Article

The harness of intellectual capital for economic progress and sustainability

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Abstract: Bio-economy is a major area of the strategy that must enable the European Union to achieve growth: smart, through the development of knowledge and innovation; and sustainable, based on a greener, more efficient economy in resource management. We believe that the progress of bio-economy cannot be achieved without the harnessing of intellectual capital. Our research aimed to emphasize the benefits of the dynamics of the intellectual capital growth on the evolution of the bio-economy. The aim of this analysis was to study the established link between the Energy Intensity of the Economy (EIE) and a number of factors that can measure the intellectual capital, such as: Market Capitalization of Bitcoin, Patent applications listed by European Patent Office and the Turnover from Innovation as a proportion of the total Turnover. The ultimate goal was represented by the generation of a regression model to see what factor influences mostly the progress of the bio-economy at European and Romanian level.

Keywords: intellectual capital; sustainability; harness**;** bio-economy; global crisis

1. Introduction

The global crisis that has given society a certain way of manifestation and behavior that is characteristic of emergencies, often defined by unbalanced strategic decisions, has a multidimensional character and includes aspects such as the crisis of the economic domain: energetic, financial, commercial; the crisis of the ecological and biosphere domain, environmental crisis [1-2].

The fundamental evolution that constantly required the development of the human race was based on solving the economic problem, meeting a growing set of needs, given the limited and insufficient resources. In the development of relationships between people and the environment in which they live, as part of nature, were structured diametrically opposite concepts, in analysis and vision. Knowledge of nature without wisdom has led to ignoring the risks of its alteration and to which attention is drawn today. The balance between man and the environment has been broken by technological progress, economic development and the demographic explosion. The law of action and reaction speaks its word. Albert Arnold Gore, the 45th Vice President of the USA, was talking about an environmental holocaust in what Karl Popper, considered to be one of the greatest science philosophers in the twentieth century, considers as an effect of disregarding nature namely the loss of the sense of piety for nature [3].

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As long as the quality of human life depends on its natural environment of existence, the artificial environment created by man and the interrelationships between humans, the ecological crisis - an invisible bomb, manifests itself through violence on nature, including man, as in human hedonism on the account of nature, including on behalf of its neighbor [4].

The concept of "bio-economy", according to Bonaiuti, who used the concept at the end of the 1960s, represented an appropriate economic order that underpins all economic activities [5]. Georgescu-Roegen who has been studying economics since the 1970s had the same opinion. Essential in Georgescu-Roegen's research on bio-economics was his concern for economic growth without limitation that is incompatible with the fundamental laws of nature [6].

In one of his work, Enriquez argues that the application of genomics discoveries leads to a restructuring of the capacities of all companies and industries in a manner that will modify the world's economic condition. He highlighted the creation of a very new economic sector, the "life sciences" [7].

The European Commission has begun to promote this concept a lot in recent years. One of the most important actors in this effort was Patermann, who was program director of "Biotechnology, Agriculture and Nutrition" at the European Commission's Directorate-General for Research, Science and Education. The first Global Bio-economic Summit took place in Berlin in December 2015. Globally, bio-economy has gained great significance in last years as a wide range of benefits have been detected by several countries [8].

Intellectual capital in the current economy becomes the new core of economic development, because the impact of financial assets and fixed assets is clearly inferior to the impact sustained by knowledge [9-10]. Reliable measurement of this one has become a major research area for practitioners and researchers since the early 1990s.

Our research aimed to emphasize the benefits of the dynamics of the intellectual capital growth on the evolution of bio-economy. The aim of this analysis was to study the established link between the Energy Intensity of the Economy (EIE) and a number of factors that can measure the intellectual capital.

2. Materials and Methods

Intellectual capital can be evaluated by various methods, but the easiest method is represented by the difference between the market established value of one company and the total value of its assets. Although intellectual capital can now be considered somewhat abstract, in the economy, the concept of intellectual capital is defined as "an estimate of a person's ability to produce income through work" [11]. Intellectual capital is considered a hidden treasure to help companies, the economy and, implicitly, bio-economy to develop in this age of technology and knowledge.

