R&D - An Innovation Catalyst for Achieving the Sustainable Development Goals

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Abstract

Innovation is a critical instrument for achieving the SDGs, playing a key role in promoting a sustainable society. In this context, technology and innovation could simultaneously integrate the three dimensions of sustainable development: economic, social and environmental. The present paper explores the impact of innovation from the perspective of R&D on these three pillars, pointing out its role for economic progress, social advancements and environmental conditions, in the case of the European Union countries. The paper starts with qualitative research of the latest specialized literature regarding the SDGs and their relation with technology and innovations, highlighting important outcomes brought by innovation on economy, society and environment. The research continues with a quantitative analysis conducted on the basis of a correlation model along with three regression analyzes that aim to capture the influence of the level of R&D on the sustainability pillars. Thus, this paper affirms and strengthens the catalytic role of innovation for sustainable development. The added value of the paper is brought by the contribution to studies on the situation of EU states in terms of R&D and their potential to achieve the SDGs. Findings from regression analyzes can provide valuable information for parties involved in public policy or private companies. This information could be a starting point for a better allocation of resources towards the innovation area, but also for the formulation of integrated strategies in the R&D sector.

Keywords

Innovation, SDGs, Research and Development, Sustainable Development, Sustainability Pillars

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Introduction

Unfolding throughout human history, we see that transitions have been driven by technological as well as institutional innovations, which resulted in new forms of social and economic organization that have gradually expanded the energy and material use. The 2030 Agenda together with its Sustainable Development Goals (SDGs) promote sustained economic prosperity, social inclusion and environmental sustainability, along with technological innovation (García Zaballos, Iglesias Rodriguez and Adamowicz, 2019). According to UNDP 2020, empowering people and promoting stewardship should become central to what it means to live a good life alongside easing planetary pressures. It is largely accepted among researchers and stakeholders that innovation is a key driving force for sustainable development, which is why the implementation of the SDGs shall be made through an integrated global innovation system that connects regions, joins production alongside with relevant information and technology (YiĞiT, 2021).

In this context, the paper discusses the catalytic role of innovations, with respect to Research and Development (R&D) in achieving the SDGs, by analysing the impact of innovation on each of the three pillars of sustainable development at the European Union level. Throughout this paper, we aim to examine to what extent the economic, social and environmental dimensions are interconnected and how the R&D of new technologies can influence the magnitude of their impact on society and the planet. We define the concept and the context of sustainable development, then we explain the place of innovation in the equation, with respect to each sustainability pillar. The research continues with a quantitative analysis based on three regression models that are going to prove the role of innovation for sustainable development pillars and, consequently, for sustainable development as a whole.

The paper contributes to the studies on identifying the importance of innovation, from the perspective of R&D, in achieving the SDGs at the level of the 27 EU states. We consider that the findings on the analysis of these dimensions can provide valuable information for the policy and decision makers. In this way, key players will be able to elaborate and implement policies that will lead to a better allocation of resources supporting R&D and investments in ICT (Information and Communication Technologies) sector. This will create a safe and favourable environment for emerging technologies and innovations.

1. Review of the scientific literature

The 2030 Agenda for Sustainable Development adopted in 2015 by 193 heads of government at the United Nations General Assembly represents a holistic approach to global efforts for achieving sustainable development, emphasising strategies for ending poverty, promoting peaceful and inclusive societies as well as helping tackle climate changes. It was designed as a plan of action which encompasses a comprehensive list of 17 SDGs and 169 related targets which integrate the economic, social, and environmental dimensions of sustainable development (García Zaballos, Iglesias Rodriguez and Adamowicz, 2019). Although the SDGs are not legally binding, governments are called for a global partnership to ensure its implementation and they are expected to establish national frameworks for achieving the 17 goals. The EU together with its Member States pledged to play an active role in maximizing progress towards the 2030 Agenda, fully integrating the goals into the European policy framework (Eurostat, 2021).

Today's challenge is to achieve a sustainable future for all in a safe and equitable operating space. However, there are significant inequalities between and within societies, with billions of people left behind and overwhelming evidence of global risks due to increasing human pressure on Earth. Ensuring future sustainability will require social and economic development that will improve overall human well-being while maintaining the resilience of the planet (Nakicenovic, et al., 2019). Beyond its key role in a country's competitiveness, innovation will lead to optimal use of limited resources, providing relevant answers to the challenges of our commitment to sustainable development in terms of economic growth, environmental preservation and social progress (Omri, 2020).

