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RESEARCH ARTICLE

The role of financial development on carbon emissions: a meta regression analysis

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Abstract

The study analyzes the role of financial development on CO2 emissions based on the primary studies in the existing literature. However, the heterogeneity in reported effect size estimates of the primary studies complicates to test the competing hypotheses for the role of financial development on CO2 emissions. The paper tries to determine and quantify the representative empirical genuine effect of financial development on CO2 emissions, if any. To address the issue, a meta-regression analysis has been carried out for 275 estimation results from 72 primary studies. We have found a substantial publication selection bias in the literature due to the design characteristics of the primary studies. The results suggest the presence of an authentic positive empirical effect of financial development on CO2 emissions beyond publication selection bias. Hence, financial development leads to environmental degradation. The effect of financial development on carbon emissions changes both in magnitude and direction depending on which financial development indicator is used, which estimation technique is employed, which countries or region are included and which time period is analyzed.

Keywords CO2 emissions · FAT-PET · Financial development · MRA

Introduction

Whether financial development leads to environmental improvement or degradation or has no effect on the environment is a controversial issue. The literature has reached no consensus on the issue, yet. There is a tie on the results of studies reporting three alternative outcomes as positive significant, negative significant and insignificant effect of financial development on CO2 emissions. The results of the studies vary depending on financial development indicator used, econometric technique employed, the countries, country group, region or provinces involved and time span considered for the analysis.

Based on three possible outcomes, three alternative hypotheses have been developed in the literature. First hypothesis emphasizes the effect of financial development on environmental degradation through the channels of energy consumption and industrialization (Abbasi and Riaz 2016; Acheampong 2019). Financial development enables households to access to cheaper consumer credits to buy high-energy demanding home appliances and automobiles, which increases energy consumption (Acheampong 2019; Sadorsky 2010). Financial development enables firms to access low cost capital, which allows them to purchase more machine and equipment, and to build new plants, which leads to increase in energy consumption (Acheampong 2019; Sadorsky 2010). Financial development generates wealth by increasing risk diversification, which boosts business and consumer confidence leading to growth, which, in turn, increases energy consumption (Acheampong 2019; Sadorsky 2010). Financial development boosts industrialization, which generally increases industrial pollution and level of greenhouse gas emissions (Acheampong 2019; Jensen 1996; World Bank, 2000). Second hypothesis emphasizes the effect of financial development on environmental improvement through the channels of growth and foreign direct investment (FDI) (Acheampong 2019; Tamazian et al. 2009). This hypothesis asserts that financial development attracts FDI and higher R&D, which reduces environmental degradation through economic growth and development. Having access to new technology, firms

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may initialize more energy efficient, clean and environment-friendly production, which consequently improves environmental sustainability both regionally and globally (Acheampong 2019; Abbasi and Riaz 2016). Well-developed financial sector allows access to low cost capital or it creates incentives for firms and governments to invest in environment-friendly projects (Dasgupta et al. 2001; Tamazian and Rao 2010; Tamazian et al. 2009). Also, financial development leads to better corporate governance of the firms, and better-governed firms are more sensitive to the environmental problems (Claessens and Feijen 2007). Foreign direct investment may transfer and allocate green technologies of home countries to host countries towards environment-friendly economic sectors, which reduces CO2 emissions (Acheampong 2019). Third hypothesis maintains the position that financial development has no direct or indirect effect on carbon emission.

The study tries to determine and quantify the representative genuine authentic empirical effect of financial development on carbon emission by employing meta-regression analysis (MRA) based on the reported estimation results in previous primary studies in order to conclude whether financial development has positive or negative role on carbon emission and whether it is significant.

Utilization of MRA helps to determine the effect of design characteristics of previous studies; financial development indicators used, the econometric method employed, countries, country group or region involved, time span considered, etc., on the association between financial development and carbon emission.

It is important to separate genuine empirical effect and publication selection bias. In case of publication selection bias, the resulted association between financial development and CO2 emission is unreliable because there exist studies in the literature that found otherwise and could not publish it (Ugur 2014). Publication selection bias is originated from the preference of statistically significant results over insignificant ones by editors, reviewers and/or researchers (Stanley 2005).

Given the motivation for the study, the paper contributes to the literature of the financial development and carbon emissions in several ways. First, it tries to determine the authentic empirical effect of financial development on carbon emissions by employing MRA to decide the direction and the significance of the effect based on the reported estimation results of published and unpublished primary studies in the literature. Second, the paper tries to determine the existence and magnitude of the publication selection bias, if any. The publication selection bias has been controlled for both the aggregate results of the primary studies and the design characteristics of the primary studies. Third, in conducting MRA, the paper categorizes different indicators for financial development that used in the primary studies, because different financial development indicators could also have different implications on carbon emissions (Acheampong 2019). Finally, the paper categorizes different estimation techniques that used in the primary studies, because same data, even the same indicators could lead to different estimation results based on the estimation techniques used.

The paper is structured in five sections. Next section discusses research question. Third section discusses literature search and data. Fourth section explains what is MRA, how it is conducted and the results of MRA. Last section concludes.

Research question

Since the aim of the study is to determine and quantify the representative empirical genuine effect of financial development on carbon emissions, the research question is 'What is the direction of the effect of financial development on CO2 emissions, if it is statistically significant?'

Literature search and data

The following keywords have been searched in Google Scholar and Web of Science to find studies that have analyzed the role of financial development on CO2 emission:

- Financial development and emission
- Financial openness and emission
- Financial performance and emission
- Financial development and environment
- Financial openness and environment
- Financial performance and environment

We found 72 studies including 65 published studies (65 article) and 7 unpublished studies (7 working paper). The search was completed on 27 September 2019.

Moderating variables, in the following analyses, have been selected according to the design characteristics of the primary studies in accordance with the following explanations:

Because different financial development indicators would have different impacts on the effect of financial development on CO2 emission, we have categorized the indicators used by primary studies in eight groups as

i) Primary studies using a measure of money and liabilities

- broad money as a share of GDP (M2/GDP)
- liquid liabilities as a share of GDP (M3/GDP)
- ratio of deposit liabilities to GDP

ii) Primary studies using a measure of credits

- total credit (% of GDP)
- non-state credit (% of GDP)
- domestic credit to the private sector as a share of GDP
- domestic credit to private sector by banks as a share of GDP

iii) Primary studies using a measure of deposits and loans

- total deposits and loans (% of GDP)
- total deposits/GDP
- total loans/GDP
- private loans/GDP
- loans/deposits
- bank deposits to GDP

iv) Primary studies using a measure of assets

- ratio of commercial bank assets to the sum of bank and central bank assets
- ratio of deposit money bank assets to GDP

v) Primary studies using a measure of stocks

- stock market capitalization (% of GDP)
- stocks traded/turnover (% of GDP)
- stock indicator

vi) Primary studies using a foreign assets and liabilities

- foreign direct investment inflows (% of GDP)
- ratio of net foreign assets to GDP
- foreign assets and liabilities (% of GDP)

vii) Primary studies using a composite index

viii) Primary studies using other measures of financial development

- financial value added (% of GDP)
- capital account convertibility
- bank concentration
- development of banking industry
- development of securities market
- financial liberalization

Type of data is either panel or time series data. Only primary studies for China have both panel and time series data.

Since different econometric techniques lead to change in the direction and magnitude of the effect of financial development on CO2 emission, we have categorized the econometric techniques used by primary studies in three groups as

i) Primary studies using static panel or time series econometric techniques

- ordinary least squares (OLS)
- fixed effect (FE)
- random effect (RE)
- least squares dummy variables (LSDV)
- panel smooth transition regression (PSTR)

ii) Primary studies using dynamic panel or time series econometric techniques

- maximum likelihood estimation (MLE)
- dynamic fixed effect (DFE)
- system generalized method of moments (Sys GMM)
- difference generalized method of moments (Dif GMM)
- bias corrected least squares dummy variables (LSDVC)
- dynamic panel threshold model
- panel vector auto regression (PVAR)

iii) Primary studies using co-integration techniques

- auto regressive distributed lag (ARDL)
- Johansen cointegration
- mean group (MG)
- pooled mean group (PMG)
- augmented mean group (AMG)
- fully modified ordinary least square (FMOLS)
- dynamic ordinary least square (DOLS)
- dynamic seemingly unrelated cointegrating regressions (DSUR)
- canonical cointegrating regression (CCR)
- continuously updated bias-corrected (CUP-BC)
- continuously updated fully modified (CUP-FM)
- cointegration with structural breaks

The study classifies countries in four groups according to the countries analyzed or classified by the author/authors of the primary studies as

- Single countries: The primary studies analyzing a single country or provinces of a single country including Bangladesh, Brazil, China, Greece, India, Indonesia, Iran, Kuwait, Malaysia, Nigeria, Pakistan, Portugal, Russia, Saudi Arabia, South Africa, Sri Lanka, Tunisia, Turkey, United Arab Emirates, the USA and Vietnam.
- Development level of countries

– All countries: Primary studies including as many countries as possible without making a difference regarding the development level of included countries.

- Developing countries: Primary studies only including developing countries.
- Emerging countries: Primary studies only including emerging countries.
- Transition countries: Primary studies only including countries in transition.

- Region: Primary studies including countries belong to the same region as Africa, Middle East & North Africa, Asia and Europe.
- Other country groupings as

- BRICS countries
- CIS (Commonwealth of Independent States)
- CIS (Commonwealth of Independent States)
- GCC (Gulf Cooperation Council)
- NEXT11 countries
- OECD countries

In order to address the heterogeneity in the reported effect size estimates of the primary studies, we have used three variables for the time period analyzed. The variable of time span refers to the number of years analyzed, the variable of start refers to the starting year of the analysis and, finally, the variable of end refers to the last year of the analysis.

We have used the number of control variables in the analysis in order to check for omitted variable bias.

Finally, we have used the variable of publication to check publication selection bias alongside with the standard procedure of MRA by examining the coefficient of standard error.

Table 4 represents the variables and their definitions.

Meta regression analysis

MRA is a systematic, unbiased and rigorous summary and analysis of empirical literature based on various effect size estimates of primary studies, which also include noise and misinformation (Stanley et al. 2013).

