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Research paper

Nexus among biomass energy consumption, economic growth, and financial development: Evidence from selected 15 countries

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ABSTRACT

The objective of this study is to examine the association among biomass energy consumption (BEC), economic growth (EG), and financial development (FD). For this purpose, panel data method is employed for the selected 15 countries (Cameroon, Democratic Congo, Tanzania, Nigeria, Haiti, Nepal, Togo, Mozambique, Ivory Coast, Niger, Kenya, Cambodia, Myanmar, Zimbabwe, Republic of Congo) utilizing the annual data over the period 1993–2017. The cointegration test results indicate the presence of long-run associations among the variables. Causality tests indicate bidirectional relationships among the variables. According to the causality test results, a bidirectional and positive relationship exists between FD and BEC, as well as between BEC and EG.

These results support the feedback hypothesis for the selected countries. Overall results indicate that in the selected countries biomass energy investments can boost economic growth and financial development. Findings of the study yield worthy signals for policymakers. The results may serve as a guide for biomass energy usage policies, and more effective decisions can be made by assessing the impacts of biomass energy consumption on economic growth and financial development.

1. Introduction

It is incontestably true that energy is a key input for economic growth (Sebri, 2015). Rapid urbanization, technological development, global warming, and economic growth in the world have boosted the dependence on fossil fuels (Pata, 2018; Gao and Zhang, 2021). Nonetheless, the increase in environmental pollution and the excessive oil price fluctuation throughout the 1970s have rendered renewable energy consumption (REC) crucial (Bildirici, 2014). Since REC reduces greenhouse gas emissions, it both contributes to the environment and reduces the dependence on fossil fuels, namely, petroleum and natural gas (Anton and Nucu, 2020). Among the renewable energy types, biomass energy constitutes a considerable part of the total energy consumption (Bildirici and Özaksoy, 2018). In accordance with the WMO (World Meteorological Organization) Statement on the State of the Global Climate in 2017, the increase in CO_2 within the last seven decades has been approximately 100 times as much and biomass energy has been evaluated as an important renewable energy source for sustainable growth and development.

As of today, although biomass energy accounts for approximately 14% of global renewable energy use, this rate reaches up to 90%, especially in rural areas of developing countries (Sansaniwal et al., 2017). Biomass energy resources are categorized into three major classifications such as wood, non-wood, and solid waste. Trees, plants, leaves belong to the wood category; whereas, bark, pellets, hemp, biogases are included in the non-wood category. Food waste, animal waste, and sewage waste constitute the category of solid waste (Bildirici and Özaksoy, 2013a,b). Wood waste, municipal waste, agricultural waste have 64%, 24%, and 5% shares in biomass energy. The annual global capacities of these resources exceed 13 billion metric tons, equivalent to almost ten times the current energy demand of the world (Müller et al., 2015). This diversity of biomass energy significantly increases the rate of use and fulfills about 35% of the energy demand of various developing countries. This rate corresponds to 14% in REC upon an evaluation on a global scale (Demirbas et al., 2009). Nonetheless, the potential of countries to increase this rate up to 61% by 2030 is anticipated (Shahbaz et al., 2014).

BEC has been an effective concept in economic growth and development as well as a clean environment and a sustainable life (Konuk et al., 2021; Ajmi and Inglesi-Lotz, 2020; Khan et al.,

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Nomenclature

ARDL	Autoregressive distributed lag
BEC	Biomass energy consumption
CCE	Common correlated effects
EC	Energy consumption
EG	Economic growth
FD	Financial development
FMOLS	Fully modified ordinary least square
GMM	Generalized method of moments
REC	Renewable energy consumption
VECM	Vector error correction model
WB	World Bank
WMO	World meteorological organization

2019). Modern biomass energy is a major driver of rural employment and revenue in developing countries. Due to labor-intensive feature of biomass production, raw material production can be a crucial resource of employment and additional revenue in rural regions (Bildirici, 2013). The association between BEC and EG has been studied in many countries and different periods throughout recent years. However, there is only a few studies investigating the association between FD and BEC. Therefore, the association between BEC and FD is determined by the 15 countries that consume the higher levels of biomass energy resources (Cameroon, Democratic Congo, Tanzania, Nigeria, Haiti, Nepal, Togo, Mozambique, Ivory Coast, Niger, Kenya, Cambodia, Myanmar, Zimbabwe, Republic of Congo). Furthermore, the effect of BEC on EG would also be investigated, since there is merely a few studies in terms of these countries. New evidence to be obtained on this subject will strengthen the existing literature. In this context, the effects of BEC on EG and FD and the relationship between the variables are considered as a subject to be analyzed and constitute the main reasons for conducting the research.15 African countries were chosen as samples in the study. This country group is preferred due to the fact that it consists of the countries that consume the highest level of biomass energy [Ethiopia (92.9%), Democratic Congo (92.2%), Nigeria (81.5%), Tanzania (85%), Nepal (80.6%), Haiti (81%), Mozambique (79.8%), Togo (79.9%), Ivory Coast (73.6%), Kenya (72.2%), Niger (73.2%), Myanmar (65.3%), Cambodia (66.9%), the Republic of Congo (59.2%), and Zimbabwe (61.8%)] (www.wordatlas.com, 2022).

The main objective of this research study is to investigate the relationships between BEC, EG and FD. In other terms, the research explicates the extent to which BEC affects EG and FD. In this context, 15 countries with the highest biomass consumption over the period 1993–2017 period are selected so as to constitute the sample of the study. Both short- and long-term relationships between variables are analyzed performing the Westerlund–Edgerton LM Bootstrap cointegration test, Common Correlated Effects (CCE) estimator, and Dumitrescu–Hurlin causality test.

Considering the selected country groups, the research is expected to contribute to the energy literature in three aspects. There is a limited number of studies examining the relationships between BEC and EG, BEC and FD in previous studies. On the other hand, no study examining the impact of BEC on EG and FD is detected besides a limited number of studies. Therefore, (i) the research fills an important gap in the literature by concurrently examining the relationships between BEC, EG, and FD. (ii) Such an impact is investigated in terms of 15 countries with the highest BEC. Upon examining the studies in the literature, it is seen that no evidence is presented for the selected countries group. (iii) The finding in the study that BEC negatively/positively affects economic growth and financial development or does not affect at all would guide the policies to be implemented for the development of biomass energy resources.

The research process is structured as follows: In the first part of the research, basic information regarding the subject is explained, and in the second part, the literature review on the subject is presented. In the third part of the study, there is explanatory information regarding the dataset, model, and method. In the fourth part, the analysis results are shown, and in the conclusion and discussion part, policy recommendations are included within the scope of the obtained results.