2.1. Setting goals and assumptions

Considering intellectual capital as a key resource for the expansion of organizational intelligence, economic growth and especially for the development of bio-economics, we have used the following objectives (of our methodology) for analysis:

- **O1:** Determining the link and the percentage in which Bitcoin's Market Capitalization (MkCapBTC) influences the EIE, at European level and at the level of Romania;
- **O2**: Determining the link and the percentage in which the Patent applications listed by European Patent Office (CB) influences the EIE at European level and, in particular, at the level of Romania;

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- **O3**: Determining the link and the percentage in which the Turnover from innovation as a percentage of Total Turnover (CA_INV) influences the EIE at European and national level.

Further, considering our scientific approach, we have established the following assumptions:

- General hypothesis: The evolution of bio-economics at European and Romanian level is influenced by intellectual capital;
- **H1**: There exists a considerable link between the EIE and the MkCapBTC;
- **H2**: Between the EIE and the CB there is a considerable link;
- **H3**: There exists a considerable link between the EIE and the CA_INV.

2.2. Operationalization of variables and data collection

The study is based on data between 2015 and 2017 on the EIE, the stock market capitalization of the Bitcoin digital coin, Patent applications listed by European Patent Office and the Turnover from Innovation. The data were taken from the Eurostat European Statistics Institute and from a very important trading platforms of cryptocurrency, coinbase.com.

The variables, described by their nature and also, used in the model, are summarized in Table 1. On these data the method of observation and statistical analysis were applied to confirm or to invalidate the assumptions of the research.

Table 1. The variables used in the econometric model

No.	Variables	Economic expression	Statistical expression
1	EIE	**Energy Intensity of the Economy** [12] In the current energy context, sustainable development means ensuring energy needs, but not by increasing its use (except for renewable energy), but by increasing energy efficiency, modernizing technologies and restructuring the economy. EIE = CBIE / GDP CBIE = Total Gross Energy Usage GDP = gross domestic product	Dependent Variable Resolvable variable Quantitative dimension Purpose of selecting the variable: defining bio-economy
2	MkCapBTC	**Market Capitalization of Bitcoin** [13] Bitcoin is a virtual currency that allows anonymous ownership and transfer without recourse to financial institutions. MkCapBTC = the number of digital coins * the market value of a currency	Independent variable Variable predictor Quantitative dimension Purpose of selecting the variable: defining intellectual capital
3	CB	**Patent applications listed by European Patent Office** [14] The indicator measures claims for the protection of an invention directed in a direct manner at the European Patent Office (EPO) or submitted under the Patent Cooperation Treaty and	Independent variable Variable predictor Quantitative dimension Purpose of selecting the variable: defining intellectual capital

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		designating an EPO (Euro-PCT), whether accepted or not. The data cover the total number of applications listed per country. If an application includes more than one inventor, the submission is equally divided between all and then in their home countries, thus avoiding double counting.	
4	CA_INV	**Turnover from Innovation as a proportion of the total Turnover** [15] This parameter is defined as the ratio between the turnover of the new products for the company and the new ones on the market as a proportion of the total turnover. It is based on the Community Innovation Survey and covers at least all enterprises with 10 or more employees. An innovation is considered to be a new or significantly improved product (as good or service) placed on the market or the introduction of a really new or meaningfully improved process in a company.	Independent variable Variable predictor Quantitative dimension Purpose of selecting the variable: defining intellectual capital

The systematization and grouping of data, indices, statistical analysis were used as methods in conducting scientific research.

Regression shows how a variable is dependent on another variable. The equation of the regression model is expressed as follows (1):

$$EIE = \beta_0 + \beta_1 * MkCapBTC + \beta_2 * CB + \beta_3 * CA\_INV + \varepsilon \quad (1).$$

2.3. Analyzing data, obtaining and interpreting the results

This analysis explores the link between the Energy Intensity of the Economy and a number of factors that can define the intellectual capital such as: Market Capitalization of Bitcoin, the number of Patent applications listed by European Patent Office and the Turnover from innovation, with the ultimate goal of generating a statistical regression model to analyze which factor had the greatest influence on the development of the bio-economy.

The analysis was carried out at European (EIE-E) and Romanian level (EIE-R).

3. Results

Among other things, the European Union and the Organization for Economic Co-operation and Development (OECD) have highlighted the need for global cooperation to facilitate the growth of bio-economic activities.

