doi: 10.36689/uhk/hed/2022-01-039 HED Hradec Economic Days

Role of Eco-Innovation and Tourism towards Carbon Neutrality in the Czech Republic

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Abstract: Even though Czechia is flourishing economically, the country is the EU's fourth-largest carbon emitter, which indicates that its economic growth achievements are not sustained simultaneously with its environmental quality. Therefore, this study analyzed the effect of economic growth, international tourist arrivals, foreign direct investment, and eco-innovation on reduction of the carbon emissions of the country. Data spanning from 2003 to 2018 was used and several econometric methods were applied to assess the effect of these variables. Findings revealed that foreign direct investment (FDI) increases carbon emissions as 1% rise in FDI leads to a 0.002% increase in carbon emissions while international tourist arrival and economic growth significantly reduce carbon emissions, as 1% rise in tourist arrival leads to -0.02% decline in the long run. Based on these findings, it is recommended that policies be put in place to further promote the Czech Republic as a destination country while observing the carrying capacity to ensure long term tourism sustainability towards reducing environmental degradation and achieving carbon neutrality.

Keywords: economic growth; eco-innovation; resource rent; environmental sustainability; tourism

JEL Classification: C52; L38; O47

1. Introduction

Since 1990, the Czech Republic has been able to reduce its greenhouse gases (GHG) drastically; however it remains the EU's fourth-largest emitter per capita (Eurostat, 2021; Hanzlík et al., 2020) as shown in Figure 1. The majority of the emissions are generated from electricity/heat generation and industry, which is 45.3 and 36.2 $MtCO_2e$ respectively as of 2020. While the contribution of tourism to the Gross Domestic Product (GDP) of the Czech Republic is relatively low – tourism ratio on GDP was around 3% in the researched period (Czech Statistical Office, 2022) – (Nižić et al., 2017), the majority of energy consumption is realized by other industries such as the manufacturing industry. According to a report by Omondi (2019), the service sector is the largest contributor to the Czech Republic's economy. While the nation does not have a substantial ratio tourism on the GDP, the sector could serve as a facilitator in achieving carbon neutrality because tourism has the potential to expedite the transition to renewable energy and enhance its contribution to the global energy mix. As a result, tourism may assist to mitigate climate change, reduce greenhouse gas emissions, and

contribute to innovative and new energy solutions in both urban and rural locations by promoting long-term and smart investments in sustainable energy sources (UNWTO, 2021).

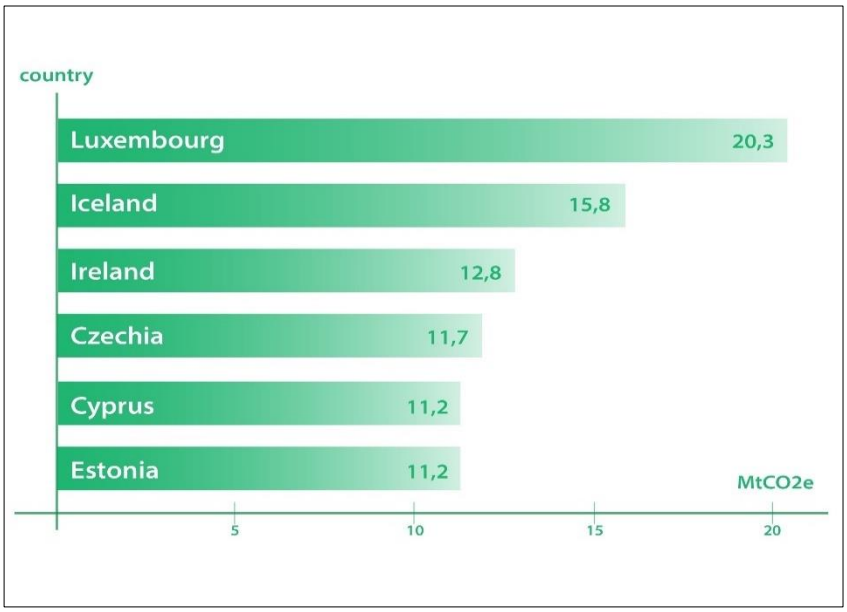

Figure 1. Greenhouse gas emissions per capita in 2019 (Eurostat, 2021)

