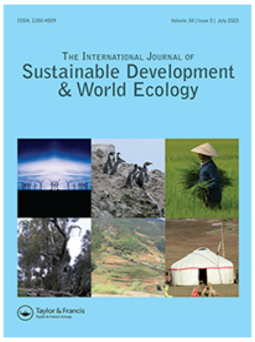

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Examining the roles of labour standards, economic complexity, and globalization in the biocapacity deficiency of the ASEAN countries

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ABSTRACT

With Singapore currently the world's most natural capital (biocapacity) deficit alongside four other Association of Southeast Asian Nations (ASEAN) countries having varying degree of ecological deficit, i.e. Indonesia, Malaysia, the Philippines, and Thailand, it then offers a clear justification for a more scrutiny of the ASEAN states' ecological footprint dynamics. To provide more insight on the drivers of ecological footprint in the overall panel and for each of the above-mentioned countries, the roles of economic complexity, average working hours, labour productivity, labour income share, and globalization were examined by employing the Dynamic Ordinary Least Squares Mean Group (DOLSMG) alongside the recently developed (non)time-variant Granger causality approaches. For the overall panel, the DOLSMG approach established that labour productivity, labour income share, and globalization reduce the biocapacity deficit by improving ecological quality while economic complexity worsen the region's environmental quality. Additionally, in the overall panel, there is Granger causality evidence from the average working hour, labour income share, labour productivity, globalization, and economic complexity to ecological footprint. Moreover, the results of the two Granger causality approaches are unanimous in evidence. For instance, average working hours per year is a significant causal of ecological footprint in all the sampled countries at varying periods. Specifically, there are Granger causalities: from labour productivity to ecological footprint in Malaysia, the Philippines, Singapore and Thailand; from globalization to ecological footprint in Malaysia, the Philippines, Singapore, and Thailand; from economic complexity to ecological footprint in Indonesia, Malaysia, the Philippines, Singapore, and Thailand, all at varying times.

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Environmental sustainability; ecological footprint; working hour; labour productivity; socioeconomic; ASEAN

1. Introduction

With the developing and emerging economies on the catch-up pathway to economic development and prosperity, there is increasing expectation from these groups of countries not to prioritize economic aspirations at the expense of environmental sustainability. Although high economic activities are arguably associated with declining environmental quality, there are increasing suggestions especially on the adoption of socioeconomic, behavioural, and even cultural environmental practices with the end goal of reducing humans' ecological footprint. Already, as reported by the Global Footprint Network (2022), several countries across the globe have their ecological footprint exceeding biocapacity, thus suggesting a potential decline in the coiuntries' environmental quality. For instance, ecological footprint of the five socioeconomically advanced members of the Association of Southeast Asian Nations (ASEAN) i.e. Indonesia, Malaysia, the Philippines, Singapore, and Thailand have already overshot their respective biocapacities by 38%, 97%, 185%, 10,400%, and 85% (Global Footprint Network 2022). Interestingly, Singapore (with 10400% increase in ecological footprint beyond its biocapacity) is the world leader in terms of countries that have overshot biocapacity, thus raising many scientific questions about the potential drawback(s) of the country's economic progress spanning over decades.

In the extant literature, environmental drawback is increasingly associated with socioeconomic activities across several spheres of the economy. Moving away from the role of population, energy utilization, economic growth and other well-studied drivers of environmental quality as documented in the literature (Bekun et al. 2019; Ike et al. 2020; Umar et al. 2021), there are increasing interests on probing other salient and overlooked socioeconomic parts such as the working hours, labour income share, and labour productivity. For instance, the study of Knight et al. (2013) found a significant nexus between working hour and the environment across the panel of the Organization for Economic Cooperation and Development (OECD) countries. Specifically, the study revealed that more resources are consumed during longer hours of work which both contribute to the increase in the Gross Domestic Product (GDP) and ecological footprint. Similar to the evidence of increased

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carbon dioxide (CO_2) emission being associated with the long hours of work, Soomro et al. (2021) observed that a positive change in labour productivity is associated with a decline in carbon emission in the short run, thus indicating that importance of labour productivity alongside energy utilization and capital productivity in driving environmental sustainability in China. Following this perspective, work hours categorization such as for leisure and non-leisure activities and by gender have also been examined in the framework of environmental sustainability (Druckman et al. 2012; Fremstad et al. 2019; Smetschka et al. 2019).

Based on the above-mentioned motivation, and especially for the reason provided about the biocapacity deficit of the aforementioned leading ASEAN countries, the current study is aimed at providing more understanding about the criticality of the countries' ecological footprint trend. The novelty of the study is construed from the perspective of labour-related anomalies associated with most of the developing and emerging countries (Nguyen et al. 2016) and with scarce literature offering environmental dimension of the challenge. Similar to the objective of examining the role of working hours in ecological footprint as demonstrated in the work of Knight et al. (2013), the current study further seeks to explore the role of labour productivity. Additionally, the nexus of labour income share and ecological footprint has rarely been explored in the literature, thus going that direction adds to the objectives of the current investigation. Moreover, adding to the existing literature on the environmental effect of economic complexity and globalization, this study also provides further insight in this direction for the ASEAN countries. Toward achieving the aforementioned objectives, the recently developed Granger causality approaches by Emirmahmutoğlu and Köse (2011) and Kónya (2006) panel causality in rolling window (which offers time inference) alongside the Dynamic Ordinary Least Squares Mean Group (DOLSMG) were both employed to provide a robust argument. In light of this endeavour, the outcome of this investigation is expected to deliver a significant contribution to the existing literature.

There are other parts of the study that are sectionally arranged accordingly. Selected related studies are discussed in section 2. In section 3, the dataset and the priori estimations are presented, while the key empirical approaches are outlined in section 4. The results of the main coefficient estimation and causality approaches are discussed in section 5, while the conclusion alongside the policy relevance of the outcome is outlined in the last section 6.

2. Related studies: a synopsis

The environmental effect of globalization and economic complexity has been widely reported in the literature (Adebayo et al. 2022a, 2022b; Saint Akadiri et al. 2020). For instance, the role of globalization and other socioeconomic factors were examined in the newly industrialized economies and Turkey in Adebayo et al. (2022b) and Saint Akadiri et al. (2020) respectively. While controlling for heterogeneity by adopting the Method of Moments Quantile Regression (MMQR), Adebayo et al. (2022b) further employed the fully modified and dynamic ordinary least square methods (i.e. FMOLS and DOLS respectively) to examine the long-term environmental effect of globalization, natural resources, economic growth, and renewable energy. While the result shows that natural resources hamper environmental quality in the examined countries (Brazil, China, India, Mexico, Malaysia, Philippines, South Africa, Turkey, Indonesia, and Thailand), the globalization, on the other hand, improves the countries' environmental quality. Importantly, the study illustrates that globalization moderates natural resources to impact an environmentally desirable effect in the long run. Meanwhile, the environmental effect of economic complexity was examined among the world's top economic complexity states (Austria, Czech Republic, Germany, Japan, Singapore, South Korea, and Switzerland) over the period 1993 to 2018. Similar to Adebayo et al. (2022b), the FMOLS, DOLS, and MMQR approaches were in Adebayo et al. (2022a) which also provide results that are largely unanimous. Importantly, the result indicates that both conventional energy utilization and economic complexity are detrimental to environmental quality by increasing carbon emission while renewable energy use and technological innovation mitigate carbon emission, i.e improve environmental quality.

On the role of working hour and labour-related indicators, there has been coverage of their respective environmental effects in the literature (Knight et al. 2013; Soomro et al. 2021; Fitzgerald 2022; Mallinson and Cheng 2022). The recent studies of Fitzgerald (2022) and Mallinson and Cheng (2022) offer a new perspective about the role of working hour in climate change mitigation. Specifically, Mallinson and Cheng (2022) advanced a previous state-level study for the United States of America (USA) that found a positive association between state-level carbon emissions and working hours over the period 2007–2013. By expanding the period of the dataset to 2007–2017, Mallinson and Cheng (2022) also found that average working hours spur carbon emissions at the country- and state-level in the USA and the effect is found to be larger over the new period 2014–2017. Similarly, Fitzgerald (2022) utilized the period 2005–2015 to explore the nexus of working hour and carbon emission in the USA while also investigating the moderating role of inequality in the relationship. As such, the result shows that working hours in the USA spur carbon emissions. Importantly, the moderating role of inequality in the relationship is established, thus affirming the proposition that inequality encourages residents to work longer hours with the resulting effects of increasing consumptions and increase in environmental footprint.

