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## Article

# Sustainable transformation of Romanian companies through industry 4.0, green production and environment commitment

Amfiteatru Economic Journal

## Provided in Cooperation with:

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*Suggested Citation:* Meghişan-Toma, Georgeta-Mădălina et al. (2022) : Sustainable transformation of Romanian companies through industry 4.0, green production and environment commitment, Amfiteatru Economic Journal, ISSN 2247-9104, The Bucharest University of Economic Studies, Bucharest, Vol. 24, Iss. 59, pp. 46-60,  
<https://doi.org/10.24818/EA/2022/59/46>

This Version is available at:

<https://hdl.handle.net/10419/281620>

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# SUSTAINABLE TRANSFORMATION OF ROMANIAN COMPANIES THROUGH INDUSTRY 4.0, GREEN PRODUCTION AND ENVIRONMENT COMMITMENT

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## Please cite this article as:

Meghișan-Toma, G.M., Puiu, S., Florea, N., Meghișan, F., Bădîrcea, R. and Manta, A., 2022. Sustainable Transformation of Romanian Companies through Industry 4.0, Green Production and Environment Commitment. *Amfiteatru Economic*, 24(59), pp. 46-60.

DOI: 10.24818/EA/2022/59/46

## Article History

Received: 20 September 2021

Revised: 10 October 2021

Accepted: 15 November 2021

## Abstract

The main aim of this research article is to develop an econometric model in order to establish the influence of green performance on digitization, green production and environment commitment. The data was collected through a questionnaire- based survey on companies' representatives. The analysis was made using the Partial Least Square – Structural Equation Modelling (PLS-SEM) with the statistical software SmartPLS. The results of the research confirm the three hypotheses. Thus, green performance of Romanian companies has a positive impact on green production, digitization and environment commitment. The novelty consists in the interconnected analysis of the four variables (green performance, digitization, green production and environment commitment), the research highlighting valuable results that can be used by the companies to improve their green performance, using green production and digitization. The paper offers a picture of the sustainable transformation of Romanian companies based on the industry 4.0, green production and environment commitment, highlighting the interdependence of the analysed variables. The research is helpful for companies that want to be more responsible towards the environment and the community.

**Keywords:** digitization; industry 4.0., sustainability, environment commitment, green performance, green production.

**JEL Classification:** M10, M12, M13, M14, M15, M21

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## **Introduction**

Companies' competitiveness can be measured through the lens of their capacity to cope with dynamic changes within the industry 4.0. According to Deloitte (2021), this industry refers to "a new industrial revolution", in which "advanced manufacturing techniques" combine themselves with "Internet of Things to create manufacturing systems that are not only interconnected, but communicate, analyse and use information to drive further intelligent action back in the physical world". Numerous research articles (Ejsmont, Gladysz and Kluczek, 2020; Beltrami et al., 2021; Khan, Ahmad and Majava, 2021) focus on the link between industry 4.0 and sustainability. Thus, proving that there is a strong connection between these two concepts is helpful for managers who want to give a more sustainable direction to their companies (Beltrami et al., 2021). According to the United Nations (2021), sustainability refers to three pillars: "economic, social and environmental". Our research focuses on environment and takes into account variables such as green performance, green production and environment commitment. The paper makes the connection between digitization and the third pillar of sustainability. The importance of sustainability for generating loyalty among customers is highlighted by Bodor et al. (2021). Dinu (2020) highlights the role played by green directions of companies when customers make the decision to buy a product.