A recent study has concluded that tourism can help in attaining carbon neutrality in Turkey context (Sun et al., 2021). Also, to reach net-zero, green technology and technological innovations have been identified by several studies (e.g. Dong et al., 2022; Shao et al., 2021; Wang et al., 2021) as important pathways towards carbon neutrality. Hanzlík et al. (2020) proposed in their study that Carbon Capture and Storage (CCS) technology represents an important system to reduce carbon emissions, therefore eco-innovation (environmental-related technology) is considered in this study. While recent studies (e.g. Yurdakul & Kazan, 2020; Geng et al., 2021) have attempted to investigate the effect of eco-innovation on environmental sustainability, most of these studies have used total spending on research and development, patent, trademarks, research and development, and technology cooperation grant as indicators of eco-innovation, which shows a gap in the theory that should be filled. Regarding tourism, the last decades show the growing importance of implementation of the concept of social corporate responsibility which leads to the increase of the eco-innovations in this sector (Pásková & Zelenka 2019).

Based on the aforementioned reasons, this study examines the nexus between foreign direct investment, economic growth, tourism, eco-innovation, and carbon emissions in the Czech Republic. This study has selected the Czech Republic because coal still accounts for half of the total domestic energy production (International Energy Agency, 2021). This study contributes to the relevant theory-building by using environment-related technologies (percentage of all technologies) and to the best of the authors' knowledge, no study has examined yet the mutual relationship of these variables in the Czech Republic.

2. Methodology

The study employs annual data between 2003 and 2018 when applying the estimation model that uses carbon dioxide emissions as the dependent variable. The explanatory

variables include Real Gross Domestic Product per capita (measured in constant 2010 USD), foreign direct investment, eco-innovation (the environment-related technologies), and international tourist arrivals. While several studies have observed the relationship between foreign direct investment, tourist arrival, carbon emission (Akadiri et al., 2021; Lasisi et al., 2020; Muhammad et al., 2021), this study applies this concept to the specific case of the Czech Republic. Additionally, the research model distinctively includes environmental-related technology, an indicator of eco-innovation, as such the research model specification is:

$$CO_2 = f\ (GDP, FDI, ERT, TOA) \tag{1}$$

$$lnCO_2 = b_0 + b_1 lngdp_t + b_2 fdi_t + b_3 ert_t + b_4 lntoa + u \tag{2}$$

For there to be constant variance in the data series, logarithmic transformation was applied. Hence, $lnCO_2$ against $lngdp_t, fdi_t ert_t,$ and $lntoa$ denotes the logarithmic transformed dependent variable versus the independent variables, where CO_2 is carbon emissions, *gdp* is Gross Domestic Product, *fdi* is foreign direct investment, *ert* is the environment-related technologies, *toa* is international tourist arrival, *u* is error term while b_0, b_1, b_2, b_3, and b_4 are regression coefficients for the parameters, in the long run, *u* is the error term and *t* is the period (2003-2018).

Several tests and methods were applied to determine the correlation of the variables. (i) The stationary of the variables were ascertained with the Fisher ADF (Dickey & Fuller, 1981) and Im et al., (2003) unit root test, (ii) long-run and cointegration regression analysis, and Dumitrescu and Hurli's (2012) causality analysis. Based on the existing theory, the following hypotheses are posited:

Hypothesis 1: There is a bidirectional causality between GDP and carbon emissions.

Hypothesis 2: There is an inverse and significant relationship between FDI and carbon emissions.

Hypothesis 3: Environmental-related technologies will reduce carbon emissions.

Hypothesis 4: There is an inverse and significant relationship between tourism and carbon emissions.

3. Results and Discussion

Table 1 shows the summary statistics. This is expedient to determine the fundamental extent of dispersion and central tendency of the variables and to know how they performed over the period considered (2003-2018). The descriptive statistics show that carbon emissions have a minimum value of 11.5104 from the start-up years with a maximum (highest) of 11.7251 over the period considered, while the gross domestic product has a minimum of 25.3293 and a maximum of 26.2405. All observed variables are positively skewed except for gross domestic product and environmental related technologies. The sample size for the study is 16 and is normally distributed.

