ICT AND ENVIRONMENTAL INDICATORS FOR GREEN GROWTH IN BULGARIA

Gallucci Teodoro[1], Lagioia Giovanni[2], Vera Amicarelli[3], Dimitrova Vesselina[4] and Kaneva Marian[5]

[1) 2) 3)] *Department of Economics, Management and Business Law, University of Bari Aldo Moro; [4) 5)] International Economic Relations, University of Economics Varna-Bulgaria*

E-mail : teodoro.gallucci@uniba.it; E-mail: vesselina.dimitrova@ue-varna.bg;
E-mail: giovanni.lagioia@uniba.it

Abstract

The focus of the green growth concept is on reducing pollution and greenhouse gas emissions, the efficient use of natural resources and the opportunities for investment and innovation in environmental services. However, green growth not only affects the quality of growth, but also the overall production process (such as low carbon economy). The purpose of the paper is to examine the interrelationship in Bulgaria between ICT indicators and environmental indicators for the period 1990-2014 (e.g. emissions, renewable energy and others) using the Granger causality test for assessing whether Bulgaria has developed green growth strategies to achieve sustainable performance in different sectors of the economy.

Keywords

Green growth, granger causality test, environmental indicators; sustainable development goals.

JEL Classification

Q56, Q570

Introduction

The term "green growth" is relatively new and has enjoyed increasing popularity in recent years. Green growth is a concept or business innovation process, contributing to the overall understanding of economic development and environmental sustainability. (OECD a, 2008; OECD b, 2008; OECD c, 2008, OECD, 2019). The general opinion of experts is that the terms "green growth" and "sustainable development" are not synonymous. The first term is rather a subset of the second. The focus of the green growth concept is on reducing pollution and greenhouse gas emissions, the efficient use of natural resources and the opportunities for investment and innovation in environmental services. However, green growth not only affects the quality of growth, but also the overall production process (such as low carbon economy) (IISD, 2012; Capgemini, 2008). It is possible to underline that green growth concept promote and support integrated approaches to sustainable development. Such approaches recognize the centrality of the 2030 Agenda for Sustainable Development, and can help to deliver optimal social, environmental, and economic outcomes of by considering the interlinkages between different sectors and governance structures. Orientation towards green growth requires both productivity on the market and good infrastructure, including energy, transport and telecommunication infrastructure. Thus, green growth strengthens the territorial cohesion between regions. Knowing new markets through green technology is a new organisational practice for each country and makes every market more stable. Guidelines for such organisational practices are closely related to the effects of the economic and financial crisis of 2008 (for example in Asia). (Ministry of Land, 2008; Zelenovskaya, 2010). ICTs have boosted significant transformations of economic and social structures and some studies have estimated that the development of IT systems can increase the efficiency of production and consumption in the energy, transportation, building and manufacturing sectors reducing the global greenhouse gas emissions by 15 per cent by 2020, compared to a business-as-usual scenario with a 2002 baseline (IISD 2011). The concept of green ICT encompasses sophisticated solutions that combine IT and indicators to help organizations save considerable energy and resources for improving business and obtaining economic benefits. ICT indicators appear as technological tools or environmental technologies for green growth. Relationships between ICT and environmental indicators are indirect and are still in the learning process (UNCTAD, 2010).

The importance of environmental and ICT indicators for green growth

According to OECD 2009, new technologies will enable economic growth offsetting critical environmental issues. Shortage of natural resources and sustainable energy production are global challenges that need alternative solutions for creating new business opportunities. The face of sustainability has evolving, with different stakeholders involved and interlinked concerns, and there is an urgent need to find practical solution to achieve the ambitious Sustainable Development Goals (SDGs). SDGs represent the evolution of the sustainable development concepts which have been ratified in 2015 with the Agenda titled "Transforming our world: the 2030 Agenda for Sustainable Development.

