Financial development–ecological footprint nexus in Malaysia: the role of institutions

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Abstract

Purpose – Motivated by the conflicting evidence on the effect of financial development on environmental quality, this study investigates the moderating role of institutional quality in the link between financial development and environmental quality using a robust proxy in Malaysia from 1984 to 2017.

Design/methodology/approach – Ecological footprint is used to measure environmental quality, while financial development is proxied using three measures (domestic credit provided by the private sector, domestic credit provided by the financial sector and domestic credit provided by the banking sector). An index of institutional quality is generated from voice and accountability, government effectiveness, regulatory quality, rule of law and control of corruption. Autoregressive Distributed Lag Bounds Test, Fully Modified Ordinary Least Square and Canonical Cointegrating Regression were used as the estimation techniques.

Findings – The results show that financial development, institutional quality, economic growth and foreign direct investment improve environmental quality in the short run, whereas trade openness and natural resources worsen it. In the long run, financial development, institutional quality, economic growth, trade openness and natural resources deteriorate the environment. Furthermore, findings from the interactive term suggest that institutions and financial development complement each other to affect the environment in the short run. However, institutions and financial development perform a substitutability role in influencing the environment in the long run.

Practical implications – The outcome of this study suggests that there are time lags in the relationship between institutional quality, financial development and ecological footprint in Malaysia. Furthermore, the study offers important policy implications to policymakers in Malaysia and other developing countries on how to mitigate environmental degradation.

Originality/value – This study contributes to the body of knowledge on the moderating role of institutional quality in the relationship between financial development and ecological footprint in Malaysia. It examines the direct and indirect effects of financial development on environmental degradation through institutional quality, which have received less attention in the context of Malaysia. The findings from this study are robust to different proxies and estimation techniques.

Keywords Ecological footprint, Financial development, Institutional quality, Malaysia

Paper type Research paper

JEL Classification — O17, P48, Q53

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1. Introduction

This study examines the role of institutional quality in the relationship between financial development and ecological footprint in Malaysia. The study is motivated based on three main strands in the research circles. First, the conflicting evidence on the role of financial development on environmental quality and degradation (Katircioğlu and Taşpinar, 2017; Rasoulinezhad and Saboori, 2018). Financial development could worsen/improve environmental quality through an increase in income, production, and technology effects. A sound financial system will increase credit availability by allowing household and firms to increase their income, consumption and production which stimulate growth in the long run. With increasing access to credit provided by the financial sector, firms and households can invest in green energy, R&D and energy-intensive technologies which enhances environmental sustainability (Gill *et al.*, 2019; Lahiani, 2020; Liu and Song, 2020; Sharimakin and Dada, 2020). On the other hand, weak financial sector development could allow sharp practices which channel credit to non-environmental-friendly activities (Pata, 2018). Also, access to capital could make investors set up new plants and machinery which in turn leads to an increase in energy demand and discharges of more waste and emission into the environment (Danish *et al.*, 2018; Baloch *et al.*, 2019). Studies by Al-Mulali and Sab (2012), Xu *et al.* (2018), Pata (2018) and Yang *et al.* (2021a, b) among others conclude that financial development worsens environmental sustainability through an increase in the level of production and consumption which intensify energy consumption. However, Omri *et al.* (2015), Shahbaz *et al.* (2016), Rasoulinezhad and Saboori (2018), Majeed and Mazhar (2019), Dogan *et al.* (2019), Yao *et al.* (2021) and Dada *et al.* (2022) among others submit that financial development reduces environmental degradation through investment in R&D and cleaner and renewable energies. The mixed evidence in the literature and most importantly the negative effect of financial development on environmental quality suggests the need for absorptive variables that could moderate the growth benefit of finance to environmental sustainability. These absorptive capacities are certain qualities that domestic economy must possess for the environment to benefit from financial development.

Second, previous studies fail to examine the role of institutional quality as an absorptive capacity in the relationship between financial sector development and ecological footprint. Institutions play a crucial role in maintaining environmental quality especially in developing countries (Panayotou, 1996; Deacon, 2003; Ibrahim and Law, 2015; Dada and Ajide, 2021; Dada *et al.*, 2021a, b). Strong institutional environment and framework facilitate efficient allocation of resources to productive activities, thus promoting environmental sustainability (Haini, 2020; Fernández and Tamayo, 2017; Law *et al.*, 2014; Olaniyi and Oladeji, 2021). However, a weak institutional environment enhances opportunistic behaviour in the financial system, which leads to diversion of credit to activities that affect the environment negatively. Furthermore, institutions may play a complementary or substitutability role to financial development in maintaining environmental sustainability. Institution plays a complementary role when strong institution and financial sector works simultaneously to reduce environmental degradation. The substitutability role occurs when strong institutional framework covers the lapses and loopholes in the financial sector to abate environmental degradation.

Third, most studies in the environment literature measure environmental quality using CO_2 emission (Akinlo and Dada, 2021; Dada *et al.*, 2021a, b; Huynh and Ho, 2020; Hanif, 2018). This measure is limited and weak in measuring environmental quality since it only measures air contamination and not total human activities on the environment (Usman and Hammar, 2021; Usman *et al.*, 2022). Thus, Ecological Footprint (henceforth EFP), which overcomes the deficiency of traditional measures of environmental quality has emerged. EFP provides an inclusive indicator of environmental degradation and environmental sustainability as it encapsulates all the three types of pollution (Solarin *et al.*, 2019; Solarin and Bello, 2018;

Yang *et al.*, 2021a, b; Dada *et al.*, 2022). Furthermore, EFP captures both direct and indirect effects of production and consumption on the environment (Ulucak and Bilgili, 2018) and natural resources consumption (Teixidó-Figueras and Duro, 2015).

Summing up the above discussion, it is important to assess the moderating role of institutions in financial development-environmental quality nexus due to the contradictory evidences in the empirical literature, using a refined measure of environmental quality. This empirical study fills this gap. The contributions of this study to the body of knowledge are as follows: (1) The study examines the moderating role of institutional quality in the nexus between financial development and environmental quality. Specifically, the direct effect of financial development on environmental quality and the indirect effect of financial development through the presence of institutional quality on environmental quality is investigated. (2) This study uses a robust proxy to measure environmental quality, financial development and institutional quality. EFP which captures the total anthropogenic on the environment is used to measure environmental quality. To the best of our knowledge, most of the previous studies that have examined the nexus between financial development and environmental qualities in Malaysia have proxy environmental quality using CO_2 emission, which does not represent the total anthropogenic activities on the environment. Furthermore, financial development is measured using three different proxies as indicated by World Bank. These are domestic credit provided by the private sector, domestic credit provided by the financial sector and domestic credit provided by the banking sector. For institutional quality, five variables namely voice and accountability, government effectiveness, regulatory quality, rule of law, and control of corruption are rescaled on an ordinary scale of 0–10 to generate an index of institutional quality. (3) This study is centred on Malaysia due to its rising environmental degradation despite various laws such as the Environmental Quality Act of 1974, Environmental quality Order of 1987 among others enacted by the government (Shahbaz *et al.*, 2013). In addition, Malaysia is a party to various treaties on the environment such as the Rio convention of 1992, the Kyoto protocol of 1997, Copenhagen Accord of 2009, Convention on Biological Diversity (CBD), etc. A cursory look at Figure 1 shows that Malaysia began to witness an ecological deficit