MRA helps to determine the effect of design characteristics of primary studies on the association between financial development and carbon emission. The design characteristics for the study are financial development indicators used, type of data analyzed, the econometric method employed, countries, country group or region involved and time span considered.

Preliminary analysis of the research base

Fixed effect weighted means

We have obtained the partial correlation coefficient (PCC) and its standard error in order to establish a common metric calculated from the *t* values and degrees of freedom for the effect-size estimates of the primary studies. PCC is a measure calculated from the association between financial development and carbon emissions in each estimate from the primary studies, while holding other explanatory variables constant (Ugur 2014).

The PCC (r_{ik}) and its standard error (se_{rik}) are calculated as follows:

$$r_{ik} = t_{ik}/\sqrt{t_{ik}^2 + df_{ik}} \tag{1}$$

$$se_{rik} = \sqrt{\left(1-r_{ik}^2\right)/df_{ik}} \tag{2}$$

where t_{ik} and df_{ik} denote the *t* value and the degrees of freedom associated with the effect-size estimates of the *i*-th estimate from *k*-th primary study (Ugur 2014).

Based on Eqs. 1 and 2, the fixed-effect weighted mean of the overall effect-size for each primary study (R_k), and its standard error (se_k) have been calculated as follows:

$$R_k = \left(\sum_{i=1}^{n} w_{ik} r_{ik}\right) / \left(\sum_{i=1}^{n} w_{ik}\right) \tag{3}$$

$$se_k = \sqrt{1/\left(\sum_{i=1}^{n} w_{ik}\right)} \tag{4}$$

where $w_{ik} = 1/se_{rik}^2$ and *n* is the number of estimates in each primary study (Lee et al., 2016). We cannot consider weighted means as genuine measures of effect size if primary study estimates are subject to publication selection bias and/or affected by within-study dependence between reported estimates (Ugur 2014). The fixed-effect weighted mean for PCCs assigns smaller weights to less precise estimates in order to take within-study variation into account.

Table 5 presents the fixed-effect weighted mean of PCCs for each study. Because this is a MRA paper, we present some characteristics of the primary studies instead of a literature survey.

Overview of the research base

While 26 primary studies (36%) yield positive fixed-effect weighted means, 24 primary studies (33%) yield negative fixed-effect weighted means and, finally, 22 primary studies (31%) yield insignificant fixed-effect weighted means according to Table 1, which is based on the fixed-effect weighted mean for each study in Table 5. Hence, the majority of the primary studies (36%) tend to report positive significant effect of financial development on carbon emission.

We see that 10% of the primary studies are unpublished and 25% of studies that are published and 14% of studies that are not published report positive significant effect. Because the percentage of studies that are not published reporting negative significant and insignificant effect (86%) is higher than the

Table 1 Aggregate results

	Positive significant	Negative significant	Insignificant
Studies			
All	26 (36%)	24 (33%)	22 (31%)
Publlished	25 (38%)	22 (34%)	18 (28%)
Unpublished	1 (14%)	2 (29%)	4 (57%)
Estimates			
All	65 (24%)	113 (41%)	97 (35%)
Publlished	61 (24%)	107 (41%)	92 (35%)
Unpublished	4 (27%)	6 (40%)	5 (33%)

percentage of studies that are published reporting negative significant and insignificant effect (62%), there may be publication selection bias in the literature in favor of a positive significant effect of financial development on CO2 emission.

While 65 estimates (24%) report positive significant effects of financial development on carbon emissions, 113 estimates (41%) report negative insignificant effects and, finally, 97 estimates (35%) report insignificant effects.

It may be confusing that 36% of studies report positive significant effects while 24% of estimates report positive significant effects and 24% of studies report negative significant effects while 41% of estimates report negative significant effects. There are two reasons for the discrepancy between the results of studies and estimates. First one is that the same study may report any combination of positive significant, negative significant and insignificant estimates. In these studies, the positive significant estimates with high *t*-values dominate the negative significant and insignificant estimates with low *t*-values in calculating the fixed-effect weighted mean for the effect-size of each primary study. Second reason is that the studies with negative significant fixed effect weighted mean report more estimates with negative significant results than the studies with positive significant fixed effect weighted mean.

Preliminary analysis of publication selection bias

The simplest and most common visual tool for identifying publication selection bias is the funnel plot. Funnel plot compares the effect-size estimates from primary studies (PCC) against some measure of its precision (the inverse standard error of the PCC) (Efendic et al. 2011).

In examining publication selection bias, the analysis of funnel plot, bivariate MRA or multivariate MRA do not make a distinction between published and unpublished studies. They make a simplistic assumption that the studies including large number of observations are less likely to remain unpublished or ignored, and they tend to provide more precise effect size estimates whether positive or negative. Hence, risk of publication selection bias is probably higher for studies that are based on small number of observations. The results of funnel plot, bivariate MRA and multivariate MRA should be interpreted with the result of previous section and the significance of the variable publication in multivariate MRA.

The funnel plot should look like an inverted funnel, reflecting the heteroscedasticity caused by different sample sizes from the primary studies and the absence of publication bias requires symmetry around the vertical line representing average effect (Efendic et al. 2011). Smaller sample size leads to lower precision that are more spread out in the base of the plot and larger sample size leads to higher precision that are more concentrated around the best estimate of the true value of the PCC at the peak of the plot (Efendic et al. 2011).

Absence of publication selection bias requires randomly and symmetrically distributed effect size estimates around the average effect, which is depicted by a vertical line in the funnel plot (Stanley 2005). The dots representing the effect size estimates of the primary studies are symmetrically scattered around the vertical line, and they are scattered on both sides of the funnel plot in Fig. 1. Since the funnel plot is not over weighted to any side, we may conclude that there is no publication selection bias in the literature analyzing the role of financial development on CO2 emissions (Stanley 2005).

Since visual inspections such as funnel plots are inherently subjective and somewhat ambiguous, we will conduct the Funnel Asymmetry Test (FAT) in the next section to decide the existence of publication selection bias (Stanley 2005).

Bivariate meta regression analysis

We need to employ Funnel Asymmetry Test and Precision-Effect Test (FAT-PET) to make a decision for the existence of publication selection bias and genuine empirical effect beyond publication selection bias (Ugur 2014). Then, we will conduct precision-effect estimation with standard errors (PEESE), in case of finding a nonlinear relationship between PCC and its

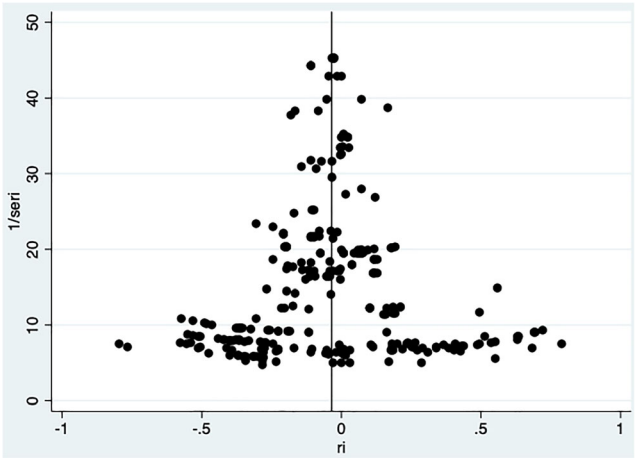


Fig. 1 Funnel plot. The PCC (r_i) versus the inverse standard error of PCC ($1/se_{rik}$). The PCC of whole sample mean is marked by vertical red line crossing the value of − 0.03

standard error according to the result of FAT-PET. We employ FAT-PET analysis according to Eq. 6 based on Eq. 5 (Ugur 2014; Efendic et al. 2011).

$$r_i = \alpha_0\, se_{ri} + \beta_0 + \epsilon_i \tag{5}$$

where r_i is PCC, se_{ri} is the standard error of the PCC and ϵ_i is the disturbance term.

Ordinary least squares (OLS) estimation of Eq. 5 is biased due to the presence of heteroscedasticity. According to Stanley (2008), we divide Eq. 5 by the standard error of PCC to reduce heteroscedasticity for more efficient estimation, which is known as the weighted least squares (WLS).

$$t_i = \alpha_0 + \beta_0 1/se_{ri} + \nu_i \tag{6}$$

Equation 6 is the WLS estimation due to the presence of heteroscedasticity, where $(1/se_{ri})$ is precision effect and ν_i is the disturbance term.

The existence of publication selection bias is evaluated by Funnel Asymmetry Test (FAT) under the null hypothesis of $H_0 : \alpha_0 = 0$, where rejection indicates publication selection bias and the existence of genuine empirical effect is evaluated by the Precision-Effect Test (PET) under the null hypothesis of $H_0 : \beta_0 = 0$, where rejection indicates genuine empirical effect (Ugur 2014; Efendic et al. 2011).

According to Table 2, FAT fails to reject $H_0 : \alpha_0 = 0$, indicating no publication selection bias, while PET fails to reject $H_0 : \beta_0 = 0$, indicating no authentic empirical effect.

Although we have found no publication selection bias in bivariate FAT-PET analysis, we need to conduct multivariate FAT-PET analysis to check for the publication selection bias based on study characteristics because bivariate FAT-PET analysis only considers PCC and its inverse standard error. Hence, it is based on reported effect size estimates. The existence of publication selection bias is evaluated only by the positive and negative significant or insignificant effect of financial development on CO2 emission. It does not take account of design characteristics of primary studies such financial development indicators used, estimation techniques employed, country, country group or region included, time period analyzed and control variables used.

The value of R^2 is too small indicating the incapability of using only two variables (inverse standard error of PCC and constant term) to explain the total variation in t values of the effect size estimates. This is just an indicator of the necessity to proceed with multivariate MRA.

Since we have found no genuine empirical effect, there is no nonlinear relationship between PCC and its standard error. Hence, we may proceed to conduct multivariate FAT-PET analysis instead of bivariate and multivariate PEESE analysis.

The bivariate FAT-PET has been carried out with cluster robust standard errors. Hence, estimates are clustered within primary studies in order to check both between study variation and within study variation.

