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Examining the environmental aspect of economic complexity outlook and environmental-related technologies in the Nordic states

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ABSTRACT

Understanding the outlook of countries' economic complexity is vital for assessing the future of industries' product characterization. It provides opportunity and insight on how to mitigate the negative externalities that arises from the increasing pressure on the ecosystem. Based on this account, the effect of economic complexity and the corresponding outlook on environmental degradation vis-a-vis greenhouse gas (GHG) emissions alongside other environmental indicators are examined for the panel of Denmark, Finland, Norway, and Sweden for the period 1995 to 2020. After employing Driscoll- Kraay's standard errors for random effect (RE) with individual effects for the examination, the results indicate that the region's level of economic complexity favors environmental sustainability. Contrarily, the economic complexity outlook spurs GHG emissions, thus suggesting that future performance of the region's economic complexity could be detrimental to its ecosystem. Another similar, and undesirable observation is that the increase in urban population hampers environmental quality as it causes a surge in GHG emissions. Meanwhile, the results then conclude that economic growth, economic complexity, and environmental-related technologies are found to be potent drivers of environmental sustainability as the indicators exert negative pressure on GHG emissions in the Nordic region. Important policies that potentially guide immediate, and future sector-wide activities toward enhancing the region's sustainable development programs are posited through the study outcome.

1. Introduction

Given the increasing global challenges, such as the climate change and depletion of natural capital, efficient and sustainable resource utilization across the economic sectors is deemed suitable for sustainable development. Thus, moving past such challenges and enhancing sector-wide productivity entails improving economic complexity (EC) which largely accounts for predicting and explaining future green economic growth (Nguyen, 2022). The level of EC, which measures a country's ability to produce, has implications for economic growth (Nan et al., 2022). The EC indicator is more than the industrial structure, because it contains a clean manufacturing technology implementation detail (Nan et al., 2022). EC represents a means of achieving economic growth to support economic and sustainable development across regions or geographical space (Nguyen, 2022; You et al., 2022). Hassan et al. (2023) argues that EC affects productivity goals for achieving carbon neutrality and the earth's quality. Global climate challenges and greenhouse gas emissions threaten human survival, thus have affected regional, social, and economic development (Alola et al., 2019).

Recent studies have emphasized how developed nations can produce, as much as possible, a more comprehensive range of goods and services using specialized knowledge resources (Balland et al., 2022; Maurya and Sahu, 2022). However, evidence from Nguyen (2022) shows that EC in developed countries is increasing environmental contamination. The theory of EC suggests that enabling technological innovation and development strategy to chase the socio-economic

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conditions can help regions to handle climate change challenges better, thus reducing greenhouse gas emissions (Balland et al., 2022). Nevertheless, it remains to be seen how the growth of specialized and diversification of knowledge among the countries, individuals, and cities impact increase or decrease the environmental pollution in countries with a high per capita income (You et al., 2022). As global warming and climate change increase, industrialized countries, such as the G20 and the G7, are becoming more aware of the effect of urban population and environmental-related technologies on climate change, the economy, and society. The EU environmental program aims to increase understanding of what specific factor(s) influences or give rise to EC. But, only limited studies have investigated the possible connection between EC and CO_2 emissions. (Agozie et al., 2022; Hassan et al., 2023; You et al., 2022).

European Union's efforts to develop a decarbonized economy, improve climate risk management, ensure climate resilience and increase the use of renewable energy sources require a bridging gap between EC and low-carbon development initiatives. However, research now recognizes that EC influences are important in shaping how economic activities relate to sustainable development initiatives. One important observation of the recent literature on EC is that there is a connection between socio-environmental-economic variables and the complexity of the economic system. These subject matters have traditionally been gaining increasing attention as reflected in the European Commission's policy initiatives from the perspective of innovation and industrial strategies effect of EC (Balland et al., 2022; Pugliese and Tacchella, 2020). Despite the growing amount of research regarding EC, there is still little understanding of how and why socio-economic conditions encourage the development of activities to gain control of a greater portion of the economy and garner the vast majority of the economy's benefits (Adjei et al., 2022; Balland et al., 2022). From the previous research studies, several factors are associated with the enhancement of complex economic systems. Therefore, it is vital to further understand the interaction between the urban population, environmental-related technologies, and Gross Domestic Product (GDP) in the process of achieving a sustainable environment.

