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# Exploring the role of export product quality and economic complexity for economic progress of developed economies: Does institutional quality matter?



Umer Shahzad<sup>a</sup>, Mara Madaleno<sup>b,\*</sup>, Vishal Dagar<sup>c</sup>, Sudeshna Ghosh<sup>d</sup>, Buhari Doğan<sup>e</sup>

<sup>a</sup> School of Statistics and Applied Mathematics, Anhui University of Finance and Economics, Bengbu 233030, China

<sup>b</sup> University of Aveiro, Department of Economics, Management, Industrial Engineering and Tourism (DEGEIT), Research Center GOVCOPP. Campus

Universitário de Santiago, Aveiro 3810-193, Portugal <sup>c</sup> Great Lakes Institute of Management, Gurgaon, Haryana 122 413, India

<sup>d</sup> Scottish Church College, West Bengal, India

Colourse Deviced Heisersite Leasts Tech

<sup>e</sup> Suleyman Demirel University, Isparta, Turkey

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## ABSTRACT

It is important to unearth the role of structural change factors for sustainable growth in developed economies. Economic complexity, export product quality, and institutional indicators represent the overall structural change and transformation in an economy. This paper probed the influence of export product quality and economics of complexity on economic growth for 28 OECD (Organization for Economic Co-operation and Development) countries using the data from 1990 to 2019. In doing so, the study employs three-panel data econometric models to investigate the role of economic complexity, export quality, and institutional quality on economic development. The paper performs the empirical tests, including the cross-sectional related dependency methods and cointegration techniques. As per the results emerging from fully modified OLS (FMOLS) and dynamic OLS (DOLS) estimation, export quality and financial development positively and significantly strongly impact growth in the long run. The empirical conclusions report detailed discussion on sustainable growth and discuss novel implications concerning product quality and institutional performance. The conclusions stress the practical implications for sustainable economic growth of OECD economies.

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1. Introduction

Over the last decade, there has been rising research in describing and analyzing countries' productive structures. New measures of the economic complexity index have been developed to determine the sophisticating nature of the procedure of production making and gains from trade. According to Hidalgo and Hausmann (2009), the economic complexity helps to analyze countries' productive capacities and the product quality of exports. Since they are more effective in estimating economic growth than traditional predictors, like GDP per capita, they are now widely used (Hausmann et al., 2014). Economic complexity occurs in a country if it can produce diversified products and export products have a more complex production structure. More specifically, economic complexity is the expanse of productive knowledge a country possesses that impacts economic performance. According to Lapatinas et al. (2019), it has been observed empirically that countries with higher complexity tend to gain additionally from trade and have a high degree of trade openness. Countries with advanced levels of economic-based complexity have higher economic capabilities since they utilize more intensive technology and high skilled labor (Hartmann et al., 2017).

The existing literature has unquestionably established that the up-gradation of exports and export quality contributes to economic growth (Hausmann et al., 2007; Zhu and Li, 2017; Fatima et al., 2021). However, other studies (Saafi and Nouira, 2018; Chrid et al., 2020) argue that growing export complexity and only rise in export quality may turn out to be non-productive. Recent studies suggest that institutional quality and human capital may

<sup>\*</sup> Corresponding author.

*E-mail addresses*: umer@aufe.edu.cn (U. Shahzad), maramadaleno@ua.pt (M. Madaleno), vishal.d@greatlakes.edu.in (V. Dagar), sudeshna.ghoshsent@outlook.com (S. Ghosh), doganbuhari@gmail.com (B. Doğan).

be instrumental for sustainable economic growth (Teixeira and Queirós, 2016; Zhu and Li, 2017). Therefore, exploring the explicit elements affecting the relations between export quality, complexity, and economic growth is crucial. Against this backdrop, the current paper explores whether product quality, economic complexity, renewable energy, and institutional quality induce the economic growth of developed countries. The current study is novel in this perspective and it attempts to explore the heterogeneous impacts of export quality and governance indicators on economic growth. Whereas, such indicators represent the overall structural change in the economy.

According to Hausmann and Hidalgo (2011), the developed economies have the highest level of economic complexity, and this could be a major determinant of economic growth. So, with higher capabilities and a complex production structure, the OECD countries can have higher economic growth. The institutional quality (democratic setup, political stability, bureaucratic quality, etc.) is a significant indicator of structural change that can affect technological innovation and productivity. Furthermore, it helps countries critically tackle policies for sustainable development and efficient energy use (Dasgupta and De Cian, 2018).

An increase in the economic complexity improves production capacity through innovation, knowledge accumulation, enhancing capabilities, and trade diversification, all of which are pertinent for economic growth. The second school of thought argues institutional quality moderates economic complexity, therefore, the crucial determining factor of economic growth. According to North (1990), institutions are "the rules of the game in a society, or, more formally, the humanly devised constraints that shape human interaction." Worthy institutes find expression in propertyrelated rights security, bureaucratic actions, enforcing in contracts, and motivation to invest in human capital formation for innovation and enhancement of productive capacities. Such processes explain the differences in wealth accumulation across the different parts of the globe.

The two channels of research in the extant seam of literature thus have diverse conclusions about economic growth determinants of economic growth. The literature has explored them as separate strands of competing arguments on economic prosperity. This paper enhances the pre-existing layer of literature by joining the two channels of empirical exploration. The study hypothesizes:

- I. "Export quality, renewable energy, foreign direct investment, and economic complexity positively influence the economic growth of OECD countries."
- II. "Human capital, institutional quality acts as key factors of structural change and impact economic growth".

This research furthers discussion to the growing body of research by delving into the importance of economic complexity as a major driver of prosperity in an economy and sustainability. Furthermore, the study uncovers the role of institutions expressed through bureaucratic quality and democratic accountability as additional drivers of economic growth.

Given the rationale for the research, the study makes two key contributions to academic scholarship. First, the research determines the impacts of economic complexity and export quality on economic progress through the lens of structural change. Second, the current research explores the heterogeneous impacts of institutional quality and human capital on economic growth to draw some novel implications. To the best of the author's knowledge, the current study uncovers novel conclusions regarding the structural impacts of economic and governance variables on economic growth. Such conclusions further allow us to draw some practical implications in line with the sustainable development goals (SDG-8: decent work and economic growth). In doing so, this research has used panel cointegrating methods to examine the longterm association across the key variables of interest. According to Hsiao (2007), the application of panel estimation techniques has improved over the cross-sectional and time series-based estimation methods. For robustness, we have employed the panel-based quantile regression estimation. Based on comprehensive empirical analysis and discussion, the study attempted to report some novel implications concerning the economic progress and structural change in developed countries. The practical suggestions might be helpful for policymakers of a country to identify the essential prerequisites to enhance the growth and maintain sustainability in energy use.