Sustainable innovations can be defined as the development of a new process, service, product or technology that contributes to the development and satisfaction of human needs and with respect to natural resources and the ability to recreate them in the environment (Tello and Yoon, 2008). Therefore, innovations are not just a key to achieve the economic growth and improvement of the standard of living, but they are also essential for orientation towards the path of sustainable growth. Supporting innovations is one of the aims of the 2030 Agenda for Sustainable Development, included in the Goal 9 - *Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation* (Szopik-Depczyńska, et al., 2018).

European Union indicates that the development of ICT is vital for Europe's competitiveness in today's digitalized world economy. During the 2014–2020 funding period, the European Regional Development Fund (ERDF) set aside more than 20 billion euros for investments in ICTs and the European Commission established the Digital Europe 2021–2027 program, which aims to support the digital transformation of Europe's economy and society, and thus bring its benefits to European citizens and businesses (Mozas-Moral, et al., 2020).

According to numerous studies, the concept of sustainability includes three interconnected pillars, environmental, economic and social, which are also called the "Triple Bottom Line" (TBL) (Jum'a, et al., 2022). Given the challenging nature of sustainability, the TBL concept was proposed to support and operationalize sustainable development implementation, also employing to attain a proper balance between the goals and targets at different levels (Ranjbari, et al., 2021).

As we can see in figure 1, all three pillars are highly interconnected. A socially resilient society is the place where basic human needs are fulfilled within stable yet dynamic societies. Economic pillar focuses primarily on healthy economies that can provide a high quality of life for people, but usually it also involves identifying alternative economic paths that could provide a safer future without compromising the natural systems. Environmental sustainability involves defining an existing boundary to meet people's current needs without sacrificing the ecosystem's quality (YiĞiT, 2021).

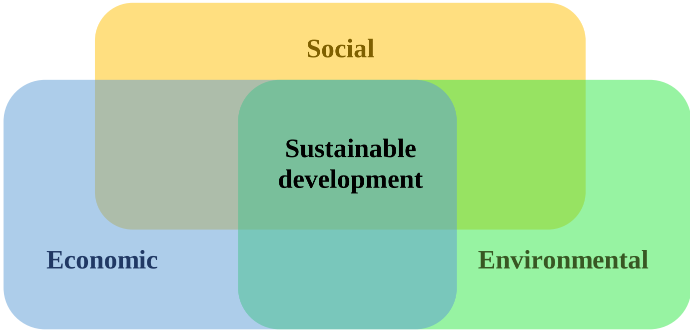

Figure no. 1. Overlapping pillars of sustainable development

Source: (Howaldt & Scwarz, 2017), (Cook & Davíðsdóttir, 2021), (Ardiwinata, et al., 2021)

Social progress - Innovation is a precious tool for developing human potential that can break the cycle of poverty. It has a positive impact on people's productivity, as well as on access to better quality goods and services and on life expectancy, providing solutions such as self-management tools that are accessible in people’s living environments (Omri, 2020). Internet and technology access provide new and free online educational resources, eliminating barriers to achieving universal quality education. Moreover, innovations in healthcare have provided physicians with new resources to improve patients' health. Real-time patient monitoring provides physicians with real-time data on patients' health, leading to improved diagnostics, cost and time savings (García Zaballos, Iglesias Rodriguez and Adamowicz, 2019).

Environment sustainability - The climate change is causing dangerous and devastating effects on the world. Recent studies have shown that climate change is jeopardizing progress on all the SDGs, as their findings suggest that climate change mitigation would directly benefit goals that are related to welfare, poverty eradication and employment, energy and water availability, health or ecosystems quality (Fuso Nerini, et al., 2019). Current mitigation pledges fall short of the Paris Agreement's temperature goals of limiting warming below 2°C, leading instead towards at least 3°C of warming by 2100. Limiting warming requires stabilizing atmospheric concentrations of greenhouse gas (GHG) by achieving net-zero global GHG emissions (Honegger, Michaelowa and Roy, 2021) and innovation together with R&D can help reduce these emissions by using more energy-efficient production technologies, changes in fuel mix and the installation of end-of-pipe technology (Omri, 2020).

