolution. After the reorganization of agriculture, large farms farmed 94% of the agricultural area and produced 2/3 of agricultural output.

At the beginning of the 1960s, there were 270 state farms, 4200 producer cooperatives and more than 400 specialized cooperatives. Later on, the cooperatives were merged, resulting in 132 state farms, 1338 producer cooperatives and 61 specialized cooperatives in 1980. The average area of state farms increased to 7600 ha and that of cooperatives to 4000 ha [7].

By the end of the 1960s, restrictions on backyard farming had been lifted, made possible by the entry into force of Act III of 1967.

A decision of the Council of Ministers, which came into force in 1975, stipulated not only that the backyard economy should be accepted but also that it should be promoted [8].

Overall, by the early 1970s, small-scale production had become an integral part of agriculture. A division of labor was established in which large farms played a dominant role in the well-mechanized sectors, while small producers played a dominant role in the production of products requiring more manual labor [9].

The new land law adopted in 1987 marked a major turning point in the life of small farmers. It widened the possibilities of acquiring and using land. The old law defined the size of a backyard farm as 800 square hectares. However, the new law also allowed individual farms to use land of other types. The new provision allowed individual ownership of up to 15 ha [10].

The relationship between small farmers and cooperatives has been significantly altered or broken following the change of regime, the compensation process and the transfer of assets [11].

In Hungary, radical changes in economic life took place in the late 1980s and early 1990s, creating the conditions for a market economy.

The effects of this economic transformation did not leave agriculture untouched. As a result of the transformation processes in agriculture, the former farm structure was completely reorganized.

The large-scale reduction of state and cooperative ownership led to the emergence of private property, but after compensation the average size of farms per farm did not reach 1.5 hectares [12].

In the new farm structure that emerged, there appeared dwarf farms with small holdings and economic companies that could only maintain their agricultural activity by renting land. Farmers who became independent were faced with a number of problems which they were unable to solve because of their economic size, and in many cases, they became completely vulnerable to market conditions.

By the mid-1990s, many landowners had abandoned farming, preferring to sell or rent their land. This process has transformed the unity of land ownership and land use, while at the same time, it started a process of concentration, in land use [12].

By the late 1990s, the process of concentration continued. And as the managers of the family farms that emerged after the change of regime moved closer to retirement age, the issue of farm transfer became timely.

For years, professional organizations have been calling for the creation of conditions to support a successful generational transition. As a result, Act No. CXXIII of 2020 on the Family Economy entered into force on 1 January 2021.

2.2 Family Farms Today

On 30th November 2020, the Parliament adopted a bill regarding a comprehensive reform of the family farming system, which came into effect on 1st January 2021.

The law defined the family farm system (Figure 1).

Accordingly, a family farmer is: "...a natural person aged 16 or over who is registered in the register of family farmers and who carries out a family farming activity on his/her own holding." "... may carry out his activity either independently or as a member of a family holding of farmers." (Act CXXIII of 2020, § 3, paragraphs 2-3) [6].

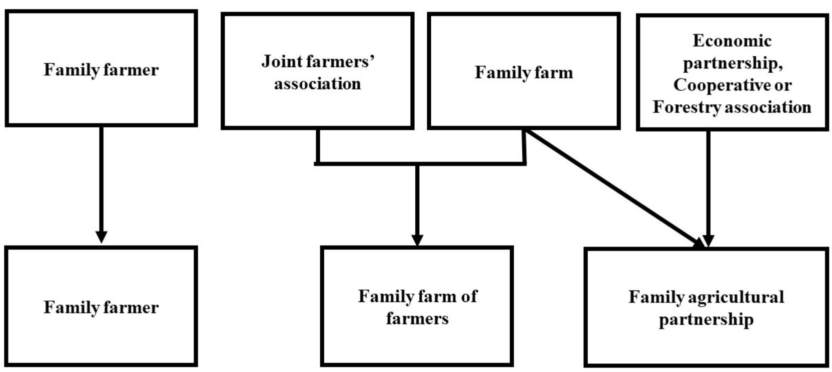

Figure 1

The family economic system in Hungary under Act CXXIII of 2020

Source: [13] based on own editing

The family farm of farmers is defined as "a production community established by at least two members of an agricultural holding who have their own juridic personality and have no separate assets from those of their members. It consists of at least two members of the agricultural holding who are related to each other, within which the agricultural holders carry out their farming activities on their holding jointly, based on the personal contribution of all members in a coordinated manner." (Act CXXIII of 2020, § 6, paragraph 1) [6].

Finally, a family agricultural partnership is considered to be: "... an economic partnership, cooperative or forestry association which is entered into the register of family agricultural partnerships and which is engaged exclusively in agricultural, forestry or complementary activities as defined in the Land Traffic Act, and which has at least two members and who are related to each other." (Act CXXIII of 2020, § 14, paragraph 2) [6].

First, we review what characterizes family farms in Hungary, based on the KSH 2020 agricultural census data [14].

Family farms are predominantly (71%) managed by men. The average age of farm managers is 57.9 years. While in 2010 almost a quarter (28%) of farms were managed by a person aged 65 or over, this proportion increased to 35% by 2020. The 60-69 age group is predominantly responsible for the management of today's farm businesses. (Figure 2)

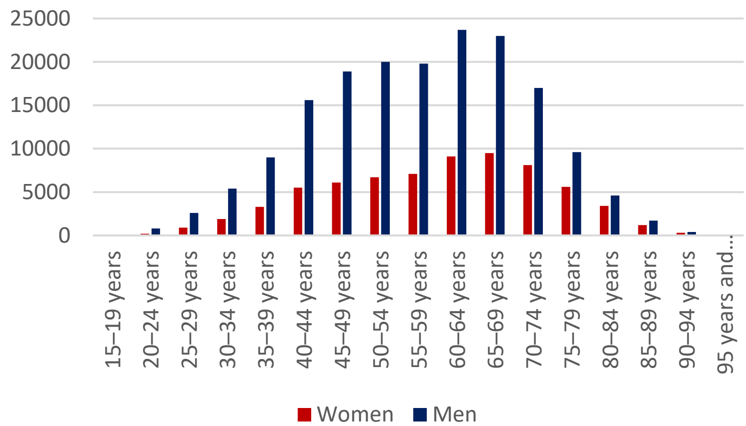

Figure 2

Number of managers of agricultural holdings by gender and life-category in 2020

Source: [14] based on own editing

However, the ratio of managers with an agricultural education has increased: while in 2010 19.8% had either secondary school education or a higher education degree, this rate increased to 38.7% in 2020 (Figure 3).

The survey also gives an idea of how family farm managers envision the future of their farms and that of themselves, and for how many years they plan to farm.

First of all, it is important to note that almost half of the respondents (45%) did not answer this question.

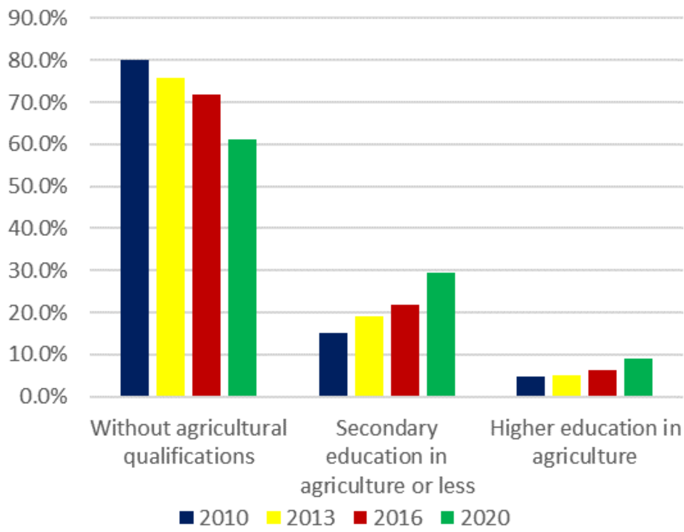

Figure 3
Distribution of the number of holdings by the manager's qualifications
Source: [14] based on own editing

33% of respondents envisage 5 years or less as a farmer, 20% plan to be active for 6-10 years and 47% said they would like to be a farmer even after a decade. It is important to note that the average age of farmers is high (see Figure 2), which may explain the responses.

Data from the 2020 agricultural census also show that 53% of family farm managers consider a maximum of 10 years of active farming, therefore it is crucial to address the issue of generational change [14].

It is also pertinent to look at the data on farmland, which is of crucial importance and can have a significant impact on the costs of farming.

The 2020 agricultural census data show that in Hungary, 216000 farms managed on nearly 4.922 million hectares.

Of this agricultural land, 45% was used by the owners 50% as tenant-occupied 5 percent was used under other claims (sharecropping, land use at farm gate).

Farmers using less than 5 hectares of land mainly cultivated their own land, while the proportion of rented land exceeded 75 percent for those who cultivated more than 300 hectares (Figure 4).

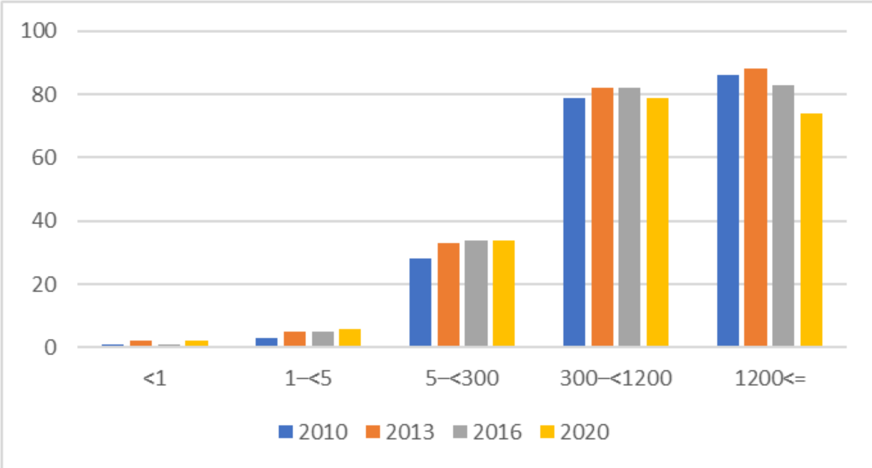

Figure 4
Ratio of rented land by size category (percentage)
Source: [14] based on own editing

Generally speaking, the price of land purchased in 2010 already tripled by 2021. The inflationary environment in 2022 could further stimulate farmland sales, and growing demands can push prices even higher.

The main reasons for the unabated rise in farmland prices over a decade are:

- Higher than average profitability of crop production
- The size of area-based subsidies
- The tax exemption of income derived from the leasing of land for at least five years
- Higher than average crop prices over many years
- A relatively favorable interest rate environment, a stable supply of funds for the purchase of farmland and the continued high level of bank activity in agriculture [15]

The most expensive county is Békés (price per hectare of 2.36 million HUF), Hajdú-Bihar, Pest, Tolna, Fejér and Győr-Moson-Sopron counties also cross the 2-million-HUF threshold (Figure 5).

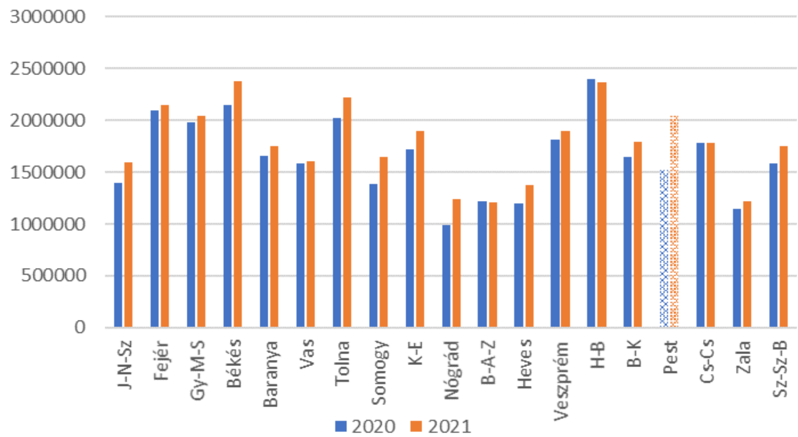

Figure 5

Average farmland prices by county

Note: The price spike in Pest county is due to technical reasons. The processing of the turnover data is significantly behind schedule here, so the column for Pest County in the chart is marked with a line coloring due to uncertainty.

Source: [15] based on own editing

2.3 Future - Tasks to be Accomplished

The ageing of population, declining fertility and expanded educational opportunities for young people challenge the intergenerational sustainability of family farming and present particular difficulties for smallholder farmers. [16]

The nationally less than favorable composition of the agricultural labor force suggests that the nature of the work, being bound to villages, the low dependency and income-generating capacity of the sector are not attractive to young people [17].

This is also supported by research carried out by European Economic and Social Committee (EESC), which found that the low level of income from farming is one of the main holdbacks of attracting young farmers to the sector. The EESC also pointed out that there is a large gap between the income generated by farming and the income available in other sectors of society in rural areas [18].

Research shows that succession decisions are significantly influenced by governmental economic policy, farm assets, age and education of present-day farmers [19].

Other research suggests that young people may be discouraged from farming for the following reasons [20]:

- Economic insecurity, uncertainty and difficulties specific to the agricultural sector

- Rural life is less attractive for young people
- Land prices (Figure 5) and rents are very high compared to incomes
- High initial start-up costs
- Farms cannot be run efficiently without agricultural and business management skills

However, the Common Agricultural Policy (CAP) resources for the period 2023 thru 2027, will be earmarked for young farmers, after Hungary's Strategic Plan for the CAP for the period 2023-2027 was approved by the EC on 7th November 2022. The total budget for the next five years of the domestic CAP is €14.7 billion, of which €8.4 billion will be provided by the European Union for Hungary [21].

From 2023 onwards, an increased focus will be on:

- Support for small and medium-sized farms
- Encouraging generational change in agriculture
- Encouraging the adoption of more environmentally sustainable farming practices (closely linked to this, for example, the extension of the concept of eligible area)

The measures of the CAP Strategic Plan are based on 2 pillars. Pillar I includes direct payments, while Pillar II covers rural development payments (Table 1).

Table 1

Measures of the Common Agricultural Policy Strategic Plan [21]

Direct payments - Pillar I	**Rural development payments – Pillar II**
— Basic Income Support — Redistributive payment — Agro-ecological Program — *Supporting young farmers* — Production coupled subsidy	— Agri-environmental management program — Organic farming — Natura 2000 compensation — Forestry measures — Investments — Cooperation — Risk management — *Supporting young farmers* — Knowledge base and information exchange

As Table 1 shows, both Pillar I and Pillar II, include options to support young farmers.

In order to facilitate generational transition, the CXLIII. Law regarding the Transfer of Agricultural Holdings, which reads as follows in its preamble: "The goal of the Parliament is to facilitate the transfer of farms as unique assets, created by the participation of family members, the joint use of their resources and the results of their work for their common well-being, to the next generation to ensure the efficiency and viability of the economy by preserving the diversity and strengthening the adaptability of agriculture and to help ensure balanced income conditions for the farmers who start, operate and develop farms." [22]

The Act provides for the possibility of transferring farms and all their elements (e.g., land, personal estates, real estates, property rights, etc.) in their entirety.

3 Family Farms in Hungary

Family businesses, including family farms, nowadays have many positive features from an economic point of view, similar to those of SMEs. Many national and international studies [23-33] have examined both SMEs and family businesses.

Among their findings, the following positive characteristics are highlighted:

- Their role in job creation is significant
- They are flexible and can adapt very quickly to constantly changing market conditions
- They are highly motivated
- Adaptable
- Growth-oriented
- Have moderate risk tolerance
- Constantly seeking new opportunities
- They play an increasingly important role in international trade
- Have an active role to meet local needs
- Contribute to the diversification of economic activity and thus to the stimulation of competition
- Play a significant role in employing people with disabilities and disadvantaged workers
- Are innovative and creative
- Are based on strong social networks
- Are based on strong family ties

- Changes in the roles and in the relationships of family members have a clear impact on decisions when setting up a business
- They are long-term thinkers (family heritage and strong personal ties make them want to preserve their businesses for their heirs)
- They have a long-term perspective (they can make appropriate decisions for the long term, even if this means sacrificing short-term income)
- They are stable [28]

As noted above, the generational transition of family businesses in Hungary has already started and is about halfway through, in a very difficult environment: the coronavirus epidemic, the Russian-Ukrainian war and unfavorable macroeconomic environment may significantly set the process of management handover back. Our own research shows that, due to the adverse environmental factors, many members of the successor generation decide to postpone passing the torch and try to navigate their businesses themselves in this chaotic economic and social environment. As one of the family business managers put it, "Now is not the time for the new generation to try to take over. Now is the time for quick decisions and to have leadership experience in order to survive."[1]

So, passing the torch is not a simple one-step process.

This is in line with Ip and Jacobs (2006), who argue that the period of time needed to integrate the successor and achieve full effectiveness is, in their experience, between 12 and 18 months [35].

The same authors have also identified the steps in the process of generational change (Figure 1).

International research also shows that the long-term survival rate of family businesses is low [36]: experience shows that 30 per cent of businesses survive the first generation and 15 per cent the second [37].

The organizational culture and managerial behavior of domestic family businesses are characterized by owner-manager dominance, which makes it difficult to pass the torch. Another typical mistake in generational change may be that personal attachment becomes dominant over competence in the appointment of a successor. Thus, the lack of management competences can jeopardize the long-term survival of the business [38].

[1] Our ongoing research analyzes family farms in terms of genertional change.

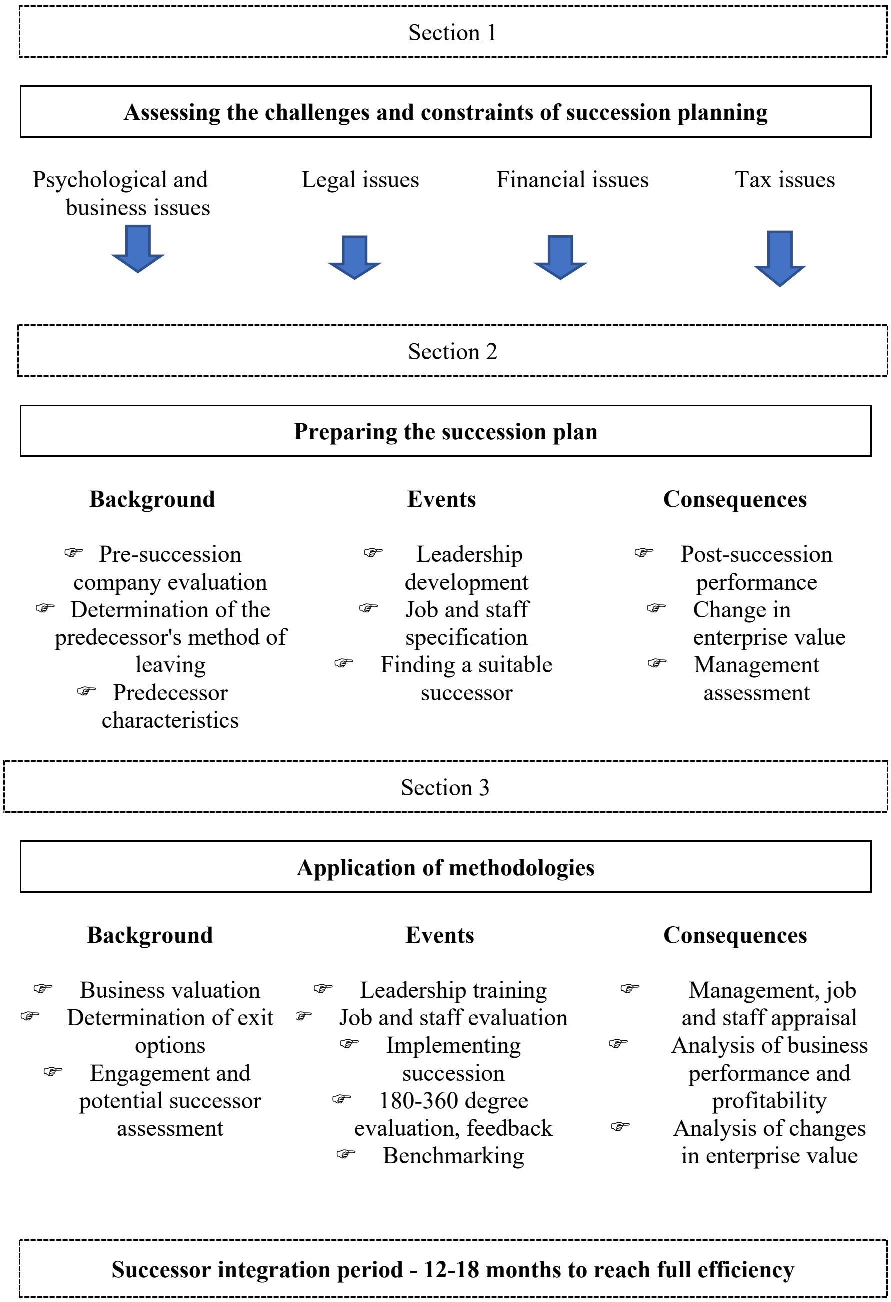

Figure 6

Three-stage succession process model [35] based on [26]

In addition to the above factors, other questions about the success of generational change can arise right from the first steps [39] [40], even before the process has started. Here are some of them:

- Does the founder really want to pass on his business to his successors in time or does he wait too long until the suitable successor has already chosen his or her own occupation? When is the optimal time to hand the management of the business over? There is no universal answer to this question. However, the research work of Handler provides some guidance in the context of succession. [39] It shows that there may be a positive correlation between the level of education of the successor, his/her work experience outside the company and the success of the generational change. In addition, it is important to gradually involve the successor in the business. Here, it is essential that the manager in office works side by side with the successor, involving him or her in the business and handling responsibility, authority and leadership gradually over. To do this, however, it is essential that there is a successor within the family who can (is capable) and wants to take the business over.
- If there are several suitable successors within the family (e.g., siblings) who could and want to take the torch over, the question may arise: how can rivalry between siblings, for example, be resolved? Ward makes the following suggestion [41]:
    - In successful family businesses, both siblings and the parent-owner work to ensure that sibling rivalry has a positive rather than a negative effect.
    - They can use techniques such as:
        - Defining a general and well-publicized philosophy for regulating salaries and promotions
        - Designating separate positions for siblings within the company
        - The development of a code of conduct to regulate the behavior of siblings towards each other
- If there is an offspring within the family who may be suitable to take the business over, but whose age or inexperience, for instance, does not make them suitable, it is possible to appoint an interim manager with the help of a consultant until the offspring is ready.
- If there is no lineal successor within the family who is able or willing to take the family business over, there is still the option of appointing a professional manager (with appropriate control but retaining ownership).
- If none of the above options are available to the family, the business may be sold or, ultimately, liquidated [42-44].

Conclusions

The role of family farms is significant in Hungary. Therefore, it is of utmost importance that the process of generational change ahead of them, goes smoothly. There is currently no tradition for farm transfer in Hungary and the transfer of the family farm management is hampered, by a number of factors.

The number of older people in the Hungarian agriculture is significantly higher than that of young people, thus, the number of young people entering the sector cannot replace the number of older people leaving it, as is also the case in many European countries. The lack of adequate replacement strategies can threaten the long-term survival of farms in Hungary.

Arable land plays an extremely important role in the life of farms. The price of farmland has already tripled, on average over a decade. By 2022 a high inflationary environment, boosted farmland sales even further, with demand growth driving prices even higher.

Land is a scarce resource. For the long-term survival of family farms, it is essential that land owned and used by the farm, remains in single ownership and is not fragmented.

In recent times, a number of measures, laws and support schemes have contributed to the success of this process, aimed at generational change and the efficient operation of family farms.

The targeted support of the Common Agricultural Policy's, Strategic Plan for the period 2023-2027 or the Act CXLIII of 2021, can further enhance the smooth and successful generation change and the unification of land ownership for the family farms in Hungary.

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The Potential of Wind Energy Development in Poland in the Context of Legal and Economic Changes

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Abstract: The main topic of the work is the analysis of the development of wind farms in Poland. In addition, the aim of the publication is to assess the current development of wind energy compared to other renewable energy sources in Poland. As well as, the comparison of the dynamics of development of this renewable energy source in Poland in relation to other European Union countries. The development of wind energy in Poland has been limited in recent years due to the legal regulations introduced in 2016. However, the current situation on the market of conventional energy resources and growing ecological standards may force dynamic changes in the legal solutions related to the possibility of building new wind farms.

Keywords: energy transition; sustainable development; energy policy; renewable energy; Poland

1 Introduction

The popularity of wind energy can be considered in several aspects. Firstly, wind is a common phenomenon and, despite the fluctuations in wind speeds (daily, monthly and seasonal fluctuations), it is easily accessible and stable. Secondly, wind is a clean source of energy that does not emit any pollutants. Especially the latter property is important from the point of view of the transformation of economies towards low-emission, including the departure from coal as the main raw material for the production of electricity and heat. In the global dimension, this applies primarily to China and India [1-3] and what is important, it is noticed in these countries in current development activities aimed at increasing the importance of RES and in development activities in the medium and long-term [4-5]. In the case of China, the large-scale deployment of wind energy installations plays an important role in the transition to energy neutrality before 2060 [6]. In relation to India, wind energy is also the largest share of all renewables and currently, opportunities for development are being sought, e.g. in the area of offshore wind farms [7-8]. The issues related to moving away from coal in the professional power industry also concern countries in Europe, including, above all, Poland. The energy policy of the European Union also gives renewable energy sources, including wind energy, a high priority of promotion by introducing a number of programs and aid packages for investors. Obviously, the basis is the development of wind farms in accordance with the principle of sustainable development. In the area of sustainable development of wind energy, the following stand out: impacts on birds, noise pollution, visual effects, microclimate and vegetation [9-11].

China is the world leader in the wind energy market [12-13]. The USA, Germany and India follow. The data from the International Renewable Energy Agency (IRENA) shows that in 2021 China had 328,973 MW of wind energy capacity, which accounted for 39.9% of global capacity. Not only is the result in terms of installed capacity impressive, but also the dynamics of changes in recent years. At the same time, China has set ambitious goals for the development of wind energy as part of its national development programs, including energy security [14]. According to the analyses, in the years 2012-2021, the increase in installed capacity in wind energy in China was more than 5-fold (from 61,597 MW in 2012). In China, the growth of the wind power is mainly influenced by policy and market (government support through various subsidies, electricity price and cheap raw material supply, etc.) [15]. In 2021, the USA had 132,738 MW of wind energy capacity (59,075 MW in 2012), Germany 63,760 MW, and India 40,067 MW [16].

Wind energy is currently the most important source of RES in total electricity consumption in the European Union [17-18]. In addition to the high capacity installed in Germany, a relatively large capacity among the European Union countries is in Spain (in 2021 - 27,497 MW) and in France (in 2021 - 18,676 MW) [16]. The total installed capacity in the EU-27 in 2021 was 187,497 MW. Therefore, analyses in the field of wind energy are very important, and the significance of the subject is determined by, among the others, huge potential of windmills and wind turbines located at sea or on land. The importance of wind energy among renewable energy sources also results from economic motives, from the ability to generate large amounts of energy at competitive costs [19-20]. Obviously, there is considerable uncertainty as to how these costs will develop in the future, however, many experts predict further reductions in the cost of energy generated on the basis of wind energy [21]. Nevertheless, in recent years there has been a significant technological progress in the area under study, including the field of turbine design in terms of efficiency increase (more MWh of electricity generated per MW of installed wind turbines). Moreover, the latest improvements in the researched area (including increased hub height, larger rotors and improved energy capture methods) can contribute to the development of wind energy in areas so far inaccessible to this RES technology (less windy regions) [22].

This article aims to describe the current situation of wind energy development in Poland against the background of the EU-27 countries, including the prospects for the development of onshore and offshore wind energy. Comparative analyses were carried out both in relation to other renewable energy sources in Poland and internationally. The basic source material was data from public statistics, both the Central Statistical Office in Poland and Eurostat. The data on installed capacity in wind energy in global terms was taken from the data of the International Renewable Energy Agency. The basic time range of the analyses covered the years 2011-2020.

The first part of the article describes the situation of wind energy in the EU-27 and in Poland. The following parts of the article present issues related to the use of this source of renewable energy in Poland, paying particular attention to the development opportunities and actions necessary to accelerate the development of this RES sector in Poland.

2 Development of Wind Energy in Poland against the Background of the European Union

Obviously, the basis for the development of wind energy are wind speed and wind power density as well as appropriate decisions on the location of turbines based on the spatial-temporal distribution of wind resources. Nevertheless, economic conditions and socio-economic factors (including local acceptance) are also very important, both at the stage of construction of wind turbines and as part of the operation of wind turbines in the energy system.

As mentioned in the introduction, wind energy is a priority (like other sources of renewable energy) supported in the European Union. Until 2020, various support schemes and programs were implemented in individual European Union countries. In the EU countries, two direct support mechanisms can be distinguished, the so-called a feed-in system in which the energy producer receives a specific price for the energy produced. This system may also include additional financial resources for electricity sold at the market price. In the second system, obligations are imposed on entities in the energy market specified in the law to purchase a certain amount of energy from renewable sources [23].