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In Figure 1 we can see the magnitude to which measures have been taken to create a global economy.

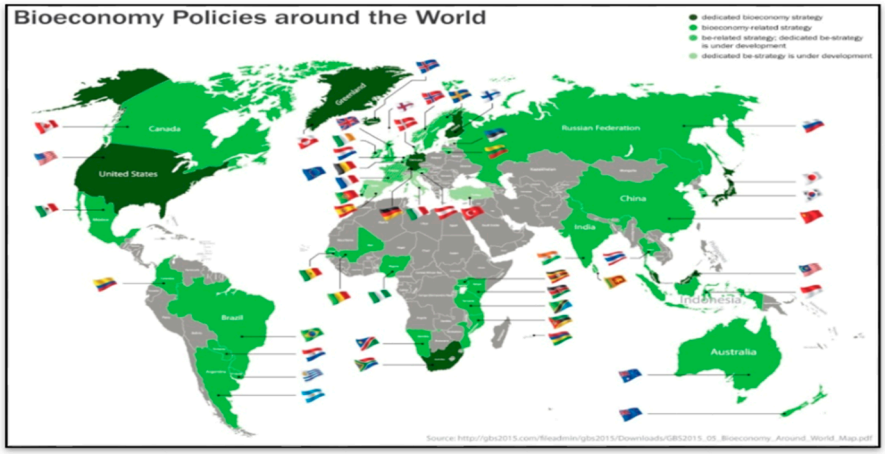

Figure 1. Bio-economic measures worldwide [16]

The number of publications listed in Scopus referring to bio-economy is presented in Figure 2.

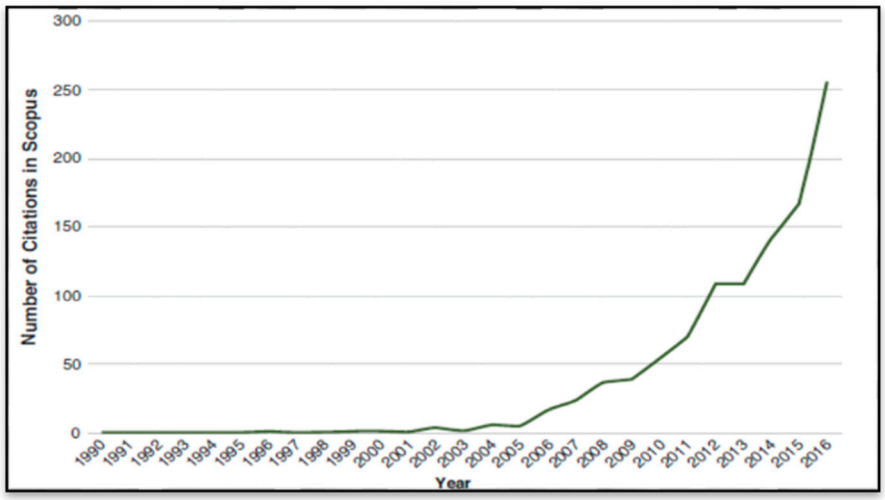

Figure 2. The number of citations listed in Scopus referring to bio-economy [17]

Considering the crisis caused by the current economy, we can state, according to market statistics, that the market value of many large companies is mostly given by intellectual capital rather than by the total value of the assets measured at market value.

3.1. Empirical analysis at European level

It is found that the most significant link is between the Energy Intensity of the Economy and the Turnover from innovation (Table 2). Between the dependent variable - the Energy Intensity of the Economy - and the independent variable - the Turnover from innovation as a percentage of the total turnover - there is really a strong direct link, the value of the correlation coefficient is equal to + 0.954, with a Sig. value less than 0.05.

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Table 2. The link that exists between variables at European level (own processing data using the SPSS 19 statistical program)

Correlations					
		EIE-E	MkCapBTC	CB	CA_INV
Pearson Correlation	EIE-E	1.000	-.726	.531	.954
	MkCapBTC	-.726	1.000	-.724	-.997
	CB	.531	-.724	1.000	.779
	CA_INV	.954	-.997	.779	1.000
Sig. (1-tailed)	EIE-E	-	.012	.011	.009
	MkCapBTC	.012	-	.024	.027
	CB	.011	.024	-	.021
	CA_INV	.047	.027	.0216	-
N	EIE-E	3	3	3	3
	MkCapBTC	3	3	3	3
	CB	3	3	3	3
	CA_INV	3	3	3	3

Table 3 highlights the fact that 95% of the variation of the Energy Intensity of the Economy can be explained by the influence of independent variables. The difference is due to other conjunctural factors.

