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Investigating the environmental externalities of tourism development: evidence from Tanzania

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ABSTRACT

Tourism growth is an important component for welfare improvement in the host destination, but it can be associated with environmental degradation. The aim of the current study is to assess the environmental impacts of tourism growth in Tanzania, using time series data for the period 1995–2017. It utilizes ecological footprints as a proxy for environmental damage, tourism receipt as an economic indicator, and primary energy consumption, urban population, and trade openness as control variables. The study employs Autoregressive Distributed Lag Bounds Testing, Vector Error Correction Model (VECM), and Granger causality test for analysis and the Wild Bootstrap approach to check the accuracy of the computed statistics. The VECM Granger causality test shows that in the case of Tanzania, international tourism revenue and trade openness compact environmental degradation, while urbanization and primary energy consumption accelerate it. Besides, while long run cointegration exists among the variables, the environmental Kuznets curve hypothesis was not ascertained in Tanzania. Therefore, Tanzania must adopt more proactive urban planning strategies to achieve sustainable urbanization thereby improving the quality of the environment. Additionally, it is important for Tanzania to make strategic use of trade and tourism receipts, such as investment on renewable energy, to lessen dependence on fossil fuels, and improve environmental sustainability. So, the study opens new policy perspectives with wide international relevancy as outlined in the policy implication section.

1. Introduction

Tourism is among the fastest growing sectors and a significant contributor to the overall economic growth of the developing economies. For instance, the World Travel and Tourism Council economic impact report affirms that in 2019, Tanzania tourism sector contributed 10.7% of the GDP and 11.1% of the total employment countrywide (WTTC, 2020). Likewise, in the same year the sector contributed 6.9% and 6.5% to GDP and total employment respectively in Africa (WTTC, 2020). Given the increasing contribution of the tourism sector to GDP and employment, policymakers in developing countries such as Tanzania have singled out tourism development as among the major suitable drivers of poverty reduction for it has consistently proved to be a reliable source of employment (Adiyia et al., 2017; Kimaro and Ndlovu, 2017; Kyara et al., 2021a, 2021b). Besides, it has been affirmed that the rapid growth of tourism is rather a global phenomenon, and it is likely to continue for a while (WTTC, 2019). Therefore, Tanzania is pitching on tourism growth for an improved livelihood because tourism is one of the country's best source of employment for poverty alleviation.

In developing countries where nature and culture tourism is domineering form of tourism, tourism activities are highly associated with the quality of the natural environment. For instance, the expansion of tourism triggers growth of transport infrastructures the and hospitality industry which in turn impacts on the environment in terms of increased pollution, waste increase, destruction of biodiversity, depletion of natural resources, etc. It is in this background we observe that the consistent tourism growth in Tanzania, and beyond, shows that tourism development is associated with environmental degradation (Kyara et al., 2021b). For example, to sustain the annually increasing number of international tourists' arrival in Tanzania, more hotels and cottages are being built; more roads, railways, and airports are in the pipeline and the existing ones are being expanded. Such infrastructural developments are necessary for improved income and in turn improved livelihood of those at the bottom of the pyramid although not without a significant violation of nature. For example, construction and transportation activities which are directly associated with tourism growth may involve forests clearing, land degradation, noise pollution, destruction of natural habitats, increased carbon dioxide (CO_2) emission leading to increased air and

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water pollution, and increased littering. All these add pressure on local resources and if not well managed they trigger various forms of environmental degradation (Choi and Turk, 2011; Ibrahim, 2018; Šimková and KASAL, 2012; WTTC, 2019).

Most developing countries in sub-Saharan Africa have singled out tourism as a tool for poverty alleviation. However, there are hardly empirical studies measuring the impacts of tourism development on the environment. Narrative studies dominate the assessment of the environmental impact of tourism growth, and most of them lack solid quantitative analysis (Zhong et al., 2011). Consequently, some of the environmental policies are based on narrative studies and imported empirical evidence from studies conducted elsewhere (Assante et al., 2012; Bateman and Fleming, 2017; Rahman, 2020a; Sherafatian-Jahromi et al., 2017), which may not reflect the actual country experience. To narrow this gap, the current study takes Tanzania as a case in point and assess the impacts of tourism growth on environment. Tanzania is chosen because of its fastest growing tourism sector (as compared with other sub-Saharan African countries), the vast stock of tourism resources in the country, and the sector's consistently significant contribution to GDP annually (Kyara et al., 2021; WTTC, 2020). Some studies have affirmed that economic activities are associated with negative ecological impacts, which tend to increase as economy grows (das Neves Almeida et al., 2017). Therefore, as tourism sector in Tanzania expands and spearhead the country's economic growth, the overall environmental externalities of economic growth are likely to increase. To balance sustainability of ecosystem and economic growth in Tanzania, it is necessary to have substantial empirical evidence to support formulation and evaluation of sustainable tourism related policies.