An important element of the development of wind energy is also the current state and energy mix in individual countries. For instance, the little importance of wind energy in Slovakia results from the fact that over 50% of electricity in this country comes from nuclear energy, and hydro-power is the most important source of renewable energy. Similarly, onshore wind plays a rather minor role in Czech renewable power generation [24].

The volumes of electricity production in the EU-27 countries in general terms, energy generated from renewable sources and energy from wind are presented in

Tab. 1. In turn, the share of wind energy production in total energy production and in the generation of energy from renewable sources is shown in Fig. 1 and 2, respectively (country codes are used to create figures).

Table 1

Total production of electricity and energy generated from renewable sources and wind in the EU-27 in 2011 and 2020

Specification	Country code	Total gross electricity production		Renewables and biofuels		Wind	
		2011	2020	2011	2020	2011	2020
		[GWh]					
European Union - 27 countries	EU-27	2,937,062.863	2,781,332.496	670,927.321	1,086,087.1	165,346.901	397,418.088
Belgium	BE	90,294.200	88,890.800	9,561.200	24,458.500	2,312.000	12,763.600
Bulgaria	BG	50,773.608	40,731.058	4,708.608	7,977.586	861.095	1,477.131
Czechia	CZ	87,390.007	81,398.928	7,946.512	11,637.853	397.003	699.083
Denmark	DK	35,229.121	28,733.461	14,180.853	23,451.670	9,774.184	16,330.214
Germany	DE	611,023.000	571,089.000	129,878.000	256,708.000	49,858.000	132,102.000
Estonia	EE	12,893.720	5,955.864	1,179.720	2,848.097	368.659	844.000
Ireland	IE	27,164.029	32,290.479	5,423.595	13,774.793	4,380.315	11,549.420
Greece	EL	59,436.571	48,251.884	8,407.571	17,650.815	3,315.227	9,310.104
Spain	ES	293,676.000	263,213.000	89,837.000	117,274.000	42,918.000	56,444.000
France	FR	572,560.345	531,201.048	71,179.656	129,182.768	12,371.621	39,791.901
Croatia	HR	11,372.169	13,385.300	5,417.169	8,698.600	201.000	1,720.700
Italy	IT	301,772.343	280,029.531	84,895.649	118,858.209	9,856.375	18,761.557
Cyprus	CY	4,929.212	4,849.194	178.212	596.648	114.665	240.408
Latvia	LV	6,094.262	5,724.846	3,077.262	3,649.529	70.894	176.842
Lithuania	LT	4,565.000	5,310.900	1,688.000	3,354.700	475.000	1,551.700
Luxembourg	LU	3,716.293	2,233.901	1,313.279	1,978.397	64.050	351.135
Hungary	HU	36,019.176	34,787.000	2,708.192	5,529.000	625.693	655.000
Malta	MT	2,178.900	2,143.050	9.900	242.788	0.000	0.058
Netherlands	NL	113,813.185	123,041.421	12,320.182	32,997.892	5,100.171	15,339.130
Austria	AT	65,801.609	72,556.246	44,451.164	58,779.511	1,936.196	6,791.530
Poland	PL	163,442.826	157,949.038	13,567.236	29,045.213	3,204.548	15,800.049
Portugal	PT	52,458.252	53,078.401	24,689.717	31,649.727	9,161.612	12,298.663
Romania	RO	62,214.975	55,934.902	16,530.975	24,926.760	1,387.200	6,945.462
Slovenia	SI	16,057.989	17,190.698	4,023.428	5,873.234	0.000	6.251
Slovakia	SK	28,578.187	28,807.000	5,367.187	7,139.000	5.000	4.000
Finland	FI	73,202.395	68,722.546	24,176.565	35,609.814	481.393	7,938.150
Sweden	SE	150,405.489	163,833.000	84,210.489	112,194.000	6,107.000	27,526.000

Source: own elaboration based on [25]

As mentioned before, Germany is the EU-27 leader in wind energy production. In 2020, 132,102 GWh of wind energy was produced in Germany, i.e. 33.2% of the volume of this energy generated in the entire EU-27. Other leading producers in the EU-27 include Spain (with a share of 14.2% in total production in the EU-27) and France (with a share of 10%). Poland was ranked 7th in the EU-27 (also behind Sweden, Italy and Denmark), with a share of 4%, taking into account the production volume in 2020.

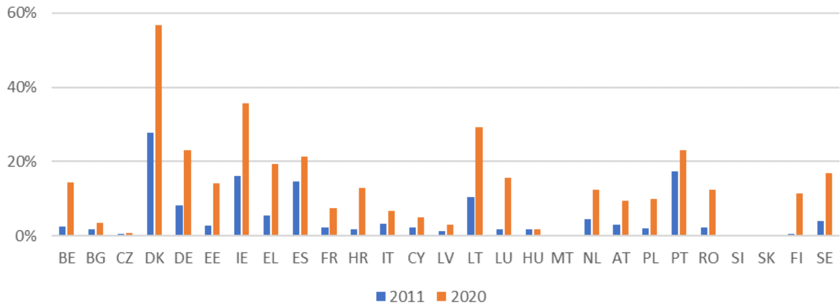

Figure 1
Share of wind energy production in total electricity production in the EU-27 in 2011 and 2020
Source: own elaboration based on [25]

Taking into account changes in the share of wind energy production in electricity production, a significant increase in this share in 2011-2020 was recorded in Denmark (by 29.1 p.p.). Denmark is the only EU-27 country where the share of wind energy volume in the structure of total energy production exceeds 50%. Also in Poland, the share of wind energy production in the total volume of electricity generation increased in the analysed years (by 8 p.p.), however, this difference is at the average level in the EU-27 (13th place in this respect out of 27 countries).

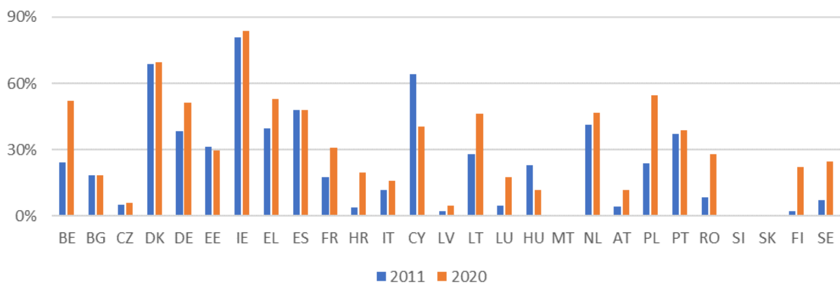

Figure 2
Share of wind energy production in renewable energy production (renewables and biofuels) in the EU-27 countries in 2011 and 2020
Source: own elaboration based on [25]

In turn, taking into account the share of wind energy generation in the production of energy from renewable sources and considering the differences in the years 2011-2020, Poland recorded the largest increase in this share in the EU-27 (by 30.8 p.p.). A large increase in this share resulted in Poland being ranked 3rd in the EU-27 in 2020 (after Ireland and Denmark). The share of wind energy generation in renewable energy production in Poland in 2020 was 54.4%.

3 Wind Power Development Opportunities in Poland

Wind energy in Poland has been developing since the early 1990s. The first windmill in Poland (150 kW turbine) producing electricity was built in 1991 in Żarnowiec. However, the first commercial wind farm (Barzowice farm) was commissioned in April 2001 in the commune of Darłowo (it consisted of six turbines with a total installed capacity of 5 MW) [26].

From 2005 to 2016, a very dynamic development of wind energy was recorded in Poland. This was favoured by legal and economic reasons. Since 2016, mainly as a result of the introduction of legal solutions unfavourable for wind energy, i.e. the entry into force of the so-called distance act. This act defined the minimum distance between wind installations, e.g. from residential buildings at a level of at least 10 times the height of the entire installation. Since then, the growth dynamics of this energy sector has been low. The entry into force of the above-mentioned act meant in practice that the windmill should be located approx. 1.5-2 km from the buildings. The technical potential calculated by Igliński indicates that only 0.02% of Poland's land area meets the requirements of this distance act [27]. In addition to the legal situation, the lack of development of wind energy was caused by the situation on the commodity and financial markets, including the record oversupply of certificates of origin (green certificates), leading to a significant reduction in their price. Problems of this nature in Poland are not isolated on the European market. One of the European leaders in this market – Spain, also experienced development problems due to the lack of an integrated regulatory framework for the industry and rapid changes in legal regulations [28-29]. Recently, an opportunity has appeared in Poland to liberalize the distance act, which is to restore the conditions for the development of this important part of the RES market. This is very important in times of energy crisis. In addition to the legal issue, it is also necessary to review and possibly adjust financial issues. Nolden's research shows that feed-in tariffs alone do not offer greater opportunities for multi-scalar energy transformations [30]. Financial support for investors is important, especially in the current situation of high inflation.

Wind energy is also a significant element in the development of Community Energy. The literature on the subject analyses the participation of citizens and communities in relation to wind cooperatives, e.g. in Denmark, Germany and

Belgium [31]. Energy cooperatives are a new phenomenon in the Polish energy sector, with great prospects for development. Undoubtedly, the experience of countries such as Germany and Denmark should be applied. Conclusions and simulations in the area of the possibility of creating profitable energy cooperatives in rural areas in Poland are optimistic. According to the analyses of Jasiński et al. [32], the functioning of such groups in practice can be associated with positive economic effects for their members, including, among other things, minimizing the sum of energy purchases from the distribution network. Investments in renewable energy sources, including in the area of grids, energy communities, can have a positive impact on reducing the scale of energy poverty. However, the issue of Energy Communities (REC) and Citizens' Energy Communities (CEC) needs to be unified within the European Union [33].

Another important issue in the development of the wind energy market are micro-installations. Creating appropriate conditions for the development of micro-installations (as was the case with photovoltaic installations) would largely enable a faster transition towards low- and zero-emission energy sources and acceleration of the energy transformation in Poland [34]. Currently, there are 69 wind micro-installations in Poland (as at the end of June 2022), and over 1.1 million photovoltaic [35]. Development opportunities concern mainly farms in Poland (there are over 1 million farms in Poland). Appropriate measures to encourage the construction of such micro-installations (financial incentives and appropriate promotion) are important. Above all, stable legal rules are crucial, including in the tax area related to wind energy (excise duty, property tax and tax on electricity from micro-installations) [36].

Offshore wind energy is also an important development area. The potential of offshore energy in the Baltic Sea, in the area of Polish maritime areas, is estimated at 28 GW [37]. PGE Polish Energy Group, which is the largest electricity company and supplier of electricity and heat in Poland, plans large investments in offshore wind farms. The plan assumes the construction of the Baltica Offshore Wind Farm by 2030, implemented in two stages – Baltica 2 and Baltica 3, with a total installed capacity of up to 2.5 GW. In addition, after 2030, the construction of the Baltica 1 Wind Power Plant with a capacity of approx. 1 GW is planned. Generally, according to the strategy, the PGE Group will build at least 6.5 GW of generation capacity installed in offshore technology by 2040 [38]. As Ziemba points out [39], investments in offshore wind farms can be an effective development impulse for the economy recovering from the crisis caused by the COVID-19 pandemic. It is also crucial from the point of view of current challenges in the area of electricity supply due to current geopolitical challenges.

The expected liberalization of legal regulations regarding the location of onshore wind farms in Poland will undoubtedly contribute to the emergence of new investment projects. Plans in this area are presented, among the others, by Tauron Group (the second largest entity in the energy sector in Poland after PGE). Currently, the Tauron Group has eleven wind farms with a total capacity of 416

MW. There are plans to build another wind farm in the north of Poland (with a capacity of 30 MW). Moreover, in June 2022, Tauron purchased the Mierzyn wind farm project in the Zachodniopomorskie Voivodeship. The implementation of this investment (60 MW capacity) is to be completed by the end of 2024 [40].

Summary

Taking into account the volume of wind energy production, in 2020 Poland was ranked 7th in the EU-27 (behind Germany, Spain, France, Sweden, Italy and Denmark), with a 4% share in the structure of this energy generation in the EU-27. In 2020, Poland was ranked third in the EU-27 in terms of the share of wind energy generation in renewable energy production.

The Polish energy sector, which does not have nuclear power plants, is traditionally based on fossil resources – hard coal and lignite. Currently, a lively discussion is taking place in Poland on the paths and development priorities in the field of energy transformation. This is due to both the adopted climate and energy commitments and the current geopolitical situation. In this context, the development of wind energy is also important from the point of view of the problem of rising electricity prices in Poland, which is the result of, among the others, higher fees for CO_2 emission allowances. However, the development of wind energy by changing the legal regulations (increasing the distance between the wind turbine and residential buildings) has clearly slowed down in Poland after 2016. Work is currently under way to modernize these regulations, additionally, there are plans to develop offshore wind energy.

The planned implementation of offshore energy projects in Poland will start a new chapter in the Polish wind energy sector, which is important not only from the point of view of a further increase in the share of RES in the structure of electricity production, but also in terms of power interconnections. Particularly important are the combinations of solar, wind and energy storage systems. According to current plans, offshore wind farms with a capacity of approx. 6 GW will be built in Poland by 2030. This requires significant financial outlays in the area of construction of equipment for the production, transmission and storage of energy as well as changes in many formal and legal regulations. The construction and operation of offshore wind farms can change the functioning of the Polish energy sector and become a pillar of the Polish energy transformation.

The development of wind energy depends to a large extent on the system of investment incentives and settlement methods on the energy market. Undoubtedly, an important issue in the development of onshore wind energy is the acceleration of activities towards the development of energy cooperatives in Poland, which can combine general objectives (low-emission development) with social objectives (reducing energy poverty). The aspect of development of micro-installations is also interesting, especially in the case of inhabitants of rural areas, including farmers. Wind micro-installations can be competitive with other RES in rural areas in a situation where there are appropriate wind conditions and where there are no terrain obstacles. Furthermore, it is possible to use hybrid solutions, e.g. with photovoltaics.

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Entrepreneurship or Resources for a Better Tourism? A K Nearest Neighbors and Decision Tree Dynamic Analysis for Romania

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Abstract: Tourism is one of the growing sectors worldwide in the last decade and one of the most affected industries after COVID-19 pandemic. Tourism is a very complex sector of the economy and depends on a very wide range of factors including tourism attractions, tourism resources but also by the entrepreneurship actions in the destinations. The aim of the paper is to find out, by using a complex statistical methodology, if the level of tourism indicators (turnover, arrivals, overnight stays) has changed after ten years (2020/2010), due to the entrepreneurial actions and/or based on specific touristic resources (natural resources and built heritages/historical monuments). A multi-methods approach was applied: explore outliers' analysis, Kruskal–Wallis test, Student t test, Pearson correlations, machine learning methods (K Nearest neighbors analysis and decision tree). Our results have both theoretical and practical contribution, fill a gap in the scientific literature, offer important outputs for all Romanian stakeholders and worldwide, especially in the actual conditions which marked a total reconsideration and rethinking of tourism after COVID-19 pandemic.

Keywords: natural resources; heritage; machine learning; cluster analysis; decision tree; Romania; county; entrepreneurship

1 Introduction

Tourism is a very complex sector of the economy and depends on a very wide range of factors [1-2] including tourism attractions and tourism resources and a basis of tourism economic development [3]. The factors underpinning tourism include resources [4] and the capitalization of cultural resources continue to be a challenge for communities and organizations [5, 6]. Tourism resources are the basic conditions for the growth and development of tourism in a region [7-8]. In order to transform the potential benefits of tourist resources into actual economic benefits, it is necessary to analyze the scale, quality, distribution, and isolation of tourist sources, conduct in-depth research and accurate statistics, and then understand its important significance [9].

Pursuant to the economic definition of 'resource', resources in tourism may be defined as all those means that can be beneficially utilized for the purpose of tourism in a given area [10]. The scientific and professional nature of tourism resources is an important foundation for the scientific development and safety of tourism resources and the guarantee for the healthy development of tourism in the region. Its scientificity is mainly reflected in the distribution of tourism resources [11]. Some authors believe that the factor separation through spatial aspect is of great importance because the complexity of resources and their distribution in space largely determine and form the tourist offer, as well as tourist demand. Those conditions that determine the tourism development in space are: attractiveness, infrastructure, hospitality and so on [12].

The evaluation methods of tourism resources include experience evaluation, technology appreciation and comprehensive analysis appreciation [13]. In the early stage of the development of evaluation, people are more accustomed to qualitative appraisal. Because there are many levels of specific contents in the comprehensive evaluation of tourism resources, people have not found a universal method for comprehensive evaluation of tourism [14]. The effectiveness and efficiency of the development of tourism resources is an important area of tourism research, and it is also an important basis for measuring the utilization and development efficiency of regional tourism industry resources [15]. Taking into consideration the fact that tourist movements reach worldwide dimensions, recently more attention is being paid on studying the factors that encourage tourism development and especially in terms of their dimensioning [16-21]. Also, other studies suggest that touristic resources are also critical determinants of tourism performance [22-23] and on local development [24].

Entrepreneurship has received increased attention within tourism research reflecting its important role [25-26] and in the last years a special attention was given to *entrepreneurial aspects of tourism* worldwide, from education to its role on national, regional and local regional development [27-29, 30 and society [31] being rich in practice but poor in theoretical development [32-33]. Starting from the scientific contribution and more integrated approach of Ateljevic and Page [34; 27 on tourism and entrepreneurship from different perspectives -cultural [35], characteristics, motivation for travel, nature-based tourism, innovations, global-local divide, etc. - and frequently from social point of view [36 it is well know the high contribution and role of entrepreneurship in fostering local development [34]. In the last years, statistical reports have shown that tourism development influences the economic growth and represents a real boost for local entrepreneurship [37 a real driver of economic growth, employment, and social development [38-39], developing new business models and often linked to creativity and innovation [39]. The sustainability of tourism not only involves the responsible use of natural resources, natural and cultural integrity [38] but also to promote entrepreneurship in the tourism industry. Tourism entrepreneurship is different from other types of entrepreneurships, and this need a specific theoretical [25] and practical insights. There are studies who proved that, on short-run, exist a positive correlation between wages in tourism and entrepreneurship [40] but on long-run tourism sector wages have a negative impact relationship with entrepreneurship [40], respectively the higher wages represent practically a higher cost to entrepreueurship, the residents of tourism destination perceived the benefits of tourism development but not the costs [41]. Entrepreneurship has a major importance for the success of tourism and hospitality and this factor has a powerful contribution to many island economies. Booth et al. [42] made a systemic literature review about tourism and hospitality entrepreneurship on islands, finding 132 related articles between 1989 and 2018 [42]. Cem et al. also made a similar literature review concerning relationship between tourism and entrepreneurship [43]. Bibliometric methods were used in the analysis of 142 articles in the field. The results of their study reveal that the articles compassing tourism and entrepreneurship are grouped under three themes: a) small and medium tourism enterprises; b) types of entrepreneurship and c) the studies about entrepreneurship in tourism industry.

As method, it`s worth to note Kallmuenzer et al. [44] article: they employed a fuzzy-set qualitative comparative analysis on quantitative data from a survey of 113 owner-managers of small and medium-sized tourism firms from Austria, searching configurations of factors that lead to high firm performance. They have found six different configurations, which led to successful paths and higher tourism performance.

At the national level, for Romanian tourism, during the last years we see a period with major structural changes and some major turning points [45]. Important studies analyzed the influence and tendencies of tourism resources [46-48] on tourist movement or tourism indicators [49-50], the management of common pool resources [51], which type of tourism resources induces a higher tourist affluence [52], the diversity and harmoniously distributed of natural and cultural resources in the territory that generates to practice of all types of tourism [53]. From entrepreneurship point of view, for Romanian tourism, there are some studies linked to the impact of absorption of structural found and European funding programme in the tourism sector [37; 39] with specially attention to the rural regions. Also, in emerging economies, like Romania, tourism development needs active entrepreneurship [40; 28]

The *aim* of the paper is to find out, by using a complex statistical methodology, if the level of tourism indicators (turnover from tourism activities, arrivals, and overnight stays) has changed for ten years (2020 compared with 2010), due to the entrepreneurial actions and/or based on specific touristic resources (natural resources and built heritages/historical monuments). The *objectives* of this research are: (1) to identify the best predictors for Romanian tourism in two different time (2010 and 2020) in terms of entrepreneurship actions and/or tourism resources; (2) to analysis what is the main indicators who split the Romanian counties in homogeneous groups/clusters; (3) to identify the counties that are similar in term of entrepreneurial actions and/or tourism resources to attract tourists. According to the literature review, we find important studies who analyzed the influence of resources on tourist movement or the link between entrepreneurial actions and tourism development but none of the research considering both aspects. Therefore, we consider that the present research results fill a gap in the literature and offer important outputs for all Romanian stakeholders and worldwide, especially in the actual conditions which marked a total reconsideration and rethinking of tourism after COVID-19 pandemic and the new trends in tourism but also another consequence of the COVID-19 pandemic is a reduction in early-stage entrepreneurial activity worldwide [54].

2 Data and Methods

According to the aim and objectives of the paper, the variables used in the research were territorial data collected from INS (National Institute of Statistic) [52; 48] for 2010 and 2020 only for all 41 Romanian counties [48; 55], without the capital, Bucharest. The variables are: (1) the *tourism* indicators: Overnight stays (number), Tourist arrivals in tourist reception facilities (number) [56]; (2) the *tourism entrepreneurship* indicators: Turnover in tourism - hotels & restaurants (current price, millions of lei), Gross investment in tangible goods of active tourism units (millions of lei) Active enterprises (number) - total, Active enterprises in tourism (number), Percent of tourism enterprises in total number of enterprises (%) [56]; (3) the *resources* indicators: Natural resources and the Built heritage/historical monuments. The data for these resources have the same values for 2010 and 2020 due of the lack of yearly statistic data at county level [57; 48]; (4) the *economic development level of counties*: GDP (current price, millions of lei) [56]; (4) the spatial differences between Romanian counties are mainly caused by the investments in tertiary industry [55].

Descriptive statistics (mean ± standard deviation) was used for all the indicators for each year (Table 1) and *One Sample Kolmogorov- Smirnov test* to verify the normal distribution of data and to apply the adequate statistical methods according to the results, all the data having normal distribution (p-value < 0.05).

For analysis the data a set of statistical methods was used, as follows: (1) *Explore Outliers* to find the extreme values for variables and to find the counties with the highest and lowest values. The main objective of this analysis is to explain a link between the most touristic Romanian counties, the entrepreneurship impact and/or tourism resources; (2) *The Independent Sample Kruskal – Wallis test* to test if there are statistically significant differences between Romanian counties regarding all the studied indicators; (3) *The Independent Student t test* to compare if there are statistically differences between 2010 and 2020 for toruism indicators (turnover in tourism, overnight stays and tourist arrivals) to decided which of tree indicators will be used for cluster analysis [58]; (4) *Pearson correlation coefficients* for analysis the direction, power, and statistical significance of the association between variables; (5) *K Nearest Neighbors (KNN)* for predictive classifications of territorial tourism data for 2010 and 2020, according to entrepreneurship and resource indicators (as features) and for analyzing the changing time clusters of Romanian counties; the tourism indicators were used as target (overnight stays (number), tourist arrivals in tourist reception facilities and turnover in tourism - hotels & restaurants). The principle of this method is based on the minimum distance between two elements of groups (in our case, counties), the elements are from different classes:

$$\boldsymbol{d}\,(\pi_1, \pi_2) = \min_{x \in \pi_1, y \in \pi_2} d\,(x, y) \tag{1}$$

(5) a *machine learning* analysis based on the *Decision tree* with CRT (Correlation and Regression Tree) and CHAID (Chi-Square Automatic Interaction Detector) "growing methods" to find the best predictor for 2010 and 2020 for grouping of counties with all the tourism indicators as dependent variables (overnight stays - number -, tourist arrivals in tourist reception facilities and turnover in tourism - hotels & restaurants) and all the entrepreneurship and resources data as independent variables. This method was applied in two conditions: with data as continuous variables and with data as category variables (under/above the median value of each year).

For statistical analyses, SPSS 23.0 (licensed) [59-60] and Microsoft Excel for graphical representation of heat maps were used. All the results are presented in the next section of the paper.

3 Results and Discussions

To analyze if there are significant changes in the studies indicators, first we start with the *descriptive statistics* for each analyzed year, with particularly mention for all type of resources with the same values for both 2010 and 2020 (Table 1). The descriptive statistic for resources is for natural resources a mean value of 525.72 ± 196.38 (155 – 976.5) and for heritage 574.0 ± 347.71 (172 - 1791).

According to the results from Table 1, all the mean values increase except for overnight stays and tourist arrivals due to the COVID-19 pandemic in 2020 with all the travel restrictions in Romania and worldwide. Also, even the number of active enterprises in tourism increases in 2020 compared with 2010, the percent of tourism enterprises in total enterprises remain approximately equal.

Table 1
Descriptive statistics for 2010 and 2020

	Turnover in tourism - hotels & restaurants (current price, mil.lei)		Tourist arrivals in tourist reception facilities		Overnight stays (number)	
	2010	2020	2010	2020	2010	2020
Mean	179.90	343.43	122598.00	142410.73	346379.09	331916.82
Median	136.00	238.00	68414.00	80727.00	199574.00	159750.00
Std. Dev.	150.42	334.18	147368.66	188446.58	521544.85	575727.44
Minimum	35.00	68.00	10600.00	5759.00	22453.00	10441.00
Maximum	767.00	1807.00	803096.00	1004521.0	3166706.0	3497428.0
	Active enterprises (number) - total		Active enterprises in tourism (number)		Percent of tourism enterprises in total number of enterprises (%)	
	2010	2020	2010	2020	2010	2020
Mean	9441.70	12302.63	524.43	629.56	5.54	5.24
Median	7572.00	9694.00	466.00	547.00	5.36	4.63
Std. Dev.	5266.58	7719.47	330.56	422.10	1.32	1.53
Minimum	3639.00	3841.00	154.00	175.00	2.72	2.78
Maximum	24258.00	36580.00	1683.00	2217.00	8.03	9.21
	Gross investment in tangible goods of active tourism units (mil. lei)		GDP (mil lei)			
	2010	2020	2010	2020		
Mean	42.80	64.65	10155.26	19525.13		
Median	24.00	38.00	9075.70	16401.90		
Std. Dev.	51.90	79.50	5562.06	11561.62		
Minimum	4.00	5.00	4151.20	7697.30		
Maximum	260.00	450.00	26940.90	55771.90		

To analyze if there are hierarchical changes between counties in 2020 compare with 2010, we applied the *explore outliers*, the results being presented in Table 2 only for the first five places and the last three for each indicator and each year.

It can be observed that there are only a few changes for all the indicators, the first places are dominated by the most developed Romanian counties, respectively: Contanța, Brașov, Cluj, Prahova, Timișoara, Sibiu, Vâlcea, Bihor.

Table 2
Extreme values for variables for Romanian counties for 2010 and 2020

	Turnover in tourism - hotels & restaurants		Tourist arrivals in tourist reception facilities		Overnight stays (number)	
	2010	2020	2010	2020	2010	2020
Highest	Constanța	Constanța	Constanța	Constanța	Constanța	Constanța
	Brașov	Brașov	Brașov	Brașov	Brașov	Brașov
	Cluj	Cluj	Prahova	Prahova	Vâlcea	Bihor
	Prahova	Timiș	Cluj	Bihor	Bihor	Vâlcea
	Timiș	Ilfov	Sibiu	Sibiu	Prahova	Prahova
Lowest	Mehedinți	Ialomița	Olt	Călărași	Teleorman	Călărași
	Călărași	Sălaj	Tulcea	Teleorman	Călărași	Teleorman
	Giurgiu	Călărași	Călărași	Giurgiu	Olt	Giurgiu
	Active enterprises (number) - total		Active enterprises in tourism (number)		Percent of tourism enterprises in total number of enterprises (%)	
	2010	2020	2010	2020	2010	2020
Highest	Cluj	Cluj	Constanța	Constanța	Constanța	Caraș Severin
	Timiș	Ilfov	Cluj	Cluj	Caraș Severin	Constanța
	Constanța	Timiș	Timiș	Brașov	Tulcea	Tulcea
	Brașov	Constanța	Brașov	Timiș	Hunedoara	Hunedoara
	Bihor	Brașov	Bihor	Mureș	Harghita	Harghita
Lowest	Botoșani	Ialomița	Călărași	Teleorman	Giurgiu	Giurgiu
	Ialomița	Covasna	Ialomița	Călărași	Ilfov	Buzău
	Mehedinți	Mehedinți	Giurgiu	Ialomița	Buzău	Ialomița
	GDP (mil lei)		Gross investment in tangible goods of active tourism units (mil. lei)		Natural resouces	Built heritage/ historical monuments
	2010	2020	2010	2020	2010/2020	2010/2020
Highest	Timiș	Cluj	Constanța	Constanța	Suceava	Cluj
	Cluj	Timiș	Ilfov	Brașov	Arge	Iași
	Constanța	Constanța	Cluj	Cluj	Bihor	Dâmbovița
	Prahova	Prahova	Bihor	Ilfov	Caraș Severin	Prahova
	Brașov	Iași	Brașov	Timiș	Maramureș	Sibiu
Lowest	Mehedinți	Tulcea	Călărași	Sălaj	Ilfov	Galați
	Giurgiu	Covasna	Olt	Tulcea	Brăila	Ialomița
	Covasna	Călărași	Giurgiu	Ialomița	Călărași	Brăila

The last places are occupied by the counties with the low level of economic development but also with the low number of touristic resources, as follows: Călărași, Giurgiu, Ialomița, Brăila, Teleorman, Olt, Covasna, Sălaj, Buzău, most of them from the south part of the country.