Table 2 Estimation results for bivariate FAT-PET

Variable	Cluster robust SE
precision (β_0)	− 0.0259
	(0.0338)
bias (α_0)	− 0.0692
	(0.8551)
Number of Observation	275
Number of Clusters	72
R^2	0.0084
Prob. > F	0.4450

t values of the effect size estimates from primary studies are taken as dependent variable. Standard errors are in brackets. ***$p \le 0.01$; **$p \le 0.05$; *$p \le 0.10$

Multivariate meta regression analysis

We conduct multivariate FAT-PET analysis according to Eq. 8 based on Eq. 7 (Ugur 2014).

$$r_i = \alpha_0\, se_{ri} + \beta_0 + \sum \beta_j Z_{ji} + \epsilon_i \tag{7}$$

where r_i is PCC, se_{ri} is the standard error of the PCC, Z_{ji} is a vector of moderating variables and ϵ_i is the disturbance term.

Ordinary least squares (OLS) estimation of Eq. 5 is biased due to the presence of heteroscedasticity. According to Stanley (2008), we divide Eq. 3 by the standard error of PCC to reduce heteroscedasticity for more efficient estimation, which is known as the WLS.

$$t_i = \alpha_0 + \beta_0 1/se_{ri} + \sum \beta_j Z_{ji}/se_{ri} + \nu_i \tag{8}$$

Equation 6 is the WLS estimation due to the presence of heteroscedasticity, where $(1/se_{ri})$ is precision effect, Z_{ji} is a vector of moderating variables and ν_i is the disturbance term.

Moderating variables are generally dummy variables, which take the value of 1 if the estimate reported in the primary studies contains the characteristic captured by the variable and 0 otherwise (Ugur 2014). Three of the moderating variables are not dummy variables. The summary of all moderating variables is given in Table 4.

We have estimated an MRA model with all moderating variables to capture different aspects of the data. Because including all moderating variables in the same regression may lead to issues of over-determination and multicollinearity, a general-to-specific modeling procedure has been followed to simultaneously reduce model complexity and to ensure conformability (Efendic et al. 2011; Ugur 2014). The most insignificant moderating variables with the largest p values have been removed from the model one at a time until all the included moderating variables are found significant (Ugur 2014). Table 3 presents the MRA results with cluster-robust standard errors.

Table 3 Estimation results for multivariate FAT-PET

Variable	Cluster robust SE		Cluster robust SE
precision (β_0)	0.3419***	Indonesia	0.2702***
	(0.0873)		(0.0589)
bias (α_0)	− 1.4864***	Iran	− 0.4195***
	(0.4622)		(0.0631)
FD1.2	− 0.0981***	Malaysia	− 0.1882 *
	(0.0172)		(0.1078)
FD1.3	− 0.0948**	Nigeria	0.4152***
	(0.0465)		(0.0467)
FD2.4	0.1599***	Pakistan	0.2938***
	(0.0313)		(0.0689)
FD3.2	0.1871***	Portugal	0.1665***
	(0.0430)		(0.0534)
FD3.3	0.2889***	Russia	− 0.7645***
	(0.0431)		(0.0482)
FD3.4	0.2519***	Saudi_Arabia	0.3606***
	(0.0431)		(0.1326)
FD3.6	0.2263***	Sri_Lanka	0.3241***
	(0.0341)		(0.0463)
FD5.1	− 0.2071***	Tunisia	0.5251***
	(0.0507)		(0.0849)
FD5.2	0.2718***	Turkey	0.5237***
	(0.0775)		(0.0831)
FD6.1	− 0.1307***	USA	0.2633***
	(0.0198)		(0.0456)
FD6.3	− 0.2122***	Vietnam	0.4508***
	(0.0587)		(0.0592)
FD8.2	− 0.1968***	Africa	0.1125***
	(0.0269)		(0.0182)
FD8.3	0.1852***	Asia	− 0.1881***
	(0.0114)		(0.0365)
FD8.5	0.0842***	CIS	− 0.0369*
	(0.0251)		(0.0198)
time_span	− 0.0029***	Europe	− 0.0716***
	(0.0011)		(0.0249)
Start	9.44e-06**	GCC	− 0.1120***
	(3.92e-06)		(0.0214)
Emerging	− 0.1698***	Next11	− 0.0721**
	(0.0348)		(0.0280)
Bangladesh	− 0.4256***	OECD	− 0.1866***
	(0.0565)		(0.0309)
Brazil	0.8207***	type_of_data	− 0.2022***
	(0.0482)		(0.0716)
China	− 0.0995***	ET1.1	− 0.1359***
	(0.0273)		(0.0446)
Greece	0.4025***	ET1.2	− 0.1473***
	(0.0458)		(0.0476)
India	0.3344*	ET1.3	− 0.1604***
	(0.2007)		(0.0541)
ET1.4	− 0.0888**	ET3.3	0.1321 **

Table 3 (continued)

Variable	Cluster robust SE		Cluster robust SE
	(0.0454)		(0.0551)
ET1.5	0.0993***	ET3.4	− 0.1502**
	(0.0321)		(0.0676)
ET2.1	− 0.1824***	ET3.5	0.1621 ***
	(0.0550)		(0.0509)
ET2.3	− 0.1361***	ET3.6	− 0.1787***
	(0.0481)		(0.0425)
ET2.4	− 0.0923**	ET3.7	− 0.1839***
	(0.0371)		(0.0470)
ET2.5	− 0.2753 ***	ET3.10	− 0.2489***
	(0.0427)		(0.0676)
ET2.7	− 0.0826**	ET3.11	− 0.2491***
	(0.0347)		(0.0676)
ET3.1	− 0.2062***	Publication	0.0534*
	(0.0670)		(0.0283)
Number of observation		275	
Number of clusters		72	
R^2		0.7341	
Prob. > F		0.000	

t values of the effect size estimates from primary studies are taken as dependent variable. Standard errors are in brackets. Cluster is the study. ***$p \le 0.01$; **$p \le 0.05$; *$p \le 0.10$

The covariates are jointly significant and account for 73% of variations in *t* values according to the estimation results in Table 3. Estimation is done with cluster-robust standard errors controlling both within-study dependence and publication selection bias.

The coefficient of bias (α_0) is significant, suggesting publication selection bias in the literature, which contradicts the result from bivariate FAT-PET. The publication selection bias should be considered as substantial since $|\alpha_0| \ge 1$ (Ugur 2014). Hence, the editors or reviewers do not favor positive significant results over negative significant or insignificant results, but they favor studies with positive significant results based on design characteristics of the studies. Also, the coefficient for the variable published is significant, suggesting publication selection bias in the study with respect to included primary studies.

The coefficient of precision (β_0) is positive and significant, indicating the overall effect of financial development on carbon emissions to be positive and significant when controlling for the moderating variables. Hence, financial development has positive significant effect on carbon emissions.

Marginal effect of corruption is conditional on the moderating variables, and marginal effect of each moderating variable is as follows.

Studies using proxies of domestic credit to private sector by banks as a share of GDP (FD2.4), total deposits over GDP (FD3.2), total loans over GDP (FD3.3), private loans over GDP (FD3.4), bank deposits over GDP (FD3.6), stocks traded over turnover (FD5.2), bank concentration (FD8.3) and development of securities market (FD8.5) tend to report positive significant impact on the effect of financial development on CO2 emissions. Studies using these financial development indicators tend to report stronger positive effects. On the other side, studies using proxies of liquid liabilities (FD1.2), deposit liabilities over GDP (FD1.3), stock market capitalization as a percentage of GDP (FD5.1), FDI inflows as a percentage of GDP (FD6.1), foreign assets plus foreign liabilities as a share of GDP (FD6.3) and capital account convertibility (FD8.2) tend to report negative significant impact on the effect of financial development on CO2 emissions. Studies using these financial development indicators tend to report weaker positive effects. Hence, different financial development indicators have different effects on carbon emissions (Acheampong 2019).

The length of the time period (time_span) has negative significant impact and starting year of the time period (start) has positive significant impact on the effect of financial development on CO2 emissions. Hence, studies analyzing a longer time period tend to report weaker positive effects, while studies analyzing later period tend to report stronger positive effects. It is justifiable since global and country level CO2 emissions and financial development increase each passing year. Also it seems that the increasing rate of CO2 emissions outpaces the increasing rate of financial development.

Studies analyzing countries in Africa tend to report positive significant impact on the effect of financial development on CO2 emission; hence, they tend to report stronger positive effects. It seems that increasing rate of CO2 emission outpaces the increasing rate of financial development in Africa. Studies

analyzing emerging markets, Asia, CIS, Europe, GCC, Next 11 and OECD tend to report negative significant impact on the effect of financial development on CO2 emission; hence, they tend to report weaker positive effects. It seems that increasing rate of financial development outpaces the increasing rate of CO2 emission in these country groupings and regions.

Studies analyzing Brazil, Greece, India, Indonesia, Nigeria, Pakistan, Portugal, Saudi Arabia, Sri Lanka, Tunisia, Turkey, USA and Vietnam tend to report positive significant impact on the effect of financial development on CO2 emissions; hence, they tend to report stronger positive effects. It seems that increasing rate of CO2 emissions outpaces the increasing rate of financial development in these countries. Studies analyzing Bangladesh, China, Iran, Malaysia and Russia tend to report negative significant impact on the effect of financial development on CO2 emissions; hence, they tend to report weaker positive effects. It seems that increasing rate of financial development outpaces the increasing rate of CO2 emissions in these countries.

Studies employing panel data analysis (type_of_data) tend to report negative significant impact on the effect of financial development on CO2 emissions. It seems that the positive effect of financial development on CO2 emission get weakens when a group of countries analyzed instead of a single country.