The rest of the paper is as follows: the subsequent section discusses the literature related to economic complexity, trade openness, energy, and institutional quality and its impact on growth. Section 3 explains the data and methods. Section 4 reports the empirical analysis and results. Section 5 provides discussion and policy suggestions, and Section 6 concludes the research.

## 2. Literature review

The recent decade has seen growing discussion in the existing seam of literature on a country-level analysis of how economic complexity enhances export competitiveness and economic growth. Furthermore, the existing literature also explores how foreign direct investment, human capital, and institutional quality moderate economic complexity and impact economic growth. According to the study of Erkan and Yildirimci (2015), economic complexity is utilized increasingly in the empirically-based literature to scrutinize the nature of complexity and sophistication of production and its effects on international trade diversification. The studies by Hidalgo and Hausmann (2009) and Lapatinas et al. (2019) argue that the economic complexity-based indicator impacts exports, and countries having a higher economic complexity-based index benefit more from trade.

Since the path-breaking studies of Hidalgo et al. (2007) and Hidalgo and Hausmann (2009), an extensive body of literature has examined the issues on the economic complexity across the globe (Mariani et al., 2015 and Gao and Zhou, 2018). These studies discuss how the network system of economic complexity impacts growth and the future diversification process of the economy.

According to the studies by Rodrik (2005) and Klinger and Lederman (2006), economic complexity plays a crucial role in helping countries to attain economic development. Further, the study by Agosin (2009) argued that trade diversification also impacts economic diversification and enables countries to grow. Economic complexity as a structural change indicator is conducive for economic growth, combating economic challenges, and adapting to technological change. Through economic complexity, technological change occurs, which nurtures innovation and competitiveness and helps economies modernize production processes, which furthermore impacts trade openness and economic growth.

The study by Erkan and Kaya (2015) discussed that economic complexity creates global competitiveness, positively impacting international trade. The study by Canh and Thanh (2020), through panel estimation methods across 70 economies from 1996 to 2014, discussed the interplay of export diversifying, economic-based complexity, and growth of the economy. The study obtained a bidirectional Granger causality between economic complexity and export-related expansion. Furthermore, the study obtained a negative relation of complexity upon growth. Other studies (Can and Gozgar, 2017; Hartmann et al., 2017; Dogan and Saboori, 2019) extensively discussed how economic complexity impacts human capital formation, and impacts environmental sustainability. The studies by Kim et al. (2016), and Carrasco and Garcia (2020) discussed the importance of the external sector and export diversification in impacting economic growth. According to the Global Competitive-

ness Index, the more complicated goals in the 2030 Agenda are SDG12 (Responsible Production and Consumption), SDG13 (Climate Action), and SDG17 (Sustainable Development) (Peace, Governance & Partnerships). Whereas, SDG9 (Industry, Innovation, and Infrastructure), SDG3 (Health and Wellbeing), SDG7 (cleaner and affordable energy), and SDG-8 (decent work and economic growth) are the most critical goals.

In this perspective, an appropriate strategy for governments might be to follow the sustainable complexity route to fully realize the 2030 Agenda, progressing from less complicated to more complex targets. Finally, future research should be focused on analyzing and identifying how the achievement of one SDG can lead to the achievement (or not) of another SDG using network theory and product-space theory for improving the environmental quality. This predicament could be a side effect of the so-called "Dutch Disease" in economics, which could have an impact on the SDGs' achievement." According to the aforementioned literature, there are several channels whereby export quality and economic complexity affect economic growth, for example, through expanding capital accumulation: spillover effects and skilled labor development, and specialization (Paramati et al., 2022; Shahzad et al., 2022).

The study by Alvarez et al. (2017) discussed the importance of economic-based complexity at the backdrop of energy use and growth. The study explored how government policies promote energy regulation and the adoption of complex energy systems with multifaceted social and environmental impacts. The paper by Dogan et al. (2020c) investigated the interconnections between economic growth, renewable energy usage, non-renewable-based energy consumption patterns, and economic expansion. Furthermore, the study examined the moderating impact of trade openness, complexity, direct foreign investment, and institutional quality upon economic growth. The study covered 32 European countries from 1995 to 2014, concluding that consuming renewably sourced energy has important implications for economic growth.

Likewise, the research of Dogan et al. (2020c) using novel estimation techniques explored how the quality of exports impacts energy intake and carbon dioxide release controlling growth, urbanization, and trade-openness for 63 developed and developing countries. The study suggests important policies which would enhance the direction on achieving the Sustainability Goals of clean energy. The empirical outcomes revealed that climate welfare augments the impact of export quality against climate welfare, reducing economic growth and urbanization. The paper concludes that policymakers should focus on incentivizing export quality to increase the consumption of renewable source-based energy. Such policy strategies would enable the countries to reduce the emission levels. More recently, Shahzad et al. (2020) employed annual data from 1971 to 2014 and examined the impacts of export diversification on carbon dioxide emissions for developing and developed countries. The empirical outcomes based on GMM methods suggest that export diversification has an emission-reducing effect across 63 developing and developed economies.

In the same line, Wang et al. (2021) explored the interdependence between carbon-based emissions, growth, use of renewable forms of energy and non-renewable forms of energy, urbanization, export diversification, and economic complexity for economies within the top ten as per the economic complexity index. The period of analysis was 1980–2014. Based on FMOLS, DOLS, and Granger-based causality methods, the empirical results suggested that export diversification and export quality reduce carbon emissions; furthermore, the use of renewably sourced energy mitigates the emission of carbon. Likewise, the study by Shahzad et al. (2021a) explored the role of export diversification for energy demand in ten newly industrializing nations. The empirical results based on FMOLS and DOLS methods suggest that export diversifying techniques significantly lower energy demand. However, economic growth, natural resources, and urbanization raise energy demand. The paper concludes that export diversification unambiguously reduces energy demand which has a climate welfare-enhancing impact. Such empirical outcomes are important for policy prescriptions for sustainable energy demand in the context of the newly industrializing countries.

More recently, Dogan et al. (2021) discussed how structural transformation towards a more sophisticated knowledge-based economy and economic complexity could drive growth in the economy and a cleaner environment. Using panel estimation techniques for 28 countries (OECD) and covering the years 1990 to 2014, the study concluded that complexity and use of renewably sourced energy helped reduce emissions and environmental degradation. Likewise, the study by Bashir et al. (2020) using alternative indicators of export diversification examined its impact on the intensity of carbon dioxide emissions and intensity of energy depletion for 29 OECD countries from 1990 to 2015. Using robust econometric techniques like sequential estimation, panel-quantile regressions, and generalized method of moments (GMM), the paper obtained that the indicators of export diversification have a reducing impact on carbon intensity. The paper further concludes that such empirical outcomes enable policy analysts to envisage strategies on green growth for sustainable development and clean energy use for the OECD economies.