To verify if these polarized distributions are statistically significant, we applied the *Independent Sample Kruskal – Wallis test* due of the fact that the comparing variable are nominal (county). The results indicate for all the indicators included in the research, for p-value < 0.05, statistically significant differences.

According to the results from Table 3 for the Independent Samples Student t test, only for the *turnover in tourism* there are statistically significant (p-value = 0.005) differences between 2010 and 2020. This result practically represents the main motivation for the present approach of our research from two important perspectives for tourism in general and for Romanian tourism especial, respectively: from the entrepreneurship perspectives and from tourism resources perspectives. We will use this information in the KNN cluster analysis.

Table 3

The results for Independent Samples Student t Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Turnov	EVA	8.179	*.005*	-2.85	80	.005	-163.53	57.23	-277.43	-49.63
	EVNA			-2.85	55.57	.006	-163.53	57.23	-278.20	-48.86
Overnight	EVA	.010	.920	.119	80	.905	14462.26	121321.09	-226974.4	255898.94
	EVNA			.119	79.23	.905	14462.26	121321.09	-227010.38	255934.92
Arrivals	EVA	.339	.562	-.530	80	.597	-19812.73	37361.00	-94163.50	54538.04
	EVNA			-.530	75.60	.597	-19812.73	37361.00	-94229.87	54604.41

EVA = Equal variances assumed; EVNA = Equal variances not assumed

Therefore, based on the results from the descriptive statistics and extreme outliers' analysis, and to verify if there are a statistically significant correlation between the economic development, entrepreneurial actions in tourism, tourism resources and tourism indicators, we applied the Pearson correlation coefficients, for 2010 (Figure 1) and 2020 (Figure 2), the results being presented as heat maps.

	Turnover in turism - hotels & restaurants (current price, millions lei)	Overnight stays (number)	Tourist arrivals in tourist reception facilities	Gross investment in tangible goods of active local units (mil. lei)	Active enterprises (number) - total	Active enterprises in tourism (number)	Percent of tourism enterpsises in total number of enterprises (%)	GDP (mil lei)	Natural resouces	Built heritage / historical monuments
Turnover in turism - hotels & restaurants (current price, millions lei)	1	0.804	0.898	0.884	0.886	0.893	.141	0.775	.209	0.439
Overnight stays (number)		1	0.932	0.756	0.558	0.748	0.377	0.463	.227	.176
Tourist arrivals in tourist reception facilities			1	0.786	0.707	0.855	0.359	0.632	.246	0.32
Gross investment in tangible goods of active local units (mil. lei)				1	0.751	0.776	.141	0.626	.097	.269
Active enterprises (number) - total					1	0.905	.011	0.873	.268	0.468
Active enterprises in tourism (number)						1	0.385	0.796	0.363	0.346
Percent of tourism enterpsises in total number of enterprises (%)							1	.050	0.456	-.058
GDP (mil lei)								1	.195	0.462
Natural resouces									1	0.34
Built heritage / historical monuments										1

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

Figure 1

Correlation matrix for 2010

From the both correlation matrices it's evident the direct (positive) correlations of a strong intensity (from the 0.707 to 0.973), a statistically significant (p-value < 0.01) between tourism indicators (*turnover in tourism, arrivals, and overnight stays*) and entrepreneurial actions (*investments, number of total numbers of active enterprises and number of active enterprises in tourism*). There is one exception, a moderate correlation between *overnight stays* and *total number of active enterprises* for both years (0.425 for 2010 and 0.558 for 2020) and between *arrivals* and *total number of active enterprises* only for 2010 (0.526). There is direct (positive) correlation but low to moderate intensity between *arrivals/overnight stays* and the *percent of tourism enterprises in the total number of enterprises* (0.359 to 0.513) but the last one has no statistically significant correlation with turnover in tourism. Another important aspect is revealed by the direct correlation of strong intensity between *gross investment in tangible goods of active tourism units* and *active enterprises in tourism*. The *turnover in tourism* correlates directly with strong intensity (0.782 in 2010 and 0.775 in 2020) with *GDP*. Also, the *arrivals and overnight stays* are a direct correlate of moderate intensity with *GDP* for both years. The *entrepreneurial actions* are also direct correlate of moderate to strong intensity with *GDP*. Regarding the correlation between tourism indicators and the specific tourism resources (natural and heritages): (1) there is no statistically significant correlation with *natural resources*; (2) there is direct correlation of low intensity, statistically significant, between turnover and built heritage for both years and between arrivals and built heritage only for 2010 (0.320). The correlation matrices reveal an important aspect according to the main objectives of the research: (1) the built heritage is a direct correlate of moderate intensity for both years with GDP; (2) the total number of active enterprises is direct correlate of moderate intensity with built heritage/historical monuments; (3) the active enterprises in tourism are a direct correlate of medium intensity with all types of resources for both studied years.

	Turnover in turism - hotels & restaurants (current price, millions lei)	Overnight stays (number)	Tourist arrivals in tourist reception facilities	Gross investment in tangible goods of active local units (mil. lei)	Active enterprises (number) - total	Active enterprises in tourism (number)	Percent of tourism enterpsises in total number of enterprises (%)	GDP (mil lei)	Natural resouces	Built heritage / historical monuments
Turnover in turism - hotels & restaurants (current price, millions lei)	1	0.854	0.884	0.969	0.816	0.963	.273	0.782	.182	0.4
Overnight stays (number)		1	0.959	0.885	0.425	0.791	0.513	0.421	.218	.179
Tourist arrivals in tourist reception facilities			1	0.88	0.526	0.855	0.497	0.527	.284	.293
Gross investment in tangible goods of active local units (mil. lei)				1	0.716	0.908	0.324	0.668	.126	.305
Active enterprises (number) - total					1	0.837	-.131	0.893	.181	0.509
Active enterprises in tourism (number)						1	0.339	0.805	0.338	0.411
Percent of tourism enterpsises in total number of enterprises (%)							1	-.016	0.476	.001
GDP (mil lei)								1	.172	0.573
Natural resouces									1	0.34
Built heritage / historical monuments										1

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

Figure 2
Correlation matrix for 2020

The explore outliers' analysis emphasis the highest and the lowest counties according to the individual values of each indicator for 2010 and 2020. The Student t test shows that only for turnover in tourism is statistically significant differences between all the 42 Romanian counties by comparing 2010 with 2020 and the Kruskal -Wallis test shows differences between counties for all the eleven variables from the study. In line with these results, we applied the *K Nearest Neighbors* (KNN) *cluster analysis* for predictive classifications of territorial tourism for 2010 and 2020 with turnover in tourism as target variable to identify the similar profiles of Romanian counties for this variable. The results of this analysis are presented separately for 2010 and for 2020 in two situations: (1) with *turnover in tourism* as *target variable* and the *entrepreneurship actions* and *GDP* as *features* by county as *case label;* (2) with *turnover in tourism* as *target* variable and the *tourism resources* as *features* by county as case label too.

For the first analysis, for 2010 we present only the results of Quadratic Map in the Figure 3. So, Constanța is grouped near Cluj, Brașov and Timiș by all the entrepreneurship actions and GDP, these counties are on the first five places in 2010 for these indicators with little exceptions for percent of tourism enterprises in total number of enterprises (only Constanța is on the highest five counties near Caraș Severin, Tulcea and Hunedoara) and for gross investment in tangible goods of active tourism units only for Constanța, Brașov and Cluj, near Ilfov and Bihor.

For the first analysis, for 2020 the Quadratic map is presented in Figure 4. It is an interesting cluster for each entrepreneurship indicators for 2020, practically the first COVID-19 pandemic year with travel restrictions for an important time of the year especially during the summer season holidays. It is interesting that, close to Constanța, Brașov and Timiș, Suceava county is included as nearest neighbor for these counties even that is not in the first five positions for these indicators.

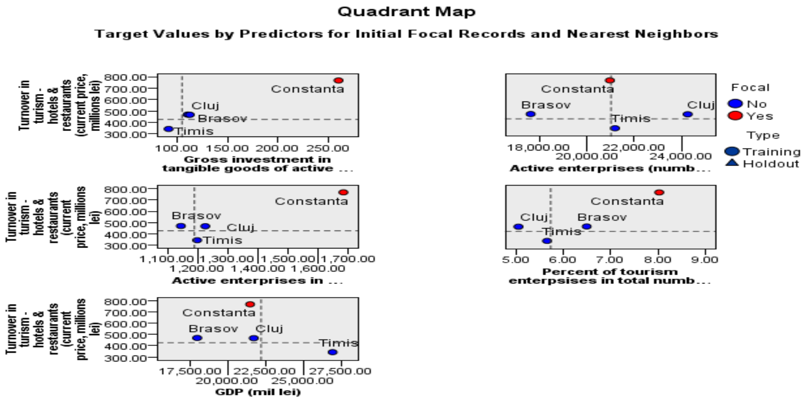

Figure 3

The KNN results: the Quadrant Map for entrepreneurial actions for 2010

Suceava is, however, on the first place by natural resources. Also, the KNN analysis emphasises that even a county on the first places for the entrepreneurial actions in 2020, these counties, from tourism point a view are not in the same clusters or similar. It is the case of Ilfov county for total number of enterprises and gross investment in tangible good of active tourism units, Mureș County for active enterprises in tourism, Caraș-Severin, Tulcea, Hunedoara and Harghita for percent of tourism enterprises in total number of enterprises, Iași for GDP.

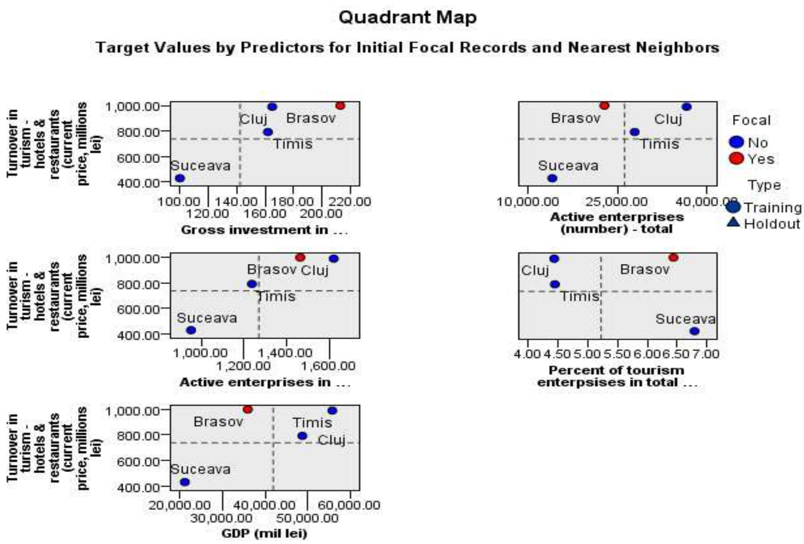

Figure 4

The KNN results: the Quadrant Map for entrepreneurial actions for 2020

For the second analysis, which is common for 2010 and 2020 due to the static characteristics of data, the results are presented in Figure 5 (the Quadratic Map).

From the Figure 5 it can be observed that from the three types of tourism resources only the natural resources are a good predictor for overnight stays, tourist arrivals and turnover in tourism. Also, the focal point of the KNN results indicate and practically confirm the first position of the extreme outlier's analysis with Constanța as the most visited Romanian county and with the high-level of turnover from tourism activities both in 2010 and 2020. The KNN reveals therefore an interesting aspect of Romanian tourism from the tourism resources point of view because, according to the results from Table 2, the Prahova County is in the first places and only by the built heritage resources, not the natural ones. By selecting the tourism resources as predictors for turnover in tourism the Quadrant Map from Figure 5 reveals that Constanța is similar Brașov, Prahova and Vâlcea in terms of tourism resources. Constanța and Brașov are on the first and the second place in 2010 and 2020 for turnover, arrivals and overnight stays. Prahova is on the fourth place in 2010 for turnover but not in the first five places in 2020. Vâlcea is on the third place in 2010 and the fourth place in 2020 for overnight stays.

The above-mentioned results from correlations matrices, descriptive statistics and extreme outliers' analysis pointed out some particularities for Romanian tourism at ten years differences. Therefore, to detailed and revealed more insides we applied, according to the second research objectives the decision tree analysis with CRT (correlate and regression tree) and CHAID (Chi-Square Automatic Interaction Detector) growing methods with the tourism indicators as dependent variable in two cases: (1) with data as continuous variables as they are collected from INSSE and (2) with dichotomous data as under/above median values for each year according to the results from Table 1.

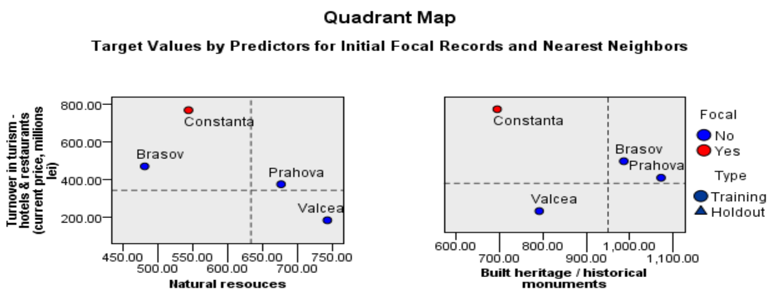

Figure 5

The KNN results: the Quadrant Map for tourism resources for 2010 and 2020

In the Figure 6 (a-c) are presented the decision trees with CRT growing methods in the following cases of dependent variable: (a) turnover, (b) overnight stays and (c) arrivals. In the first case of turnover as dependent variable the best predictor is the total number of active enterprises. In the second analysis, for overnight stays, the best predictor is the number of active enterprises in tourism and for the arrivals the best predictors is the gross investment in tangible of active tourism units.

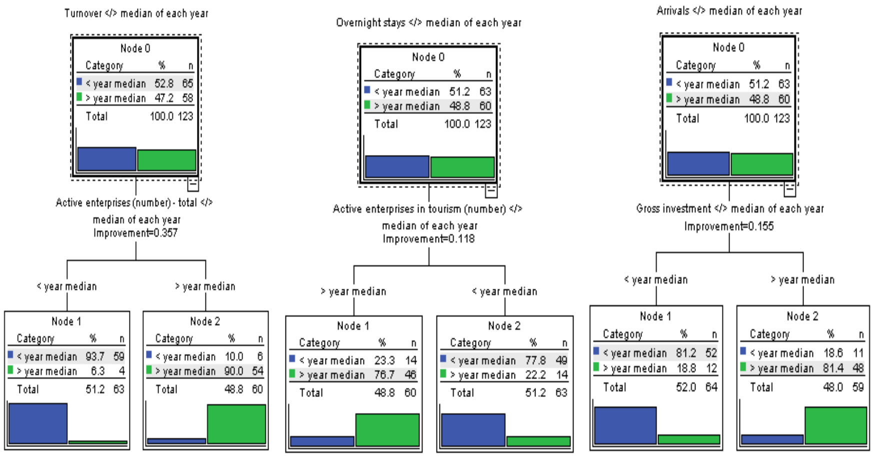

Figure 6 a-c
Decision trees with CRT growing method

The normalized importance of these decision trees pointed out that (Figure 7a-c): (1) for the *turnover*, the most important independent variables are (from high to low): total number of active enterprises (100%), number of active enterprises in tourism (77%), gross investment in tangible of active tourism units (75%), GDP (55%); (2) for *overnight stays*, the most important independent variables are (from high to low): number of active enterprises in tourism (100%), gross investment in tangible of active tourism units (100%), total number of active enterprises (75%), built heritage/historical monuments (55%), natural resources (50%); (3) for *arrivals*, the most important independent variables are (from high to low): gross investment in tangible of active tourism units (100%), total number of active enterprises (100%), number of active enterprises in tourism (100%), natural resources (50%), GDP (50%).

After the detailed the analysis based on decision tree for 2010 and 2020, we find out important differences after ten years in Romanian tourism at the county level and, more important, this machine learning algorithm emphasis these particularities. In Figure 7 (a-c) are presented the normalized importance for 2010, separately for each case of dependent variable and Figure 8 (a-c) for 2020 in the same conditions. Analyzing the results from figures 6 (a-c) for 2010 the gross investment is the most important indicator which separates the counties according to the median value of each tourism indicators (turnover, arrivals and overnight stays). However, in the case of turnover the hierarchy is as follows: gross investment, GDP, active enterprises in tourism, built heritage. In the case of overnight stays, after gross investment follow active enterprises in tourism, percent of enterprises in tourism in total number of enterprises and natural resources. For the arrivals, the gross investment is followed (from distance) by the active enterprises in tourism, percent of enterprises in tourism in total number of enterprises.

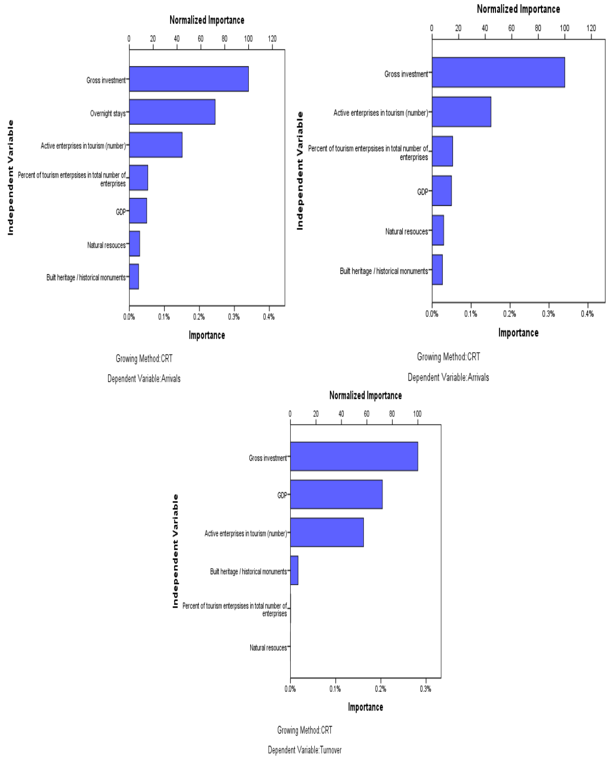

Figure 7 a-c

Normalized importance of independent variables for 2010

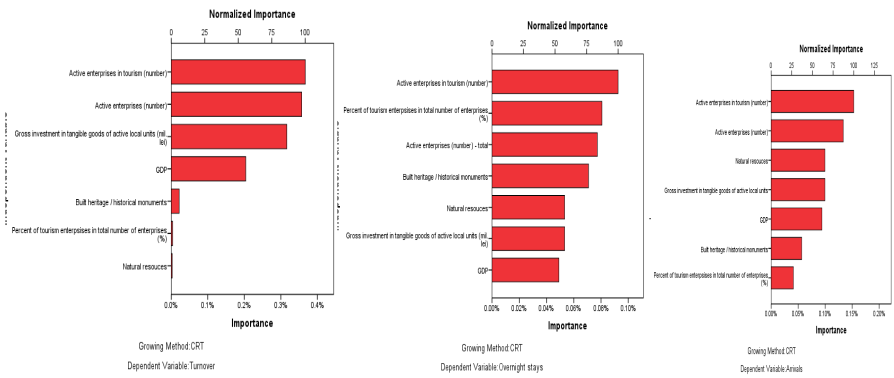

Figure 8 a-c

Normalized importance of independent variables for 2020

The situation for 2020 is somewhat different. For example, for the turnover in tourism, the most important independent variables which group the counties are (from high to low): active enterprises in tourism, total number of enterprises, gross investment in tangible good of active enterprises and GDP.

For the analysis with the overnight stays as dependent variable the hierarchy is: active enterprises in tourism, percent of enterprises in tourism in total number of enterprises, total number of enterprises, built heritage/historical monuments, natural resources, gross investment, and GDP. For the last situation, with the arrivals as dependent variable of the analysis, the most important independent variables are the active enterprises in tourism follow by: total number of enterprises, natural resources, gross investment, GDP, built heritage/historical monuments, and percent of enterprises in tourism in total number of enterprises.

Conclusions

The attractions of destinations for tourists normally dependent on destinations' resources as primary tourism products [61]. Our research results emphasis important aspects for Romanian tourism at county level: (1) due of the uniform territorial distribution of tourism resources in Romania is still available the destination-based tourism product concentration and diversification [61]; (2) nature continue to be (and in our opinion for 2020 it could be the effect of travel restrictions during COVID-19 pandemic) the most important experience element for tourists confirming the theory of nature-based destination [59] and the results of Wang & Zhang [62] that natural resources are still an important part for tourism; (3) confirm that the big and medium cities the cultural resources represent the attractive resources for Romanian tourists [63; 5] while for the small cities the natural resources have a strong relation with tourists arrivals [52]; (4) the role of entrepreneurship in tourism reveal the changes in the tourism demand and the need to adjust products and destinations to meet these changes [38] during the analyzed ten years, from 2010 to 2020. For Romania, for example, there are potentially many opportunities for a sustainable entrepreneurship in tourism, to develop different type of tourism nature -based destination (such as: wine tourism, wildlife tourism, adventure tourism, winter and ski tourism, babymoon tourism, medical and spa tourism) or cultural-based destination (dark tourism, Dracula tourism, communist heritage tourism, etc.). Practically the ”raw materials” for Romanian tourism are invariably the local resources [38], the tourism sector being a full of entrepreneurial opportunities and relatively easy access to the market [38]; (5) our results confirm the results of Dan & Popescu [39] that regions with reach cultural heritage have registered more entrepreneurial inputs. Practically the regions (in our case counties) with a tourism strategy and targeted strategies to support entrepreneurs predict tourism growth [64].

Our study is a first step to find the most important factors influencing the main tourism outputs. We started from the question, what is more important to develop tourism and to attract visitors: the existing natural and cultural resources or the business culture, the level of entrepreneurial spirit and the general economic development of a region? There are several papers that claim postmodern tourism needs less classical resources, but more creativity, more invented attractions [65-66] and more entrepreneurial activity [67; 64]. Since the creativity is hard to measure, especially at tourism enterprises level, we proposed to capture the number and the share of tourism enterprises, the extent of investments in tourism, and the general economic development, expressed by GDP.

We have found in the first place that the means of the most economic figures have raised between 2010 and 2020, only the overnights in tourism have decreased since 2020 was an atypical, and a very negative year in global tourism. We have also seen, that some counties in Romania hold a dominant position, not only in terms of the economic development, but in many cases this is overlapped by a higher the tourism development, too: Brasov, Cluj and Constanta counties have high incomes and GDP/capita, due to their developed urban economy, but also developed a dynamic and strong tourism as well, thanks to their highly valued natural and cultural environment. Counties like Tulcea and Covasna, despite their rich resources (Danube Delta in Tulcea and mineral waters in Covasna), do not bring excellent results in tourism only in a few dimensions such as overnight or the number of tourism enterprises.

We considered the turnover of tourism enterprises, the overnights and the arrivals as output variables, the main indicators of a destination's success. On the other hand, there could be several independent or input variables which influence in many ways tourism performance [68-69]. Out of the many, we chose some with high relevancy, namely the number of enterprises and the number of tourism enterprises, the gross investments at tourism enterprises, the GDP at county level, and the natural resources and the built heritage and monuments, on the other hand. With correlation we checked every relation between these variables, for the 41 counties from Romania. The results show that the tourism turnover correlates best with the travel data (overnight and arrivals – which makes sense, the income usually is higher where the circulation is high). The main travel indicators go together the best with the turnover and enterprise data, less with the resource type indicators. The number of tourism enterprises only medium to low correspondence show with the natural and built heritage resources, more the percent of the tourism enterprises correlate with resources. This could mean, in a primary interpretation that resources alone do not generate tourism, they could generate enterprises, but only in rural areas where there are no other economic options. The high number of tourism enterprises not necessarily bring higher tourism travel results, as we can see here, without a well-structured and strong economic background, steady investments and good service environment tourism cannot flourish.

In both years analyzed (2010 and 2020) the tourism travel indicators (overnights and arrivals) are realized where investments in tourism are on high-level, and not where natural resources and historical monuments are vast. There is a medium relation between resources especially in Brasov, Prahova, Constanta and Vâlcea counties, so in those places where economic development and modernization is advanced. In 2020, Brasov, Cluj and Timiș counties have high number of tourism enterprises and investments in tourism, and high tourism turnover, showing similar development patterns, according to KNN method. All three counties have major cities and a well-established urban society, good infrastructure (airports, industrial parks, relatively good position and access within the country, etc.).

Best predictors for turnover in tourism has proven the number of active enterprises, the number of enterprises in tourism and the gross investments in tangible goods at tourism enterprises. For arrivals, the number of total and tourism enterprises, but also the natural resources can be held responsible (the latter in a lower extent, though). As we have seen, for overnights beyond the entrepreneurial indicators the historical monuments and heritage also can bring some improvement. Altogether, we can claim that this is a first – and important step – to evince with exact numbers that not the classical resource-based tourism concept is working in practice, the tourism needs entrepreneurial skills, investments in tangible goods, and of course a sound and safe economic background, based on a modern service-focused structure. Resources and the attractions that derive from resources are important, but they can be easily replaced with human creativity, virtual and real experiences [47]. In recent evolution, tourism creates its own attractions, such as theme parks, cultural events, gastronomy, or sport infrastructure.

Our study has its *limitations*, too. There could be a larger scale of territorial observations, in more than one country for example or in local, city level too (if there would be data on local level). Moreover, economic development could be expressed better with more indicators, such as the structure of the territorial units (here: counties) or the innovation capacity; the tourism development should include the level of qualification of the human workforce employed in tourism or the number of tourism institutions and civil initiatives are present in every destination, too. Ideally, the tourism resources should be expressed at the attractions level, too: how many resources are included in tourism processes, how well developed and sophisticated are these cultural and natural attractions, of what kind of man-made attractions are present in different destinations. Knowing all this at large scale (more than 100 destinations, or relevant territorial units) could help to complete a tourism demand and supply model, which expresses the exact influence of each input indicator to the tourism output. One of the important *limits* of our research is given by the methodological aspects of collecting data for natural resources and built heritage in Romania, being a quite static data and the missing data from National Plan for territorial Planning for localities not listed here [48].

Our theoretical contributions confirm, at the county level for Romania, that spatial proximity of among products and resources/attractions increased likelihood that tourist who visit one attraction to visit others [61]. Also, from the methodological point of view, the geographical clusters of attractions and resources increase aggregate visitors number and create business opportunities and extent length of stay [61]. Our practical contribution is helpful for Romanian local governments and tourism resources developers.

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The Impact of Russian Import Ban on the International Peach Trade Network

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Abstract: In 2014, the destabilisation of eastern Ukraine and Russian aggression led the United States and its Western allies, to impose diplomatic and economic sanctions against Russia. In response, Russia imposed counter-sanctions against some Western countries. The sanctions imposed consisted of a total ban, by Russia, on imports of some agricultural products, including peaches and nectarines, from the sanctioning countries. In this study the authors analysed the impact of Russian embargo on the international trade network. The impacts for fresh peaches, including nectarines, as an agricultural product group, under tariff heading 080930, were examined. For analysis in this article, the Social Network Analysis (SNA) was used. According to the authors, the Russian embargo has had a great impact and has significantly altered the global trade network for peaches, as an agricultural product.

Keywords: destabilization of Ukraine; impact of sanctions; Social Network Analysis; peach international trade

1 Introduction

1.1 Impact and Effectiveness of Sanctions

To maintain a competitive edge against other businesses, companies must ensure that the most effective strategies are in place [1]. Over the last ten years, the number of studies on the effectiveness of sanctions has increased significantly. The earliest studies on this topic conclude that the sanctions' only purpose is to change the perceived inappropriate behaviour of the target country [2-4]. These authors agree that sanctions have minimal political effectiveness. Barber and James have argued that sanctions may have not just one, but several different purposes [5] [6]. According to the first large sample quantitative research, the authors conclude that one third of the 174 studied sanctions were effective [7]. Pape has criticised these research findings. In his view, sanctions should not be considered if any change is essentially the result of military intervention [8]. Baldwin argues that sanctions should be treated like any other diplomatic and economic means available. In his view, when considering effectiveness, the costs, risks and consequences of alternative options should be included in the analysis [9]. Drezner makes the seemingly surprising and contradictory observation in his study that although sanctions are imposed on enemy states, in fact sanctions are much more effective against our allies [10]. Another literature listed similar argument, namely that the multilateral UN sanctions tend to have a stronger impact on GDP growth in the target country than sanctions imposed just by a single country [11]. Larger-scale and multilateral sanctions have a greater impact on financial stability due to the possibility of 'speculative attacks' based on the political risks associated with sanctions [12]. A study on the long-term effects concludes that trade sanctions can lead to protectionism, as the target country can strengthen its domestic production and maintain domestic market protection after sanctions are lifted [13]. Trade activities affected both directly and indirectly by several factors [14] [15]. Before 2014, sanctions imposed on North Korea have 'deepened' business relations between North Korean and Chinese firms and have led to more effective economic cooperation [16]. It is difficult to draw conclusions on the effects of sanctions due to the different methodological approaches used in studies. Some researchers build game-theoretic models of sanctions [17]. Others use conflict management theory to analyse the effectiveness of sanctions [18]. Sanctions are more likely to be effective when there is greater interdependence between the target country and the countries issuing sanctions [19]. Some previous studies have already applied the social network approach to explore the effects of economic sanctions [20] [21]. Özdamar and Shahin argue in their paper that the application of network theory of interdependence can answer many questions of the researchers and provide a clearer analytical method for analysing the effects of sanctions [19]. Sultonov demonstrates how sanctions have affected the Russian economy and foreign exchange market and how their impact may spill over to the economies and foreign exchange markets of other CIS countries. The author used seasonally adjusted real quarterly time series, monthly nominal exchange rate time series, exogenous dummy variables for sanctions, and a combination of the vector autoregressive model and the Granger causality test for estimations [22]. In another study, the authors analysed the global impact of sanctions against Russia on fossil energy trade, using complex network theory as a methodology [23]. Klomp examined the impact of Russian sanctions on the return of agricultural commodity futures in the EU [24]. The study explores whether the retaliation sanctions taken by Russia were already expected by investors. The results show that the publication of news about the sanctions, prior to the official announcement, caused a significant drop in the futures yield of many banned agricultural commodities. Timofeyev argues that the sanctions introduced against Russia will not be effective enough for the countries that initiated them to achieve their political goals [25]. The sanctions have not changed Russia's policy towards Ukraine, and for the time being there is no chance that it will change. In addition, some efficiency is visible in terms of damage to the Russian economy. Although the Russian economy avoided immediate collapse, the sanctions are affecting the performance of Russian companies.