Studies employing panel smooth transition regression (ET1.5), mean group (ET3.3) and augmented mean group (ET3.5) tend to report positive significant impact on the effect of financial development on CO2 emission. Hence, studies using these estimation techniques tend to report stronger positive effects. On the other side, studies employing ordinary least squares (ET1.1), fixed effect (ET1.2), random effect (ET1.3), least square dummy variables (ET1.4), maximum likelihood estimator (ET2.1), system generalized method of moments (ET2.3), difference generalized method of moments (ET2.4), least square dummy variable corrector (ET2.5), panel vector auto regression (ET2.7), auto regressive distributed lag (ET3.1), pooled mean group (ET3.4), fully modified ordinary least square (ET3.6), dynamic ordinary least square (ET3.7), continuously updated bias corrected (ET3.10) and continuously updated fully modified (ET3.11) tend to report negative significant impact on the effect of financial development on CO2 emission. Hence, studies using these estimation techniques tend to report weaker positive effects. It seems that studies employing dynamic panel or dynamic time series estimation techniques do not tend to report stronger positive effects, while studies employing static panel or static time series estimation techniques and studies employing co-integration analyses mostly report weaker positive effects.

We could not have found a significant coefficient for the number of control variables used in the primary studies. We may conclude that there is no omitted variable bias in the literature analyzing the effect of corruption on inward FDI.

In order to compare our multivariate MRA estimation results with the results of the primary studies, we need to compute overall effect of financial development on carbon emissions by adding the coefficients of moderating variables, which are used by the primary studies, to authentic empirical effect. According to MRA results, the overall effect could vary between -0.9101 ($0.3419 - 0.2122 - 0.7645 + 0 - 0.2753 + 0$) and 1.5049 ($0.3419 + 0.2889 + 0.8207 + 0 + 0.0534$). Hence, an unpublished study analyzing the role of financial development on carbon emissions would most likely find the highest negative significant effect if it uses foreign assets plus liabilities (% of GDP) as a financial development indicator and analyzes Russia with bias-corrected least squares dummy variables technique for time series estimation. Similarly, a published study analyzing the role of financial development on carbon emissions would most likely find the highest positive significant effect, if it uses total loans over GDP as a financial development indicator and analyzes Brazil with a Johansen cointegration technique for time series estimation.

The simplistic equation used for the calculation of overall effect is 'overall effect = authentic empirical effect + the coefficient of financial development indicator + the coefficient of the unit analyzed + the coefficient of the type of data + the coefficient of the estimation technique + the coefficient of publication status'.

For the study of Abbasi and Riaz (2016) on Pakistan, our results does not support the negative significant estimation result found for the financial development indicator of total credit as a share of GDP ($0.3419 + 0 + 0.2938 + 0 - 0.2062 + 0.0534 = 0.4829$) and support the positive significant estimation result found for the financial development indicator of stocks traded/turnover as a share of GDP ($0.3419 + 0.2718 + 0.2938 + 0 - 0.2062 + 0.0534 = 0.7547$). For the study of Acheampong (2019) on Sub-Saharan Africa, our results support the positive significant estimation results found for the financial development indicators of broad money as a share of GDP ($0.3419 + 0 + 0.1125 - 0.2022 - 0.1361 + 0.0534 = 0.1695$), domestic credit to private sector by banks as a share of GDP ($0.3419 + 0.1599 + 0.1125 - 0.2022 - 0.1361 + 0.0534 = 0.3294$) and domestic credit to private sector as a share of GDP ($0.3419 + 0 + 0.1125 - 0.2022$-$0.1361 + 0.0534 = 0.1695$). For the study of Ali et al. (2015a) on Pakistan, our results support the positive significant estimation result found for the financial development indicator of domestic credit to private sector by banks as a share of GDP ($0.3419 + 0.1599 + 0.2938 + 0 + 0 + 0.0534 = 0.8490$). For the study of Ali et al. (2015b) on Pakistan, our results support the positive significant estimation result found for the financial development indicator of M2 over GDP ($0.3419 + 0 + 0.2938 + 0 + 0 + 0.0534 = 0.6891$). For the study of Ali et al. (2019) on Nigeria, our results support the positive significant estimation result found for the financial development indicator of domestic credit to private sector as

a share of GDP (0.3419 + 0 + 0.4152 + 0 − 0.2062 + 0.0534 = 0.6043). For the study of Alper and Onur (2016) on China, our results do not support the negative significant estimation result found for the financial development indicator of ratio of net foreign assets to GDP (0.3419 + 0 − 0.0995 + 0 − 0.1787 + 0.0534 = 0.1171). For the study of Amri (2018) and Farhani and Ozturk (2015) on Tunusia, our results support the positive significant estimation result found for the financial development indicator of domestic credit to private sector as a share of GDP (0.3419 + 0 + 0.5251 + 0 − 0.2062 + 0.0534 = 0.7142). For the study of Balogh and Jámbor (2017), our results support the negative significant estimation results found for the financial development indicator of foreign direct investment inflows as a share of GDP (0.3419 − 0.1307 + 0 − 0.2022 − 0.1361 + 0.0534 = − 0.0737). For the study of Boutabba (2014) on India, our results support the positive significant estimation results found for the financial development indicator of domestic credit to private sector as a share of GDP (0.3419 + 0 + 0.3344 + 0 − 0.2062 + 0.0534 = 0.5235). For the studies of Çetin and Ecevit (2017) and Cetin et al. (2018) on Turkey, our results support the positive significant estimation results found for the financial development indicator of domestic credit to private sector as a share of GDP (0.3419 + 0 + 0.5237 + 0 − 0.2062 + 0.0534 = 0.7128). For the study of Charfeddine and Khediri (2016) on United Arab Emirates, our results support the positive significant estimation results found for the financial development indicator of domestic credit to private sector as a share of GDP (0.3419 + 0 + 0 + 0 + 0 + 0.0534 = 0.3953). For the studies of Dogan and Seker (2016a) and Dogan and Seker (2016b), our results do not support the negative significant estimation results found for the financial development indicator of domestic credit to private sector as a share of GDP (0.3419 + 0 + 0 − 0.2022 − 0.1839 + 0.0534 = 0.0092 and 0.3419 + 0 − 0.1866 − 0.2022 + 0 + 0.0534 = 0.0065, respectively). For the study of de Haas and Popov (2018), our results both support the positive significant estimation results found for the financial development indicator of domestic credit to private sector by banks as a share of GDP (0.3419 + 0.1599 + 0 − 0.2022 − 0.1359 + 0 = 0.1637) and the negative significant estimation results found for the financial development indicator of stock market capitalization as a share of GDP (0.3419 − 0.2071 + 0 − 0.2022 − 0.1359 + 0 = − 0.2033). For the study of Hao et al. (2016), our results support the negative significant estimation result found for the financial development indicator of total deposit and loans as a share of GDP (0.3419 + 0 − 0.0995 − 0.2022 − 0.1473 + 0.0534 = −0.0537) and does not support the negative significant estimation result found for the financial development indicator of loans over deposits (0.3419 + 0 − 0.0995 − 0.2022 − 0.0923 + 0.0534 = − 0.0013). For the study of Haseeb et al. (2018) that used the financial development indicator of domestic credit to private sector as a share of GDP, our results support the positive significant estimation results found for Brazil, South Africa and BRICS countries (0.3419 + 0 + 0.8207 + 0 − 0.1787 + 0.0534 = 1.0373, 0.3419 + 0 + 0 + 0 − 0.1787 + 0.0534 = 0.2166 and 0.3419 + 0 + 0 − 0.2022 + 0 + 0.0534 = 0.1931, respectively). Our results support the negative significant estimation result found for Russia (0.3419 + 0 − 0.7645 + 0 − 0.1787 + 0.0534 = − 0.5479) but does not support the negative significant estimation result found for China (0.3419 + 0 − 0.0995 + 0 − 0.1787 + 0.0534). For the study of Huang and Zhao (2018) on China, our results support the negative significant estimation results found for the financial development indicators of total deposit and loans as a share of GDP, non-state credit as a share of GDP and financial value added as a share of GDP (0.3419 + 0 − 0.0995 − 0.2022 − 0.1361 + 0.0534 = − 0.0425). For the study of Ibrahim (2018) on developing countries, our results support the positive significant estimation results found for the financial development indicators of total credit as a share of GDP and broad money as a share of GDP (0.3419 + 0 + 0 − 0.2022 − 0.1361 + 0.0534 = 0.057). For the study of Işik et al. (2017) on Greece, our results support the positive significant estimation results found for the financial development indicator of domestic credit to private sector as a share of GDP (0.3419 + 0 + 0.4025 + 0 − 0.2062 + 0.0534 = 0.5916). For the study of Jalil and Feridun (2011) on China, our results support the negative significant estimation results found for the financial development indicators of ratio of deposit liabilities to GDP (0.3419 − 0.0981 − 0.0995 + 0 − 0.2062 + 0.0534 = − 0.0085), foreign direct investment inflows as a share of GDP (0.3419 − 0.1307 − 0.0995 + 0 − 0.2062 + 0.0534 = − 0.0411) and foreign assets plus liabilities as a share of GDP (0.3419 − 0.2122 − 0.0995 + 0 − 0.2062 + 0.0534 = − 0.1226). But our results do not support the negative significant estimation results found for the financial development indicators of domestic credit to the private sector and ratio of commercial bank assets to the sum of bank and CB assets (0.3419 + 0 − 0.0995 + 0 − 0.2062 + 0.0534 = 0.0896). For the studies of Javid and Sharif (2013,Javid and Sharif 2016) on Pakistan, our results support the positive significant estimation results found for the financial development indicator of domestic credit to private sector as a share of GDP (0.3419 + 0 + 0.2938 + 0 − 0.2062 + 0 = 0.4295 and 0.3419 + 0 + 0.2938 + 0 − 0.2062 + 0.0534 = 0.4829, respectively). For the study of Karimzadeh et al. (2014) on Iran, our results support the negative significant estimation result found for the financial development indicator of domestic credit to private sector by banks as a share of GDP (0.3419 + 0.1599 − 0.4195 + 0 − 0.2062 + 0.0534 = − 0.0705). For the study of Katircioğlu and Taşpinar (2017) on Turkey, our results do not support the negative significant estimation result found for the financial development indicator of composite index (0.3419 + 0 + 0.5237 + 0 − 0.1839 + 0.0534 = 0.7351). For the study of Khan et al. (2018), our results do not support the negative significant estimation results found for the