ICT solutions give a set of new smart technologies and actions, which can affect energy efficiency and waste management by making production more resource-efficient. ICT solutions should allow the different countries to foresee their comparative advantages in global trade helping to manage risk and providing insights into effective policy and practice (Kamal-Chaoui and Plouin, 2012). Furthermore, ICT can create the conditions to increasing productivity without harming the environment and making productive investments in different sectors favoring at the same time the achievements of diverse SDGs, as Industry innovation and infrastructure, Sustainable cities or Responsible consumption and production. According to experts, investments in ICT improve green growth even if there are two significant problems which are characteristics of the study of IT and environmental indicators: (1) the information gap and (2) the capacity gap. The information gap represents a lack of reliable data on eco-activities and the capacity gap includes a lack of capacity in developing green technologies for improving economic performance. So, the interrelations between ICT and the environment could involve either positive or negative impacts (Culler, 2004; OECD, 2009). Positive relationships affect the general performance on climate change, energy use patterns and waste management / carbon pollution. Constant monitoring of such indicators is a key for any business and its users. Negative impacts are connected with the adequate management of GHG emissions, transport / manufacturing and e-waste. The improvement of these negative relationships should be a priority subject in the work of both governments and international organizations. (Jänicke, 2012). Several examples of the application of ICT for green growth are illustrated in Fig. no. 1. This kind of correlation between ICT and green growth can be used to assess forecast scenarios on environmental sustainability. The purpose of this paper is to examine the interrelationship in Bulgaria between ICT indicators and environment indicators for the period 1990-2014 (e.g. emissions, renewable energy and others) for assessing whether Bulgaria has developed green growth strategies.

Data and Methodology

In this paper we study–the causal link between ICT and environmental indicators for assessing green growth development in Bulgaria. Granger causality is a broader concept based on the sentence that "the past can influence the future, but not vice versa". This postulate of Granger is seen in the informative aspect in order to clarify which part of the variances of the current levels of environmental indicators (Y) can be explained with its own previous levels, and by adding the previous meanings of ICT indicators (X) can be well-improved this explanation. The methodology of Granger proposes results that remain hidden by the classical correlation analysis. While correlation analysis can only appreciate how strongly is interacting two variables between, the test of Granger can determine the direction of the interaction between two dynamic processes, even if each of them develops under the influence of many other factors. To do this, firstly, a set of environmental indicators were chosen and then the economic sectors and ICT applications with the greatest impact on these indicators were identified. It is important to underline that there are areas of interaction (e.g. the Internet or dematerialization of paper, etc.) which have not been investigated yet and for which data are not available. It is noteworthy that most organizations which study green growth recognize as leading determinants for green business models ICT indicators, rather than the environmental indicators. For this study have been selected indicators: a) extrapolated by Euromonitor database b) characterizing the most appropriate correlation between ICT and green growth in Bulgaria. The indicators are differentiated in ecological indicators and ICT indicators. The paper uses annual data for the period 1990-2014 and the database is from Euromonitor. To respond to the theoretical requirements of the econometric analysis with time series, the data are disaggregated in advance of semiannual data using spline functions, based on three points. The investigated indicators are divided in two principal groups: environmental and ICT indicators. As a result of pre-selection, the indicators used in this paper are presented in tables no.1 summarized what is included in different ICT groups considered. Economic development is a broader concept than economic growth and refers to improving the quality of life and business as noted by the economist Amartya Sen Economic growth is one aspect of the process of economic development. In this study we also add as indicators the total productivity and the total population of Bulgaria to the traditional indicator of GDP growth (table no. 2). All the variables in the current database are logarithmically transformed. Such a transformation is not applied to derivatives indicators from the ICT sector. Logarithmic transformation provides comparability of these two indicators. New time series are investigated with respect to the nature of their tendency by parallel application of autocorrelation analysis, tests of unit root and stationary tests (ADF-test; KPSS-test).

Table no. 1 Used indicator details

Natural resources		
Indicators	*Measure*	*Variables*
Arable land	% of land area	AL_land
Arable land	hectares per persons	AL_person
Arable land	Hectares	ArabLand
Forest area	% of land area	Forest
Forest area	km^2	Forest_SQKM
Energy mix-demand, supply, efficiency		
Energy production from renewable sources	GWh	EP_Renew
Atomic and nuclear energy	% of total energy use	EP_ANE
Electricity production	GWh	EP_Total
Electricity production per capita	kWh	EP_percap kwh

Fossil fuel energy consumption	% of total	E_Fossil
Primary energy consumption	Tons/1000	Primencons
Energy efficiency	USD	ENEFF
Emissions		
CO_2	Kt	CO_2
CO_2	Metric tons per capita	CO_2_cap
CO_2 from solid fuel consumption	% of total	CO_2_solid
Greenhouse gas emissions	Kt	GHGE

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Table no. 2 Economic growth

Indicators	Measure	Variables
GDP	Constant prices 2014	GDP
GDP per capita	USD, 2014	GDP per capita
Productivity	USD, 2014	Product