In the extant literature, the above-mentioned environmental indicators and others have been discussed for several cases. However, there is little coverage of the Asian countries in that direction. Moreover, the case of the ASEAN countries is yet to receive the expected attention considering the below standard of labour-related activities across the region (Nguyen et al. 2016). Therefore, the current study provides a significant contribution to the existing knowledge from the perspective of the environment and socioeconomic factors.

3. Data and preliminary tests

This study employed annual data covering the period 1979 to 2017 for five ASEAN countries (including Indonesia, Malaysia, the Philippines, Singapore, and Thailand) to analyse the effect of average working hours, labour income share, labour productivity, globalization and economic complexity on ecological footprint. The definition of variables alongside the renaming and source of the dataset is presented in Table 1. Moreover, in Figure 1, the different trends of ecological footprint in the aforementioned economies are illustrated.

Table 1. Definition of variables.

Variable	Code	Unit	Source
Ecological Footprint	EF	Global Hectares per person	Global Footprint Network
Average Working Hours	WH	Working Hours	Penn World Table
Labour Income Share	LS	Percent	Penn World Table
Labour productivity	PR	Output per worker	World Bank
Globalization	GI	KOF Index of Globalisation	KOF Swiss Economic Institute
Economic Complexity	EC	Index	OEC.world

3.1 Model and priori tests

The established econometric model is based on the STIRPAT (Stochastic Impacts by Regression on Population, Affluence and Technology) model extended by Dietz and Rosa (1997). However, the use of independent variables, especially regarding labor standards, provides a different contribution to the STIRPAT model. As the independent variables affecting the CO_2 emission or ecological footprint are different in the main STIRPAT model. The STIRPAT model proposed by Dietz and Rosa (1997) is as follows.

$$I_i = aP_i^b A_i^c T_i^d u_i \tag{1}$$

In Equation 1, I is environmental degradation, a is the constant term, b is population coefficient, c is economic development coefficient, and d is technology coefficient. In the literature, and following the environmental model, ecological footprint has been widely employed as a potentent environmental indicator (Udemba 2020; Akadiri et al. 2020; Adebayo et al. 2022a; Westerlund 2007). Given the aim of this study which is to examine the effect of labour-related parameters alongside globalization and economic complexity on ecological footpint, the carbon model is given by the following:

$$\text{EF} = f(\text{WH}, \text{LS}, \text{PR}, \text{GI}, \text{EC}) \tag{2}$$

From Equation (2), the form of econometrics model is further represented in Equation 3 by performing the logarithmic transformation (ln) of the variables.

$$\text{lnEF}_{it} = \text{B}_{0i} + \text{B}_{1i}\text{lnWH}_{it} + \text{B}_{2i}\text{lnLS}_{it} + \text{B}_{3i}\text{lnPR}_{it} + \text{B}_{4i}\text{lnGI}_{it} + \text{B}_{5i}\text{EC}_{it} + \text{u}_{it} \tag{3}$$

where i and t subscripts represent country and time; B_i and u_{it} represent each country's individual and the vector of residuals respectively.

3.1.1 Cross-section dependence test and homogeneity test

The spectacular developments in transportation, and communication technologies, the economic, political, cultural, etc. of the nation states are characterization of

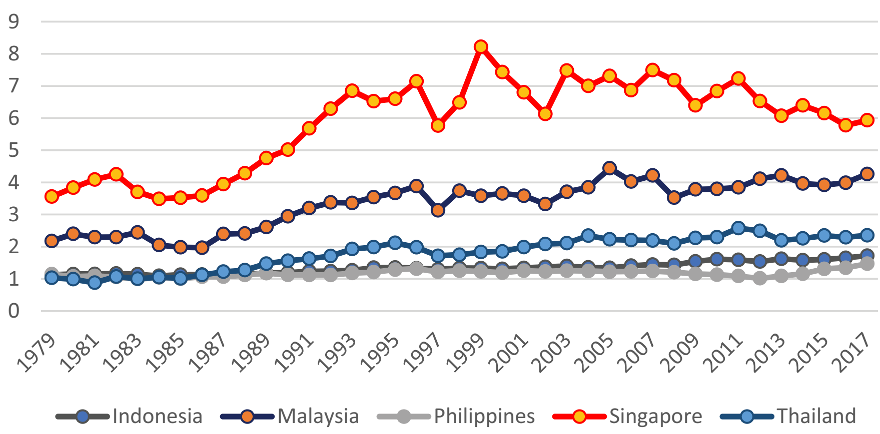

Figure 1. Ecological footprint in ASEAN countries (Source. https://www.footprintnetwork.org/).

the world economy, and these aspects also differ from geographical locations and countries. Obviously, these development aspects bring the elements of states closer to each other, thus providing a noticeable increase in integration processes. However, the differentiation of the elements of the states account for the necessity of the cross-section dependency test which emerges as a result of the acceleration in the said integration process. In this respect, beyond a theoretical perception, the application of the tests that account for the cross-sectional dependency between countries are carewfully carried out in the study.

In the first step, Breusch and Pagan (1980) which proposed the Langrange Multiplier test statistic (LM) in order to test the cross-sectional dependency is applied. The basic equation used for analysis is as follows:

$$CD_{LM1} = T\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{ij}^{2}, \tag{4}$$

$\hat{\rho}_{ij}^{2}$ expresses the estimation of the correlation coefficients between the residuals obtained by the least squares (OLS) estimators. Under the null hypothesis that the cross-section number (N) is constant or small and the time period (T → ∞) is large enough, the cross-sectional dependency is not, the statistical value has a chi-square asymptotic distribution with N (N-1)/2 degrees of freedom. Considering the validity of the LM test, the hypotheses of the relevant test are presented as follows. $H_0 : Cov\left(\in_{it}, \in_{jt}\right) = 0$; The null hypothesis in the form states that there is no cross-sectional dependency between the series.

$H_1 : Cov\left(\in_{it}, \in_{jt}\right) \neq 0$; The alternative hypothesis in the form states that there is a cross-sectional dependency between the series.

However, the LM test is not a viable test method for large N (cross-section size). The scaled LM test statistics (Pesaran Scaled LM2) developed by Pesaran (2021) to solve this problem is calculated through the following equation:

$$CD_{LM2} = \sqrt{(\frac{1}{N(N-1)})}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}(T\hat{\rho}_{ij}^{2-1)} \tag{5}$$

where the scaled LM2 test is functional under the null hypothesis, i.e. in the absence of cross-sectional dependence, under the condition T → ∞ and N → ∞, that is, a sufficiently large cross-section size and time period can be included in the analysis. In addition, this test has an asymptotic standard normal distribution. Pesaran (2021) presents the cross-sectional dependency test that can be used when the cross-section dimension (N) is large and the time period (T) is small, with the help of the following equation:

$$CD_{LM3} = \sqrt{(\frac{2T}{N(N-1)})}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}(\hat{\rho}_{ij}) \tag{6}$$

Here, the test statistic in the last equation is asymptotically standard normal distribution, and H_0 null hypothesis is that there is no cross-sectional dependency between the series; H_1 alternative hypothesis shows the presence of cross-sectional dependency between series.

The homogeneity or heterogeneity investigation of the slope coefficient for panel data analysis has a critical role in the selection of test methods to be used and in the interpretation of parameter estimates. The foundations of the first study on homogeneity analysis were laid by Swamy (1970). Hashem and Yamagata (2008) and Westerlund (2008) developed the Delta test by implementing Swamy's homogeneity test in a different stage. For the homogeneity or heterogeneity test, the hypotheses of the homogeneity test are as follows:

H_0:$\beta_i = \beta$; the null hypothesis of the test states that the slope coefficients are homogeneous,

H_1:$\beta_i \neq \beta$; alternative hypothesis of the test states that the slope coefficients are heterogeneous.