Considering the above motivation on economic complexity and the drivers of environmental quality, this study's objective is designed to examine the nexus of greenhouse gas emission and economic complexity alongside other potential drivers of environmental quality in the Nordic region. This study makes important contributions to economic and environmental sustainability literature. Before now, empirical studies have shown significant evidence associating environmental indicators with economic complexity and alongside several other socio-economic and macroeconomic indicators. However, uniquely for the Nordic economies, the current study employs economic complexity outlook (ECO) alongside economic complexity, a rare endeavour in the literature. Moreover, this study considers the case of the Nordic countries, which are largely known for their impressive economic and environmental quality performance. Additionally, studies on the nexus of environmental indicators and EC on regional and country-level conditions have also been conducted considering other socio-economic factors such as urbanization and behavioural aspects (Nguyen, 2022; Maurya and Sahu, 2022; Balland et al., 2022). Therefore, it is further enlightening that the current case is deepening the conversation by factoring in the role of environmental technologies.

In the remaining parts of the study, a synopsis of the related studies is described in section 2. The description of the dataset and the empirical method, alongside the results, are presented in section 3. Consequently, the results are further discussed in section 4 before highlighting the conclusion with policy and recommendations for future research in section 5.

2. Literature review: A synopsis

Previous studies have also shown the aspects of EC and ECO and especially the climate change and environmental-related effects. Using a two-step methodology (panel quantile regression and slacks-based measure (SBM)-data envelopment analysis), Kazemzadeh et al. (2022a) looked at the effects of export quality, resource and energy efficiency, and other factors on ecological footprint in 16 emerging nations between 1990 and 2014. The results show that the population, GDP, and use of fossil fuels contributes to the decline of the environmental footprint, but export quality and urban population only slightly worsen it. Using club convergence and panel quantile regression, Kazemzadeh et al. (2022b) further examined the impact of economic complexity and export quality on the ecological footprint of 98 countries from 1990 to 2014. The findings demonstrate that while urbanization helps to lessen the ecological footprint, GDP, nonrenewable energy usage, and population harm the environment. In addition, trade openness and export quality both lessen environmental impact, but not evenly.

By employing sub-sample data from 115 economics between 1995 and 2017, Nguyen (2022) shows that EC patterns negatively influence the absolute and relative size of the economy in the long run. Therefore, a focus on EC provides a useful information on how a country should use environmental technology to gain long-term benefits of economic growth. For instance, by investigating a global sample of 81 countries, Maurya and Sahu (2022) showed that there are beneficial effects of individualism on economic complexity. The study establishes stronger patterns of this relationship among the countries with higher levels of innovation. Subsequently, Ajide (2022) implements recent dataset covering 1995–2018 for 32 African countries and found that improvement in the EC is associated with increase in financial development, trade openness, human and institutional capital amidst the existence of resource curse hypothesis among the examined countries.

Additionally, Adebayo et al. (2022) used the case of the top seven global performing countries in terms of economic complexity (Austria, Czech Republic, Germany, Japan, Singapore, South Korea, and Switzerland) and examined the drivers of carbon emission during the period 1993–2018. By employing the method of moments quantile regression alongside the fully-modified ordinary least squares and dynamic least squares methods, the study affirms that environmental degradation is spurred by an increase in conventional energy consumption and EC since the indicators are responsible for increasing CO_2 emission. Contrarily, as largely revealed by the estimation techniques, both renewable energy profile and technological innovation deliver expected results by showing significant evidence of improving environmental quality through the mitigation of carbon emissions.

Moreover, You et al. (2022) utilized the recently developed Granger causality approach by Juodis et al. (2021) to examine the causation between EC, economic growth, and carbon emission for selected panel of 85 countries. As revealed by the study, the result indicates that countries with high-level of EC need to find an efficient balance between EC and GDP, as findings reveal that EC may positively reduce CO_2 emissions. This discrepancy in the results by previous studies is connected to several factors such as the groups of nations or regions, time series, and the authors' methodology. As expected, this contradiction has continued to stimulate more research interest on this area of study. Moreover, several works of literature have reported the environmental effects of EC as well hinting at the role of other potential drivers of environmental sustainability, such as natural resources and energy mix (Kazemzadeh et al., 2023; He et al., 2021; Doğan et al., 2022; Rafei et al., 2022; Sun et al., 2022).

2.1. *Contribution to literature*

In spite of the enumerated literature, there is sparse or no-existent of study on the environmental effect of the outlook perspective of economic complexity. As there is little research on the environmental effects of the outlook perspective of economic complexity, this study contributes to the literature and enrich the understanding of the relationship between economic complexity and environmental sustainability. Therefore, with the conceptualization of the study as presented in Fig. 1, three hypotheses that guide the direction of the empirical investigation are constructed as follows: hypothesis 1: economic complexity does affect greenhouse gas; hypothesis 2: economic complexity outlook does affect greenhouse gas; hypothesis 3: socioeconomic aspect does affect greenhouse gas.