Table 3. The percentage of the link between European variables (own processing data using the SPSS 19 statistical program)

Model Summary[a]				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	.958[b]	.918	.505	2901.64993
2	.895[c]	.801	.701	2234.68446
3	.849[d]	.720	.665	1884.86021

a. dependent variable: EIE-E; b. independent variables: MkCapBTC, CB, CA_INV; c. independent variables: CB, CA_INV; d. independent variables: CA_INV.

Table 3 shows for each regression model the value of the correlation coefficient (R), the value of the coefficient of determination (R Square) and the standard error. The correlation coefficient (R) increases as many variables are introduced into the model. Model 1 analyzes the correlation between all the variables included in the study. Model 2 and 3 eliminate the variables in order of the weakest influence: MkCapBTC and CB, respectively (see Pearson coefficient in Table 2).

The equation (1) of the regression model according to the data presented below is the following (2):

$$EIE\text{-}E = (-3641.119) + 22.354*MkCapBTC + 13.066*CB + 62.455*CA\_INV \quad (2)$$

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The Regression coefficients are as stated in Table 4, e.g. β_0 = -3641.119; β_1 = + 22.354; β_2 = + 13.066; β_3 = + 62.455.

Table 4. The Regression coefficients at European level (own processing data using the SPSS 19 statistical program)

Coefficients[a]							
Model 1	**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig**	**Collinearity Statistics**	
	β	**Std. Error**	**β**			**Tolerance**	**VIF**
(Constant)	-3641.119	23414.050	0.000	0.000	0.000	0.000	0.000
CB	13.066	0.001	0.476	0.157	0.0901	0.393	-2.543
CA_INV	62.455	1234.000	0.583	0.402	0.0970	0.293	2.743
MkCapBTC	22.354	356.235	0.367	0.207	0.0720	0.172	1.892
a. dependent variable: EIE-E; independent variables: CB, CA_INV, MkCapBTC.							

Model 1 reflects the influence of the evolution of the number of Patent applications to the European Patent Office, the Turnover from innovation and the stock market capitalization of the Bitcoin digital coin, all on the Energy Intensity of the Economy at European level.

From the analyzed model, a few ideas are drawn:

- if we keep constant the Turnover from innovation and the value of Market capitalization of the Bitcoin, a percentage increase in the number of Patent applications listed by European Patent Office generate an increase in the Energy Intensity of the Economy by 13 percent;
- if we maintain constant the number of Patent applications listed by European Patent Office and the value of Bitcoin's stock market capitalization, a percentage increase in Turnover from innovation leads to an increase in the Energy Intensity of the Economy by 62 percent;
- if we maintain constant the value of Turnover from innovation and the number of Patent applications listed by European Patent Office, a percentage increase in the value of Bitcoin's stock market capitalization leads to an increase in the Energy Intensity of the Economy by 22 percent.

Compliance with the hypothesis required by the regression analysis can be graphically checked using the histogram in Figure 3.

3.2. Empirical analysis at the Romanian level

It is noted that the most significant link is between the Energy Intensity of the Economy and the number of Patent applications to the European Patent Office (Table 5). Between the dependent variable - the Energy Intensity of the Economy - and the independent variable - the number of Patent applications to the European Patent Office - there is really a strong direct link, the value of the correlation coefficient is + 0.810, with a Sig. value less than 0.05.