As climate change is a worrying reality, companies are now becoming more responsible and incorporate various solutions to reduce the carbon footprint and, also, to be more environment friendly. Entering the industry 4.0, by making important steps towards digitization and having a greener vision towards the future of the company, bring important benefits for both the business and the community. Acciarini et al. (2021) argue that there is a strong connection between digitization and sustainability, the former determining the companies to have a more sustainable approach in developing their businesses. Esses, Csete and Nemeth (2021) talk about "sustainability and digital transformation" and their research proves "a strong relationship" between the variables. Chen, Despeisse and Johansson (2020) analyse the relation between digitalization and environment sustainability, showing that there are both positive and negative implications of the technologies specific to the industry 4.0, on the environment. Besides digitization and environment commitment, our research takes into consideration two other variables, such as green performance and green production. Green performance reflects the capacity of companies to protect the environment and reduce the negative impact of their activities. According to Tseng et al. (2011, p.367), green performance "is vital for enterprises in making continuous improvements to maintain sustainable competitive advantages". Wagner and Schaltegger (2004) also analyse the impact of green performance on the competitiveness and economic performance of companies, underlying the importance of being more friendly to the environment. According to the European Commission (2018), green production or green manufacturing "is the solution for reducing production waste", in order to manufacture products with increased life spans. The present paper represents a starting point for future research that can use the novelty brought by our contribution in defining some of the items for the analysed variables. On one hand, these variables were approached in an interconnected manner in order to analyse the impact of companies' green performance on digitization, green production and environment commitment. On the other hand, we added new items for the studied constructs, contributing to the research in this area.

The paper is structured on the following sections: the literature review regarding the analysed topic; the research methodology; the results and discussions; and the last section presenting the conclusions, the limitations of the study, and also the future research directions.

## **1. Literature review**

The present research analyses the impact of green performance on digitization, green production and environment commitment, in accordance with similar findings in this field. This approach is important for companies' representatives who want to be more responsible and sustainable, understanding that being greener means having an important competitive advantage.

### **1.1. Conceptual background**

Green performance is analysed in several works (Wagner and Schaltegger, 2004; Tseng et al., 2011; Ionescu, 2021; Sharma et al., 2021). The authors highlight the role of green performance in the sustainable transformation of companies. Nowadays, more consumers choose to buy products and services from companies who protect the environment, are more efficient in using natural resources and reduce their waste. Thus, green performance indicators, which "assess the energy efficiency of a resource or system" (Chen et al., 2011) can be used by every company. They can be tailored to each field of activity, underlying: resource usage; water and energy consumption; produced waste and capacity to reduce it; durability of products brought on the market; implementation of circular economy principles (Jasch, 2000; Hermann, Kroeze and Jawjit, 2007; Kipp et al., 2012; Mahmoud and Ahmad, 2012). According to Hermann, Kroeze and Jawjit (2007), green performance indicators compare a standard index, established by the company's manager or by the industry, to the performance registered by that company, in order to make the necessary corrections for the company to become greener and more sustainable. May, Hao and Carter (2021) highlight the connection between the green behaviour of the employees and the organisation's sustainability, connection which is mediated by trust and the identification with the organisation.

Digitization refers to the digital transformation and represents the central point of the industry 4.0. Ghobakhloo (2020) analyses the benefits brought by digitization to sustainability, these two being interconnected. McKinsey (2015) defines "industry 4.0 as digitization of the manufacturing sector, with embedded sensors in virtually all product components and manufacturing equipment". Cohen (2021) approaches sustainability in the context of the extended digitization in the smart cities, which facilitates data collection with the aim of using it for developing a greener environment. Klymenko et al. (2019) highlights the role of digitization and the transformations brought by the industry 4.0, which help companies collect valuable data from supply chain, thus making more informed and responsible decisions, in accordance to the principles of sustainable development. Also, the authors Valaskova, Ward and Svabova (2021) showed that big data analysis and automatization contribute to the development of sustainable production systems. Many of these features reflecting digitization have been implemented rapidly during the COVID-19 pandemic, since 2020. While a part of the employees worked from home, the digital transformation of the companies had become a necessity. This transformation had important benefits on the environment. Moreover, companies that were more environment