3. Data, model, and empirical results

This study scrutinizes the impact of Gross Domestic Product, Urban Population, Environmental-Related Technologies, and Economic complexity on Greenhouse Gases using annual data covering 1995 to 2020 for four Nordic countries (Denmark, Finland, Norway, and Sweden). The definition of variables is illustrated in Table 1.

Empirical procedures including the preliminary tests and the main estimations as illustrated in Fig. 2 were performed by employing the econometric software Stata 17.0. Additionally, the following Stata commands (for example, xtline, summarize, corr, xtmixed, xtreg, xttest, rhausman, xtsktest, xtcsd, xtregar, resetxt, xtscc) were used in this analysis process. Table 2 presents summary statistics of the data used in the study. According to the raw data, it is seen that the standard deviation of GDP and GHG are the highest. Regarding standard deviation, ERT, UPOP, ECI, and ECOI follow these variables, respectively. Fig. 3 presents a graphical view of the variables.

3.1. *Empirical model*

By utilizing the theoretical STIRPAT (Stochastic Impacts by Regression on Population, Affluence and Technology) model extended by Dietz and Rosa (1997), the log-linear function that establishes the econometric model was built. In this context, the mathematical and econometric model is given by the following:

$$\text{Model 1: } \ln GHG = f(\ln GDP, \ln UPOP, \ln ERT, \ln ECI, ECOI) \quad (1)$$

From equation (1), the form of econometrics model is further represented as:

$$\text{Model 2: } \ln GHG_{it} = \alpha_{0i} + \alpha_{1i}\ln GDP_{it} + \alpha_{2i}UPOP_{it} + \alpha_{3i}ERT_{it} + \alpha_{4i}ECI_{it} + \alpha_{5i}ECOI_{i} + \mu_i + \lambda_t + u_{1it} \quad (2)$$

where i and t subscripts represent country and time; α_i and u_{it} represent coefficient and the vector of residuals, respectively. In addition, μ_i and λ_t indicate individual effect and time effect, respectively. In Table 4, it was proven that the bidirectional model with individual and time effects should be used. Fig. 4 indicates regression relationships between GHG and independent variables.

According to Fig. 4, GHG emission is presented in the X-axis such that the figure presents the negative relationship between GHG and GDP,

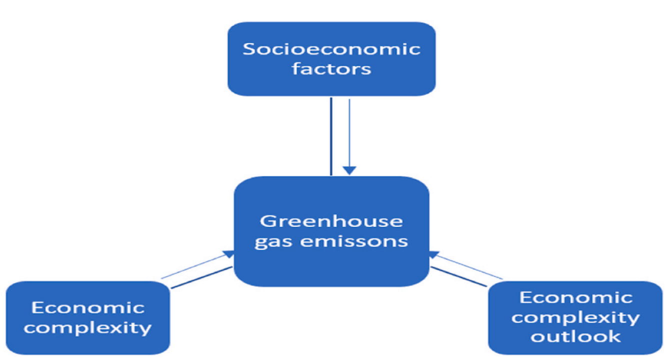

Fig. 1. Conceptualizing the environmental effect of economic complexity aspects
Source: Authors' construction.

Table 1
Definition of variables.

Variable	Code	Unit	Source
Greenhouse gases.	GHG	Thousand tonnes.	Global material flow database. (https://www.resourcepanel.org/global-material-flows-database)
Gross domestic product.	GDP	Constant 2015 USD.	Global material flow database (https://www.resourcepanel.org/global-material-flows-database)
Urban population	UPOP	% of total population.	World Bank. database. (https://data.worldbank.org/)
Environmental-related technologies.	ERT	% of percentage of all technologies.	OECD database. (https://data.oecd.org/)
Economic complexity.	ECI	Index.	The Atlas of economic complexity. (https://atlas.cid.harvard.edu/)
Economic complexity outlook.	ECOI	Index.	The Atlas of economic complexity. (https://atlas.cid.harvard.edu/)

Note: OECD is the Organisation for Economic Co-operation and Development.