On the same lines, Shahzad et al. (2021b) probed the impacts of export diversification on renewable energy consumption for the G7 and E7 nations covering the data from 1990 to 2017. The empirical outcomes from the study depict a nonlinear association between export diversification and consuming renewable-based energy for the concerned nations. However, the threshold levels of turning points are diverse across the G7 and E7 nations, respectively. Based on newly industrializing countries, Can et al. (2021) reported a bidirection in causality across the energy use and economic complexity. Such findings have noteworthy policy implications in pursuing the Sustainable Development Goals related to climate welfare and emission reductions. Using a cross-sectional autoregressive distributed lag model, the study obtained that institutional quality improved environment sustainability through the moderating role of economic complexity (Ben Jebli et al., 2020). Furthermore, the study obtained that renewable energy reduced the ecological footprint. The paper concluded that accelerating complexity (economic) and improving institutional quality will reduce the ecological footprint and expand sustainable economic growth.

Recently, a study by Rafique et al. (2021) researched the impacts of economic complexity on renewable energy consumption. The study covered panel data of G7 and E7 nations respectively. The empirical results depicted a significant and positively based impact of complexity on renewable source-based energy consumption patterns. The paper explains that economic complexity is crucial for renewable energy generation. The policy thrust of these countries should be towards improving the complexity (economic) levels in these nations. Such strategies will enable us to move towards green growth and clean energy promotion, as argued by the authors.

There is a comparable growing literature that argues that the quality consciousness of institutions is a major determining factor of economic growth along with interlinkages with economic complexity, human capital formation, foreign direct investment, and trade diversification (Dias and Tebaldi, 2012; Khan et al., 2020). These studies discussed that institutional quality and governance level is essential for enhancing market functioning. Good institutions are revealed in implementing laws and regulations, enforcing property-related rights, and enforcing contracts (Ghazouani et al., 2020). According to Zhu and Li (2017), human capital enhances productive capabilities and economic complexity, and growth. An

educated workforce can better produce complex products, which leads to export diversification and foreign-based investment.

The study by Gala (2020), using the economic complexity indicator for 210 countries, investigated how complexity and human capital formation impacted the economy (Nakhli et al., 2022). The study concluded that economic complexity and capital (human) formation impacted the economy's growth both in the short-run and the long term. There is a growing unanimity in the literature that good institutions offer inducements for entrepreneurial events, human capital formation, and innovation. Thus, institutional quality provides the horizon and facilitation for innovating and creating complex production structures, essential for economic prosperity. Recently, Nouira and Saafi's (2021) documented the nonlinear nexus between export diversification and economic growth. The results concluded that export diversification could impact economic growth significantly if certain threshold conditions apropos human capital and institutional quality are satisfied.

The preceding discussion deliberates extensively on the most difficult and interesting questions. "Why do some countries grow faster and are hence more affluent than some others?" As evident from the literature, the line of inquiry is through two-pronged conduits. The first school of thought explored how economic complexity helps identify trade diversification patterns, foreign direct investment, ecological footprint, and economic development (Hidalgo and Hausmann, 2009; Hausmann et al., 2014; Santoalha and Boschma, 2020). These studies conclude that robust growth and environmental sustainability are seen in those countries whose production processes are geared towards sophistication and economic complexity (economic) sets up a robust measure of the concerned country's innovation and trade diversification.

#### 3. Data, model specification, and methodology

## 3.1. Data and model specification

The prime objective of this study is to explore the role of export product quality, economic complexity, and institutional quality as key indicators of structural change for the economic progress of OECD countries. The on-hand research consists of a panel data set of 28 OECD countries, comprising the period 1990 to 2019. The authors attempt to explore the impacts of economic complexity, institutional quality, export quality on economic growth for the developed OECD countries. In doing so, authors gather the data for GDP, representing economic growth, export quality (EQ), the economic complexity index (ECI), renewable energy consumption (REC), trade (Trade), the financial development index (FD), the Human capital index (HC), urbanization level (urban), the democratic accountability index (DAI), and the bureaucratic quality index (BQI). The authors gather the data on renewable energy, trade, Human development, urbanization, and institutional indicators from (World Bank, 2021). Data for institutional indicators was accessed from (ICRG, 2022), whereas the human capital data is sourced from Penn World Table 9.0. The data for export product quality and financial development was obtained from (International Monetary Fund, 2022) database. Finally, the economic complexity data was obtained from the (Observatory of Economic Complexity, 2022).

The baseline models are represented in Eqs. (1), (2), and (3), respectively.

Model 1:

$$GDP_{it} = EQ_{it} + ECI_{it} + REC_{it} + Trade_{it} + FD_{it} + \varepsilon_{it}$$
(1)

Model 2:

$$GDP_{it} = EQ_{it} + ECI_{it} + REC_{it} + HC_{it} + DAI_{it} + \varepsilon_{it}$$
(2)

Model 3:

$$GDP_{it} = EQ_{it} + ECI_{it} + REC_{it} + urban_{it} + BQI_{it} + \varepsilon_{it}$$
(3)

In all models, *i* stands for the country and t for time,  $\varepsilon$  is the error term. The empirical methodology applied will be presented next, following all the steps, including robustness check methodologies applied.

## 3.2. Methodology

As stated previously, we add to the extant literature by exploring the relationship between economic complexity, export product quality, institutional quality, and energy use. In doing so, we employ panel cointegration techniques to examine these variables' long-run relationships. We first make a preliminary analysis of the descriptive statistics. The empirical exercise begins with the Pesaran (2015) cross-sectional dependence (CD) test to examine cross-sectional dependence occurs in the panel data. To deal with the problems associated with cross-sectional dependence, the study adopts the second-generation panel estimation techniques robust to panel heterogeneity and cross-sectional dependence. Panel unit root tests are also employed. After obtaining the order of integration of the time series observations, both the Westerlund panel cointegration and Pedroni panel cointegration tests are applied to explore the variables' long-run associations. The fully modified least square (FMOLS) model and the dynamic least square model (DOLS) are used to estimate long-run elasticities. Lastly, the authors employ a robustness check on the model specifications by employing the panel quantile regression estimation.

a. Preliminary analysis

We begin our empirical analysis with Pesaran's (2015) CDtest for weak cross-sectional dependence in panel context. It is a method of investigation of the mean correlation between panel data. The null hypothesis in Pesaran (2015) is of weak dependence, provided the null hypothesis of cross-sectional independence of Pesaran (2004) is very strong and unlikely to be met in a large panel. Pesaran's (2015) null hypothesis of cross-section independence, having CD  $\sim$  N (0,1), and p-values lower than 5%, indicate that data are correlated across the panel. The weak dependence means that when N or T converges to infinity in the limit, the cross-sectional dependence (weak relations) disappears, turning the estimator consistent. The strong dependence assumption poses real problems like that of omitted variable bias.