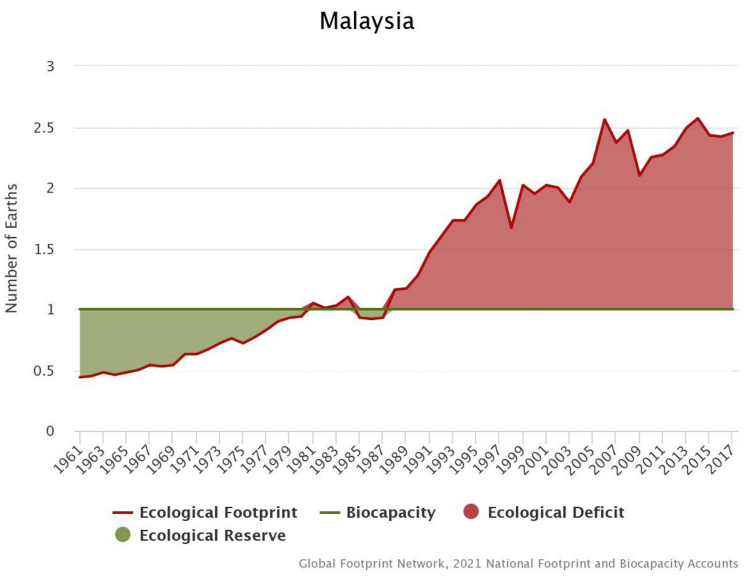

Figure 1. Ecological footprint and bio-capacity in Malaysia

(i.e. EFP exceeded its bio-capacity) from 1980 and this became more pronounced in 1987. As a result of this, the ecological footprint of Malaysia soared more than 140% for the period 1971 to 2017, while the bio-capacity during this period fell by more than 50% (Ahmed *et al.*, 2019; GFN, 2021). Similarly, the financial sector is one of the fastest growing sectors in Malaysia (Ali *et al.*, 2016), and it is one of the factors responsible for the annual growth rate of over 6% recorded between 1971 and 2017 (Bekhet *et al.*, 2017; Ahmed *et al.*, 2019). (4) Autoregressive Distributed Lag (ARDL) is used to estimate both the short and long runs effect which is important for policy prescription.

The remaining part of this article is sectionalised as follows. Literature review is presented in Section 2, while Section 3 describes the methodology. Results and discussion are presented in Section 4, while Section 5 concludes the paper.

2. Literature review

In the literature, the Environmental Kuznets curve (EKC) framework has been used to explain the relationship between income and the environment (Grossman and Krueger, 1991, 1994). The EKC hypothesis suggests an inverted *U* shape relationship between economic growth and pollution emissions (Grossman and Krueger, 1991, 1994; Shafk, 1994; Shafk and Bandyopadhyay, 1992). That is, pollution emission rises at the early stage of economic growth, but decreases after a particular threshold of income/economic growth. The EKC hypothesis gain support from early researchers, however, later studies found mixed results concerning the EKC hypothesis. These mixed results generated criticisms that the EKC framework failed to consider other structural, institutional, and macroeconomic variables that tend to influence the environment. Furthermore, recent studies have incorporated structural, institutional, and macroeconomic variables in testing the EKC hypothesis using CO_2 emission, nitrogen dioxide (NO2), sulphur dioxide, industrial waste, water pollution, threatened species, and deforestation to measure environmental degradation (Kubicova, 2014; Opoku and Boachie, 2020; Dada and Ajide, 2021; Akinlo and Dada, 2021; Dada and Akinlo, 2021). Nevertheless, these proxies only capture part of the environmental pollution; that is they do not represent the entire human activities on the environment.

Thus, to resolve the aforementioned problem, Ecological Footprint (EFP) is being used. EFP provides a single indicator of environmental degradation and environmental sustainability (Solarin *et al.*, 2019; Usman and Makhdum, 2021). EFP captures biologically productive land and water an individual and the entire population consumes; and also, the human-caused pressure on the environment (Nathaniel *et al.*, 2020a, b; Ulucak and Bilgili, 2018). The EFP measures the environment in six main areas namely; "*the built-up land, carbon emissions, cropland, fishing grounds, forestry products, and grazing land (Ecological Footprint Network (EFN), 2019)*", thus providing a wide-ranging measure of environmental degradation, and an unswerving and vigorous result than other conventional proxies.

On the impact of financial development on EFP, empirical results can be generally regarded as inconclusive. Table 1 provides a summary of recent empirical studies that have investigated the effect of institutional, structural, and macroeconomic variables on environmental degradation/quality using diverse proxies. The mixed results of the extant studies on the effect of financial development on the environment have prompted the need to explore other variables (such as institutions) that could serve as absorptive capacity. Furthermore, no known study especially in Malaysia has examined the moderating role of institutional quality in the nexus between financial development and EFP, hence the necessity for this study.

Table 1. Empirical literature

Study	Data Span	Measurement of environmental quality (MEQ)	Country	Method	Findings
Shahbaz *et al.* (2013)	1971–2011	CO_2	Malaysia	ARDL	FD → EQ
Ali *et al.* (2016)	1971–2012	CO_2	Malaysia	ARDL, DOL	EKC valid
Maji *et al.* (2017)	1980–2014	CO_2	Malaysia	ARDL	FD ← EQ
Xu *et al.* (2018)	1971–2016	CO_2	Saudi Arabia	ARDL, VECM	FD, EC ← EQ FD <==> CO_2
Yasin *et al.* (2019)	1996–2016	EFP	110 countries	Second generation estimation techniques	EKC valid, FD ← EQ TOP, INS and URB → EQ
Hafeez *et al.* (2019)	1980–2016	CO_2	56 countries	DOL, FMOL, D-H	EKC valid FD ← EQ FD <==> CO_2
Ahmed *et al.* (2019)	1971–2014	EFP	Malaysia	ARDL	GLO, EC, EG ← EQ
Destek and Sarkodie (2019)	1977–2013	EFP	China and Malaysia		FD → EQ
Dogan *et al.* (2019)	1971–2013	EFP	MINT countries	ARDL	EKC valid EC, FD, URB, EX → EQ
Baloch *et al.* (2019)	1990–2016	EFP	59 Belt and Road Countries	D-K	FD, EG, EC, FDI, URB ← EQ
Lahiani (2020)	1977–2013	CO_2	China	NARDL	+FD → EQ
Rahman *et al.* (2019)	1991–2014	EFP	16 CEE countries	DSUR D-H	FD, EC ← EQ REW → EQ FD <==> EFP
Saud *et al.* (2019a)	1990–2014	EFP	OBORI countries	PMG	FD, GLO ← EQ FD, GLO<==> EFP
Saud *et al.* (2019b)	1980–2016	CO_2	CEEC	DSUR, D-H	EKC valid FD, EG, EC ← EQ TOP, URB → EQ
He *et al.* (2019)	1978–2013	EFP	Malaysia	ARDL	EKC not valid EG, EC, TOP ← EQ
Godil *et al.* (2020)	1986–2018	EFP	Turkey	QARDL	EKC valid TOR, FD, GLO ← EQ

(*continued*)

Table 1.