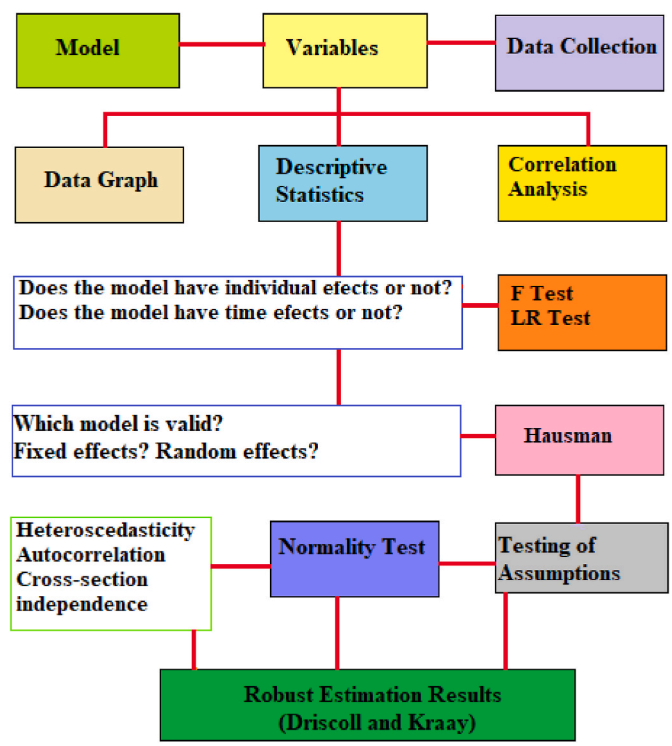

Fig. 2. Conceptual stepwise procedure
Source: Authors' design.

Table 2
The descriptive statistic of study.

Variable	Mean	Maximum	Minimum	Standard deviation
GHG	44366.83	95911.08	14143.18	18926.53
GDP	3.19E+11	5.46E+11	1.53E+11	9.20E+10
UPOP	83.36763	87.994	73.787	3.507993
ERT	11.69298	23.37	4.05	5.514208
ECI	1.413174	2.291723	0.359254	0.51497
ECOI	0.702558	1.511389	−0.280378	0.48301

Fig. 3. Graphical view of variables by country. **Note.** 1 denotes Denmark, 2 denotes Finland, 3 denotes Norway, 4 denotes Sweden.

GDP and ERT, and GDP and ECI. It further shows that a positive relationship exists between UPOP and ECOI. As is known, correlation analysis indicates the direction of the relationship between variables. Therefore, the correlation analysis results shown in Table 3 are parallel with the regression lines in Fig. 4. In other words, there is a negative correlation between lnGDP, lnERT, lnECI and GHG, and a positive correlation between lnUPOP and ECOI and GHG.

Correlation analysis is also used to determine whether there is a relationship between the independent variables expressed as the multicollinearity problem. If there is a relationship, the obtained parameters will be biased. This would pose a problem for a reliable and strong estimator. For this reason, it is investigated whether there is a multicollinearity problem. In short, the results of the correlation analysis prove that there is no high correlation between the independent variables. In other words, no multicollinearity problem was detected. Table 4 presents the test results that for the investigation of the presence of individual and time effects. The test results prove that the null hypothesis that ignores the existence of individual and time effects is rejected as probability values are less than 0.01 significance level. As a result, the bidirectional model with individual and time effects was tested. The null hypothesis of the Hausman test (H_0) states that the fixed effects model is consistent and the random effects model is effective, while the alternative hypothesis (H_1) denotes that the consistent random effects model of the fixed effects model is inconsistent (Hausman, 1978). The Robust Hausman (rhausman) test produces more reliable results against possible deviations from the assumption under the same hypotheses than the Hausman test. In this framework, in the continuation of the analysis, the random effects (RE) model is employed for individual effects. In contrast, the fixed effects (FE) model is used for the time effects model.

Table 5 presents assumptions deviation tests for the random effects model with individual and fixed effects model with time effect. First, for the random effects model, the D'agostino et al. (1990) normality distribution test, which allows the error component and the unit effects error component to be examined separately, was utilized. Accordingly, the null hypothesis of the test in question is not rejected for u_{it} of the error components. In other words, the error component is assumed to be normally distributed. This study utilized D'Agostino, Belange, and D'Agostino Normality Test results for the fixed effects model with time effect; the test results indicate that the error component is normally distributed. The null hypothesis of the heteroscedasticity test is that there is no heteroscedasticity problem, while the alternative hypothesis is that there is a heteroscedasticity problem. In this context, it is concluded that the null hypothesis is rejected. Finally, the heteroscedasticity problem for both models was detected. Bhargava et al. (1994); Durbin-Watson and Baltagi-Wu LBI test results were greater than 2. This result shows that the basic hypothesis that there is no autocorrelation problem can not be rejected. Therefore, there is no