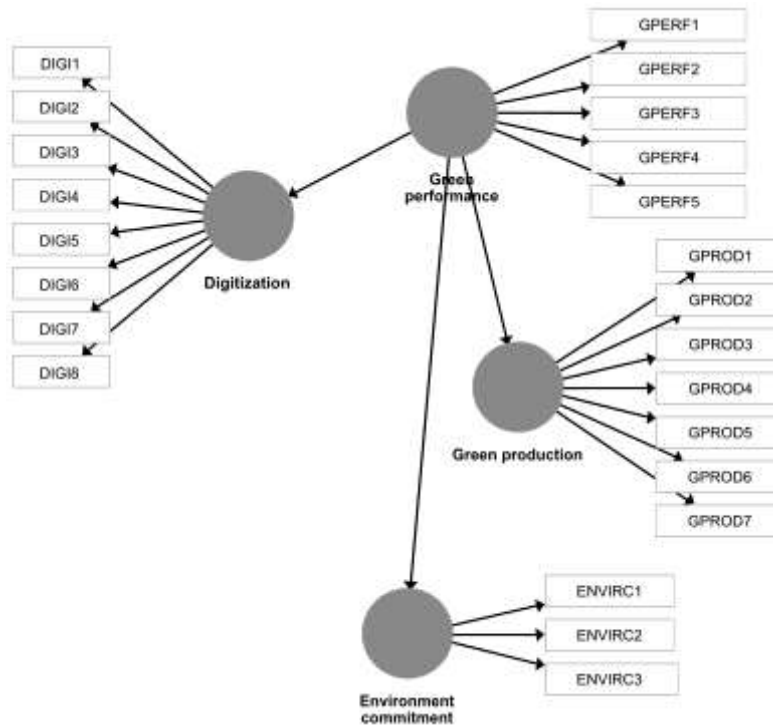
friendly made the transition to digitization easier, using technologies within the industry 4.0 to reduce waste and recycle.

Green production, also known as green manufacturing or sustainable production, was studied in many research works (Baines et al., 2012; Paul, Bhole and Chaudhari, 2014; Bag et al., 2021; Sharma et al., 2021). This way of production can represent a competitive advantage for companies with an environment friendly orientation towards all production processes. Baines et al. (2012) reached the following conclusions: green production is about reducing the negative impact, while enhancing the positive impact on the environment; the concept evolved from waste reduction to a more efficient way of using resources; there are incentives from the government and a pressure from the community representatives to implement greener technologies in production processes. Maruthi and Rashmi (2015) focus on the necessity to adopt green manufacturing, due to the fact that industrialization came with more and better products on the market but, at the same time, more resources were used, while the generated waste and the greenhouse gas emissions increased at an alarming level. Several researchers also underlined the impact of certain sectors of the economy on the emissions of chemical pollutants in the atmosphere (Marcu et al., 2016).

As Davis, Green and Reed (2009, p.173) state, the environment commitment is a "theoretical construct that predicts environmental behaviour". The commitment to protect the environment is a statement of the companies, but their actions really matter for mitigating climate changes and reducing carbon footprint. Davis, Le and Coy (2011, p.257) developed a model to predict the "willingness to sacrifice", deriving from environmental commitment. Their study approaches the subject from an individual perspective, but companies act in a similar manner. Environment commitment is also closely linked to the standard of living. Several authors included in their analysis variables that have an influence on the standard of living: population, density of the population and inflation rate (Florea, Meghişan and Nistor, 2016). Environmental commitment gained "in importance within organisations", "becoming part of organisational strategic agendas" (Keogh and Polonsky, 1998, p.38). Neumayer (2002) concludes that environmental commitment is also dependant on the level of democracy in a country, highlighting that the democratic countries are more interested in tackling environmental problems. Ling-Yee (2008) focuses on consumers who put a pressure on the companies to become greener. Other researchers choose to analyse environmental commitment for specific industries, such as the airline industry (Lynes and Dredge, 2010) and hotel industry (Rahman and Reynolds, 2016) or, for specific companies, such as small and medium enterprises (Roy and Therin, 2007). Lynes and Dredge (2010) also emphasize the role played by the organizational culture towards environmental commitment.

## **1.2. Hypotheses deduction and the research model development**

In our research, four constructs were underlined, beginning from previous research: (1) Digitization; (2) Green performance; (3) Green production; (4) Environment commitment (figure no. 1). We used five items for the construct green performance: economic sources of energy; new IT equipment; practices for reducing water- waste; practices for reducing waste in general; practices for recycling.