Study	Data Span	Measurement of environmental quality (MEQ)	Country	Method	Findings
Omoke *et al.* (2020)	1971–2014	EFP	Nigeria	NARDL	+FD → EQ –FD ← EQ
Usman *et al.* (2020)	1995–2017	EFP	20 highest Emitting Countries	AMG	EKC not valid FD, EC ← EQ TOR → EQ
Yang *et al.* (2021a)	1990–2016	EFP	BRICS	Second generation estimation techniques	FD REM← EQ TEC → EQ EKC valid
Yang *et al.* (2021b)	1990–2017	EFP	Six Gulf Cooperation Council	Second generation estimation techniques	GLO, FD, EC ← EQ
Pata and Yilanci (2020)	1980–2015	EFP	G7	Threshold cointegration test	FD, GLO → EQ FD GLO = => EQ
Rafique *et al.* (2020)	1990–2017	CO_2	BRICS	AMG, D-H	FDI, FD, TEC → EQ EG, EC, TOP, URB ← EQ FD, EG, TOP EC <==> CO_2
Yasin *et al.* (2019)	1996–2016	CO_2	59 less developed countries	EGLS, GMM	FD, EC ← EQ INS TOP → EQ
Yao *et al.* (2021)	1995–2014	EFP, EG	BRICS and Next 11	SGMM	FD NAT TEC → EQ
Dada *et al.* (2022)	1970–2017	EFP	Nigeria	ARDL	EG, TOP, POP, FDI ← EQ FD, NAT, URB → EQ
Usman and Hammar (2021)	1990–2017	EFP	APEC	Second generation techniques	FD, REW →EQ TEC, EG, POP ← EQ FD, REW, TEC, EG, POP <==>EQ
Ahmed *et al.* (2021)	1971–2016	EFP	Japan	ARDL, NARDL	FD, +FD, -FD, EC, GLO ← EQ +GLO, −GLO → EQ
Usman and Makhdum (2021)	1990–2018	EFP	BRICS-T	Second generation techniques	NREW, FD ← EQ REW → EQ

(*continued*)

Table 1.

Study	Data Span	Measurement of environmental quality (MEQ)	Country	Method	Findings
Baloch *et al.* (2021)	1990–2017	CO_2	OECD	PMG/ARDL	EKC valid FD, GLO → EQ
Kihombo *et al.* (2021)	1990–2017	CO_2	11 West Asia and Middle East countries	DSUR, D-H	R&D → EQ FD, EI ← EQ FD, R&D <==> CO_2
Destek and Manga (2021)	1995–2016	EFP	BEM countries	Second generation techniques	TEC → EQ FD ← EQ
Zafar *et al.* (2021)	1990–2017	CO_2	45 Asian countries	FMOLS, D-H	FD ← EQ GLO → EQ
Usman *et al.* (2021a)	1990–2017	GHG	8 Arctic countries	Second generation techniques	REW, FD → EQ GLO, EG, EC ← EQ
Usman *et al.* (2021b)	1990–2014	EFP	20 Asian economies	Second generation techniques	EG, NREW ← EQ REW → EQ
Usman *et al.* (2022)	1990–2018	EFP	Financially resource-rich countries	Second generation techniques	FD, NAT, NREW ← EQ GLO, REW → EQ

Note(s): Where EFP is ecological footprint, CO_2 is carbon emission, GHG is greenhouse gases, EG is economic growth, FD is financial development, INS is institution, URB, is urbanization, TOR is tourism, GLO is globalization, EKC is environmental Kuznets curve, EC is energy consumption, EI is energy intensity, EQ is environmental quality, REM is remittances, TEC is technological innovation, EX is export, REW is renewable energy, NAT is natural resources, NREW is non-renewable energy "←" means worsening environmental quality while " →" signifies an improvement in environmental quality, "<==>" means bidirectional, "= =>" suggest one-way causality, "+" means positive shock, "–" negative shock

3. Materials and methodology

This study examines the role of institutions in the link between financial development and ecological footprint in Malaysia over the period of 1984–2017. In order to achieve the objective of the study, the study modified existing model in the environmental literature to include institutional quality (Baloch *et al.*, 2019; Ahmad *et al.*, 2020; Omoke *et al.*, 2020; Alola *et al.*, 2019; Yang *et al.*, 2021a, b; Dada *et al.*, 2022). Thus, the base-line model is stated as follows:

$$EFP = f(GDP, FD, INS, X) \tag{1}$$

where EFP_t is ecological footprint. GDP represents economic growth, FD is financial development, INS is institutional quality and X a vector of other control variables related to EFP. Equation (1) is expressed as

$$EFP_t = \alpha + \beta_1 GDP_t + \gamma_1 FD_t + \delta_1 INS_t + \kappa_1 X_t + \varepsilon_t \tag{2}$$

ε_t is the error term. To account for the moderating role of institutional quality in the nexus between finance and EFP in Malaysia, an interactive term of the institution and financial development is added to equation (2).

$$EFP_t = \alpha + \beta_1 GDP_t + \gamma_1 FD_t + \delta_1 INS_t + \eta_1 (FD_t * INS_t) + \kappa_1 X_t + \varepsilon_t \tag{3}$$

where $FD_t * INS_t$ is the interactive term that mediates the role of financial development on EFP. Following equation (3), a positive significant effect of the interactive term (η) shows a complementarity between financial development and institutional quality in reducing environmental degradation. In order words, finance and institutions work hand in hand to improve environmental quality. On the other hand, a negative significant value of the interactive term suggests substitutability between financial development and institutional quality in affecting EFP. Thus, institutions substitute for the weak financial system. While an insignificant coefficient of the interactive term indicates that neither financial development nor institutional quality complement or substitute in reducing environmental degradation. The *a priori* expectations of other variables are ambiguous. Positive (negative) values of the parameters suggest an increase (reduction) in environmental degradation.