The results of the application of the cited methods showed, that none of the methods of logarithms with absolute values of indicators can be accepted as stationary. Through these defined methods the type of transformation of original time series is made in terms of stationarity required by the subsequent econometric analysis. The time series are stationary with their first differences, so they are identified as integrated time series from the first level. This implies that with the use of the VAR-model, which is at the basis of the Granger causality test, it is necessary to implement the first difference of the logarithms for the corresponding variables. In general, the first differences (differences into two adjacent time periods) of the logarithmic variables make sense of the increase, because the difference of the logarithms of the both values is a logarithm of the quotient of these same variables. So, for any indication of the ICT sector or environmental indicators the following equations are valid:

$$DLn(EI_{j,t}) = Ln(EI_j)_t - Ln(EI_j)_{t-1} = Ln\left(\frac{EI_{j,t}}{EI_{j,t-1}}\right) \quad (1)$$

$$DLn(ICT_{j,t}) = Ln(ICT_j)_t - Ln(ICT_j)_{t-1} = Ln\left(\frac{ICT_{j,t}}{ICT_{j,t-1}}\right)$$

where: EI - some environmental variables; ICT -variables of ICT group

The transformation takes an economic sense of rate of change for the relevant primary variable. These newly available time series are the core for the Granger causality test. The indicators that make up the research database in this paper can be viewed as cause and as a consequence of one another (or relative to one another) Descriptive analysis and Direct (Pairwise) Granger Causality Tests are used in the paper. Descriptive analysis was used to identify the time series and to assess their integrity.

To assess the nature of their relationship the Pairwise Granger causality test is implemented. "Causality Granger" is associated with the fact that "the past can influence the future, but not vice versa." This postulate of Granger is seen in an informative aspect in order to clarify how many variations in the current levels of environmental indicators (Y) can be attributed to its previous meanings. In addition, also to explain if the previous levels of ICT indicators (X) can improve this explanation. The Granger causality test of the paper was carried out by the VAR-model:

$$EI_t = cons_{EI} + \sum_{j=1}^{p} \alpha_j ICT_{t-j} + \sum_{j=1}^{p} \beta_j EI_{t-j} + v_t$$
$$ICT_t = cons_{ICT} + \sum_{j=1}^{p} \alpha_j ICT_{t-j} + \sum_{j=1}^{p} \beta_j EI_{t-j} + u_t \qquad (2)$$

where*:* (*ICT*) and *(EI)* are vectors of variables and their lags respectively - for ICT and environmental indicators, and α_j and β_j are matrices of coefficients to *:(ICT*) and *(EI)*. The disturbance terms v_t and u_t were assumed to be uncorrelated. The verification shall be limited to checking the null hypothesis of equality of zero coefficients of a group (Granger, 1969).

$H_{0(1)}: \alpha_1 = \alpha_2 = ..\alpha_p = 0$ and $H_{0(2)}: \beta_1 = \beta_2 = ...\beta_p = 0$.

According to the test, variables that verify the existence of causality are independent of each other. According to the test results of Granger, the following outputs are possible:

1) No one variable can be classified as a cause in Granger;
2) One-way causality $(ICT \rightarrow EI)$ and not vice versa;
3) One-way causality $(ICT \leftarrow EI)$ but not vice versa.
4) The variables (X) and (Y) represent a two-way Granger cause $(ICT \rightleftarrows EI)$.

Following the theoretical background, the test can be applied to each of the indicators that characterize the green growth. Hypotheses to be verified are:

$H_{0(1)}$:ICT indicators do no Granger Cause under the impact of the environmental indicators i.e.

$H_{0(2)}$:Environmental indicators do not Granger Cause under the impact of ICT indicators i.e.

both tested hypotheses relate to the rates of change of the underlying variables. Both of the tested hypotheses are related to the rates of change of the variables. In this sense, both hypotheses are checked: the first one- the rate of change in ICT indicators are not the cause of the rates of change of environmental indicators; and the second one- the rate of change of the environmental indicators are not the cause of the rate of change of the environmental indicators. To reach the conclusion that (ICT) influences (EI) i.e. (ICT→EI) it is necessary to meet simultaneously the following conditions:

1) Rejected hypothesis $H_{0(1)}$: “(ICT) does not affect (EI)".
2) Accepted hypothesis $H_{0(2)}$: "(EI) does not affect (ICT)".