**Figure no. 1. Conceptual structural model**

Source: Authors' own analysis using SmartPLS v3 software

For the variable digitization, we developed eight items which we addressed in a questionnaire- based survey: self-configured workstations (Bag et al., 2021); online procedures for the employees' activity; use of artificial intelligence where possible; each employee working on a computer; big data for analysing information (Bag et al., 2021; Kumar and Bhatia, 2021); digital training for the employees; implementation of cybersecurity; cloud storage (Kumar and Bhatia, 2021). Thus, we developed the following hypothesis that links green performance to digitization, in Romanian companies:

*H1. Green performance has a positive impact on digitization in the companies from Romania.*

For the green production construct, we developed seven items which we addressed in in our study: materials used in the production are less pollutant; materials used in the production are energy-efficient; products are easy to recycle, reuse and decompose (Sharma et al., 2021); product design takes into consideration circular economy; product design takes into consideration end-of-life resource management; the company designs for environment (Bag et al., 2021); the company designs for remanufacturing (Bag et al., 2021). We developed a second hypothesis, which considers the impact of green performance on green production.

*H2. Green performance has a positive impact on green production in the companies from Romania*

For the variable environment commitment, we developed three items: employees' interest in environment commitment of the company; employees' interest for the environmental problems; employees' interest for the environmental efforts of the organization (Sharma et al., 2021). Thus, we developed a third hypothesis which considers the impact of green performance on environment commitment:

*H3. Green performance has a positive impact on environment commitment in the companies from Romania*

## 2. Research methodology

We considered the latest findings that cover: digitization, green performance, green production and environment commitment, in developing the hypotheses (table no. 1).

**Table no. 1. Constructs and items used in the model**

Construct	Code	Item	Source
(1) Digitization	DIGI1	In my company, self-configured workstation line is used	Bag et al., 2021
	DIGI2	In my company, online procedure for employees' activities is used	Authors' own contribution
	DIGI3	In my company, every employee works on a computer	Authors' own contribution
	DIGI4	In my company, artificial intelligence is used when possible	Authors' own contribution
	DIGI5	In my company, big data is used to analyze the information	Kumar and Bhatia, 2021; Bag et al., 2021
	DIGI6	In my company, digital training is provided for each employee	Authors' own contribution
	DIGI7	In my company, cybersecurity is implemented	Authors' own contribution
	DIGI8	In my company, cloud is used to store information	Kumar and Bhatia, 2021
(2) Green performance	GPREF1	My company uses economic sources of energy (halogen lightening)	Authors' own contribution
	GPREF2	My company uses new IT equipment (A+ class etc.)	Authors' own contribution
	GPREF3	My company implements practices for diminishing water-waste (water sensors etc.)	Sharma et al., 2021
	GPREF4	My company implements practices for recycling (paper, glass etc.)	Sharma et al., 2021
	GPREF5	My company implements practices for waste reduction (reuse of papers etc.)	Sharma et al., 2021
(3) Green production	GPROD1	The enterprise uses materials with the least pollution during the process of product development, design or production	Sharma et al., 2021
	GPROD2	The enterprise uses the most energy-efficient materials during the process of product development, design or production	Sharma et al., 2021
	GPROD3	The enterprise examines whether products	Sharma et al.,

Construct	Code	Item	Source
		are easily recycled, reused and decomposed during the process of product development design or production	2021
	GPROD4	The enterprise uses circular product design and production	Bag et al., 2021
	GPROD5	The company uses end-of-life resource management to protect the environment	Bag et al., 2021
	GPROD6	The company implements design for environment	Bag et al., 2021
	GPROD7	The company implements the concept of design for remanufacture	Bag et al., 2021
(4) Environment commitment	ENVIRC1	I care about the environmental concern of my organization	Sharma et al., 2021
	ENVIRC2	I feel as if my organization's environmental problems are my own	Sharma et al., 2021
	ENVIRC3	I would feel guilty about not supporting the environmental efforts of my organization	Sharma et al., 2021