After checking for weak cross-section dependency, we apply the panel unit root tests. The first one was the CIPS-test developed by Pesaran (2007) to be applied in heterogeneous panels in the presence of cross-section dependence. The cross-sectional Im, Pesaran, and Shin (CIPS) by Pesaran (2007) has a nonstandard distribution, even with large N (Im et al., 2003). The second used test of panel unit-roots was that of the CADF test (covariate augmented Dickey-Fuller) developed in Hansen (1995) and proposed in Pesaran (2007).

Once cross-sectional correlations are detected, we need panel unit root tests accounting for data stationarity. To this end, we employ the second-generation tests (CIPS and CADF). Both CIPS and CADF tests rely on the factor structure approach. The CADF test is based on the mean of individual Dickey-Fuller t-statistics of each unit in the panel, parallel to the CIPS test (Im et al., 2003). The null hypothesis of the CADF test assumes that all series are nonstationary, as does the null of the CIPS test.

Moving forward, panel cointegration tests were executed. These are necessary when time series are nonstationary to determine if they have stable long-run relationships. However, sometimes, not even doing so will turn them stationary (which is the situation in the present article. Provided nonstationary time series tend to

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Variable		Mean	Std. Dev.	Min	Max	Observations
Economic growth	overall	27.095	1.209	25.090	30.485	<i>N</i> = 840
	between		1.210	25.480	30.194	<i>n</i> = 28
	within		0.217	26.361	27.778	T = 28
Export quality	overall	0.976	0.054	0.708	1.057	N = 840
	between		0.052	0.782	1.035	<i>n</i> = 28
	within		0.018	0.852	1.040	T = 26.64
Complexity	overall	0.998	0.422	-0.373	1.748	N = 840
	between		0.414	-0.121	1.648	n = 28
	within		0.112	0.590	1.274	T = 28
Renewable energy	overall	21.888	2.085	14.509	26.420	N = 840
	between		1.618	17.153	25.507	n = 28
	within		1.349	16.403	26.204	T = 28
Trade	overall	0.718	0.355	0.160	2.260	N = 840
	between		0.329	0.249	1.611	n = 27
	within		0.147	0.019	1.367	T = 28
Financial development	overall	0.616	0.179	0.176	1.000	<i>N</i> = 840
	between		0.151	0.350	0.900	<i>n</i> = 28
	within		0.100	0.291	0.812	T = 28
Human capital	overall	0.715	0.072	0.490	0.844	N = 840
	between		0.062	0.573	0.820	n = 28
	within		0.038	0.579	0.850	T = 28
Democratic accountability	overall	5.616	0.691	2.000	6.000	<i>N</i> = 840
	between		0.448	4.378	6.000	<i>n</i> = 28
	within		0.530	2.953	7.238	T = 26.28
Urbanization	overall	16.507	1.176	14.509	19.402	N = 840
	between		1.193	14.711	19.251	n = 28
	within		0.094	16.143	16.821	T = 28
Bureaucratic quality	overall	3.567	0.590	2.000	4.000	N = 840
	between		0.501	2.215	4.000	n = 28
	within		0.326	2.000	4.586	T = 26.28

*Note:* n shows the number of countries, N shows observations and T is the number of years.

wander, cointegration states they wander jointly, and thus there is a long-run equilibrium relationship among them.

The cointegration tests to be used are those of Westerlund (2005) and Pedroni (1999, 2001, 2004). The Westerlund cointegration variance test imposes fewer restrictions having as null the no cointegration hypothesis. The alternative hypothesis is that some (not necessarily all) of the panels are cointegrated. For nonstationary heterogeneous panels with large T and N, Pedroni's tests for cointegration among one or more regressors, for a total of seven possible test statistics. This is done for all under the null of no cointegration. These estimate the cointegrating equation for each N and the group mean of the panel, allowing for time dummies and an unbalanced panel. In this study, we apply three of these tests, as a form of robustness check. Pedroni (1999, 2001, 2004) provides a detailed analysis of these tests.

b. Long-run elasticities

To compute long-run elasticities we used both panels Fully Modified Ordinary Least Squares (FMOLS) and the Dynamic Ordinary Least Squares (DOLS) models. These are usually employed to estimate long-run equilibrium relationships among the variables. Allow correcting for endogeneity bias and serial correlation and standard normal inference (Baltagi and Kao, 2001; Pedroni, 2000). The FMOLS is a nonparametric method allowing to correct for serial correlation. The DOLS method is parametric and allows for an estimation of lagged first-differenced parameters.

Both DOLS and FMOLS are superior to the simple OLS as stated in Pedroni (2001), which also explains that the between-group estimators are preferable to the within-group estimates. DOLS and FMOLS take care of endogeneity by adding the leads and lags and using white heteroscedastic standard errors. The literature also points that the DOLS outperforms the FMOLS approach (Kao and Chiang, 2000) since it is computationally simpler and reduces bias better than FMOLS. Leads and lags are introduced in the DOLS to cope with the order of integration and the existence or absence of cointegration. c. Robustness Check: Panel quantile regression estimation For robustness check, we made use of the quantile regression model. These allow accounting for unobserved heterogeneity and heterogeneous covariates effects. Panel quantile regression models also allow to include fixed effects to control for some unobserved covariates (Graham et al., 2015). The quantile regression approach is more efficient than the OLS method if residuals are non-normal. It provides a more flexible and complete characterization of the model variables relationship at higher and lower levels. Besides, results are robust to outliers and heavy-tailed distributions, which is useful when the relationship among variables is nonlinear.

Quantile regression was introduced by Koenker and Basset (1978). This process represents an extension of the classical least-squares estimation (that of the conditional mean to a collection of models for different conditional quantile functions. Results are presented for the 10th, 25th, 50th, 75th<sup>,</sup> and 90th quantiles, and pooled OLS results are also used for comparison. Quantile plots for the three models presented earlier are provided. We have a structural interpretation for the slope coefficients associated with panel quantile regressions (Baker et al., 2016). It also corrects the bias stemming from the endogenous regressors in panel data. Therefore, we may find homogeneous or heterogeneous spillovers across quantiles, providing practical implications for policy strategies. The next section of empirical findings gives insights based on the models specified in this study. All the variables have been converted in the logarithmic form before conducting the empirical operations.

#### 4. Empirical results and findings

## 4.1. Empirical results

Table 1 reports the details of summary statistics for the data considered from 28 OECD countries for our key variables of interest, i.e., economic growth, export quality, complexity, renew-

#### Table 2

Cross-sectional dependence test using Pesaran, (2015).

Variable	CD-test	p-value	average joint T	mean $\rho$	mean $abs(\rho)$
Economic growth	96.816	0.000	28.00	0.94	0.94
Export quality	15.112	0.000	25.52	0.16	0.42
Complexity	38.331	0.000	28.00	0.37	0.66
Renewable energy	80.666	0.000	28.00	0.78	0.79
Trade	62.207	0.000	28.00	0.58	0.60
Financial development	80.447	0.000	28.00	0.78	0.78
Human capital	40.28	0.000	28.00	0.39	1.00
Democratic accountability	2.619	0.009	25.91	0.03	0.21
Urbanization	73.063	0.000	28.00	0.71	0.83
Bureaucratic quality	0.75	0.454	25.91	0.01	0.16

*Note:* Under the null hypothesis of cross-section independence,  $CD \sim N(0,1)$ . P-values close to zero indicate data are correlated across panel groups. https://ideas.repec.org/c/boc/bocode/s458385.html. (For details on estimation codes).