financial development indicator of broad money as a share of GDP for the panel data analysis of Bangladesh, India and Pakistan (0.3419 + 0 + 0 − 0.2022 − 0.1787 + 0.0534 = 0.0144) and for the time series analysis of Pakistan (0.3419 + 0 + 0.2938 + 0 − 0.1787 + 0.0534 = 0.5104) and support the negative significant estimation result found for the financial development indicator of broad money as a share of GDP for the time series analysis of Bangladesh (0.3419 + 0 − 0.4256 + 0 − 0.1787 + 0.0534 = − 0.2090). For the study of Lee et al. (2015) on OECD countries, our results support the negative significant estimation result found for the financial development indicator of domestic credit to private sector by banks as a share of GDP (0.3419 + 0.1599 − 0.1866 − 0.2022 − 0.1787 + 0.0534 = − 0.0123) and do not support the negative significant estimation result found for the financial development indicator of the ratio of bank deposits to GDP (0.3419 + 0.2263 − 0.1866 − 0.2022 − 0.1787 + 0.0534 = 0.0541). For the study of Mohammadi (2017) on middle-income countries, our results support the positive significant estimation result found for the financial development indicator of domestic credit to the private sector as a share of GDP (0.3419 + 0 + 0 − 0.2022 + 0.0993 + 0.0534 = 0.2924). For the study of Nazir et al. (2018), our results do not support the negative significant estimation results found for the financial development indicator of domestic credit to the private sector as a share of GDP (0.3419 + 0 + 0–0.2022-0.0923 + 0.0534 = 0.1008). For the study of Park et al. (2018) on European countries, our results support the negative significant results found for the financial development indicator of domestic credit to the private sector as a share of GDP by employing pooled mean group estimator, fully modified ordinary least square estimator and dynamic ordinary least square estimator (0.3419 + 0 − 0.0716 − 0.2022 − 0.1502 + 0.0534 = − 0.0287, 0.3419 + 0 − 0.0716 − 0.2022 − 0.1787 + 0.0534 = − 0.0572 and 0.3419 + 0 − 0.0716 − 0.2022 − 0.1839 + 0.0534 = − 0.0624, respectively). For the study of Pata (2018a) on Turkey, our results support the positive significant results found for the financial development indicator of domestic credit to the private sector as a share of GDP by employing auto regressive distributed lag estimator, fully modified ordinary least square estimator and canonical cointegrating regression (0.3419 + 0 + 0.5237 + 0 − 0.2062 + 0.0534 = 0.7128, 0.3419 + 0 + 0.5237 + 0 − 0.1787 + 0.0534 = 0.7403 and 0.3419 + 0 + 0.5237 + 0 + 0 + 0.0534 = 0.9190, respectively). For the study of Pata (2018b) on Turkey, our results support the positive significant results found for the financial development indicator of domestic credit to the private sector as a share of GDP (0.3419 + 0 + 0.5237 + 0 − 0.2062 + 0.0534 = 0.7128). For the study of Rasoulinezhad and Saboori (2018) on CIS countries, our results support the positive significant results for the financial development indicator of composite index by fully modified ordinary least square (0.3419 + 0 − 0.0369 − 0.2022 − 0.1787 + 0.0534 = − 0.0225) and by dynamic ordinary least square (0.3419 + 0 − 0.0369 − 0.2022 − 0.1839 + 0.0534 = − 0.0277). For the study of Saidi and Mbarek (2017) on emerging market economies, our results do not support the negative significant results for the financial development indicator of domestic credit to the private sector as a share of GDP (0.3419 + 0.1599 − 0.1698 − 0.2022 − 0.1361 + 0.0534 = 0.0471). For the study of Salahuddin et al. (2015) on GCC countries, our results support the negative significant results found for the financial development indicator of domestic credit to private sector by banks as a share of GDP by employing fully modified ordinary least square estimator and dynamic ordinary least square estimator (0.3419 + 0 − 0.1120 − 0.2022 − 0.1787 + 0.0534 = − 0.0976 and 0.3419 + 0 − 0.1120 − 0.2022 − 0.1839 + 0.0534 = − 0.1028, respectively) and do not support the negative significant estimation results found for the financial development indicator of domestic credit to private sector as a share of GDP by dynamic fixed effect (0.3419 + 0 − 0.1120 − 0.2022 + 0 + 0.0534 = 0.0811). For the study of Salahuddin et al. (2018) on Kuwait, our results do not support the negative significant results found for the financial development indicator of domestic credit to private sector as a share of GDP (0.3419 + 0 + 0 + 0 − 0.1839 + 0.0534 = 0.2114). For the study of Shahbaz et al. (2013a) on South Africa, our results do not support the negative significant estimation result found for the financial development indicator of domestic credit to private sector as a share of GDP (0.3419 + 0 + 0 + 0 − 0.2062 + 0.0534 = 0.1891). For the study of Shahbaz et al. (2011) on Pakistan, our results do not support the negative significant estimation result found for the financial development indicator of stock market capitalization (0.3419 − 0.2071 + 0.2938 + 0 − 0.2062 + 0 = 0.2224). For the study of Shahbaz et al. (2012) and Shahbaz et al. (2013b) on Malaysia, our results support the negative significant estimation result found for the financial development indicator of domestic credit to private sector as a share of GDP (0.3419 + 0 − 0.1882 + 0 − 0.2062 + 0 = − 0.0525). For the study of Shahbaz et al. (2018), our results support the positive significant estimation results for BRICS countries found for the financial development indicator of domestic credit to private sector as a share of GDP by employing mean group estimator and augmented mean group estimator (0.3419 + 0 + 0 − 0.2022 + 0.1321 + 0.0534 = 0.3252 and 0.3419 + 0 + 0 − 0.2022 + 0.1621 + 0.0534 = 0.3552, respectively) and support the positive significant estimation results for Next-11 countries found for the financial development indicator of domestic credit to private sector as a share of GDP by employing mean group estimator and augmented mean group estimator (0.3419 + 0 − 0.0721 − 0.2022 + 0.1321 + 0.0534 = 0.2531 and 0.3419 + 0 − 0.0721 − 0.2022 + 0.1621 + 0.0534 = 0.2831, respectively). For the studies of Shahzad et al. (2017) and Siddique (2017) on Pakistan, our results support the positive significant estimation

result found for the financial development indicator of domestic credit to private sector as a share of GDP (0.3419 + 0 + 0.2938 + 0 − 0.2062 + 0.0534 = 0.4829). For the study of Sharif et al. (2019), our results do not support the negative significant results found for the financial development indicator of domestic credit to private sector as a share of GDP by employing fully modified ordinary least square and dynamic ordinary least square (0.3419 + 0 + 0 − 0.2022 − 0.1787 + 0.0534 = 0.0144 and 0.3419 + 0 + 0 − 0.2022 − 0.1839 + 0.0534 = 0.0092, respectively). For the study of Shi et al. (2019), our results do not support the negative significant result found for the financial development indicator of domestic credit to private sector as a share of GDP (0.3419 + 0 + 0 − 0.2022 − 0.1787 + 0.0534 = 0.0144). For the study of Solarin (2014) on Malaysia, our results do not support the negative significant estimation results found for the financial development indicator of broad money as a share of GDP by employing auto regressive distributed lag estimator and dynamic ordinary least square estimator (0.3419 + 0 − 0.1882 − 0.2062 + 0.0534 = 0.0009 and 0.3419 + 0 − 0.1882 − 0.1839 + 0.0534 = 0.0232, respectively). For the study of Tamazian and Rao (2010) on transition economies, our results do not support the negative significant estimation results found for the financial development indicator of financial liberalization by employing random effect estimator and system GMM estimator (0.3419 + 0 + 0 − 0.2022 − 0.1604 + 0.0534 = 0.0327 and 0.3419 + 0 + 0 − 0.2022 − 0.1361 + 0.0534 = 0.0570, respectively). For the study of Tamazian et al. (2009), our results support the negative significant estimation results found for the financial development indicators of foreign direct investment inflows as a share of GDP, capital account convertibility, foreign assets and liabilities as a share of GDP and stock market capitalization as a share of GDP (0.3419 − 0.1307 + 0 − 0.2022 − 0.1604 + 0.0534 = − 0.0980, 0.3419–0.1968 + 0 − 0.2022 − 0.1604 + 0.0534 = − 0.1641, 0.3419 − 0.2122 + 0 − 0.2022 − 0.1604 + 0.0534 = − 0.1795 and 0.3419 − 0.2071 + 0 − 0.2022 − 0.1604 + 0.0534 = − 0.1744, respectively) and does not support the negative significant estimation results found for the financial development indicator of ratio of deposit money bank assets to GDP (0.3419 + 0 + 0 − 0.2022 − 0.1604 + 0.0534 = 0.0327). For the study of Tsaurai (2019) on Western Africa, our results support the positive significant estimation results found for the financial development indicator of domestic credit to private sector by banks as a share of GDP (0.3419 + 0.1599 + 0.1125 − 0.2022 − 0.1359 + 0.0534 = 0.3296). For the study of Xiong et al. (2017) on China, our results support the positive significant estimation results found for the financial development indicators of total loans over GDP, private loans over GDP and total deposits over GDP (0.3419 + 0.2889 − 0.0995 − 0.2022 − 0.0923 + 0.0534 = 0.2902, 0.3419 + 0.2519 − 0.0995 − 0.2022 − 0.0923 + 0.0534 = 0.2532 and 0.3419 + 0.1871 − 0.0995 − 0.2022 − 0.0923 + 0.0534 = 0.1884, respectively). For the study of Haifeng et al. (2017) on Chinese provinces and European countries, our results support the negative significant estimation results found for the financial development indicator of broad money as a share of GDP and stock (0.3419 + 0 − 0.0995 − 0.2022 − 0.1824 + 0.0534 = − 0.0888) for Chinese provinces and support the negative significant estimation results found for the financial development indicator of broad money as a share of GDP and banking industry development (0.3419 + 0 − 0.0716 − 0.2022 − 0.1824 + 0.0534 = − 0.0609) for European countries. For the study of Xu et al. (2018) on Saudi Arabia, our results support the positive significant estimation results found for the financial development indicator of domestic credit to the private sector as a share of GDP (0.3419 + 0 + 0.3606 + 0 − 0.2062 + 0.0534 = 0.5497). For the study of Khoshnevis Yazdi and Ghorchi Beygi (2018) on Africa, our results support the positive significant estimation results found for the financial development indicator of broad money as a share of GDP (0.3419 + 0 + 0.1125 − 0.2022 − 0.1502 + 0.0534 = 0.1554). For the study of Zaidi et al. (2019) on APEC countries, our results support the negative significant estimation results found for the financial development indicator of domestic credit to the private sector as a share of GDP by employing continuously updated fully modified estimator, continuously updated bias-corrected estimator and pooled mean group estimator (0.3419 + 0 − 0.1881 − 0.2022 − 0.2491 + 0.0534 = − 0.2441, 0.3419 + 0 − 0.1881 − 0.2022 − 0.2489 + 0.0534 = − 0.2439 and 0.3419 + 0 − 0.1881 − 0.2022 − 0.1502 + 0.0534 = − 0.1452, respectively).

