FISCAL SUSTAINABILITY TO SUSTAINABLE ECONOMIC DEVELOPMENT IN THE ERA OF DIGITAL TRANSFORMATION

Emilia Mioara Câmpeanu[1]

Abstract: *Countries are thrust into a quadruple transition to revision of the economy by enhancing a more competitive, sustainable, inclusive and resilient society. In this context, the paper aims to investigate how fiscal sustainability induces sustainable economic development while considering the impact of digital transformation and climate challenges for 27 European Union (EU) countries. The novelty approach involving data covering multidimensional facets of the quadruple transition and panel regressions brings new perspectives and approaches for sustainable economic development of EU contributing to the knowledge creation. The research findings highlighted that the less fiscal policy is sustainable, the more sustainable development is affected with a pronounced reaction due to short-term sustainability issues, while digitalization, climate change, trade openness and some socio and governance variables are engine for sustainable development.*

Keywords: *fiscal sustainability, sustainable development, digital transformation, climate change, governance, EU countries.*
JEL: *H39, O38, Q01.*

1. Introduction

The need to preserve the access of future generations to current resources is imperative today by designing better policies with the right trade-offs between pitfalls and priorities. Intergenerational equity is assessed by acquiring the sustainable development goals (SDGs) while encountering turbulences coming from technology, climate and exacerbated fiscal imbalances and debt. These four pillars of the new age of turbulence induce a dilemma in applying adequate measures to tackle the quadruple transition for a more reliable and livable life for current and future generations. The widening gap between advanced economies and emerging and developing economies threatens the progress in achieving the SDGs, spotlighting the disparities among the development perspectives due to the multi-speed pattern. The effects of the desynchronised pattern of development are doubled by the 'fiscal blind spot'. For example, relying on Eurostat data for 27 EU countries, the gap between emerging and developing economies and advanced economies is of 1.03 for economic growth mixed with 2.75 for public debt dynamic, compared 2023 with 2000. Therefore, growth-friendly fiscal sustainability, doubled with climate changes and digital transformation, is not only a necessity but, above all, an integral pathway to sustainable development, switching from short to medium- and long-term goals and enhancing a more competitive, sustainable, inclusive and resilient economy.

[1] *Emilia Mioara Câmpeanu, Professor PhD, Bucharest University of Economic Studies, Faculty of Finance and Banking, Department of Finance, Romania, emilia.campeanu@fin.ase.ro.*

In this context, evaluation and recalibration of government actions and policies are required to mitigate the negative consequences of fiscal unsustainability and of the transformation process of societies. The paper fills the gap in the literature regarding the incidence of fiscal sustainability, digitalization, climate and socio-economic and governance achievements on sustainable economic growth. Previous research is concerned primarily on digitization, economic issues and sustainable development (Vărzaru et al., 2023; Gariba, Arthur, Odei, 2024; Lei et al., 2024; Ma et al., 2024). As a consequence, this paper adds new insights into the investigation of factors of sustainable development from an economic perspective.

The paper aims to verify whether fiscal sustainability drives sustainable economic development while considering the impact of climate challenges and digital transformation for 27 EU countries. The research is relying on data covering multidimensional facets of the quadruple transition revealed by environmental, fiscal sustainability, digital transformation and sustainable development performances based on the results of the mainstream of literature and on the introduction of new variables that were not previously considered as factors to influence sustainable economic development. In terms of environmental challenges, the climate change performance index is used, while for digital transformation, e-government development is considered. Fiscal sustainability is rendered through its dimension on short- and long-term based on calculating fiscal indexes, and on overall performance referring to government revenue and expenditure and public debt. As control variables, economic, social and governance performances are included. These multidimensions ensure a comprehensive view of the factors that could influence the achievement of the SDGs.

The investigation method relies on balanced panel regression through the inclusion of both temporal and spatial dimensions of the variables for a stable time horizon 2000-2023 constrained by the data availability. The review of literature reveals the focus more on the research on sustainable development as a demanding task that requires innovative approaches to manage realities and to provide an equilibrium between society, environment and economy (Mensah, 2019). In terms of factors that influence sustainable development, economic variables, such as trade openness, inflation rate, unemployment rate, and digital transformation are considered, neglecting other important aspects that could impact it. This research contributes to the creation of knowledge about sustainable development by including other variables to address climate, digital and fiscal sustainability challenges through indexes based on a holistic approach. The research findings are coming from panel regression models with fixed effects where control variables reflect economic, social and governance systems. As a result, the findings are built on a holistic view that takes into account categories of factors for sustainable economic development that have not been evaluated in previous research. Additionally, the research results allow the identification of measures necessary to boost sustainable economic development based on multidimensional facets sheltering the environmental, fiscal sustainability, economic, social and governance performance.

The structure of the paper includes five sections. The Introduction indicates the context, the research purpose and niche, the core information of data used and the knowledge contribution. The review of the relevant literature is detailed in Section 2 to encompass the relationship between fiscal sustainability and transformation emanating from climate and digitalization and sustainable economic development under the pressures of different control variables. Section 3 exposes the research methodology with data presentation and methods. The next section is dedicated to results based on panel regressions, discussions of the findings

significance and contextualization within the mainstream of literature. The final section presents the conclusions and contributions coupled with insights for further research.

2. Review of the literature

In the Era of digital transformation and expanding fiscal sustainability weaknesses, EU countries are confronted with growth barriers and perspectives during revision of the economy connected with climate change, socio-economic and governance vulnerabilities. Therefore, achieving sustainable development is challenging and requires adequate supportive policies and actions capable of assessing intergenerational equity.

The sustainable development has been a debated topic since the 18th century, when its groundwork was settled (Carlowitz, 1713). The 1970s reactivated this subject with the model of Meadows et al. (1972) where the output is expected to be sustainable without disruption, urging a sustainable equilibrium on long-term. This brings into attention the interdependence of economy and environment because economic growth has environmental deterioration, depletion of resources and social effects as core costs. Only in the 1980s, the concept of sustainable development was launched as "sustainable utilization of species and ecosystems" (IUCN, 1980, p. vi).