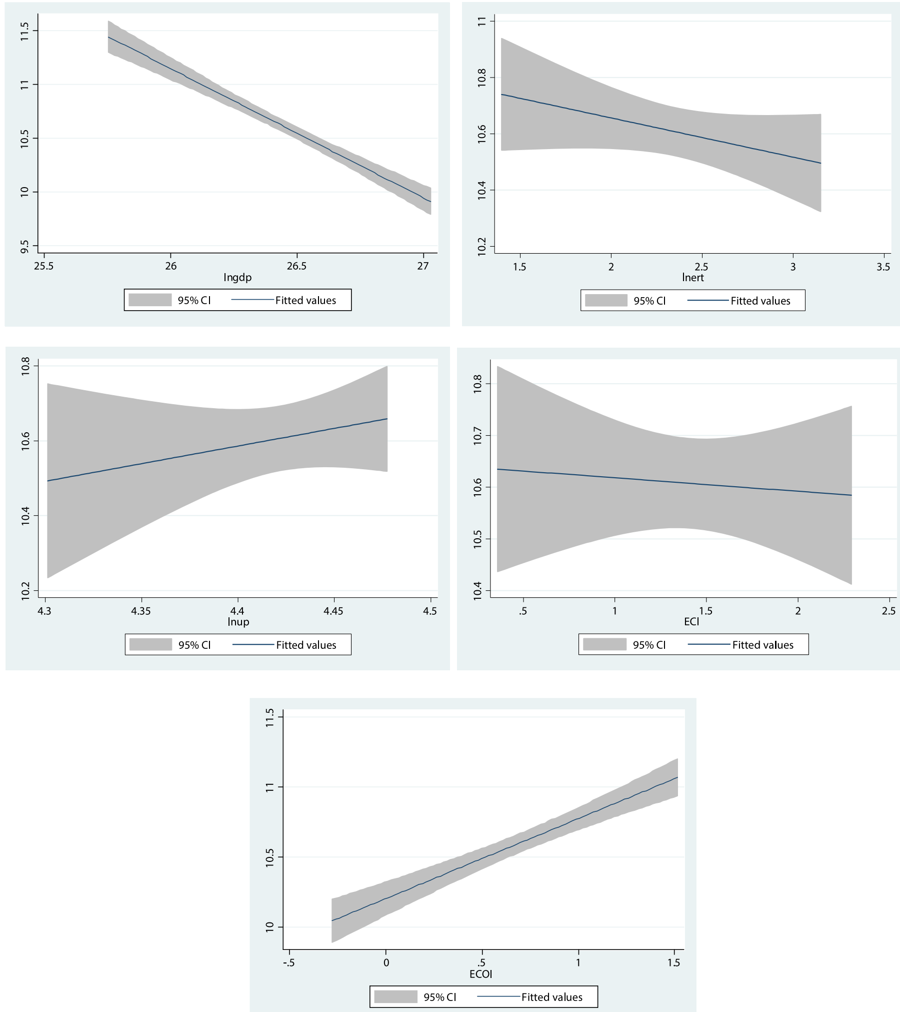

Fig. 4. Graphical representation of the relationship between GHG emission and the indicators.

Table 3
Correlation analysis results.

	lnGHG	lnGDP	lnUPOP	lnERT	lnECI	ECOI
lnGHG	1.00					
lnGDP	−0.78	1.00				
lnUPOP	0.09	0.15	1.00			
lnERT	−0.14	0.23	0.65	1.00		
lnECI	−0.03	−0.21	0.53	0.11	1.00	
ECOI	0.62	−0.49	0.69	0.26	0.58	1.00

Table 4
Testing the individual and time effect.

Tests	Individual Effect		Time Effect	
	Test Stat.	Prob.	Test Stat.	Prob.
F	32.61	(0.000)*	4.05	(0.000)*
LR	49.82	(0.000)*	14.08	(0.001)*
Hausman Test				
Robust Hausman for model with individual effect	Prob> χ^2 = 0.03			
Robust Hausman for model with time effect	Prob> χ^2 = 0.00*			

Note. * denotes 1% significance level.

autocorrelation problem.

The null hypothesis of the Pesaran and Friedman cross-section dependence test is that there is no cross-section dependence, while the alternative hypothesis is that there is a cross-section dependence. Except for Pesaran's test for individual effects, the results show no cross-sectional dependence on the other results. Finally, Ramsey Specification ResetF, DeBenedictis-Giles Specification ResetL, and DeBenedictis-Giles Specification ResetS results reveal that the model is specified (DeBenedictis & GILES, 1999).

Table 6 presents the robust estimation results of the individual and time effect model. First, the authors focus on the test results of Driscoll-Kraay's standard errors for RE with individual effects. Accordingly, the Wald test results prove that the model is statistically significant. The R^2 test result shows that the power of the independent variables to explain the dependent variable is 83%. Considering the statistically significant parameters, it is found that a 1% increase in GDP decreased GHG by 1.02%, a 1% increase in ERT decreased GHG by 0.25%, and a 1% increase in ECI decreased GHG by 0.49%.