Conclusion

A systematic general evaluation of the research base tends to report mostly positive effect of financial development on CO2 emission. An MRA analysis has been carried out to evaluate and synthesize the effect-size estimates from the primary studies taking heterogeneity and publication bias into account. The bivariate FAT-PET analysis has indicated an insignificant effect of effect of financial development on CO2 emission and could not detect publication selection bias as in the case of funnel plot analysis.

Because the bivariate FAT-PET analysis overlooked the potential sources of heterogeneity and considered only the publication selection bias, we estimated a multivariate FAT-PET analysis to include moderating variables. We found the overall effect of financial development on carbon emission to be positive significant when we controlled for the moderating variables. The magnitude of the effect of financial development on CO2 depends on model specification; the marginal effect of financial development changes both in magnitude and direction based on financial indicators used, the estimation technique employed, the countries, country group or region included and the time period analyzed. The multivariate FAT-PET reported a substantial bias. Hence, we

conclude that the publication bias is not due to the result of reported effect size estimates (positive significant, negative significant or insignificant effects) but due to the design characteristics (moderating variables).

The positive significant effect of financial development on carbon emission supports the first hypothesis, which asserts that financial development leads to the environmental degradation through the channels of energy consumption and industrialization. Financial development increases the energy consumption by proliferation of consumer credits leading to higher demand for home appliances and automobiles, by enabling lower cost capital to firms leading to more machine and equipment purchases and building of new plants and by generating wealth leading to economic growth. Final effect is that financial development boosts industrialization, which generally increases industrial pollution and level of greenhouse gas emissions.

The deteriorating effect of financial development on environmental quality is more severe for Brazil, Greece, Nigeria, Tunusia, Turkey and Vietnam. Specifically, these countries should closely monitor their domestic credit to private sector, bank deposits, total deposits, private and total loans, stocks traded/turnover, bank concentration and securities market because an increase in these indicators lead to higher carbon emissions. These countries should try to increase their liquid and deposit liabilities, stock market capitalization, foreign direct investment inflows, foreign assets and liabilities and capital account convertibility to decrease the magnitude of deteriorating effect of financial development on environmental quality. Finally, these countries should alleviate the positive effect of financial development on carbon emissions by proliferating renewable energy use as a green trading policy.

Acknowledgments I would like to thank Mehmet Ugur for his instant replies to my e-mails regarding the application of metaregression analysis.

Appendix 1

Table 4 Definition of variables

Variable	Description
ri	partial correlation coefficient (PCC)
seri	standard error of PCC
inv_seri	inverse of standard error of PCC
n	number of observations
FD1.1	broad money as a share of GDP (M2/GDP)
FD1.2	liquid liabilities as a share of GDP (M3/GDP)
FD1.3	ratio of deposit liabilities to GDP
FD2.1	total credit (% of GDP)
FD2.2	non-state credit (% of GDP)
FD2.3	domestic credit to the private sector as a share of GDP
FD2.4	domestic credit to private sector by banks as a share of GDP
FD3.1	total deposit and loan (% of GDP)
FD3.2	total deposits/GDP
FD3.3	total loans/GDP
FD3.4	private loans/GDP
FD3.5	loans/deposits
FD3.6	the ratio of bank deposits to GDP
FD4.1	ratio of commercial bank assets to the sum of bank and CB assets
FD4.2	ratio of deposit money bank assets to GDP
FD5.1	stock market capitalization (% of GDP)
FD5.2	stocks traded/turnover (% of GDP)
FD5.3	stock indicator
FD6.1	foreign direct investment inflows (% of GDP)
FD6.2	ratio of net foreign assets to GDP
FD6.3	foreign assets plus liabilities (% of GDP)
FD7.1	composite index
FD8.1	Financial value added (% of GDP)
FD8.2	capital account convertibility

Table 4 (continued)

Variable	Description
FD8.3	bank concentration
FD8.4	development of banking industry
FD8.5	development of securities market
FD8.6	a measure of financial liberalization
cont_var	number of control variables
time_span	number of years
start	starting year
end	ending year
unit	number of countries or provinces
all	estimates not making a distinction between developed and developing countries
developing	estimates only including developing countries
emerging	estimates only including emerging countries
transition	estimates only including transition countries
brics	estimates only including BRICS countries
cis	estimates only including Commonwealth of Independent States
gcc	estimates only including member countries of Gulf Cooperation Council
mena	estimates only including countries in Middle East and North Africa
next11	estimates only including eleven countries
oecd	estimates only including OECD countries
africa	estimates only including countries in Africa
asia	estimates only including countries in Asia
europe	estimates only including countries in Europe
bangladesh	estimates only including Bangladesh
brazil	estimates only including Brazil
china	estimates only including China or Chinese provinces
greece	estimates only including Greece
india	estimates only including India
indonesia	estimates only including Indonesia
iran	estimates only including Iran
kuwait	estimates only including Kuwait
malaysia	estimates only including Malaysia
nigeria	estimates only including Nigeria
pakistan	estimates only including Pakistan
portugal	estimates only including Portugal
russia	estimates only including Russia
saudi_arabia	estimates only including Saudi Arabia
south_africa	estimates only including South Africa
sri_lanka	estimates only including Sri Lanka
tunisia	estimates only including Tunusia
turkey	estimates only including Turkey
uae	estimates only including United Arab Emirates
usa	estimates only including the USA
vietnam	estimates only including Vietnam
type_of_data	1 for panel and 0 for time series
ET1.1	ordinary least squares
ET1.2	fixed effect
ET1.3	random effect
ET1.4	least squares dummy variables
ET1.5	panel smooth transition regression

Table 4 (continued)

Variable	Description
ET2.1	maximum likelihood estimation
ET2.2	dynamic fixed effect
ET2.3	system generalized method of moments
ET2.4	difference generalized method of moments
ET2.5	bias corrected least squares dummy variables
ET2.6	dynamic panel threshold model
ET2.7	panel vector auto regression
ET3.1	auto regressive distributed lag
ET3.2	Johansen cointegration
ET3.3	mean group
ET3.4	pooled mean group
ET3.5	augmented mean group
ET3.6	fully modified ordinary least squares
ET3.7	dynamic ordinary least square
ET3.8	dynamic seemingly unrelated cointegrating regressions
ET3.9	canonical cointegrating regression
ET3.10	continuously updated bias-corrected
ET3.11	continuously updated fully modified
ET3.12	cointegration with structural breaks
publication	1 for published and 0 for unpublished

Table 5 Description of primary studies

Primary study	No. of estimate	Indicator	Type of data	Econometric technique	FE weighted mean	Significant
Abbasi and Riaz (2016)	14	FD2.1, FD2.3,FD5.1, FD5.2	TS	ET3.1	0.061	No
Abid (2016)	20	FD2.3	P	ET1.1, ET1.2, ET1.3,ET2.3, ET2.4,ET2.5,ET3.7	0.047	Yes
Acheampong (2019)	6	FD1.1,FD1.2,FD2.3, FD2.4, FD6.1	P	ET2.3	0.071	Yes
Ali et al. (2015a)	1	FD2.4	TS	ET3.2	0.724	Yes
Ali et al. (2015b)	1	FD1.1	TS	ET3.2	0.277	Yes
Ali et al. (2019)	1	FD2.3	TS	ET3.1	0.429	Yes
Alper and Onur (2016)	1	FD6.2	TS	ET3.6	−0.275	Yes
Amri (2018)	1	FD2.3	TS	ET3.1	0.490	Yes
Asumadu-Sarkodie and Owusu (2016)	1	FD1.1	TS	ET3.1	0.180	No
Aye and Edoja (2017)	3	FD2.3	P	ET2.6	0.010	No
Baloch et al. (2018)	2	FD7.1	TS	ET3.1	0.011	No
Balogh and Jámbor (2017)	2	FD6.1	P	ET2.3	−0.169	Yes
Boutabba (2014)	1	FD2.3	TS	ET3.1	0.634	Yes
Cetin and Ecevit (2017)	4	FD2.3	TS	ET3.1	0.311	Yes
Cetin et al. (2018)	1	FD2.3	TS	ET3.1	0.242	Yes
Charfeddine and Kahia (2019)	1	FD2.3	P	ET2.7	−0.029	No
Charfeddine and Khediri (2016)	2	FD2.3	TS	ET3.12	0.177	Yes

Table 5 (continued)