To account for the short-run and long-run moderating role of institutional quality in the link between financial development and EFP, Autoregressive Distributed Lag (ARDL) is employed. The approach is advantageous to this study since it produces an unbiased estimate, accommodates I(0) and I(1) variables and also allows checking the existence of long-run relationship through the bound test (Fabiyi and Dada, 2017; Dada and Fanowopo, 2020). The ARDL specification of the equation is stated thus:

$$\begin{aligned}\Delta EFP_t = \alpha &+ \sum_{j=1}^{o} \rho_j \Delta EFP_{t-j} + \sum_{j=0}^{p} \beta_j \Delta GDP_{t-j} + \sum_{j=0}^{n} \gamma_j \Delta FD_{t-j} + \sum_{j=0}^{s} \delta_j \Delta INS_{t-j} \\ &+ \sum_{j=0}^{m} \eta_j \Delta (FD*INS)_{t-j} + \sum_{j=0}^{q} \kappa_j \Delta X_{t-j} + \lambda_1 EFP_{t-1} + \lambda_2 GDP_{t-1} + \lambda_3 FD_{t-1} + \lambda_4 INS \\ &+ \lambda_5 (FD*INS)_{t-1} + \lambda_6 X_{t-1} + e_t\end{aligned} \tag{4}$$

From equation (4), the short-run movements are preceded with Δ, while the long-run coefficients are λ_j ($j = 1, 2, \ldots, 6$). The optimum lag length that is chosen by Akaike Information Criterion is denoted by o, p, n, s, m, and q. e_t is the white noise. Similarly, from equation (4), the null hypothesis of no long-run cointegration ($\lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5 = \lambda_6 = 0$) is tested against the alternative hypothesis of long-run cointegration ($\lambda_1 \neq \lambda_2 \neq \lambda_3 \neq \lambda_4 \neq \lambda_5 \neq \lambda_6 \neq 0$).

Furthermore, Augmented Dickey-Fuller (ADF) and Philip and Perron unit root tests, and Zivot and Andrews single break unit root test are used to access the level of stationarity of the variable. This is important in order not to include I(2) variable(s), which makes ARDL *F*-statistic not reliable. For robustness check, Fully Modified Ordinary Least Squares (FMOLS) and Canonical Cointegrating Regression (CCR) are used to verify the long run results of the ARDL bound test.

Measurement and description of variables used are presented in Appendix

4. Results and discussions

4.1 Statistical and econometric criteria

This section examines both the statistical and econometric criteria of the variables and models used in this study. Descriptive statistics and pairwise correlation is used to drive out the statistical criteria, while the econometric criteria are unit root tests and ARDL bound testing. The result of descriptive statistics and correlation are presented in Table 2. The result suggests that the mean value of EFP per capita is 3.413 which is less than its median value. This signifies that EFP in Malaysia is negatively skewed. Financial sector development proxies by domestic credit provided the financial sector (DCFS), domestic credit to the private sector (DCPS) and domestic credit to the private sector by bank (DCPSB) have mean values of 128.257, 112.074, and 111.069 respectively. Even though credit provided by the financial sector has the highest maximum value (163.355), domestic credit to the private sector is the most dispersed variable among the three proxies of financial sector development. In terms of skewness, domestic credit provided by the financial sector is negatively skewed, while other proxies are positively skewed.

Furthermore, the average value of the institutional quality index (INS) is 4.404 while its median and maximum values are 4.442 and 5.183 respectively on an ordinary scale of 0–10. This suggests that the value of institutional quality is relatively below average in Malaysia, which is also supported by the negative value of the skewness statistics. Kurtosis, which measures the peakness of the distribution shows that institutional quality is platykurtic relative to normal distribution since its value is less than 3. The average value of real GDP per capita (GDP) is 7157.206 which is higher than the middle value (7024.355). This suggests that the GDP per capita distribution is positively skewed. The highest per capita income in Malaysia was $11728.980, recorded in 2017, while the least value of $3708.5 was witnessed in 1986. Other variables such as foreign direct investment (FDI), natural resources (NAT), population (POP), and trade openness (TOP) have the values of their mean and median very close, suggesting that those variables have a normal distribution. Further, the variables fall within their respective minimum and maximum value. All the variables used in this study exhibit normal distribution as revealed by the Jacque-Bera probabilities.

Pairwise correlation presented at the lower section of Table 2 reveals that the variables have a moderate correlation with each other except for highly correlated measures of financial development. Since these measures of financial development are introduced separately into the modes, thus, it posed no problem to the regression results. From the correlation matrix, institutional quality (INS), natural resources (NAT), and population (POP) are negatively correlated with EFP, while measures of financial development, economic growth, foreign direct investment are positively related to EFP in Malaysia.

The unit root tests (ADF and PP) and structural break unit root test in Tables 3 and 4 respectively show that the variables are combination of I(0) and I(1) variables (i.e. stationary at level and first difference). Specifically, the Zivot and Andrew structural break show that breaks occur during 1998, 2009, 1992, 1992, 1988, 1998, 2000, 1991, 2016 and 2000 for EFP, domestic credit provided the financial sector, domestic credit to the private sector, domestic credit to the private sector by bank, institutional quality, economic growth, foreign direct

Table 2. Descriptive statistics and pairwise correlation matrix

	EFP	DCFS	DCPS	DCPSB	INS	GDP	FDI	NAT	POP	TOP
Mean	3.413	128.257	112.074	111.069	4.404	7157.206	3.874	14.127	2.181	164.034
Median	3.635	130.451	110.412	110.179	4.442	7024.355	3.501	11.840	2.260	158.629
Maximum	4.450	163.355	158.505	154.892	5.183	11728.980	8.761	27.510	2.984	220.407
Minimum	1.960	72.674	69.413	69.413	3.233	3708.500	0.057	5.510	1.340	105.057
Std. Dev	0.684	20.152	21.653	20.289	0.475	2347.242	1.913	6.192	0.526	34.817
Skewness	−0.863	−0.901	0.191	0.026	−0.395	0.175	0.541	0.852	−0.258	−0.072
Kurtosis	2.693	4.141	2.969	2.959	2.737	2.052	3.539	2.585	1.833	1.837
Jarque-Bera	4.354	2.447	0.207	0.006	0.982	1.448	2.067	4.353	2.306	1.944
Probability	0.113	0.140	0.902	0.997	0.612	0.485	0.356	0.113	0.316	0.378
Observations	34.000	34.000	34.000	34.000	34.000	34.000	34.000	34.000	34.000	34.000
EFP	1	0.201	0.507	0.528	−0.028	0.843	0.164	−0.227	−0.756	0.560
DCFS		1	0.823	0.832	−0.054	0.307	−0.408	−0.513	−0.216	0.177
DCPS			1	0.997	0.184	0.405	−0.027	−0.729	−0.256	0.557
DCPSB				1	0.172	0.440	−0.036	−0.749	−0.294	0.535
INS					1	−0.266	0.188	−0.033	0.265	0.235
GDP						1	−0.089	−0.634	−0.456	0.176
FDI							1	0.069	0.161	0.162
NAT								1	0.780	−0.481
POP									1	−0.056
TOP										1