In the event that both hypotheses are rejected, so the relationship between the two variables exists. If both hypotheses are accepted, the causal relationship between variables in the sense of Granger does not exist. It should be noted that the test results will show only in a purely statistical sense whether past values of one variable may contribute to the explanation of the variation in another variable. The application of Granger causality test enforces the requirements on the construction of the autoregressive models with distributed lag, as well as those for ensuring stability of VAR-system. Practically (de facto) the test of hypotheses is through F-test:

$F = \frac{(SSR_R - SSR_U)/h}{SSR_U/(n-k_U)}$, degrees of freedom, $v_1=h$, $v_2=n-k_U$, n – number of observations; k_R – parameters in the unrestricted regression; h – number restrictions $h=(k_U-k_R)$; SSR_u, SSR_R – sum of squared residuals in unrestricted and restricted AR-model. The test was applied to the AR-model with significant parameters and normal distribution residuals. VAR-systems are tested and specified in terms of Lag Structure by Lag Exclusion Wald Tests, Lag Order Selection is determined by co-application of the following tests: LR: sequential modified, AIC, SC information criterion. For the residuals are used autocorrelation analysis, LM-test and Normality tests. All calculations are carried out by statistical software EViews 9.5. Therefore, such a relationship cannot be used to bring theoretical conclusions, but only for acceptance or rejection of such relationship. The procedure of the Granger causality test sets out in pairs of the variables groups: ICT and environmental indicators. So, for the purpose of this paper have been tested all possible pairs of causality variables on the principle "each with each". The results of the paper are logically justified by the relationship between ICT and environment indicators.

Result and discussion

From the study emerges that inclusive green growth policies in Bulgaria is progressing slowly (Mancheva, 2012). The test results in table no. 3, for example, show that a well-developed ICT sector stimulates no renewable higher electricity production. The rates of change of the components of ICT intensity are an incentive for energy production and consumption. The relationships from Intensity ICT indicators to total energy production, including also nuclear sources or renewable sources, are one-way causality relationships. Only the variables total traffic from mobile networks and energy production from nuclear sources or renewable sources represent a Granger causality or can be considered as endogenous variables. It can be argued that not only the availability of ICT infrastructure or the access to ICT are the main reasons for the electricity production from different sources. These results only show that the rates of change of ICT indicators and electricity production can be defined as coherent. Existing energy mix is a necessary but not sufficient element for the ICT development. The test results in table no. 4 show that the indicators for Access to ICT (without differences between the types of traffic) can be identified as the cause in Granger as regards the primary energy consumption. In recent years, both the number of subscribers of fixed telecommunication networks in Bulgaria and their consumption have fallen very quickly. The test results in table no. 4 show that the indicators for Access to ICT (without differences between the types of traffic) can be identified as the cause in Granger as regards the primary energy consumption. In recent years, both the number of subscribers of fixed telecommunication networks in Bulgaria and their consumption have fallen very quickly.

Table no. 3 Pairwise Granger Causality (GC) Tests for the energy mix

Hypothesis	Lags: 2			Lags: 3			Conclusions
	Obs	F-Stat	Prob	Obs	F-Stat	Prob	
FIXED_MLN *d_n GC* [§] EP_ANE	42	4,478	0,0181				$(Fixed\_min \rightarrow EPane)$
EP_ANE d_n GC FIXED_MLN		2,754	0,0768				
MOBILE_MIN d_n GC EP_ANE	42	1,452	0,2471				$(Mobile\_min \rightleftarrows EP\_ane)$
EP_ANE d_n GC MOBILE_MIN		3,182	0,0530				
FIXED_MLN d_n GC EP_RENEW	42	0,786	0,4631				$(Fixed\_min \rightarrow EP\_renew)$
EP_RENEW d_n GC FIXED_MLN		3,033	0,0603				
MOBILE_MIN d_n GC EP_RENEW				41	4,260	0,011	$(Mobile\_min \rightleftarrows EP\_renew)$
EP_RENEW d_n GC MOBILE_MIN					9,0680	0,001	

FIXED_MLN d_n GC EP_TOTAL	42	3,4228	0,0433				$(Fixed\_min \rightarrow EP\_total)$
EP_TOTAL d_n GC FIXED_MLN		1,6585	0,2043				
MOBILE_MIN d_n GC EP_TOTAL				41	3,504	0,025	$(Mobile\_min \rightarrow EP\_total)$
EP_TOTAL d_n GC MOBILE_MIN					0,196	0,898	