The current research has two objectives. First, taking Tanzania as a case in point, the study makes an empirical assessment of the environmental impacts of tourism to inform tourism and environmental policy formulation in Tanzania. In that way, it will add a voice to Tanzania's tourism and environmental sustainability literature by bringing in some of the missing empirical evidence. Second, the study will investigate the Environmental Kuznets Curve (EKC) hypothesis[1] for Tanzania. To the best understanding of the authors, this hypothesis has not been tested in Tanzania using environmental footprints (EF) as a comprehensive environmental damage indicator.

This study makes three unique scientific contributions to the tourism literature: First, it employs EF as environmental damage indicator and tourism revenue as an economic indicator, to generate empirical evidence on whether the on-going growth of the tourism sector in Tanzania comes with significant environmental externalities. To the best understanding of the authors, no study in Tanzania has used EF and tourism revenue to estimate environmental impacts of tourism growth. Elsewhere, this kind of empirical study considered CO_2 emission as an environmental indicator (Al-mulali, 2012; Ozturk and Al-Mulali, 2015; Rahman, 2020a; Shahbaz et al., 2013a,b). Unlike CO_2 emission, EF is a more comprehensive indicator of environmental damage for it considers the overall impact of human activities on the ecosystem and the extent the human economy depends on the scarce world stock of natural resources such as minerals, soil, clean water, and living organism (Ozturk et al., 2016).

Second, by focusing on tourism sector impacts on the natural environment, the study is introducing a new trend of assessing environmental quality by focusing on economic activities of a specific sector (proxied by sectoral income) to shade more light on the traditional trend of focusing on aggregate economy, proxied by GDP. The sectoral specific assessment will significantly improve the traditional aggregate approach, by providing relevant data to show which sector has greater influence on the national environmental damage data and so set policy targeting sectors with more environmental damaging activities. Third, the study will pioneer verifying whether the EKC hypothesis exists in Tanzania. So far, the existing tourism literate provides no evidence of a research work carried to test this hypothesis using Tanzanian EF data.

To achieve the study objectives, we first review the literature of some selected works on tourism growth and environment. Then an environmental damage model is constructed and estimated using time series data for the period 1995–2017. We utilize EF as an environmental damage indicator, tourism receipt as an economic indicator, and energy consumption, urban population, and trade openness as control variables. The sources of data and the rationality for using these variables are explained in subsection 3.1 and 3.2 of this paper. Stationarity analysis is done using the Augmented Dickey-Fuller (ADF) test, and then the cointegration relationship among the variables will be assessed using the ARDL bounds testing procedure. Causal relationship among the variables is examined using the VECM Granger causality test. Additional diagnostic tests i.e., serial correlation and normality tests, are performed to assess the reliability of the model. Finally, bootstrapping approach is employed to ascertain the accuracy of the computed statistics.

2. Literature review

2.1. Theoretical framework of EKC hypothesis

The EKC hypothesis is modeled after the Kuznets' per capita income-inequality curve, which was proposed in 1955 by an American Economist Simon Kuznets. He attested that in the early stages of economic growth, the economy transition from agrarian to industrialized economy, and income inequality increases with increasing income. Then, rapid economic growth and rural-urban migration following a transition to the industrial economy, heighten income inequality between rural and urban population as urban industrial workers experience higher income compared to rural agricultural workers. Inequality keeps increasing with the rise of income up to a point beyond which it will start declining because the democratization and rise of the welfare state, which is associated with the process of industrialization, will lead to a more equitable sharing of the benefits of rapid growth. In this case, Kuznets propounded that the income-inequality relationship will follow an inverted U-shaped curve (Kuznets, 1955).