Sustainability related to economic growth and development has different approaches in the literature with the purpose of clarifying their distinction. Growth is more connected with output or consumption, as a quantitative view of the economy, while development describes better a state, a process, or a vector for well-being with an equitable distribution of wealth, as a qualitative aspect (Coomer, 1979; Georgescu-Roegen, 1988; Barbier et al., 1990). Both economic growth and development need to be sustainable in the long-term (Porritt, 1984) or even at an infinite horizon. But the mainstream of literature proves that sustainable development has multiple facets, including economic growth, poverty contraction and efficient environmental management (United Nations, 1987), to assess a sustainable society (Coomer, 1979). The same view is embraced by Gherghina (2023), who investigated sustainable economic growth applying a broader approach to evaluate the incidence of various factors considering EU countries while demonstrating the sensitivity of the research results to the technical tools applied. The above view of sustainable economic development is expressed in this research, which relies on the global index score for sustainable development to also capture the economic progress.

In 2015, sustainable development was legitimated as a global goal by the United Nations with the principal focus on combating poverty, protecting the environment and ensuring economic prosperity until 2030 as an extension of the Millennium Development Goals. From 2000, with only eight development goals to be attained until 2015, there has been a diversification of the development facets to 17 SDGs whose fulfilment imposes strong political will, institutional capacity, sources of financing, national policies and strategies (Câmpeanu, 2024).

The investigation of the relevant literature indicates the main two pillars of research that focus on factors that influence sustainable economic development. Firstly, fiscal sustainability as a key driver of sustainable development is approched based on its incidence on economic growth. Alshaib et al. (2023) demonstrated who fiscal sustainability, based on government

revenue, expenditure and external debt, is imperative to assess sustainable development in Egypt relying on autoregressive distributed lag (ARDL) bounds testing and unrestricted error correction model for the period 1980-2018. Government expenditure and external debt affected sustainable economic growth in both the short- and long-term, while government revenue from the previous year negatively influenced growth in the short-term. Additionally, local government debt is influencing economic sustainability in China according to Han, Guo and Diao (2024) who used Two-Regime Spatial Lag Models to demonstrate the spatial interaction of the debt of 332 subgovernments during 2015 - 2019. The effect of fiscal sustainability, indicated based on public debt, on sustainable economic growth is sensitive to corruption (Kim, Ha and Kim, 2017) because a country with less corruption, strong institutions, increasing transparency and positive dynamic of public debt could face a boost of economic growth in the long-term according to research results relying on the pooled ordinary least squares (OLS), panel regressions with fixed effects and on the dynamic panel generalised method of moments (GMM) models for 77 countries from 1990 to 2014.

Secondly, digital technologies contribute to the assessment of long-term sustainable development through their ability to intensify efficiency and competitive advantage. Alojail and Khan (2023) investigated 760 stakeholders based on a survey designed to identify the perception on how sustainable principles are integrated into the digital transformation. The findings revealed that the long-term sustainability outcomes of the investigated organizations are more empowered when digitization goals are coordinated with the SDGs. The synergistic effects of innovative digital technologies with social, environmental and economic impact convey to sustainable adoption of innovative digital technologies which is related with Goal 9 of the SDGs that could reinforce economic growth. Furthermore, based on a Cobb-Douglas production function, with cost minimization and new economic geography, and panel data for 30 Chinese sub-governments, from 2015-2021, Ma et al. (2024) present the strong influence of digital economy on sustainable economic development based on its capacity to mix economies of scale with economies of scope through improvements of market supply and demand and reduction of carbon dioxide emissions.

Lei et at. (2024) highlight a strong positive relationship between progress and intensification of digitalization development and uprising of sustainable development for 36 advanced economies (OECD members) spanning from 2010 to 2020 with pooled regressions, fixed effects panel regression and dynamic panel model. Technological innovation is influencing the scale of the sustainable economic development due to its ability to shape lifestyles and production and to change from the traditional view to a greener approach. The transformative capacity of the digitalization is inducing sustainable development, which indicates inertia due to previous behaviours. Also, governance and innovation could influence digital transformation and cause a direct and indirect relationship between technologies and sustainable development (Mendez-Picazo, Galindo-Martin and Perez-Pujol, 2024) for 15 EU countries based on the structural equation model for 2019-2022 with pre- and post-pandemic periods. The magnitude of the effects is affected by the manifestation of the crisis.

The influence of digital transformation on sustainability is investigated by Vărzaru et al. (2023) through their impact on government revenue in EU countries based on artificial neural network and cluster analysis. The three homogeneous EU countries are high sustainability oriented, embracing digital transformation with higher level of government revenues (Denmark, Sweden, Finland, Austria, Germany, Italy, France, Belgium and Greece), low

sustainability oriented with reduced performance for digitalization and government revenue (Poland, Slovakia, Hungary, Bulgary, Cyprus, Czech Republic, Slovenia, Portugal, Croatia and Romania) and no sustainability oriented with lack of government revenue and a relatively high level of digitalization (Netherlands, Spain, Luxembourg, Lithuania, Malta, Estonia and Latvia). The research of Gariba, Arthur and Odei (2024) explores the capacity of the public sector digitalization and technological innovation in EU countries, for 2018-2023, with structural equation model, to positively reinforce economic and environmental sustainability. Similar results for EU countries were obtained by Bocean and Vărzaru (2023).

Other research focused more on aspects involving: i) impact of technological innovation on green development (Lv and Wu, 2024), government efficiency (Yang, Gu and Albitar, 2024); ii) effects of digital tax administration on government debt (Cheng, Chen and Luo, 2024) or digital economy on taxation (Anomah et al., 2024) and tax avoidance (Chen, Zhao and Jin, 2024); iii) sustainability and open innovation (Kwilinski, 2023; Robertsone and Lapina, 2023).

The literature review reinforces the importance of investigating sustainable economic development in a more broader view including variables already used in previous research while considering a new one to cover the multidimensional facets of the quadruple transition (environmental, fiscal sustainability, digital transformation and sustainable development performances). The contributions to the body of knowledge are: i) including other factors that could impact sustainable economic development such as climate change performance for environmental challenges and e-government development as a reflection of digital transformation from the government perspectives; ii) calculating fiscal sustainability as a composite index to enfold its dimension on both short- and long-term; iii) using fiscal sustainability indexes established based on the review of relevant literature; iv) considering social and governance indicators and not only economic variables as in previous research. The methodological aspects of the paper are detailed in the next section.