Note(s): EFP is ecological footprint, DCFS is domestic credit provided by the financial sector, DCPS is domestic credit to the private sector, DCPSB is domestic credit to the private sector by bank, INS is institutional quality, GDP is economic growth, FDI is foreign direct investment, NAT is natural resources rent, POP is the population growth rate and TOP is trade openness

Table 3. Unit root tests

Philip Perron unit root test (PP) At level		EFP	DCFS	DCPS	DCPSB	INS	GDP	FDI	NAT	POP	TOP
With Constant	*t*-Statistic	−1.407	−2.713*	−2.181	−2.249	−2.526	1.429	−2.824*	−0.970	0.171	−1.555
With Constant and Trend	*t*-Statistic	−2.155	−2.724	−2.020	−2.106	−2.572	−2.179	−2.850	−2.033	−4.225**	−0.802
Without Constant and Trend	*t*-Statistic	1.023	−0.001	0.214	0.273	−0.782	5.812	−1.015	−1.377	−1.430	0.061
At first difference		d(EFP)	d(DCFS)	d(DCPS)	d(DCPSB)	d(INS)	d(GDP)	d(FDI)	d(NAT)	d(POP)	d(TOP)
With Constant	*t*-Statistic	−8.516***	−5.351***	−4.82***	−5.091***	−4.083***	−5.137***	−6.504***	−5.603***	−2.634*	−3.750***
With Constant and Trend	*t*-Statistic	−14.433***	−5.247***	−4.773***	−5.036***	−4.005**	−5.321***	−6.518***	−5.515***	−1.942	−5.438***
Without Constant and Trend	*t*-Statistic	−7.864***	−5.422***	−4.885***	−5.156***	−4.132***	−2.934***	−6.623***	−5.49***	−2.321**	−3.78***
Augmented Dickey-Fuller unit root test (ADF) At level		EFP	DCFS	DCPS	DCPSB	INS	GDP	FDI	NAT	POP	TOP
With Constant	*t*-Statistic	−1.630	−5.369***	−1.965	−2.146	−2.321	1.429	−2.805*	−0.832	−0.451	−1.892
With Constant and Trend	*t*-Statistic	−2.321	−4.847***	−4.350***	−4.302**	−2.335	−1.913	−2.851	−1.714	−2.187	−0.860
Without Constant and Trend	*t*-Statistic	1.055	0.012	0.020	0.303	−0.754	5.892	−0.593	−1.442	−3.512***	0.170
At first difference		d(EFP)	d(DCFS)	d(DCPS)	d(DCPSB)	d(INS)	d(GDP)	d(FDI)	d(NAT)	d(POP)	d(TOP)
With Constant	*t*-Statistic	−8.181***	−5.339***	−4.829***	−5.103***	−4.260***	−5.145***	−5.210***	−5.566***	−3.235**	−3.697***
With Constant and Trend	*t*-Statistic	−8.338***	−5.247***	−4.782***	−5.049***	−4.199**	−5.321***	−5.206***	−5.467***	−2.218	−4.466***
Without Constant and Trend	*t*-Statistic	−7.917***	−5.423***	−4.893***	−5.165***	−4.294***	−2.834***	−5.295***	−5.399***	−0.790***	−3.729***

Note(s): Where ***, **, * represent 1%, 5% and 10% level of significant respectively

Table 4. Unit root with single structural break

Variables	At level With Constant	At level Breakpoint	At first difference With Constant	At first difference Breakpoint	Status
EFP	−3.680	1,990	−9.286***	1,998	I(1)
DCFS	−5.795***	2,009			I(0)
DCPS	−3.982	1,996	−5.770***	1,992	I(1)
DCPSB	−3.750	1,996	−6.108***	1,992	I(1)
INS	−3.664	2,010	−5.649***	1,988	I(1)
GDP	−0.201	2,010	−6.793***	1,998	I(1)
FDI	−6.811***	2,000			I(0)
NAT	−3.702	1,990	−6.805***	1,991	I(1)
POP	−3.210	1,996	−4.534***	2,016	I(1)
TOP	−2.470	2,004	−5.626***	2,000	I(1)

Note(s): ***, **, * represent 1%, 5 and 10% respectively

investment, natural resources, population, and trade openness respectively. Since the dependent variable (EFP) is stationary at the first difference, and other independent variables are mixture of I(1) and I(0) variables, then the technique of estimation adopted in this study is justified. The ARDL bound test of the long-run relationship is presented in Table 5. In model 1, domestic credit provided by the financial sector is used as the measure of financial development and interacted with institutional quality while in model 2, domestic credit to the private sector by bank is interacted with institutional quality. Further, domestic credit to the private sector is used as the measure of financial development and interacted with institutional quality in model 3. The results in Table 5 reject the null hypothesis of no long-run relationship among the variables since the *F*-statistics in all the models is higher than the upper bound critical values at different levels of significance.

4.2 Short- and long-run moderating effect of institutional quality in financial development-ecological footprint nexus

The results of the short- and long-run effect of institutional and macroeconomic variables on EFP are presented in Table 6. Financial sector development reduces ecological footprint in the short run but contributes positively to it in the long run in all the models estimated using different proxies of financial sector development. Specifically, domestic credit by the financial sector, domestic credit by the private sector and domestic credit provided by bank significantly reduces ecological footprint by 0.082%, 0.079% and 0.078 respectively in the

Table 5. ARDL Bounds Test (H_0: No long-run relationship)

	ARDL models selected	*F*-statistic	*K*
Model 1 (DCFS)	(1, 2, 2, 2, 2, 2, 1, 2, 2)	7.775***	8
Model 2 (DCPS)	(1, 2, 2, 2, 2, 2, 2, 2, 2)	5.156***	8
Model 3 (DCPSB)	(1, 2, 2, 2, 2, 2, 2, 2, 2)	4.940***	8
Critical Values		10% 1.85–2.85	
		5% 2.11–3.15	
		2.5% 2.33–3.42	
		1% 2.62–3.77	

Note(s): (1) ***, **, * indicate significance at 1%, 5 and 10% respectively. (2) In Model 1, domestic credit by the financial sector is used as a proxy of the financial sector and interacted with institutional quality. (3) In Model 2, domestic credit by the private sector is interacted with institutional quality. (4) In Model 3, domestic credit provided by bank is used as a measure of financial development and interacted with institutional quality