Additionally, Pesaran and Yamagata (2008) proposed two separate test statistics for large and small samples in order to test hypotheses. Accordingly, the test statistics for large samples are calculated as Equation (7), while the test statistics for small samples are calculated as Equation (8).

$$\hat{\Delta} = \sqrt{N}\left(\frac{N^{-1}\tilde{S}-k}{2k}\right) \sim \chi_k^2 \tag{7}$$

$$\hat{\Delta}_{adj} = \sqrt{N}\left(\frac{N^{-1}\tilde{S}-k}{v(T,k)}\right) \sim N(0,1) \tag{8}$$

In this framework, the cross-sectional dependence test results which largely show the rejection of the null hypothesis are presented in Table 2.

Specifically, Table 2 illustrates results of cross-sectional dependence test. Accordingly, the result in Table 2 reveals that the probability values of the series are less than 1% and 5% significant level. Therefore, the null hypothesis (H_0) can be rejected. In the other words, this result indicates the presence of cross-sectional dependency in series. The presence of cross-section dependency reveals that the shock that occurs in any event of the countries may affect other countries as well. Considering the results of the cross-section dependency test, it would be appropriate to use the recently developed panel unit root test that account for this concern. Testing whether the slope coefficients are homogeneous or heterogeneous after the determination of the presence of cross-section dependency is a necessary condition for consistent and reliable evaluation of the statistical findings in the next stage of study. According to the results obtained from Pesaran (2008) delta (Δ) test, it can be shown that the probability values of delta tests are less than 1% significant level. Accordingly, the null hypothesis stating

Table 2. Results of cross-sectional dependence test.

Variable	Breusch-Pagan LM1	Pesaran Scaled LM2	Bias Adjusted CD Test	Pesaran CD
lnEF	232.04 (0.000)[c]	49.65 (0.000)[c]	59.58 (0.000)[c]	14.81 (0.000)[c]
lnWH	61.28 (0.000)[c]	11.46 (0.000)[c]	11.40 (0.000)[c]	−2.40 (0.010)[b]
lnLS	110.22 (0.000)[c]	22.41 (0.000)[c]	22.32 (0.000)[c]	0.39 (0.692)
lnPR	288.86 (0.000)[c]	62.35 (0.000)[c]	62.28 (0.000)[c]	16.68 (0.000)[c]
lnGI	378.02 (0.000)[c]	82.29 (0.000)[c]	82.22 (0.000)[c]	19.44 (0.000)[c]
EC	267.76 (0.000)[c]	57.63 (0.000)[c]	57.57 (0.000)[c]	16.16 (0.000)[c]

[a, b, c]denote significance at 1%, 5% and 10% level, respectively. Numbers in parentheses are probability values.

slope coefficients are homogeneous can be rejected. Consequently, it is determined that the slope coefficients are heterogeneous given the Pesaran (2008) delta homogeneity test results presented in Table 3.

3.1.2. Panel unit root test

The stationarity test of the series used in the panel was investigated by the cross-sectionally augmented Dickey Fuller (CADF) test method, one of the second-generation unit root tests developed by Pesaran (2007). For the cross-sectionally augmented Im, Pesaran and Shin (CIPS) test, the CADF test statistics values of all cross-section units (countries) used in the panel are determined, then the arithmetic mean of these tests is obtained and the CIPS test values for the panel are found. Therefore, while CADF statistics test the stationarity results of cross-section units, CIPS statistics produce stationarity results about the panel in general. In this context, CADF test statistics values are calculated as follows (Pesaran 2007, p. 269):

$$\Delta y_{it} = a_i + b_i y_{i,t-1} + c_i \bar{y}_{t-1} + d_i \Delta \bar{y}_t + e_{it} \tag{9}$$

Denoting this t-ratio by t_i (N, T) we have

$$\text{ti}(N,T) = \frac{\Delta y_i' \bar{M}_w y_{i,-1}}{\widehat{\sigma}_i \left(y'_{i,-1} \bar{M}_w y_{i,-1} \right)^{1/2}} \tag{10}$$

As given in Equation (10), after the CADF test statistics values are calculated, the CIPS statistics values are calculated as follows (Pesaran 2007, p. 276):

Table 3. Pesaran (2008) homogeneity test results.

	Delta	p-value
	13.506	0.000
adj.	14.910	0.000

$$\text{CIPS}(N,T) = t - \text{bar} = N^{-1} \sum_{i=1}^{N} t_i(N,T) \tag{11}$$

where t_i (N, T) is the *i* th cross-section unit in the CADF regression defined by Equation (18), such that the hypotheses of these tests are;

H_0: $\beta i = 0$ there is a unit root

H_1: $\beta i < 0$ there is no unit root.

According to the unit root results obtained in Table 4, the null hypothesis stating that the series have a unit root test can only be rejected for lnLS and lnGI variables. In the other words, only these series (lnLS and lnGI) are stationary at level values, while the others including the dependent variable are not stationary at level (i.e. the null hypothesis for lnEC, lnWH, lnPR, and lnEC variables can not be rejected). Therefore, these non-stationary series can become stationary after taking their first differences as seen in Table 4. Additionally, in Table 5, unit root test results by country and test for the panel as a whole. There are differences in some results compared to Table 4. However, we will refer to the results in Table 4 in the study. In order to make a choice between cointegration tests, first of all, the cross-section dependency test results for the model should be examined. As it is known, if the cross-section dependency is determined for the model, it is appropriate to conduct second-generation cointegration tests. The results in Table 6 indicate the presence of cross-section dependence for the model. Thus, the Westerlund (2008) test which applies the Durbin-Hausman approach is performed. The advantage of this test is that the series focuses on the cointegration relationship even at different

Table 4. Pesaran CADF unit root test results.

	t-bar	cv10	cv5	cv1	Z[t-bar]	P-value
lnEF	−2.308	−2.21	−2.33	−3.807	−1.257	0.104
ΔlnEF	−4.868	−2.21	−2.33	−2.55	−7.346	0.000[c]
lnWH	−1.75	−2.21	−2.33	−2.55	0.071	0.528
ΔlnWH	−3.924	−2.21	−2.33	−2.55	−5.101	0.000[c]
lnLS	−2.426	−2.21	−2.33	−2.55	−1.537	0.062[a]
lnPRO	−1.309	−2.21	−2.33	−2.55	1.12	0.869
ΔlnPRO	−3.524	−2.21	−2.33	−2.55	−4.148	0.000[c]
lnGI	−2.919	−2.21	−2.33	−2.55	−2.71	0.003[c]
lnEC	−2.308	−2.21	−2.33	−2.55	−1.257	0.104
ΔlnEC	−4.868	−2.21	−2.33	−2.55	−7.346	0.000[c]

[a, b, c]show significance at 1%, 5%, and 10% level, respectively.

Table 5. CIPS unit root test results.