In agriculture, IoT solutions can monitor environmental and soil conditions, helping farmers decrease production costs and waste and contribute to a more sustainable agriculture by predicting the optimal amount of water and agrochemicals. Innovations for Life Under Water (SDG14) include satellite maps that help track endangered animal migration patterns, monitor oxygen levels, global fish stocks or ocean currents. Innovations for life ON LAND (SDG15) help monitor waterflows, wind patterns, desertification, floods, terrestrial ecosystems and the state of the planet (García Zaballos, Iglesias Rodriguez and Adamowicz, 2019). As climate change related challenges are the biggest environmental problems humanity is facing, a sustainability roadmap needs to be urgently adapted (Mauree, et al., 2019).

Economic growth - According to growth theory, innovation leads to increased technological progress and, consequently, to economic productivity. Moreover, it has been found that a greater number of patents leads to technological progress, which promotes economic growth (Omri, 2020). In addition to this, innovation is closely linked to the company’s performance and represents one of the driving forces for a country’s economic and sustainable growth. The entrepreneurship literature recognizes that companies that adopt and develop innovations are more likely to thrive in highly competitive environments (Tóth, et al., 2020).

The interconnectivity between SDGs - Achieving the sustainable development requires the complex interaction of environmental, economic and social processes, from local to global dimensions. Investigating the interlinkages among SDGs is key to unlocking their full potential as well as ensuring that progress in one area is not made at the expense of another. Interlinkages can be identified as negative (trade-offs), when improvements in one dimension can constrain progress in another one, or in contrast, positive (synergies), when achieving one target, can also help achieving another one (Eurostat, 2021). It is particularly important to have control over the consumption of natural resources, especially non-renewable ones, and to monitor the state of the natural environment (Yigitcanlar and Teriman, 2015). Researchers claim that the success of a sustainable environmental policy requires first and foremost cooperation between the public and private sectors (Arbolino, et al., 2018).

2. Research methodology

According to specialized literature and to past performed analyzes, innovation seems to be a catalyst for all the other SDGs. In accordance with this idea, this study aims to examine the impact of R&D, as a key component of innovation, on the pillars of sustainable development for the 27 EU states.

Throughout the study, nonparametric correlation methods as well as regression models were conducted using SPSS software (26 version) in order to analyze the interdependencies between innovation, through the research and development component and the variables specific to each pillar - economic, social and environmental. The data for variables refer to the most recent year available for each of them (varying from 2018 to 2021).

The variables belonging to R&D dimension (innovation) chosen for the analysis are R&D personnel and Scientific and technical journal articles, included in the specific indicators corresponding to Goal 9. In order for the indicator related to *Scientific articles* to become comparable, it refers in this paper to the number of scientific and engineering articles published in various fields, divided by the number of researchers in a specific country expressed as per million (World Bank, 2022). *The R&D personnel* data are presented in full-time equivalents as a share of the economically active population and refer to the personnel hired in several institutional sectors: business enterprise, government, higher education, private non-profit (Eurostat, 2021).

The social variable is represented by EU Social Progress Index (SPI) and includes 55 indicators and 12 components, representing a direct metric of social progress. The score is calculated based on a 0-100 scale, with 0 meaning the worst performance, 100 the best (ideal) performance (European Commission, 2022). The economic variable is the *GDP* per capita defined as Gross domestic product at market prices and it has as unite of measure chain linked volumes (2010), expressed in euro per capita (Eurostat, 2021). For environmental pillar, we considered *GHG emissions* per capita, which measures total national emissions of the so-called 'Kyoto basket' of greenhouse gases, including carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and the F-gases, and it is expressed in units of CO2 equivalents per capita (Eurostat, 2021).

Given the proposed specifications, the hypotheses we test in this research are the following:

- #1 The first hypothesis assumes that R&D as part of innovation is a determining factor for social pillar in the EU countries.
- #2 The second hypothesis is affirming that the states with a favourable economic situation are the states which also have a higher level of R&D.
- #3 The third hypothesis assumes that innovation is related to the amount of GHG emissions, so the higher level of R&D as part of innovation, the lower the amount of GHG emissions should be.

3. Results and discussion

This paper is seeking to examine the ability of R&D as part of innovation to influence the three pillars of sustainability, thus leading to economic growth and improved environmental and social conditions. The variables included in the analysis are presented in Table no. 1.