3. Research methodology

This research entails the following core questions: i) What is the relationship and magnitude of the incidence of fiscal sustainability on sustainable economic development?; ii) Who digital transformation is inducing a reaction of the sustainable economic development?; iii) Is there an influence on sustainable economic development coming from the climate challenges?; iv) How sensitive are the intensity and relationship of the quadruple transition to economic, social and governance performance? The investigation is based on a multidimensional view for a comprehensive understanding of the factors that could affect sustainable economic development of the 27 EU countries, covering the time span 2000-2023, which is restricted by data availability. Variables included in the balanced panel regression are grouped into seven categories. The first is for the dependent variable to cover the facet of sustainable economic development. The other indicators are exerting influences on the dependent variable, as are demonstrated in the relevant literature, and are highlighted in reports of international organizations (for example United Nations with Digital Economy Report, or World Bank with Digital Progress and Trends Report). The details of the variables are in Table 1.

Table 1. Variables for the research

Variables	Acronym	Meaning	Source
Dependent variables			
Sustainable Development Goal Index Score	SDG	indicates the overall progress in achieving all 17 SDGs.	Online database for the Sustainable Development Report 2024 https://dashboards.sdgindex.org/explorer
Independent variables			
Climate Change Performance	CCPI	evaluates the progress of climate protection at country level	Data are collected from each annual report "The climate change performance index" https://ccpi.org/downloads/
E-Government Development	EGOV	assesses the progress of the e-government development	Data are extracted from the UN e-Government Knowledgebase https://publicadministration.un.org/egovkb/en-us/Data-Center
GDP growth rate	G	increase in the size of the country's economic activity based on the value of all goods and services	Eurostat https://ec.europa.eu/eurostat/web/main/data/database
Trade openness	TO	total exchanges of products between countries	Eurostat https://ec.europa.eu/eurostat/web/main/data/database
Inflation rate	IR	general price increase for goods and services based on a harmonised approach	Eurostat https://ec.europa.eu/eurostat/web/main/data/database
Unemployment rate	UR	unemployed population from 15 to 74 years as a percentage of the population in the labour force	Eurostat https://ec.europa.eu/eurostat/web/main/data/database
Fiscal stability index	FSTI	calculated as a composite index to reflect the fiscal sustainability on short-term	Eurostat https://ec.europa.eu/eurostat/web/main/data/database
Fiscal sustainability index	FSUI	determined as a composite index to reflect the fiscal sustainability on long-term	Eurostat https://ec.europa.eu/eurostat/web/main/data/database
Index of fiscal policy soundness	FPSI	composite index covering the multidimensional aspects of fiscal sustainability	Eurostat https://ec.europa.eu/eurostat/web/main/data/database
Old age dependency ratio	OADR	calculated as population aged 65 or older as % of people of working age	Eurostat https://ec.europa.eu/eurostat/web/main/data/database
Population growth	POPG	calculated as an annual growth rate with chain base	Eurostat https://ec.europa.eu/eurostat/web/main/data/database
Poverty and social exclusion risk	PSER	persons at risk of poverty and social exclusion as % of population	Eurostat https://ec.europa.eu/eurostat/web/main/data/database
Control of corruption	CC	perception that public power is used by governors or by public officials for the purpose of their own or private interests	World Bank https://www.worldbank.org/en/publication/worldwide-governance-indicators
Government effectiveness	GE	perceptions of the quality of public services, the quality of formulation and implementation of policies, the credibility of governments' commitment to such policies, and the independence of public services from political pressure	World Bank https://www.worldbank.org/en/publication/worldwide-governance-indicators
Political stability and	PS	perceptions about the potential for	World Bank

absence of violence/terrorism		political instability and/or political-motivated violence, including terrorism	https://www.worldbank.org/en/publication/worldwide-governance-indicators
Rule of law	RL	perceptions of agents' confidence and compliance with society's rules	World Bank https://www.worldbank.org/en/publication/worldwide-governance-indicators

Source: own elaboration.

The selected indicators are in line with the mainstream of literature and include variables that were not considered in previous research. Therefore, the paper fills the gap on the impact of various variables on sustainable economic development to address other challenges through a holistic approach. The investigation methods included 648 observations, excluding models with lags (621 observations). Using Eviews, balanced panel regressions were applied due to its utility for the purpose of the research because it reveals the way some factors impact sustainable economic development for all the 27 EU countries. Fixed effects due to Correlated Randon effects-Hausman test are used, allowing the explanation of the country variations and controlling the unrevealed country characteristics that could bias the results due to endogeneity issues. The findings contribute to the identification of measures to improve the performance in achieving sustainable development. Therefore, using a homogeneous group of countries in terms of economic, social, governance, environment, digitization and fiscal sustainability, the research results could bring new insights to ameliorating the quadruple transition for a time span as comprehensive as possible relying on data from official sources.

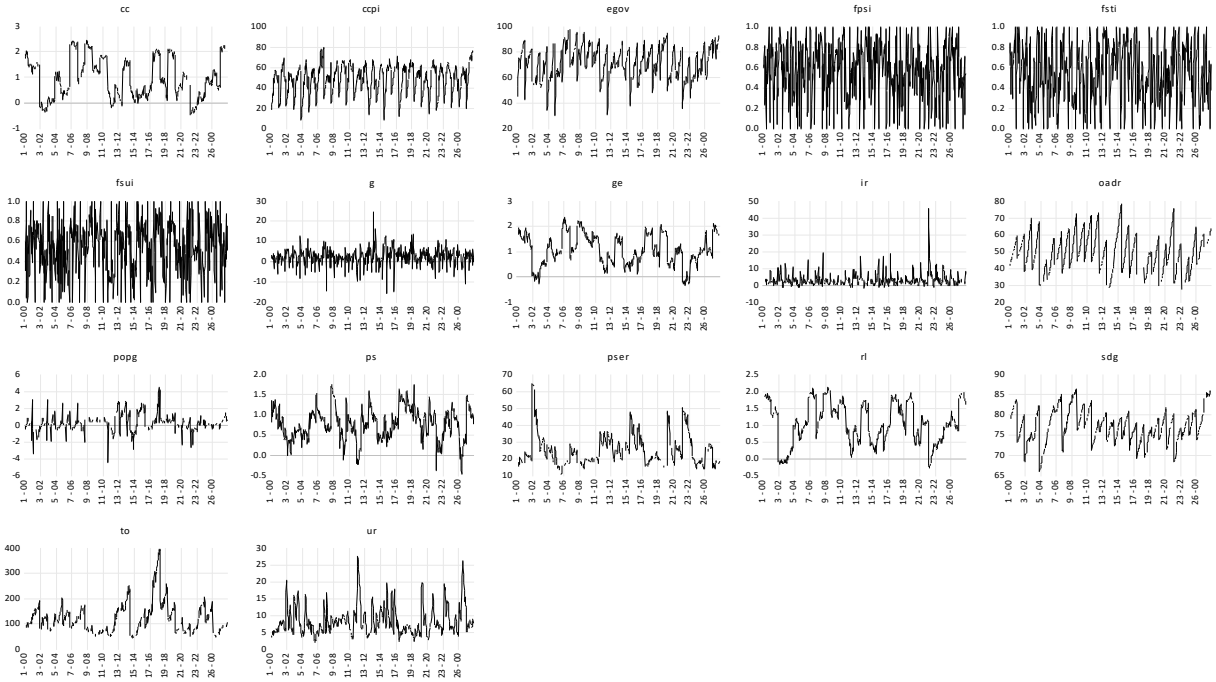
Panel regression models are as follows:

$$SDG_{i,t}=\gamma_1+\gamma_2 CCPI_{i,t}+\gamma_3 EGOV_{i,t}+\gamma_4 G_{i,t}+\gamma_5 TO_{i,t}+\gamma_6 IR_{i,t}+\gamma_7 UR_{i,t}+\gamma_8 FS_{i,t}+\gamma_9 POP_{i,t}+$$
$$+\gamma_{10} PSER_{i,t}+\gamma_{11} GOV_{i,t}+\varepsilon_{i,t} \quad (1)$$

where: *i* = country; *t* = year; *FS* = fiscal sustainability index represented by *FSTI* and *FSUI*, on the one hand, or *FPSI*, on the other hand; *POP* = population variables expressed by *OADR* or *POPG*; *GOV* = each of the four variables to indicate governance (*CC*, *GE*, *PS*, *RL*).

Figure 1 reveals the evolution of the variables considered.

Figure 1. Evolution of the variables



Source: own elaboration.

In the following (Table 2), the descriptive statistics for the variables utilised in the panel regression models are presented.

Table 2. Descriptive statistics for 27 EU countries, 2000-2023

Variables	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
SDG	77.31249	77.24662	86.41798	65.99550	4.046099	-0.03105	2.729058
CCPI	48.33084	50.98000	79.61000	7.840000	13.92811	-0.52935	2.618826
EGOV	71.93860	72.26050	97.82200	30.25200	12.64547	-0.33028	2.695605
G	2.477623	2.600000	24.60000	-16	3.841143	-0.39183	7.098322
TO	119.2975	105.6500	394.2000	45.20000	58.99410	1.735228	7.351088
IR	3.044753	2.300000	45.70000	-1.7	3.736102	4.440536	38.73420
UR	8.372994	7.300000	27.50000	2.000000	4.268720	1.524847	5.688251
FSTI	0.557235	0.575310	1.000000	0.000000	0.278687	-0.2473	2.136607
FSUI	0.540740	0.566996	1.000000	0.000000	0.253452	-0.30552	2.482778
FPSI	0.572913	0.607782	1.000000	0.000000	0.259199	-0.49237	2.606213
OADR	48.47024	47.79419	77.92240	27.12984	10.95094	0.211469	2.438437
POPG	0.234545	0.178061	4.439842	-4.49846	0.908469	0.374585	6.730329
PSER	24.39070	21.60000	64.90000	10.70000	9.050578	1.648614	6.391722
CC	0.976326	0.861745	2.459118	-0.51062	0.785259	0.189932	1.856769
GE	1.072137	1.028095	2.347191	-0.36397	0.605069	-0.1288	2.293628
PS	0.771431	0.794788	1.758681	-0.4746	0.395412	-0.15282	3.019865
RL	1.068161	1.044270	2.124762	-0.26561	0.609870	-0.2153	2.042573

Source: own elaboration.

The descriptive statistics highlight the general picture of the variables for 27 EU countries. The 648 observations offer accurate estimates for the model parameters, as is revealed by

mean, median and standard deviation. Sustainable economic development has an average above the central tendency, as is the case for other explanatory variables. Significant volatility is observed for trade openness, climate challenges and digital transformation, which could be considered normal due to high rate of adoption and diffusion of economies revisions to tackle vulnerabilities. The shape of the time series distribution is indicated by the values for Skewness (coefficient of asymmetry) and Kurtosis. An almost perfectly symmetrical distribution was obtained in the case of SDG, CCPI, EGOV, G, FSTI, FSUI, FPSI, OADR, POPG, CC, GE, PS and RL, which have values close to 0. The most asymmetric distribution is in the case of variables where we have a negative asymmetry or a longer tail to the left as smaller values predominate in the sample. The distribution of the time series is Positive Kurtosis (values above 3) for some of the variables (G, TO, IR, UR, POPG, PSER, PS).

In the panel regression, stationary variables were used, and the correlation matrix indicates a high degree of correlation (more than 0.94) between CC and GE, on the one hand, and RL, on the other hand, and between GE and RL. Table 3 presents the correlation matrix.