*Source: Authors' own analysis using SmartPLS v3 software.*

The data was collected through a questionnaire-based survey, the items being measured through the 5-points Likert scale, where the response options were between "totally disagree = 1" and "totally agree = 5". Sample representatives were: managers, legal advisors, economists, accountants, assistant managers, computer operators, programmers, logistic coordinators, sales operations analysts, engineers, marketing specialists, customer relations managers, sales managers, office managers, junior managers, basic operators, brand managers, call center agents, area managers, so as to receive a wider approach on the organizations' level of digitalization, together with its approach on sustainable transformation. The questionnaire was sent online to more than 700 employees, while the valid questionnaires that were received, were 150. The collection of the data was done between 1<sup>st</sup> of July and 1<sup>st</sup> of September 2021. The respondents are aged between 19 years old and 58 years old, with a job experience from less than one year to 38 years (table no. 2).

**Table no. 2. Demographic summary**

Metric	Years	Number of respondents	Percentage
Age (years old)	< 25 years old	45	30.0
	25-34 years old	59	39.4
	35-44 years old	32	21.3
	45-54 years old	12	8.0
	55-65 years old	2	1.3
	> 65 years old		
Work experience (years)	< 5 years	79	52.7
	5-10 years	27	18.0
	11-20 years	31	20.6
	>20 years	13	8.7

*Source: Authors' own analysis*

### 3. Results and discussion

Partial least square equation modelling (PLS-SEM) was applied with SmartPLS software. This method was used to analyse the connections between observed variables and latent



variables. Busu and Gyorgy (2021) use this method because it “enables complex models with many constructs, indicator variables and structural paths without imposing distributional assumptions on the data” (Hair, 2019).

### 3.1. Reliability and validity

Items' validity analysis imposes the rejection of three indicators from Digitization, whose loadings do not exceed 0.7: DIGI1, DIGI2, DIGI3. The variance inflation factor (VIF) should not exceed 5, so all the indicators that did not meet this criterion were eliminated (GPROD2, GPROD5, GPROD6, GPROD7). In order to confirm the convergent validity, all the values for Average Variance Extracted (AVE) are higher than 0.6. Also, the Cronbach's Alpha coefficients are above 0.7. Thus, the exogenous variables in our model are significant (table no. 3).

**Table no. 3. Reliability and validity**

Construct	Cronbach's Alpha	Rho_A	Composite Reliability	Average Variance Extracted (AVE)
Digitization (DIGI)	0.857	0.862	0.897	0.637
Environment commitment (ENVIRC)	0.895	0.900	0.935	0.827
Green performance (GPERF)	0.911	0.913	0.934	0.740
Green production (GPROD)	0.906	0.907	0.941	0.842

*Source: Authors' own analysis using SmartPLS v3 software*

For discriminant validity, the square roots of AVE, which are represented on the matrix' diagonal, are higher than the absolute correlations between constructs. For this test, we used Fornell-Larcker Criterion Analysis (table no. 4).

**Table no. 4. Fornell-Larcker Criterion Analysis for Discriminant Validity**

Construct	Digitization (DIGI)	Environment commitment (ENVIRC)	Green performance (GPERF)	Green production (GPROD)
Digitization (DIGI)	<b>0.798</b>			
Environment commitment (ENVIRC)	0.377	<b>0.909</b>		
Green performance (GPERF)	0.602	0.499	<b>0.860</b>	
Green production (GPROD)	0.647	0.513	0.821	<b>0.918</b>

*Source: Authors' own analysis using SmartPLS v3 software*

Bootstrap *t*-statistics was analyzed. The model is significant at the level of 0.05, if *t*-statistics are higher than 1.96. All the path coefficients are statistically significant.

### 3.2. Structural model assessment

The model fit was assessed by standardized mean square root (SRMR). According to Hu and Benter (1999), the value of SRMR should be beneath 0.08 for a good fit of the model. The SRMR value in our model is 0.078. The Stone-Geisser's values ( $Q^2$ ) are 0.223; 0.199 and 0.561, depicting medium and large predictive relevance of the PLS-path model (table no. 5).