Table 3

Panel Unit root testing.

Test	Variable	Level	First Difference
	Economic growth	-1.898	-3.977***
	Export quality	-1.818	-5.796***
CIPS test	Complexity	-1.643	-4.418 ***
	Renewable energy	-1.712	-3.473**
	Trade	-1.746	-3.980***
	Financial development	-2.478***	-5.368***
	Human capital	0.885	2.610***
	Democratic accountability	-0.948	-3.183***
	Urbanization	-1.602	-1.990
	Bureaucratic quality	0.021	-1.630
	Economic growth	-1.996*	-3.212***
	Export quality	-1.526	-4.514***
	Complexity	-1.686	-2.969***
CADF test	Renewable energy	-2.407***	-2.863***
	Trade	-2.276***	-3.189***
	Financial development	-2.261***	-3.788***
	Human capital	0.900	2.610***
	Democratic accountability	-0.997	-2.616***
	Urbanization	-2.234***	-1.825***
	Bureaucratic quality	0.105	-1.101

*Notes*: \*\*\*\*, \*\*, \* denotes significance level at 1%, 5% and 10%. CIPS test assumes crosssection dependence is in the form of a single unobserved common factor.

able energy, trade, financial development, human capital, democratic accountability, urbanization, and bureaucratic quality. Further, Table 1 gives information about the summary statistics in the form of the overall, between, and the within specifications. The values of mean, standard deviation, minimum and maximum distribution with a total number of observations have been added. The number of observations comprises the values for 'N', 'n', and 'T' which means the total number of observations in the panel, the total number of countries (OECD) selected in the study, and the total number of years say from 1990 to 2019 (annual database).

Table 2 shows the cross-sectional dependence using a test of Pesaran (2015) concerning p-values, average joint 'T', mean 'p', and mean absolute 'p' values for all the variables considered in this study. Taking care of the obtained p-values, we observe that all variables except Bureaucratic quality data are correlated across panel groups, following the CD-test.

Table 3 shows the results of the panel unit root test with Cross-Sectional Im-Pesaran-Shin (CIPS) and Cross-Sectional Augmented Dickey-Fuller (CADF) after assuming the conditions of cross-sectional dependence in the form of a single unobserved common factor. The ten selected variables of this study have been evaluated with their level and at first difference.

Table 4 shows the results of panel cointegration analysis for Model-1, Model-2, and Model-3 with their statistics and P-value of the test i.e., Westerlund Cointegration with variance ratio, and Pe-

droni Cointegration with t-statistics and p-value for Panel Phillips-Perron statistics and Cross-Sectional Phillips-Perron statistics with Panel ADF-statistics. For the Westerlund Cointegration, the statistics in Model-1 and 2 have been evaluated for variance ratio are 0.0571 and -2.0095 at 5% significance and with p-values of 0.0712 and 0.0222 respectively. For Model-3 the value of statistics has been evaluated -1.3034 at a 1% significance and with a p-value of 0.0096.

Based on the FMOLS estimation under three separate model behaviors, the significant long-run elasticities on renewable energy are 22.6 percent, 83.3 percent, and 9.45 percent separately as per FMOLS and 21.60 percent, 35.40 percent, and 10.10 percent individually as per DOLS. In the case of export quality, the FMOLS estimation revealed the variable's significant and positive impact on economic growth, as evident from elasticities of 53.10 percent, 79.48 percent, and 64.27 percent as per FMOLS and 61.70 percent, 81.30 percent, and 68.46 percent as per DOLS. The study has also highlighted the critical role of financial development, as indicated by its long-run elasticity values of 16.86 percent (FMOLS) and 16.15 percent (DOLS). Economic-based complexity has a positive impact on economic growth. Under the DOLS estimation, the long-run elasticity estimates for this variable are 10.14 percent, 35.50, and -17.90 percent respectively, while for the FMOLS estimation, the elasticity values are 10.60 percent, 44.70 percentage, and -19.90 percent individually. The panel quantile regression estimates applied for robustness estimates confirm the aforementioned findings.

The results emerging from Table 5 indicate that export quality, renewable energy, financial development, and economic complexity have a positive and significant impact on economic growth. In contrast, trade openness affects economic growth negatively. Hence, Hypothesis I is accepted for all the aforementioned variables except for trade. Further, the results also highlight that the variables export quality, renewable energy consumption, institutional quality, when interacted with human capital, positively impact growth in the economy for the set of OECD countries analysis. Meanwhile, bureaucratic quality mentioned positive impacts on economic growth, indicating the significance of bureaucratic decisions and the role of institutions. Based on these findings, Hypothesis II is accepted for export quality, renewable energy consumption, institutional quality but rejected for economic complexity.

The robustness of the model specifications has been tested using panel quantile regression for all the variables included in the analysis. The results emerging from quantile regression for Models 1, 2, and 3 are shown in Tables 6(a), 6(b), and 6(c) along with Fig. 1(a), 1(b), and 1(c) respectively.

The empirical results show that export quality, complexity, renewable energy, financial development, democratic accountability, human capital, and bureaucratic quality in OECD countries impact economic development and act as structural change factors. The

#### Table 4

Panel Cointegration analysis.

Test	Model-1		Model-2		Model-3	
Westerlund Coint	Statistic	P-value	Statistic	P-value	Statistic	P-value
Variance ratio	0.0571**	0.0712	-2.0095**	0.0222	-1.3034***	0.0096
Pedroni Coint	t-statistics	P-value	t-statistics	P-value	t-statistics	P-value
Panel Phillips-Perron statistics	4.5557***	0.0000	3.802***	0.0001	4.6859***	0.0000
Panel Phillips-Perron statistics	0.6601	0.2546	-0.329***	0.0371	0.6784**	0.0248
Panel ADF-statistic	2.3901***	0.0084	1.7261**	0.0422	2.6296***	0.0043

*Notes*: \*\*\*\*, \*\*, \* denotes significance level at 1%, 5% and 10%. The models are applied as per baseline specifications, with different controls.

#### Table 5

Long run Empirics using FMOLS and DOLS.