Furthermore, the correlation matrix analysis was conducted to investigate the nexus between the observed variables, as shown in Table 2. An inverse statically significant relation between carbon emissions and economic growth has been identified, which indicates that economic growth mitigates carbon emissions. A plausible reason for this in the case of Czechia could be because of the economic freedom of the country (freedom score of 74.4 in

2022) (The Heritage Foundation, 2022) and economic freedom have been found to reduce carbon emissions (Shahnazi & Shabani, 2021). However, for foreign direct investment, there

Table 1. Descriptive statistics

	LCO_2	LGDP	FDI	ERT	LTOA
Mean	11.61891	25.95171	4.308955	10.79625	17.06539
Median	11.61796	26.06150	4.190054	11.46500	17.03134
Maximum	11.72505	26.24052	10.01153	12.89000	17.40645
Minimum	11.51042	25.32934	0.904051	7.63000	16.81663
Std. Dev.	0.079797	0.256574	2.209848	1.545876	0.172679
Skewness	0.060756	-1.238198	0.899010	-0.658171	0.684642
Kurtosis	1.420134	3.477105	4.022702	2.340895	2.439424
Jarque-Berra	1.673838	4.240108	2.852529	1.444783	1.459457
Probability	0.433045	0.120025	0.240205	0.485589	0.482040
Observations	16	16	16	16	16

is a positive and significant relationship with carbon emissions but an insignificant inverse relationship with economic growth. Environmentally related technology has an insignificant and positive relationship with carbon emissions and economic growth but a positive and statistically significant relationship with foreign direct investment, which implies that eco-innovation will increase foreign direct investment. For tourist arrival as *apriori* expectation, an inverse and significant relationship with carbon emission and a significant positive relationship with economic growth are noted. Notably, no outcome can be validated only by the correlation coefficient estimation analysis, as such, the study advances by conducting econometric analysis to reliably refute or validate the research objectives.

Table 2. Correlation matrix

	LCO_2	LGDP	FDI	ERT	LTOA
LCO_2	1.000000				
LGDP	-0.628588***	1.000000			
FDI	0.375255*	-0.212572	1.000000		
ERT	0.078663	0.281250	0.493417**	1.000000	
LTOA	-0.745575***	0.418047*	0.006842	0.064530	1.000000

Note: ***, **, * represents 0.01, 0.05, and 0.10 at 1%, 5%, and 10% significance level

Table 3. Result of unit root

	ADF- Fisher		Im, Pesaran Shin	
	Level	First Difference	Level	First Difference
LCO_2	-0.853065	-3.331654**	-0.791709	-3.568052**
LGDP	-2.914859	-2.727672	-3.324212**	-2.697627
FDI	-3.733431(0.0152)	-6.131453***	-3.751611**	-8.337362***
ERT	-3.773636(0.0141)	-6.497358***	-3.775384**	-6.671700***
LTOA	-0.105768	-1.645102	-0.105768	-3.375184**

In econometric analysis, the stationarity test was used to circumvent spurious regression trap and the result of the unit root analysis is shown in Table 3. At the first difference, it was observed that the foreign direct investment and environmental-related technologies are stationary at a 1% significant level in both ADF-Fisher and Im Pesaran Shin unit root test.

Carbon emission is stationary at 5% significant level at the first difference for both unit root tests, while gross domestic product is stationary at 5% significant level only in Im Pesaran Shin unit root test and international tourist arrivals are stationary at 5% significant level, first difference in Im Pesaran Shin unit root test. Therefore, it can be concluded that all series are mixed order integrated as stated by the unit root tests.

Furthermore, the long-run nexus between the variables were examined. Based on the Kao residual cointegration test, there is an equilibrium relationship (long-run) between carbon emissions, economic growth, foreign direct investment, environmental-related technologies, and tourist arrivals over the considered period. Therefore, the investigation of the cointegration magnitude of the variables ensued, and the result is shown in Table 4 through the ARDL model estimation. The long-run estimations show that the coefficients of economic growth are statistically significant and positive in the long run. The study reflects a statistically significant and inverse association between carbon emission and economic growth as a 1% increase in economic activities results in a 0.06% decrease in carbon emission which is in congruences with previous studies (e.g. Lee & Unger, 2012). This study supports the environmental Kuznets inverted U-curve hypothesis, which states that once rising incomes goes beyond a turning point, pollution levels begin to drop as increased national income necessitates greater measures to reduce pollution emissions. On the other hand, there is a positive and significant relationship between foreign direct investment and carbon emission which has been confirmed by several studies such as Do and Dinh (2020); Essandoh et al. (2020); Lee (2013) This indicates that with FDI, there will be easier or cheaper access to financial capital which can be used in constructing new factories or expanding existing operations, thereby increasing industrialization which may inevitably lead to an increase in carbon emissions.