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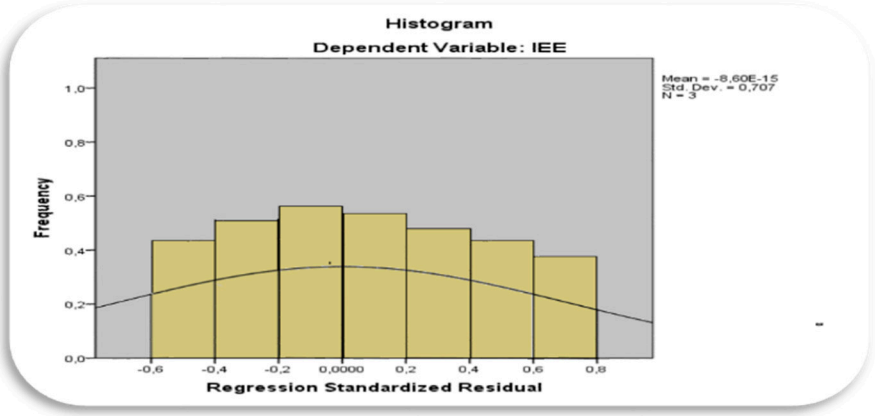

Figure 3. Verifying the normality of the research at European level through the histogram (own processing data using the SPSS 19 statistical program)

Table 5. The link that exists between variables at the Romanian level (own processing data using the SPSS 19 statistical program)

Correlations					
		EIE-R	MkCapBTC	CB	CA_INV
Pearson Correlation	EIE-R	1.000	-.526	.810	.732
	MkCapBTC	-.526	1.000	-.632	-.997
	CB	.810	-.732	1.000	.779
	CA_INV	.732	-.897	.779	1.000
Sig. (1-tailed)	EIE-R	-	.011	.021	.008
	MkCapBTC	.011	-	.024	.027
	CB	.024	.024	-	.021
	CA_INV	.027	.027	.0216	-
N	EIE-R	3	3	3	3
	MkCapBTC	3	3	3	3
	CB	3	3	3	3
	CA_INV	3	3	3	3

Table 6 highlights the fact that 92% of the variation of Energy Intensity of the Economy can be explained by the influence of independent variables. The difference is due to other conjunctural factors.

Table 6. The percentage of the link between the variables at Romanian level (own processing data using the SPSS 19 statistical program)

Model Summary[a]				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	.926[b]	.915	.605	3901.4513
2	.797[c]	.903	.701	4134.5846

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3	.738[d]	.821	.665	1227.6021

a. dependent variable: EIE-R; b. independent variables: MkCapBTC, CB, CA_INV; c. independent variables: CB, CA_INV; d. independent variables: CB.

Table 6 shows for each regression model the value of the correlation coefficient (R), the value of the coefficient of determination (R Square) and the standard error. The correlation coefficient (R) increases as many variables are introduced into the model. Model 1 analyzes the correlation between all the variables included in the study. Model 2 and 3 eliminate the variables in order of the weakest influence: MkCapBTC and CA_INV, respectively (see Pearson coefficient in Table 5).

The equation (1) of the regression model according to the data presented below is the following (3):

$$EIE\text{-}R = 841.328 + 12.305*MkCapBTC + 43.136*CB + 32.034*CA\_INV \quad (3)$$

The Regression coefficients are as stated in Table 7, e.g. $\beta_0 = +841.328$; $\beta 1 = +12.305$; $\beta 2 = +43.136$; $\beta 3 = +32.034$.

Table 7. The Regression coefficients at Romanian level (own processing data using the SPSS 19 statistical program)

Coefficients[a]							
Model 1	**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig**	**Collinearity Statistics**	
	β	**Std. Error**	**β**			**Tolerance**	**VIF**
(Constant)	841.328	414.03	0.000	0.000	0.000	0.000	0.000
CB	43.136	0.001	0.46	0.21	0.089	0.377	1.343
CA_INV	32.034	231.00	0.67	0.29	0.090	0.298	1.533
MkCapBTC	12.305	446.24	0.27	0.21	0.073	0.178	0.874

a. dependent variable: EIE-R; independent variables: CB, CA_INV, MkCapBTC.

The model reflects the influence of the evolution of the number of Patent applications to the European Patent Office, the Turnover from innovation and the stock market capitalization of the Bitcoin digital coin on the Energy Intensity of the Economy at the level of Romania.