Table 3. Correlation matrix

	CC	CCPI	EGOV	FPSI	FSTI	FSUI	G	GE	IR	OADR	POPG	PS	PSER	RL	SDG	TO	UR
CC	1.0000	0.0913	0.5120	0.0558	-0.0822	0.2632	-0.0935	0.9404	-0.2306	0.0193	0.2000	0.5740	-0.6311	0.9470	0.4324	0.1586	-0.3531
CCPI	0.0913	1.0000	0.5395	-0.0662	-0.0656	0.0059	-0.2058	0.0814	-0.2305	0.5041	0.1091	-0.1147	-0.2014	0.1495	0.5090	0.1181	0.0290
EGOV	0.5120	0.5395	1.0000	0.0820	-0.0226	0.1332	-0.1332	0.4508	-0.1444	0.6077	0.1193	0.1194	-0.5588	0.5041	0.6682	0.1501	-0.2607
FPSI	0.0558	-0.0662	0.0820	1.0000	0.5755	0.6083	0.3740	0.0621	-0.0640	0.0462	0.0440	-0.0174	0.0281	0.0192	0.0413	0.0053	-0.0368
FSTI	-0.0822	-0.0656	-0.0226	0.5755	1.0000	-0.1348	0.4115	-0.0320	0.0442	0.0068	-0.0603	-0.0312	0.0368	-0.0866	-0.0668	0.0602	-0.1568
FSUI	0.2632	0.0059	0.1332	0.6083	-0.1348	1.0000	0.0891	0.2435	-0.0831	-0.0347	0.1748	0.1240	-0.0698	0.2284	0.1241	0.1095	-0.0041
G	-0.0935	-0.2058	-0.1332	0.3740	0.4115	0.0891	1.0000	-0.1029	0.1255	-0.2141	-0.0402	0.0922	0.1343	-0.1128	-0.1842	0.1756	-0.1325
GE	0.9404	0.0814	0.4508	0.0621	-0.0320	0.2435	-0.1029	1.0000	-0.2791	-0.0210	0.2201	0.6096	-0.6811	0.9435	0.4093	0.1818	-0.3139
IR	-0.2306	-0.2305	-0.1444	-0.0640	0.0442	-0.0831	0.1255	-0.2791	1.0000	-0.0773	-0.0156	-0.1598	0.2429	-0.2472	-0.1534	0.0007	-0.1527
OADR	0.0193	0.5041	0.6077	0.0462	0.0068	-0.0347	-0.2141	-0.0210	-0.0773	1.0000	-0.1216	-0.2953	-0.1632	0.0100	0.5808	-0.2817	-0.0381
POPG	0.2000	0.1091	0.1193	0.0440	-0.0603	0.1748	-0.0402	0.2201	-0.0156	-0.1216	1.0000	0.2635	-0.1248	0.2525	0.1524	0.3474	-0.1124
PS	0.5740	-0.1147	0.1194	-0.0174	-0.0312	0.1240	0.0922	0.6096	-0.1598	-0.2953	0.2635	1.0000	-0.4996	0.6165	0.1802	0.3898	-0.4270
PSER	-0.6311	-0.2014	-0.5588	0.0281	0.0368	-0.0698	0.1343	-0.6811	0.2429	-0.1632	-0.1248	-0.4996	1.0000	-0.6794	-0.5094	-0.2476	0.4495
RL	0.9470	0.1495	0.5041	0.0192	-0.0866	0.2284	-0.1128	0.9435	-0.2472	0.0100	0.2525	0.6165	-0.6794	1.0000	0.4365	0.2135	-0.3816
SDG	0.4324	0.5090	0.6682	0.0413	-0.0668	0.1241	-0.1842	0.4093	-0.1534	0.5808	0.1524	0.1802	-0.5094	0.4365	1.0000	-0.1599	-0.1572
TO	0.1586	0.1181	0.1501	0.0053	0.0602	0.1095	0.1756	0.1818	0.0007	-0.2817	0.3474	0.3898	-0.2476	0.2135	-0.1599	1.0000	-0.3112
UR	-0.3531	0.0290	-0.2607	-0.0368	-0.1568	-0.0041	-0.1325	-0.3139	-0.1527	-0.0381	-0.1124	-0.4270	0.4495	-0.3816	-0.1572	-0.3112	1.0000

Source: own elaboration.

The next section details the research results based on panel regressions in order to cover the research aim and questions, to bring a new perspective and approach to sustainable economic development in the EU, and to contribute to knowledge-based development.

4. Results and discussion

Digital transformation challenged with climate change, fiscal sustainability, on the one hand, and economic, social and governance performance, on the other hand, could provide promising solutions to achieving sustainable economic development. This aspect is approached based on a multidimensional view to capture the interference of variables in the EU's SDGs. In the research carried out with the aim of identifying the impact of the quadruple transition and other variables to highlight the trade-offs in pursuing sustainable development and effective policies to ensure a sustainable, inclusive and resilient society. Therefore, panel regression models were analysed with a different mix of explanatory variables. Panel regressions are applied for the investigated variables with the consideration that, first, fiscal sustainability is taken with short- and long-term dimensions (Tables 4 and 5) among the independent variables to reveal which is more important from the point of view of sustainable economic development. Second, the regressions are tested with the explanatory variables, while fiscal sustainability is indicated based on only one variable (Tables 6 and 7), as a composite index which reveals the country performance in terms of public indebtedness and government revenue and expenditure.

Table 4 presents the results when one of the social performances is reflected by OADR. The findings reveal that only fiscal sustainability in the short-term negatively influences sustainable economic development, while fiscal sustainability in the long-term has no impact. Therefore, the less fiscal policy is sustainable, the more sustainable development is affected with a pronounced reaction due to short-term sustainability issues. Climate change, digital transformation, trade openness, old age dependency, poverty and social exclusion, and political stability could boost sustainable economic development with a contemporaneous reaction. Combating corruption does not have an influence on sustainable economic development because this relationship is not statistically validated in the models below.

Table 4. Results of regression models (I)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
CCPI	0.033619*	0.034560*	0.034098*	0.035108*	0.035379*	0.037857*
EGOV	0.017276*	0.026087*	0.015817*	0.024787*	0.016929*	0.022581*
G	-0.026086*	-0.025227*	-0.028853*	-0.026897*	-0.028115*	-0.016016***
TO	0.020590*	0.019803*	0.020523*	0.019656*	0.020170*	0.019018*
IR	-0.035497*	-0.039547*	-0.036272*	-0.040771*	-0.035668*	-0.038661*
UR	-0.024315***	-0.029077**	-0.024975**	-0.031955*	-0.028030**	-0.028218* (-1)
FSTI	-0.557455*	-0.605036*	-0.514361*	-0.582157*	-0.565638*	-0.581077*
FSUI	0.045713	-	0.053824	-	0.052468	-
OADR	0.176999*	0.173633*	0.177669*	0.173575*	0.176856*	0.168790*
PSER	0.014889	0.023744** (-1)	0.014519	0.022884** (-1)	0.014043	-
CC	-0.144263	-	-	-	-	-
PS	0.484542*	0.551690*	0.582193*	0.608871*	0.550326*	0.569591*
GE	-	-	-0.415674**	-0.311338*** (-1)	-	-
RL	-	-	-	-	-0.410873***	-0.388855***
Const	63.47545*	62.72845*	63.75760*	63.14807*	63.77787*	64.09640*
R-squared	0.968122	0.968803	0.968354	0.968956	0.968285	0.968788
Observations	648	621	648	621	648	621

Source: own elaboration. Note: *, **, *** p<1%, 5%, 10%; () indicates lag.