Likewise, environmental degradation increases with the rising income per capita up to a threshold level beyond which, the quality of the environment improves with the increase of per capita income. Akin to the income-inequality relationship, the income-environment relationship follows an inverted U-shaped curve. The EKC, therefore, depicts the long-run relationship between economic growth and the consequent environmental impacts (Dinda, 2004). According to the EKC hypothesis, initially, environmental degradation increases as economic growth advances from an agrarian economy to an industrialized economy. In turn, such advancements attract structural changes in the economy: changes towards information-intensive industries and services. The structural changes gradually lead to increasing environmental awareness and regulations, the use of cleaner production technology, and higher demand for improved environmental quality. Then, as the income keeps increasing, environmental degradation starts to increase at a decreasing rate, and once the EKC turning point (TP) is reached, any further increase in income leads to a reduction in environmental damages. Thus, the EKC reflects economic growth natural movement from a clean agrarian economy to an environmentally damaging industrial economy, and then to a clean service economy (Dinda, 2004).

The EKC hypothesis started with the seminal work of Grossman and Krueger, where they carried out an empirical analysis of the environmental impacts of a North America trade agreement. The researchers

[1] The concept of EKC Hypothesis was first developed by economist Simon Kuznets in the1960s. The EKC hypothesis postulates an Inverted-U-shaped relationship between different pollutants and per capita income, i.e., environmental pressure increases up to a certain level as income goes up; then after a certain level of income somSe part of the income is invested in the environment and the ecology is restored. Detailed exploration of EKC hypothesis is presented under literature review section.

presented empirical evidence to show that a reduction in trade barriers will have at least 3 significant environmental impacts: it will lead to expansion of economic activities, alter the composition of economic activities, and transform production techniques (G. M. Grossman and Krueger, 1991). Among other tests, they studied the relationship between air quality and economic growth using panel data for 42 countries and concluded that at a low level of national income the concentration of sulfur dioxide and smoke increases with per capita GDP but decreases with GDP growth at higher levels of national income.

The pioneering work of Grossman and Krueger immediately attracted more researches (Shafik and Bandyopadhyay, 1992), explored the economic growth vs. environmental quality relationship by analyzing the patterns of environmental transformation for countries with varying levels of income, taking various indicators as proxies for environmental damage. They established that income maintains the most consistent significant effect with all the environmental indicators and that as income increases, most environmental indicators worsen initially, then improve as technology improves and the economy reaches the middle-level incomes. Then, the World Bank in its 1992 development and environment report popularized the EKC school of thought by contending that the demand for improved environmental quality will increase with an increase in income because it is possible to dedicate more resources to environmental conservation as income increases (Mondiale, 1992).

Considering the above 3 initial studies, it has been affirmed that the EKC hypothesis essentially shows that a higher level of economic growth is normally associated with a gradual decline of ecological damage following structural changes towards improved technological production and environmental awareness (T, 1993). To this end, Stern (2004), confirms that improvement in the state of technology entails changes in emission and productivity.

2.2. Tourism growth and the quality of environment

Tourism industry and related economic activities are usually perceived as a geographical and economic phenomenon, while undermining the associated environmental issues. Nevertheless, such activities have negative social and environmental externalities (Ozturk et al., 2016; Rahman, 2017). For instance, unchecked soaring numbers of tourists' arrivals excite excessive pressure on resources and facilities in the host environment such as lodges, hotels, water, energy, and transportation. Ultimately, unsustainable pressure on the natural environment is associated with increased pollution (e.g., through increased CO_2 emissions and littering), natural resources depletion and disruption of cultural traditions, social processes, and livelihood systems (Al-Mulali et al., 2016; Njoya and Seetaram, 2018).

Increased numbers of tourist arrivals above the host environment carrying capacity, has immediate economic returns accompanied with negative environmental impacts which tend to erode the long-run economic returns from the tourism sector itself; unchecked mass tourism carries potential seeds for eliminating specific features or uniqueness of an area or product itself (Ozturk and Al-Mulali, 2015; Shahbaz et al., 2013a,b). Established ways to ensure sustainable tourism include consistent monitoring and evaluation of tourism and tourism-related activities, effective urban planning, adopting environmentally friendly travel infrastructure and optimal exploitation of natural resources (Castellani and Sala, 2008; Choi and Turk, 2011; Janjua et al., 2021; Mandić, 2019; Ozturk and Al-Mulali, 2015; Šimková and Kasal, 2012; WTTC, 2019). Besides, the International Labour Organization (ILO) has summarized three fundamental pillars of sustainable tourism as environmental integrity, economic development, and social justice (Modica, 2015).