On the other hand, a 1% increase in UPOP raises GHG by 3.3%, and a unit increase in ECOI raises GHG by 3.9%. The second area of emphasis is Driscoll-standard Kraay's errors for FE with time effect test results. Therefore, it is concluded that the model is statistically significant according to F test results. R2 test results indicate that the power of the independent variables in the model to explain the dependent variables is 91%. The parameters estimation showed that a 1% rise in GDP reduces greenhouse gas emissions by 0.95%, while a 1% increase in ECI reduces

Table 5
Results of diagnostic testing.

Random effects model with individual effect			Fixed effects model with time effect		
Test Stat.		*Prob.*	*Test Stat.*		*Prob.*
Normality Test:	μ_i	0.000**	D'Agostino, Belange, and D'Agostino Normality	Skewness	0.202
	u_{it}	0.374	Test:	Kurtosis	0.228
Levene, Brown and Forsythe test for heteroscedasticity (Levene, 1960)	$W_0 = 4.05$	0.009**	Modified Wald test for groupwise heteroskedasticity	$\chi^2 = 5272.98$	0.000*
	$W_{50} = 3.71$	0.014*			
	$W_{10} = 3.97$	0.010*			
DW test proposed by Bhargava et al. (1994) for autocorrelation	2.40		Modified Bhargava et al. for autocorrelation	2.33	
LBI test proposed by Baltagi-Wu for autocorrelation	2.75		LBI test proposed by Baltagi-Wu for autocorrelation	2.72	
Pesaran's test of cross sectional independence (Pesaran, 2004)	10.260	0.000**	Pesaran's test of cross sectional independence	−0.760	0.447
Friedman's test of cross sectional independence (Friedman, 1937)	21.785	0.648	Friedman's test of cross sectional independence	1.523	1.000
Ramsey Specification ResetF Test by Ramsey and Schmidt (1976)					
Ramsey RESETF1 Test: Y = X Yh2		0.374	P-Value > F(1, 97) 0.5425		
Ramsey RESETF2 Test: Y = X Yh2 Yh3		1.256	P-Value > F(2, 96) 0.2893		
Ramsey RESETF3 Test: Y = X Yh2 Yh3 Yh4		0.842	P-Value > F(3, 95) 0.4740		
DeBenedictis-Giles Specification ResetL Test (Giles and Johnson, 2002)					
Debenedictis-Giles ResetL1 Test		1.115	P-Value > F(2, 96) 0.3320		
Debenedictis-Giles ResetL2 Test		1.143	P-Value > F(4, 94) 0.3412		
Debenedictis-Giles ResetL3 Test		1.200	P-Value > F(6, 92) 0.3135		
DeBenedictis-Giles Specification ResetS Test					
Debenedictis-Giles ResetS1 Test		0.427	P-Value > F(2, 96) 0.6535		
Debenedictis-Giles ResetS2 Test		2.238	P-Value > F(4, 94) 0.0707		
Debenedictis-Giles ResetS3 Test		1.892	P-Value > F(6, 92) 0.0905		

Note. * and ** denote 1% and, 5% significance level, respectively.

Table 6
Robust estimation results by Driscoll and Kraay (1998).

Variable	Driscoll-Kraay standards errors for RE with individual effect	Driscoll-Kraay standards errors for FE with time effect
lnGDP	−1.02 (0.000)*	−0.95 (0.01)**
lnERT	−0.25 (0.000)*	−0.01 (0.83)
lnUPOP	3.35 (0.059)***	4.74 (0.06)***
lnECI	−0.49 (0.000)*	−0.67 (0.00)*
ECOI	0.039 (0.016)**	0.37 (0.10)
Constant	23.25 (0.000)*	14.93 (0.02)**
Wald χ^2	1530.88*	–
Prob> χ^2	0.000	–
F	–	6450.99*
Prob > F	–	0.000
R-squared	0.83	0.91
Obs.	104	104

Note. *, ** and *** denote 1%, 5%, and 10% significance level, respectively.

emissions by 0.67%. Additionally, a 1% rise in UPOP results in a 4.74% increase in GHG.