2. Literature review

Despite the prevalence of literature regarding the association between energy consumption (EC), EG, and FD, studies are insufficient because of the altering nature of swift technological advances and economic development. In response to this, it is apparent that energy, environmental, EG, and FD researches are critical for achieving sustainable development. There is a common opinion that researches investigating the associations between EG and EC were first initiated by Kraft and Kraft (1978). While there was a unilateral causality running from EG to EC in the research study, no causality was detected in the opposite direction. Research results verified the conservation hypothesis, which reflects the existence of a unilateral causality from EG to EC (Destek and Sarkodie, 2019; Cheng and Lai, 1997). Also, the influence of FD on EG has been extensively studied (Levine, 1997; Xu, 2000; Fung, 2009). According to the general point of view, FD results in higher levels of EG (Ibrahim and Alagidede, 2018; Calderón and Liu, 2003; Gregorio and Guidotti, 1995). According to Fung (2009), the positive effect of FD on EC was bidirectional. Accordingly, while the rise in factor productivity provides EG, factor accumulation becomes a driving force on EG with the effective use of financial resources (Bell and Rousseau, 2001). Similarly, Sadorsky (2010) stated that FD was a major driver of EG in developing countries. FD renders investments attractive and encourages countries by increasing the efficiency of financial markets and economic activities (Shahbaz and Lean, 2012). In this context, it can be stated that strong associations exist among FD, EG, and REC. Nevertheless, Eren et al. (2019) considered five structural breaks for the sample of India over the period 1971–2015 and concluded that FD was the driving force of EG and renewable EC in the long-run, and bidirectional causality existed between EG and REC.

Payne (2011) is one of the pioneering studies examining the association between EG and BEC. The Toda–Yamamoto causality test was performed in the study covering the period 1949–2007, and a unilateral causality was found from BEC to gross national product, which verifies the growth hypothesis. Following Payne's (2011) research study, studies on different country groups, in different periods and with different methods, are noteworthy. Apergis and Payne (2015) explicated the cointegration and causality among EG, REC, and CO_2 emissions in 11 South American countries over the period 1980–2010. The research findings indicated the presence of a long-term cointegration association among the variables in the long-run, and the panel error correction model verified the presence of the feedback hypothesis. Bildirici (2013) investigated the short- and long-term causal and cointegration associations between EG and BEC employing the autoregressive distributed lag (ARDL) method on 10 different countries over the period 1980–2009. It was concluded that a cointegration association existed between EG and BEC in all countries. No cointegration relationship could be determined for Paraguay. Bildirici and Özaksoy (2013a,b) detected a unidirectional causality from

EG to BEC for Turkey and Austria, and from BEC to EG for Hungary and Poland in their study examining the association between the ARDL and vector error correction models (VECM) and BEC and EG in 10 selected countries over the period 1960–2010. They also determined a unidirectional causality from BEC to EG for Hungary and Poland, and a bidirectional causality from BEC to EG for Sweden, Spain, and France. Bildirici (2014), employing the panel ARDL and Pedroni cointegration analyses for 10 economies in transition, analyzed the association between BEC and EG over the period 1990–2011. The results obtained from the research study indicate that BEC and EG were cointegrated and that BEC had a positive impact on EG. Shahbaz et al. (2016) indicated that BEC strengthened EG in the BRICS countries and the feedback hypothesis was valid between EG and BEC. Bildirici and Özaksoy (2018) investigated the relationships between BEC and EG for three different country groups. While the causality test results reveal the validity of the conservation hypothesis for Albania, Bulgaria, and Romania in the short- and long-run, they supported the growth hypothesis for Bosnia & Herzegovina, Hungary, Czech Republic, Slovakia, Macedonia, Bulgaria, and Romania. Furthermore, it was concluded that the feedback hypothesis was valid for all country groups of the research study, including the third group countries (Croatia, Estonia, Latvia, Slovenia). Aydın (2019) concluded that the growth hypothesis was valid for Brazil and India; whereas the conservation hypothesis was valid for China and South Korea over the period 1992–2013. The main finding of the research study was that BRICS countries needed to enhance their BEC for attaining a sustainable environment and reduce their energy dependence by encouraging EG.

Theoretically, scholars agree that the CO_2 increases due to FD (Al-Mulali et al., 2015; Boutabba, 2014). Because it is believed that development would eventually reduce BEC as the modern form of energy will take place (World Bank, 1996). According to Sadorsky (2011), the level of FD has three impact pathways on EC: These are the direct impact, the business impact, and the wealth impact. Customers who, in the context of effective financial intermediation, obtain resources readily and can thus buy durable products, increasing EC, are referred to as having a direct influence. The business effect is fueled by a growing trend of FD, which provides businesses with easier access to capital. FD enables businesses to obtain less expensive financial capital to expand their operations or launch a new enterprise, hence increasing EC. The trust corporations and households have in the established stock market create the wealth effect. This viewpoint demonstrates that FD, which demonstrates the actual availability of financial resources for productive activities and funding channels for projects by banks and stock markets, can play a constructive and critical role in the fight against environmental deterioration, primarily through the reduction of CO_2 emissions (Sadorsky, 2010; Charfeddine and Kahia, 2019).

A few papers investigated the effect of FD on EC and more specifically on biomass, but the results are mixed. Sadorsky (2010) found a positive relationship between FD and EC in his research employing the generalized method of moments (GMM) method between 1990–2006 for 22 developing countries. Shahbaz and Lean (2012) detected bidirectional associations between EC and FD; FD and industrialization; and industrialization and EC over the period 1971–2008 for Tunisia. Anton and Nucu (2020) investigated the relationship between the renewable energy demand and the level of FD of 28 European Union member countries employing the panel fixed effects model over the period 1990–2015. The results of the research study revealed that the level of development in the banking sector, bond sector, and capital markets had positive impacts on REC. Zeren and Hızarcı (2021) detected that FD and BEC had been positively cointegrated in the long-run.

Studies in the literature indicate that the association among FD, EG, and BEC can be explained by four basic hypotheses; namely, the growth hypothesis, feedback hypothesis, conservation hypothesis, and neutrality hypothesis. According to the growth hypothesis, EC takes place in production processes as a complement to capital and labor, and this reveals a causal association from EC to EG (Payne, 2011; Aydın, 2019). Secondly, according to the conservation hypothesis, EG is the determinant and driving force of BEC. Accordingly, a unilateral causality running from EG to EC exists. According to this hypothesis, although energy-saving policies mitigate greenhouse gas emissions and enhance energy efficiency, they are not effective on EG (Bildirici, 2013; Ajmi and Inglesi-Lotz, 2020). Thirdly, according to the feedback hypothesis, a bidirectional causality exists between BEC and EG. Given the fact that this hypothesis reveals the relationships between BEC and EG, it states that one is complementary to the other. Accordingly, policies aimed at increasing EC may boost EG, but in the opposite case, energy-saving policies may also slow down EG (Bildirici and Özaksoy, 2018; Aydın, 2019). According to the last hypothesis, namely, the neutrality hypothesis, BEC has a quite limited influence on EG. Accordingly, even if energy-saving policies are implemented, no negative impact on EG is anticipated (Destek, 2017).