In line with the ILO pillars of sustainable tourism, to address some statistical gaps in the tourism-environment literature, the World Tourism Organization (UNWTO) is leading the efforts towards expanding tourism statistical analysis beyond economic focus to embrace associated features such as social-cultural and environmental impacts (UNWTO, 2018). Adequate statistical analysis is a need for formulating effective policies that can harness tourism benefits and manage the associated negative externalities (Assante et al., 2012; Bateman and Fleming, 2017; Zhong et al., 2011). Although small economies, such as Tanzania, depends on tourism revenue to grow her economy, there are only few detailed empirical studies focusing at measuring the impacts of economic activities such as tourism on the environment in such economies (Akinboade and Braimoh, 2010; Al-Mulali et al., 2016; Kara and Mkwizu, 2020; Njoya and Seetaram, 2018; Odhiambo, 2011; Wamboye et al., 2020). In the case of Tanzania, there is still much reliance on descriptive methodology as compared to quantitative analytical approach thereby falling short of adequate empirical analysis for dependable policy formulation (Anderson, 2015; Anderson and Sanga, 2019; Buzinde et al., 2014; Gardner, 2012; Shoo and Songorwa, 2013).

Modern econometric methods such as Granger Causality, Vector Autoregressive, nonlinear autoregressive distributed lag model and Fully Modified Ordinary Least Square, are regularly used to investigate the relationship between economic activities and environmental degradation (Al-Mulali et al., 2016; Kara and Mkwizu, 2020; Njoya and Seetaram, 2018; Nkalu et al., 2020; Odhiambo, 2011; Sherafatian-Jahromi et al., 2017; Wamboye et al., 2020), and between economic growth and CO_2 emissions to validate the ECK hypothesis (Azam et al., 2018; Ozturk and Al-Mulali, 2015; Rahman, 2020a; Shahbaz et al., 2013a,b).

The above literature affirms that globally, uncontrolled tourism growth threatens natural environment. Further, the review confirms that empirical studies assessing environmental impacts of economic activities were conducted largely in Asia, North America, and the Middle East (Al-mulali, 2012, p. 201; G. Grossman and Krueger, 1995; G. M. Grossman and Krueger, 1991; Rahman, 2017; Shahbaz et al., 2013; Shahbaz et al., 2012; Sherafatian-Jahromi et al., 2017), only a few focused on Africa, South of the Sahara (Kohler, 2013; Shahbaz et al., 2013). Those which focused on Africa, none has attempted to use tourism revenue and EF as proxies for economic indicator and environmental damage, respectively. In the case of Tanzania, there are only a few empirical studies on environmental impacts of tourism growth (Mohammed et al., 2015). At least to the best knowledge of the authors, the EKC hypothesis has not been validated in Tanzania using EF as an environmental damage indicator and tourism revenue as an economic indicator. Likewise, the comprehensive relationship between urbanization and environmental quality has not been empirically assessed in Tanzania. Therefore, the need for generating adequate quantitative evidence regarding the environmental impacts of tourism growth in Tanzania is the gap the current study intends to address.

3. Methodology

3.1. Data and variables

To assess environmental effects of economic activities such as tourism development, the current paper will utilize the following variables:

3.1.1. Ecological footprints

The CO_2 emissions have been regularly used as a proxy for environmental damages (Galeotti et al., 2006; Kusumawardani and Dewi, 2020; Mohammed et al., 2015; Ozturk and Al-Mulali, 2015; Rahman, 2020a). Gradually, EF is being endorsed as a more comprehensive indicator of environmental damage because it takes into account the overall human dependence on the environment to sustain a particular lifestyle, and so it is a more reliable measure of sustainability (Castellani and Sala, 2008; Elshimy and El-Aasar, 2020; Figge et al., 2017; Hopton and White, 2012; Ozturk et al., 2016; Rojas-Downing et al., 2018).