	Variable	lnEF	lnWH	ΔlnWH	lnLS	ΔlnLS	lnPR	ΔlnPR	lnGI	lnEC	ΔlnEC
Constant	Indonesia	−1.26 [1] (> = 0.10)	−2.53 [3] (> = 0.10)	−2.80 [4] (> = 0.10)	−3.57 [1] (<0.05)	−3.53 [4] (> = 0.10)	−1.40 [0] (> = 0.10)	−4.59 [0] (<0.01)	−3.57 [1] (<0.05)	0.20 [1] (> = 0.10)	−5.41 [0] (<0.01)
	Malaysia	−5.02 [0] (<0.01)	−1.82 [0] (> = 0.10)	−5.82 [0] (<0.01)	2.13 [0] (> = 0.10)	−2.63 [0] (<0.01)	−1.19 [0] (> = 0.10)	−5.23 [0] (<0.01)	−3.09 [1] (<0.10)	−3.32 [1] (<0.10)	−4.93 [0] (<0.01)
	Philippines	−3.41 [3] (<0.05)	−1.56 [3] (> = 0.10)	−2.31 [3] (> = 0.10)	−2.87 [4] (> = 0.10)	−4.64 [3] (> = 0.10)	−0.65 [4] (> = 0.10)	−2.02 [4] (> = 0.10)	−2.69 [2] (> = 0.10)	−1.09 [1] (> = 0.10)	−2.48 [1] (> = 0.10)
	Singapore	−1.84 [0] (> = 0.10)	−2.15 [0] (> = 0.10)	−1.49 [2] (> = 0.10)	−3.14 [2] (> = 0.10)	−4.47 [2] (> = 0.10)	−2.54 [3] (> = 0.10)	−2.32 [3] (> = 0.10)	−3.42 [0] (<0.05)	−3.08 [0] (<0.10)	−8.42 [0] (<0.01)
	Thailand	−2.61 [3] (> = 0.10)	−1.24 [4] (> = 0.10)	−2.95 [4] (> = 0.10)	−2.57 [4] (<0.10)	−4.60 [4] (> = 0.10)	−0.44 [1] (> = 0.10)	−5.50 [0] (<0.01)	−0.62 [0] (> = 0.10)	−1.57 [0] (> = 0.10)	−5.02 [0] (<0.01)
	Panel CIPS	−2.83[c] (<0.01)	−1.86 (> = 0.10)	−3.07 [c] (<0.01)	−2.00 (> = 0.10)	3.97 [c] (<0.01)	−1.24 (> = 0.10)	−3.93 [c] (<0.01)	−2.68 [c] (<0.01)	−1.77 (> = 0.10)	−5.25 [c] (<0.01)
Constant and trend	Indonesia	−2.44 [3] (> = 0.10)	−3.51 [4] (<0.10)	−2.36 [4] (<0.10)	−5.70 [1] (<0.01)	−3.27 [4] (> = 0.10)	−1.39 [0] (> = 0.10)	−4.55 [0] (<0.05)	−3.65 [1] (<0.10)	0.26 [1] (> = 0.10)	−7.04 [0] (> = 0.10)
	Malaysia	−4.96 [0] (<0.01)	−1.59 [0] (> = 0.10)	−5.85 [0] (<0.01)	0.73 [4] (> = 0.10)	−3.63 [3] (<0.01)	−1.19 [0] (> = 0.10)	−5.65 [0] (<0.01)	−4.56 [2] (<0.05)	−3.28 [1] (> = 0.10)	−4.84 [0] (> = 0.10)
	Philippines	−3.76 [3] (<0.10)	−2.50 [4] (> = 0.10)	−8.13 [4] (<0.01)	−3.43 [1] (> = 0.10)	−4.62 [4] (<0.01)	−1.41 [4] (> = 0.10)	−4.53 [4] (<0.05)	−3.06 [2] (> = 0.10)	−1.41 [1] (> = 0.10)	−6.47 [0] (> = 0.10)
	Singapore	−3.02 [2] (> = 0.10)	−0.37 [0] (> = 0.10)	−7.39 [0] (<0.01)	−2.08 [1] (> = 0.10)	−4.70 [0] (<0.01)	−3.22 [3] (> = 0.10)	−3.44 [3] (> = 0.10)	−3.33 [3] (> = 0.10)	−3.13 [0] (> = 0.10)	−8.33 [0] (> = 0.10)
	Thailand	−4.57 [3] (<0.05)	−2.05 [4] (> = 0.10)	−2.34 [4] (> = 0.10)	−1.91 [4] (> = 0.10)	−5.37 [4] (<0.01)	0.27 [1] (> = 0.10)	−6.05 [0] (> = 0.10)	−0.88 [1] (> = 0.10)	−1.22 [0] (> = 0.10)	−5.18 [0] (> = 0.10)
	Panel CIPS	−3.75 [c] (<0.01)	−2.00 (> = 0.10)	−5.71 [c] (<0.01)	−2.48 (> = 0.10)	−4.32 [c] (<0.01)	−1.39 (> = 0.10)	−4.84 [c] (<0.01)	−3.10 (> = 0.10)	−1.75 (> = 0.10)	−6.37 [c] (<0.01)

[a, b, c]show significance at 1%, 5%, and 10% level, respectively. The lag lengths (p) are selected according to Schwarz information criterion.

Table 6. Cross-section dependence test for cointegration model.

Test	Statistic	d.f.	Prob.
Breusch-Pagan LM	63.56	21	0.000[a]
Pesaran scaled LM	36.43		0.000[a]
Pesaran CD	3.00		0.0027[a]

[a]shows significance at 1% level.

stationary levels, just like the bounds testing method explored by Pesaran et al. (2001).

4. Empirical methods

4.1 Panel cointegration by Durbin-Hausman (Durbin-H)

The recently developed panel cointegration tests have been implemented to overcome cross-sectional dependency issue. In this regard, the approaches in Westerlund (2007), Westerlund and Edgerton (2007) for Lagrange Multiplier (LM) Bootstrap, Westerlund (2008), and Westerlund (2006) for multiple breaks are considered as second-generation panel cointegration tests. The Durbin-Hausmann panel cointegration test is employed in this study by using the following hypotheses:

H_0: $\emptyset_i = 1$, there is no cointegration relationship between variables. (i = 1,2, ….n)

H_1: $\emptyset_i < 1$, there is a cointegration relationship between variables. (i = 1,2, ….n)

In the Durbin-H cointegration method, the existence of long-term relationship is estimated in two ways. It is accepted that the autoregressive parameter in the panel test is the same for all cross-section units, whereas in the group test, the autoregressive parameter differs between cross-section units. The evaluation of the rejection or acceptance of the null hypotheses is decided by comparing the obtained test statistics with the critical values of the normal distribution table. Westerlund (2008) Durbin-H test results are presented in Table 7.

In Table 7, the result of the panel cointegration test is presented. It can be indicated that the group and panel statistics values are statistically significant. According to this test result, the null hypothesis can be rejected. These results indicate that there exists cointegration relationship between variables. Following that, the Dynamic Ordinary Least Squares Mean Group (DOLSMG) estimator developed by Pedroni (2001), which can be employed for second-generation and heterogeneous panels, is applied to estimate the cointegration coefficient. Accordingly, under the ceteris paribus condition, a 1% increase in labour income would reduce the ecological footprint by 1.01%, while a 1% increase in labour productivity would reduce the ecological footprint by 1.46%. In addition, under the ceteris paribus condition, a 1% increase in the level of globalization decreases the ecological footprint by 0.56%, while a 1% increase in the economic complexity index leads to rise the ecological footprint by 18 units. These results we obtained are statistically significant. On the other hand, we concluded that a 1% increase in average working hours increased the ecological footprint by 5.7%. However, this result is not statistically significant.

4.2 Panel Granger causality approaches

4.2.1 Panel causality: Emirmahmutoğlu and Köse (2011) approcah

In the first attempt, the panel causality test developed by Emirmahmutoğlu and Köse (2011) is employed. Basically, the general structure of this test is similar to Toda and Yamamoto (1995). That is, the stationarity levels of the series do not affect the size of the analysis. To put it more clearly, it is the inclusion of I (0) and I (1) series in the analysis together by ensuring that the series contain more information by using their level values. In addition, Asymptotic Granger produces and employs bootstrap critical values instead of causality critical values and thus automatically avoids cross-sectional dependency, so it gives more reliable results than other panel causality tests. In the causality test developed by Emirmahmutoğlu and Köse (2011), the bivariate VAR model (12) and (13). It is established as follows:

$$x_{i,t} = \mu_i^x + \sum_{j=1}^{k_i+dmax_i} A_{11,ij}x_{i.t-j} + \sum_{j=1}^{k_i+dmax_i} A_{12,ij}y_{i.t-j} + \mu_{i,t}^x \tag{12}$$

$$y_{i,t} = \mu_i^y + \sum_{j=1}^{k_i+dmax_i} A_{21,ij}x_{i.t-j} + \sum_{j=1}^{k_i+dmax_i} A_{22,ij}y_{i.t-j} + \mu_{i,t}^y \tag{13}$$

where d_{max} shows the maximum level of integration for each i in the system, Accordingly, a modified Wald

Table 7. Durbin-Hausman (2008) panel cointegration test results.