1.2 Restrictive Measures in Response to the Ukraine Crisis

After the economic and political destabilisation of eastern Ukraine, the United States and its Western allies have decided to impose progressively diplomatic and economic sanctions on Russia. The first step of targeted sanctions was imposed on 17 March 2014, when 21 Ukrainian and Russian officials were banned from entering the EU countries and their assets were closed - the list of sanctioned individuals was later expanded. There was a general ban on exports and imports of items on the EU Common Military List. Sanctions were also extended to the exports of dual-use goods and technology. Subsequently, restrictions on Foreign Direct Investment (FDI) into Russia were also imposed, mainly on investments in transport, telecommunications, and energy sectors, including projects related to oil and gas exploration and mining. This restriction has been complemented by a ban on the export of key products and technologies to strategic sectors, and then to related financial financing and insurance services [26].

In response, Russia has announced an embargo on imports of entire categories of products from countries that have announced economic sanctions against Russian entities and individuals. Russia imposed a complete ban on imports of some foodstuffs, including peaches and nectarines, from these countries. On 5 September 2014, a ceasefire agreement was reached in Minsk, however it did not live up to expectations and fighting resumed from January 2015 [26]. The events in February 2022 marked a new situation when Russia launched an operation against Ukraine. The Western European countries initially imposed only targeted sanctions on travel and property restrictions on individuals, and then extended them to control access to capital and financial markets. On 24 February 2022, the EU Heads of State and Government agreed on further restrictions covering a range of sectors. These measures were followed by a further package of sanctions, in which the EU excluded seven Russian banks from the SWIFT system [26]. On 2 March 2022, the EU imposed a third package of sanctions on Russia, which included the suspension of the broadcasting activities of certain Russian media outlets. Then, the EU agreed to a fourth package of restrictive measures against Russia, i.e., a far-reaching ban on new investment across the Russian energy sector, moreover, the list of sanctioned persons and entities has been further extended [26].

1.3 International Trade in Fresh Peaches and Nectarines

Table 1 shows the world's largest importers of peaches, like Germany, Russia, France, Italy, the United Kingdom and Poland [27]. These six countries contribute nearly fifty percent of the world's peach trade. In 2014, Russia imposed import restrictions on the United States and its allies for several agricultural products, including fresh peaches and nectarines. According to publicly available data, the Russian imports have fallen significantly after the embargo. Russia imported more than 230,500 tonnes of peaches in 2013, however its import volume was less than 200,000 tonnes in 2015 [27]. In the period between 2018 and 2021, Russia increased its imports year by year. 2021 was a record year for import. Russia had imported 225,000 tonnes of peaches, which was close to the 2013 level.

Table 1
The world's largest peach importing countries (in 2021)

Country	Global import (%)
Germany	16%
Russia	11%
France	9%
Italy	6%
United Kingdom	5%
Poland	4%

Source: [27]

Before the embargo, Russia's largest supplier of peaches was the European Union, mainly Spain, Greece and Italy (see Table 2). Outside the European Union, Belarus, Turkey and Serbia were also important trading partners. After 2014, the sanctions meant that Russian traders were unable to buy from Western countries, and nowadays the largest trading partners are Turkey, Morocco, Serbia and China [27].

Table 2
Russia's largest peach exporters

Country name	Russia's peach imports (%)	Country name	Russia's peach imports (%)	Country name	Russia's peach imports (%)
2013		2015		2021	
Spain	51%	Turkey	27%	Turkey	57%
Greece	19%	Morocco	16%	Uzbekistan	13%
Belarus	7%	Serbia	11%	Azerbaijan	10%
Turkey	5%	China	8%	Georgia	9%
Italy	5%	Egypt	7%	Serbia	4%

Source: [27]

Spain remains the largest peach and nectarine exporter worldwide, with a share of 26% in terms of the global volume in 2021 (see Table 3).

There are significant export volumes from Turkey, Greece, Italy, Chile and the United States, as well [27]. These six countries contribute almost 50% of global peach export volumes. The Russian embargo has led to a significant drop in peach export volumes from Spain, Italy and Greece, but the export trends of these three countries have followed a completely different path since 2018.

While the export volumes of Spain and Greece almost reached the 2013 level by 2021, Italy's exports dropped significantly. Turkey, Serbia and China have seen their peach export volumes increase several times, after the sanctions.

Table 3

The world's largest peach exporting countries (in 2021)

Country	Global export (%)
Spain	26%
Turkey	6%
Greece	4%
Italy	4%
Chile	4%
USA	3%

Source: [27]

2 Methodology of Research

In this study, Social Network Analysis (SNA) is used to analyse the impact of the Russian embargo on trade networks of peaches and nectarines. All data in this study refers to HS Code 080930, peaches and nectarines. Data for tariff heading 080930 were extracted from the UN Comtrade database, which contains key export and import data for global trade by year, by trading partner and by commodity code [27]. The compiled database by the authors includes data from countries whose annual peach trade reached USD 1,000,000 in the years under review, according to the UN Comtrade database.

The international trade of the products under analysis can be described as a network, where the nodes are the countries that trade with each other, and the edges are the trade links between countries. Data of the yearly trade networks are constructed for the period 2011-2021. The network is a directed graph, i.e., country A exports and country B imports peaches, therefore the movement's direction is important. Weighted edges were considered, i.e., the volume of exports from a country to another was taken into analysis. Among the global network indicators, network diameter, average clustering coefficient and network density were calculated.

For the local network metrics and for each node the following measures were calculated: degree, indegree, outdegree, weighted degree, weighted indegree and weighted outdegree. In addition, betweenness centrality, closeness centrality, local clustering coefficient were measured. Finally, analysis of modularity was performed to examine clusters. Patterns of trade networks before and after the sanctions were explored.

The network visualization and network analysis software Gephi 0.9.7 was used to carry out the research [28]. Gephi is a visualization and exploration software for all kinds of graphs and networks. There were created the trade network from the compiled database, calculated the network indicators and produced a network diagram with this software. ISO Alpha-3 country codes were used in the tables and network diagrams in this study for transparency.

3 Results

3.1 Analysis of the Network's Global Indicators

The nodes in the network are the countries. A link between two countries is established when country 'A' exports peaches to country 'B'. If country 'A' has not exported to 'B', no edge appears between them. The global indicators of the network do not provide us with information on the role of each node in the network, but on the network as a whole.

The networks were constructed consisted of 183 edges (links) and 78 nodes (countries). The average network density was 0.03, which means that only 3% of all possible connections were achieved. With so few potential connections, it can be concluded that there is likely to be significant clustering in the network. The average clustering coefficient is 0.23 (see Table 4). This indicator can be characterised as the average number of connections between neighbours of each node in the network being around 23%. Each year the network forms a coherent large component, i.e., there are no isolated smaller clusters, which means that the network is coherent.

Table 4

Global indicators of the network

Name of network indicator	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Avg. Clustering Coefficient	0.239	0.234	0.260	0.267	0.233	0.212	0.208	0.190	0.220	0.240	0.222
Network Density	0.030	0.031	0.033	0.029	0.028	0.028	0.030	0.030	0.031	0.031	0.032

3.2 Analysis of the Network's Local Indicators

Local network indicators do not provide information about the network as a whole, but about the role of each node in the network. In this research, the authors examined each country in terms of its role in the trading network. The node degree is the number of relations (edges) of the nodes. However, in the case of directed networks, we distinguish between indegree (number of incoming neighbours) and outdegree (number of outgoing neighbours) of a vertex.

The edge count shows how many other nodes (countries) a selected node (country) has direct connections with. For this indicator, both incoming and outgoing connections were taken into consideration, therefore in our case both exports and imports.

Spain has the highest number of connections in all years considered, therefore the number of outgoing edges is significant, however the number of incoming edges is not negligible for the network as a whole. Spain is a major exporter of peaches, with diversified partnerships throughout the world. This important position remained despite of the loss of the Russian market. Italy comes second in the ranking of countries. As in the case of Spain, Italy also has a diversified partner network and it has not lost its 2nd place after the sanctions.

Overall, the top two countries have not been affected by the sanctions and remained in the top two for the edge count indicator. Russia was the third country with the highest edge score between 2011 and 2014, but since 2015, it has fallen back to 9th and 10th due to the sanctions, as the number of possible trading partner countries have been limited. Greece has been in contact with more export partners after the sanctions. While in the pre-sanctions period it was in the 5th and 6th place, since 2015 it reached a permanent 3rd place.

Degree has generally been extended to the sum of weights when analysing weighted networks and labelled node strength, so the weighted degree and the weighted in- and outdegree was calculated. The weighted degree of a node is like the degree. It is based on the number of edges for a node, but pondered by the weight of each edge. In our case, the weights are the export volumes. If a country exports and imports many peaches, it has a high weighted degree. Therefore, if weighted edges are considered, the order is almost the same as for unweighted edges, with two exceptions. The exceptions are the cases of Germany and Russia.

Table 5 shows that Germany was already in the 3rd place in the ranking of countries before the sanctions, ahead of Russia, and in the post-sanctions period it moved up to the 2nd place, ahead of Italy. If the weights are ignored, Germany only ranked the 8th in the pre-sanctions period and 6th in the post-embargo period. Therefore, Germany has fewer countries to trade with than Italy, but a much larger volume of trade with them. Russia has dropped significantly in the ranking of countries in terms of unweighted edges in the post-embargo period, however if the weight of the edges (i.e., the trade volume) is taken into consideration, it can be seen that it has dropped only one place from the 3rd to 4th. The reason for this situation is that Russia has trade relations with far fewer countries in the post-embargo period, but the trading volume is much larger than before the embargo.

Table 5
Local indicators of the network: Weighted Edge Count

Ranking and values of the countries in terms of weighted degrees*								
in 2011			**in 2014**			**in 2021**		
1	ESP	799679522	1	ESP	970922865	1	ESP	1104770798
2	ITA	407973774	2	DEU	390838125	2	DEU	485310457
3	DEU	339427042	3	ITA	343191963	3	ITA	303949734
4	RUS	280171045	4	RUS	251962775	4	FRA	255671587
5	FRA	219806825	5	FRA	244118025	5	RUS	239141807

*: DEU (Germany), ESP (Spain), FRA (France), ITA (Italy), RUS (Russia)

The indegree indicator shows that how many countries does one country import peaches from. Before and after the sanctions, Russia has the largest number of importing partners. However, there has been such a significant decline in the number of Russian relationships, that Germany has the biggest number of relationships with other countries by 2021, and Russia moved back to the 2nd place (see Figure 1 and Figure 2).

The colours of the nodes show the clusters, the size of the nodes represents the number of imports, the edges show the connections between the two countries.

Unlike the indegree indicator, the weighted indegree also takes weights into consideration. In our case, the weight is the import volume. Therefore, countries that import a lot have a high weighted indegree.

If weights are also taken into consideration, Germany was in the 1st and Russia was in the 2nd place in the pre-sanctions period and in the post-sanctions period (see Table 6), however by 2021 Russia dropped down to the 5th place. Therefore, Germany may have had fewer import relations with countries than Russia before the embargo, but it imported a much larger volume of peach.

The counterpart of the indegree indicator is the outdegree, which shows the number of countries to which a country exports peach. Spain is the biggest exporter of peach in the world.

Figure 3 shows that Italy ranked 2nd place in 2012. However, due to sanctions, Italy's outdegree has fallen on average by 20% per year.

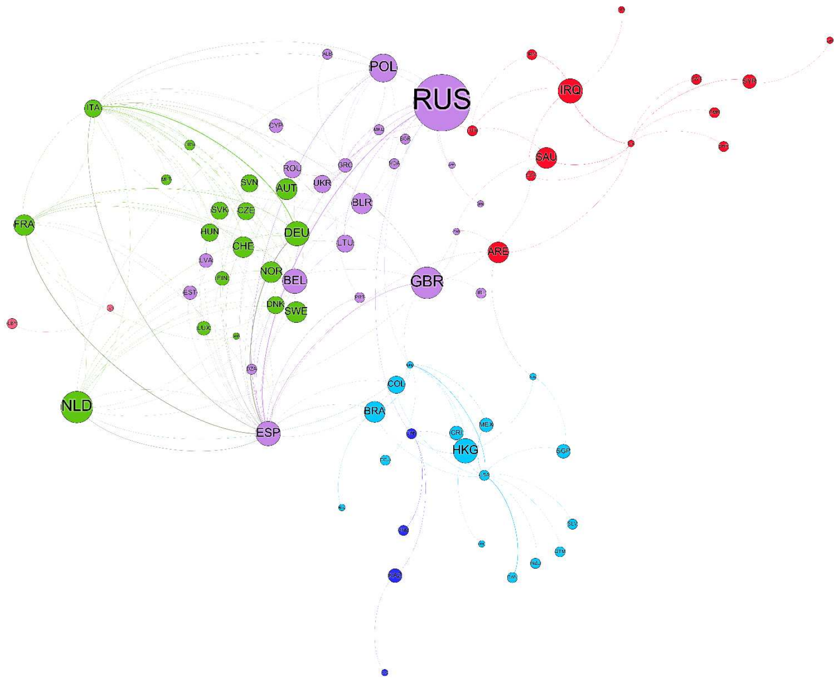

Figure 1
International peach trade network in 2011. Node weight: indegree

Greece remained on the 3rd place both before and after the embargo. Greece was able to increase its trading partners' number by about 10% in the post-sanctions period.

The US was generally ranked 4th before the embargo, then saw its export relations' number drop significantly after the embargo resulting a fall to the 11th place in the outdegree ranking by 2021. The number of US relations has shrunk by almost half compared to the period before the sanctions were imposed.

China and Turkey were able to grow export relations slightly after the embargo. Germany has seen a decline in its relations after the sanctions.

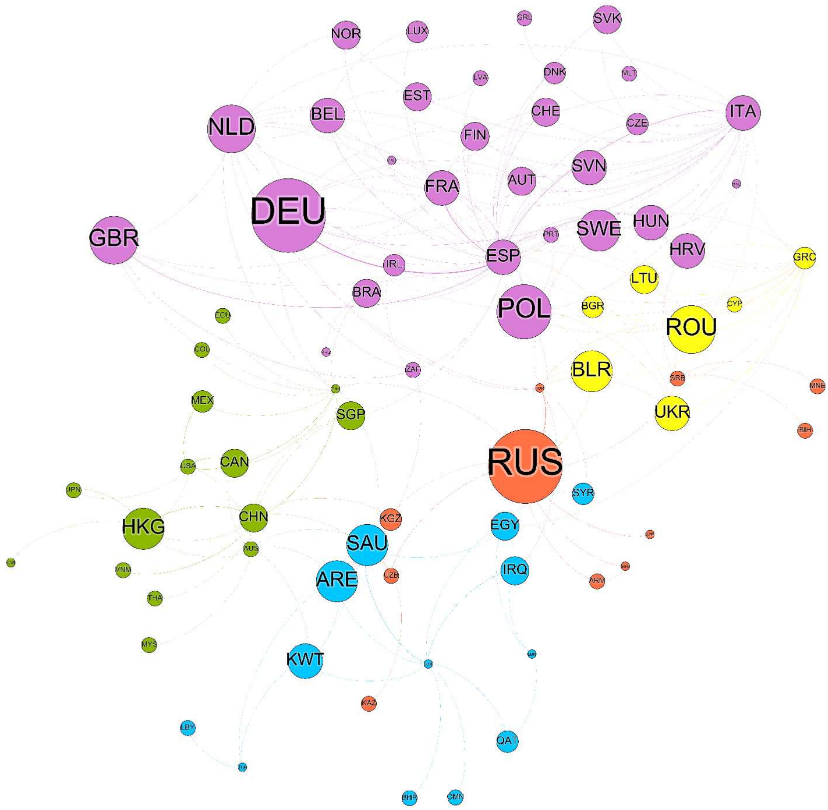

Figure 2
International peach trade network in 2021. Node weight: indegree

Table 6
Local indicators of the network: Weighted Indegree

Ranking and values of the countries in terms of weighted indegrees*					
in 2011		in 2014		in 2021	
1	DEU	1	DEU	1	ESP
2	RUS	2	RUS	2	DEU
3	FRA	3	FRA	3	ITA
4	GBR	4	GBR	4	FRA
5	ITA	5	ITA	5	RUS

*: DEU (Germany), ESP (Spain), FRA (France), GBR (United Kingdom), ITA (Italy), RUS (Russia)

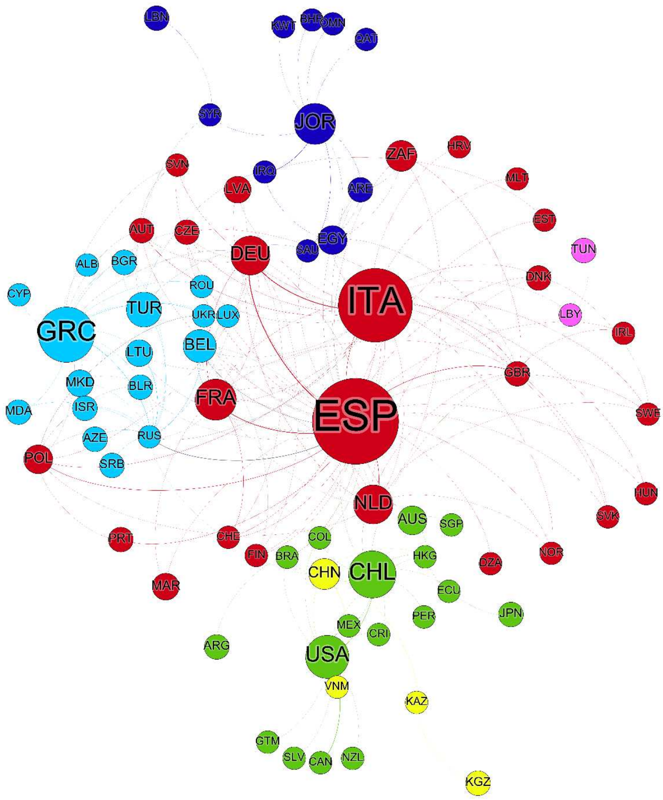

Figure 3

International peach trade network in 2012. Node weight: outdegree

The weighted outdegree shows how many countries does the examined country export to, while taking into consideration the weights. In this case the weights are export volumes. Thus, countries with high outdegree values are those with a significant volume of peach exports to many countries. The data in Table 7 and Figure 4 clearly shows that Spain was in 1st place, both before and after the embargo. Italy was in the 2nd place before the sanctions, but afterwards it slipped back to the 3rd place and Turkey took over the 2nd place. It can be seen that Turkey is one of the winners of the embargo in the sense that it has managed to acquire part of the Russian imports. The weighted outdegree of the US and Greece initially decreased, however it increased from 2019 onwards, reaching 2011 levels by 2021. China's weighted outdegree nearly doubled by 2021. For Germany, the outdegree indicator decreased after the embargo but the weighted outdegree remained unchanged. Serbia is the other biggest beneficiary of the Russian sanctions, as its Weighted Outdegree almost doubled following the embargo.

Table 7
Local indicators of the network: Weighted Outdegree

Ranking and values of the countries in terms of Weighted Outdegrees*								
in 2011			**in 2014**			**in 2021**		
1	ESP	786342641	1	ESP	958571429	1	ESP	1098617742
2	ITA	318444301	2	ITA	234607045	2	TUR	161502773
3	USA	129551968	3	USA	160248611	3	ITA	160704703
4	CHL	114076126	4	GRC	107973939	4	USA	135164936
5	FRA	85233265	5	CHL	94248054	5	JOR	128979573

*: CHL (China), ESP (Spain), FRA (France), GRC (Greece), ITA (Italy), JOR (Jordan), TUR (Turkey), USA (United States of America)

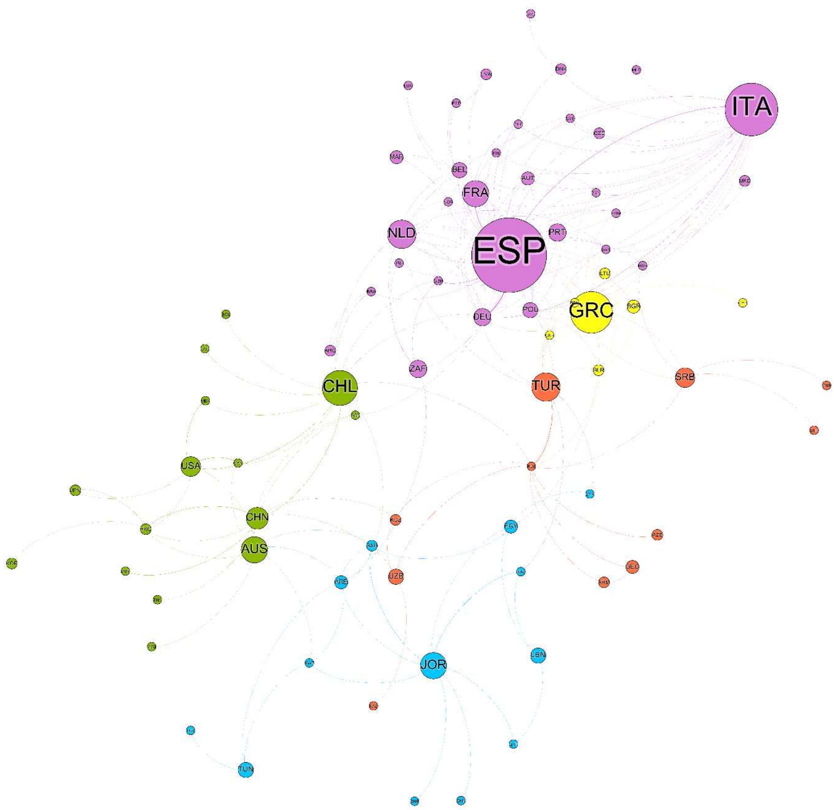

Figure 4
International peach trade network in 2021. Node weight: outdegree

Betweenness centrality indicator was also examined, which measures how often a node occurs on all shortest paths between two nodes. If the node has a significant mediating role in the network, it can be considered as central. In the examined network, this means that there are groups of countries that trade mainly between each other and if there is a country that connects a group of countries with other groups of countries, this country is called the hub. Of the countries with significant export links, only Spain was able to increase the value of the betweenness centrality indicator as a result of the embargo (see Table 8).

Table 8
Local indicators of the network: Ranking of Betweenness Centrality*

Ranking	2011	2014	2021
1	ESP	ESP	ESP
2	NLD	NLD	NLD
3	GRC	ITA	FRA
4	ITA	DEU	GRC
5	FRA	FRA	ITA

*: DEU (Germany), ESP (Spain), FRA (France), GRC (Greece), ITA (Italy), NLD (The Netherlands)

The clustering coefficient is calculated as the number of actual connections between the neighbors of the node under consideration, divided by the total number of possible connections. The value is 1 if everyone is connected to everyone else, and 0 if neighbors are not connected to each other. In the case of the examined network, this means that if the country under study exports to other countries, then the partner countries are connected. If this relationship is significant, the value of the indicator is high, otherwise it is low. In terms of results, neither Spain nor the Netherlands have a high clustering coefficient. The reason for this is that both countries are well embedded in international trade and, due to their central role, they tend to act as a bridge between clusters rather than as exclusive members of clusters. In general, small countries and countries with few connections have a high clustering coefficient.

3.3 Network Modularity

The Louvain method [29] was integrated into the network analysis and visualization software Gephi, which is designed to detect, analyze, evaluate and visualize clusters. The algorithm developed for cluster detection generates a modularity class value for each cluster, which is used to denote the communities within the network. The procedure detected 5-6 sub-networks annually. Unsurprisingly, the clusters that emerge show that countries belonging to a cluster share a common characteristic of geographical proximity to each other. Thus, with a few exceptions, neighboring countries were generally classified into one group. The individual clusters are described below. Clusters are identified by the name of the central country in the cluster.

Spanish community: In general, it was the cluster with the most nodes in each year examined, i.e., it is the cluster with the most countries. Almost all the EU Member States belong to this community, and until 2012, Russia did too. The Spanish community was a giant cluster within the network until the introduction of Russian sanctions in 2014. Since then, the number of nodes in other clusters has been approaching, sometimes even reaching, the number of members of the Spanish community.

USA community: This community includes almost without exception the countries of North America, Central America and South America.

Egypt community: This group includes Egypt and its surrounding Arab countries with a few exceptions.

Greece community: This community did not exist until 2012, but it was a part of the Spanish community. Each year from 2012 to 2021 (as long as the data is publicly available) it had its own cluster. Russia was also part of this cluster from 2012 to 2016.

Chinese community: This cluster includes most of Asia, and since 2016, Russia.

It is also important to note that in each of the years studied, there were some isolated countries that did not belong to any of the clusters or formed a mini-community in pairs. These countries included Afghanistan, Pakistan, Tunisia, Libya, and for several years India.

Conclusions

In 2014, Russia imposed counter-sanctions on imports of some agricultural products – including peaches and nectarines – from countries that had imposed economic sanctions against it. In our study, Social Network Analysis (SNA) was used, to explore the impact of the Russian embargo on the trade network. Our research examined the impact for one product group only, namely products under tariff heading 080930. This product group consists of fresh peaches, including nectarines. Trade networks per year were prepared for the time period 2011-2021. The imposed Russian embargo in 2014, has completely changed the international trade network for peaches, as an agricultural product. Not only was the network of countries affected by the sanction change (Russia as an emitter and Western allies as a destination), but also the network of third countries. As a result of the embargo, many new relationships were established and significant and traditional relationships built up over decades were destroyed.

In our modularity analysis of the global trade network for peaches, it can be concluded, that the Russian embargo has led to an increase in the number of clusters and the disappearance of the former giant cluster, which has been replaced by a number of smaller clusters, including countries with strengthened intra-cluster peach trade links and trade with countries, outside the cluster, on a smaller scale or not at all. This phenomenon was less prevalent in the world peach trade network before the Russian embargo, where there was a giant cluster of countries across continents, regardless of geographical proximity. This cluster was the main driver of the global peach trade. The disintegration of this giant cluster had already begun before the 2014 embargo, but the Russian sanctions severely damaged the existing links and started the process of 'blocking'. Today, analyzing the global trade network of peaches in 2021, the primary determinant of cluster formation is geographical proximity. It seems perhaps conclusive that the closer a country is geographically located to another country, the greater the likelihood of trade links is. Far more counter-examples appeared in the network before the 2014 Russian embargo than after its release.

The global trading system of peaches, built up over decades, has been severely damaged by import restrictions on agricultural products. This is reflected in the immediate negative impact on trade in peaches for all countries affected by the sanction, including both the sending and the destination countries. In fact, the seven to eight years that have passed, have not been sufficient to restore Russian import volumes and export volumes from Western allies, to the levels of the period prior to 2014. Although Spain and Greece's peach export volumes have nearly reached the pre-2014 levels, in 2021, they are still lower. In any case, the embargo has had a severe impact in the short term, with a significant drop in trade volumes for all countries concerned, during the 3-4 years following the introduction of the sanctions. It took time to build new relationships with the rest of the global trading network.

As a result of the embargo in 2014, Russia's peach import relations have seen a significant reduction in diversification. This means that the number of countries with which it has import relations is much smaller when weights are taken into consideration, since this phenomenon is proving to be permanent, as the lower level of the weighted indegree, compared to the pre-embargo period is persistently evident, until the end of the period under review.

It was reasonable to assume that the Russian embargo has had the most negative impact on international trade in Spanish peaches, as Spanish peaches represented more than half of Russian imports. In our research, we concluded that this assumption is not correct, because although in the short term, the volume of Spanish exports and trade relations did decrease, this was not to the same extent as in the case of other major peach exporting countries, such as Italy. In fact, by 2021, the volume of Spanish peach exports and the number of trade relations was close to the 2013 level, while Italy is still far from the previous level. Analyzing the global peach trade network, it can be concluded that Spain has not built new export relationships to counter the impact of the Russian embargo, but has strengthened its existing trade partnerships and increased export volumes with countries already in export relationships. This does not mean that the population of existing trading partners (i.e., Germany, France) consumes more peaches, but those trading partners have reduced the volume of imports from their former import partners (i.e., Italy) and have bought more Spanish peaches. This phenomenon has been observed in several countries. Greece was also able to nearly reach their volumes of 2021, compared to the period before the Russian embargo, but achieved this in a completely different way than Spain. Greece has established completely new trade relations, mainly with Romania, Ukraine and Bulgaria.