3.1.2. International tourism receipts

To assess the impacts of tourism expansion on the environment, the current study employ data on international tourism receipts, measured in constant US$, as a proxy for sectoral economic growth. Although GDP is traditionally used as an economic indicator to provide a comprehensive picture of the overall relationship between economic growth and the environment, for sectoral planning and policy formulation, it is also appropriate to assess how economic activities of various sectors impact on the environment (Ozturk et al., 2016).

3.1.3. Primary energy consumption

Since increased economic activities such as tourism stimulate additional demand for energy (e.g., electricity, fossil fuels, solar, etc.), the current study employs time series data on primary energy consumption (EC), measured in Kilotonne of oil equivalent (ktoe), to assess its influence on the quality of natural environment. In developing countries such as Tanzania where access to clean and renewable energy is still limited, human activities especially fossil fuel combustion in the manufacturing and transport sector are responsible for the rapidly increasing greenhouse gases in the atmosphere.

3.1.4. Trade openness

To assess the impact of international trade on the environment, the current study utilizes timeseries data on the sum of Tanzania's merchandise exports and imports as a proxy for country's openness to international trade. While international trade is growing rapidly in Tanzania, and by extension in sub-Saharan Africa, empirical studies on the impact of trade on the environment are quite scant as compared to extensive studies on key Tanzania's trading partners such as Middle East, Asia, and North America, where trade-environment nexus has been extensively examined. When international trade not well monitored, it can deplete natural resources, (such as sea and forest products, minerals, and oil) through excessive exploitation and allows importation of environmentally damaging products such as obsolete electronics and vehicles.

3.1.5. Urbanization

The current study utilizes urban population data (thousands of people living in urban areas) as a proxy for urbanization because urbanization is confirmed to go hand in hand with increased urban population (Al-mulali, Weng-Wai, Sheau-Ting and Mohammed, 2015; Apergis and Ozturk, 2015; Liu et al., 2021; Ozturk and Al-Mulali, 2015; Ozturk et al., 2016). Increasing urbanization is associated with mounting urban population, increased industrialization, expansion of physical infrastructures, etc., which exerts additional pressure on the natural resources such that the rate of exploitation supersedes the natural rate of renewal.

3.2. Econometric model specification

To assess the environmental impacts of tourism growth and to test the EKC hypothesis for Tanzania, the study employs time series data for 1995–2017. The selection of this period is based on the availability of reliable data and the significant growth registered by the tourism sector during this period. Importantly, the ecological footprint data for Tanzania are only available up to year 2017. Besides, year 1995 coincides with the period when Tanzania started implementing major macroeconomic and political reforms which elicited significant managerial and productivity changes in the tourism sector. The study formulates a time series model using EF as an environmental indicator and international tourism receipts as an economic indicator. Following section 3.1, EF also depends on other factors, which influence the quality of the natural environment. These include the rate and type of primary energy consumption; the growth of population especially in the urban areas; the effectiveness of the leading government; the amount and type of goods and services traded, etc.

Following Farhani and Rahman (2019), Ozturk et al. (2016), Rahman (2020b) and Shahbaz et al. (2013a,b), the general empirical model can be expressed as follows:

$$EF = f(TOR, EC, TR, UP) \tag{1}$$

where: EF symbolizes ecological footprints measured in global hectares (gha). EF is a measure of humans' dependence on natural resources to sustain a particular lifestyle. It measures the demand versus the scarce supply of nature. EF is a more comprehensive proxy for environmental damage as compared with the traditional proxy, CO_2 emissions (Ozturk et al., 2016). TOR signifies the international tourism receipts; they are expenditures by international inbound visitors plus payments to national carriers for international transport. EC denotes the total primary energy consumption, measured in Kilotonne of oil equivalent (ktoe). UP designates thousands of people living in urban areas as defined by the country's statistics office. The UP is used here as a proxy for urbanization. TR represents total trade openness, which is the sum of country's merchandise exports and imports.