	FMOLS			DOLS		
Variables	Model-1	Model-2	Model-3	Model-1	Model-2	Model-3
Export quality	0.531	7.948**	6.427***	0.617	8.130*	6.846***
	(2.662)	(3.823)	(1.070)	(3.191)	(4.668)	(1.188)
Complexity	1.060***	0.447	-0.199	1.014***	0.355	-0.179
	(0.311)	(0.446)	(0.139)	(0.368)	(0.544)	(0.152)
Renewable energy	0.226***	0.383***	0.0945***	0.216***	0.354***	0.101***
	(0.0540)	(0.0641)	(0.0222)	(0.0637)	(0.0780)	(0.0247)
Trade	-1.689***			-1.622***		
	(0.271)			(0.308)		
Financial development	1.686**			1.615*		
	(0.726)			(0.853)		
Human capital		-4.464**			-4.312*	
		(2.091)			(2.497)	
Democratic accountability		-0.195			-0.258	
-		(0.188)			(0.249)	
Urbanization		. ,	0.866***		. ,	0.836***
			(0.0412)			(0.0438)
Bureaucratic guality			0.318***			0.292***
1 0			(0.0775)			(0.0855)
Constant	20.77***	14.79***	3.526***	20.93***	15.59***	3.558***
	(2.630)	(3.243)	(1.154)	(3.164)	(4.021)	(1.263)
Observations	840	840	840	840	840	840
R-squared	0.175	0.015	0.612	0.717	0.559	0.923

Notes: Standard errors in parentheses. \*\*\* p < 0.01, \*\* p < 0.05, \* p < 0.1. FMOLS and DOLS are applied as long-run empirical methods on all three baseline models.

#### Table 6(a)

Robustness Check with Panel Quantile Regressions (model-1).

Variables	Pooled OLS	Quantile 10th	Quantile 25th	Quantile 50th	Quantile 75th	Quantile 90th
Export quality	-0.252*	0.331	-3.712***	1.228*	2.263***	3.287***
	(1.254)	(1.103)	(1.262)	(0.704)	(0.617)	(0.921)
Complexity	1.028***	0.703***	1.068***	0.911***	0.823***	0.727***
	(0.101)	(0.136)	(0.156)	(0.0870)	(0.0763)	(0.114)
Renewable energy	0.215***	0.0725***	0.101***	0.244***	0.280***	0.297***
	(0.0160)	(0.0251)	(0.0287)	(0.0160)	(0.0141)	(0.0210)
Trade	-1.536***	-0.932***	-1.903***	-1.679***	-1.365***	-1.452***
	(0.162)	(0.126)	(0.144)	(0.0801)	(0.0703)	(0.105)
Financial development	1.758***	2.116***	3.259***	1.354***	0.883***	0.618**
	(0.150)	(0.327)	(0.374)	(0.209)	(0.183)	(0.273)
Constant	21.67***	22.90***	26.31***	20.19***	18.89***	18.10***
	(0.874)	(1.137)	(1.300)	(0.725)	(0.636)	(0.949)
Observations	840	840	840	840	840	840
R-squared	0.710	0.3107	0.3345	0.4782	0.5783	0.6136

Notes: Standard errors in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. Pooled OLS is applied with Driscoll-Kraay standard errors. Panel quantile regression is applied at conditional quantiles.

findings reveal the short and long-run positive relationship of institutional quality and the aforementioned macroeconomic variables with sustainable development. Hence, it is crucial to work on governance level, export quality, and human knowledge and skills to attain sustainable development.

In some cases, the leading economies from the perspective of renewable energy use, FMOLS and DOLS find a unidirectional but short-run solution that may help in continuing these economies with the same level of institutional quality, which may cause users of the same level of non-renewable energy. The same thing may take place in the combination of other remaining variables, i.e., urbanization to institutional quality; export quality to institutional quality; financial development to renewable energy use; urbanization to financial development; export quality to financial development; non-renewable energy generation to renewable energy generation; and urbanization to renewable energy generation and nonrenewable energy use.

The statistical analysis provides empirical evidence that renewable energy, along with policies aimed at improving the level of bureaucratic quality and urbanization, may increase industrial pro-

Table 6(b)		
Robustness Che	k with Panel Quantile Regressions (model-2	2).

Variables	Pooled OLS	Quantile 10th	Quantile 25th	Quantile 50th	Quantile 75th	Quantile 90th
Export quality	4.582*	5.737***	3.477***	6.798***	7.278***	4.271***
	(2.645)	(0.599)	(0.882)	(0.992)	(0.893)	(0.866)
Complexity	0.593**	0.0930	0.450***	0.542***	0.412***	0.685***
	(0.217)	(0.0766)	(0.113)	(0.127)	(0.114)	(0.111)
Renewable energy	0.349***	0.210***	0.257***	0.361***	0.358***	0.372***
	(0.0269)	(0.0124)	(0.0183)	(0.0205)	(0.0185)	(0.0179)
Human capital	-3.068***	-3.179***	-3.060***	-4.359***	-2.322***	-2.014***
	(0.721)	(0.402)	(0.591)	(0.665)	(0.598)	(0.580)
Democratic accountability	-0.137***	0.00832	-0.148***	-0.165***	-0.134**	-0.0240
	(0.0494)	(0.0371)	(0.0546)	(0.0614)	(0.0553)	(0.0536)
Constant	17.38***	18.00***	19.87***	16.15***	14.85***	16.77***
	(1.592)	(0.565)	(0.832)	(0.935)	(0.842)	(0.817)
Observations	840	840	840	840	840	840
R-squared	0.516	0.2281	0.1980	0.2771	0.3951	0.4603

Notes: Standard errors in parentheses. \*\*\* p < 0.01, \*\* p < 0.05, \* p < 0.1. Pooled OLS is applied with Driscoll-Kraay standard errors. Panel quantile regression is applied at conditional quantiles.

Table 6(c)			
Robustness Check with	Panel Quantile	Regressions	(model-3)

Variables	Pooled OLS	Quantile 10th	Quantile 25th	Quantile 50th	Quantile 75th	Quantile 90th
Export quality	5.019***	7.437***	6.569***	5.163***	4.692***	2.195***
	(0.866)	(0.438)	(0.310)	(0.319)	(0.489)	(0.703)
Complexity	-0.00632	-0.0467	-0.158***	-0.0353	0.0936	0.152
	(0.0828)	(0.0621)	(0.0440)	(0.0452)	(0.0693)	(0.0996)
Renewable energy	0.111***	0.106***	0.108***	0.104***	0.106***	0.104***
	(0.00551)	(0.0109)	(0.00772)	(0.00793)	(0.0122)	(0.0175)
Urbanization	0.833***	0.895***	0.879***	0.859***	0.811***	0.751***
	(0.0111)	(0.0206)	(0.0146)	(0.0150)	(0.0230)	(0.0331)
Bureaucratic quality	0.275***	0.263***	0.336***	0.287***	0.167***	0.155**
	(0.0296)	(0.0380)	(0.0269)	(0.0276)	(0.0424)	(0.0610)
Constant	5.068***	1.477***	2.567***	4.605***	6.319***	10.08***
	(0.584)	(0.522)	(0.370)	(0.380)	(0.583)	(0.838)
Observations	840	840	840	840	840	840
R-squared	0.910	0.6679	0.6975	0.7261	0.7287	0.7232

Notes: Standard errors in parentheses. \*\*\* p < 0.01, \*\* p < 0.05, \* p < 0.1. Pooled OLS is applied with Driscoll-Kraay standard errors. Panel quantile regression is applied at conditional quantiles.