To sum up, the biggest winners from the Russian embargo are Serbia, Turkey and China. All three countries were able to increase export volumes significantly as a result of the Russian embargo. These countries immediately took advantage of the opportunities in the Russian market, as a result of the embargo against Western countries, thus, multiplying export volumes to Russia, which they were able to maintain, until the end of the period under this study. Serbia was also able to increase the number of partners significantly, following the imposition of the sanctions.

Further research is needed to investigate the reasons for the break-up of the giant cluster known as the 'Spanish community', prior to the Russian embargo and the process of blocking that started to erode the diversified trade links that had previously existed between Global Countries.

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Food Security of Tunisia: Comprehensive Analysis of a Composite Index

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Abstract: For decades, food security has been the main concern of a large number of researchers. With the emerging of the COVID-19 pandemic, growing research that try to measure the food security status. Different studies have attempted various measurement methods aiming to quantify the level of food insecurity for some countries. Seventeen indicators have been selected to build a unique food security index. Principal Component Analysis (PCA) method has been employed to determine a comprehensive evaluation of index. 2 factors have been resulted to comprehend the food security index movement based on yearly indicators. Furthermore, the econometric model, Vector Error Correction Model (VECM) has been employed to detect the relationship between the built food security index and macroeconomic indicators. a long run causality relationship has been identified between the food security index, exchange rate, GDP, and global food price index. The resulted food security index is positively affected by the food price and there is an adjustment of 42.7% annually of the food security disequilibrium.

Keywords: Food import; Food price; Food security Index; Tunisia; VECM

1 Introduction

Food security has been always a challenge for the humankind. Therefore, understanding the main drivers of food security is the key to identify the most important factors leading to mitigate the insecurity level and to forecast which country is more sensitive to food insecurity. FAO defined the food security concept as the state "*when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food in order to respond to their needs for an active and healthy life*" [1]. Four pillars have been identified for food insecurity: availability, access, utilization and stability [1].

The United Nations (UN) has identified a group of goals to end hunger by 2030 [1]. Roser and Ritchie in the framework of their research affirmed that the current situation is far from reaching this goal. They found that 820 million people, equivalent to 11% of the world population, are undernourished. About 1.8 billion people, which equals to a quarter of the world population are moderately or severely facing food insecurity [2]. At the end of 2019, the spread of the new Coronavirus epidemic (COVID-19) interrupted a considerable part of socio-economic processes in the world life. It aggravated the situation of people who already had been suffering from food insecurity and malnutrition. The COVID-19 made a pressure for policymakers to take quick decisions to mitigate the effect of the pandemic, e.g., in West Africa, which is dependent on rice import. The governments have established new policies trying to reduce the impact of the pandemic on the rice trade [3]. The lockdown resulted from COVID-19 has endangered the food security of vulnerable and low-income households which are highly linked on labour income [4]. The world food program forecasts a number of 130 million of hunger people resulted from the COVID-19 [5]. The fast transmission of COVID-19 harmed different sectors leading to various concerns. The highest concern during this critical situation was that people find their food needs. The COVID-19 endangered as well the food security in some developed countries, but mostly the developing countries had been proven the most vulnerable [6]. A bibliometric study between the food security and their price shows the importance link between the food price and the nutrient intakes especially in developing countries [7].

The world population growth leads to the increase of the food demand, which is accompanied by an income growth and urbanization. The problem is that how to feed and to respond the needs of a global population that is predicted to attain near 10 billion by mid-century (2050). The main concern is that the ability of achieving the required production increases under the pressure of various, demographic, climatic and political factors, just a name a few [8]. Urbanization is defined by the growing share of people who are settling in urban areas and aftermath; the share of people who are living in rural areas is reducing [9].

On the other hand, the agriculture is facing a huge task to realize a secure food for all the population. In addition to the rapid urbanization, people and governments will be confronting further enormous challenges [10]. At the beginning, food security research concentrated on economic policy and global issues and later on the literature has been enlarged to include other subjects such livelihoods, health, and the environment [11]. This paper suggests a simple and relatively comprehensive method to analyse the food security, based on Tunisian case. Tunisia is the northernmost African county, neighbour of Algeria and Libya.

Tunisian households are facing a decrease of their real incomes, as a consequence of the increasing of food prices, caused by climate change [12]. In last decades the governments of Tunisia could increase the self-sufficiency in case of many products [13], [14], [15], but despite of the partial successes, Tunisia is highly dependent on cereal imports regardless the quantity produced. 3.7 million tons of cereal are forecasted had to be imported during 2021-2022. Tunisia is mainly producing cereals, olives, fruits. It suffers from the lack of water availability (450 m^3/capita/year) and in next decades a growing water scarcity is expected [16] Many united factors may affect the quality and the productivity of the different agricultural commodities. Most of the people who are deprived from food constitute the poor segment of the population. Based on the food security index, in 2018, Tunisia has occupied the rank 51 from 113 countries [17]. In current situation a comprehensive food security strategy is needed [18], [19], importance of which is highlighted the fact that Tunisia will suffer significantly from the war between Russia and Ukraine, which could affect the imported quantity of cereals. Ukraine and Russia are the main sources of cereal from where Tunisia import cereals [20].

2 Theoretical Frameworks

Food security is jeopardised by a wide range of factors, e.g., the disruption of the food supply chains or income losses, just to name a few [21, 22, 23]. Price fluctuations could disturb the consumer diet, forcing them to change their preferred food [24]. Food security always presents the hub of research, especially in case of extreme situations, e.g., pandemic or war. The uncertain spread of the pandemic COVID-19 aggravated the situation, its evolution around the world menaced food security by reducing food production [25]. Vulnerable households such as small-scale farmers were highly affected by the COVID-19, threatening the food availability and accessibility [26]. The pandemic weakened the food production, modified the demand and food access [27], [28], [29], [30]. As a summary it can be stated that COVID-19 presented critical situation for the global food security [31], as opposed to the former local crises. To evaluate the food security situation in developing countries, two criteria should be taken into account. The first criterion is about food availability, which means the food that is physically available by production and import. The second criterion is the access economically to food which means that food is well distributed to the population and people have enough income to buy it [32]. In 2019, Popp et al., elaborated a study which is considered the first one that focuses on the food supply systems in Africa in order to figure out the most important stages responsible to boost the food security [33]. In order to reach the sustainability of food security, a long-range strategy should be elaborated, which aim is to respond the health requirements of contemporary people, without endangering the needs of future generations. For these reasons, various studies have been published trying to estimate food security using different indicators which may cover some of its dimensions [34], [35], [36]. Two levels are considered to assess the food security: the national level and the household level. To investigate the household level, survey method is needed while secondary data could be used to assess the national level. Blekking et al, in 2020, analysed the household level urban food security situtation on base of a panel of 718 households, using survey method. Two measures have been used for that; the food consumption score and the coping strategy index [37]. A comparative study has been established by Omidvar et al, in 2019 to assess food security between different countries within MENA region. They used the food insecurity experience scale applying different statistical methods (e.g., descriptive statistics and binary logistic regression, etc.) to identify three groups of countries from severe to moderate food insecurity [38]. In developed countries, food insecurity could be affected by socio-economic and demographic indicators. It has been revealed that people who live alone and don't have social life are more food insecure [39]. The level of education, number of children and the home location present a significant effect on food insecurity [40] and also on the ecological footprint and after all on the climate change process [41]. In 2017, Akinboade and Adeyefa collected primary data to investigate the household food security of low income, poor urban households. ANOVA method has been applied to detect the existence or the absence of difference between different analysed groups. A food insecurity index has been developed as a potential indicator [42]. It has been built with the probability of covariate shock happening, the experience of food insecurity accumulation and household's endurance [43]. After the introduction of food security index by the Economic Intelligence Unit in 2012, many research papers have been published to assess the global food security [44], employing the Data Envelopment Analysis (DEA) and Principal Component Analysis (PCA) methods, showing, how the global food security is sensitive the selected indicators such as food consumption as a share of household expenditure. Caccavale and Giuffrida in 2020 built a new composite index by selection variables, weighting, normalization and aggregation and they tested it using Monte Carlo procedure [45]. To measure the food security index, many researchers have classified drivers into groups. Two main groups of factors are introduced by Smith in 1990, which influence the food security status. The first group involves the supply determinants. It includes the following factors: weather circumstance, imported products, policy inducement, stocks, and production. The second group covers demand determinants and it contains population progress, income development and distribution, and export income [46]. Ulezko and Pashina, suggested three groups of indicators; macroeconomic, trade and subjective one. The macroeconomic group contains macroeconomic variables such as GDP and the agricultural production. The trade group has data about the volume of agricultural raw materials import and export. The subjective group involves market determinants, commodity suppliers and consumers [47]. A recent study was elaborated to analyse food security index in China, in 2021 by Lv et al., [48] using agricultural, climatic, and socioeconomic factors. An analysis was carried out, using stepwise regression, to identify the spatiotemporal prevailing factors leading to food security. There are different methods to assess the food situation. Based on the amount of production and purchases of agricultural commodities, the food market potential in developing economies could be evaluated. Another method of assessment employs demand and supply, the level and nature of the prices, market infrastructure, and market adjustment [49]. The usability of these methods much depends on data availability and complexity. In 2021, Sam et al., estimated the food security index in India based on group of factors using PCA method as a weighing method to generate a unique indicator [50].

Based on the advantages and limitations of this measurement methodology the current study is established to construct a non-subjective weighted index which allows providing a quantitative analysis and objective evaluation of Tunisia's food security. Tunisia experiences a specific case because of two overlapping concerns: from one side the overweight and obesity and the deficiency of micronutrients (i.e. anaemia) from the other side. The percentage of children under 5 years who have anaemia is 28 in 2017. Despite the low-level of hunger, Tunisia suffers from regional disparities which hamper the vulnerability of certain region more vulnerable for food security. These regions face an access problem to healthy and nutritious meals caused low purchasing power. For this reason, the World Food Program (WFP) with the collaboration of the government, in 2017, served schools with meals to facilitate the access to nutritious food for children [51].

3 Methodology and Data Collection

In accordance with to the implication of food security, the factor measurably and data availability, 17 indicators have been selected in this paper, covering Food exports (% of merchandise exports), agricultural raw materials exports (% of merchandise exports), food imports (% of merchandise imports), mortality rate, under-5 (per 1,000 live births), food supply kcal, cereal yield (kg per hectare), Life expectancy at birth total (years), agriculture, forestry, and fishing, value added (% of GDP), food production index (2014-2016 = 100%), livestock production index

(2014-2016 = 100%), fixed telephone subscriptions (per 100 people), rural population growth (annual %), agricultural land (% of land area), population growth (annual %), daily protein supply per capita (g/capita/day), arable land (hectare per person) and agricultural raw materials imports (% of merchandise imports). The selected indicators could be classified into four groups. The first one includes the trade indicators which provide an image about the Tunisian ability to rely on local resources (food, agricultural raw materials). To take into consideration the trade balance, it can be analysed the country's dependence on import. It includes agricultural raw materials imports, agricultural raw materials exports, food exports (% of merchandise exports), and food imports. The second group forms the quality of life, including mortality rate under five rate (mortality per 1,000 live births) and life expectancy at birth (years). The third group constitutes the economic and development component. It has population growth (annual %), rural population growth and value added in agriculture, forestry, and fishing (% of GDP), arable land per person, agricultural land and fixed telephone subscriptions (per 100 people). The fourth group forms the supply feature. It involves food supply, daily protein supply per capita, livestock production index, food production index and cereal yield. Livestock production has been involved as an indicator of diet quality [52].

3.1 Data Sources

This data has been collected from FAO statistics and World Bank databases, where 17 yearly measured variables have been obtained from 1967 to 2017. Ind1, Ind2, Ind5, Ind6, Ind7, Ind10, Ind11, Ind12, Ind13, Ind14, Ind15, Ind 16 and Ind17 are positive indicators. Ind3, Ind4, Ind8 and Ind9 are reverse indices. The indexes are presented in Table 1.

Table 1

List of indicators used in food security index estimation

Variables	Dimension	Code
Food exports	% of merchandise exports	Ind1
Agricultural raw materials exports	% of merchandise exports	Ind2
Food imports	% of merchandise imports	Ind3
Mortality rate, under-5	number, per 1000 live births	Ind4
Food supply	kcal/capita	Ind5
Life expectancy at birth, total	years	Ind6
Daily protein supply per capita	g/capita/day	Ind7
Arable land	hectares per person	Ind8
Agricultural raw materials imports	% of merchandise imports	Ind9
Population growth	annual change, %	Ind10
Agricultural land	% of land area	Ind11
Rural population growth		Ind12

Fixed telephone subscriptions	% per 100 people	Ind13
Livestock production index	% 2014-2016 = 100	Ind14
Food production index	%, 2014-2016 = 100	Ind15
Cereal yield	kg/ha	Ind16
Agriculture, forestry, and fishing, value added	% of GDP)	Ind17

The min-max standardization, 0-1 scaling, has been adopted to normalize the chosen indicators.

3.2 Principal Component Analysis (PCA)

PCA is a statistical multivariate method that has been used to study large sets of data. It is chosen to be utilized to combine different data in a constricted way. PCA is not a subjective methodology; it produces a unique aggregated value built under an objective approach. The weight of each indicator presents a critical component for the final assessment results of food security in Tunisia. To avoid biased results which could be caused by the correlation between the variables and objectively demonstrate the food security situation in Tunisia, this paper uses factor analysis by the principal component analysis. Factor analysis allows deriving a relatively small number of independent variables from many dependent variables. Two tests have been considered to check the validity of the use of the PCA method; the Bartlett test of sphericity and the Kruskal-Meyer-Olkin (KMO) test [53]. These tests justify the use of factor analysis.

4 Empirical Results and Analysis

4.1 Factor Choosing and Identification

Two factors have been deducted from 17 variables. Each factor has an eigenvalue greater than 1 and their cumulative variance explanation is 89%. In other words, the resulted two factors present nearly 90% of the variance of 17 indicators.

The food security score has been obtained by the multiplication of each factor by its variance and divided by the cumulative variance (89%). It is the sum of weighted factor1 and factor2. A comprehensive food security index of Tunisia's has been found from 1967 to 2017. The weight of each factor is presented by their variance explanation. The equation is the following:

$$FSI_t = a\,Factor1 + b\,Factor2 \qquad (1)$$

In the equation 1, FSI means food security index, *t* means year (t = 1967 -2017), "*a*" and "*b*" are two coefficients which present the weight of each factor. The food security index resulted from the weighted factors (factor1 and factor2) are presented in Table 2.

The value of the KMO test is equal to 0,861, which is greater than 0.5 and closer to 1. Bartlett's test has a significant *p*-value. It indicates that there is a strong correlation between variables. Both tests justify the suitability of the use of PCA and its application on our database.

Table 2

Principal component analysis results: Percentage of variance contribution of factors

Comp.	Initial Eigenvalues			Rotation Sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	13.9	78	78	7.7	45	45
2	1.7	10	89	7.4	43	89

Source: SPSS output

PCA method results have been highlighted in Table 3. using Varimax rotation. Factor explained 45.388% of total variance and factor explained 43% of the total variance. The cumulative variance is equal to 89%. The weighted sum of these two factors and the normalized value of the resulted index. Food and agricultural raw material export have the highest variance percentage contribution to build factor 1. Having high export value leads to surplus of food trade balance. Arable land per person is a decreasing index which plays a disadvantageous determinant for small farmers engendering the reduction of their income and increasing their cost of production. Hence, it handicaps their access to health services. Factor 2 encompasses demographic development and production indicators. Population growth, agricultural land and rural population growth have the highest variance percentage contribution. The population growth is the highest explained variable by factor 1. This could be explained by the dietary change of people, they become protein consumers more than pulses. The government should take in consideration this change in order to offer the need of population food.

Table 3

Rotated Component Matrix: The rotation method is Varimax with Kaiser Normalization

Indicators	Factors	
	1	2
Food exports	-0.942	-0.145
Agricultural raw materials exports	-0.941	-0.176
Food imports	0.867	0.352
Mortality rate. under-5	0.850	0.514
Food supply	0.816	0.535

Life expectancy at birth. total	0.808	0.576
Daily protein supply per capita	0.787	0.575
Arable land	-0.751	-0.617
Agricultural raw materials imports	0.638	0.595
Population growth	0.189	0.957
Agricultural land	0.352	0.863
Rural population growth	-0.148	-0.854
Fixed telephone subscriptions	0.457	0.851
Livestock production index	0.527	0.824
Food production index	0.541	0.771
Cereal yield	0.476	0.705
Agriculture. forestry. and fishing. value added	-0.611	-0.644

Source: SPSS output

Table 4 presents the descriptive statistics of FSI.

Table 4
Factor analysis results of Food Security Index

	Factor 1	Factor 2	Total	Normalised
min	-130106	-242367	-182217	0.00
1st quarter	-0.64	0.14	-0.78	0.35
median	-0.14	0.37	0.31	0.60
mean	1902	-25546	-13206	0.60
3rd quarter	0.71	0.48	0.70	0.91
max	140792	100807	138749	1.00

Source: Own calculation

Figure 1 shows the two factors' scores and the resulted food security index. The two factors are moving oppositely. Two intersections have been registered: the first one was in 1974 and the second intersection was 2000. In 1982 the trade and life quality factor has registered its highest value, meanwhile demand and development factor had the lowed score. The up-warding movement of trade factor is explained by the trade policy adopted by Tunisia, to encourage exports by giving fiscal benefits to companies. The production and development factor has witnessed an increase which could be justified by the introduction of new technologies in agricultural activities and mechanization of the agriculture field. After 2000, the production and development factor surpassed the trade and life quality factor. This downward could be explained by the deficit of food trade balance and the deterioration of the food quality and health services.

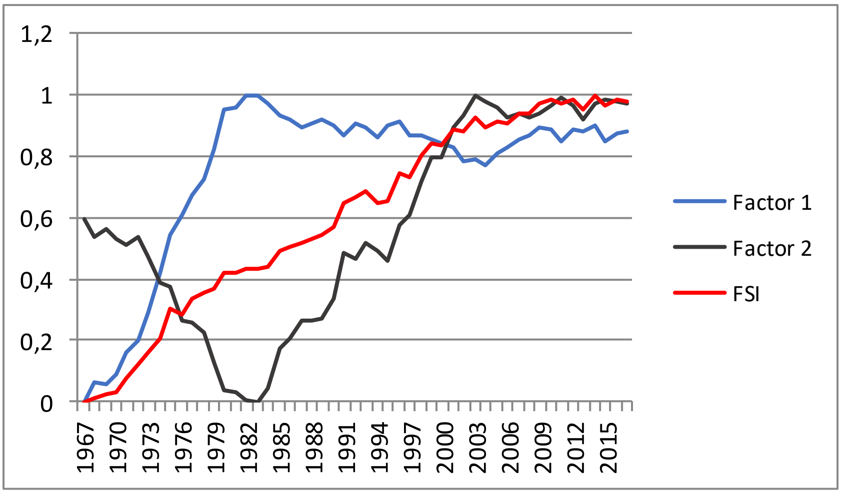

Figure 1
The fluctuation of food security based on factor score

4.2 Assessment of the Estimated Food Security Index: VEC Model

Comparing the resulted index and existed indicators of food security on FAO website. A correlation coefficient test has been done to show the strength of the relationship. Food security data was used by different proxies. Mainly the number of calories that people consume and food production index. Average energy supply is a strong indicator because of its strong inversely relationship in determining the undernourishment prevalence Furthermore, of its, availability. it contributes to ameliorate the nutritional status [54].

Table 5 shows the high correlation between the estimated food security index and two indicators (i.e., average energy supply and average protein supply), that researchers use as a proxy for food security index. This result reveals the consistence of the calculated index with food security proxy indices.

Table 5
Correlation coefficient between the calculated food security index and food security proxy indicators

Correlation coefficient	Estimated food security index
Average energy supply (kcal/capita/day)	0.959
Average protein supply	0.966

According to Akaike information criterion (AIC) the selection of lag order was determined. Lag 3 was identified and used in the model estimation. In order to evaluate the causal relationship in short and long run between the estimated food security index and global food price volatility, we included yearly database retrieved from FAO and World bank. Exchange rate, GDP, global food price was extracted. First, we checked the order of integration of these variables. Using ADF test, we justified that all variables are integrated at order1 which means, they are stationary after applying the first difference. Results of unit root test are displayed in Table 6. To check the existence of co-integration between the variables.

Table 6

Unit root test result

	ADF		Integration order
Variables	Level	First difference	I(1)
Log(food security index) (Lfsi)	-2.172 (0.218)	-8.235***	I(1)
Log (Global food price Index) (Lfpi)	-1.669 (0.440)	-5.564***	I(1)
Log(Gross domestic products) (Lgdp)	1.990 (0.988)	-2.089**	I(1)
Log (Exchange rate) (Lexr)	-0.295	-4.384***	I(1)

Johensen test has been employed. One co-integration equation is confirmed. Results are presented in table 7. After demonstrating that variables are co-integrated. VAR model could not be used. VECM should be estimated.

Table 7

Johansen Cointegration—Eigenvalue test Statistic

No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.679840	52.39092	28.58808	0.0000
At most 1	0.357304	20.33584	22.29962	0.0918

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

Table 8

Pairwise Granger causality tests

	GDP-FSI	FPI-FSI	EXR-FSI	FSI-GDP	FSI-FPII	FSI-EXR
F-Statistic	14.357	1.875	25.472	0.14521	2.29721	1.64131
Probability	0.000	0.149	0.000	0.9322	0.092	0.195

Based on Table 8, the value of the error term is significant, negative, and less than 1, which proves the existence of long run causality relationship between the variables. The negative sign indicates the short-term trend stabilization towards long-run equilibrium. The following equation has been formulated to illustrate the causality relationship in short and long run between the resulted food security index, GDP and exchange rate.

D(Lfsi) = C(1)(Lfsi(-1) + 0.501325242278*Lfpi(-1) - 0.529514099681 * Lgdp(-1) + 0.062056361906*Lexr(-1) + 1.48492920419) + C(2) *D(Lfsi(-1)) + C(3)*D(Lfsi(-2)) + C(4)*D(Lfsi(-3)) + C(5)*D(Lfpi(-1)) + C(6)*D(Lfpi(-2)) + C(7)*D(Lfpi(-3)) + C(8)*D(Lgdp(-1)) + C(9)*D(Lgdp(-2)) + C(10)*D(Lgdp(-3)) + C(11)*D(Lexr(-1)) + C(12)*D(Lexr(-2)) + C(13) *D(Lexr(-3)) + C(14)* (4)

Summary of the Vector Error Coefficient Model is presented in Table 11.

Table 2

Results of VECM model

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.427186	0.086218	-4.954739	0.0000
C(2)	-0.184091	0.114461	-1.608330	0.1176
C(3)	0.092507	0.081873	1.129890	0.2669
C(4)	0.314014	0.074615	4.208433	0.0002
C(5)	0.027005	0.110262	0.244913	0.8081
C(6)	0.215279	0.106710	2.017413	0.0521
C(7)	0.069191	0.109822	0.630025	0.5332
C(8)	0.682086	0.274044	2.488968	0.0182
C(9)	-0.474658	0.204530	-2.320722	0.0268
C(10)	-0.376327	0.301357	-1.248775	0.2208
C(11)	0.745747	0.284219	2.623841	0.0132
C(12)	-0.274466	0.207684	-1.321554	0.1957
C(13)	-0.163985	0.268637	-0.610434	0.5459
C(14)	0.017349	0.011858	1.463048	0.1532
R-squared	0.850216	Mean dependent var		0.024294
Adjusted R-squared	0.789367	S.D. dependent var		0.047187
S.E. of regression	0.021656	Akaike info criterion		-4.581244
Sum squared resid	0.015008	Schwarz criterion		-4.024701
Log likelihood	119.3686	Hannan-Quinn criter.		-4.372760
F-statistic	13.97244	Durbin-Watson stat		2.185853
Prob(F-statistic)	0.000000			

Six coefficients are significant at 1, 5 and 10%. Lag 3 of food security index has a positive effect on GDP is significant at present with lag value. GDP has negative relation with FPI because, when GDP increase then there is much chance to increase investment in other sectors (e.g., industrial, touristic) rather than agriculture sector [55]. A positive relationship has been registered between the food security index and food price. This registered positive relationship could be explained by the increase of production, which results the price increase. In short run the global food price has a non-significant effect on food security index.

$$D(Lfsi) = C(1)*(Lfsi(-1) + 0.501325242278*Lfpi(-1) - 0.529514099681 * Lgdp(-1) + 0.062056361906*Lexr(-1) + 1.48492920419) + C(2) *D(Lfsi(-1)) + C(3)*D(Lfsi(-2)) + C(4)*D(Lfsi(-3)) + C(5)*D(Lfpi(-1)) + C(6)*D(Lfpi(-2)) + C(7)*D(Lfpi(-3)) + C(8)*D(Lgdp(-1)) + C(9)*D(Lgdp(-2)) + C(10)*D(Lgdp(-3)) + C(11)*D(Lexr(-1)) + C(12)*D(Lexr(-2)) + C(13) *D(Lexr(-3)) + C(14) \quad (5)$$

Figure 2 and 3 prove the adequacy of the econometric model use. CUSUM and CUSUM square curves do not exceed the limited line which means that VECM is a suitable model to determine the causality relationship between the dependent variable (i.e., the resulted food security index) and the independent variables (i.e., exchange rate. GDP and food price index).

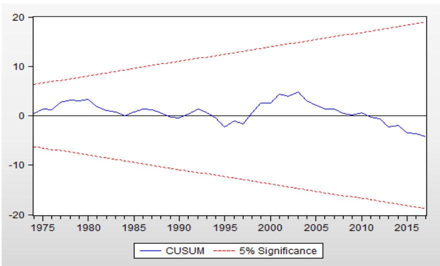

Figure 2
Cumulative sum (CUSUM) of residuals

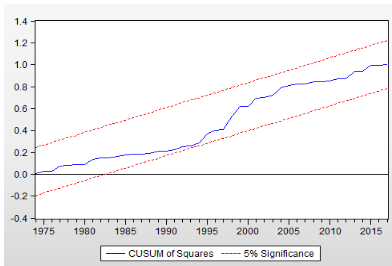

Figure3
CUSUM square of residuals

Conclusions

This paper applied seventeen indicators to build a comprehensive unique index for food security assessment. Findings show that the food security follows an upward trend resulted from two opposing tendencies. This trend could be explained by the improvement of the life quality and the health status. The significant change of dietary consumption system which accompanied the rise of their income, and their demand for food increases. On the other hand, the production level could not meet the level of consumption upward, which leads to the enlarging the gap between the production and consumption, then the food import increased in order to reduce the gap. To tackle the food insecurity risk, Tunisia should focus on the national food production to provide the food and to maintain the sustainability of the alimentary trade balance. This result was admitted by Ouassar et al. in 2021 [6]. Also, this gap could be explained by the rapid growth of population, which is emphasized by a decrease of rural population, migrating to urban areas. In addition, the dietary change became animal protein oriented. A significant long run relationship has been determined between the estimated food security index and the explicative variables (i.e., exchange rate. GDP and food price index).

This study is limited in timeframe; however, it could be extended to more recent times and includes more data. Furthermore, it identifies the weight of each indicator in building a unique index. This study helps future researches by providing an idea about the movement of the food security index based on selected variables, which cover different aspects.

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Energy Transition in Power, Heating and Transport Sectors, based on the Majority of RES and Energy Storage

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Abstract: The world is facing problems that are related to climate change and pollution, which are partially caused by the emission of toxic compounds and CO_2, from the combustion of fossil fuels. The natural resource of fossil fuels, have been exploited for many years, such resources have also been depleted dramatically. The above-mentioned facts determine the need to conduct research that will demonstrate the technological and socio-economical possibilities of transforming energy systems and parts of transport systems from fossil fuels to renewable energy. This paper presents the idea of supplying a selected region, 100% with RES, accounting for costs and environmental efficiencies, for the entire energy system. Further, the analysis of the subject indicated a need to conduct research on correlations derived from integrating collective heating, transport systems with high V2G energy storage capacity and power systems, in order to optimize the functioning of the entire energy market. Furthermore, the above considerations suggest that there is a need to propose a new model for electrical systems, different than the one based on the classical concept of producer-recipient. This research was carried out through a combination of quantitative and qualitative methods. The quantitative analysis applied agent-based modelling; A method supported by extensive qualitative research. The conducted research indicates that renewable energy systems demonstrate greater cost and environmental competitiveness, than conventional energy systems. Furthermore, it has been shown that the integration of collective heating and transport systems, with the energy system has a positive impact on the efficiency of the entire system, by reducing primary energy demand and decreasing carbon dioxide emissions. Finally, the conducted research revealed that the reduction of energy demand, has a positive effect on the transformation of a conventional energy system, into a RES system

Keywords: grid planning; V2G energy storage; smart EV transportation; renewable energy; optimization; energy transition; decarbonization; smart buildings heating

1 Introduction and Literature Review

Currently, most of the energy systems in the world are based on fossil fuels. However, the possibilities of supplying the energy system with renewable energy sources have been discussed in the literature for many years [1-3]. At the beginning of this century, a lot of researchers were of the opinion that renewable energy sources could cover only a few percent of the energy needs of a country the size of Germany. Afterward, when renewable energy sources became constantly present on the day-ahead markets, it was examined whether wind energy could take part in balancing markets (following the day-ahead markets) [4] [5]. Nowadays, the participation of this energy source is becoming reality [6]. Many regions, not only in Europe, are currently introducing plans to modernize energy systems in order to cover most of the demand for electricity by RES within several or several dozens of years (Costa Rica 100% until 2021, Denmark 100% until 2050, Sri Lanka until 2030) [7].