For estimation, this study employs the Bounds Testing approach to Cointegration and autoregressive distributed lag (ARDL) methodology. Three key advantages of ARDL methodology are: first, the approach takes the satisfactory number of lags. Second, it provides a user-friendly way of deriving the error correction model without losing long-run information. Third, its handy in the presence of small and finite sample data size (Bano et al., 2021; Haug, 2002; Jalil and Mahmud, 2009; Narayan and Smyth, 2005). Thus, Eq. (1) can be log-transformed to make it a linear equation and get direct elasticities from the coefficient values (Farhani and Rahman, 2019; Ozturk et al., 2016; Shahbaz et al., 2013a,b) as follows:

$$LNEF_t = \beta_0 + \beta_{tor}LNTOR_t + \beta_{ec}LNEC_t + \beta_{up}LNUP_t + \beta_{tr}LNTR_t + \mu_t \tag{2}$$

where: LN denotes natural logarithms of the variables. β_0, β_{tor}, β_{ec}, β_{up}, and β_{tr} are slopes coefficients to be estimated. μ is an error term and t is the period from 1995 to 2017. To test the validity of the EKC hypothesis, LNTORS, which is the square of LNTOR must be introduced in Eq. (2) as shown below:

$$LNEF_t = \beta_0 + \beta_{tor}LNTOR_t + \beta_{tor2}LNTORS_t + \beta_{ec}LNEC_t + \beta_{up}LNUP_t + \beta_{tr}LNTR_t + \mu_t \tag{3}$$

The EKC hypothesis demonstrates the nexus between environmental damage and income (Laverde-Rojas et al., 2021). It postulates that income and environmental damage are positively related at the early stages of economic growth. Then, as income increases, this relationship reaches a stationary point beyond which income and environmental damage are negatively related. Therefore, the curve explaining the relationship between income and environmental damage is an inverted U-shaped curve. To ascertain if the EKC hypothesis exists in Tanzania, the study will examine the sign and the significance of the slope coefficients β_{tor} and β_{tors}. If $\beta_{tor} > 0$ and significant and $\beta_{tors} < 0$ and significant, then EKC hypothesis in Tanzania is affirmed.

The expected sign of β_{ec} is positive because increased primary energy consumption will be associated e.g., with a higher generation of CO_2 emission which is harmful to the environment. Likewise, the expected sign of trade openness is negative i.e., $\beta_{tr} < 0$, if the nature of the goods and services traded are environmental-friendly due to the existence of effective environmental policies. However, $\beta_{tr} > 0$ if pollutant domestic industries, import of pollutant commodities, and similar environmental damaging activities are significantly operational in the economy (Grossman and Krueger, 1995; Halicioglu, 2009). Finally, the sign of β_{up} can be positive or negative depending on the level of effective checks and balance to the urban growth. The check on urban population growth is one of the fundamental attributes of sustainable urbanization. Consequently, when environmental policy decisions effectively utilize strategies to improve urban planning, then β_{up} takes a negative sign. The vice versa is also true.

3.3. Estimation strategies - cointegration methodology

In the cointegration analysis, we estimate Eq. (3) and examine the existence of a long-run relationship among the variables. One of the challenges of using time series data is the risk of generating spurious regression results whenever the series data are non-stationary. Differencing the series makes them stationary but prevents long-run analysis (Jalil and Mahmud, 2009). To circumvent this problem, the bounds testing approach to Cointegration and ARDL methodology by Pesaran et al. (2001) is broadly used as a reliable approach to assess the impacts of economic growth on the environment (Ang, 2007; Farhani et al., 2014; Jalil and Mahmud, 2009; Kohler, 2013).

First, we perform stationarity test because cointegration tests assume that the variables are integrated of the same order. To this end, we employ the Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1979). Time series regression is sensitive to lag length. So, the second step will involve determination of optimal lag length. Third, we endeavor to establish if there is a cointegration relationship between the variables in Eq. (3) by utilizing *bounds testing of cointegration* (Pesaran et al., 2001; Rahman and Kashem, 2017; Shahbaz et al., 2012, 2013). Bounds testing is a necessary and first step of ARDL methodology; it helps to ascertain if the variables are cointegrated and inform our decision on the appropriate form of ARDL cointegration regression to estimate. In the event that all the series are cointegrated of the same order, we will perform Johansen cointegration test on Eq. (3) and compare the results with the one from bounds testing (Johansen and Juselius, 1990). If cointegration exists among the regressors in Eq. (3), then the ordinary least squares (OLS) approach is the ideal estimation method and the resulting parameters will be consistent (Alves and Bueno, 2003). The bounds testing for cointegration inform the choice of the form of ARDL cointegration regression to estimate: Vector Error Correction Model (VECM) if all the equations are cointegrated, Error Correction Model (ECM) if only some equations are cointegrated, and ARDL short-run form only if there is no cointegrating equation.