Variable	Model 1 Coefficient	Model 1 *t*-Statistic	Model 2 Coefficient	Model 2 *t*-Statistic	Model 3 Coefficient	Model 3 *t*-Statistic
Short run Estimate						
D(GDP)	−0.0006***	−8.4643	−0.0006***	−4.9979	−0.0006***	−4.9080
D(GDP(−1))	−0.0005***	−6.1742	−0.0010***	−8.6746	−0.0011***	−8.7766
D(DCFS)	0.0094	0.8620				
D(DCFS(−1))	−0.0829***	−5.7762				
D(DCPSB)			−0.0798***	−5.1511		
D(DCPSB(−1))			−0.1751***	−7.6685		
D(DCPS)					−0.0778***	−5.1969
D(DCPS(−1))					−0.1874***	−8.0418
D(INS)	−0.0452	−0.1258	−2.5432***	−6.8285	−2.5047***	−6.8747
D(INS(−1))	−2.4125***	−5.0858	−3.2439***	−6.3789	−3.5955***	−6.8853
D(DCFS*INS)	0.0025	1.0550				
D(DCFS*INS) (−1))	0.0174***	5.3961				
D(DCPSB*INS)			0.0237***	6.9198		
D(DCPSBI*INS) (−1))			0.0362***	7.5154		
D(DCPS*INS)					0.0235***	7.0014
D(DCPS*INS(−1))					0.0392***	7.9386
D(FDI)	0.0674***	5.0315	0.2637***	11.4779	0.2561***	11.090
D(FDI(−1))	−0.0522***	−4.7281	−0.1880***	−11.572	−0.1769***	−10.8992
D(NAT)	0.0986***	8.7495	0.1727***	10.8746	0.1744***	10.3751
D(NAT(−1))			0.0844***	7.1567	0.0709***	5.7865
D(POP)	1.4667*	2.0338	−9.1929***	−9.9383	−9.0788***	−9.3994
D(POP(−1))	−8.7275***	−8.2186	7.0121***	8.1944	6.6293***	7.5153
D(TOP)	0.0096***	5.5849	0.0082***	4.3959	0.0112***	5.6836
D(TOP(−1))	0.0046**	2.4073	0.0058**	3.0101	0.0071**	3.4815
CointEq(−1)*	−0.6644***	−13.3311	−0.7928***	−11.3542	−0.8885***	−11.1138
Long run Estimate						
GDP	0.0008**	2.6539	0.0003**	2.6912	0.0004**	2.8586
DCFS	0.1555**	2.3500				
DCPSB			0.2909**	2.3050		
DCPS					0.2767**	2.3217
INS	4.8449**	2.3429	5.3889**	2.2705	5.2729**	2.3147
DCFS*INS	−0.0302*	−2.1938				
DCPSB*INS			−0.0550**	−2.2462		
DCPS*INS					−0.0525**	−2.2643
FDI	0.0553	0.7144	0.5714	1.2338	0.5019	1.2294
NAT	0.1804***	4.3931	0.2225**	2.0944	0.2340**	2.2245
POP	1.0772	0.9045	−1.4552	−0.5709	−1.3813	−0.5761
TOP	0.0086**	2.5999	0.0158**	2.2519	0.0161	2.3745
C	−33.2334**	−2.6543	−32.5276	−1.3484	−32.177	−1.4229

Note(s): (1) ***, **, * indicate significance at 1%, 5 and 10% respectively. (2) In Model 1, domestic credit by the financial sector is used as a proxy of the financial sector and interacted with institutional quality. (3) In Model 2, domestic credit by the private sector is interacted with institutional quality. (4) In Model 3, domestic credit provided by bank is used as a measure of financial development and interacted with institutional quality

Table 6. Short-run and long-run estimates (dependent variable: EFP)

short run. While in the long run, domestic credit by the financial sector, domestic credit by the private sector and domestic credit provided by bank raises the environmental degradation significantly by 0.15%, 0.29 and 0.27% respectively. The short-run result suggests that financial sector support green energy and environmentally friendly equipment by providing fund in support of entrepreneurial activities. On the other hand, the positive effect of finance on EFP, in the long run, lends credence to the fact that the current state of the financial sector is not enough to abate environmental degradation in the long run. This implies that the financial

sector does not channel enough resources to the agricultural sector, research and development, and green energy product which boost environmental quality and have a positive effect on the environment in the long run. In addition, the long-run result suggests that the financial sector increases the buying power through the provision of loans and credit, which allows households to buy luxury goods that put pressure on the environment (Baloch *et al.*, 2019). The short-run result is in support of the studies of Park *et al.* (2018), Uddin *et al.* (2017) and Aydin and Turan (2020) which stresses the importance of finance in abating environmental degradation. Usman and Hammar (2021) conclude that financial development contributes to environmental quality in Asia Pacific Economic Cooperation (APEC) countries, using STIRPAT model. Specifically, studies by Destek and Sarkodie (2019), Gill *et al.* (2019) and Ahmed *et al.* (2019) conclude that financial development reduces CO_2 emissions in Malaysia but against studies of Ali *et al.* (2016). Furthermore, the long-run finding of financial development worsening environmental quality is congruent with the empirical submission of Baloch *et al.* (2019), Xu *et al.* (2018), Charfeddine (2017), Shahbaz *et al.* (2016), Bekhet *et al.* (2017), Nathaniel *et al.* (2019) and Khalid *et al.* (2021) for Bangladesh and Sri Lanka.

Institutional quality also exhibits different effects on EFP in Malaysia. In the short run, the ecological footprint is reduced through institutional quality while it increases in the long run. This result suggests that the present trend of institutional quality in Malaysia is not enough to drive long-run environmental sustainability. Further, as indicated by the descriptive statistics, the institutional quality indicator is less than average on an ordinary scale of 0–10. The long-run result indicates that economic agents through weak institutional quality could easily have their way to produce goods that are not environmentally friendly (Sohail *et al.*, 2021; Fredriksson and Mani, 2002). Concerning the interactive effect of financial development and institutional quality on ecological footprint, the result shows that in the short run, all the measures of financial development with institutional quality have a positive and significant effect, while in the long run, the effect is negative. The positive effect in the short-run shows a complementarity between financial sector development and institutional quality in influencing EFP. Further, institutions help in mobilizing and channelling funds to activities that are environmentally friendly since both institutions and finance complement each other in the short run. The short-run interactive term further reveals that finance is not enough to reduce environmental degradation and may even worsen the environmental quality if strong institutions are not in place. On the other hand, the substitutability role of financial development and institutional quality, in the long run, suggests that strong institutions could substitute the ineffective financial sector. Strong institutions could instil discipline and limit opportunist behaviour in the financial market, and reduce transaction costs which have a multiplier effect on the environment through investment in R&D, green energy, etc. (Ahmed, 2014; Dada and Abanikanda, 2021). Furthermore, the results show that the long-run substitutability role dominates the short-run complementarity effect in all the models. The long-run result is supported by the finding of Yao *et al.* (2021) who submits that at a lower level of corruption, financial development improves environmental quality in BRICS and the next 11 countries.