4. Discussion of results

According to Driscoll- Kraay's standard errors for RE with individual effects, an increase in GDP would likely have a negative impact on greenhouse gas emissions. The result of Kirikkaleli and Adebayo (2021) on the correlation between CO_2 emissions and real GDP using the global economy and those of Alola and Adebayo (2022) on the effect of GDP on GHG emissions in the chosen Nordic nations are refuted by this result. Instead, the effect of GDP on the environment indicate that economic expansionary policies' pressure to accelerate economic growth reduces greenhouse gas emissions in the Nordic region. This result furthers the green transition and the development of a sustainable economy by highlighting the region's current strong position as a driving force in pursuing a sustainable environment and carbon neutrality (Nordic Co-operation, 2022). It also suggests that more environmental and climate change regulations are being incorporated and implemented in productive economic activities. This path of development is recommended for the region to remain environmentally sustainable. Similarly, an increase in ERT is responsible for a decrease in GHG in the selected nordic countries. Specifically, the results corroborate Shahbaz et al. (2020), who discovered a negative association between technical innovations and CO_2 emissions in China, and Zhao et al. (2022), that noted a negative relationship between energy innovation and ecological footprint. In other words, increasing technological advancement can help reduce environmental degradation through technology adoption and environmental-relation innovation across businesses and industrial activities (Gu et al., 2019 & Lin and Zhu, 2019). This outcome demonstrates how ERT enhances the state-of-the-art application of technologies in environmentally friendly maner in this region. It then translates to the reduction in energy use and lowering the release of GHG emissions into the ecosystem. Furthermore, environmentally-related technologies reduce ecological degradation, including GHG emissions, through switching from traditional economic growth (i.e. the use of traditional production factors) to innovation-driven model (Awan, 2019; Awan et al., 2022). One of the strengths of technological advancement is that it can also eliminate high-polluting sunset sectors and encourage the growth of low-carbon industries, which in turn supports carbon emission reduction. It is recommended for the region to continue inventing ERT as the technology offers ways to reducing emmissions thereby, favouring the sustainability of the environment.

On the other hand, the urban population is shown to affect greenhouse gas emissions in the Nordic region positively. This outcome is consistent with a priori expectations and past studies, all of which demonstrated that an increase in population causes environmental deterioration (Zhao et al., 2022; Safdar et al., 2020; Solarin and Lean, 2016; Ozturk and Al-Mulali, 2015). Contrarily, Alola et al. (2022) claimed that a rise in population results in a reduction in the ecological footprint, which contradicts this claim. The positive effect of urban population on greenhouse gases show that population density, especially in the Nordic urban areas, is a problem given that it spurs the emission of greenhouse gases. In other words, a growing urban population undermines the ambitious climate goals of the Nordic region by increasing greenhouse gas emissions. Therefore, the region should endeavor to pay attention to its population changes to avoid the negative impact of overpopulation on its environment. Additionally, the result indicate that a rise in ECI lowers GHG emissions. While the result of this investigation aligns with Romero and Gramkow (2021), who found a negative relationship between economic output and greenhouse gas emission, the results of Adebayo et al. (2022) and Balland et al. (2022) aligns with this finding. Contrarily, the current findings contradict those of Agozie et al. (2022), who discovered a positive association between economic complexity and environmental deterioration in BRICS nations, and other authors who also posited that economic complexity contributes to an increase in environmental degradation (Rafique et al., 2022; Akadiri et al., 2022; He et al., 2021). This finding implies that encouraging development strategies to match socioeconomic conditions can assist the region in better coping and improving the economy's productive capacity amidst the global climate change concerns, hence reducing greenhouse gas emissions. Importantly, there is a contrary revelation showing the environmental demerit of economic complexity outlook arising from its positive impact on GHG emission. The complexity outlook index measures how well-positioned countries are in the product space by gauging how close the goods they make are to the goods they do not make, weighted by how complex those products are. This contrasts with the economic complexity index, which shows how complex countries are currently. The finding of Neagu and Teodoru (2019), who argues that highly sophisticated and complex products may contain industrial technology that is potentially more polluting, agrees with this outcome. The Economic complexity outlook measures prospectively how well-positioned countries are in the product space by weighing how similar the items they produce are to the products they do not produce. Therefore, when businesses and legislators decide to include products with a higher complexity outlook in the export baskets, they should concentrate on integrating energy considerations into the product design stage and encourage environmentally friendly investments. In other words, imports may be a viable option if the complexity of the product results in increased greenhouse gas emissions. Nevertheless, as Can and Gozgor (2017) noted, a thorough examination of the degree of environmental deterioration in each business is required.

Similarly, the results of the Driscoll-Kraay standards errors for FE with time effect is in harmony with the Driscoll-Kraay standards errors for RE with time effect. The results further show the robustness of the model used.