Upon examining the literature within the scope of the study, it is seen that research studies have been conducted on many different country groups and in quite different periods. It is seen that the results obtained differ by country groups, even between countries located in the same region and continent, and different hypotheses are valid. Therefore, new evidence is needed to render the relationships between BEC, EG, and FD more comprehensive. This research study covered the 20 countries with the highest BEC. The period of 1993–2017, upon obtaining the uninterrupted data, was examined in the research study. Thus, the largest possible dataset was used in the research study, and the obtained results provide important benefits for international investors, lawmakers, and policy practitioners. Although there are quite limited studies examining the relationship between BEC and FD, this study deals with BEC, EG, and FD, and provides a new contribution to the literature in terms of 20 countries using biomass energy resources in the highest volume. In this context, the questions of whether BEC provides EG for the country group or whether FD increases BEC have been answered. Due to these aspects, the research study includes an original approach.

3. Data, model, and methodology

Upon examining Table 1, the annual data are used in all studies examining BEC, FD, and EG. The annual data over the period 1993–2017 obtained from 15 countries are utilized in parallel with the literature. In the study, the data of 15 countries with available data are utilized in order to create a balanced panel among the 20 countries (Democratic Congo, Tanzania, Nigeria, Haiti, Nepal, Togo, Mozambique, Ivory Coast, Niger, Kenya, Cambodia, Myanmar, Cameroon, Zimbabwe, and the Republic of Congo) with the highest levels of BEC.

Upon examining Table 2, FD indicator is used to represent the level of financial development and per capita national income is used to represent EG, 2015 fixed prices and real GDP data evaluated in dollars are from the World Bank (WB) database, the data of BEC was obtained from global material flow database portal and the evaluation was made. The following models are developed within the framework of Destek (2017) and Zeren and Hızarcı (2021); which examined the relationship between biomass energy consumption and economic growth and financial development.

$$lnFD_{it} = \beta_0 + \beta_1 lnBEC_{it} + \vartheta_t \quad (1)$$

Table 1
Literature review.

Sources	Sample (Countries)	Period (Frequency)	Econometric method	Empirical findings
				Cointegration causality
Payne (2011)	USA	1949–2007	Toda–Yamamoto Causality	BEC → EG
Aslan (2016)	USA	1961–2011 (annual)	ARDL	BEC → EG
Destek (2017)	10 biomass energy consumer country	1980–2013 (annual)	AMG, Panel bootstrap causality	BEC → EG
Ali et al. (2017)	Sub-Sahran countries	1980–2011 (annual)	MG, PMG, OLS, DOLS, FMOLS	BEC → EG
Adewuyi and Awodumi (2017)	West African Countries	1980–2010 (annual)	3SLS	BEC ↔ EG
Bildirici and Ozaksoy, 2017	African countries	1980–2012 (annual)	ARDL, Granger Causality	BEC ↔ EG
Ali et al. (2018)	9 ASEAN economic union member country	1980–2011 (annual)	Panel cointegration, OLS, DOLS, FMOLS	BEC → EG
Aydın (2019)	BRICS countries	1992–2013 (annual)	Panel cointegration, panel causality	BEC ↔ EG
Solarin and Bello (2019)	Brazil	1980–2015 (annual)	Regression, Taylor Series	BEC → EG
Sinaga et al. (2019)	Indonesia	1980–2017 (annual)	ARDL	BEC → EG
Ajmi and Inglesi-Lotz (2020)	26 OECD countries	1980–2013 (annual)	VECM, OLS	BEC ↔ EG
Shah et al. (2020)	38 Countries of Asia	1990–2017 (annual)	Granger causality test	EG ↔ FD
Zeren and Hızarcı (2021)	10 Developing countries	1990–2018 (annual)	CCE, AMG	BEC ↔ FD
Adediran et al. (2021)	Nigeria	1981–2017 (annual)	ARDL	BEC → EG
Konuk et al. (2021)	11 Countries (named Next-11)	1970–2017 (annual)	Panel cointegration, panel causality	BEC ↔ EG
Bui et al. (2021)	BRICS	1990–2017 (annual)	Panel quantile regression, Dumitrescu–Hurlin causality test	BEC ↔ EG
Gao and Zhang (2021)	13 Asian developing countries	1980–2010 (annual)	Panel cointegration, FMOLS	GDP BEC (short-run) BEC ↔ GDP (long-run)

Note: BEC represents biomass energy consumption, FG represents financial development and EG represents economic growth. In addition, → sign indicates unilateral causality relation, ↔ sign indicates bidirectional causality relation.

Table 2
Information on the dataset of the paper.

Variables used in the study	Abbreviation of variables	Unit of the variables	Researches using the variables
Biomass Energy Consumption	BEC	Domestic Extraction per capita	Payne (2011), Destek (2017), Solarin and Bello (2019)
Financial Development Index	FD	Domestic credit to the private sector (% of GDP)	Tang and Tan (2014); Shahbaz et al. (2016), Shah et al. (2020).
Economic Growth	EG	GDP per capita (Real constant 2015)	Gao and Zhang (2021); Ali et al. (2018); Ajmi and Inglesi-Lotz (2020)

$$lnEG_{it} = \beta_0 + \beta_1 lnBEC_{it} + \vartheta_t \quad (2)$$

The lnFD variable in Model 1 is the FD level of the countries with the natural logarithm taken to represent financial development, the lnBEC variable is the biomass energy use per capita with the natural logarithm taken, the lnEG variable in Model 2 is the economic growth per capita (2015 base year) represents the national income, and ϑ_t denotes the error term.

In the study, first of all, the dependence relationship among the cross-sections that make up the panel is examined performing the LM test developed by Breusch and Pagan (1980) and the bias-adjusted LM_{adj} tests developed by Pesaran et al. (2008). To test the stationarity of the series, Hadri–Kurozumi's (2012) 2nd generation unit root test, which takes into consideration the cross-sectional dependence, is performed. The Westerlund–Durbin–Hausman cointegration test is performed to detect the cointegration relationship between the series, and the causality among the variables is detected by performing the Dumitrescu and Hurlin (2012) panel causality test. Analyses within the scope of the study are conducted by utilizing Gauss 6 and Stata 12 software.

Testing the cross-sectional dependence among the countries included in studies to be conducted with panel data analysis is a matter to be considered. A shock experienced by any country may also affect other countries. In this context, it is essential to consider the cross-sectional dependence in terms of the fact that the examined countries have established regional unities. Cross-sectional dependence can be examined with the LM test developed by Breusch and Pagan (1980) and the CD test developed by Pesaran (2004). First of all, the Lagrange Multiplier (LM) test, which is frequently used, is performed to examine the cross-sectional dependence.