Table no. 1. Descriptive statistics for the variables included in the analysis

Variables	Code	Source
Scientific articles per Researcher - total number of scientific articles divided by the number of researchers engaged in R&D in a specific country, expressed as per million	SAR	World Bank
R&D personnel (% of population in the labour force)	RDP	Eurostat
GDP per capita (euro)	GDP	Eurostat
GHG emissions per capita (units of Co2 equivalent)	GHC	Eurostat
EU-SPI (score from 1 to 100)	SPI	European Commission

Source: made by authors based on research.

According to the analyzed data, the smallest number of articles is registered in Malta (422), though if we are to divide it to the number of researchers engaged in R&D, we can see that the minimum value is registered in Luxembourg. On the other hand, the maximum value for the SAR indicator is recorded by Italy, though in terms of number of articles, Germany and France are in the first positions (with 104 and 71 thousand articles, respectively). The largest *R&D personnel* is in Denmark with 2.1% comparing to 0.4% in Romania which has the lowest number, while the average is a shy 1.2% at the EU level.

Regarding the *GDP*, the lowest value is in Bulgaria, approximately 6690 euro per capita, while Luxembourg has the highest GDP, of approximately 8,6550 euro per capita, followed by Ireland (70920 euro per capita) and Denmark (50200 euro per capita).

It is worth noting that Luxembourg is at the top of the EU states ranking of GHG emissions (20.3 metric tons of CO2 equivalent per capita), followed by Ireland (18.8 metric tons per capita) and the Czech Republic (11.7 metric tons per capita). Sweden (5.2 metric tons), Malta (5.3 metric tons) and Romania have the lowest values (5.9 metric tons).

Concerning the *social progress* level, we see important discrepancies among EU states. Finland, Sweden and Denmark are in top 3 with the highest scores of approximately 82 out 100 all three of them. On the opposite side, Romania has the lowest SPI score with only 47.9, outran by Bulgaria with 50.1, and at a greater distance by Greece (56.5).

Table no. 2. Nonparametric Correlations

			SAR	RDP	SPI	GDP	GHG
Spearman's rho	SAR	Correlation Coefficient	1.000	0.131	-.150	-0.001	-0.171
		Sig. (2-tailed)	.	0.514	0.456	.996	0.394
		N	27	27	27	27	27
	RDP	Correlation Coefficient	0.131	1.000	0.769**	.789**	0.381*
		Sig. (2-tailed)	0.514	.	0.000	0.000	0.050
		N	27	27	27	27	27
	SPI	Correlation Coefficient	-0.150	0.769**	1.000	0.853**	0.355
		Sig. (2-tailed)	0.456	0.000	.	0.000	0.069
		N	27	27	27	27	27
	GDP	Correlation Coefficient	-0.001	0.789**	0.853**	1.000	0.398*
		Sig. (2-tailed)	0.996	0.000	0.000	.	0.040
		N	27	27	27	27	27
	GHG	Correlation Coefficient	-0.171	0.381*	0.355	0.398*	1.000
		Sig. (2-tailed)	0.394	0.050	0.069	0.040	.
		N	27	27	27	27	27

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

Source: made by authors based on own research.

Following the application of the non-parametric correlation analysis, a direct, strong and statistically significant link between GDP and SPI is identified (Tabel no.2). At the same time, innovation, from the perspective of R&D staff, is directly correlated with the variables specific to the three pillars. The results of the regression analysis as well as the correlation results determine the elimination of the variable SAR - Scientific articles per Researcher from the following regression models conducted in order to validate the research hypotheses. The diversity of topics addressed in the scientific articles may justify the lack of correlations between SAR and other variables used in the analysis. In this regard, a future direction of research can be outlined to allow the analysis of the interdependencies between the SAR variable - determined on specific topics for each pillar and specific variables to each dimension of sustainable development.