Thus, from the analyzed model a few ideas are drawn:

- if we keep constant the Turnover from innovation and the value of Market capitalization of the Bitcoin, a percentage increase in the number of Patent applications listed by European Patent Office leads to an increase in the Energy Intensity of the Economy by 43 percent;
- if we maintain constant the number of Patent applications listed by European Patent Office and the value of Bitcoin's stock market capitalization, a percentage increase in Turnover from innovation leads to an increase in the Energy Intensity of the Economy by 32 percent;
- if we maintain constant the value of turnover from innovation and the number of Patent applications listed by European Patent Office, a percentage increase in the value of Bitcoin's stock market capitalization leads to an increase in the Energy Intensity of the Economy by 12 percent.

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Compliance with the hypothesis required by the regression analysis can be graphically checked using the histogram in Figure 4.

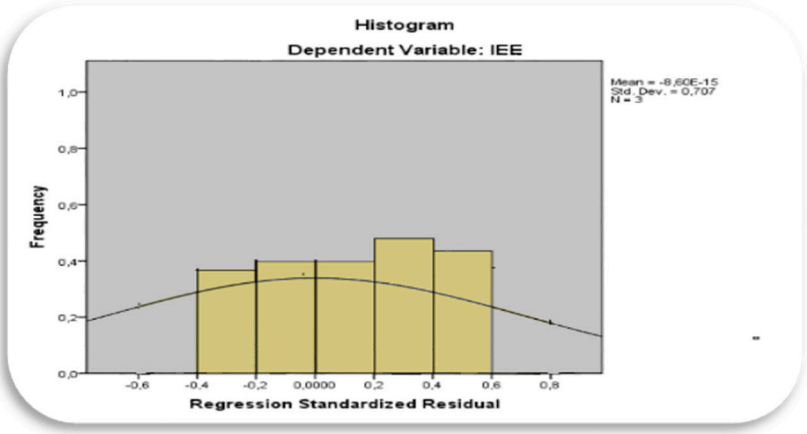

Figure 4. Verifying the normality of the research at Romanian level through the histogram (own processing data using the SPSS 19 statistical program)

3.3. Hypothesis testing using data processed

In this part of the analysis we will perform the test of the force of each hypothesis, testing being done predominantly with the help of figures and graphs from the previous parts of the study.

Thus, Table 8 systemizes:

- Pearson correlation coefficients to determine whether there is a significant link between the dependent variable aka Energy Intensity of the Economy and the independent variables that characterize intellectual capital: Market Capitalization of Bitcoin, Patent applications listed by European Patent Office and the Turnover from innovation as a percentage of the total Turnover;
- regression coefficients that determine the degree of influence of independent variables on the bio-economy.

Table 8. Systematization of regression coefficients and Pearson coefficients (own processing data using the SPSS 19 statistical program)

Intellectual capital	Pearson coefficients		Regression coefficients	
	European Level	Romanian Level	European Level	Romanian Level
MkCapBTC	-.726	-.526	13.066	12.305
CB	.531	.810	22.354	43.136
CA_INV	.954	.732	62.455	32.034

On the other hand, Table 9 summarizes the assumptions made at the beginning of the research and the decisions regarding their validation or invalidation based on the econometric model used.

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Table 9. Validation of hypotheses

Aim	Hypotheses	Decision using the regression model	
		European Level	Romanian Level
Highlighting the benefit of developing intellectual capital in the development of bio-economy	**H1**: There is a significant link between the Energy Intensity of the Economy and the Bitcoin Market Capitalization	The hypothesis is validated	The hypothesis is validated
	H2: Between the Energy Intensity of the Economy and the Patent applications listed by European Patent Office there is a significant link	The hypothesis is validated	The hypothesis is validated
	H3: There is a significant link between the Energy Intensity of the Economy and the Turnover from innovation.	The hypothesis is validated	The hypothesis is validated

4. Discussion

Edvinsson and Malone described the intellectual capital as a metaphor. They imagined the firm as a tree. They overlapped the compiled plans of the company, the reports annually and quarterly developed, the brochures and all other documents of the firm as the trunk, as well as the branches and the leaves of the living organism. The wise angle will be the examination from the point of view of fruit production. The biases might evolve from the judging of only the visible side of the tree. Since an important part of the tree is out of sight. Even if we appreciate the tree as being healthy starting from the fruits (tasty and with nice color), it will be of real interest to study the tree's roots in the view of its evolution in the future. Thus might be described the intellectual capital [18].