The LM test equation is as follows;

$$Y_{it} = a_i + \beta_i x_{it} + \varepsilon_{it,} i = 1 \ldots, N, t = 1 \ldots, T, 1 \quad (3)$$

In the above equation, i denotes the cross-section size, and t represents time. The estimation of the Lagrange Multiplier (LM) test is as follows:

$$LM = T \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{P}_{ij}^2 \mathfrak{X}^2_{N(N-1)/2} \quad (4)$$

While the LM test yields accurate results for panels that fulfill the condition of small cross-section N and adequately high time T, the LM test was developed by Pesaran (2004) for cases in which the time and cross-section unit are too high. The developed LM test is estimated as follows (Pesaran, 2004: 5; Destek, 2016).

$$CD_{LM} = \left(\frac{1}{N(N-1)}\right)^{1/2} \sum_{i=1}^{N-1} \sum_{J=i+1}^{N} \left(T\hat{p}_{ij}^2 - 1\right) N(0, 1) \quad (5)$$

In response to this circumstance, the LM test was redeveloped by Pesaran et al. (2008) due to the reduced power of the CD test in some cases. The redeveloped LM test version is as follows:

$$LM_{adj} = \sqrt{\frac{2T}{N(N-1)} \sum_{i=1}^{N-1} \sum_{J=i+1}^{N} T_{\hat{P}_{ij}}} \frac{(T-k)\,\hat{p}_{ij}^2 - \mu_{Tij}}{\sqrt{u_{Tij}^2}} \quad (6)$$

In Eq. (6), μ_{Tij} denotes the number of variables, u_{Tij}^2 represents the mean, and $(T-k)\,\hat{p}_{ij}^2$ indicates the variance (Pesaran et al., 2008: 109; Koçbulut and Altıntaş, 2016: 153).

The null hypothesis of these tests implies that "there is no cross-sectional dependence", and the alternative hypothesis implies that "there is cross-section dependence". From this point of view, if the null hypothesis is accepted, it would be claimed that no cross-sectional dependence exists among the examined countries, and if the alternative hypothesis is accepted, a cross-sectional dependence exists among the examined countries. When H_0 is accepted, the analysis would be continued using the 1st generation panel unit root tests, and when H_1 is accepted, the 2nd generation panel unit root tests would be performed.

Hadri–Kurozumi's (2012) test, one of the 2nd generation unit root tests that take into consideration the cross-sectional dependence, is a test, same as the KPSS unit root test, in which the null hypothesis is switched with the alternative hypothesis. The model predictions of the test are as follows (Hadri–Kurozumi, 2012: 32).

$$Y_{it} = Z_t'\hat{\delta}_i + \hat{\phi}_{i1}\gamma_{it-1} + \cdots\ldots\ldots\ldots\ldots\ldots.. + \hat{\phi}_{ip}\gamma_{it-p} + \hat{\psi}_{i0}\overline{y}_t + \cdots\ldots\ldots\ldots\ldots + \hat{\psi}_{ip}\overline{\gamma}_{t-p} + \hat{\upsilon}_{it} \quad (7)$$

Z_t is deterministic when i = 1,……,N and t = 1,……,T, it can explain the change in the dependent variable. Hadri–Kurozumi's test statistics are estimated as follows:

$$Z_A^{SPC} = \frac{1}{\hat{\sigma}_{iSPC}^2 T^2} \sum_{t=1}^{T} (S_{it}^{\omega})^2 \quad (8)$$

$$Z_A^{LA} = \frac{1}{\hat{\sigma}_{iLA}^2 T^2} \sum_{t=1}^{T} (S_{it}^{\omega})^2 \quad (9)$$

In studies using panel data analysis, it is necessary to choose the cointegration test to be performed in compliance with the findings obtained after determining the cross-sectional dependence and stationarity. In this direction, the Westerlund and David (2007) Panel LM bootstrap cointegration test is preferred for the series examined in the study.

The Westerlund and David (2007) cointegration test, which is based on the Lagrange test multiplier developed by McCoskey and Kao (1998), takes the cross-sectional dependence into consideration. Moreover, it is observed that the test yields good results in small samples. The null hypothesis of the test implies that "there is a cointegration relationship" and the alternative hypothesis implies that "there is no cointegration relationship" (Westerlund and Edgerton, 2007: 186). As seen in Eq. (10), the panel cointegration test is derived.

$$\gamma_{it} = \alpha_i + x_{it}'\beta_{it} + Z_{it} \quad (10)$$

$$Z_{it} = \mu_{it} + V_{it} V_{it} = \sum_{J=1}^{t} \eta_{ij} \quad (11)$$

In Eq. (10); t represents the time-series, i denotes the cross-section unit, and Z_{it} stands for the error term. The LM statistics in which the Westerlund and David (2007) test represents cointegration for the overall panel in econometric models with LM test bootstrap critical values under cross-sectional dependence are as follows:

$$LM_N^+ = \frac{1}{NT^2} \sum_{i=1}^{N} \sum_{t=1}^{t} \hat{\omega}_i^{-2} S_{it}^2 \quad (12)$$

In Eq. (12), the partial sum of the Z_{it} the error term is indicated as S_{it}^2, and the long-term variance of μ_{it} is indicated as $\hat{\omega}_i^{-2}$ (Westerlund and Edgerton, 2007: 186; Şahin, 2018: 345).

To estimate the cointegration coefficients among the series, it is necessary to use coefficient estimators that take into consideration the cross-sectional dependence. In this respect, the "Common Correlated Effects" (CCE) coefficient estimator proposed by Pesaran (2006) would be used. The basic model of this method is as follows;

$$\gamma_{it} = \alpha_i' d_t + \beta_i' x_{it} + e_{it} \quad (13)$$

In Eq. (13), d denotes the observable common effects, and x denotes the explanatory variables. The error terms obtained within the scope of the model are defined as follows:

$$e_{it} = \gamma_i' f_t + \varepsilon_{it} \quad (14)$$

The expression f in Eq. (13) is the unobservable common effects vector, and along with the parameter found, it allows the cross-sectional dependence. The relationships among the variables are tested with the cointegration test and a relationship is determined. The direction of such a relationship is determined by the causality test. Dumitrescu and Hurlin's (2012) causality test, which yields accurate results, is performed due to the presence of cross-sectional dependence in our study. The Dumitrescu Hurlin causality test can yield accurate results in heterogeneous panels, when N>T or T>N (Dumitrescu and Hurlin, 2012: 1451).