Fig. 1. (a): Quantile plot of model-1 estimates, Fig. 1(b): Quantile plot of model-2 estimates, Fig. 1(c): Quantile plot of model-3 estimates.

duction and advancements in manufacturing processes in ways that may ultimately improve environmental quality. Further, for the export quality, complexities, renewable energy, urbanization, and bureaucratic quality, the outcomes of the analysis show two-way short-run different types of causality among complexities, renewable energy, and institutional quality. At the same time, unidirectional type of causal connections in institutional quality and renewable energy, urbanization, and bureaucratic quality have been observed. The FMOLS and DOLS may give a bidirectional output for the short-run with the current level of causality and relationship among all variables for better governance for renewable energy to institutional quality (Wang et al., 2021).

The value of pooled OLS for constant in model 3 has been estimated at 5.068 with a standard error of 0.584 at 1% significance, and 0.910 R-squared, it has 1.477 with a standard error of 0.522 at 1% significance. Further, 0.6679, 0.6975, 0.7261 and 0.7232, Rsquared for 25th, 50th, 75th and 90th quantile, 25.67, 4.605, 6.319, and 1.08 with a standard error 0.370, 0.380, 0.583 and 0.838 at 1% significance. Pooled OLS is applied with Driscoll-Kraay standard errors, and panel quantile regression is employed at conditional quantiles for all three models. The next section involves brief discussions based on the output of all these three models for suggesting better policies related to the economic complexities and economic growth with all the considered variables.

For the OECD countries with FMOLS and DOLS models approach, the fixed effect of renewable energy use and urbanization on institutional quality has been found negative but statistically significant only for some of the estimated parameters of urbanization. Overall, renewable energy use, bureaucratic quality, export quality, and institutional quality have shown positive heterogeneous impacts on economic growth. Based on these highly flexible macroeconomic variables during the long-run process, the estimations have the following impact. First, a 1% increase within the urbanization process may bring down the use of renewable energy with an average share of 0.8%. Moreover, a 1% hike in the urbanization process may improve institutional quality and increase the use of renewable energy. The above-mentioned results are similar to those of Rafique et al. (2021) and Can et al. (2021). The progressive implications of economic complexity renew the crucial importance of the need for technological sophistication in the context of the OECD countries. Our empirical outcomes confirm the findings of other studies (Alvarez et al., 2017; Dogan et al., 2021), that economic complexity raises the capacity for adaptability into a sustainable economic system.

## 5. Discussions and policy suggestions

This study has utilized three models to bridge the research gap on economic complexity for a country that starts producing diversified products and exporting products with a more complex production structure. The results emerging from the analysis enable the identification of factors of sustainable economic growth. The factors considered in this study have been previously explored in the literature individually, making the empirical conclusions on economic prosperity incomplete. This study has attempted to add and integrate almost all the major input variables in the existing layer of literature by joining the two conduits of empirical explorations.

The empirical results have reported a significant relationship between export quality, economic complexity, institutional quality, and economic growth. The empirical outcomes of this study strengthen the findings of the literature amongst export quality, diversification, and economic growth (Dogan et al., 2020c; Shahzad et al., 2021a-c; Wang et al., 2021). Further confirming the earlier empirical studies (Bashir et al., 2020; Can et al., 2021), our empirical outcomes provide significant evidence on the positive impact of renewable-source based energy use for sustainability in economic growth and allow us to draw novel implications.

The next frontier in financing sustainable development is to unite all actors in the investment chain behind the SDGs to respond to the crisis in the near term and rebuild for a more resilient and sustainable future in the long run. Misalignment support should be phased off. The COVID-19 dilemma offers nations a once-in-a-lifetime opportunity to build a unified SDG alignment framework that can be turned into tangible measures for many players. All essential stakeholders must be on board to safely place people and the planet at the core of the global financial system. Based on our key variables of interest, it was discovered that improving institutional performance, product quality, human knowledge, and technical skills had a beneficial impact on economic growth.

The study further helps to understand the role of institutional quality as a driver of sustainable growth. The amount of useful knowledge of a country's economy is measured using two key indicators: diversity and ubiquity, which indicate the country's economic complexity. The ubiquity and diversity of collected knowledge in a specified economy are related to economic complexity. Then, a more complicated economy might be predicted when more people from various industries interact and combine their knowledge to make various products in a given country. Only when knowledge is embedded in a people's network or in organizations that use it for constructive reasons can it be accumulated, transmitted, and maintained. If creating a product necessitates a particular type or combination of knowledge, the countries that produce it demonstrate that they possess the necessary capabilities and expertise. The policy relevance of this conclusion is that trade reforms, technological shifts, and strengthening institutions allow these countries to have smooth and sustainable economic growth, which is a path towards sustainable economic growth (SDG-8: sustainable growth).

The findings of this study imply that higher-quality institutions will aid in improving sustainable economic growth. The proper functioning of these countries' institutions will deliver proper laws, regulations, property rights, and ways to combat corruption, which, if followed systematically, will reduce environmental externalities such as carbon dioxide emissions. The study contributes to the growing research by highlighting the role of economic complexity as a major driver of growth and structural change (Dogan et al., 2020c). Global trade is expanding, and global value chains are becoming more integrated, raising questions about trade, technological changes, economic growth, and environmental issues. Economic growth with an increase in the volume of trade brought on by trade expansion might influence the environment negatively, such as increased pollution or degradation of natural resources.

As a country's export sector grows more connected to the global economy, it becomes more vulnerable to environmental restrictions imposed by major importers. On the other hand, increased commerce can contribute to a stronger capacity to manage the environment more effectively by supporting economic growth, development, and social welfare. More importantly, free markets can increase access to new technologies that reduce the consumption of energy, water, and other environmentally hazardous elements in local production processes, making them more efficient. Similarly, trade and investment liberalization might encourage companies to adopt stricter environmental norms. Changes required to achieve these standards run backward through the supply chain, encouraging the adoption of cleaner manufacturing techniques and technology.

Providing a reasonable prediction during COP 26 for SDGs with bilateral trade flows across several world areas for decades into the future is a difficult challenge, and then overlaying it with data on the economic repercussions of climate change complicates things even more. These projections are surrounded by a lot of uncertainty. First, international trade flows are expected to grow significantly in future decades, emphasizing trading outside the OECD. However, the direct effects of climate change on international trade and infrastructure are mostly unfavorable, meaning that climate change will impede some of the expected gains in trade. Furthermore, climate damages will exert downward pressure on almost all regions' economies. Trade flows will be smaller when climate damages are taken into account than when the naive baseline, which ignores economic feedback from climate change, is used. These implications are most pronounced in Africa and Asia, where estimates show high economic growth rates mixed with rising trade dependence and significant climate change damages.