3.4. ARDL error correction regression

The general ARDL error correction model consists of an error correction term (ECT) which is used for adjusting disequilibrium in the cointegration relationships. The ARDL error correction regression tests long-run and short-run relationships among cointegrated variables. Following Farhani et al. (2014), Farhani and Rahman (2019), Manzoor et al. (2021), Saayman and Saayman (2015), Shahbaz et al. (2013a,b), and Shahbaz et al. (2012), this study seek to first estimate the ARDL error correction model representation of Eq. (3), which is specified below:

$$\begin{aligned}\Delta LNEF_t = {} & \beta_0 + \beta_1 LNEF_{t-1} + \beta_2 LNTOR_{t-1} + \beta_3 LNTORS_{t-1} + \beta_4 LNEC_{t-1} \\ & + \beta_5 LNUP_{t-1} + \beta_6 LNTR_{t-1} + \sum_{i=1}^{p} \beta_7 \Delta LNEF_{t-i} + \sum_{j=0}^{q} \beta_8 \Delta LNEC_{t-j} \\ & + \sum_{k=0}^{r} \beta_9 \Delta LNTOR_{t-k} + \sum_{l=0}^{p} \beta_{10} \Delta LNTORS_{t-l} + \sum_{m=0}^{v} \beta_{11} \Delta LNUP_{t-m} \\ & + \sum_{n=0}^{z} \beta_{12} \Delta LNTR_{t-n} + \mu_t \end{aligned} \tag{4}$$

where: Null hypothesis of no cointegration is depicted as: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = 0$.

Following Farhani et al. (2014), Farhani and Rahman, (2019) and Shahbaz et al. (2013), at the second stage of ARDL, the error correction model is built as follows:

$$\begin{aligned}\Delta LNEF_t = {} & \alpha_0 + \sum_{i=1}^{p} \alpha_1 \Delta LNEF_{t-i} + \sum_{j=0}^{q} \alpha_2 \Delta LNEC_{t-j} + \sum_{k=0}^{r} \alpha_3 \Delta LNTOR_{t-k} \\ & + \sum_{l=0}^{s} \alpha_4 \Delta LNTORS_{t-l} + \sum_{m=0}^{v} \alpha_5 \Delta LNUP_{t-m} + \sum_{n=0}^{z} \alpha_6 \Delta LNTR_{t-n} + \lambda ECT_{t-1} + \varepsilon_t \end{aligned} \tag{5}$$

where: ECT_{t-1} are residuals obtained by estimating the long-run cointegration model i.e., Eq. (4). Δ denotes the first difference, and λ is the coefficient of the ECT, i.e., the adjustment coefficient. The ECT epitomizes long-run representation. Estimation of Eq. (5) is sensitive to lag length, and so appropriate lag length criterion has to be used (Ouattara, 2004; Shahbaz et al., 2013a,b).

Following the studies of Jalil and Mahmud (2009), Kyara et al. (2021), Ozturk and Acaravci (2013), Rahman and Kashem (2017) and Shahbaz et al. (2013), the causality, if any among the variables, will be examined using the Granger causality test. Finally, subsidiary tests, i.e., Residual Serial Correlation LM Test and Normality Test will be carried out.

3.5. Wild bootstrap approach

To evaluate the accuracy of the model statistics, the study employs bootstrapping approach – a re-sampling methods which quantify and explain the accuracy of calculated statistics. In data science, bootstrapping is used as a key to a better understanding of the model statistics; it provides scientific insights on the accuracy level of computed statistics (Bello et al., 2021; Bootstrapping, 2021). Thus, bootstrapping is useful for model validation (see Table 1).

4. Empirical findings

The variables in Eq. (3) were subjected to the ADF stationarity test and the results are summarized in Table 2. The variables are integrated of different orders: order zero of integration, hereafter denoted as I(0), and order one of integration, hereafter denoted as I(1). Since there is no variable is integrated of order 2, specifying ARDL model is the most ideal approach. Further, these results attest that Johansen Cointegration test cannot be applied to test for cointegration because the variables are cointegrated of different orders.