The use of renewable sources in classical energy systems does not always imply that the entire system needs to be reconstructed. It is possible to supply the system with up to 25% of energy coming from fluctuating renewable sources without major system modifications. However, problems arise only if one wants to create a system powered almost 100% from renewable sources in which the majority of energy comes from fluctuating sources of renewable energy, such as solar, wind, or wave energy [8-10]. From the system operator's point of view, what is the ideal source of renewable energy are hydroelectric power plants the power of which can be freely modulated. In countries such as Norway, Brazil, and Venezuela, more than 65% of energy comes from hydroelectric power plants [11]. Unfortunately, most countries, due to their geographical location and climate, are forced to seek other renewable energy sources which are not as stable as hydroelectric power plants. Systems powered mostly by fluctuating sources require the system operator to search for methods to compensate power fluctuations. These considerations raise a number of questions related to the impact of modern technologies used to obtain electricity from RES on the nature and structure of the electricity market, both in Europe and worldwide. These questions formed the basis for conducting research on the idea of supplying a selected region with high-RES participation, taking into account cost and environmental efficiencies for the entire energy system. Further, the analysis of the subject indicated the need to conduct research on correlations that derive from integrating collective heating and transport systems with an electricity system in order to optimize the functioning of the entire energy market.

The issue, as outlined above, determines the objectives of this research, i.e., exploring the possibility of supplying a selected region with high renewable energy sources participation, identifying correlations between the integration of a supply system powered by RSE with collective heating and transport sector. The spatial scope refers primarily to the empirical part of the research and concerns Poland, however, supported by data from all over Europe. The conducted research focuses on the economic analysis from the perspective of electricity end-users and does not encompass legal and political aspects. In particular, it encompasses data from national energy operators, materials made available by statistical offices, and the International Renewable Energy Agency.

2 Research Methods and Calculation Parameters

This research was carried out through a combination of quantitative and qualitative methods. The quantitative analysis applied agent-based modeling; a method supported by extensive qualitative research. In order to forecast the input data for the model, such as demand or variable environmental parameters on the basis of historical data, Idat-Matlab functions based on inter alia ARIMA models were used. Model simulations were carried out with the application of the multilayered Danish algorithm, used by the state Danish operator and research institutes for modeling the impact of RES on the whole energy system. Simulations and the process of designing the new system structure were performed in the MATLAB environment, and with the use of Energy Plan, Idat and Simulink (UniPR Tools) software, on a yearly basis, in hourly steps, reflecting the typical day-ahead market. Based on the related literature [12-15], the following dependencies were adopted for model simulations:

Definition of demand in the model:

Electricity demand is defined as the difference between total demand and heat demand and is broken down into hourly parts of the whole year.

$$dE' = De - dEH \tag{1}$$

$$\text{if } dE' < 0 \text{ then } dE' = 0$$

$$DE' = \sum dE'$$

where: DE'- total annual electricity demand, dEH – heat demand, dE' – demand for electricity at a selected time of the year

Production of thermal energy

The demand for thermal energy from the sun is supported by production from cogeneration, heat pumps, and thermal heating plants. Conventional heat energy is defined as the difference between total production and thermal energy produced from solar energy.

$$qM\text{-}Oil = hM\text{-}Oil - q'\,Solar\text{-}M\text{-}Oil \tag{2}$$

where: $qM\text{-}Oil$ – conventional heat energy, $hM\text{-}Oil$ – total heat demand

Production from renewable energy sources

$$eRes' = eRes * 1 / [1 - FACRes * (1- e\,Res)] \quad (3)$$

were: *eRes* - energy produced in *RES, FACRes* - production factor for a given hour

Fuel demand in heating plants

$$f\,M\text{-}Oil = QM\text{-}Oil / \mu M\text{-}Oil \quad (4)$$

where: heat energy in collective heating, *μM-Oil* - efficiency of the turbine/boiler, *QM-Oil* – heat demand

Generating hydrogen:

The hydrogen production per hour is defined as follows:

$$f\,ElcM = f\,M\text{-}H2CHP\text{-}Average = FM\text{-}H2CHP / 8784 \quad (5)$$

then the content of the hydrogen tank is calculated for each hour *SElcM(x)*

$$SElcM(X) = SElcM(X\text{-}1) + f\,M\text{-}H2CHP\text{-}Average - fM\text{-}H2CHP\,(X) \quad (6)$$

If the capacity of the tank is exceeded in a given hour, the hydrogen production will be limited

$$If\ SElcM > SElcM\ then\ f\,ElcM = f\,ElcM - (\,SElcM - SElcM) \quad (7)$$

$$CElc\text{-}MIN = Hour\ max(\,f\,ElcM\,) / \alpha ElcM \quad (8)$$

where: *SElcM*- the amount of hydrogen in the tank, *f ElcM* – hydrogen produced, *f M-H2CHP-Average* – average demand for hydrogen in a condensing turbine

Geothermal energy:

Electricity production by geothermal power plants:

$$Geothermal=FACGeothermal*CGeothermal*dGeothermal/Max(dGeothermal) \quad (9)$$

$$f\,Geothermal = eGeothermal / \mu Geothermal$$

where: *eGeothermal* - energy production from geothermal sources, *Cgeothermal* - installed capacity of geothermal power plant MW, *μGeothermal* – efficiency, *dGeothermal* - distribution of production in hourly intervals/year, *FACGeothermal* - production-to-installed capacity coefficient f, *FGeothermal* - fuel demand for a geothermal power plant, *eGeothermal* - production of geothermal energy

Water energy, Electricity production through hydropower plants

$$eHydro\text{-}ave = \mu Hydro * WHydro / 8784 \quad (10)$$

where: *μHydro* - turbine efficiency, *WHydro* - water available

Input data in the conducted simulations come from, among others, the bases of national energy operators and European bases:

EU: International Renewable Energy Agency (IRENA 2021), European Statistical Office (Eurostat 2021), Agency for the Cooperation of Energy Regulators (ACER

2021), Council of European Energy Regulators (Ceer 2021). Spain: Red Eléctrica de España (Red Eléctrica 2021), [16, 17, 18]

Poland: Urząd Regulacji Energetyki (Energy Regulatory Office, ure.gov.pl 2021), Główny Urząd Statystyczny (Main Statistical Office, GUS 2021), Instytut Meteorologii i Gospodarki Wodnej (Institute of Meteorology and Water Management, IMGW 2021) [19, 20, 21]

Calculation parameters were selected on the basis of the binding standards in the years 2015-2017 in the Danish and German energy systems, mainly based on the Danish model of the energy system transformation [22].

3 The System with High V2G Energy Storage Capacity, Wind Energy, PV and Non-Renewable Energy Sources Methodology

Simulation 1

The subject of the analysis is a system enriched by large battery capacities in V2G. The battery capacity corresponds to 15 million urban cars driven in the V2G with the battery capacity of 25 KWh and the value of 375 GWh. It should be noted here that the adopted capacity of KWh is much lower than that in the new cars now offered in the market. For example, new Tesla cars have a battery with the capacity of over 80KWh [23], which reduces the number of necessary cars in the storage system of the same capacity to five million vehicles. In the selected simulation, the provider of stored energy can earn in two ways: through the sale and purchase of energy from the network or through the sale of their own energy produced in power peak times. The energy system operator shares 30% of the costs of photovoltaic panels; thus, the annual cost of electricity also takes into account the depreciation of PV. As regards the storage system, the changing market price of energy should be a motivation to use the additional option of each modern EV. For example, energy prices in the Spanish day-ahead market may fluctuate from 0 to 150 euros [24]. Owing to the significant increase in the capacity of electricity storage, the import of energy decreased by almost 2 TWh, while its export practically remained constant and is on the level of 46.43 TWh, which accounts for about 35% of the overall demand of Poland in 2015.

The high installed capacity of wind power plants and a few-day long continuous wind in February allowed powering the energy system with RES in 100%, with the significant advantage of wind turbines (blue color). In real conditions, electricity prices could stay on level zero or have negative values [20]. In Figure 1 (from the right), we can notice a small area in yellow color, which reflects conventional energy sources.

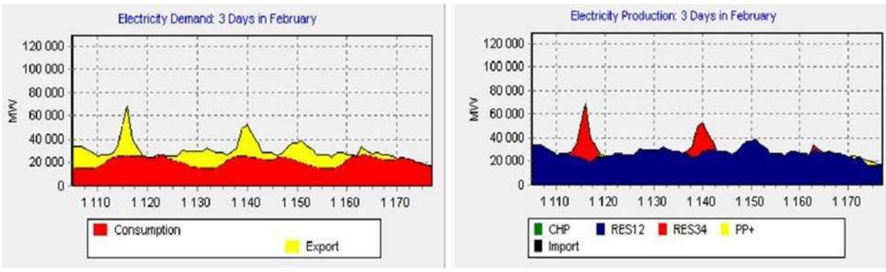


Figure 1
Three-day electricity production in February, with a breakdown by the production technology (the chart on the right), the three-day demand for electricity with the export of production surpluses in February (the chart on the left)
Source: Authors' own work

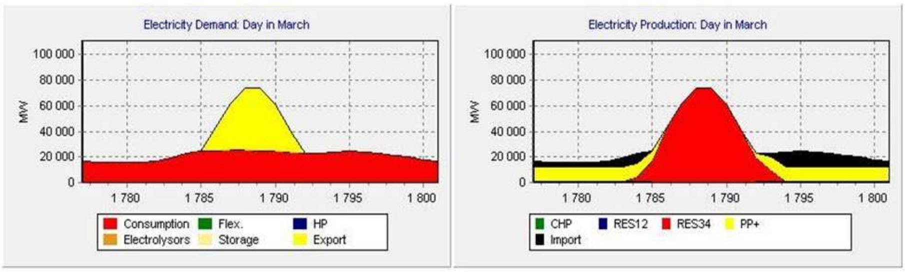


Figure 2
One-day electricity production in March with a breakdown by the production technology (the chart on the right), the one-day demand for electricity with the export of production surpluses in March (the chart on the left)
Source: Authors' own work

It is solar power (red color) that is the dominant energy source (the chart on the right). It can be a source of energy only during the day. Because there was no wind on the day of the analysis, electricity is supplied from NO-RES and, from the V2G battery (yellow). The remaining shortage is compensated by imports. We can see that the batteries are used practically during the whole period of lack of solar radiation and they play an important role in supplying the power system.

The excess of export over the import of energy may play a key role from the economic point of view. In Figure 3, navy blue color refers to the export of electricity generated by PV, while import is marked with green. The selected day is quite characteristic and shows the huge variability of some RES, in this case - sun and wind. Electricity import is caused by the lack of wind and NO-RES limited production capacity, as well as limited storage possibilities. It should be noted here that it is an exceptional day because excess production in the examined year represents 35% of the annual demand for energy.

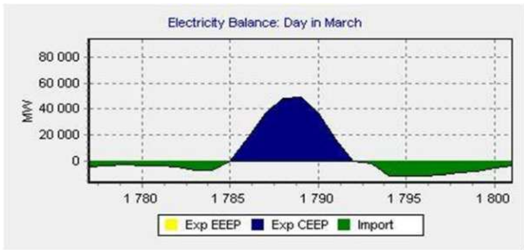


Figure 3
Import and export on the selected day in March
Source: Authors' own work

4 The Increasing Share of Electric Vehicles in the Integrated Energy System Results

The increased share of electric vehicles in transport entails a rise in demand for electricity to be used for transport. Owing to energy storage capability, electric vehicles contribute to the improved efficiency of systems with significant RES dominance (simulation 1). V2G systems have a positive impact on the economy thanks to the excess production of energy and partly compensate for energy shortages, which are usually filled with imports in non-storage systems. What is another important aspect of the change in the structure of transport is a drop in the emission of carbon dioxide and other substances which are a product of the combustion of fossil fuels.

Simulation 2

The assumption is an increase in the share of electric vehicles in satisfying the demand for electricity in the integrated energy system. In 2015, were 20723000 passenger cars registered in Poland [25]. For the sake of the simulation, we assumed the share of electric passenger vehicles from 0 to 100%, the average annual mileage 20000 km, with the demand of 1l of petrol per 14 km for internal combustion cars and 1 kWh for 6 km for electric vehicles, which corresponds to European statistics.

In Figure 4, the vertical axis refers to the demand for electricity in TWh over a year, while the horizontal axis shows the number of passenger cars. Red color represents the relationship between the number of vehicles and EV's demand for energy, while yellow color shows the same relationship for combustion vehicles.

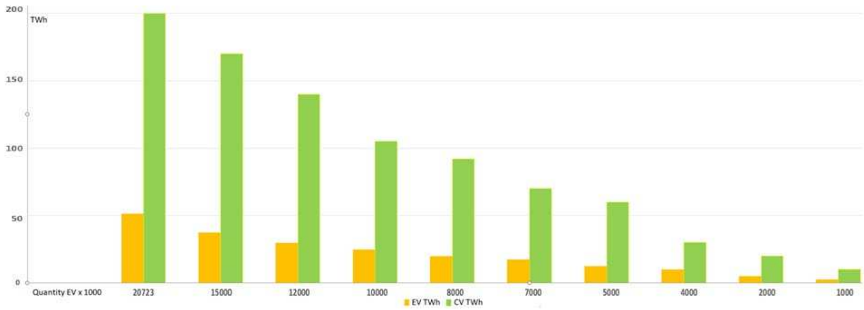


Figure 4
The relationship between the number of electric and combustion vehicles and the demand for energy
Source: Authors' own work

The analysis of the chart shows that electric vehicles have a significantly lower demand for energy than cars with internal combustion engines. This is mainly due to the efficiency of both engine types, which is about 90% for an electric engine, and about 30% in the case of internal combustion engines [13]. Owing to the use of energy from RES, electric vehicles will be powered in an entirely ecological way, while the batteries of parked cars may optimize the efficiency of energy consumption in accordance with the simulation from point 1.

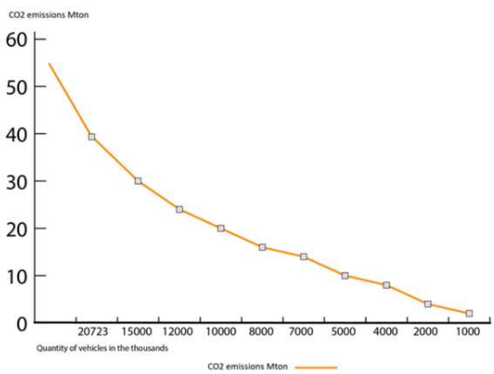


Figure 5
The relationship between the number of internal combustion cars and carbon dioxide emission
Source: Authors' own work

The reduction of carbon dioxide emission and of other substances produced by burning fossil fuels is an increasingly important issue in Europe (Willenbacher 2017). In Figure 5, the vertical axis refers to carbon dioxide emission in millions of tons, while the horizontal axis represents the number of vehicles in the analyzed system, which, in the initial phase, corresponds to the number of passenger cars in Poland in 2015. In that year, passenger cars emitted about 511 million tons of carbon dioxide. At the same time, it must be emphasized that emission standards for combustion vehicles are the same as for new cars from 2015 [27]. The simulation results show that the transformation of the transport system dominated by fossil fuels, into the one with a significant share of electric vehicles, significantly contributes to the elimination of carbon dioxide emissions.

5 The Integrated Electricity and Heating System

As far as cogeneration (the generation of electricity and heating power within a single process) is concerned, the Polish district heating system looks quite good in comparison to the rest of Europe. In 2015, over 63% of thermal energy came from thermoelectric power stations. The situation is worse when it comes to the type of fuels used by energy producers. About 75% of the energy used in district heating came from coal, while only 7.4% came from RES. The other fuels used in district heating include natural gas, fuel oil, and biomass. In 2015, the demand for thermal energy in district heating systems in Poland was 94.937 TWh [20], while the consumption of energy in individual, household heating systems amounted to 129.6 TWh.

Simulation 3

For the sake of the simulation, we assumed the installed capacity of licensed thermal energy producers at the level of 56048 MW and the demand for system heat of 94937 TWh, while the demand of individual heating systems in households was assumed at the level of 129.6 TWh, which corresponds to the actual parameters of thermal energy systems in

Poland in 2015. In accordance with simulations concerning the increased share of EV in transport and simulation 1 presenting the optimum energy system, we may conclude that:

a) The carbon dioxide emission of passenger cars for the state close to the year 2015 is 51.1 Mt, but it may be reduced down to zero by introducing into transport all-electric vehicles powered by non-emission RES.

b) In the electricity sector, CO2 emission in 2015 was about 109 Mt, but, through the reduction of the consumption of fossil fuels and introducing non-emission RES, it could be reduced down to 37.6 Mt.

c) The volume of carbon dioxide emission in the district heating sector for the system reflecting the Polish energy system of 2015 was 61.2 Mt.

In order to reduce CO2 emission and improve the use of the excess production from RES, the integrated systems of electricity and heating will be integrated into the current simulation. The energy system will be the same as in simulation 1, while the heating system will reflect the actual Polish heating system from 2015 in the first steps of the simulation. The overall sum of CO_2 emissions for these systems is 98.853 Mt. It is possible to reduce the emitted pollution owing to replacing some of the coal-fired power plants with heat pumps, which in particular are powered by the excess production of energy from RES.

When comparing Figures 7 and 8, one might notice that by replacing a part of coal-fired power plants of the installed capacity of 10000 MW with heat pumps of the same capacity we can significantly reduce the export of energy, with only a slight increase of import. On a yearly basis, export decreased by 22.2 TWh, while imports increased by 2.3 TWh. Savings from the better use of electricity production surpluses thanks to the utilization of heat pumps result not only from the reduction of export but first of all from the replacement of expensive fossil fuels used in district heating. What is of significance is also the characteristics of a heat pump which can produce three times as much energy as it consumes [22]. By increasing the share of RES in the heating system, we could reduce carbon dioxide emission by about 10 Mt. As heat pumps can be used both in individual and district heating systems, it is important to select the proper types of RES in the system of heating and electricity generation.

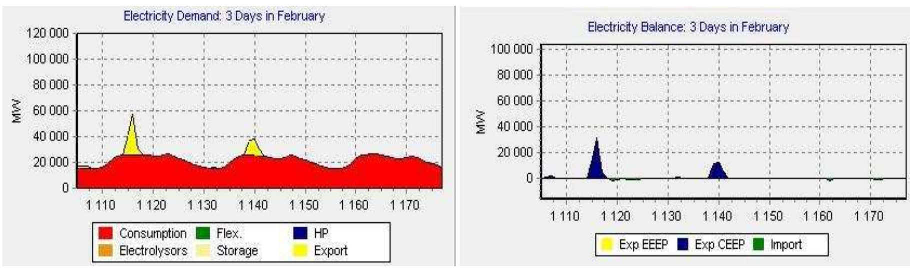


Figure 6
District heating demand in 2015
Source:(GUS 2021), (URE 2021), Authors' own work

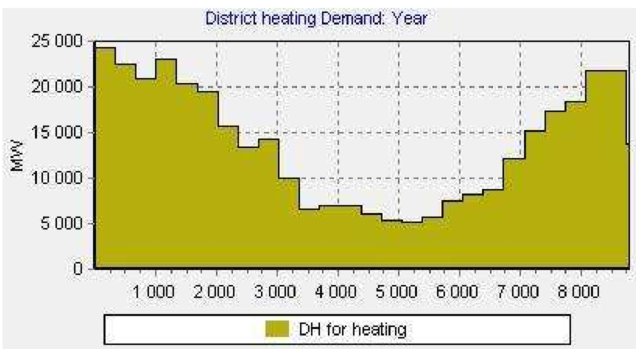
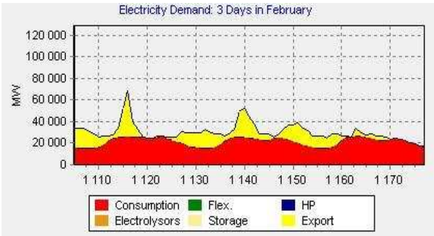


Figure 7
Three-day demand for electricity along with the export of production surpluses in February (the chart on the left), three-day export/import of electricity in February (the chart on the right), in the integrated system of electricity and heating generation without the share of heat pumps
Source: Authors' own work



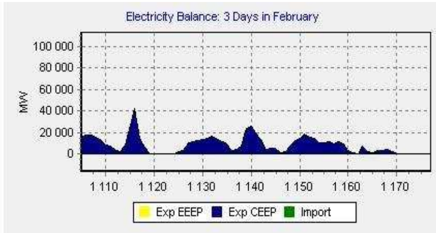


Figure 8

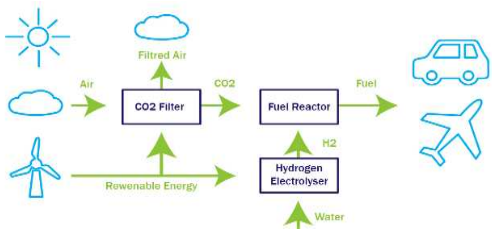
Three-day demand for electricity along with the export of production surpluses in February (the chart on the left), three-day export/import of electricity in February (the chart on the right), in the integrated system of electricity and heating generation with the share of heat pumps

Source: Authors' own work

6 The Production of Biofuels and Synthetic Fuels on the Basis of the Excess Production of Electricity from RES

Simulation 4

The production of synthetic fuels and biofuels based on electrical energy from RES is a lot more complex process than the use of heat pumps in the heating system described in simulation 3. The main advantage of the production of synthetic fuels is the use of the existing carbon dioxide already in the natural environment or when it is produced in industrial processes.



Schem1

The simplified scheme of the production of synthetic fuel based on RES

Source: Authors' own work

Synthetic fuels or biofuels may be used in industry or transport, which, due to their characteristics, makes use of internal combustion engines. Because of the high cost of the process itself, the production of the abovementioned fuels plays a secondary role in the simulation. Energy from the excess production of RES is first used in heat pumps and then transferred to the production of fuels. One of the assumptions of the simulation is the minimization of import and export, and in the case of crisis situations/energy peak times, synthetic fuels may also be used for the production of electricity.

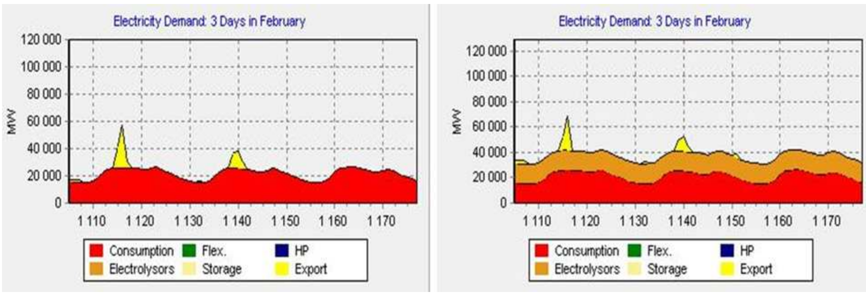


Figure 9

Three-day demand for electricity along with the export of production surpluses in February in the integrated system of the production of electricity and heating power and electricity with the share of heat pumps (the chart on the left). The chart on the right presents the system enriched with the possibility of the production of synthetic fuels and biofuels

Source: Authors' own work

Owing to adding heat pumps to the energy system and the possibility of the production of synthetic fuels and biofuels based on the available sources (Figure 9), export was reduced. On a yearly basis, there was a drop in export by another 8 TWh, while the demand for electricity rose because of the need to use electrical energy in the production of synthetic fuels and biofuels. The production of fuels was established at the level of 150 TWh annually.

Conclusions

This research paper presents the diverse aspects of the energy system transformation, within the context of the increasing share of renewable energy sources and V2G energy storage. The main criterion of the study was the cost and environmental efficiency of the whole energy system. The detailed analysis of energy systems revealed the need to undertake research into the dependencies resulting from the integration of the energy system with the transport system and the district heating system in order to optimize the functioning of the whole energy market.

The first simulation shows that increasing the capacity of battery storage significantly enables the system to be powered by photovoltaic energy stored in batteries during periods of no solar radiation. Using electric vehicles in the energy system as energy storage opens up new possibilities for decentralized energy storage.

The analysis of the model (simulation 2) which assumes an increase in the share of electric vehicles in transport shows that as the number of combustion vehicles in the system decreases, carbon dioxide emission decreases. In the examined model, internal combustion cars are replaced with electric ones, which are powered by non-emission renewable energy. Following the reduction of the emission of carbon dioxide and other substances produced by burning fossil fuels, the environmental efficiency of the system increases. When the share of electric vehicles in the transport system reaches 100%, carbon dioxide emission amounts to zero.

A change in the method of powering passenger vehicles not only results in the reduction of environmental pollution, but it also decreases the demand for energy in transport. Owing to the introduction of electric vehicles in the transport system model, it is possible to reduce the consumption of energy from the level of 280 TWh to the level of 70 TWh on an annual basis. This brings enormous financial and environmental benefits. The advantage of electric vehicles is to a large degree the result of the higher efficiency of the electric engine, which is about 90%, as compared to the efficiency of the combustion engine (25-30%).

The concept of combining a power plant with a thermal energy plant is quite a common practice, but the increasing share of RES in the energy market provides new opportunities to use production surpluses from fluctuating renewable sources in heating. The simulation of the integrated model of district heating and electricity (simulation 3) clearly shows that by replacing the production of heating energy coming from thermal energy plants with the energy from heat pumps, we can significantly reduce carbon dioxide emissions. Energy used in heat pumps is derived from the RES excess production, owing to which there is no need to burn expensive and high-emission fossil fuels. The integration of both systems and a change in the technology of power generation raises the cost and environmental efficiency of the whole energy system.

Taking into consideration the integration of the electrical energy and transport systems through the production of synthetic fuels and biofuels from the RES excess electricity production (simulation 4), it is possible to integrate the heavy transport systems and other systems in which petroleum products are used, thanks to which, the share of RES increases in other sectors of the economy.

To conclude, owing to the integration of the systems of electrical energy, heating, and transport, the volume of carbon dioxide emission in the whole system has dropped by a half and the demand for energy produced by burning fossil fuels has gone down by almost 210 TWh, which accounts for about 40% of the classical primary demand, in the coal-based energy system, for a country the size of Poland.

Further research should focus on proposing alternative structures of the electrical energy market and on the analysis of relationships between professional and individual energy producers.

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Investigating the "Resource Curse" in China: Is it Sufficient to use the Usual Methods?

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Abstract: Our article on the study of the "Resource Curse" in Chinese provinces, was written with two objectives. First, by reviewing the international and Chinese literature and analyzing the economic development of the relevant Chinese provinces, we sought to explore *whether the resource curse phenomenon exists or can be demonstrated. And second, we want to draw the reader's attention to the fact that Chinese and Asian economies in general have central planning models, the main purpose of which is to define and focus on national economic development priorities. The sub-divisions of the central development plans include development targets for each region, which naturally take into account the economic performance of each province and the factors that determine it. It follows from the latter line of thinking that the economic development of the four Chinese provinces concerned (Gansu, Guizhou, Qinghai and Shanxi) cannot be interpreted in a 'piecemeal' way, based solely on the existence or otherwise of the resource curse phenomenon. In writing this article, we also wish to draw attention to this holistic, comprehensive Chinese (Asian) way of thinking.*

Keywords: resource curse; China; regional development; energy consumption; energy policy

1 Introduction

The Government of Hungary, launched its *Opening to the East* foreign economic policy in 2012, more than a decade ago, with the main aim of diversifying Hungary's exports of goods and services. The 'diversification' of exports was justified by the huge dependence on exports to Europe, reinforced by the dominance of FDI from other European countries. The foreign economic policy of opening-up, to the East, thus aimed not only to increase exports of goods to the countries of East, South-East and South Asia, but also to attract further FDI from these countries, especially China, and seek substantial increases.

The domestic economic policy initiative coincided in time and objectives with the Belt and Road Initiative (BRI), a Chinese initiative established in 2013 and now involving 151 countries and international organisations, which aims to connect the two continents (Asia and Europe) via land, rail and water transport routes, starting from China and involving all regions of Asia.

However, in addition to the mutually reinforcing and supportive economic policy intentions, it is of paramount importance to understand and bridge the differences in mindsets that stem from the different geographical, historical and cultural backgrounds of the two continents. In the following paper, we have explored the interpretability of the resource curse theories of economic development based on the exploitation of non-renewable resources in China and in the resource-rich provinces of China.