The linear model in which the test determines the causal relationship between X and Y, where the variables must be stationary to investigate the association among the variables, is as follows.

$$Y_{i,t} = \alpha_i + \sum_{k=1}^{K} Y_i^{(k)} Y_{i,t-k} + \sum_{k=1}^{K} \beta_i^{(k)} X_{i,t-k} + \varepsilon_{i,t} \quad (15)$$

K in the model denotes the optimal lag length. The null hypothesis of the test implies that no causality exists between the examined variables, whereas the alternative hypothesis implies that a causal relationship exists.

4. Empirical findings

Testing the cross-sectional dependence between the series in studies conducting the panel data analysis is quite crucial

Table 3
Cross-sectional dependence test results by variable.

Variables	LM (Breusch and Pagan, 1980)		CDLM (Pesaran, 2004)		CD (Pesaran, 2004)		LMadj (PUY, 2008)	
	Constant Model							
	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.
LNFD	202.053***	0.000	**6.697*****	**0.000**	−2.362***	0.009	1.311*	0.095
LNEG	145.362***	0.006	**2.785*****	**0.003**	−2.261**	0.012	4.906***	0.000
LNBIO	163.086***	0.000	**4.008*****	**0.000**	−2.715***	0.003	1.799**	0.036

Note: *, **, and *** indicate significance at 1%, 5%, and 10% significance levels, respectively.

Table 4
Hadri–Kurozumi panel unit root test results.

Levels		
Constant and Trend Model		
Variables	Z_A^{SPC}	Z_A^{LA}
LNFD	−2.400(0.991)	−3.112(0.999)
LNEG	−2.536(0.994)	−1.472(0.929)
LNBIO	−1.052(0.853)	0.838(0.200)

Note: The optimal lag length is determined according to the Schwarz Information Criterion.

Table 5
Westerlund–Edgerton LM bootstrap cointegration test results.

Model 1	LM statistic	Asymptotic −p-value	Boostrap −p-value
LMN^T	2.935	0.002	0.136
Model 2	LM statistic	Asymptotic −p-value	Boostrap −p-value
LMN^T	5.667	0.000	0.593

Note: The number of bootstrap iterations is 1000. The test result is obtained with the constant and trend models.

in terms of the guidance to be followed and the methods to be employed. Prior to initiating the analysis, the cross-sectional dependence between the series is tested. The test results of the variables used in the two models developed in the study are presented in Table 3. In the study, since the (T) time dimension exceeds the cross-sectional dimension (N), the correlation is investigated by considering the (Pesaran, 2004) CD test results. It is seen that the probability value of all variables is lower than the critical value of 0.10. According to the obtained findings, the H_0 hypothesis implying "no cross-sectional dependence" is strongly rejected.

After determining that a cross-sectional dependence exists among the variables used in the study, Hadri and Kuruzomi's panel unit root test of the 2nd generation unit root tests is conducted to determine the stationarity of the variables, and the results are shown in Table 4.

According to Hadri and Kuruzomi's panel unit root test results, the stationarity of the series at the level I(0) and H_0 hypothesis implying that "the series have unit roots" are strongly rejected. After determining that the series do not contain unit roots, the long-term cointegration association between the series is analyzed by performing the Westerlund–Edgerton LM Bootstrap Cointegration (2007) test.

The Westerlund–Edgerton LM Bootstrap Cointegration test analysis results are shown in Table 5. Upon considering the cross-sectional dependence between the series, the Bootstrap-p-value is taken into consideration from the results presented in Table 5. Since the Bootstrap-p-value exceeds 0.10, according to the Westerlund–Edgerton LM Bootstrap Cointegration test result, the null hypothesis implying "the existence of cointegration" is accepted. These results suggest that the series move together in the long-run.

Table 6
Long-term CCE coefficient estimator results (Model 1).

Model 1 $lnFD_{it} = \beta_0 + \beta_1 lnBEC_{it} + \vartheta_t$			
Dependent Variable: FD	CCE		
Panel	Coefficient	Standard Error	Probability
BEC	0.528	0.769	0.492
Cameroon			
BEC	1.253	0.089	0.160
Democratic Congo			
BEC	**3.515*****	0.503	0.000
Tanzania			
BEC	2.184	1.660	0.188
Nigeria			
BEC	−0.371	0.841	0.659
Haiti			
BEC	0.977	0.855	0.253
Nepal			
BEC	**4.213*****	1.331	0.001
Togo			
BEC	−0.040	0.535	0.940
Mozambique			
BEC	0.259	0.435	0.550
Ivory Coast			
BEC	**1.111*****	0.422	0.008
Niger			
BEC	0.924	0.859	0.283
Kenya			
BEC	**−1.038****	0.515	0.044
Cambodia			
BEC	**3.569*****	0.074	0.000
Myanmar			
BEC	**−1.546*****	0.424	0.000
Zimbabwe			
BEC	1.308	0.082	0.112
Republic of Congo			
BEC	**−8.404*****	1.465	0.000

Note: *, **, and *** indicate significance at 1%, 5%, and 10% significance levels, respectively.

After determining the long-term cointegration relationship of the series, the direction of cointegration and coefficient estimation of the series in Model 1 are analyzed utilizing the CCE (Common Correlated Effects) estimator, which takes into consideration the cross-sectional dependence. In the CCE estimator panel results shown in Table 4, no statistically significant association exists between BEC and FD. Upon considering the analysis results by country, BEC has a positive and statistically significant impact on FD for Democratic Congo, Nepal, Ivory Coast, and Cambodia. On the other hand, BEC has negative impact on FD for Kenya, Myanmar, and the Republic of Congo. The results are determined statistically insignificant for other countries such as Cameroon, Tanzania, Nigeria, Haiti, Togo, Mozambique, Niger, and Zimbabwe within the scope of the study (see Table 6).

In Model 2 developed in our study, the influence of BEC on EG is analyzed. According to the CCE coefficient estimator panel results presented in Table 7, BEC has a significant and positive impact on EG for the examined country group. Upon examining the individual results of the countries included in the panel, it is seen that BEC negatively affects EG for Cameroon, Tanzania, and Niger,

Table 7
Long-term CCE coefficient estimator results (Model 2).

Model 2	$lnEG_{it} = \beta_0 + \beta_1 lnBEC_{it} + \vartheta_t$		
Dependent Variable: EG		CCE	
Panel	Coefficient	Standard Error	Probability
BEC	**0.442****	0.207	0.033
Cameroon			
BEC	**−0.557*****	0.129	0.000
Democratic Congo			
BEC	**2.362*****	0.273	0.000
Tanzania			
BEC	**−0.225***	0.135	0.096
Nigeria			
BEC	−0.007	0.228	0.974
Haiti			
BEC	0.166	0.105	0.116
Nepal			
BEC	−0.180	0.353	0.608
Togo			
BEC	**0.780*****	0.194	0.000
Mozambique			
BEC	**0.689*****	0.435	0.003
Ivory Coast			
BEC	**1.134*****	0.188	0.000
Niger			
BEC	**−0.018***	0.103	0.076
Kenya			
BEC	−0.191	0.137	0.163
Cambodia			
BEC	0.211	0.333	0.525
Myanmar			
BEC	**1.492*****	0.074	0.000
Zimbabwe			
BEC	**1.132*****	0.327	0.001
Republic of Congo			
BEC	0.012	0.029	0.965

Note: *, **, and *** indicate significance at 1%, 5%, and 10% significance levels, respectively.