Unexpectedly, environmental-related technologies have a significant and positive relationship with carbon emissions, as a 1% increase in environmental-related technologies will result in a 0.002% increase in carbon emissions, which opposes Xin et al. (2021) study of the United States, Ahmad and Zheng's (2021) and Danish and Ulucak's (2020) study of the BRICS countries. As expected, there is an inverse and significant relationship between international tourist arrival and carbon emissions. This result is noteworthy for environmental and tourism economists as a 1% increase in international tourist arrival leads to a 0.02% decline in carbon emissions. This opposes studies like Alola et al.(2021) but the negative association has been confirmed in previous studies (e.g. Ben Jebli & Hadhri, 2018; Gao & Zhang, 2021). A plausible reason could be the several agreements between the Ministry of Industry and Trade (MIT) and energy suppliers (both retail and distribution system operators) and energy-intensive industries. Also, the recent agreement with PKN ORLEN could also help in reducing carbon emission because the aviation-fuel supplier is considering low- and zero-carbon hydrogen renewable energy sources (PKN ORLEN, 2022). This indicates that the Czech Republic implements sustainable energy policies in the tourism industry to prevent carbon emissions in the long run as the share of renewable energy has increased by 71% since 2009 (International Energy Agency, 2021, p. 11).

Finally, following Dumitrescu and Hurlin's (2012) procedural outline, the study employed the Granger causality test and the report of the test is shown in Table 5.

Table 4. ARDL estimation result

Model: $\ln CO_2 = f\ (lnGDP, FDI, ERT, lnTOA)$				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LGDP	-0.061923	0.000514	-120.4783	0.0000
FDI	0.002457	0.000737	3.335098	0.0087
ERT	0.002155	0.001299	1.659029	0.1315
LTOA	-0.023405	0.000220	-106.3488	0.0000
C	4.621947	0.146168	31.62072	0.0000
Hypothesized No. of CE (s)	Eigenvalue	Trace Statistics	0.05 Critical Value	Prob
None*	0.966503	78.81710	47.85613	0.0000
At most 1*	0.808696	31.26912	29.79707	0.0336
At most 2*	0.431910	8.114645	15.49471	0.4532

Table 5. Granger causality test

Null Hypothesis	F-Statistic	Prob.	Causality
LGDP "does not Granger Cause" LCO2	2.91801*	0.1055	$CO_2 \leftrightarrow GDP$
LCO2 "does not Granger Cause" LGDP	4.91307**	0.0361	
FDI "does not Granger Cause" LCO2	0.38818	0.6891	
LCO2 "does not Granger Cause" FDI	1.65082	0.2451	
ERT "does not Granger Cause" LCO2	1.27058	0.3266	
LCO2 "does not Granger Cause" ERT	1.03970	0.3924	
LTOA "does not Granger Cause" LCO2	0.56941	0.5850	
LCO2 "does not Granger Cause" LTOA	2.15315	0.1721	
FDI "does not Granger Cause" LGDP	0.90475	0.4385	$GDP \rightarrow FDI$
LGDP "does not Granger Cause" FDI	1.69723***	0.0009	
ERT "does not Granger Cause" LGDP	1.65227	0.2448	
LGDP "does not Granger Cause" ERT	0.72166	0.5121	
LTOA "does not Granger Cause" LGDP	3.36271**	0.0812	$TOA \rightarrow GDP$
LGDP "does not Granger Cause" LTOA	1.55692	0.2626	
ERT "does not Granger Cause" FDI	2.30635	0.1554	
FDI "does not Granger Cause" ERT	1.25846	0.3297	
LTOA "does not Granger Cause" FDI	4.78426**	0.0384	$TOA \rightarrow FDI$
FDI "does not Granger Cause" LTOA	1.56029	0.2620	
LTOA "does not Granger Cause" ERT	0.09980	0.9060	
ERT "does not Granger Cause" LTOA	1.08532	0.3782	

NB: The number of observations is 14

There is a bidirectional relationship between carbon emissions and economic growth. This suggests that economic growth is increased by industrial activities while the economy's structural interactions increase carbon emissions. It can indicate a feedback mechanism between economic growth and environmental deterioration in the Czech Republic. Therefore, it is imperative that there is a structural shift from a carbon and energy-intensive economy to a decarbonized services and economy to achieve carbon neutrality. There is

unidirectional causality from economic growth to foreign direct investment which is in accordance with Faisal, Muhammad, and Tursoy's (2016); Pao and Tsai's (2011) study.