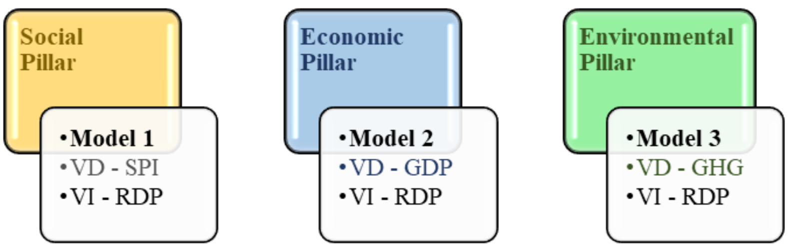

Figure no. 2. Regression models

Source: made by authors based on own research

Thus, for the validation of the research hypotheses, the regression analysis was used having as exogenous variable (VI) RDP - R&D personnel (% of population in the labour force), and as endogenous variable (RV) the specific indicators of each pillar of sustainable development resulting thus three regression models (Figure no. 2). The results of the analysis (Table no. 3) show the validity of the three regression models (sig. <0.05), indicating an influence of innovation, from the perspective of R&D, on the three dimensions of sustainable development, for the 27 states included in the analysis.

Model 1 (Table no. 3) analyzes the regression between research and development as part of innovation and the social dimension. The result obtained validates the first research hypothesis (# 1) thus confirming that R&D influence the social pillar of sustainable development, leading to progress. The positive value of the regression coefficient, indicating a direct link between the two indicators, translates into the idea that the interest shown for the R&D sector is positively correlated with social progress that aims to increase the quality of life.

Table no. 3. Regression results for the three models

Model	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
Model[a1]					
1 (Constant)	48.943	3.111		15.732	0.000
R&D personnel	14.671	2.348	0.781	6.249	0.000
Model[a2]					
2 (Constant)	-3444.383	7385.549		-.466	0.645
R&D personnel	25616.105	5573.949	0.677	4.596	0.000
Model[a3]					
3 (Constant)	5.858	1.557		3.763	0.001
R&D personnel	2.433	1.175	0.383	2.071	0.049

Notes: a1. Dependent Variable: SPI
a2. Dependent Variable: GDP
a3. Dependent Variable: GHG

Source: made by authors based on own research.

Testing the extent to which research and development have an influence on the value of GDP and therefore on economic growth is carried out through the second regression model, which shows that the influence of innovation on GDP is about 70%, which confirms that a high degree of R&D in a state also indicates a high level of economic well-being thus validating the second hypothesis (# 2).

Regarding the last regression model, the focus is on the environmental component of sustainable development. The hypothesis aims to show that R&D leads to a change in the level of GHG emissions. Unlike previous models, the model explains less than 50% the variability of GHG emissions per capita depending on R&D personnel. Although the validity of the model is confirmed, innovation from a R&D perspective does not seem to have a significant influence on the environmental pillar. Moreover, the positive correlation of the two variables indicates an increase in GHG emissions as the level of R&D increases, which dismisses the third hypothesis (# 3). An explanation of this result will be offered in the following rows based on results in other studies from specialized literature.

Recent studies explored the impact of innovation on environmental quality. There are mixed results in terms of the association between innovation and the environment, with a positive, negative or no significant relationship. The heterogenity of findings may be due to the endogenous variables employed, with no clear trend identified for carbon emissions and air pollution (Mongo, Belaïd and Ramdani, 2021).

Although the air emissions intensity of industry has improved since 2013, innovation and developments are rather harmful. For example, in the sector of sustainable transport, new passenger vehicles increased CO2 emissions between 2016 and 2019, having the EU derailing from reaching the 2020 target (Eurostat, 2021). Moreover, the existence of the energy rebound effect should not be ignored. In Xu, et al. (2021) research, it was found that energy output induced by energy rebound effect grow faster in energy-intensive industries, decreasing the carbon emission performance. Innovations may also affect carbon emission performance through urbanization, which can be considered a key factor in the performance of carbon emissions.

While there is no standard method for calculating internet related energy consumption, estimates suggest that approximately 10% of global electricity in 2018 was consumed by ICT. It was found that the carbon footprint of a single Artificial Intelligence system is five times the lifetime emissions of the average car, while the digital economy has a growing material footprint, including electronic waste (UNDP, 2020).

According to Omri (2020) research, the impact of per capita GDP positively contributes to environmental degradation. The magnitudes of 0.094 indicate that a 1% rise in economic growth raises carbon emissions by around 0.1%, confirming that economic growth increases CO2 emissions. In this context, UK economist Nicholas Stern calculated, in his landmark 2006 review, that decarbonisation of more than 3–4% is incompatible with economic growth.