Other control variables added to the model have a different effect on EFP. Similar to financial development, economic growth proxied by per capita income has a significant negative effect on the ecological footprint in the short run, but the effect turns positive in the long run in all the models. These results suggest that economic growth improves environmental quality in the short run, but worsens it in the long run. The long-run result suggests that an increase in economic growth necessitates an increase in energy demands and consumption which is one of the factors responsible for environmental pollution, especially if the energy demands are met via fossil fuel and non-renewable energy. Similarly, an increase in economic growth also comes with both production and consumption wastes which deteriorate long-run environmental quality. The short-run result of negative effect of economic growth on

ecological footprint is supported by the finding of Danish *et al.* (2019), while the long-run result is in tandem with the works of Uddin *et al.* (2017), Mrabe *et al.* (2017), Zafar *et al.* (2019), Ibrahiem and Hanafy (2020), Usman *et al.* (2021a, b), Yang *et al.* (2021a) and Dada *et al.* (2021b) whose findings conclude that economic growth degenerates the environment.

In the short run, current foreign direct investment contributed positively to EFP while previous lag (historical value) of foreign direct investment has a reducing effect on environmental degradation in Malaysia. This suggests that there is a time lag before foreign direct investment could enhance environmental sustainability. This result further reveals that previous FDI is channelled towards R&D, green energy products, and environmentally friendly technologies, which improve the environmental quality. The reducing effect of FDI on EFP is in tandem with the empirical submission of Solarin and Al-mulali (2018) and Zafar *et al.* (2019) but negates the conclusion of Baloch *et al.* (2019). In the long run, foreign direct investment has no significant effect on the environmental quality of Malaysia. On the other hand, natural resources and trade openness have a positive and significant effect on EFP in all the models. These results show that natural resources in Malaysia are not efficiently used, thus worsening the environmental quality. Also, the regenerative capacity of natural resources to offset environmental degradation is low. A similar conclusion is also reached by Hassan *et al.* (2018). Equally, the positive effect of trade openness suggests that Malaysia does not benefit from the scale, technique, and composition effects of international trade. The positive effect of trade openness on EFP aligns with the submissions of Al-Mulali *et al.* (2015), Le *et al.* (2016) and Dada and Akinlo (2021) who conclude that trade openness spurs environmental degradation. Nevertheless, studies by Chen *et al.* (2018), Fakher (2019) and Dada *et al.* (2021a, b) found that trade openness improves environmental quality. Population (proxy by population growth rate) has different significant effects on EFP in the short run, while in the long run, the effects are not significant. The models also correct its short-run disequilibrium through the error correction terms which are negative and significant.

4.3 Diagnostic tests

Table 7 and Figures 2–4 present the diagnostic tests of the ARDL estimate. Jarque-Bera statistics show that the error terms are normally distributed since its probability is not significant in all the models estimated. Furthermore, the Breusch-Pagan-Godfrey heteroscedasticity test reveals the absence of heteroscedasticity in the variance of the error in the models. Similarly, the coefficient of the Ramsey reset test suggests that the model is completely free from specification error. The stability of the models is also verified through the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) of the recursive residuals estimated. The results of the CUSUM and CUSUMSQ for the models are presented in Figures 2–4. The results suggest that the parameters and models estimated are stable since the lines are within 5% critical boundaries. Since the models are stable, free from heteroscedasticity, and the errors are normally distributed, thus, inference could be drawn from the models (Dada and Abanikanda, 2021).

	Model 1	Model 2	Model 3
Diagnostic Statistics			
Adj. *R*-Sq	0.966	0.932	0.957
F-stat	38.371***	31.440***	28.901***
Normality Test/Jarque–Bera Test (*p*-val)	0.367	0.673	0.334
Heterosc. Test(BPG)/*p*-val	0.614	0.456	0.679
Ramsey RESET test (*p*-val)	0.482	0.625	0.432

Table 7. Diagnostic tests

4.4 Robustness analysis

To perform a robustness analysis, financial development index (FD) is generated from the three proxies of financial development used in this study. Also, alternative long-run cointegrating regressions namely Fully Modified Ordinary Least Squares (FMOLS) and Canonical Cointegrating Regression (CCR) are employed. FMOLS addresses the problem of serial correlation and endogeneity in the regressors, while CCR removes the second-order biasness of the OLS estimator (Ajide, 2020). The results of both FMOLS and CCR are presented in Table 8. The results are consistent with the long-run estimates of ARDL except for foreign direct investment that has a significant positive effect on EFP.