From 1947 till 2011 there was an important shift in the balance of productive and unproductive economy of US. The starting point of such an analysis was the Marxist theory that the knowledge and information as economic categories are unproductive. The first observed pattern phase, meaning the 1947-79 one, had as absolute priority the productive accumulation. Beginning with the 1980s, there was a fast and important shift toward the unproductive activities (accumulation), taking various developing forms as income, fixed assets and employment. The shining production of explosive knowledge and information became an important proportion of capital stock as well as of unproductive income. The rapid changing of the balance between the stagnant productive accumulation and fast rising of unproductive one gave birth to an enhanced exploitation of productive workers and to a widened inequality of income [19].

One of the most important aspect of modern bio-economy is represented by the digitalization of markets, having as consequence the appearance and development of some consumption patterns visible at the macroeconomic scale. The new tendencies of consumer's behavior, basically based on the reconfiguration of their approaches and expectations, have their origin in the corroboration of new sustainable economy's needs with the advances in digital technologies. The empowering of consumers squeezes out of the emergence of their online communities and of the online intellectual capital. The newest social aggregations of online type allow deepened transformations in actual

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society, starting from the need of an enhanced communication and flows of information on products of the digital markets which are bio-labelled [20].

Economic growth in modern era is no more related to the growth limits, growth opportunities being far way more important. The last ones are basically involving the developing knowledge, research investments, innovative trends and performance of technology, all known as smart economic growth. On the other hand, sustainable economic growth is based on green energy, policies involving low-carbon emissions and high reduction of collateral effects on environment. There exists important global interdependencies between economic growth, circular economy and the newest trend represented by intellectual capital. All of them when discussing the bio-economy advances. The regression models used to study such interdependencies are including various variables. Thus, the performance of innovation might be quantified using as proxy variable the number of patents. Circular economy would be measured using as dependent variable the added value. Intangible (knowledge/intellectual capital) and renewable resources used in a cascade are highly influencing the sensitivity of economic growth, in turn quantified using the gross domestic product. The intellectual property turned into patents is deepened influenced by the amount of the allocated funds for research and development, as well as by the fiscal freedom. When focusing on added value created in circular economy, there was found an important correlation with the export of recyclable raw material, employment of population in such domain as well as with the rate of the recycling of municipal waste Remarkable is the observed fact that the economic growth in the EU region is positively correlated with the productivity of employees from bio-economy domains [21].

5. Conclusions

The global crisis characterized by the crisis of the energy, ecology and the biosphere, and the environment requires solving the economic problem, satisfying a growing set of needs, given the limited and insufficient resources.

Bio-economy must be the basis for all economic activities and unlimited economic growth must be compatible with the fundamental laws of nature.

The results of our analysis lead to the conclusion that research and innovation play an important role in the evolution of bio-economy both at European level and at the level of Romania.

We believe that the progress of bio-economy cannot be achieved without the harness of intellectual capital.

Significant potential for bio-resources could be exploited through bio-economic approaches. In order to achieve this capitalization, new solutions are needed for the sustainable intensification of the production of biological resources and for intelligent exploitation of bio-resources.

However, the practical development and implementation of these new solutions implies a significant investment in education and research, bio-economic branches with high added value, meanwhile being branches of the knowledge-based economy.

The analysis leaves room for further interpretations and future research because the study was only conducted for a period of 3 years and the number of variables was limited.

Author Contributions

Conceptualization, Irina Chiriac; Data curation, Irina Chiriac; Formal analysis, Gabriela Ignat, George Ungureanu and Dragos Alexandru Robu; Methodology, Irina Chiriac; Project administration, Carmen Luiza Costuleanu; Supervision, Carmen Luiza Costuleanu; Validation, Gabriela Ignat,

George Ungureanu, Dragos Alexandru Robu and Carmen Luiza Costuleanu; Visualization, Irina Chiriac, Gabriela Ignat, George Ungureanu, Dragos Alexandru Robu and Carmen Luiza Costuleanu; Writing – original draft, Irina Chiriac; Writing – review & editing, Irina Chiriac, Gabriela Ignat, George Ungureanu, Dragos Alexandru Robu and Carmen Luiza Costuleanu.

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Conflicts of Interest

The authors declare no conflict of interest.

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