Primary study	No. of estimate	Indicator	Type of data	Econometric technique	FE weighted mean	Significant
De Haas and Popov (2018)	4	FD2.4	P	ET1.1	− 0.098	Yes
Dogan and Seker (2016a)	2	FD2.3	P	ET3.6,ET3.7	− 0.166	Yes
Dogan and Seker (2016b)	1	FD2.3	P	ET3.8	0.111	No
Dogan and Turkekul (2016)	1	FD2.3	TS	ET3.1	0.294	Yes
Farhani and Ozturk (2015)	1	FD2.3	TS	ET3.1	0.029	Yes
Hao et al. (2016)	7	FD3.1,FD3.5	P	ET1.1,ET1.2,ET2.4	− 0.150	Yes
Haseeb et al. (2018)	6	FD2.3	P and TS	ET3.6,et3.8	0.119	Yes
Huang and Zhao (2018)	6	FD2.2,FD3.1,FD8.1	P	ET2.3	− 0.164	Yes
Ibrahim (2018)	6	FD1.1,FD1.3	P	ET1.4,ET2.3,ET2.4,	0.007	No
Işik et al. (2017)	1	FD2.3	TS	ET3.1	0.262	Yes
Jalil and Feridun (2011)	14	FD1.3,FD2.3,FD4.1, FD6.1,FD6.3	TS	ET3.1	− 0.350	Yes
Jamel and Maktouf (2017)	2	FD2.4	P	ET1.2,ET1.3	0.016	No
Javid and Sharif (2013)	1	FD2.3	TS	ET3.1	0.345	No
Javid and Sharif (2016)	1	FD2.3	TS	ET3.1	0.343	No
Karimzadeh et al. (2014)	1	FD2.4	TS	ET3.1	− 0.388	No
Katircioğlu and Taşpinar (2017)	1	FD7.1	TS	ET3.7	− 0.268	No
Khan et al. (2018)	4	FD1.1	P and TS	ET3.6	− 0.173	Yes
Lee et al. (2015)	2	FD2.4,FD3.6	P	ET3.6	− 0.114	Yes
Lu (2018)	1	FD2.3	P	ET3.3	− 0.001	No
Menon (2019)	1	FD2.3	TS	ET3.1	0.011	No
Mohammadi (2017)	1	FD2.3	P	ET1.5	0.124	Yes
Nazir et al. (2018)	3	FD2.3	P	ET2.4	− 0.068	Yes
Omri et al. (2015)	1	FD2.3	P	ET2.3	− 0.091	No
Ozturk and Acaravci (2013)	1	FD2.3	TS	ET3.1	0.116	No
Park et al. (2018)	3	FD2.3	P	ET3.4,ET3.6,ET3.7	− 0.164	Yes
Pata (2018a)	9	FD2.3	TS	ET3.1,ET3.6,ET3.9	0.608	Yes
Pata (2018b)	2	FD2.3	TS	ET3.1	0.547	Yes
Rasoulinezhad and Saboori (2018)	2	FD7.1	P	ET3.6,ET3.7	− 0.165	Yes
Saidi and Mbarek (2017)	3	FD2.4	P	ET2.3	− 0.075	Yes
Salahuddin et al. (2015)	4	FD2.3	P	ET2.2,ET3.3,ET3.6,ET3.7	− 0.166	Yes
Salahuddin et al. (2018)	2	FD2.3	TS	ET3.1,ET3.7	− 0.136	No
Shahbaz (2012)	2	FD2.3	TS	ET3.1	− 0.014	No
Shahbaz et al. (2013c)	2	FD2.3	TS	ET3.1	− 0.189	Yes
Shahbaz et al. (2011)	2	FD5.1	TS	ET3.1	− 0.306	Yes
Shahbaz et al. (2012)	3	FD2.3	TS	ET3.1	− 0.473	Yes
Shahbaz et al. (2013a)	2	FD2.3	TS	ET3.1	0.258	Yes
Shahbaz et al. (2013b)	3	FD2.3	TS	ET3.1	− 0.365	Yes
Shahbaz et al. (2018)	8	FD2.3	P	ET3.3,ET3.5	0.140	Yes
Shahzad et al. (2014)	2	FD2.3	TS	ET3.6,ET3.7	− 0.080	No
Shahzad et al. (2017)	1	FD2.3	TS	ET3.1	0.497	Yes
Sharif et al. (2019)	2	FD2.3	P	ET3.6,ET3.7	− 0.106	Yes
Shi et al. (2019)	1	FD2.3	P	ET3.6	− 0.124	Yes
Siddique (2017)	1	FD2.3	TS	ET3.1	0.313	Yes
Solarin (2014)	2	FD1.1	TS	ET3.1,ET3.7	− 0.009	No
Sy et al. (2016)	2	FD2.4	P	ET1.2,ET1.3	0.016	No

Table 5 (continued)

Primary study	No. of estimate	Indicator	Type of data	Econometric technique	FE weighted mean	Significant
Tamazian and Rao (2010)	12	FD8.6	P	ET1.3,ET2.3	− 0.057	Yes
Tamazian et al. (2009)	40	FD4.2,FD5.1,FD6.1,FD6.3,FD8.2	P	ET1.3	− 0.322	Yes
Thanh and Khuong (2017)	1	FD2.3	TS	ET3.1	0.290	No
Tsaurai (2019)	6	FD2.4	P	ET1.1,ET1.2,ET1.3	0.144	Yes
Xiong et al. (2017)	8	FD3.1,FD3.2,FD3.3,FD3.4	P	ET2.4	0.125	Yes
Xu et al. (2017)	6	FD1.1,FD5.3,FD8.3,FD8.4,FD8.5	P	ET2.1	− 0.138	Yes
Xu et al. (2018)	3	FD2.3	TS	ET3.1	0.349	Yes
Khoshnevis Yazdi and Ghorchi Beygi (2018)	1	FD1.1	P	ET3.4	0.076	Yes
You et al. (2015)	6	FD7.1	P	ET1.1	− 0.021	Yes
Zaidi et al. (2019)	3	FD2.3	P	ET3.4,ET3.10,ET3.11	− 0.172	Yes

FE is fixed effect, P is panel and T is time series. See Table 4 for the definition of FD and ET codes

References

Abbasi F, Riaz K (2016) CO2 emissions and financial development in an emerging economy: an augmented VAR approach. Energy Policy 90:102–114

Abid M (2016) Impact of economic, financial, and institutional factors on CO2 emissions: evidence from sub-Saharan Africa economies. Util Policy 41:85–94

Acheampong AO (2019) Modelling for insight: does financial development improve environmental quality? Energy Econ 83:156–179

Ali A, Khatoon S, Ather M, Akhtar N (2015a) Modeling energy consumption, carbon emission and economic growth: empirical analysis for Pakistan. Int J Energy Econ Policy 5(2):624–630

Ali S, Waqas H, Ahmad N (2015b) Analyzing the dynamics of energy consumption, liberalization, financial development, poverty and carbon emissions in Pakistan. J Appl Environ Biol Sci 5(4):166–183

Ali HS, Law SH, Lin WL, Yusop Z, Chin L, Bare UAA (2019) Financial development and carbon dioxide emissions in Nigeria: evidence from the ARDL bounds approach. GeoJournal 84(3):641–655

Alper A, Onur G (2016) Environmental Kuznets curve hypothesis for sub-elements of the carbon emissions in China. Nat Hazards 82(2):1327–1340

Amri F (2018) Carbon dioxide emissions, total factor productivity, ICT, trade, financial development, and energy consumption: testing environmental Kuznets curve hypothesis for Tunisia. Environ Sci Pollut Res 25(33):33691–33701

Asumadu-Sarkodie S, Owusu PA (2016) Energy use, carbon dioxide emissions, GDP, industrialization, financial development, and population, a causal nexus in Sri Lanka: with a subsequent prediction of energy use using neural network. Energy Sources, Part B: Economics, Planning, and Policy 11(9):889–899

Aye GC, Edoja PE (2017) Effect of economic growth on CO2 emission in developing countries: evidence from a dynamic panel threshold model. Cogent Economics & Finance 5(1):1379239

Baloch MA, Meng F, Zhang J, Xu Z (2018) Financial instability and CO 2 emissions: the case of Saudi Arabia. Environ Sci Pollut Res 25(26):26030–26045

Balogh JM, Jámbor A (2017) Determinants of CO2 emission: a global evidence. Int J Energy Econ Policy 7(5):217–226

Boutabba MA (2014) The impact of financial development, income, energy and trade on carbon emissions: evidence from the Indian economy. Econ Model 40:33–41

Çetin M, Ecevit E (2017) The impact of financial development on carbon emissions under the structural breaks: empirical evidence from Turkish economy. J Econ Manag Perspect 11(1):64–78

Cetin M, Ecevit E, Yucel AG (2018) The impact of economic growth, energy consumption, trade openness, and financial development on carbon emissions: empirical evidence from Turkey. Environ Sci Pollut Res 25(36):36589–36603

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

Charfeddine L, Khediri KB (2016) Financial development and environmental quality in UAE: Cointegration with structural breaks. Renew Sust Energ Rev 55:1322–1335

Claessens S, & Feijen E (2007). Financial sector development and the millennium development goals. The World Bank

Dasgupta S, Laplante B, Mamingi N (2001) Pollution and capital markets in developing countries. J Environ Econ Manag 42(3):310–335

De Haas, R., & Popov, A. A. (2018). Financial development and industrial pollution. Eur Bank Reconstruc Dev, working paper no. 217

Dogan E, Seker F (2016a) The influence of real output, renewable and non-renewable energy, trade and financial development on carbon emissions in the top renewable energy countries. Renew Sust Energ Rev 60:1074–1085

Dogan E, Seker F (2016b) An investigation on the determinants of carbon emissions for OECD countries: empirical evidence from panel models robust to heterogeneity and cross-sectional dependence. Environ Sci Pollut Res 23(14):14646–14655

Dogan E, Turkekul B (2016) CO 2 emissions, real output, energy consumption, trade, urbanization and financial development: testing the EKC hypothesis for the USA. Environ Sci Pollut Res 23(2):1203–1213

Efendic A, Pugh G, Adnett N (2011) Institutions and economic performance: a meta-regression analysis. Eur J Polit Econ 27(3):586–599

Farhani S, Ozturk I (2015) Causal relationship between CO 2 emissions, real GDP, energy consumption, financial development, trade openness, and urbanization in Tunisia. Environ Sci Pollut Res 22(20):15663–15676

Haifeng XU, Yang LI, HUANG H (2017) Spatial research on the effect of financial structure on CO2 emission. Energy Procedia 118:179–183

Hao Y, Zhang ZY, Liao H, Wei YM, Wang S (2016) Is CO 2 emission a side effect of financial development? An empirical analysis for China. Environ Sci Pollut Res 23(20):21041–21057