Table no. 5. Blindfolding

Construct	SSO	SSE	Q <sup>2</sup>
Digitization (DIGI)	750.000	583.065	0.223
Environment commitment (ENVIRC)	450.000	360.259	0.199
Green performance (GPERF)	750.000	750.000	0.000
Green production (GPROD)	450.000	197.511	0.561

Source: Authors' own analysis using SmartPLS v3 software

The construct Green performance explains: 67.4% of the variance of the endogenous construct Green production ( $R^2 = 0.674$ ); 36.2% of the variance of the endogenous construct Digitization ( $R^2 = 0.362$ ); 24.9% of the variance of the endogenous construct Environment commitment ( $R^2 = 0.249$ ) (figure no. 2).

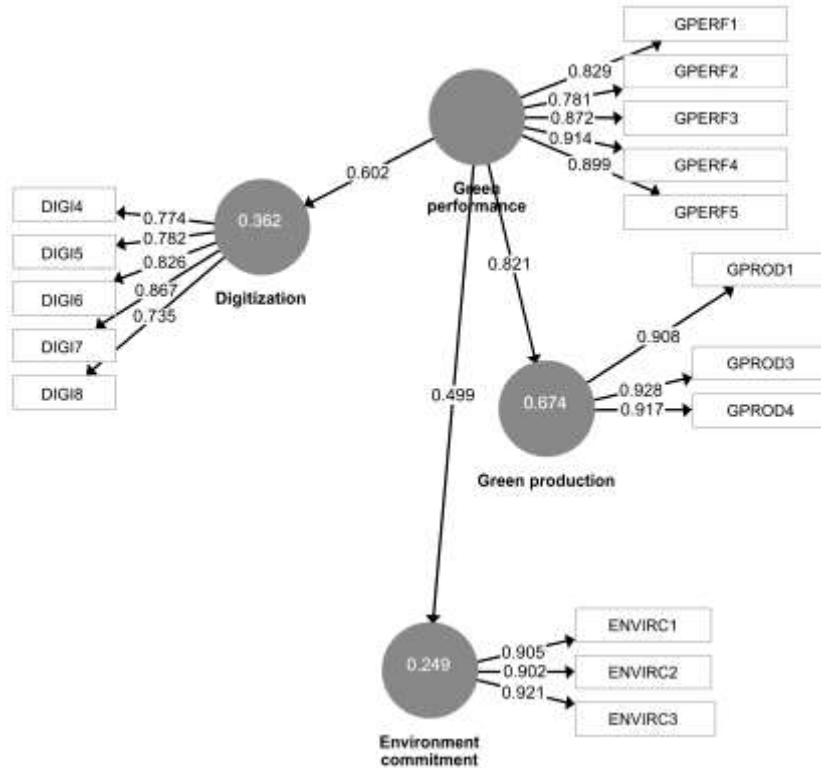


Figure no. 2. PLS-SEM measurement model

Source: Authors' own analysis using SmartPLS v3 software

All the hypothesized paths are statistically significant: *H1. Green performance has a positive impact on digitization in the companies from Romania*; *H2. Green performance has a positive impact on green production in the companies from Romania*; *H3. Green performance has a positive impact on environment commitment in the companies from Romania* (table no. 6).

**Table no. 6. Results of testing the statistical hypotheses (H1- H3)**

Hypothesis	Path coefficients	Decision
H1: Green performance (GPERF) -> Digitization (DIGI)	0,602	Accepted
H2: Green performance (GPERF) -> Green production (GPROD)	0,821	Accepted
H3: Green performance (GPERF) -> Environment commitment (ENVIRC)	0,499	Accepted

*Source: Authors' own analysis*

According to the data from table no. 7, the means of the retained indicators vary from 3.080 to 4.020.