Furthermore, there was a unidirectional causality from tourism to economic growth, which confirms the tourism-led growth hypothesis in the Czech Republic. This implies that Prague being the 22nd most visited city in the world (Johnston, 2019) increases foreign exchange income in the country, which has a significant impact on the nation's economy, and the trade balance and current account are influenced by tourism receipts (Sokhanvar et al., 2018). Lastly, there is unidirectional causality from tourism to foreign direct investment, which indicates that with tourism, the Czech Republic can expand its foreign direct investment, therefore the government should endeavor to promote tourism and ensure tourism sustainability to further attract the foreign direct investment. Succinctly, the first hypothesis which states that there is a bidirectional causality between GDP and carbon emission is confirmed, however, the second hypothesis (an inverse and significant relationship between FDI and carbon emissions) was rejected. Also, hypothesis three (Environmental-related technologies will reduce carbon emissions) was rejected, while hypothesis four was accepted.

4. Conclusions

The Sustainable Development Report in 2019 ranks the Czech Republic as the 7th most advanced nation (Pirodsky, 2019), however, despite a "…36% decrease since 2009, coal still accounts for half of the total domestic energy production…" (International Energy Agency, 2021, p. 11), as such, it is pertinent to identify the macroeconomics factors affecting the country. In this study, the effects of economic growth, eco-innovation, tourist arrivals, and foreign direct investment, on carbon emission of the Czech Republic between 2003 and 2018 are examined. The stationary of the variables was ascertained with the Fisher ADF (Dickey & Fuller, 1981) and Im et al. (2003) unit root test, cointegration, and long-run regression analysis, and Dumitrescu and Hurli's (2012) causality analysis were carried out to establish the relationships between the variables.

The ARDL model reveals a significant and inverse relationship between carbon emission and economic growth but a positive and significant relationship between foreign direct investment and carbon emissions. Environmental-related technologies have a positive and significant relationship with carbon emissions while there is an inverse and significant relationship between international tourist arrival and carbon emissions. The Granger causality test indicates a bidirectional relationship between carbon emissions and economic growth. There is unidirectional causality from economic growth to foreign direct investment and the tourism-led growth hypothesis was confirmed in the Czech Republic. Lastly, there is unidirectional causality from tourism to foreign direct investment, which indicates that with tourism, the Czech Republic can expand its foreign direct investment.

Considering that the objective of the study is to determine how the Czech Republic can achieve carbon neutrality and also to determine if eco-innovation can play a role in achieving this goal, the following recommendations are suggested: (i) Implementation of sustainable energy policies in the tourism industry to prevent carbon emissions; (ii) a structural shift from

carbon and energy-intensive economy to a decarbonized services; (iii) the governmental stimulation to promote tourism and ensure tourism sustainability to further attract the foreign direct investment, and (iv) increase of the tax rate on carbon emission from energy use because the country has the lowest rate in OECD countries.

In view of the findings, the study suggests that tourism plays a vital role in reducing carbon emissions in the Czech Republic, further research should consider how tourism innovation through innovation pillars (e.g., institutions, infrastructure, and human capital and research) can foster economic growth and help in achieving carbon neutrality. Recent studies have concluded that low-carbon smart tourism can also help in reducing carbon emission (Ma et al., 2021). From this reason, the future research should consider the role of ICT readiness by individuals and business in the tourism sector. In addition, the qualitative case studies should be realized to further confirm the findings of this study and to deepen understanding of the identified general patterns in the concrete contexts.

Acknowledgments: This contribution was financially supported by the Faculty of Informatics and Management of the University of Hradec Králové (FIM UHK) within the framework of the Specific Research Project "Information and knowledge management and cognitive science in tourism". The authors wish to express their thanks to Zuzana Kroulíková, FIM UHK student, who assisted with the graphical elements.

Conflict of interest: none

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