	Panel ve Group Statistic	*Test Statistic Value*	*Prob.-Value*	Decision
Constant	Durbin-H_g	−1.421	0.078[a]	*There exists a cointegrating relationship between variables*
	Durbin-H_p	-1.305	0.096[a]	*There exists cointegrating relationship between variables*
Constant and Trade	Durbin-H_g	3.621	0.930	*No cointegrating relationship between variables*
	Durbin-H_p	5.495	0.093[a]	*There exists a cointegrating relationship between variables*

[a]shows significance at 10% level.

$$\left.\begin{array}{c} lnEF_{1,t} = \alpha_{1,1} + \sum_{l=1}^{llnEF} \beta_{1,1,l} lnEF_{1,t-1} + \sum_{l=1}^{llnWH} \gamma_{1,1,l} lnWH_{1,t-1} + \\ \sum_{l=1}^{llnPR} \eta_{1,1,l} lnPR_{1,t-1} + \sum_{l=1}^{llnWH} \mu_{1,1,l} lnWH_{1,t-1} + \sum_{l=1}^{llnLS} \theta_{1,1,l} lnLS_{1,t-1} \\ + \sum_{l=1}^{llnGI} \rho_{1,1,l} lnGI_{1,t-1} + \sum_{l=1}^{lEC} \delta_{1,1,l} EC_{1,t-1} + \varepsilon_{1,1,t} \\ lnEF_{N,t} = \alpha_{1,N} + \sum_{l=1}^{llnEF} \beta_{1,N,l} lnEF_{N,t-1} + \sum_{l=1}^{llnWH} \gamma_{1,N,l} lnWH_{N,t-1} + \\ \sum_{l=1}^{llnPR} \eta_{1,N,l} lnPR_{N,t-1} + \sum_{l=1}^{llnWH} \mu_{1,N,l} lnWH_{N,t-1} + \sum_{l=1}^{llnLS} \theta_{1,N,l} lnLS_{N,t-1} + \\ \sum_{l=1}^{llnGI} \rho_{1,N,l} lnGI_{N,t-1} + \sum_{l=1}^{lEC} \delta_{1,N,l} EC_{N,t-1} + \varepsilon_{1,N,t} \end{array}\right\} \quad (14)$$

$$\left.\begin{array}{l} lnWH_{1,t} = \alpha_{1,1} + \sum_{l=1}^{llnEF} \beta_{1,1,l} lnEF_{1,t-1} + \sum_{l=1}^{llnWH} \gamma_{1,1,l} lnWH_{1,t-1} + \sum_{l=1}^{llnPR} \eta_{1,1,l} lnPR_{1,t-1} + \\ \sum_{l=1}^{llnWH} \mu_{1,1,l} lnWH_{1,t-1} + \sum_{l=1}^{llnLS} \theta_{1,1,l} lnLS_{1,t-1} + \sum_{l=1}^{llnGI} \rho_{1,1,l} lnGI_{1,t-1} + \sum_{l=1}^{lEC} \delta_{1,1,l} EC_{1,t-1} + \varepsilon_{1,1,t} \\ lnWH_{N,t} = \alpha_{1,N} + \sum_{l=1}^{llnEF} \beta_{1,N,l} lnEF_{N,t-1} + \sum_{l=1}^{llnWH} \gamma_{1,N,l} lnWH_{N,t-1} + \sum_{l=1}^{llnPR} \eta_{1,N,l} lnPR_{N,t-1} + \\ \sum_{l=1}^{llnWH} \mu_{1,N,l} lnWH_{N,t-1} + \sum_{l=1}^{llnLS} \theta_{1,N,l} lnLS_{N,t-1} + \sum_{l=1}^{llnGI} \rho_{1,N,l} lnGI_{N,t-1} + \sum_{l=1}^{lEC} \delta_{1,N,l} EC_{N,t-1} + \varepsilon_{2,N,t} \end{array}\right\} \quad (15)$$

$$\left.\begin{array}{l} lnLS_{1,t} = \alpha_{1,1} + \sum_{l=1}^{llnEF} \beta_{1,1,l} lnEF_{1,t-1} + \sum_{l=1}^{llnWH} \gamma_{1,1,l} lnWH_{1,t-1} + \sum_{l=1}^{llnPR} \eta_{1,1,l} lnPR_{1,t-1} + \\ \sum_{l=1}^{llnWH} \mu_{1,1,l} lnWH_{1,t-1} + \sum_{l=1}^{llnLS} \theta_{1,1,l} lnLS_{1,t-1} + \sum_{l=1}^{llnGI} \rho_{1,1,l} lnGI_{1,t-1} + \sum_{l=1}^{lEC} \delta_{1,1,l} EC_{1,t-1} + \varepsilon_{2,1,t} \\ lnLS_{N,t} = \alpha_{1,N} + \sum_{l=1}^{llnEF} \beta_{1,N,l} lnEF_{N,t-1} + \sum_{l=1}^{llnWH} \gamma_{1,N,l} lnWH_{N,t-1} + \sum_{l=1}^{llnPR} \eta_{1,N,l} lnPR_{N,t-1} + \\ \sum_{l=1}^{llnWH} \mu_{1,N,l} lnWH_{N,t-1} + \sum_{l=1}^{llnLS} \theta_{1,N,l} lnLS_{N,t-1} + \sum_{l=1}^{llnGI} \rho_{1,N,l} lnGI_{N,t-1} + \sum_{l=1}^{lEC} \delta_{1,N,l} EC_{N,t-1} + \varepsilon_{3,N,t} \end{array}\right\} \quad (16)$$

$$\left.\begin{array}{l} lnGI_{1,t} = \alpha_{1,1} + \sum_{l=1}^{llnEF} \beta_{1,1,l} lnEF_{1,t-1} + \sum_{l=1}^{llnWH} \gamma_{1,1,l} lnWH_{1,t-1} + \sum_{l=1}^{llnPR} \eta_{1,1,l} lnPR_{1,t-1} + \\ \sum_{l=1}^{llnWH} \mu_{1,1,l} lnWH_{1,t-1} + \sum_{l=1}^{llnLS} \theta_{1,1,l} lnLS_{1,t-1} + \sum_{l=1}^{llnGI} \rho_{1,1,l} lnGI_{1,t-1} + \sum_{l=1}^{lEC} \delta_{1,1,l} EC_{1,t-1} + \varepsilon_{4,1,t} \\ lnGI_{N,t} = \alpha_{1,N} + \sum_{l=1}^{llnEF} \beta_{1,N,l} lnEF_{N,t-1} + \sum_{l=1}^{llnWH} \gamma_{1,N,l} lnWH_{N,t-1} + \sum_{l=1}^{llnPR} \eta_{1,N,l} lnPR_{N,t-1} + \\ \sum_{l=1}^{llnWH} \mu_{1,N,l} lnWH_{N,t-1} + \sum_{l=1}^{llnLS} \theta_{1,N,l} lnLS_{N,t-1} + \sum_{l=1}^{llnGI} \rho_{1,N,l} lnGI_{N,t-1} + \sum_{l=1}^{lEC} \delta_{1,N,l} EC_{N,t-1} + \varepsilon_{4,N,t} \end{array}\right\} \quad (17)$$

$$\left.\begin{array}{l} EC_{1,t} = \alpha_{1,1} + \sum_{l=1}^{llnEF} \beta_{1,1,l} lnEF_{1,t-1} + \sum_{l=1}^{llnWH} \gamma_{1,1,l} lnWH_{1,t-1} + \sum_{l=1}^{llnPR} \eta_{1,1,l} lnPR_{1,t-1} + \\ \sum_{l=1}^{llnWH} \mu_{1,1,l} lnWH_{1,t-1} + \sum_{l=1}^{llnLS} \theta_{1,1,l} lnLS_{1,t-1} + \sum_{l=1}^{llnGI} \rho_{1,1,l} lnGI_{1,t-1} + \sum_{l=1}^{lEC} \delta_{1,1,l} EC_{1,t-1} + \varepsilon_{5,1,t} \\ EC_{N,t} = \alpha_{1,N} + \sum_{l=1}^{llnEF} \beta_{1,N,l} lnEF_{N,t-1} + \sum_{l=1}^{llnWH} \gamma_{1,N,l} lnWH_{N,t-1} + \sum_{l=1}^{llnPR} \eta_{1,N,l} lnPR_{N,t-1} + \\ \sum_{l=1}^{llnWH} \mu_{1,N,l} lnWH_{N,t-1} + \sum_{l=1}^{llnLS} \theta_{1,N,l} lnLS_{N,t-1} + \sum_{l=1}^{llnGI} \rho_{1,N,l} lnGI_{N,t-1} + \sum_{l=1}^{lEC} \delta_{1,N,l} EC_{N,t-1} + \varepsilon_{5,N,t} \end{array}\right\} \quad (18)$$

(MWALD) test is applied for the lag. The null hypothesis of the test is that there is no causality relationship from Y to X while the alternative hypothesis indicates there exists a causality relationship from Y to X.