**Table no. 7. Descriptive statistics of items**

Code	Mean	Std. deviation	Loading
DIGI4	3.433	1.309	0.774
DIGI5	3.880	1.216	0.782
DIGI6	3.693	1.316	0.826
DIGI7	3.940	1.261	0.867
DIGI8	3.707	1.374	0.735
ENVIRC1	4.020	0.990	0.905
ENVIRC2	3.593	1.138	0.902
ENVIRC3	3.820	1.065	0.921
GPERF1	3.373	1.359	0.829
GPERF2	3.767	1.202	0.781
GPERF3	3.240	1.417	0.872
GPERF4	3.627	1.364	0.914
GPERF5	3.520	1.384	0.899
GPROD1	3.240	1.215	0.908
GPROD3	3.253	1.255	0.928
GPROD4	3.080	1.129	0.917

*Source: Authors' own analysis using SmartPLS v3 software.*

### 3.3. Discussions

The results underline the fact that green performance has a direct impact on the level of digitization, green production and environment commitment, from the perspective of Romanian companies' representatives. Out of these three factors, green production is the most important (0.821), followed by digitization (0.602) and environment commitment (0.499). Thus, in terms of limited resources, the companies should emphasize mostly on green production and digitization in order to attain green performance. Green production is not a single- dimension factor, being represented by: the use of materials with the least pollution during the process of product development, design or production; examination of products to be easily recycled, reused and decomposed during the process of product development, design or production; use of circular product design and production. Digitization is represented by: use of artificial intelligence when possible; use of big data to analyse the information; digital training for each employee; implementation of cybersecurity; usage of cloud to store information. The positive relationship between green performance and digitization contributes to the creation of capabilities for companies, so that they can implement their operations efficiently, by improving the quality of their products and the speed of information transmission. (Li et al., 2020)

The results are consistent with those of the authors Kumar et al. (2021). The authors use the phrase “environmental dynamism”, which influences industry 4.0. The authors also demonstrated the influence of Industry 4.0 on market performance, but also on environmental performance. Jayaram et al. (2014) point out the link between process innovation strategies and business performance. Green performance or the adoption of I4.0 technologies help drive innovation in the industry, along with improving the design and production of goods (Oberg and Graham, 2016). Moreover, Kumar et al. (2021) highlights other implications of the adoption of I4.0 technologies, with an emphasis on waste management, customized products, increased receptivity to changes within the turbulent environment, contribution to sustainability. Bag et al. (2021) introduces a new variable, demonstrating the link between I4.0 and the circular economy, part of the environment commitment.

## **Conclusions**

This research is unique in that it emphasizes the link between green performance, digitization, green production and environmental engagement. Hypothesis H1 is validated. H1. Green performance has a positive impact on digitalization in Romanian companies. Hypothesis H2 is also validated. H2. Green performance has a positive impact on green production in Romanian companies. Hypothesis H3 is validated. H3. Green performance has a positive impact on the commitment to the environment in Romanian companies.

In terms of novelty for the business theory, it consists in putting together the four variables from the research theory: green performance, digitization, green production and environment commitment. This research has demonstrated a theoretical model that connects key resources from green performance, digitization, green production and commitment to the environment. This paper is an important contribution to the existing literature, because its results have identified the key elements that will help companies in the processes of digital transformation and sustainable development.

In terms of implications for business practice, the research article underlines valuable results in order to improve the green performance of a company, mainly based on digitization and green production. Thus, companies need to consider the use of I4.0 technologies in order to achieve the desired results, especially in terms of green performance. The relationship between green performance and commitment to the environment indicates the need for companies to adopt strategic changes in response to the environment specific. The link between green performance and green production underlines the need for a large number of innovations in a given industry, with an emphasis on highlighting the competitive advantage. Thus, the competitive advantage can be the result of both incremental innovations and radical innovations. Moreover, the paradigm of disruptive innovations is changing the approach of companies and it is placing more and more emphasis on environmental issues. Today, companies must no longer see profitability as the ultimate goal, but must integrate the sustainable development in all the actions taken.

The main limits of our study consist in the number of respondents to the survey, together with the subjective responses given. For the future research, these constraints could be overcome by increasing the number of respondents and also by adding trap questions in the questionnaire in order to verify the honesty of the responses. Also, the topic chosen for the analysis is current, which leads to the existence of a rather small volume of validated

results. This was a challenge for the authors, who interpreted the results in connection with the cultural and economic specific of the country in which the research was conducted. Regarding the future approach, the authors consider the analysis of the influence of other variables such as: human resources, economic development of the area, degree of rivalry between companies etc.

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