A cornerstone instrument would be *decoupling of economic growth from environmental impacts*. The disconnection between the benefits of economic activity and its costs is not inevitable, but it can be addressed. Decoupling the benefits of economic activity from its costs is essential and its outcome could help put people, societies and nature on the path to sustainable development. The world needs new economic models such as the circular economy with production system that enhance planetary resilience and biodiversity while reducing consumption and waste, ultimately decoupling economic growth from environmental impact. New techniques and substitute technologies help reduce the stress on the global environmental commons (Independent Group of Scientists appointed by the Secretary-General, 2019).

Conclusions

A common agreement of the existing literature is that innovation has a positive impact on the quality of the environment, which is often referred to as a technological effect. Investments in innovation, through R&D, must be made compatible with the environment. In addition, data from the Global Footprint suggest that GDP growth per capita may increase on the long-term CO2 emissions (Mongo, Belaïd and Ramdani, 2021). However, there is no doubt that digital technology is a critical enabler in development. Innovative technologies may ease planetary pressures and advance human development, however, not without associated risks (Omri, 2020).

As a note of caution, inequality contributes to limiting the potential for innovation and increases vulnerability to climate change and environmental threats. A major problem is that development choices are often framed in a set of narrow paths, which ultimately prove to be unsustainable. Therefore, in the face of this complex society, progress must be made in an adaptive quality of learning through practice, fueled by broad innovations and anchored in shared decision-making. Investing in new technologies and their deployment are essential parts of the process, yet embedding them into broader and more fundamental economic and social changes must also be considered. That is why it is important to pursue innovation together with increasing governance and equity.

Although in this paper we looked at the scientific articles in general, which proved not to have a significant influence on our models, in the future studies we will look for the most cited scientific articles, which are more relevant both for their areas of interest, as well as from a practical point of view. Thus, they will become a starting point for identifying policies in a certain field. Likewise, the R&D component itself covers only a small part of the innovation dimension, which is a possible reason why the goodness of fit for the environmental regression model has not been probative. In the future, we will consider an index that integrates more indicators relevant for innovation.

As a closing remark, but with an open ending we can affirm that the transformation towards sustainability must be harmonized with the threats, opportunities and dynamics of the digital transformation, as well as with the goals of the 2030 Agenda.

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References

Arbolino, R., De Simone, L., Carlucci, F., Yigitcanlar, T. and Ioppolo, G., 2018. Towards a sustainable industrial ecology: Implementation of a novel approach in the performance evaluation of Italian regions. *Journal of Cleaner Production*, [online] 178, pp.220–236. https://doi.org/10.1016/j.jclepro.2017.12.183.

Eurostat, 2021. *Sustainable development in the European Union: monitoring report on progress towards the SDGs in an EU context*, [online] Publications Office of the European Union, Luxembourg. Available at: <https://ec.europa.eu/eurostat/web/products-statistical-books/-/ks-03-21-096> [Accessed 12 March 2022].

Fuso Nerini, F., Sovacool, B., Hughes, N., Cozzi, L., Cosgrave, E., Howells, M., Tavoni, M., Tomei, J., Zerriffi, H. and Milligan, B., 2019. Connecting climate action with other Sustainable Development Goals. *Nature Sustainability*, [online] 2(8), pp.674–680. https://doi.org/10.1038/s41893-019-0334-y.

García Zaballos, A., Iglesias Rodriguez, E. and Adamowicz, A., 2019. *The Impact of Digital Infrastructure on the Sustainable Development Goals: A Study for Selected Latin American and Caribbean Countries*. [online] Inter-American Development Bank. https://doi.org/10.18235/0001685.

Honegger, M., Michaelowa, A. and Roy, J., 2021. Potential implications of carbon dioxide removal for the sustainable development goals. *Climate Policy*, [online] 21(5), pp.678–698. https://doi.org/10.1080/14693062.2020.1843388.

Jum'a, L., Zimon, D., Ikram, M. and Madzík, P., 2022. Towards a sustainability paradigm; the nexus between lean green practices, sustainability-oriented innovation and Triple Bottom Line. International Journal of Production Economics, [online] 245, p.108393. https://doi.org/10.1016/j.ijpe.2021.108393.