Based on the international and Chinese literature and a review of the economic development of four resource-rich provinces (Gansu, Guizhou, Qinghai and Shanxi) in China, we conclude that although the resource curse is a phenomenon widely researched by Chinese authors, resource wealth or dependence on resource wealth does not become the sole determinant of the development of individual provinces in China, neither at the local nor at the regional level.

Our results have been used to argue that China, as is common in centrally planned Asian economies, sets national economic development priorities, and thus the mechanism for redistributing national economic revenues is aligned with central planning objectives, and that it is not appropriate to analyse the economic development of individual provinces in isolation from the economy as a whole. For this reason, proving or disproving the existence of a resource curse that determines the economic development of individual provinces is not only not possible, but, in our view, fundamentally alien to the Chinese way of thinking about economic development.

2 The Resource Curse Phenomenon

Economists have always been curious about the factors on which the economic development of a nation depends. The neoclassic growth theory, introduced by Solow [1] and Swan [2], says that the main drivers of economic dynamics in a country are capital formation and labour force. However, with time, other factors have been discovered which also contribute to a nation's growth and the model was extended by several other scholars. Stiglitz [3] was the first to include the endowment of natural resources into this model, by stating that the economic expansion of a country is affected by the amount of natural resources it has.

For several decades, it seemed that the greater amount of natural resources a country had, the bigger the economic growth it could realize and many countries with natural resource abundance were economically outperforming nations with poor resource stocks [4]. However, after the 1970s, when several shocks caused structural changes in the world economy, researchers noticed that many developing countries with significant natural resource bases were starting to fall behind in terms of economic development. Their growth rates were significantly slower than other nations with fewer natural resources [4]. Earlier theorists have also observed this phenomenon. "It is generally observed that in countries of the greatest plenty there is the poorest living" [5]. Auty has christened this phenomenon "the resource curse" [6]. This phenomenon, also known as the paradox of plenty or the poverty paradox, is when countries with an abundance of natural resources having less economic growth, less democracy, or worse development outcomes than countries with fewer natural resources [7].

The importance of the phenomenon is easily understandable based on the paper of Anthony J. Venables [8]. According to this article "the IMF classifies 51 countries, home to 1.4 billion people, as resource-rich. This classification is based on a country deriving at least 20 percent of exports or 20 percent of fiscal revenue from non-renewable natural resources based on 2006–2010 averages as explained by the IMF." The IMF measured the GNI per capita (2010 US$), the natural resource exports as a percentage of total exports (2006–2010 average), and natural resource fiscal revenue as a percentage of fiscal revenue (2006–2010 average). In many of these countries, there is extreme dependence on natural resources for fiscal revenues, export sales, or both. In these low-income resource-rich economies savings have generally been low. The growth performance of all the resource-rich economies as a group has been generally poor.

Measuring the resource curse phenomenon involves conducting empirical research and analyzing various indicators and factors. There is no universally agreed methodology for measuring the resource curse, despite its importance. Without attempting to be comprehensive, there follow some common approaches and considerations:

- Economic indicators have a significant role in measuring the presence and impact of the resource curse. Macroeconomic performance indicators, natural resource dependency, export dependence on resources, income inequality, poverty rates and economic diversification play a significant role in indirectly measuring this phenomenon. Negative trends in macroeconomic performance, correlations between resource abundance and negative economic outcomes can all refer to the analysed phenomenon.
- Naturally, Governmental and Institutional factors are important in measuring macroeconomic performance. Indicators related to corruption, transparency, accountability, rule of law, and political stability are widespread. Weak governance and institutions can strengthen the resource curse, with rent-seeking behaviour, corruption and the fostering of mismanagement.
- Social and human development indicators are important to understand the effects of resource wealth on the well-being of the population. Education levels, healthcare outcomes, access to basic services, poverty rates, and social inequality are the most important indicators for measuring social and human development. Look for disparities or underperformance in areas that should benefit from resource wealth.
- The environmental consequences of resource extraction and its effect on sustainability are decisive. Indicators measuring deforestation, pollution, greenhouse gas emissions, biodiversity loss, and natural resource depletion are important in relation to this topic.
- Long-term economic diversification efforts are also essential. It is necessary to analyze the progress and effectiveness of efforts to diversify the economy away from resource dependence. The analysis of policies and initiatives aimed at promoting non-resource sectors, fostering innovation, and building a resilient and diversified economy could also be necessary.

After the initial observations, many scholars have started to analyse the resource curse from several points of view. Corden [9] has created a model on how a country's resource dependency causes harm to other sectors and to its economic development by analysing the decline of the Dutch manufacturing industry after the discovery of a natural gas field in 1959. Following this, by analyzing 97 developing countries, Sachs and Warner [10] found evidence that countries with abundant natural resources generally increased less rapidly than economies with scarce natural resources.

The essence of the natural resource curse lies in several aspects which can be categorized into economical and political mechanisms [11]. Economically, one of the most important reasons for the resource curse is the so called Dutch disease model, coined after the phenomenon described by Corden above. This model states that when a natural resource boom happens, it increases income and the demand for goods in the country. This causes inflation and appreciation of the real exchange rates. Because of this, prices generally increase and all the goods of the country become more expensive on the international market, even those which are not connected to the natural resource industry. So these goods become less competitive, their export decreases, they attract fewer investments, and finally the sectors producing them regress [11]. The second economic aspect is the volatility of natural resource prices on the international market which, with their unpredictability, reduce economic growth. The third cause lies in the inadequate economic policies regarding natural resource revenue. Governments often do not use these incomes to develop other parts of the economy – they fail to invest in industries with more value-added products, research and development, or education. This is called the crowding-out effect. Collier and Laroche [12] did an analysis of the steps required to exploit natural resources and at each step examined what factors cause the appearance of the resource curse and what good practices governments should implement in order to avoid its occurrence. They concluded that it is especially hard for developing countries to get the natural resource management policies right, because there are next to no international guidelines or established best practices to follow. Most of the OECD countries being poor in natural resources, there was no demand for producing such documents. The problem with the natural resources in question is that they are non-renewable. Sooner or later they will run out and other sectors of the country's economy will not be able to take their place in the economic performance [4]. If we look at the political aspects of the resource curse, we find that one of the most important reasons is so-called rent-seeking behaviour. It means that the windfall from natural resource revenues will strengthen the power of the political elites and will widen the income inequality in the country. This immediately leads to corruption, weak institutional structure and social instability [4] [11].

Empirical evidence of the existence of the resource curse is not indisputable but there are significantly more studies supporting it. Van der Ploeg [13] argues that natural resources can be both a "blessing" or a "curse", as countries with low institutional quality, weak rule of law, widespread corruption, and underdeveloped financial systems are unable to take full advantage. As a result, fragile states with natural resources tend to face real exchange rate appreciation and deindustrialization, leading to milder economic growth. Moreover, based on Van der Ploeg's further hypothesis, resource rich developing countries can face rent grabbing and social unrest, while they are unable to transform the advantages of natural resources into productive assets. Based on the World Bank's dataset, these results hold for a global aspect. Mehlum et al. [14] also conclude that the quality of institutions determine the existence of the "resource curse".

With time, studies criticizing or even denying the existence of the resource curse phenomenon have started to appear. Brunnschweiler and Bulte [15] argue that most studies supporting the relationship between resource dependence and slow economic growth threaten the former as an exogenous explanatory variable. But they found that resource dependence is endogenous in the regressions and, if treated this way, the correlation between resource dependence and slow economic growth vanishes. They also found that the causality between the factors of the natural resource curse model might be reversed, so natural resources are not the cause of weak institutions, conflict and slow growth, but these factors make the country dependent on resource extraction. Alexeev and Conrad [16] argue that abundant natural resources on economic growth have been balance positive in the long term and the claims of the existing literature supporting the natural resource curse is mainly due to the misinterpretation of the data available. They also concluded that these types of resources have neutral effects on the quality of institutions of a country.

This paper focuses on the resource curse phenomenon in China. The topic is especially interesting because China has had an exceptionally fast economic development since 1978 and is one of the countries with the largest reserves of natural resources, but there are huge differences in terms of regional development between the country's Eastern and Western provinces [17].

Just like their International Colleagues, Chinese scholars have also tried to investigate whether these large developmental differences can be traced back to the natural resource curse phenomenon. They have conducted numerous tests using several research methods and models and their results are just as ambiguous as those of their international counterparts. Shao and Qi [18] have examined the resource curse hypothesis by studying the relationship between energy exploitation and economic growth in Western China. They found evidence that energy exploitation did have a negative effect on economic growth in that region and concluded that the resource curse does exist in the area. Qiang and Jian [19] tried to explore the relation between economic growth (measured by the GDP of each region), natural resources and institutional quality, based on a sample of 30 provinces, cities and autonomous regions. They found evidence for the existence of the resource curse effect and conclude that the low quality of the former two institutional factors make "resource curse" more severe in Chinese provinces, whereas increasing market openness is able to weaken the negative effect. Sun and Wang [20] also analyze the effect of natural resources on economic growth in 30 Chinese regions, but they also include its impact on environmental pollution. They highlight the negative correlation between natural resources and economic growth, thus the existence of the "resource curse". Furthermore, the effect of natural resources on environmental pollution is even greater than the impact on the per capita GDP of the region. Ma and Cheng [21] confirmed the existence of the resource curse at the provincial level in China by applying fixed effect model and threshold panel model, that is, rich natural resources inhibit technological progress and thus have negative effects on economic development. However, they also found that the initial development of the resource sector has a significant promoting effect on technological progress which can be called a resource blessing, but when the scale of the resource industry expands to a certain extent, the resource curse phenomenon begins to appear.

Some Chinese scholars have also analyzed the phenomenon on smaller scales. Wen and Jia [22] analyzed 236 cities in China to examine the relationship between natural resource dependence and economic development, measured by the GDP per capita. Cities with a declining number of resources tend to experience “resource curse”, while an increasing resource base rather brings a “resource blessing”. Moreover, based on the analyzed time period, the effect of resource dependency on growth differs, as it is negative in the short run, but positive in the long run. Based on the panel data of typical resource-based cities in China from 2003 to 2013, Zhao et al [23] retested the resource curse hypothesis by using the generalized method of moments, and under the condition of considering potential endogeneity, they also discussed whether the human capital of resource-based cities can effectively alleviate the resource curse. Results show that resource curse is common in resource-based cities in China. Han and Zou [24] divided natural resources into point resources and scattered resources conceptually for the first time, and used panel data of 12 provinces and cities in western China to carry out quantitative analysis, finding that resource curse does exist in western regions. Additionally, by referring to the successful case of solving resource curse in Norway, they put forward some policy suggestions for the government to solve resource curse. Lu et al [25] conducted a case study of various types of resource-dependent cities in China to analyze the resource curse effect by calculating the resource curse coefficient. They grouped the cities according to their resource development stages and found that regardless of whether these cities were in the early, intermediate or late stages of their resource development, they were always negatively affected by the resource curse phenomenon. They concluded that natural resources can support economic growth to a certain point, but the process results in many unfavorable aspects that make economic development unsustainable.

Other Chinese scholars found no evidence for the existence of the natural resource curse effect or even found that abundant natural resources support economic growth. Zhang and Brouwer’s study [26] summarizes this ambiguous side of the research field by collecting and analyzing 44 studies published in Chinese at provincial and city level between 2005 and 2017. They discovered that, even though most of the research found evidence for the existence of the natural resource curse, there is not a negligible number of studies finding just the opposite. They also concluded that only a number of the studies included sufficient control in the estimated models to reliably investigate the existence of the phenomenon. Rui et al [27] used the functional coefficient regression model to examine the resource curse hypothesis in 95 cities in China between 1997 and 2005 and found no evidence of its existence. They also examined the transmission channels between natural resources and economic development and found that the positive impact of the abundance of resources in one city flows through several transmission channels to another city in the province. Hu et al [28] also concluded that there is no resource curse in China in general, but they grouped the provinces under examination according to their different degrees of the resource curse and found that 6 of these provinces would display negative economic growth should they increase their resource dependence.

Most studies dealing with the resource curse phenomenon use macroeconomic performance indicators and their relation. If high dependence on natural resources is combined with a low GDP per capita, a declining population, a decrease in the number of school enrollments, and a negative trade balance, it reinforces the presence of the recourse curse phenomenon. In this study, following the mainstream literature, we follow this methodological path and investigate the presence of the resource curse phenomenon in relation to four Chinese provinces that rely on natural resources to varying degrees.

3 The Resource Curse Phenomenon in Selected Chinese Provinces

This chapter provides an overview of selected indicators of four Chinese provinces - Gansu, Guizhou, Qinghai and Shanxi - as they are rich in natural resources (see Figure 1). Occasionally, overall data for China has been included for the sake of comparison. The data has been collected from the respective Provincial Statistical Yearbooks [29]-[72] and the China Statistical Yearbooks [73]-[83]. The analysis covers the ten-year time period between 2010 and 2020. The cases of the four highlighted provinces are designed to underpin the statements of our paper.

Figure 1 reflects the fact that two of the analyzed provinces, Shanxi and Guizhou, have also produced large amounts of energy over the reviewed time period. It is noteworthy that in most cases high volatility can be detected, while certain time series show an increasing tendency, with others reflecting decreasing amounts. Overall, Shanxi province’s natural resource output can be considered outstanding, within the analyzed group.

We refer to resource dependency as a percentage of tax revenue from mining in the percentage of the total tax revenue. Based on Figure 2, the four provinces under review reflect great differences, as this percentage amounted to 64.85% in Shanxi, while in Guizhou in 2020 it was merely 8.22%. Despite significant volatility, in all of the reviewed provinces the resource dependency showed a decreasing tendency over the time period analyzed. Nevertheless, the respective ratios are still over the Chinese average.

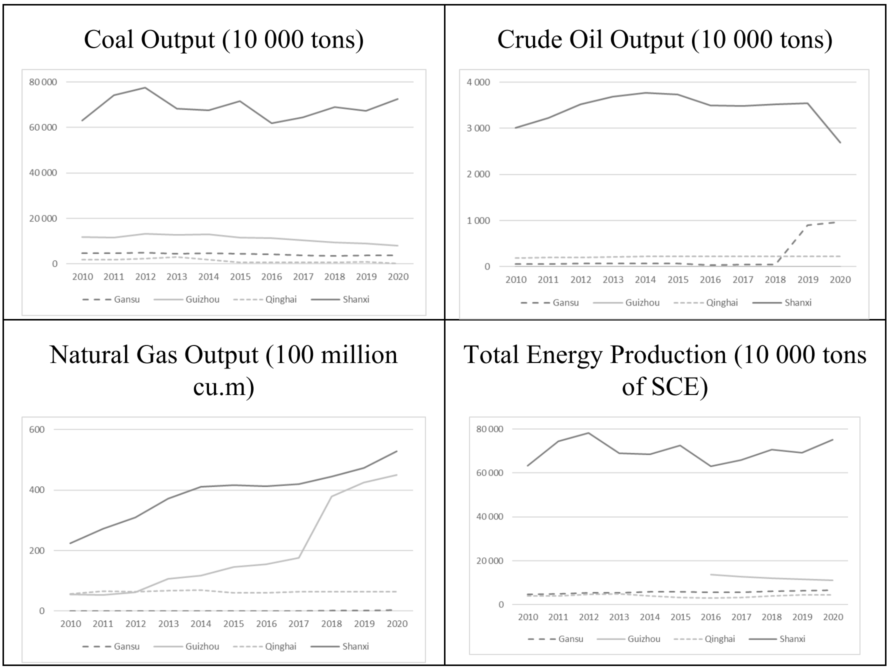

Figure 1

Output of selected natural resources

(Sources: Provincial Statistical Yearbook (selected years between 2011 and 2021) [29]-[72], China Statistical Yearbook (selected years between 2011 and 2021) [73]-[83])

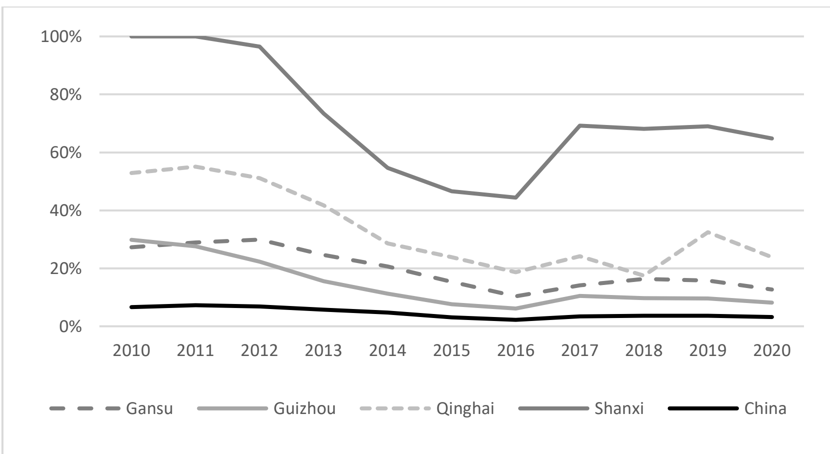

Figure 2

Resource dependency

(Sources: Provincial Statistical Yearbook (selected years between 2011 and 2021) [29]-[72], China Statistical Yearbook (selected years between 2011 and 2021) [73]-[83], own calculations)

As the resource curse phenomenon is usually analyzed by the variable of the GDP per capita, Figure 3 reflects the development of this indicator in the four provinces under review and in China. Generally, the four provinces have a lower GDP per capita level, and a rather modest growth compared to the overall Chinese average.

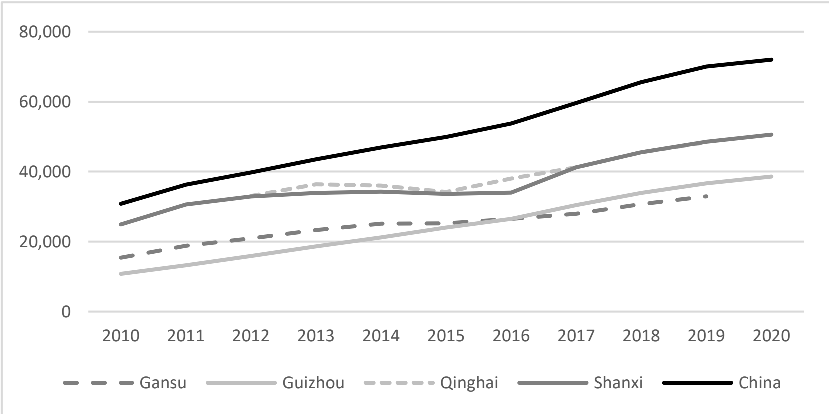

Figure 3
GDP per capita (Yuan)
(Note: Data for Qinghai in 2011 and 2020, and for Gansu in 2020 are not available.)
(Sources: Provincial Statistical Yearbook (selected years between 2011 and 2021) [29]-[72], China Statistical Yearbook (selected years between 2011 and 2021) [73]-[83])

During the reviewed time period, further macroeconomic indicators underpin economic stability (see Table 1). Namely, the average consumer price index in all of the provinces was constantly between two and four percent during the analyzed period. The percentage change of the trade balances reflects greater variety, as in the case of Guizhou a rapid surplus growth was registered, while in Qinghai the trade was rather balanced. Nevertheless, major external imbalances were not present. As for the labor market, in Shanxi, secondary school enrolment decreased by 34% and the number of employed persons by 3.55%, which might indicate certain labor market tension, also from the aspect of the Chinese average.

Resource dependency exceeding the national average and GDP per capita below the national average are typical in all 4 examined provinces. However, the population decline of Shanxi province and the stagnant population of the other investigated provinces, as well as the decrease in further education and employment data indicate a decrease in efficiency in addition to high resource exposure. All of these are combinations of phenomena that, according to the literature, point to the presence of the resource curse phenomenon.

Table 1
Selected macroeconomic indicators

	Average between 2010 and 2020	Growth (percentage change between 2010 and 2020)				
	Consumer price index (%)	Trade balance (%)	Local General Budgetary Revenue (%)	General Budgetary Expenditure (%)	Secondary School Enrolment (%)	Number of Employed Persons (%)
Gansu	2.60	(-)26.16	128.63	118.18	n.a.	n.a.
Guizhou	2.41	575.74	234.78	251.80	-0.42	6.35
Qinghai	3.20	-81.85	173.55	160.00	n.a.	n.a.
Shanxi	2.34	(-)213.78	135.58	164.63	-34.00	-3.55
China	2.58				0.05	-0.01

(Note: In the case of the trade balance, in Gansu and Shanxi, the deficit turned to surplus, in Qinghai there is continuously a minor surplus.)

(Source: Own calculations, based on the statistics of the Provincial Statistical Yearbook (selected years between 2011 and 2021) [29]-[72], China Statistical Yearbook (selected years between 2011 and 2021) [73]-[83])

At this level it is important to examine the relationship between natural resource exposure and GDP per capita. Analysis of the correlation of these indicators could be informative about the resource curse phenomenon. A strong negative correlation (high resource dependency and low -high negative- GDP/per capita) is the indirect indicator of the analyzed phenomenon. In order to check the relation between two key indicators, namely the GDP per capita and the natural resource dependency, a correlation analysis has been included in this section, using the results of Pearson correlation and autocorrelation (see Table 2). The strong positive relationship, i.e., high resource exposure, low GDP per capita indicates that the province that lives on the income from the extraction of natural resources operates with lower efficiency. Since we are analyzing time series, the analysis of the autocorrelation is obligatory. If the absolute value of the autocorrelation coefficient is high (above 0,7), it is worth investigating due to changes in natural resource exposure and per capita income and to calculate the correlation between them. The high negative correlations are interesting and important, to put it simply.

In Gansu province the GDP per capita and the natural resource dependency are autocorrelated. For this reason, we took their percentage change into account, which are not autocorrelated. The linear relationship between them is weak positive (0.30), meaning that the annual percentage change of the GDP per capita and the annual percentage change of the natural resource dependency show a weak correlation in the examined time interval. This indicates that the annual percentage change of the natural resource dependency can explain the annual percentage change of the GDP per capita only to a small extent. We reach the same conclusion in the case of Guizhou province. In the latter case as well, the time series are autocorrelated, but at merely 0.01, the relation between the percentage change of the two indicators is even lower than in Gansu. Thus, only a very weak co-movement exists between the two variables. This is also the case in Guizhou.

It is only Qinghai province, where the GDP per capita and the natural resource dependency are not autocorrelated. However, in this case, the coefficient amounts merely to (-0.28), which reflects a weak negative correlation between the analyzed indicators. Last but not least, the most resource rich province within the analyzed group, Shanxi province, stands as a specific case, as autocorrelation exists here as well, but the correlation coefficient is 0.74, showing significant correlation. Nevertheless, this number indicates a positive relation between the GDP per capita and the natural resource dependency, which is not in line with the existence of the resource curse phenomenon. The analysis of the correlation between natural resource dependency shows the resource curse phenomenon may be present only in Qinghai.

Table 2
Correlation indicators (2010-2020)

Province	Indicator	Correlation between GDP per capita and natural resource dependency	Autocorrelation of GDP per capita and natural resource dependency	Correlation between percentage change of GDP per capita and percentage change of natural resource dependency	Autocorrelation percentage change of GDP per capita and percentage change of natural resource dependency
Gansu	GDP/capita	-0.78	0.98	0.30	0.53
Gansu	Natural resource dependency		0.87		0.18
Guizhou	GDP/capita	-0.82	1.00	0.01	0.85
Guizhou	Natural resource dependency		0.94		0.07
Qinghai	GDP/capita	-0.28	-0.31	-0.68	-0.07
Qinghai	Natural resource dependency		0.38		0.04
Shanxi	GDP/capita	-0.38	0.94	0.74	0.22
Shanxi	Natural resource dependency		0.81		0.18
China	GDP/capita	-0.82	0.99	0.48	0.42

China	Natural resource dependency		0.79		0.15

(Sources: Provincial Statistical Yearbook (selected years between 2011 and 2021) [26]-[69], China Statistical Yearbook (selected years between 2011 and 2021) [70]-[80])

4 Export-led Growth vs. Dual Circulation-driven Domestic Economic Strategy

After nearly 30 years of state control of all assets, the government of China embarked on a program of economic reform. In an effort to awaken a dormant economic giant, China encouraged the formation of rural enterprises and private businesses, liberalized foreign trade and investment, invested in industrial production and the education of its workforce. By nearly all aspects, the strategy has worked perfectly. Although, capital accumulation in China [84] was very important, as was the increased productivity of the Chinese workers, which proved to be one of the driving forces behind the economic boom. During 1979-94, productivity gains accounted for more than 42% of China's growth and by the early 1990s had overtaken capital as the most significant source of that growth [85].

Measuring Growth

Economists studying China tend to face theoretical issues related to the country's central planning and strict government control, which tend to distort prices and redistribute resources. Since the Chinese national accounting system differs from the systems used in most Western nations, it is difficult to draw a comparison, as figures for Chinese economic growth consequently vary, depending on the analyst's decision how to apply them.

In order to understand asset distribution and the order of command, we must acknowledge that the Chinese economy combines important features of a market economy and a planned economy. To research the potential existence of the resource curse we first need to study policy making and the role of economic planning in China by reviewing its history [86]. During the period from 1953, when the first Five-Year Plan [84] began, to the end of the 1970s, China practiced central planning under the direction of the State Planning Commission (SPC). The main function of planning was to direct the production of major products by state-owned enterprises. Although the market economy functions effectively in China, the idea that planning is essential for China's economic development remains in the mind of government officials until today. Production in many sectors of the Chinese economy is carried out by both state-owned and non-state enterprises. Both politically and economically, China is under the leadership of the Communist Party, hence the NDRC [87] is instructed by the Party in drafting the Five-Year Plan. The chain of command goes from the central government to governments at the provincial, city, county and small community level. Government actions at all levels are under the direction of the Communist Party. The provincial level financial revenue derived from land and all kinds of natural resources have been one of the most important sources of local government revenue in China since the “paid transfer of land use rights” [88] programme was instituted in 1988. Local governments consider incomes from those sources as their own, in contrast to the central government, which via the state-owned enterprises (SOE) [89] drain and re-distribute revenues from the provinces, giving top priority to state-wide economic and social sustainable development goals. This process is also the main source of rapid urbanization, with a larger number and size of cities across the country. That process enhances efficiency and increases grassroots domestic demand, and has started to decrease its reliance on export-led economic growth. As such, the successful implementation of the dual-circulation strategy is a key indicator of whether China is capable of avoiding the middle-income trap (MIT) [90].

Conclusions

Although the vast number of natural resources across the country plays a very important role in the steady and swift economic rise of China, beyond capital accumulation, the untapped and very competitive labor force, and its fast-improving productivity, could be highlighted as one of the main underlying factors for the unprecedented growth. As suggested by this research paper, unlike in other countries - *where the resources curse is fairly easy to prove* - in China, revenues from natural resources are hardly the only, or the main source of economic growth, even on the wider regional or provincial level.

Regarding another key indicator of the *resources curse,* in China the volatility of both short and long-term global resource prices is balanced and cushioned at a central level, where Beijing smoothens the transitory effects. The potential regional excess revenues or deficits are swallowed up and balanced out by the state-owned enterprises, which strictly act upon the guidance and instructions of the state planning. Accordingly, the phenomenon of Dutch disease and its consequences, such as inflation and the appreciation of real exchange rates - both of which are measured and controlled at central government level - can hardly be applied. Following that logic from the political aspect, the rent-seeking behaviour and the consequent widening income inequality and corruption can also only be assumed by a weak supporting institutional structure, which it would not only be mistaken to assume, but in reality rather the opposite is true.

Having researched the *resource curse* and its potential implications on the regional and resource-rich provincial level in China, we can thereby conclude that such phenomena can only be interpreted in political and economic terms when the environment under research is considered closed-loop, and assuming that the goods produced are strictly redistributed within the given system. We examined the resource curse phenomenon in 4 provinces, characterized by higher dependence on natural resources than the Chinese national average. In each province, the high dependence on natural resources was accompanied by macroeconomic indicator values (decreasing population, enrollment, negative external balance, negative linear relationship between GDP/capita and dependence) that make the resource curse phenomenon likely. Briefly about limitations and possibilities: The investigated indicators only give an indirect indication of real economic processes, their availability being limited. That is why only cautious conclusions can be drawn from their analysis.

Other economic indicators, governmental and institutional factors, social and human development indicators, environmental consequences can be analyzed further and access to these data is a significant limitation.

A further development opportunity is to change the number and composition of the provinces and to compare the analysis with the results of other countries.

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Trend Assessment and Comparison of Primary Renewable Energy Consumption in the European Union and India: Possibilities after Covid-19 and War

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Abstract: This paper is an attempt to bring attention to the ways in which global renewable energy consumption has been transforming, by the recent shocks in the energy markets caused by the covid-19 pandemic and the war in Ukraine. Evaluating global trends would require a much more extensive study, yet this article attempts to make empirical conclusions, by observing the trend in percentage changes in unconventional energy consumption time series data, collected over the span of 10 years from the European Union and India. A trend analysis of these characteristics can be useful in making informed predictions for formulating renewable energy policies, to reduce interdependency on other countries, supply chains and political instabilities. The comparison between the European Union and India is justified on the grounds of size and their similar dependency on neighboring superpowers for fulfilling domestic energy needs. In conclusion, this study proposes to focus on the untapped potential of the EU-India relationship and to mutually strengthen their position in Europe and Asia. India has an abundance of non-renewables and the potential for generating renewable energy, which the EU can tap into, via new energy trade agreements. In exchange, the EU has the expertise and technical resources to provide backing to the energy initiatives of India.