4.2.2. Bootstrap panel causality test in rolling windows

Second, panel causality test developed by Konya (2006) which is based on the Zellner (1962) estimator is applied. For this study, we used Akaike information criteria. Also, to investigate on the causality relationship between variables, we focus on significance of slope coefficients in the above equations by employing the Wald test with cross-section-specific bootstrap critical values (Yilanci and Ozgur 2019). Kónya (2006) produces result for the overall panel causality analysis. However, the causality relationship between the variables may change from time to time. For this reason, the panel causality using Kónya's (2006) bootstrap panel causality test in a time-varying approach proposed by Yilanci and Ozgur (2019) is further implemented to provide a more robust understanding.

5. Discussion of results

Given the DOLSMG test results in Table 8, both average working hour and economic complexity are found to spur ecological footprint. Therefore, in the ASEAN countries, it is likely that people generally work for long hours which in turn increases rates of consumptions of goods and services and as such increasing the ecological footprint, i.e hampering environmental quality. This observation is close experiences from other cases as established in the literature (Knight et al. 2013; Soomro et al. 2021; Fitzgerald 2022; Mallinson and Cheng 2022). Contrarily, labour income share and labour productivity reduces ecological footprint in the examined panel, suggesting that environmental quality is improved by the indicators. Additionally, the environmental effect of economic complexity and globalization is in opposite direction. The result shows that the countries' economic complexity is not robust enough to stop environmental degradation in the region. Moreso, the integration of the global economies, i.e globalization, helps to reduce ecological footprint, meaning that environmental quality among the countries improves with globalization. These results are in largely in line with the evidence from the existing studies: globalization (Adebayo et al. 2022b) and economic complexity (Adebayo et al. 2022a).

Table 8. DOLSMG test results.

Variables	β	t-stat
LNWH	5.736	−1.401
LNLS	−1.01	−7.421[a]
LNPR	−1.46	−8.433[a]
LNGI	−0.56	−3.175[a]
EC	0.18	−14.43[a]

[a]shows significance at 1% level.

5.1 Causality results

Moreover, the results of Emirmahmutoğlu and Köse (2011) panel Fisher test are illustrated in Table 9. As indicated in the reported chart, the existence of a causal relationship from lnEC to lnEF was found only in Indonesia and the Philippines. Although the trend of ecological footprint in these two countries are the lowest (see Figure 1), the evidence of causality implies that the countries' energy consumption profile could hamper environmental quality arising from the presure emanating from its usage on ecological footprint. This observation is not unexpected considering that the causal nexus between energy utilization and environmental sustainability aspects has been widely documented in the literature (Bekun et al. 2019; Alola et al. 2022). According to the bootstrap probability values, the existence of a causal relationships from lnWH and lnPR to lnEF for the overall panel is also found. Looking at the cross-section units, there is a causality relationship from lnWH to lnEF only in the Philippines. The explanation for this observation is that the increasing ecological footprint could be explained by the length of work duration or work time. This implies that intensive human labour approach rather than the application of technology to perform a work task is likely to be predominant acoss the panel countries. Additionally, a causal relationship from lnPR to lnEF was found in Thailand. One of the early important studies that offer a good insight into working hour and environmental sustainability nexus is Knight et al. (2013). The result of the study concludes that longer working hours increase

Table 9. Panel Fisher test results.

	lnWH→lnEF		lnLS→ lnEF	
Countries	Wald	p-value	Wald	p-value
Indonesia	0.547	0.460	5.898	0.015[b]
Malaysia	0.658	0.417	1.990	0.158
Philippines	3.863	0.049[b]	0.811	0.368
Singapore	1.255	0.263	1.104	0.293
Thailand	1.953	0.162	0.067	0.795
Panel Fisher	15.631		16.976	
Asymptotic p-value	0.111		0.075[a]	
Bootstrap p-value	0.068[a]		0.580	
	lnPR→ lnEF		**lnGI→ lnEF**	
	Wald	p-value	Wald	p-value
Indonesia	0.776	0.378	4.007	0.135
Malaysia	0.039	0.843	5.138	0.023[b]
Philippines	1.022	0.312	4.027	0.045[b]
Singapore	0.760	0.383	0.667	0.414
Thailand	9.313	0.002[c]	2.095	0.148
Panel Fisher	18.703		23.316	
Asymptotic p-value	0.044[b]		0.010[b]	
Bootstrap p-value	0.001[c]		1.000	
	EC→ lnEF			
	Wald	p-value		
Indonesia	2.782	0.095[a]		
Malaysia	0.882	0.348		
Philippines	5.630	0.018[b]		
Singapore	0.037	0.847		
Thailand	0.334	0.563		
Panel Fisher	16.366			
Asymptotic p-value	0.090[c]			
Bootstrap p-value	0.344			

[a, b, c]show significance at 1%, 5%, and 10% level, respectively. The Akaike Information Criterion is utilized in determining the lag length.

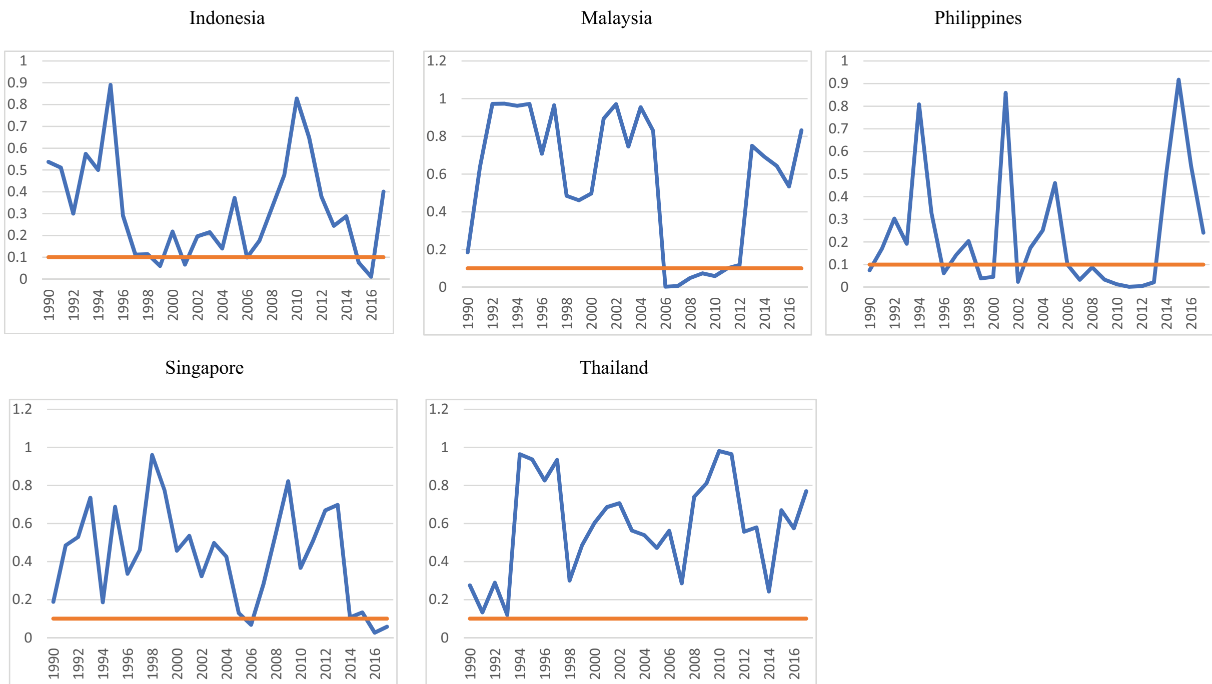

Figure 2. Bootstrap with probability values for causality from WH to EF in rolling window estimation. The orange line shows the significance level at 10%.