Mauree, D., Naboni, E., Coccolo, S., Perera, A.T.D., Nik, V.M. and Scartezzini, J.-L., 2019. A review of assessment methods for the urban environment and its energy sustainability to guarantee climate adaptation of future cities. *Renewable and Sustainable Energy Reviews*, [online] 112, pp.733–746. https://doi.org/10.1016/j.rser.2019.06.005.

Mongo, M., Belaïd, F. and Ramdani, B., 2021. The effects of environmental innovations on CO2 emissions: Empirical evidence from Europe. *Environmental Science & Policy*, [online] 118, pp.1–9. https://doi.org/10.1016/j.envsci.2020.12.004.

Mozas-Moral, A., Bernal-Jurado, E., Fernández-Uclés, D. and Medina-Viruel, M., 2020. Innovation as the Backbone of Sustainable Development Goals. *Sustainability*, [online] 12(11), p.4747. https://doi.org/10.3390/su12114747.

Nakicenovic, N., Messner, D., Zimm, C., Clarke, G., Rockström, J., Aguiar, A.P.D., Boza-Kiss, B., Campagnolo, L., Chabay, I., Collste, D., Comolli, L., Gomez-Echeverri, L., Goujon, A., Grubler, A., Jung, R., Kamei, M., Kamiya, G., Kriegler, E., Kuhn, M., Leininger, J., Martin-Shields, C., Mayor Rodriguez, B., Miller, J., Miola, A., Riahi, K., Schewenius, M., Schmidt, J., Skierka, K., Selomane, O., Svedin, U., Yillia, P., Arimoto, T., Colglazier, B., Contejean, A., Dombrowsky, I., Jaluka, T., Lotze-Campen, H., Murray, K., Noussan, M., Roco, M., Spini, L., Stoeckle, M., Van Der Leuw, S., Van Vuuren, D.P. and Zusman, E., 2019. The Digital Revolution and Sustainable Development: Opportunities and Challenges. Report prepared by the World in 2050 initiative. [online] https://doi.org/10.22022/TNT/05-2019.15913.

Omri, A., 2020. Technological innovation and sustainable development : Does the stage of development matter? *Environmental Impact Assessment Review*, [online] 83, p.106398. https://doi.org/10.1016/j.eiar.2020.106398.

Ranjbari, M., Shams Esfandabadi, Z., Zanetti, M.C., Scagnelli, S.D., Siebers, P.-O., Aghbashlo, M., Peng, W., Quatraro, F. and Tabatabaei, M., 2021. Three pillars of sustainability in the wake of COVID-19: A systematic review and future research agenda for sustainable development. *Journal of Cleaner Production*, [online] 297, p.126660. https://doi.org/10.1016/j.jclepro.2021.126660.

Szopik-Depczyńska, K., Kędzierska-Szczepaniak, A., Szczepaniak, K., Cheba, K., Gajda, W. and Ioppolo, G., 2018. Innovation in sustainable development: an investigation of the EU context using 2030 agenda indicators. *Land Use Policy*, [online] 79, pp.251–262. https://doi.org/10.1016/j.landusepol.2018.08.004.

Tello, S.F. and Yoon, E., 2008. Examining Drivers of Sustainable Innovation. *International Journal of Business Strategy*, 8(3), pp.164-169.

Tóth, J., Migliore, G., Balogh, J.M. and Rizzo, G., 2020. Exploring Innovation Adoption Behavior for Sustainable Development: The Case of Hungarian Food Sector. *Agronomy*, [online] 10(4), p.612. https://doi.org/10.3390/agronomy10040612.

Xu, L., Fan, M., Yang, L. and Shao, S., 2021. Heterogeneous green innovations and carbon emission performance: Evidence at China's city level. *Energy Economics*, [online] 99, p.105269. https://doi.org/10.1016/j.eneco.2021.105269.

YiĞiT, S., 2021. An Empirical Perspective on the Relationship Between Innovation Performance and Sustainable Development. *Ege Akademik Bakis (Ege Academic Review)*, [online] pp.47–57. https://doi.org/10.21121/eab.874020.

Yigitcanlar, T. and Teriman, S., 2015. Rethinking sustainable urban development: towards an integrated planning and development process. *International Journal of Environmental Science and Technology*, [online] 12(1), pp.341–352. https://doi.org/10.1007/s13762-013-0491-x.