Table 8
Dumitrescu–Hurlin panel causality test results.

Model 1	W-statistic	Z-Bar statistic	Probability
$lnBEC \nrightarrow lnFD$	3.481*	1.870	0.061
$lnFD \nrightarrow lnGBEC$	5.148***	4.399	0.000
Model 2	W-statistic	Z-Bar statistic	Probability
$lnBEC \nrightarrow lnEG$	3.705***	5.939	0.000
$lnEG \nrightarrow lnGBEC$	4.081***	6.799	0.000

The maximum lag length is taken as 2. (***), (**), (*) indicate significance at 1%, 5% and 10% significance levels, respectively.

and in this regard, BEC negatively affects EG. BEC has a positive and statistically significant impact on EG for Democratic Congo, Togo, Mozambique, Ivory Coast, Myanmar, and Zimbabwe. Long-term investments are required in order to transform biomass energy sources into energy resources and to have a positive effect on EG. From this point of view, it is considered that the differences in country-specific results may be due to differences in investments ventured on biomass energy resources.

The causality relationships of the series with cointegration relationships are analyzed with the Dumitrescu and Hurlin (2012) causality test. It can yield accurate results in heterogeneous panels when N>T or T>N (Dumitrescu and Hurlin, 2012: 1451).

The results of the causality between the variables are presented in Table 8. A bidirectional positive association exists between the FD and BEC variables in Model 1, which is developed within the scope of the study. Also, a bidirectional and positive causality exists between BEC and EG in Model 2. Research study results reveal validity of the feedback hypothesis within the context of selected countries. The Dumitrescu–Hurlin causality test results are found to comply with that of Shahbaz and Lean (2012), Apergis and Payne (2015), Shahbaz et al. (2016), and Eren et al. (2019), whereas they seem to be inconsistent with the studies such as Payne (2011), Bildirici (2013), Aydın (2019), Ajmi and Inglesi-Lotz (2020) and Konuk et al. (2021). Upon comparing our study with Payne's (2011) study, it is considered that the reason for the difference is that Payne (2011) was conducted for the USA and a long period of 58 years. Other studies with inconsistent results are Bildirici (2013), Aydın (2019) and Konuk et al. (2021), in which different developing country groups were examined and it is considered that the biomass investment levels in these countries might have caused differences.

5. Conclusion

The objective of the paper was to explicate the association between FD and BEC as a renewable energy resource using panel data of 15 countries between 1993–2017. Developing countries need the energy to achieve EG, and in this context, they are dependent on energy-exporting countries. Biomass energy has the importance to affect FD and EG by reducing the dependence of the 15 developing countries on fossil fuels. Besides, biomass projects need to be implemented and invested to convert biomass resources into energy and support EG in the long-run. Thus, biomass investments can create new employment areas by supporting EG and can also play a role in reducing current unemployment. In this context, selected countries need to create new energy policies and take decisions to support biomass energy investments. These decisions can also reduce environmental degradation. The cross-sectional dependence exists among series. In addition, a long-run relationship is confirmed under the investigation by the Westerlund and David (2007) cointegration test and that shows the series move together in the long-run.

The most important findings of the paper can be summarized in three points. Firstly, BEC has a positive impact on FD in Democratic Congo, Nepal, Ivory Coast, and Cambodia while has a negative impact in Kenya, Myanmar, and Cambodia. There is no statistically significant relationship between selected other countries. Secondly, BEC has a statistically significant and positive impact on EG. The long-term coefficients of the conducted regressors are estimated by the CCE estimation technique. Thirdly, Dumitrescu–Hurlin panel causality test results reveal bidirectional causal relationships among variables. Accordingly, a bidirectional relationship exists between BEC and FD, as well as between EG and BEC. These results support the feedback hypothesis for the selected countries. The feedback hypothesis reveals the relationships between BEC and EG, and states that these two variables are complementary to each other. For this reason, policies aimed at increasing EC can boost EG, but in the opposite case, energy-saving policies may also slow down EG.

If there is a development in the financial markets and a more effective composition is reached in the volume, quality, and distribution of loans given to the private sector, this new situation will trigger EG. However, it should not be overlooked that the financial structure in developing countries is not very strong compared to developed countries, and therefore, it cannot achieve FD and increase BEC in a short term. What should be aimed here is to ensure the development of financial markets in the medium- and long-run, and thus to encourage companies for renewable energy investments, and thus to realize EG, which is the main goal in the long-run. Significant changes are also occurring in the financial and industrial structures of countries with EG. Social awareness and technological change are at the forefront of these. After experiencing EG, financial markets will continue to develop and the demand for REC will increase.

Studies investigating the association among BEC, EG, and FD are still quite limited. Therefore, this research, which we have done by covering 15 countries, contributes by expanding the literature, which is still very new, and by presenting new evidence. Nevertheless, the findings are not compatible with the results of Bildirici and Özaksoy (2013a,b), Konuk et al. (2021) and Zeren and Hızarcı (2021). However, since the subject is still very new, the relevant literature needs to be developed a little more to make a healthier comparison. In this context, the handling of different country groups and periods reflects the originality of this study, therefore it has a unique structure in terms of both sample and variables.

The policy differences of countries towards renewable energy sources may account for differences in the impacts of biomass energy consumption on economic growth and financial development of the countries. Besides, the impacts of biomass energy consumption may vary by country due to the fact that financial markets have different dynamics and conditions for each country. For instance, unclean and extremely polluting biomass energy resources adversely affect human health, hamper efficiency, and have a negative impact on economic growth for 15 African countries including Benin, Burkina Faso, Cape Verde, Guinea, Ghana, The Gambia, Guinea-Bissau, Liberia, Mali, Mauritania, Nigeria, Niger, Sierra Leone, Senegal, and Togo (Maji et al., 2019). Moreover, notwithstanding the validity of the feedback hypothesis is asserted in this study, Bildirici and Ersin (2015) detected the validity of the conservation hypothesis for Austria, Germany, Finland, and Portugal, whereas the validity of the feedback hypothesis for the USA. In this regard, the impacts of biomass energy consumption on economic growth and financial development differ by the development levels of the countries.