5. Conclusion and policy recommendation

In order to minimise environmental damage and enhance economic efficiency, policymakers are encouraged to seek sustainable economic policies. The research's primary contribution is analysing the factors influencing environmental deterioration brought on by greenhouse gas emissions using novel variables, economic complexity and technologies relevant to the environment. In this study, authors examined whether economic complexity and environmental-related technologies, as well as other covariates, resulted in the reduction in climate change from 1995 to 2020 in the Nordics.

The findings suggest that environmental technologies, economic complexity, and GDP all considerably influence the reduction of GHG emissions, while economic complexity outlook and urban population increase GHG emissions. This research offers significant evidence in favour of the hypothesis that complex economies are more likely to create capabilities that can contribute to pollution reduction through creating green innovations. These findings confirm earlier research and show that complex economies can offer viable opportunities for sustainable development. The paper also suggests that complex and sophisticated products can incorporate industrial technologies that may be more polluting. Interesting and practical findings were obtained by applying the necessary empirical procedures, particularly those considering panel estimate flaws such as cross-sectional dependency. Two distinct estimation approaches were employed to ensure the robustness of the result: the Driscoll-Kraay standards errors for RE with individual effect and the Driscoll-Kraay standards errors for FE with time effect. The results showed that a unit increase in economic complexity and environmental-related technologies resulted in a 0.49% and 0.25% decrease in GHG emissions, respectively. Growth also led to a decline in GHG by 1.02%, while urban population and economic complexity outlook spurred GHG emissions in the Nordic region by 3.35% and 0.03%, respectively. The results of this study are useful for advancing the literature and will especially benefit complex economies that must implement measures to prevent environmental damage.

5.1. Policy recommendation

This investigation further illustrates that greenhouse gases still pose a challenge, especially from the region's urban population growth and economic complexity outlook. Therefore, a more pragmatic socioeconomic policies should be implemented to decentralize and decongest the metropolitan population, thus promoting the growth and attractiveness of rural, semi-urban, and suburban areas. Moreover, the undesirable effect of economic complexity outlook on GHG emission is a source of concern to the Nordic countries on the need to re-assess and reinvigorate the production value-chain of their respective economy. As such, environmental performance of product characterization across the economic sectors could be improved by revisiting labels and standards. Specifically, the reconfiguration of product labels based on present and future durability and uncertainties can incentivize economic complexity indirectly. It further suggests that policy actors should take advantage of improving sustainable economic productivity. This potentially accounts for high economic complexity while promoting circular economy approaches given the low circular material use rate of the Nordic states i.e., 7.8% for Denmark, 6.6% for Sweden, 2% for Finland, and data documented for Norway (European Commission, 2023).

To address the positive externalities of climate change and improve on the gain of environmental performance in the region, GDP, ERT and ECI could be utilized in further drafting indicator-specific ambitious goals that align with the environmental and sustainable development policies to reduce the emission of GHG. In addition, countries in the region must continually improve their current economic and technological policies to enhance their environmental sustainability.

5.2. Limitation and future implementation

Finally, the current research could be replicated in the future given the limitations in the adopted approach. For instance, future study could be extended to cover other European states as against the selected Nordic countries in the present context. Additionally, this research is constrained in some ways by the brevity of the dataset period which is due to lack of accessibility (especially of economic complexity index) to longer period. With access to longer period of dataset, future advancements in research can benefit from econometric methods that separate the total influence into different periods or temporal dimensions. Moreover, to further explore the environmental pattern of economic complexity in the Nordic countries, future study could seek to understand or validate the existence of inverted U- or U-shaped relationship between economic complexity aspect and environmental indicator. Furthermore, other important indicators that measures financial progress, innovation activites, and socioeconomic dimensions which are relevant scenarios in the European states could be considered in future studies. Lastly, in future implementation abd depending of data sustainability, numerical modelling could be considered as an alternative or robustness to econometric approach.

CRediT authorship contribution statement

Andrew Adewale Alola: Data curation, Conceptualization, Formal analysis, and, Corresponding. **Ali Celik:** Methodology, and, Formal analysis. **Usama Awan:** Writing – original draft. **Ibrahim Abdallah:** Writing & . **Hephzibah Onyeje Obekpa:** Writing – review & editing, and, revision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Glossary

ERT: Environmental-related technologies
FE: Fixed effects
GDP: Gross domestic product
GHG: Greenhouse gas
EC(I): Economic complexity index
ECO(I): Economic complexity outlook index
RE: Random effect
RESET: Ramsey Regression Equation Specification Error Test
SBM: Slacks-based measure
STIRPAT: Stochastic Impacts by Regression on Population, Affluence and Technology
UPOP: Urban population