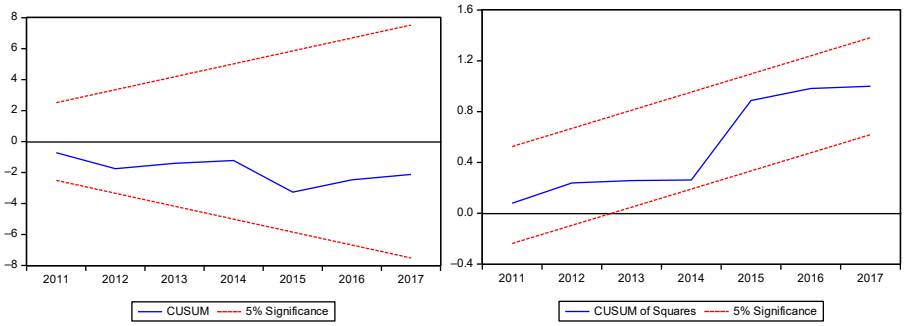

Figure 2.
CUSUM and CUSUM of square for model 1

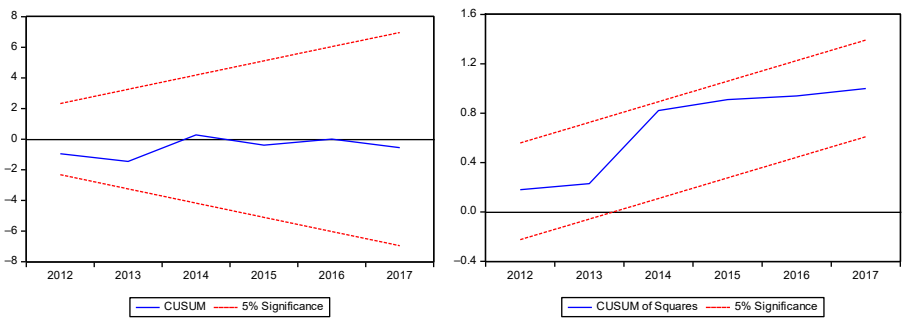

Figure 3.
CUSUM and CUSUM of square for model 2

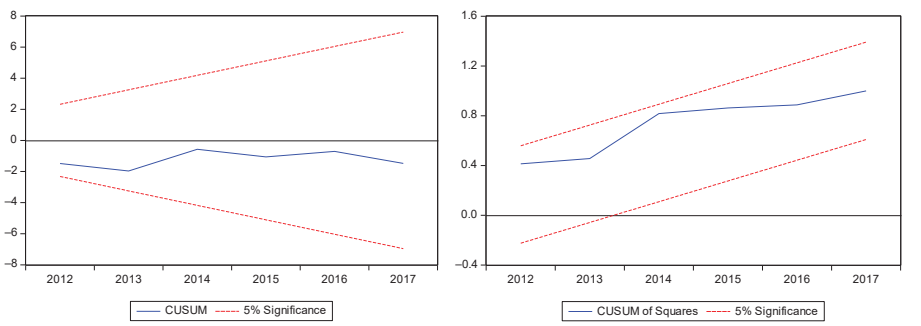

Figure 4.
CUSUM and CUSUM of square for model 3

Dependent variable: Ecological footprint (EFP)	Fully modified least squares (FMOLS)		Canonical cointegrating regression (CCR)	
Variable	Coefficient	*t*-statistic	Coefficient	*t*-statistic
GDP	0.0002***	4.3529	0.0001**	2.7914
FD	0.0031*	2.1786	0.0216**	2.7692
INS	0.0491**	3.0919	−0.4934	−0.6081
FD*INS	−0.0005*	−2.1445	−0.0046**	−2.7741
FDI	0.0593**	3.3842	0.0598**	2.4574
NAT	0.0162	1.1140	0.0149	0.6527
POP	−0.1179	−0.4539	−0.3339	−1.0493
TOP	0.0090***	7.4966	0.0094***	5.9888
C	−0.1580	−0.0556	3.1076	0.6823
Adj. *R*-sq		0.8914		0.8810
Long run variance		0.0216		0.0216
Mean dep. Var		3.4430		3.4430
SE of Reg		0.2211		0.2315

Note(s): (1) ***, **, * indicate significance at 1%, 5 and 10% respectively. (2) FD is financial development, INS is institutional quality, FD*INS is the interactive term of financial development and institutional quality, GDP is economic growth, FDI is foreign direct investment, NAT is natural resources rent, POP is the population growth rate and TOP is trade openness

Table 8. Robustness check

5. Concluding remarks

This study examines the moderating role of institutional quality in the relationship between financial development and ecological footprint in Malaysia for the period 1984–2017. The study differs from previous studies on the finance-environment relationship in Malaysia by unearthing the moderating effect of institutional quality in such nexus. In this study, EFP is used as a proxy for environmental degradation to overcome the weakness of most extant studies that used CO_2, SO_4, methane, etc, to measure environmental quality. Further, three different proxies were used to capture financial development, while a comprehensive index was generated to measure institutional quality. These different proxies were used to ensure the validity and reliability of the results. To account for both short and long-run relationships in such a link, Autoregressive Distributed Lag (ARDL) was used. Furthermore, Fully Modified Ordinary Least Square (FMOLS) and Canonical Cointegrating Regression (CCR) were equally employed as a robustness check to increase the adequacy of the estimates.

The outcome of this research provides interesting results both in the short run and long run. Findings from the study reveal that financial development, institutional quality, economic growth, and foreign direct investment have a significant negative effect on EFP in Malaysia in the short run. This implies that they do not contribute to environmental degradation in the short run. However, trade openness and natural resources worsen environmental quality in the short run. Concerning the moderating role of institutional quality in the short run, the result shows that the interactive term has a positive and significant effect on ecological footprint. This suggests a complementary role between financial sector development and institutional quality in reducing environmental degradation. Hence, both the financial sector and institutions are important in curbing the menace of environmental degradation.

The long-run findings on the other hand show different results from the short-run estimates. Financial development, institutional quality, economic growth, trade openness, and natural resources have a positive and significant effect on EFP in the long run, hence they worsen environmental sustainability. The long-run interactive term of financial development

and institutional quality has a significant negative effect on EFP. Thus, finance and institution substitute each other in affecting the ecological footprint of Malaysia in the long run. This means that strong institution covers up for the inefficient financial sector in reducing ecological footprint in the long run. These results also persist when other long-run cointegration estimation techniques were used.

The policy implications of the results are as follows. First, there is a need for policy variations in both the short and long run in Malaysia. Based on the finding, policies that target strong financial sector development and institutional quality are to be pursued concurrently in the short run, since they complement each other in reducing the ecological footprint. In the long run, strong institutional quality and a well-developed financial sector are to be pursued independently to curb the hazard of environmental degradation. The long-run effect of financial development suggests that policymakers need to formulate laws and policies that will mandate the financial system to invest in innovative technologies through investment in R&D, and renewable and green energy. Financial sector should set aside some percentage of their loanable fund for firms ready to invest in eco-friendly projects, and provide credit at lower interest rate. Financial services should be tailored to projects that are energy-efficient and eco-friendly. In general, the financial sector should be actively involved in the sensitization programme against the harmful effect of environmental degradation. Lastly, institutions especially, those related to enforcing environmental laws and regulations should be strengthened so as to prosecute and punish environmental offenders. With this, economic agents will adhere strictly to environmental laws.

It is imperative to give a hint that this study has contributed to the environment literature by examining the mediating role of the institution in the finance-environment nexus in Malaysia using a robust proxy of EFP to measure environmental degradation. Furthermore, three different proxies were used to capture financial development. However, this study should be viewed in the light of some limitations. This study only considered Malaysia and used aggregate EFP to capture environmental quality. Future studies can complement this research for other emerging economies, and also examine the effect on the six sub-components of EFP.

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Appendix

Variable	Measurement	Source
Ecological Footprint (EFP)	Ecological footprint measures human generation action in six major areas: the built-up land, carbon emissions, cropland, fishing grounds, forestry products, and grazing land. It is calculated as per capita of a global hectare (gha)	Ecological Footprint Network (EFN) 2019
Financial Development (FD)	Three variables are used to measure financial development namely, domestic credit provided the financial sector, domestic credit to private sector and domestic credit to private sector by bank. These variables are expressed as a percentage of GDP	World Development Indicator (2019) edition
Institutional Quality (INS)	Five indicators are used to measure institutional quality namely: corruption control, law and order, government stability, bureaucracy quality, and democratic accountability. These indicators are rescaled and averaged to compute an index of institutional quality	International Country Risk Guide (2019)
Economic Growth (GDP)	Per capita gross domestic product in 2010 US$	World Development Indicator (2019) edition
Foreign Direct Investment (FDI)	This is calculated as FDI net inflow as a percentage of gross domestic product	World Development Indicator (2019) edition
Natural Resources (NAT)	Total natural resource rent as a proportion of the gross domestic product	World Development Indicator (2019) edition
Population (POP)	Population growth rate is used as proxy	World Development Indicator (2019) edition
Trade Openness (TOP)	This is measured as the sum of export and import to gross domestic product	World Development Indicator (2019) edition

Table A1. Measurement and description of variables

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