ecological footprint because more resources are being consumer while carbon dioxide is being emitted in the process. Similarly, the work of Soomro et al. (2021) concludes that labour productivity is crucial to the drive towards achieving green economy through a low-carbon development approach. Moreover, a causality

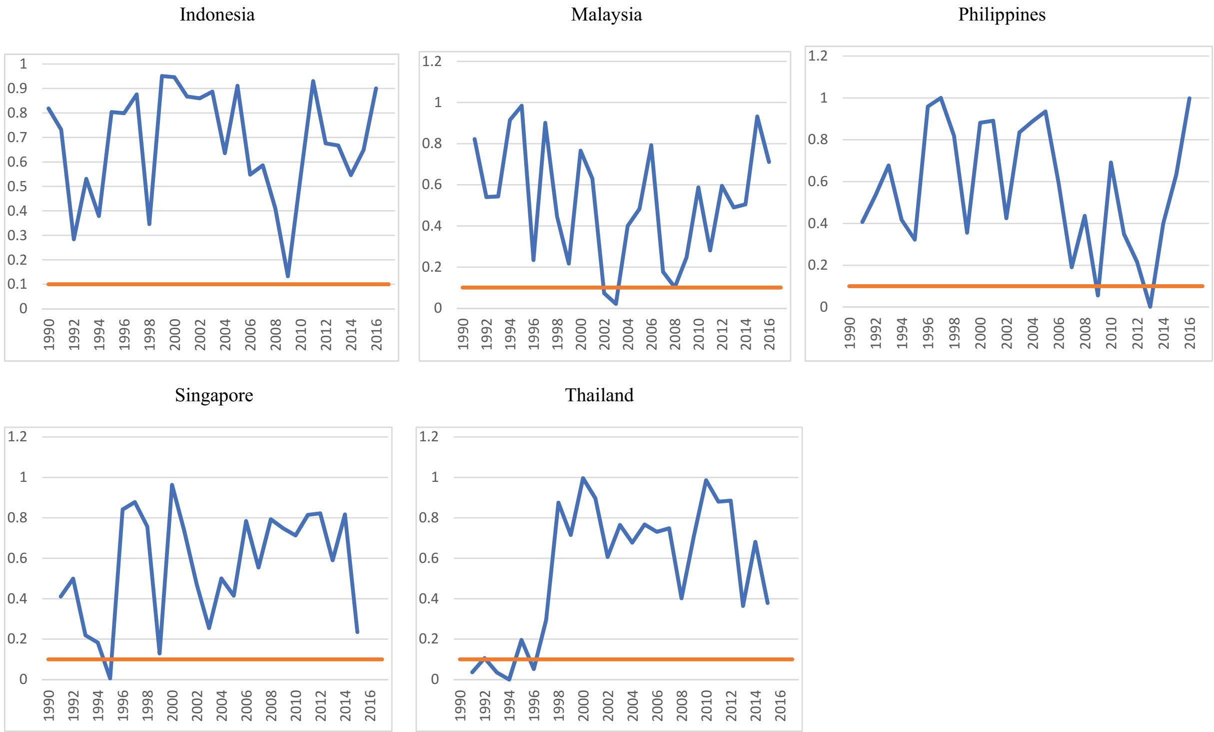

Figure 3. Bootstrap with probability values for causality from PR to EF in rolling window estimation. The orange line shows the significance level at 10%.

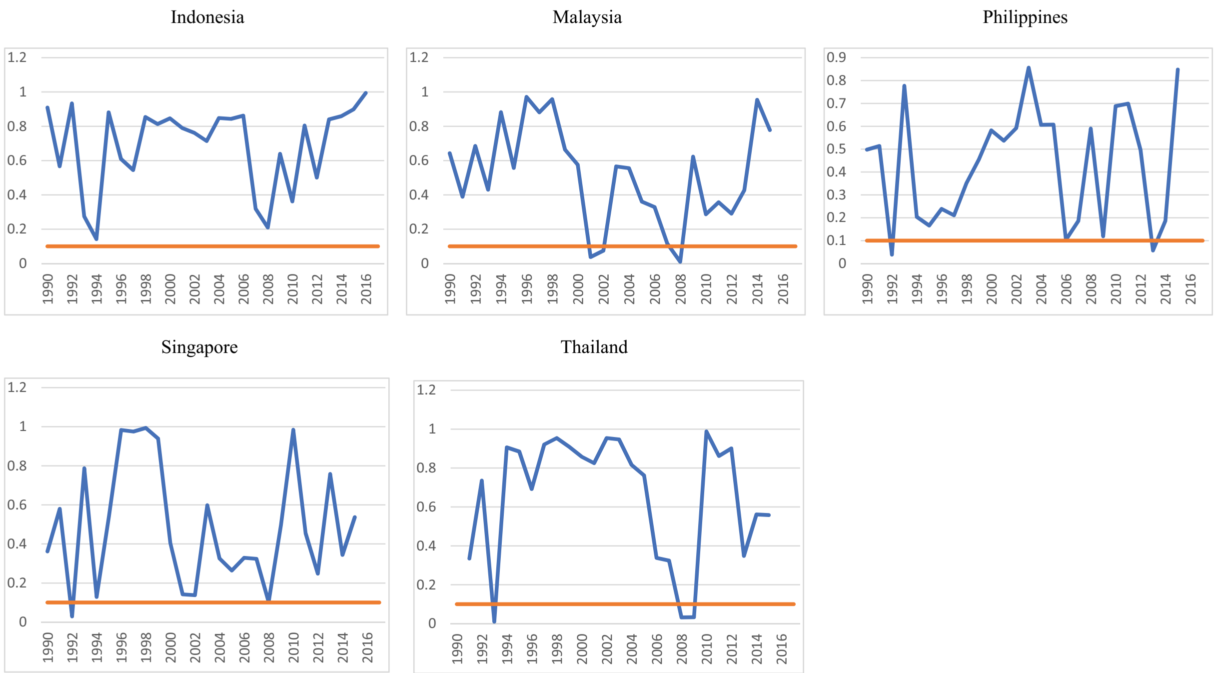

Figure 4. Bootstrap with probability values for causality from GI to EF in rolling window estimation. The orange line shows the significance level at 10%.

relationship from lnLS to lnEF was determined in Indonesia, while a causality relationship from lnGI to lnEF was found in Malaysia and the Philippines. Similar to the extant literature, the role of globalization in environmental sustainability has remained divisive (Saint Akadiri et al. 2020; Adebayo et al. 2022).