Keywords: Renewable and non-renewable energy; primary energy consumption; geo-politics; trend analysis

1 Introduction

The aftermath of the past 3 years of a constant chaos, in global energy markets, has left a lot of economies with high inflation, higher cost of living and above all, steep rises in energy prices and supply crisis. The turmoil was largely cause due to the onset of the global Covid-19 pandemic followed by the political unrest in the Russia-Ukraine region leading up to a still on-going war that continues to put pressure on major economies to reform and redirect their energy acquisition strategies to other regions or to more sustainable, domestically available and renewable sources of generating energy to fulfill their population's needs without causing a total collapse of their currency and economy. A number of economies were attempting to recuperate from the effect of Covid-19 all through 2020-21, and now and again managing the post-pandemic rises in prices of energy like oil, gas, and petroleum, the annexation of Ukraine by Russia and the accompanying conflict escalated the energy emergency in the European Union.

The actual barriers put on supply pipelines by Russia and the resulting sanctions placed on Russia for trading have disturbed the energy exchange and brought about skyrocketing energy costs. Based on the insights from World Bank, energy costs are expected to exhibit about 50% increment in price by the end of 2022, which along with different effects of the war might direct the worldwide economies to a recession of a magnitude that has never been experienced in the past. As the EU has critical energy requirements fulfilled from Russian supplies which account for approximately 40% of gas, 25% of fuel, and about half of coal needed in normal conditions. The international unrest pushed the energy emergency in EU, bringing about severe disagreements among the constituting EU states on successfully formulating strategies for sustainable energy consumption and acquisition that could ensure energy security for the member states harmoniously and fairly.

India's stand on the Russian intrusion into Ukraine has been different from the majority of other governments and among U.S. vital accomplices. Regardless of its disagreement with the Ukrainian conflict, the government of India has embraced a neutral stance in the situation. It has avoided giving support to sanctioning Russia in the United Nations Security Council and Human Rights Council. India didn't cast a vote even in the United Nations general assembly on a proceeding that censured Russian animosity in Ukraine and up to this point has declined to openly acknowledge Russia as the agitator of the emergency. India's neutrality has been disheartening on the grounds that it instigated a sharp disparity in US-India relations on a matter of global scale which is utilizing power to annex a democratic country's regions through a glaring conflict beyond any reason. No matter what their perspectives were at the beginning and during the onset of the war, most prominent Indian leaders concede their country's discretionary nonpartisanship. It is in other words, “soft-support” of the Russian intentions. This appears to be especially hypocritical since India stands side by side with the US in restricting Chinese forces in the Indo-Pacific while simultaneously seeming lenient toward the boundlessly more terrible Russian actions in Europe.

2 Literature Review

The Covid-19 pandemic has had a significant impact on global renewable energy consumption. Renewable energy consumption has been affected due to the decrease in economic activity, disruption of supply chains, and reduced investments in clean energy. The war in Ukraine has also had an impact on renewable energy consumption as the conflict has disrupted energy supply networks and prevented new investments in renewable energy projects. About the reaction of the war on the European Union, Umar et al. quote that EU was the first clean and conventional energy market that suffered an immediate set-back from the day 1 since the escalation of the war in Ukraine [1]. Additionally, the decrease in oil prices has reduced the incentive to invest in renewable energy, leading to a decrease in renewable energy consumption. While supporting Ukraine may also help the European Union to tap into the abundance of critical resources available within the regions of Ukraine when the market prices are as low as in 2022 [2].

The European Union (EU) and India have both experienced a decline in renewable energy consumption due to the impacts of Covid-19 and war. In the EU, the decline in renewable energy consumption has been primarily due to the decrease in demand for electricity caused by the pandemic. As in the case of Hungary, a member of EU since 2004 but not a part of the Euro-zone suffered due to the energy price shocks and it had an effect on the currency exchange rates too[3]. The inflation in the Euro-zone as well as in the members of the EU will evidently keep increasing in the foreseen future if the Ukraine-Russia conflict continues [4].The EU can also exchange its experience and technology to support a post-war Ukraine to rebuild itself using the technology to produce and store unconventional energy resources such as solar and wind energy [5]. Ukraine itself is currently is still heavily dependent on conventional energy as many post-Soviet Union countries with high carbon-footprint [6].

In the context of India, the ties between India and Russia are far to complex and go deeper than just trade and geopolitical cooperation and the inter-dependency creates a sense of neutral stance of India in the conflict [7]. In India, the decline has been due to a combination of factors, including reduced economic activity, the impacts of conflict in Kashmir, and the lack of access to funds for renewable energy projects [8]. In the EU, renewable energy consumption decreased by 5.3% in 2020 compared to 2019, while in India it decreased by 4.3%. This decline was especially pronounced in the EU due to the significant drop in electricity demand in the wake of the pandemic. In comparison, India's decline was due to a combination of factors, including a significant decrease in economic activity, the conflict in Kashmir, and the lack of access to funds for renewable energy projects. The outlook for renewable energy consumption in both the EU and India is uncertain. In the EU, renewable energy consumption is expected to rebound in 2021, although the growth rate is likely to be lower than pre-pandemic levels. In India, the outlook is less certain, as the impacts of the pandemic.

The COVID-19 pandemic had a significant impact on electricity prices in the European Union (EU). In the early stages of the pandemic, electricity demand decreased significantly as a result of lockdowns and other measures to curb the spread of the virus. This led to a drop in electricity prices, as excess supply outstripped demand. In the latter stages of the pandemic, as economies began to recover and demand for electricity increased, prices began to rise again. Based on the evidences from Italy shared by Pizarro-Irizar in a recent article, the effect on the electricity cost in the country due to the pandemic was rapid, significant but not long-lasting [9].

Overall, the impact of COVID-19 on electricity prices in the EU was complex and varied, depending on the specific circumstances in each country. Some countries saw prices decline, while others saw prices rise. The specific impact on electricity prices also varied depending on the type of electricity generation and the mix of sources used in each country.

2.1 Impact on Accessibility to Energy

The accessiblity to renewable energy is different in developed and developing countries around the world. A typical assumption is that India would have lesser access to renewable energy resources but statistically it has been the biggest consumer of renewable energy besides super powers like the United states and China [10]. The Covid-19 pandemic has had a significant impact on renewable energy consumption in the world. The pandemic has caused a decline in the number of people who are able to access clean energy, and this decline has had a knock-on effect on the renewable energy sector. In particular, the Covid-19 pandemic has led to a decline in the number of people who are able to access solar energy, as this technology is particularly reliant on sunlight. This has had a knock-on effect on the global market for solar panels, and this has led to a decline in the price of these panels. In addition, the Covid-19 pandemic has led to a decline in the number of people who are able to access wind power, as this technology is particularly reliant on wind. This has had a knock-on effect on the global market for wind turbines, and this has led to a decline in the price of these turbines.A 2017 study by Acemoglu, suggests that a sudden focus on renewable energy, over non-renewable energy sources, can cause a price instability in the energy market and hence have an effect on the welfare of society or purchasing power of the countrys' population [11].

2.2 Determinant Factors of Renewable Energy Utilization which were Affected by COVID-19 and War

There are several factors that can affect the development of renewable energy sources. The determinants factors within the European Union were studied by Tu et al. in 2022 and concluded that highly developed economies with high employment in the advanced technology industry, sustainability driven policies and high economic freedom per capita were the biggest driving forces for improvement in renewable energy and its consumption [12]. The common determinents for alternative energy consumption between European Union and India are:

- Government policies and incentives: Both the EU and Indian governments play a significant role in promoting the development of renewable energy through policies such as subsidies, feed-in tariffs, and renewable portfolio standards through various programs implemented over the years.
- Technological advancements: As renewable energy technologies improve and become more cost-effective, it becomes easier to develop and deploy them. In India there is a necessity to rapidly develop technologies which can manage to sustain the demands of the large population.
- Natural resources: Some regions may have an abundance of natural resources such as sunlight or wind, which can make it easier to develop renewable energy projects. Both the EU and India have huge potential for producing energy from windmill and solar panel installations.
- Public attitudes: Public attitudes towards renewable energy can also play a role in its development. If the public is supportive of renewable energy, it may be easier to gain political and financial support for projects. There is a sudden change in the perception of the masses all over the world after the pandemic and the energy crisis due to the war. People have come to the realization that every single individual is directly or indirectly afftected by the disruption caused by these unprecedented events.
- Financial considerations: The cost of renewable energy technologies is an important factor in their development. As the cost of renewable energy continues to decline, it becomes more competitive with traditional energy sources. Due to technoligical advancements, the cost of producing and distributing renewable energies has come to a very competive level with usual energy supplies and not at a premium anymore.
- Energy demand: The demand for energy can also influence the development of renewable energy. As demand increases, the need for new energy sources may drive the development of renewable energy technologies. It is common knowledge that non-renewables are on consistant depleting curve and are not replenishable but the demand for energy is ever increasing in contrast to the availability.

In a 2022 study, Olabi et al. suggest that a governmnt driven stimulus package can help recover from the disruption that the energy market is facing due to the war and continued affects from 2019 due to the pandemic [13]. The European Union (EU) has implemented a number of policies and incentives to promote the development of renewable energy. Below is a table comparing the various initiatives, programs and incentives implemented and encouraged by the European Union and the Indian government:

Table 1
Comparision of Government initiatives for Renewable energy development

Initiatives	**India**	**European Union**
Renewable energy directive		The EU's Renewable Energy Directive sets targets for member states to achieve a certain share of their energy mix from renewable sources by a certain date [14].
Feed-in tariffs	The Indian government provides feed-in tariffs to support the development of renewable energy projects, with higher tariffs for certain technologies such as solar and wind [15].	These are financial incentives that support the development of renewable energy by providing a fixed payment for every unit of electricity produced from renewable sources [16-17].
Renewable energy support schemes/funding	The government provides financial support to help cover the costs of developing renewable energy projects, such as through grants and low-interest loans [18].	These schemes provide financial support to help cover the costs of developing renewable energy projects, such as through grants or low-interest loans [19].
Renewable energy quota systems/obligations	Under these obligations, power distribution companies are required to source a certain percentage of their power from renewable energy sources [20].	Under these systems, energy companies are required to source a certain percentage of their energy from renewable sources or purchase credits from renewable energy producers [21].
Tax incentives	The Indian government offers tax incentives for the development of renewable energy projects, including income tax exemptions and customs duties exemptions on certain equipment [22].	

3 Methodology

The method that can be used to compare time series data on renewable energy consumption between EU and India are statistical test such as a Mann-Whitney U test or a Wilcoxon rank-sum test to compare the two time-series. These tests are similar to the two-sample t-test, but they are more robust to violations of the assumptions of normality that are required for the t-test. The Mann-Whitney U test was developed by Henry Mann and Donald Whitney in the 1930s. It is also known as the Mann-Whitney-Wilcoxon test, the Wilcoxon rank-sum test, or the U test [23].

The Mann-Whitney U test is a nonparametric statistical test that is used to compare the median of two independent samples. It is often used in social science research because it does not assume that the data is normally distributed, which is a common assumption for many parametric statistical tests. The test can be used to determine whether there is a statistically significant difference between the two samples in terms of the median value of the variable being measured. The test is often preferred in social science research because it is less sensitive to deviations from normality than parametric tests, and it can be used with small sample sizes. To interpret the result of a Mann-Whitney U test, we look at the test statistic (U) and the p-value. The test statistic is calculated based on the ranks of the values in the two samples, and it reflects the difference between the two samples. The p-value is the probability of obtaining a test statistic at least as extreme as the one observed, given that the null hypothesis is true.

If the p-value is less than the alpha level (the level of statistical significance that has been chosen), then it can be concluded that there is a statistically significant difference between the two samples. In other words, the difference between the two samples is not likely to have occurred by chance alone.If the p-value is greater than the alpha level, then the null hypothesis cannot be rejected, and the conclusion is that there is not a statistically significant difference between the two samples.In this study we have utilised the Mann-Whitney U test which is a statistical test that is used to determine whether there is a significant difference between the means of two independent samples.

To perform a Mann-Whitney U test, we first needed to organize the data obtained from source into two separate samples, one for each country. We acquired our data from a highly acclaimed and trusted secondary data source for energy related statistics called the ourworldindata.org. The data was prepared for the calculation by adding up the renewable energy consumption from solar, wind, hydro and other renewable energy resources as total to be used for the nominal variable used for the analysis. We then calculated the means and standard deviations of each sample, and used these values to compute the Mann-Whitney U value. This resulting value is a measure of the difference between the means of the two samples, standardized by the standard deviations of the samples.

If this value is significantly different from 0, it suggests that there is a significant difference between the means of the two samples, and that this difference is unlikely to have occurred by chance. In this case, with a value of 8, we can conclude that there is a significant difference in energy consumption between the two countries.

The details of the method are elaborated as below:

To reach conclusive evidence for the topic understudy we came up with the below null and alternative hypothesis. Then based on the descriptive statistics produced by inputting the data sets, a Mann-Whitney U test was performed to test the hypothesises.

Null hypothesis	**Alternative hypothesis**
There is no difference between the European Union and India groups with respect to the dependent variable total renewable energy consumption (TWh)	There is a difference between the European Union and India groups with respect to the dependent variable total renewable energy consumption (TWh)

Table 2

Descriptive statistics

		N	**Mean**	**Median**	**Standard deviation**
Total renewable energy consumption (TWh)	European Union	10	28.39	20.46	22.63
	India	10	81.52	77.83	42.55

The results of the descriptive statistics show that the European Union group had lower values for the dependent variable Total renewable energy consumption (TWh) (Mdn = 20.46) than the India group (Mdn = 77.83).

Table 3

Mann-Whitney U

	Values
Mann-Whitney U	8
Z	-3.17
Asymptotic Significance (2-tailed)	0.001
Exact Significance (2-tailed)	0.001

The result of the Mann-Whitney U-Test showed that the difference between European Union and India with respect to the dependent variable Total renewable energy consumption (TWh) was statistically significant, U=8, p=.001, r= 0.71. Thus, the null hypothesis is rejected.

The results show that there is a significant difference between the consumption between EU and India and also that, India consumes much more renewable energy compared to the European Union. Thereby, the effect of Covid-19 and the war would be much more adverse on the economy of the European Union which is much more dependent on the traditional forms of energy generation compared to India which has been tapping into the renewable resources since before the pandemic and the war.

4 Discussion

The COVID-19 pandemic has caused a global economic recession, and the EU has been hit particularly hard due to its reliance on international trade and tourism. Many countries in the EU have implemented lockdowns and other measures to slow the spread of the virus, which has disrupted supply chains and led to a decline in consumer spending. The economic downturn has also led to job losses and an increase in government debt as countries have implemented fiscal stimulus measures to support their economies.

The conflict in Ukraine has also had negative economic consequences for the EU. The conflict has resulted in economic sanctions being imposed on Russia, which is a major trading partner for many EU countries. The sanctions have disrupted trade and led to economic losses for both the EU and Russia. In addition, the conflict has led to an increase in energy prices, as the EU relies on Russia for a significant portion of its energy needs. The increase in energy prices has had a negative impact on the EU's economic growth. The European Union (EU) has made a significant contribution to the development of renewable energy in its member countries. The EU has set ambitious targets for the use of renewable energy, including a goal of achieving at least 32% of the EU's energy consumption from renewable sources by 2030. To achieve this goal, the EU has implemented a number of policies and programs to support the development of renewable energy. The Renewable Energy Directive, which sets binding targets for the use of renewable energy in the EU and provides a framework for promoting renewable energy at the national and EU level.The European Investment Bank, which provides funding for renewable energy projects in the EU through loans, guarantees, and other financial instruments.

The European Fund for Strategic Investments, which helps to finance renewable energy projects and other investments that support the transition to a low-carbon economy.The Horizon 2020 research and innovation program, which provides funding for research and development projects related to renewable energy, including projects focused on developing new technologies and improving the efficiency of existing technologies.Overall, the EU has played a key role in supporting the development of renewable energy in its member countries and promoting the transition to a low-carbon economy.

On the other hand, India has a rapidly growing economy and a large population, and as a result, energy demand in the country has been increasing over the past several decades. Between 2010 and 2019, India's primary energy consumption increased by an average of 5% per year. The main sources of energy in India are coal, oil, and natural gas, and the country is also increasing its reliance on renewable energy sources such as solar and wind power. In recent years, India has implemented various policies and initiatives to increase energy efficiency and reduce the country's reliance on fossil fuels. These efforts have included the implementation of energy efficiency standards for buildings and appliances, the expansion of renewable energy generation capacity, and the promotion of electric vehicles.

India has a diverse mix of renewable energy resources, including solar, wind, hydropower, bioenergy, and geothermal energy. Solar energy is a particularly important renewable resource in India. The country has a large solar potential due to its abundance of sunshine, and it has made significant investments in solar power generation in recent years. As of 2021, India had an installed solar power capacity of over 40 GW, making it one of the largest solar markets in the world. The government has set a target of achieving a total installed solar power capacity of 100 GW by 2022.

Wind energy is also an important renewable resource in India. The country has a large wind energy potential, particularly in the coastal areas and in the western and southern states. As of 2021, India had an installed wind power capacity of over 48 GW, making it the fourth largest wind market in the world. Hydropower is another important renewable resource in India. The country has a large hydropower potential, with a total installed capacity of over 45 GW as of 2021. The government has set a target of achieving a total installed hydropower capacity of 145 GW by 2024.Bioenergy, including biomass and biofuels, is another important renewable resource in India. The country has a large potential for bioenergy production, particularly from agricultural residues and forestry waste. As of 2021, India had an installed bioenergy capacity of over 10 GW. Geothermal energy is a lesser-known renewable resource in India, but the country has a small potential for geothermal power generation. As of 2021, India had an installed geothermal power capacity of just over 0.5 GW.

The European Union (EU) and India are both large, diverse regions with a range of technological capabilities. the EU and India have a strong trade relationship and have signed a number of agreements to promote cooperation in various sectors, including energy. For example, the EU-India Energy Dialogue is a forum for discussing energy issues and promoting cooperation in areas such as renewable energy, energy efficiency, and clean coal technology. In addition, the EU and India have signed a Memorandum of Understanding on Energy Cooperation, which aims to strengthen their partnership in the energy sector through exchanges of information, technical assistance, and research and development.When comparing the level of each regions capability in tackling with the disruption caused by Covid-

19 and the war, we also have to consider the comparison of advanced technology the production and implementation of these resources in these two regions:

Research and development: The EU is known for its strong research and development sector, with many world-class universities and research institutions. It is a leader in fields such as biotechnology, renewable energy, and information and communication technologies (ICT). India also has a growing research and development sector, with a particular focus on software engineering and IT services.

Infrastructure: The EU has a highly developed infrastructure, with advanced transportation systems, reliable electricity and water supplies, and widespread internet access. India's infrastructure is not as well-developed, with some significant disparities between urban and rural areas.

Industrial base: The EU has a diverse industrial base, with strong manufacturing sectors in fields such as automotive, aerospace, and pharmaceuticals. India's industrial base is also diverse, with a particular focus on textiles, chemicals, and engineering.

Overall, it is difficult to make a direct comparison between the level of advanced technology in the EU and India, as both regions have their own strengths and areas of focus. However, the EU is generally considered to be more technologically advanced in due to its strong research and development sector and well-developed infrastructure.

The discussion below follows the interpretations made by observing the changes in percentage consumption of energy from eight different energy sources namely, coal, gas, oil, solar, wind, nuclear, hydro-power and some other resources of renewable energy. It is important to highlight that for better representation, the graphs are divided between the no-renewable and renewable energy consumption categories. The differentiation also assists in comparing the dependency on each type of resources. The first figure is the representation of the percentage change in utilization of non-renewable energy within all the member countries of the European Union.

As represented in Figure 1, in the span of 9 years between 2012 to 2020, the EU had gradually decreased its dependency overall on all the non-renewable energy sources but after the set-back from Covid-19 pandemic, there seems to be a drastic increase in the consumption of these resources in 2021. The least amount of deviation, thereby stable demand in EU is for gas. The change in consumption of coal increased only in 2021 out of all 10 years in comparison. This is evidence of the effect of the pandemic on the energy consumption volumes in the region.

Figure 2 depicts the percentage change in the consumption of renewable energy resources in the European Union between 2012 to 2021. As per observation, it can be interpreted that the after the onset of pandemic, regions in the European Union started to increase the consumption of nuclear and other unconventional energy resources, while the usage of hydro and wind generated energy reduced from 2019 to 2021.

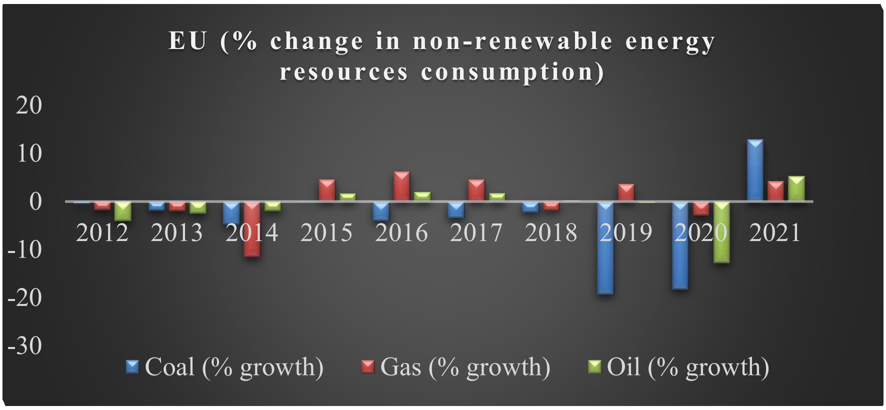

Figure 1
OurWorldInData.org [24]

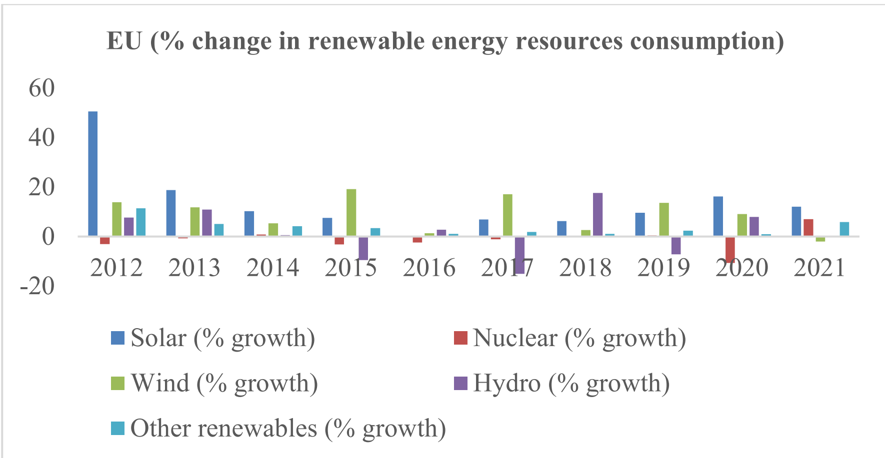

Figure 2
OurWorldInData.org [24]

Figure 3 represents the same statistics as in Figure 1 but in the case of India in the span of 10 years. In 2021, we see the largest spike in the utilization of coal as a source for conventional energy while in 2020 both coal and oil consumption were much lower due to long and strict lockdowns put into action by the government of India to curb the spread of coronavirus. Therefore, once the lockdowns were lifted, we can see an increase in demand for all kinds of fuels and energy.

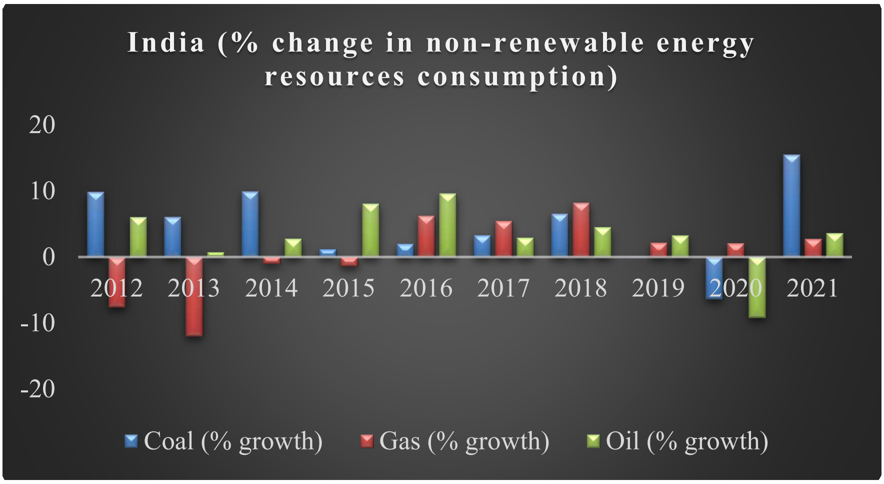

Figure 3
OurWorldInData.org [24]

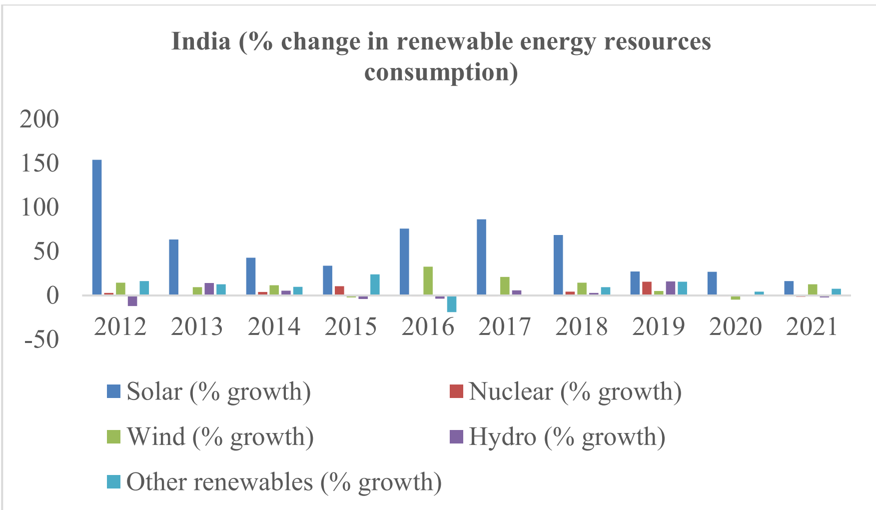

Figure 4
OurWorldInData.org [24]

The above Figure 4, is also the same statistic as Figure 2, for India and it portrays the inferences from the literature that we found that India has already been at the forefront of development, acceptance, implementation and consumption of renewable and unconventional energy resources compared to the European Union and therefore, no drastic or unusual trend is observed. Nonetheless, it can be still noted that the overall it was more volatile until 2019 before the onset of the Covid-19 pandemic.

Conclusions

This paper discusses the impact of the COVID-19 pandemic and the war in Ukraine on global primary energy consumption. It uses data from the European Union and India to evaluate trends in primary energy consumption over the past 10 years and make predictions about the future. The authors suggest that a focus on the relationship between the EU and India could help both regions strengthen their positions in Europe and Asia, with the EU providing expertise and technical resources to support India's energy efforts and India offering non-renewable and renewable energy resources to the EU through new trade agreements. The paper concludes by proposing that such a partnership could help reduce dependence on other countries and political instability.

The COVID-19 pandemic has had a significant impact on the non-renewable energy sector. The sharp drop in global demand for energy due to lockdowns and economic downturns has led to a decrease in the price of oil, natural gas, and other fossil fuels. This has had a negative impact on the profitability of many non-renewable energy companies, and some have had to reduce production or shut down operations temporarily. In addition, the pandemic has disrupted supply chains and transportation systems, which has affected the production and distribution of non-renewable energy sources. Finally, the focus on renewable energy and the push to reduce carbon emissions in response to the climate crisis has gained renewed momentum during the pandemic, leading to increased competition for non-renewable energy sources.

Wars can have a significant impact on the global energy market, as they can disrupt the production, transportation, and distribution of energy resources. Though we can use different economic models based on historical experiences to predict the implications of the Russia-Ukraine conflict, the outcomes of war in the modern world can be drastically different and long-lasting as seen in not so old geo-political crisises. The situation of resource rich Russia can be identical to the oil-producing regions, such as the Middle East and North.

Africa, where crisis lead to shortages and price spikes, as happened during the Gulf Wars in the 1990s. Wars can also lead to the destruction of infrastructure, such as oil rigs and pipelines, which can disrupt production and transportation. Additionally, the uncertainty and instability caused by wars can discourage investment in energy projects, leading to a decline in production and supply. Overall, wars can have significant and long-lasting impacts on the global energy market and can lead to significant economic consequences for both the affected region and the global economy.

The way forward from here, can be to await the more comprehensive data and statistics published for 2022 in 2023 and perform extensive studies further with different combination of countries and entities like European Union, to predict the effect of such crisis and conflicts in the future.

The limitations we faced in the formulation of this article were as fundamental as not having access to the latest and factual developments in the conflict in real time and therefore, the situations discussed here may change rapidly within a matter of days. Another limitation was the lack of availability of data for the year of 2022, which will only be published by the source in 2023.

Conflict of Interest

The authors declare no conflict of interest.

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