However, the positive impact of biomass energy consumption, as a policy proposal, on economic growth for the entire selected country group clearly reveals the necessity of incentive given to biomass energy consumption by states and governments. In order to prevent the depletion of biomass energy resources that may occur for 15 countries included in the research, investment in biomass energy infrastructure should be made and protective energy policies should be implemented. If countries can increase their biomass energy consumption, they would also be able to minimize their dependence on fossil fuels such as petroleum and natural gas. Furthermore, it should be noted that the use of cleaner renewable energy resources such as solar, wind and hydropower may provide the opportunity of minimizing the probable adverse impacts on human health and productivity.

The research study incurs certain limitations. Since the research covers the period between 1993–2017 and involves 15 selected countries, the obtained results should be assessed in terms of the study period and the selected country group. In future research, the relationships between biomass energy consumption, economic growth and financial development may be explicated regarding different country groups. More detailed results can be yielded by including different variables such as CO_2 emissions in research models. Concurrently, by analyzing the relations between biomass use and economic growth and financial development on a sectoral basis by country, outcomes for sustainable economic growth and financial development can be presented to policymakers.

CRediT authorship contribution statement

Mustafa Kevser: Data curation, Conceptualization, Writing – original draft. **Murat Tekbaş:** Methodology, Review & editing. **Mesut Doğan:** Methodology, Formal analysis. **Selçuk Koyluoglu:** Investigation, Writing.

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.

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References

Adediran, O.S., Benibo, I., Akinpelumi, D., 2021. Biomass energy consumption and economic growth, an assessment of the relevance of sustainable development goal in Nigeria. Int. J. Energy Econ. Policy 11 (6), 43–49.
Adewuyi, A.O., Awodumi, O.B., 2017. Biomass energy consumption, economic growth, and carbon emissions: Fresh evidence from West Africa using a simultaneous equation model. Energy 119, 453–471.
Ajmi, A.N., Inglesi-Lotz, R., 2020. Biomass energy consumption and economic growth nexus in OECD countries: A panel analysis. Renew. Energy 162, 1649–1654.
Al-Mulali, U., Ozturk, I., Lean, H.H., 2015. The influence of economic growth, urbanization, trade openness, financial development, and renewable energy on pollution in Europe. Nat. Hazards 79 (1), 621–644.
Ali, Hamisu Sadi, Adaa, Abdelhaklem Hamed Mohamed Ali, Lin, Woon Leong, Youssouf, Mbodou Ali, 2018. Biomass energy consumption and economic growth: panel data evidence from ASEAN member countries. GeoJournal 83, 1339–1348. http://dx.doi.org/10.1007/s10708-017-9839-y.
Ali, Hamisu Sadi, Law, Siong Hook, Yusop, Zulkornain, Chin, Lee, 2017. Dynamic implication of biomass energy consumptionon economic growth in Sub-Saharan Africa: evidence from panel data analysis. GeoJournal 82, 493–502. http://dx.doi.org/10.1007/s10708-016-9698-y.
Anton, S.G., Nucu, A.E.A., 2020. The effect of financial development on renewable energy consumption. a panel data approach. Renew. Energy 147, 330–338.
Apergis, N., Payne, J.E., 2015. Renewable energy. output, carbon dioxide emissions, and oil prices. Evidence from South Africa. Energy Sources B: Econ. Plann. Policy 10 (3), 281–287.
Aslan, A., 2016. The causal involvement between biomass energy use and economic growth in the United States. Renew. Sustain. Energy Rev. 57, 362–366.
Aydın, M., 2019. The effect of biomass energy consumption on economic growth in BRICS countries. a country-specific panel data analysis. Renew. Energy 138, 620–627.
Bell, C., Rousseau, P.L., 2001. Post-independence India: A case of finance-led industrialization? J. Dev. Econ. 65, 153–175.
Bildirici, M.E., 2013. Economic growth and biomass energy. Biomass Bioenergy 50, 19–24. http://dx.doi.org/10.1016/j.biombioe.2012.09.055.
Bildirici, M.E., 2014. Relationship between biomass energy and economic growth in transition countries. Panel ARDL approach. GCB Bioenergy 6, 717–726. http://dx.doi.org/10.1111/gcbb.12092.
Bildirici, M., Ersin, Ö., 2015. An investigation of the involvement between the biomass energy consumption, economic growth and oil prices. Procedia-Social Behav. Sci. 210, 203–212.
Bildirici, M.E., Özaksoy, F., 2013a. The relationship between economic growth and biomass energy consumption in some European countries. J. Renew. Sustain. Energy 5 (2), http://dx.doi.org/10.1063/1.4802944.
Bildirici, M.E., Özaksoy, F., 2013b. The relationship between economic growth and bio- mass energy consumption in some European countries. J. Renew. Sustain. Energy 5 (2), 023141.
Bildirici, M.E., Özaksoy, F., 2018. An analysis of biomass consumption and economic growth in transition countries. Econ. Res.- Ekonomska Istraživanja 31 (1), 386–405.
Boutabba, M.A., 2014. The impact of financial development, income, energy and trade on carbon emissions: evidence from the Indian economy. Econ. Model. 40, 33–41.
Breusch, T.S., Pagan, A.R., 1980. The Lagrange multiplier test and its applications to model specification tests in econometrica. Rev. Econom. Stud. 47, 239–253.
Bui, Quocviet, Wang, Zhaohua, Zhang, Bin, Le, Hoang Phong, Vu, Kim Dung, 2021. Revisiting the biomass energy-economic growth linkage of BRICS countries: A panel quantile regression with fixed effects approach. J. Clean. Prod. 316, http://dx.doi.org/10.1016/j.jclepro.2021.128382.
Calderón, C., Liu, L., 2003. The direction of causality between financial development and economic growth. J. Dev. Econ. 72 (1), 321–334.
Charfeddine, L., Kahia, M., 2019. Impact of renewable energy consumption and financial development on CO2 emissions and economic growth in the MENA region: A panel vector autoregressive (PVAR) analysis. Renew. Energy 139, 198–213. http://dx.doi.org/10.1016/j.renene.2019.01.010.
Cheng, B.S., Lai, T.W., 1997. An investigation of co-integration and causality between energy consumption and economic activity in Taiwan. Energy Econ. 19 (4), 435–444.
Demirbas, M.F., Balat, M., Balat, H., 2009. Potential contribution of biomass to the sustainable energy development. Energ Convers. Manage. 50, 1746–1760. http://dx.doi.org/10.1016/j.enconman.2009.03.013.
Destek, M.A., 2016. NATO ülkelerinde askeri harcamalar ve ekonomik büyüme ilişkisi: Yatay kesit bağımlılığı altında panel veri analizi. Uluslararası Yönetim iktisat Ve İşletme Dergisi 12 (28), 209–223.