Furthermore, the results in Table 4 highlight how the government effectiveness produces impact only if political stability is reinforced while confidence and compliance to the society's rules have a neutral effect on sustainable economic development. The effect of the rule of law is empowered by the political stability, and only together could they affect sustainable economic development in a positive way, in the case of PS, and with a negative incidence when it is mixed with RL. Also, lagged reactions with 1 year is in the case of UR, PSER and GE due to the necessary time to generate a specific reaction on the sustainable economic development.

Table 5 indicates the findings for regressions that have POPG as one of the indicators covering social aspects, while fiscal sustainability is considered as a multidimensional variable.

Table 5. Results of regression models (II)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
CCPI	0.054564*	0.055535*	0.054383*	0.055626*	0.058271*	0.058188*
EGOV	0.090658*	0.097607*	0.090846*	0.092265*	0.091943*	0.092624*
G	-0.022605***	-0.024787**	-0.024773**	-0.022643**	-0.026928**	-0.022934***
TO	0.024453*	0.025139*	0.024638*	0.024486*	0.024061*	0.023716*
IR	-0.036327*	-0.040219*	-0.037207*	-0.036048*	-0.034300*	-0.035588*
UR	-0.069598*	-0.088692*	-0.063879*	-0.061665*	-0.069667*	-0.068844*
FSTI	-0.618693*	-0.676416*	-0.549654*	-0.572128*	-0.616981*	-0.646025*
FSUI	0.151470	-	0.143130	-	0.155883	-
POPG	-0.066526	-	-0.066184	-	-0.059165	-
PSER	-0.033289**	-	-0.033537**	-0.030849**	-0.032998**	-0.031789**
CC	-0.555752**	-0.593543**	-	-	-	-
PS	-0.330611	-	-0.301216	-	-	-
GE	-	-	-0.416272***	-0.511047**	-	-
RL	-	-	-	-	-0.745012*	-0.748610*
Const	67.87373*	66.49061*	67.66016*	67.36678*	67.64002*	0.942020*
R-squared	0.942327	0.941425	0.942083	0.941755	0.942157	67.68434
Observations	648	648	648	648	648	648

Source: own elaboration. Note: *, **, *** p<1%, 5%, 10%; () indicates lag.

The panel regression models in Table 5 demonstrate that the fiscal sustainability component in the long-term and population growth do not have an incidence on sustainable economic growth, while political stability is in a neutral relationship with sustainable economic development. Additionally, short-term fiscal sustainability has a significant positive impact (almost 0.15) followed by digital transformation (almost 0.09) and climate change (almost 0.05). These relationships are similar to the previous ones (Table 4) but are of higher magnitude. All three governance indicators are shown to induce a contractionary effect on sustainable economic development.

The next table (Table 6), with OADR as one of the social indicators, establishes the relationship between the variables considered when fiscal sustainability is indicated by a single indicator that could reveal the overall performance in terms of public debt and government revenue and expenditure.

Table 6. Results of regression models (III)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
CCPI	0.033092*	0.035375*	0.033842*	0.035902*	0.032520*	0.033183*
EGOV	0.018550*	0.027186*	0.016759*	0.025257*	0.018996*	0.027349*
G	-0.030664*	-0.023274**	-0.033310*	-0.024959*	-0.028973*	-0.027150*
TO	0.019883*	0.019329*	0.019822*	0.019320*	0.019375*	0.018317*
IR	-0.035884*	-0.043383*	-0.036794*	-0.044913*	-0.040379*	-0.041805*
UR	-0.012422	-0.034443* (-1)	-0.015334	-0.037724* (-1)	-0.018651	-0.021736***
FPSI	-0.375507*	-0.381151*	-0.348555**	-0.354481**	-0.376564*	-0.404345*
OADR	0.177922*	0.174295*	0.178220*	0.174634*	0.172222*	0.168290*
PSER	0.015078	0.030303*	0.014574	0.029833*	0.010532	0.017458*** (-1)
CC	-0.065923	-	-	-	-	-
PS	0.464018*	0.571755*	0.584968*	0.676111*	-	-
GE	-	-	-0.459332**	-0.387235**	-	-
RL	-	-	-	-	-0.165420	-
Const	63.22575*	62.40511*	63.67664*	62.87176*	64.20160*	63.56665*
R-squared	0.967467	0.968340	0.967787	0.968568	0.967093	0.967463
Observations	648	621	648	621	648	621

Source: own elaboration. Note: *, **, *** p<1%, 5%, 10%; () indicates lag.

The results in Table 6 bring novelty to the body of knowledge creation due to the fact that government actions to reduce corruption and to reinforce obedience and compliance with the society's rules have no impact on sustainable economic development, while the unemployment rate and poverty and social exclusion affect it with a delay of one year. Furthermore, Table 7 expresses the findings for regressions having POPG as one of the indicators that cover social aspects.

Table 7. Results of regression models (IV)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
CCPI	0.054021*	0.054067*	0.054103*	0.055516*	0.057650*	0.057754*
EGOV	0.092832*	0.093079*	0.092379*	0.093339*	0.094127*	0.094329*
G	-0.027078**	-0.025078**	-0.028769**	-0.028798**	-0.031351**	-0.029641**
TO	0.023589*	0.023178*	0.023828*	0.023662*	0.023279*	0.022897*
IR	-0.037149*	-0.037525*	-0.038182*	-0.036097*	-0.034735*	-0.035059*
UR	-0.055345*	-0.055777*	-0.052722	-0.051770*	-0.055364*	-0.055902*
FPSI	-0.392761**	-0.397244**	-0.362223***	-0.360536***	-0.390413**	-0.394461**
POPG	-0.057572	-	-0.058292	-	-0.051519	-
PSER	-0.032974**	-0.032635**	-0.033256**	-0.031408**	-0.032364**	-0.032077**
CC	-0.461060**	-0.459574***	-	-	-	-
PS	-0.363379***	-0.368090***	-0.304853	-	-	-
GE	-	-	-0.461105***	-0.563067**	-	-
RL	-	-	-	-	-0.664748**	-0.675738**
Const	67.62616*	67.63787*	67.60030*	67.28299*	67.35996*	67.38212*
R-squared	0.941331	0.941259	0.941305	0.941053	0.941147	0.941090
Observations	648	648	648	648	648	648

Source: own elaboration. Note: *, **, *** p<1%, 5%, 10%; () indicates lag.

Table 8 illustrates the identified relationship between variables used in empirical investigations for 27 EU countries based on a time span of 2000-2023.