Accordingly, Figures 2–4 present Kónya's (2006) bootstrap panel causality test in a time-varying

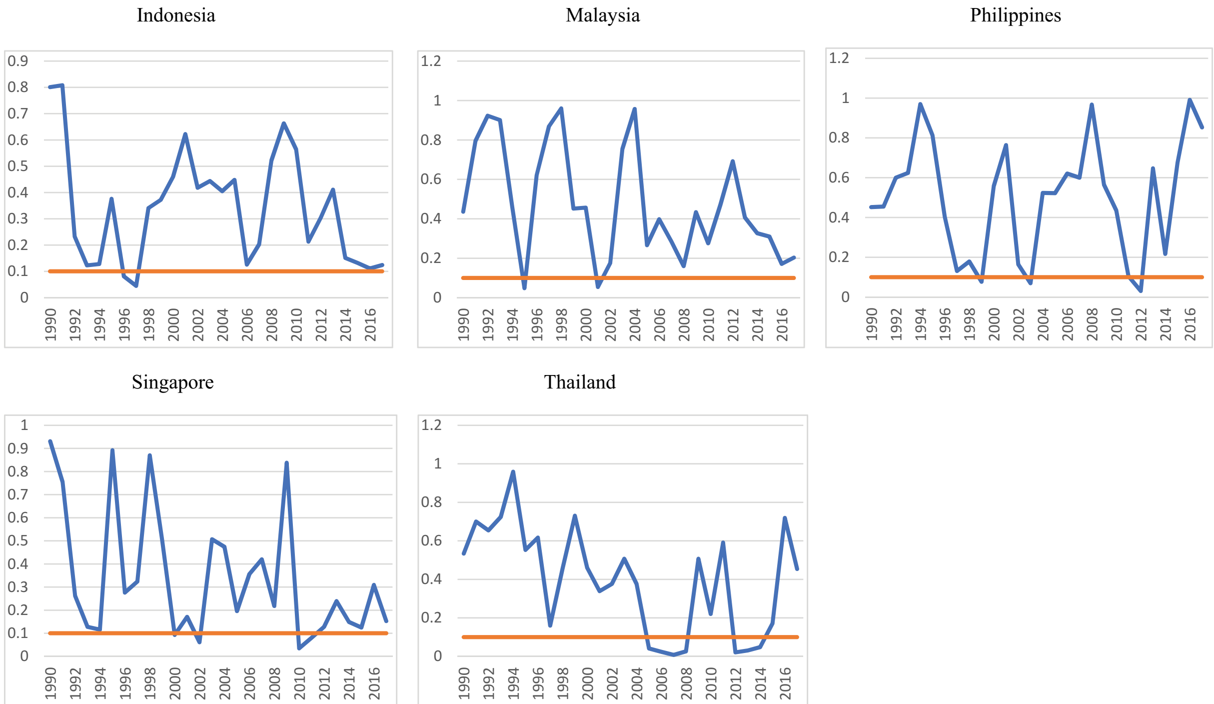

Figure 5. Bootstrap with probability values for causality from EC to EF in rolling window estimation. The orange line shows the significance level at 10%.

observation. Specifically, Figure 2 shows that average working hours per year are the causal of the ecological footprint in all the sampled countries. Looking at subsamples period, this causal relationship, i.e lnWH to lnEF, is valid for Indonesia in 1998–1999, 2006, and 2015–2016; for Malaysia in 2006–2011; for the Philippines in 1990, 1996, 1999–2000, 2002, and 2007–2014; for Singapore in 2006 and 2016–2017; and for Thailand in 1993. This evidence further loud the previous result from Emirmahmutoğlu and Köse's (2011) approach. On the basis of bootstrap rolling window estimation given in Figure 3, it is also determined that causality nexus exists from lnPR to lnEF in Malaysia in 2002–2003; in the Philippines in 2009 and 2013–2014; in Singapore in 1995, and in Thailand in 1991–1992, 1994–1994 and 1997. Additionally, Figure 4 illustrates that there exists a causality relationship from lnGI to lnEF in Malaysia in 2001–2002 and 2007–2008; in the Philippines in 1992 and 2013; in Singapore in 1992; and in Thailand in 1993 and 2008–2009. Finally, the investigation established the causality relationship from EC to lnEF in Indonesia in 1996–1997; in Malaysia in 1995 and 2002; in the Philippines in 1999, 2003, and 2011–2012; in Singapore in 2000, 2002, and 2010–2011; and in Thailand in 2005–2008 and 2012–2014 (Figure 5). In general, with the exception of the 2008–2009 global financial crisis period, most of the indicated periods in the examined countries are largely characterized by economic boom and growth arising from higher economic activities through labour productivity and working hour-led growth. For instance, even with the Asian financial crisis, Thailand's economic growth remained steady at about 5% while millions of people were pulled out of poverty between 1960 and 2005 (World Bank 2022).

6. Conclusion and policy recommendation

The five economically leading ASEAN countries, i.e Indonesia, Malaysia, the Philippines, Singapore, and Thailand, are not only showing semblance in their economic compositions, the countries also share common ecological properties. Given the increasing socioeconomic and environmental danger associated with the depletion of the ecological capacity and especially that the above-mentioned ASEAN countries have already overshot their respective biocapacities, this study looked at the potential drivers of their ecological footprint over the period 1979–2017. Alongside other socioeconomic indicators, the ecological effect of labour productivity, labour income share, and average working hours were examined by employing the recently developed Granger causality approaches by Emirmahmutoğlu and Köse (2011) and Kónya (2006) alongside the DOLSMG to provide more insightful outcome. Before performing the above-mentioned techniques, relevant priori estimations such as the stationarity, cross-section dependence test, homogeneity tests, correlation, and cointegration tests were performed to justify the approach.

Given the result of the DOLSMG approach, the result established a statistically significant and negative impact of labour productivity, labour income share, and globalization on the overall ecological footprint of the countries, thus suggesting that these indicators are geared towards improving ecological quality. While the impact of average working hour in not statistically significant, there is a statistically significant evidence that economic complexity worsen the region's environmental quality. For the result of Emirmahmutoğlu and Köse (2011), in the overall panel, Granger causality is established from the average working hour, labour income share, labour productivity, globalization, and economic complexity to ecological footprint. Whereas, for country-wise, there are causalities from average working hour to ecological footprint only for the Philippines, labour income share to ecological footprint in Indonesia, labour productivity to ecological footprint in Thailand, globalization to ecological footprint in Malaysia and the Philippines, and economic complexity to ecological footprint in Indonesia and the Philippines.

Moreover, the results of Kónya's (2006) bootstrap panel causality test in a time-varying observation offer additional country-specific insight which largely aligns with that of Emirmahmutoğlu and Köse (2011). For instance, average working hours per year are a significant causal of ecological footprint in all the sampled countries at varying periods. Additionally, statistically significant causality exists from labour productivity to ecological footprint in Malaysia in 2002–2003; in the Philippines in 2009 and 2013–2014; in Singapore in 1995, and in Thailand in 1991–1992, 1994–1994, and 1997. Furthermore, there exists a causality relationship from globalization to ecological footprint in Malaysia in 2001–2002 and 2007–2008; in the Philippines in 1992 and 2013; in Singapore in 1992; and in Thailand in 1993 and 2008–2009. Lastly, statistically significant causality relationship is also established from economic complexity to ecological footprint in Indonesia in 1996–1997; Malaysia in 1995 and 2002; the Philippines in 1999, 2003, and 2011–2012; Singapore in 2000, 2002, and 2010–2011; and Thailand in 2005–2008 and 2012–2014. Although the current study is limited in that it only accommodates five ASEAN countries and also exploring a restricted number of indicators, however, the results obtained have potential policy relevance.

6.1 Policy recommendation

While labour productivity, labour income share, and globalization seem to show desirable ecological effect, a more proactive policy measure is essential especially in thwarting the potential environmental setbacks of economic complexity and working hours. Given this urgency, a more deliberate attempt at incorporating or adopting more stringent environmental measures in all social and economic activities, i.e across the production and service value chain, should further curb environmental impediments. While sectoral diversification is key to improving the countries' ease of economic productivity, i.e improving economic complexity, exploring the requisite knowledge and expertise from the society, firms, and stakeholders towards advancing sophistication and social welfare could be another effective measure that promotes environmental sustainability. More household-level and private sector engagement in environmentally friendlier practices including corporate social responsibility should further boost green contributions from trade, balance of output, and employment which are the key components of labour and economic structure. One important and underlying environmental factor which has not been considered in this study is the energy structure of the countries. As a policy oversight, ecological footprint could be eased should the ASEAN countries further adopt a more ambitious energy transition agenda across the sectoral activities.

Disclosure statement

No potential conflict of interest was reported by the authors.

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