Destek, M.A., 2017. Biomass energy consumption and economic growth: evidence from top 10 biomass consumer countries. Energy Sources B: Econ. Plan. Policy http://dx.doi.org/10.1080/15567249.2017.1314393.
Destek, M.A., Sarkodie, S.A., 2019. Investigation of environmental kuznets curve for ecological footprint: The role of energy and financial development. Sci. Total Environ. 650, 2483–2489.
Dumitrescu, E.I., Hurlin, C., 2012. Testing for Granger noncausality in heterogeneous panels. Econ. Model. 29 (4), 1450–1460.
Eren, B.M., Taspinar, N., Gokmenoglu, K.K., 2019. The impact of financial development and economic growth on renewable energy consumption: An empirical analysis of India. Sci. Total Environ. 663, 189–197.
Fung, M.K., 2009. Financial development and economic growth: convergence or divergence? J. Int. Money Finance 28, 56–67.
Gao, J., Zhang, L., 2021. Does biomass energy consumption mitigate co_2 emissions? The role of economic growth and urbanization: evidence from developing Asia. J. Asia Pacific Econ. 26 (1), 96–115.
Gregorio, J., Guidotti, P.E., 1995. Financial development and economic growth. World Dev. 23 (3), 433–448.
Hadri, Kaddour, Kurozumi, Eiji, 2012. A simple panel stationarity test in the presence of serial correlation and a common factor. Econom. Lett. 115, 31–34. http://dx.doi.org/10.1016/j.econlet.2011.11.036.
Ibrahim, M., Alagidede, P., 2018. Effect of financial development on economic growth in Sub-Saharan Africa. J. Policy Model. 40 (6), 1104–1125.
Khan, M.T.I., Yaseen, M.R., Ali, Q., 2019. Nexus between financial development, tourism, renewable energy, and greenhouse gas emissions in high-income countries: A Continent-wise analysis. Energy Econ. 83, 293–310.
Konuk, F., Zeren, F., Akpınar, S., Yıldız, Ş., 2021. Biomass energy consumption and economic growth: Further evidence from next-11 countries. Energy Rep. 7, 4825–4832.
Kraft, J., Kraft, A., 1978. On the relationship between energy and GNP. J. Energy Dev. 3 (2), 401–403.
Levine, Ross, 1997. Financial development and economic growth: views and agenda. J. Econ. Lit. 35 (2), 688–726.
Maji, I.K., Sulaiman, C., Abdul-Rahim, A.S., 2019. Renewable energy consumption and economic growth nexus: A fresh evidence from West Africa. Energy Rep. 5, 384–392.
Müller, A., Weigelt, J., Götz, A., Oscar, S., I, Alva, L., Matuschke, I., Ehling, U., Beringer, T., 2015. The role of biomass in the sustainable development goals: A reality check and governance implications. In: Institute for Advanced Sustainability Studies E. V. IASS, second ed..
Pata, U.K., 2018. Renewable energy consumption, urbanization, financial development, income and CO2 emissions in Turkey: Testing EKC hypothesis with structural breaks. J. Cleaner Prod. 187, 770–779.
Payne, J.E., 2011. On biomass energy consumption and real output in the US. Energy Sources B 6, 47–52.
Pesaran, M.H., 2004. General diagnostic tests for cross section dependence in panels. In: Cambridge Working Papers in Economics. p. 435.
Pesaran, Hashem M., 2006. Estimation and ınference in large heterogeneous panels with a multifactor error structure. Econometrica 74, 967–1012.
Pesaran, M.H., Ullah, A., Yamagata, T., 2008. A bias-adjusted lm test of error cross-section independence. Econom. J. 11, 105–127.
Sadorsky, P., 2010. The impact of financial development on energy consumption in emerging economies. Energy Policy 38, 2528–2535.
Sadorsky, P., 2011. Financial development and energy consumption in Central and Eastern European frontier economies. Energy Policy 39, 999–1006.
Şahin, D., 2018. Gelişmiş Ülkelerde Finansal Gelişme ve Gelir Eşitsizliği İlişkisi. Iğdır üniversitesi Sosyal Bilimler Dergisi. (15), 299–322.
Sansaniwal, S.K., Rosen, M.A., Tyagi, S.K., 2017. Global challenges in the sustainable development of biomass gasification: An overview. Renew. Sustain. Energy Rev. 80, 23–43.
Sebri, M., 2015. Use renewables to be cleaner: Meta-analysis of the renewable energy consumption-economic growth nexus. Renew. Sustain. Energy Rev. 42, 657–665.
Shah, S.A.R., Naqvi, S.A.A., Riaz, S., Anwar, S., Abbas, N., 2020. Nexus of biomass energy, key determinants of economic development and environment: A fresh evidence from Asia. Renew. Sustain. Energy Rev. 133, 110244.
Shahbaz, M., Khraief, N., Uddin, G.S., Ozturk, I., 2014. Environmental Kuznets curve in an open economy: A bounds testing and causality analysis for Tunisia. Renew. Sustain. Energy Rev. 34, 325e336.
Shahbaz, M., Lean, H.H., 2012. Does financial development increase energy consumption? The role of industrialization and urbanization in Tunisia. Energy Policy 40, 473–479.
Shahbaz, M., Rasool, G., Ahmed, K., Mahalik, M.K., 2016. Considering the effect of biomass energy consumption on economic growth: Fresh evidence from BRICS region. Renew. Sustain. Energy Rev. 60, 1442–1450.
Sinaga, O., Saudi, M.H.M., Roespinoedji, D., Jabarullah, N.H., 2019. Environmental ımpact of biomass energy consumption on sustainable development: Evidence from ARDL bound testing approach. Ekoloji 28 (107), 443–452.
Solarin, S.A., Bello, M.O., 2019. Interfuel substitution, biomass consumption, economic growth, and sustainable development: Evidence from Brazil. J. Cleaner Product 211, 1357–1366.
Tang, C.F., Tan, B.W., 2014. The linkages among energy consumption, economic growth, relative price, foreign direct investment and financial development in Malaysia. Qual. Quant. 48 (2), 781–797.
Westerlund, J., David, L.E., 2007. A panel bootstrap cointegration test. Econom. Lett. 97 (3), 185–190.
World Bank, 1996. Rural energy and development-improving energy supplies for two billion people. https://www.worldatlas.com/articles/20-countries-burning-the-most-waste-and-biomass-for-energy.html.
Zeren, F., Hızarcı, A.E., 2021. Biomass energy consumption and financial development: evidence from some developing countries. Int. J. Sustain. Energy 40 (9), 858–868.

Further reading

Dinda, S., 2004. Environmental Kuznets curve hypothesis: A survey. Ecol. Econ. 49, http://dx.doi.org/10.1016/j.ecolecon.2004.02.011.

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