Table 8. Identified relationships based on regression models

Variables	SDG
CCPI	+
EGOV	+
G	-
TO	+
IR	-
UR	-
FSTI	-
FPSI	-
OADR	+
PSER	+ (with OADR) or - (without OADR)
CC	- (without OADR)
PS	+ (with OADR) or - (without OADR)
GE	-
RL	-

Source: own elaboration.

Climate change and sustainable economic development could emerge and reinforce each other (Lu et al., 2019) despite their complementarity because investment in green transition will bring positive effect on economies with upturns and downturns due to climate conditions (such as extreme weather events). These could exacerbate the disparities and inequalities between advanced economies and emerging and developing economies and threaten economic development (United Nations, 2024, p. 5) even so the core principle is "to leave no one behind". Therefore, according to the World Economic Forum, alternative economic models are required that focus on sustainable resources and reduce the strong dependence of socio-economic progress on continuous economic growth. Until now, countries policies have struggled to cope with the core purpose of pro-climate, pro-growth and growth-friendly sustainable fiscal policy.

Another positive relationship between digital transformation and sustainable economic growth is confirmed, according to the literature review. Therefore, innovative technologies could enhance sustainable economic development through long-term sustainable outcomes (Alojail and Khan, 2023; Lei et al., 2024; Ma et al., 2024). Also, trade openness tends to strengthen sustainable economic development in EU countries as a result of the intensity of the commercial transactions intra and extra EU as is the case for an economic union as EU or BRICS (Monyela and Saba, 2024), while for emerging economy the relationship is indirect (Sheikh, Malik and Masood, 2020).

The ageing population, captured with the indicator of OADR, could boost sustainable economic development due to its behaviour that is more focused on recycling things and taking care of the environment despite the waste-oriented behaviour of the young generations.

This finding is contrary to the literature (Wang, Liang and Wang, 2024) despite a focus concentrated more on healthy ageing that could bring positive benefits in terms of standard of living (WHO, 2024).

Additionally, research findings acknowledge the major drawbacks of sustainable economic development that need to be considered by policymakers, practitioners and the broader citizens communities to integrate insights in designing adequate policies and actions with the purpose to assess improvements in terms of green-oriented growth with intensifying recycling activities, to safeguard fiscal policy soundness, to include population of working age in a more green labour market, and to boost the green innovation technologies for increasing efficiency, transparency and access to personalised services based on public needs.

5. Conclusions

Countries are thrust into a quadruple transition to revision of the economy by enhancing a more competitive, sustainable, inclusive and resilient society. In this context, challenges coming from digitalization, climate, fiscal sustainability, socio-economic and governance issues need to be addressed by policies and actions to mitigate risks and vulnerabilities and to empower sustainable economic growth for current and future generations. The paper brings new knowledge for the investigation of the fiscal sustainability, digitalization, climate and socio-economic and governance achievements on sustainable economic growth based on panel regressions with fixed effects for 27 EU countries covering the time span of 2000-2023. The perspectives of the holistic approach are detailed in the research expressing the contribution of the research in strong connection with previous relevant literature.

The review of the literature is a synthesis of the research findings that covers the aspects followed in this paper and reveals which are the research novelties. To our knowledge, we have not identified research with a similar purpose that includes the multitude aspects of factors that could enforce sustainable economic development.

Research results demonstrate that long-term fiscal sustainability, population growth, and some governance indicators taken one by one (CC, RL) are more in a neutral relationship with sustainable economic development, while the unemployment rate and poverty and social exclusion affect it with a delay of one year. Additionally, the risk of fiscal unsustainability impacts sustainable economic development due to the short-term sustainability issues. Climate change, digital transformation, trade openness, old age dependency, poverty and social exclusion, and political stability could boost sustainable economic development with a contemporaneous reaction.

Policymakers, practitioners and the broader citizens communities need to know the major drawbacks of sustainable economic development in order to improve behaviour in terms of green-oriented growth in the long-term, to address the barriers for vulnerable populations and to provide intergenerational equity.

The research limitations are concretised by data availability and some disparities among 27 EU countries, which will be addressed in future research that will analyse how considered variables disturb sustainable economic development for groups of countries. These groups will be established based on common characteristics to verify the presence of disparities

between EU countries. Additionally, sustainable economic development will be expressed on the basis of a composite index to cover the facets of growth on a sustainable path.

References

Alojail, M. and Khan, S. B. (2023). Impact of Digital Transformation toward Sustainable Development. – Sustainability, 15, 14697, [online] Available at:<https://doi.org/10.3390/su152014697>.

Alshaib, B. M., Al Khatib, A. M. G., Nuta, A. C., Hamra, M., Mishra, P., Gautam, R., Hussain, S., and Zamfir, C. G. (2023). Fiscal Sustainability and Its Implications for Economic Growth in Egypt: An Empirical Analysis. – SAGE Open, 13, p. 1–19, [online] Available at:<https://doi.org/10.1177/21582440231215983>.

Anomah, S., Ayeboafo, B., Aduamoah, M. and Agyabeng, O. (2024). Blockchain technology integration in tax policy: Navigating challenges and unlocking opportunities for improving the taxation of Ghana's digital economy. – Scientific African, 24, [online] Available at:<https://doi.org/10.1016/j.sciaf.2024.e02210>.

Barbier, E. B., Markandya, A., and Pearce, D. W. (1990). Environmental Sustainability and Cost-Benefit Analysis. – Environment and Planning A: Economy and Space, 22(9), p. 1259-1266, [online] Available at:<https://doi.org/10.1068/a221259>.

Bocean, C. G., Vărzaru, A. A. (2023). EU countries's digital transformation, economic performance, and sustainability analysis. – Humanities Social Sciences Communications, 10, [online] Available at:<https://doi.org/10.1057/s41599-023-02415-1>.

Câmpeanu, E. M. (2024). Habilitation thesis. Bucharest University of Economic Studies, Council of Doctoral School of Finance.

Carlowitz H.C. (1713). Sylvicultura Oeconomica, p. 105-106.

Chen, M., Zhao, K., and Jin, W. (2024). Corporate digital transformation and tax avoidance: evidence from China. – Pacific-Basin Finance Journal, 85, [online] Available at:<https://doi.org/10.1016/j.pacfin.2024.102400>.

Cheng, Q., Chen, B. and Luo, J. (2024). The impact of digital tax administration on local government debt: Based on the revision of the tax collection and administration law. – Finance Research Letters, 67(B), [online] Available at:<https://doi.org/10.1016/j.frl.2024.105938>.