Second, policymakers will need to comprehend how climate change will affect their sectoral production patterns and how it will affect the economy of the regions with which they compete on international markets. Without considering changes in international commerce, a national climate change assessment can lead to erroneous conclusions about the consequences of climate change on domestic competitiveness. Despite being badly impacted by climate change, a region's competitiveness may improve if other competitors for a particular market are more seriously harmed or opt to specialize in the production of different items. Exports fell faster than imports and GDP in the worst-affected countries.

Third, the mechanisms influencing trade patterns are intricate, with mutually reinforcing and dampening effects. Climate shocks are generally better absorbed by countries with larger domestic markets and more diverse trade patterns than by more specialized countries. Comparative advantage tends to erode in countries where climatic damage causes significant reductions in export quantities, whereas locations with the least fluctuating export price levels can gain export volumes. Additionally, the efficacy of economic complexity to enable product sophistication and the application of technology for energy transition strategies have a long-term impact on sustainability and economic growth. However, regarding trade openness and export quality diversification, our results contradict the findings of Saafi and Nouira (2018) and Chrid et al. (2020), who shows the role of trade openness and export upgrading have a negligible impact on economic growth.

The major policy implication arising from the findings is that economic complexity should be considered as a major driver for ensuring economic prosperity and sustainability. The influence of renewable energy on economic growth suggests the need for developing policies on adopting renewable source-based energy for climate welfare. Such policies will enable economies to move towards sustainable development goals SDG-7 (on clean and affordable energy), SDG-8 (sustainable growth), and SDG-13 (on climate change). Adopting economic sophistication will push the economies towards high productive capacities and efficient energy use. From this study, it can be suggested that the focus of almost all economic activities should be based on SDG 8 (promote as well as sustained an inclusive kind of sustainable economic growth, the full and highly useful in terms of productive employment with a type of decent work for all). Further, this study helps in restoring the employment level as per SDG 8 to reduce the economic complexities which will be a crucial factor for expanding sustainable economic development in near future. The process of restoring technical efficiency in women's, young man force, and disabled people's access to well-paying jobs will be especially crucial because these groups have historically had lower labor force participation rates and wages (SDG target 8.5). Returning to the status quo, however, will not be sufficient to fulfill SDG 8. Improving employee productivity will also be crucial. The amount of money workers make and GDP are inextricably linked (SDG target 8.1 and target 8.2). Work productivity can be improved in a variety of ways, including enhancing human capital through improvements in education and health, upgrading infrastructure, and using new technologies (SDG target 8.2). Economic transformation is another, and the subject of the rest of this chapter. Long-term growth requires economies to restructure in a way that encourages high-productivity jobs (SDG target 8.2 and target 8.3). Transitioning from low-productivity to high-productivity sectors accounted for more than two-thirds of total productivity increase in low-income economies. This has often entailed a change from low- to highproductivity agriculture, a move toward urbanization, and a move away from precarious work. Lastly, the countries should focus on strengthening institutional quality as it adds leverage to economic complexity and positively affects economic prosperity.

## 6. Concluding remarks and implications

International trade and industrial activities are conducive to the economic development of emerging and developed economies. However, the bolster economic objectives come with the repercussions of environmental externalities and structural transformation challenges. The on-hand research study is an effort to examine the heterogeneous impacts of structural change and institutional quality on economic growth. In doing so, the current study draws novel conclusions and implications regarding the sustainable development goals and sustainable growth in developed economies. This research attempted to explore the nexus among economic growth, economic complexity, export quality, financial development, human capital, renewable energy, and institutional quality for 28 OECD economies. In doing so, the study employed the annual data from 1990 to 2019 and tested three model specifications using extensive empirical analysis such as cross-sectional dependency tests by Pesaran (2015), Westerlund cointegration tests, and Pedroni cointegration tests, FMOLS, and DOLS.

The empirical results highlight that greener and renewable energy have an important role to play for industrial activities, economic development and it can act as an alternative to achieve sustainable economic growth. Export quality leads to strengthening the trade by improving the quality of products, ultimately it can lead towards the economic progress of countries. Further, it can be interpreted that overall economic complexity encompasses financial development and product complexity, both of which are conducive for the growth of the economy.

Sustainable economic development should focus on the utilization of renewable natural input resources, export sophistication, human knowledge and skills, use of cleaner and renewable energy sources. In this process, the major efforts should be focused on enhancing the quality of exported products with the possible minimum loss of natural input resources. These natural resources will enable them to move towards the path of sustainable growth. Further, these nations should provide important policy insights which can serve as lessons for other developing countries towards their journey of sustainable growth. The results and findings from the empirical analysis from this study help in drawing highly useful and important policies for OECD countries. The enhancement of greener energy and technological innovation helps the policy makers to suggest environment-friendly economic growth solutions, in the same direction this study becomes a solid blueprint to study the underlines that the policies of the existing government which should encourage the process of new eco-friendly innovation, in particular, the use of renewable energy in almost all developed nations is helpful as the largest users of fossil fuels. The shift in innovation must be promoted for the usage of renewable energy which may help in the reduction of the use of fossil fuel and at the same time to increase the percentage share of renewable energy besides improved export quality and institutional quality. The improved institutional quality has a direct causal effect on the export quality and renewable energy consumption in all OECD countries. This effect can be controlled via an improved innovation level, specifically, in the process of utilizing renewable energy, this option is also assumed as the second-best alternative solution to replace fossil fuel consumption, therefore, the decrease in the environmental quality can be possible via improved institutional quality. The technological innovation and the process of progress in adopting new methods for producing energy with more renewable sources are crucial for the enhancement of development for optimizing clean energy. The sources for renewable energy do not only alternate the usage of fossil fuel but also assure the use of clean and renewable energy independence with wider security perspectives which support the system to promote the decarbonization process in the OECD economies. The present study can be extended to other panel countries with different intensities of economic complexity. In addition, future research may explore the role of other additional variables (income inequality) as a driver towards economic prosperity. The scope of research can be enhanced by applying more sophisticated estimation techniques like structural equation modeling, machine learning, and data envelopment analysis.

## Ethics approval and consent to participate

Not applicable.

## **Consent to publish**

Not applicable.

## Availability of data and materials

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## **CRediT** authorship contribution statement

**Umer Shahzad:** Methodology, Formal analysis, Data curation, Writing – original draft, Conceptualization. **Mara Madaleno:** Writing – original draft, Methodology, Writing – review & editing, Visualization. **Vishal Dagar:** Writing – review & editing, Writing – original draft, Funding acquisition. **Sudeshna Ghosh:** Conceptualization, Data curation. **Buhari Doğan:** Conceptualization, Supervision, Writing – review & editing.

#### Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.strueco.2022.04.003.

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