d_n GC §: does not Granger Cause

Table no. 4 Pairwise Granger Causality Tests for ICT infrastructure

Hypothesis:	Lags: 2			Lags: 3			Conclusions
	Obs	F-Stat	Prob	Obs	F-Stat	Prob	
TTS *d_n GC* § PRIMENCONS	42	2,644	0,084				$(TTS \rightleftarrows Prim\_c)$
PRIMENCONS d_n GC TTS		3,327	0,047				
FIXED d_n GC PRIMENCONS	42	0,547	0,583				Yes, does not Granger cause
PRIMENCONS d_n GC FIXED		1,442	0,249				
MOBILE d_n GC PRIMENCONS	42	2,713	0,079				$(Mobile \rightleftarrows Prim\_c)$
PRIMENCONS d_n GC MOBILE		3,860	0,030				
IS d_n GC PRIMENCONS				41	3,766	0,019	$(IS \rightleftarrows Prim\_c)$
PRIMENCONS d_n GC IS					2,445	0,080	
IU d_n GC PRIMENCONS				41	4,209	0,012	$(IU \rightleftarrows Prim\_c)$
PRIMENCONS d_n GC IU					2,306	0,094	
PRIMENCONS d_n GC INVEST_ICT				41	6,674	0,001	$(Invest \rightleftarrows Prim\_c)$
INVEST_ICT d_n GC RIMENCONS					3,418	0,028	

d_n GC §: does not Granger Cause

The test results in table no. 5 show logical relationships, so that the ICT infrastructure and ICT access do Granger cause for forest areas. Furthermore, the arable land does Granger cause for GDP and Internet infrastructure. During the sampling for this paper, we discovered that there is no difference in Bulgaria between the use of GDP and Net National product as replaceable indicators.

Conclusions

The presented results lead to the following observations for the green growth trends in Bulgaria, based on environmental and ICT indicators: tables no. 3, 4 and 5 show that the levels of rejection of the null hypothesis are far below than the traditionally accepted in similar studies α = 0, 05.

Table no. 5 Pairwise Granger Causality Tests for natural resources

Hypothesis:	Lags: 2			Conclusions
	Obs	F-Stat	Prob,	
AL_PERSON d_n GC GDP	41	3,189	0,053	$(Al\_per \rightleftarrows GDP)$
GDP d_n GC AL_PERSON		3,533	0,040	
AL_PERSON d_n GC IU	41	3,189	0,053	$(Al\_per \rightleftarrows IU)$
IU d_n GC AL_PERSON		3,533	0,040	
ARABLAND d_n GC GDP	41	3,910	0,029	$(Arabland \rightleftarrows GDP)$
GDP d_n GC ARABLAND		3,821	0,031	
ARABLAND d_n GC IU	41	3,910	0,029	$(Arabland \rightleftarrows IU)$
IU d_n GC ARABLAND		3,821	0,031	
ARABLAND d_n GC TTS	47	4,981	0,012	$(Arabland \rightleftarrows TTS)$
TTS d_n GC ARABLAND		5,510	0,008	
FOREST_SQKM d_n GC FIXED	47	6,369	0,004	

FIXED d_n GC FOREST_SQKM	47	0,310	0,735	$(Fixed \rightarrow Forest\_sq)$
FOREST_SQKM d_n GC IS	37	12,601	0,000	$(IS \rightarrow Forest\_sq)$
IS d_n GC FOREST_SQKM		0,755	0,478	
FOREST_SQKM d_n GC MTL_1000	47	3,280	0,048	$(MTL'000 \rightarrow Forest\_sq)$
MTL_1000 d_n GC FOREST_SQKM		0,726	0,490	
FOREST d_n GC IU_1000	47	4,841	0,013	$(Forest \rightleftarrows IU'000)$
IU_1000 d_n GC FOREST		3,763	0,031	

d_n GC §: does not Granger Cause

So, the proposed Granger test designs some trends for the selected indicators (included in an econometric model) in order to predict their future development as possible. The studied relationships between ICT and the ecological indicators proves that in Bulgaria the pattern of "green growth" is not going in the right direction according to the worldwide and European trends. At this stage, the green growth in the country can be described as chaotic and uncertain. The Granger test is useful in demonstrating the different interrelations highlighting the strong and the weak correlations. The test has showed only indirect links between ICT and environmental indicators, with the leading role of the ICT indicators. This is because the ICT sector in Bulgaria is well-developed, but the policy for developing natural resources management is still not well-realised. The collected information for environmental indicators in Bulgaria is relatively "young", with different frequencies of collection and cannot allow distinguishing a long-term co-integration relation between the variables. For this reason, no important relationship for green growth strategies can be associated with the possible reduction of green houses gases (GHG) emissions. This means that Bulgaria is in delay in taking actions towards the transition to green growth. It would be necessary many significant long-term investments and innovations to replace inefficient technology with costly new infrastructure. For such investments and actions to address sustainable and equitable outcomes, the decision-policy makers have to deliver new form of investments in order to make the transition to green growth effective in Bulgaria. Another essential recommendation is to unify the content of environmental indicators in Bulgaria with the international database for environmental indicators internationally, maintaining a database with lower frequencies of surveillance - eg. monthly and quarterly data.

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