Coomer, J. C. (1979). The nature of the quest for a sustainable society. – In: Coomer, J. C. (ed.), Quest for a Sustainable Society. New York: Pergamon Press, [online] Available at:<https://doi.org/10.1016/C2013-0-03517-7>.

Gariba, M. I., Arthur, E. E., and Odei, S. A. (2024). Assessing the impact of public digitalization on sustainability: the mediating role of technological innovation in the context of the EU. – Discover Sustainability, 5(204), [online] Available at:<https://doi.org/10.1007/s43621-024-00397-x>.

Georgescu-Roegen, N. (1988). About economic growth - a variation on a theme by David Hilbert. Economic Development and Cultural Change. University of Chicago Press, 36(3), p. 291-307.

Gherghina, Ş. C. (2023). *Quantitative Methods in Finance. Exploring the Drivers of Sustainable Economic Growth in the EU*. Springer Cham.

Han, N., Guo, H. and Diao, W. (2024). Spatial Interaction of Local Government Debt: Evidence from China. – Sustainability, 16, 3482. [online] Available at:<https://doi.org/ 10.3390/su16083482>.

IUCN (1980). World Conservation Strategy. Living Resource Conservation for Sustainable Development, [online] Available at:<https://portals.iucn.org/library/efiles/documents/wcs-004.pdf>.

Kim, E., Ha, Y. and Kim, S. (2017). Public debt, corruption and sustainable economic growth. – Sustainability, MDPI, 9(3), p.1-30, [online] Available at:<https://doi.org/10.3390/su9030433>.

Kwilinski, A. (2023). The Relationship between Sustainable Development and Digital Transformation: Bibliometric Analysis. – Virtual Economics, 6(3), p. 56-69, [online] Available at:<https://doi.org/10.34021/ve.2023.06.03(4)>.

Lei, X., Shen, Z. Y., Štreimikien, D., Baležentis, T., Wang, G., and Mu, Y. (2024). Digitalization and sustainable development: Evidence from OECD countries. – Applied Energy, 357, [online] Available at:<https://doi.org/10.1016/j.apenergy.2023.122480>.

Lu, S., Bai, X., Zhang, X., Li, W., and Tang, Y. (2019). The impact of climate change on the sustainable development of regional economy. – Journal of Cleaner Production, 233, p. 1387-1395, [online] Available at:<https://doi.org/10.1016/j.jclepro.2019.06.074>.

Lv, X. and Wu, Z. (2024). The green effect of digital transformation: The impact of digital transformation in fiscal and taxation on regional green development. – Economic Analysis and Policy, 81(C), p. 787-800, [online] Available at:<https://doi.org/10.1016/j.eap.2023.12.025>.

Ma, X., Feng, X., Fu, D., Tong, J., and Ji, M. (2024). How does the digital economy impact sustainable development? - An empirical study from China. – Journal of Cleaner Production, 434, [online] Available at:<https://doi.org/10.1016/j.jclepro.2023.140079>.

Meadows, D. H., Meadows, D. L., Randers, J. and Behrens, W. (1972). The Limits to Growth. New York: Universe Books, [online] Available at:<https://collections.dartmouth.edu/content/deliver/inline/meadows/pdf/meadows_ltg-001.pdf>.

Mendez-Picazo, M. T., Galindo-Martin, M. A., and Perez-Pujol, R. S. (2024). Direct and indirect effects of digital transformation on sustainable development in pre- and post-pandemic periods. – Technological Forecasting & Social Change, 200, [online] Available at:< https://doi.org/10.1016/j.techfore.2023.123139>.

Mensah, J. (2019). Sustainable development: Meaning, history, principles, pillars, and implications for human action: Literature review. – Cogent Social Sciences, 5(1), [online] Available at:<https://doi.org/10.1080/23311886.2019.1653531>.

Monyela, M. N. and Saba, C. S. (2024). Trade openness, economic growth and economic development nexus in South Africa: a pre- and post-BRICS analysis. – Humanities and Social Sciences Communications, 11(1108), [online] Available at:<https://doi.org/10.1057/s41599-024-03604-2>.

Porritt, J. (1984). Seeing Green - The Politics of Ecology Explained. Oxford: Basil Blackwell.

Robertsone, G. and Lapiņa, I. 2023. Digital transformation as a catalyst for sustainability and open innovation. – Journal of Open Innovation: Technology, Market, and Complexity, 9, [online] Available at:<https://doi.org/10.1016/j.joitmc.2023.100017>.

Sheikh, M. A., Malik, M. A. and Masood, R. Z. (2020). Assessing the effects of trade openness on sustainable development: evidence from India. – Asian Journal of Sustainability and Social Responsibility, 5(1), p. 1-15, [online] Available at:<https://doi.org/10.1186/s41180-019-0030-x>.

United Nations (1987). Report of the World Commission on Environment and Development: “Our common future”, [online] Available at:< https://digitallibrary.un.org/record/139811?v=pdf#files>.

United Nations (2024). The Sustainable Development Goals Report 2024, [online] Available at:< https://unstats.un.org/sdgs/report/2024/The-Sustainable-Development-Goals-Report-2024.pdf>.

Vărzaru, A. A., Bocean, C. G., Simion, D., Berceanu, D., and Mangra, M. G. 2023. Digital Revolution, Sustainability, and Government Revenues: A Transversal Analysis of how Digital Transformation and Sustainable Practices Impact Sustainable Government Revenues. – Systems, 11(546), [online] Available at:<https://doi.org/10.3390/systems11110546>.

Yang, C., Gu, M. and Albitar, K. (2024). Government in the digital age: Exploring the impact of digital transformation on governmental efficiency. – Technological Forecasting and Social Change, 208, [online] Available at:<https://doi.org/10.1016/j.techfore.2024.123722>.

Wang, L., Liang, J., Wang, B. (2024). Population aging and sustainable economic development: An analysis based on the role of green finance. – Finance Research Letters, 70, 106239, [online] Available at:<https://doi.org/10.1016/j.frl.2024.106239>.

World Health Organization (2024). Making older persons visible in the Sustainable Development Goals’ monitoring framework and indicators. Geneva: World Health Organization, [online] Available at:<https://iris.who.int/bitstream/handle/10665/376154/9789240090248-eng.pdf?sequence=1>.