Haseeb A, Xia E, Baloch MA, Abbas K (2018) Financial development, globalization, and CO 2 emission in the presence of EKC: evidence from BRICS countries. Environ Sci Pollut Res 25(31):31283–31296

Huang L, Zhao X (2018) Impact of financial development on trade-embodied carbon dioxide emissions: evidence from 30 provinces in China. J Clean Prod 198:721–736

Ibrahim MH (2018) Trade–finance complementarity and carbon emission intensity: panel evidence from middle-income countries. Environ Syst Decis 38(4):489–500

Işik C, Kasımatı E, Ongan S (2017) Analyzing the causalities between economic growth, financial development, international trade, tourism expenditure and/on the CO2 emissions in Greece. Energy Sources, Part B: Economics, Planning, and Policy 12(7):665–673

Jalil A, Feridun M (2011) The impact of growth, energy and financial development on the environment in China: a cointegration analysis. Energy Econ 33(2):284–291

Jamel L, Maktouf S (2017) The nexus between economic growth, financial development, trade openness, and CO2 emissions in European countries. Cogent Econo Finance 5(1):1341456

Javid M, Sharif F (2013) Energy Consumption, Financial development and CO2 emissions in Pakistan

Javid M, Sharif F (2016) Environmental Kuznets curve and financial development in Pakistan. Renew Sust Energ Rev 54:406–414

Jensen AL (1996) Beverton and Holt life history invariants result from optimal trade-off of reproduction and survival. Can J Fish Aquat Sci 53(4):820–822

Karimzadeh M, Bazkhaneh ST, Dalfardi HK, Barakchian M (2014) Studying the relationship between financial development and emissions of Carbon Dioxide in Iran: using Autoregressive-Distributed Lag. Open Access J Resistive Econ (OAJRE) 2:94–105 96

Katircioğlu ST, Taşpinar N (2017) Testing the moderating role of financial development in an environmental Kuznets curve: empirical evidence from Turkey. Renew Sust Energ Rev 68:572–586

Khan AQ, Saleem N, Fatima ST (2018) Financial development, income inequality, and CO 2 emissions in Asian countries using STIRPAT model. Environ Sci Pollut Res 25(7):6308–6319

Khoshnevis Yazdi S, Ghorchi Beygi E (2018) The dynamic impact of renewable energy consumption and financial development on CO2 emissions: for selected African countries. Energy Sources, Part B: Economics, Planning, and Policy 13(1):13–20

Khuong ND (2017) Factors affecting CO2 emission in Vietnam: a panel data analysis. Organ Mark Emerg Econ 9(2)

Lee JM, Chen KH, Cho CH (2015) The relationship between CO2 emissions and financial development: evidence from OECD countries. Singapore Econ Rev 60(05):1550117

Lu WC (2018) The impacts of information and communication technology, energy consumption, financial development, and economic growth on carbon dioxide emissions in 12 Asian countries. Mitig Adapt Strateg Glob Chang 23(8):1351–1365

Menon P (2019) An Indian story on carbon emission, energy consumption, trade openness, and financial development. J Public Affairs 19: e1953

Mohammadi T (2017) Economic growth, financial development and CO2 emission: PSTR approach. Iran J Econ Stud 5(2):145–171

Nazir MR, Nazir MI, Hashmi SH, Fareed Z (2018) Financial development, income, trade, and urbanization on Co2 emissions: new evidence from Kyoto annex countries. J Innov Sustain. RISUS ISSN 2179–3565 9(3):17–37

Omri A, Daly S, Rault C, Chaibi A (2015) Financial development, environmental quality, trade and economic growth: what causes what in MENA countries. Energy Econ 48:242–252 IZA DP No 8868

Ozturk I, Acaravci A (2013) The long-run and causal analysis of energy, growth, openness and financial development on carbon emissions in Turkey. Energy Econ 36:262–267

Park Y, Meng F, Baloch MA (2018) The effect of ICT, financial development, growth, and trade openness on CO 2 emissions: an empirical analysis. Environ Sci Pollut Res 25(30):30708–30719

Pata UK (2018a) Renewable energy consumption, urbanization, financial development, income and CO2 emissions in Turkey: testing EKC hypothesis with structural breaks. J Clean Prod 187:770–779

Pata UK (2018b) The effect of urbanization and industrialization on carbon emissions in Turkey: evidence from ARDL bounds testing procedure. Environ Sci Pollut Res 25(8):7740–7747

Rasoulinezhad E, Saboori B (2018) Panel estimation for renewable and non-renewable energy consumption, economic growth, CO 2 emissions, the composite trade intensity, and financial openness of the commonwealth of independent states. Environ Sci Pollut Res 25(18):17354–17370

Sadorsky P (2010) The impact of financial development on energy consumption in emerging economies. Energy Policy 38(5):2528–2535

Saidi K, Mbarek MB (2017) The impact of income, trade, urbanization, and financial development on CO 2 emissions in 19 emerging economies. Environ Sci Pollut Res 24(14):12748–12757

Salahuddin M, Gow J, Ozturk I (2015) Is the long-run relationship between economic growth, electricity consumption, carbon dioxide emissions and financial development in gulf cooperation council countries robust? Renew Sust Energ Rev 51:317–326

Salahuddin M, Alam K, Ozturk I, Sohag K (2018) The effects of electricity consumption, economic growth, financial development and foreign direct investment on CO2 emissions in Kuwait. Renew Sust Energ Rev 81:2002–2010

Shahbaz M (2012). *Multivariate granger causality between CO2 emissions, energy intensity, financial development and economic growth: evidence from Portugal*. MPRA paper no. 37774

Shahbaz M, Islam F, & Muhammad Sabihuddin B (2011). *Financial development, energy consumption and CO2 emissions: evidence from ARDL approach for Pakistan*. MPRA paper no. 30138

Shahbaz M, Solarin SA, & Mahmood H (2012). Does financial development reduce CO2 emissions in Malaysian economy? A time series analysis. MPRA paper no. 40603

Shahbaz M, Hye QMA, Tiwari AK, Leitão NC (2013a) Economic growth, energy consumption, financial development, international trade and CO2 emissions in Indonesia. Renew Sust Energ Rev 25: 109–121

Shahbaz M, Solarin SA, Mahmood H, Arouri M (2013b) Does financial development reduce CO2 emissions in Malaysian economy? A time series analysis. Econ Model 35:145–152

Shahbaz M, Tiwari AK, Nasir M (2013c) The effects of financial development, economic growth, coal consumption and trade openness on CO2 emissions in South Africa. Energy Policy 61:1452–1459

Shahbaz M, Destek MA, Polemis ML (2018) Do foreign capital and financial development affect clean energy consumption and carbon emissions? Evidence from BRICS and Next-11 countries. SPOUDAI-J Econ Bus 68(4):20–50

Shahzad SJH, Rehman MU, Hurr M, & Zakaria M (2014). Do economic and financial development increase carbon emission in Pakistan: empirical analysis through ARDL cointegration and VECM causality. MPRA paper no. 60310

Shahzad SJH, Kumar RR, Zakaria M, Hurr M (2017) Carbon emission, energy consumption, trade openness and financial development in Pakistan: a revisit. Renew Sust Energ Rev 70:185–192

Sharif A, Raza SA, Ozturk I, Afshan S (2019) The dynamic relationship of renewable and nonrenewable energy consumption with carbon emission: a global study with the application of heterogeneous panel estimations. Renew Energy 133:685–691

Shi X, Liu H, Riti JS (2019) The role of energy mix and financial development in greenhouse gas (GHG) emissions' reduction: evidence from ten leading CO 2 emitting countries. Econ Polit 36(3):695–729

Siddique HMA (2017) Impact of financial development and energy consumption on CO2 emissions: evidence from Pakistan. Bull Bus Econ 6:68–73

Solarin SA (2014) Tourist arrivals and macroeconomic determinants of CO2 emissions in Malaysia. Anatolia 25(2):228–241

Stanley TD (2005) Beyond publication bias. J Econ Surv 19(3):309–345

Stanley TD (2008) Meta-regression methods for detecting and estimating empirical effects in the presence of publication selection. Oxford Bulletin of Economics and statistics, 70(1):103–127

Stanley, T. D., Doucouliagos, H., Giles, M., Heckemeyer, J. H., Johnston, R. J., Laroche, P., ... & Rosenberger, R. S. (2013). Meta-analysis of economics research reporting guidelines. J Econ Surv, 27(2), 390–394

Sy A, Tinker T, Derbali A, Jamel L (2016) Economic growth, financial development, trade openness, and CO2 emissions in European countries. Afr J Acc Aud Finance 5(2):155–179

Tamazian A, Rao BB (2010) Do economic, financial and institutional developments matter for environmental degradation? Evidence from transitional economies. Energy Econ 32(1):137–145

Tamazian A, Chousa JP, Vadlamannati KC (2009) Does higher economic and financial development lead to environmental degradation: evidence from BRIC countries. Energy Policy 37(1):246–253

Tsaurai K (2019) The impact of financial development on carbon emissions in Africa. Int J Energy Econ Policy 9(3):144–153

Ugur M (2014) Corruption's direct effects on per-capita income growth: a meta-analysis. J Econ Surv 28(3):472–490

World Bank (2000) Is Globalization Causing a „Race to the Bottom "in Environmental standard. PREM Economic Policy Group and Development Economics Group

Xiong L, Tu Z, Ju L (2017) Reconciling regional differences in financial development and carbon emissions: a dynamic panel data approach. Energy Procedia 105:2989–2995

Xu Z, Baloch MA, Meng F, Zhang J, Mahmood Z (2018) Nexus between financial development and CO 2 emissions in Saudi Arabia: analyzing the role of globalization. Environ Sci Pollut Res 25(28):28378–28390

You WH, Zhu HM, Yu K, Peng C (2015) Democracy, financial openness, and global carbon dioxide emissions: heterogeneity across existing emission levels. World Dev 66:189–207

Zaidi SAH, Zafar MW, Shahbaz M, Hou F (2019) Dynamic linkages between globalization, financial development and carbon emissions: evidence from Asia Pacific economic cooperation countries. J Clean Prod 228:533–543

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