The results presented in Appendix 1 show that lag 1 is suggested by Final prediction error (FPE), Schwarz information criterion (SC) and Hannan-Quinn information criterion (HQ) criteria. Traditionally, the SC is the most used criteria as compared with FPE and HQ. So, the study takes lag 1 as proposed by SC.

Since we have a combination of I(0) and I(1), Bounds test as proposed by Pesaran et al. (2001) is an ideal test for cointegration (Saayman and Saayman, 2015). Taking each variable in Eq. (3) in turn as the dependent variable and perform bounds testing, we establish that when LNEF, LNTOR, LNTORS, LNEC, and LNTR are dependent variable, the resulting equations are cointegrated at the 5% level. The Bounds testing results are summarized in Table 3.

Since there is cointegration across all equations, then the appropriate form of ARDL to be estimated is Vector Error Correction Model (VECM). Appendix 2a and 2b present Vector Error Correction Model (VECM) estimation results and the corresponding p-values, respectively. These results form a crucial part of this research: they display both the short-run estimates and error correction term (ECT) estimates. Coefficients C(1), C(9), C(17), C(25), C(33) and C(41) are error correction terms (ECT_{t-1}) in model 1 to 6 respectively. In order to confirm a long run relationship among D(LNEF), D(LNTOR), D(LNTORS), D(LNEC), D(LNTR) and D(LNUP), we run coefficient test for C(1), C(9), C(17), C(25), C(33) and C(41). Appendix 2b confirms that C(33) and C(41) are not statistically significant, meaning that there is no long run relationship between LNUP and LNEF. The rest of the ECT_{t-1} coefficients i.e. C(1), C(9), C(17), and C(25) are statistically significant meaning that there is long run relationship among LNEF, LNTOUR, LNTORS, LNEC AND LNTR. Further, testing the significance of the other coefficient one by one we observe that C(3), C(4), C(6), C(7), C(8), C(9), C(25),C(29), C(31),C(32) and C(47) are significant; their corresponding p-values are smaller than 0.05.

The key model of interest in our study is model 1 i.e.,:

D(LNEF) = C(1)*(LNEF(-1) + 5.99030094107*LNTOR(-1)
-0.571768335353*LNTORS(-1) - 2.33139609733*LNEC(-1) +
0.630597223598*LNTR(-1) + 4.11832498114*LNUP(-1) - 91.5923470799) +
C(2)*D(LNEF(-1)) + C(3)*D(LNTOR(-1)) + C(4) *D(LNTORS(-1)) + C(5)*
D(LNEC(-1)) + C(6)*D(LNTR(-1)) + C(7) *D(LNUP(-1)) + C(8)   (6)

Table 1. Summary of types and sources of data.

Variable	Description	Data sources
Ecological footprints (EF); measured in global hectares (gha).	Proxy for environmental damage	(Network, 2019)
International tourism receipts (TOR); measured in constant US$.	Proxy for tourism growth	(NBS, 2021; WDI, 2021)
Primary energy consumption (EC); measured in Kilotonne of oil equivalent (ktoe).	Proxy for energy consumption	(IEA, 2020)
Urban population (UP); thousands of people living in urban areas.	Proxy for urbanization	(WDI, 2021)
Trade openness (TR); the sum of country's merchandise exports and imports	Proxy for country's openness to international trade.	(WDI, 2021)

Table 2. Unit root test - Augmented Dickey-Fuller Test. Null Hypothesis (H_o): The series has unit root, and it is not stationary.

Variable	Stationary at:	ADF-statistic	P-value	Remark
LNEF	1st difference	-3.9886	0.0065	Reject H_o
LNTOR	1st difference	-5.7823	0.0003	Reject H_o
LNTORS	1st difference	-6.3302	0.0001	Reject H_o
LNEC	1st difference	-3.3372	0.0292	Reject H_o
LNTR	Level	-3.8574	0.0180	Reject H_o
LNUP	Level	-4.9178	0.0040	Reject H_o

Table 3. ARDL long run form and bounds test.

Dependent variable	F-Statistic	Critical value for I(0)	Critical value for I(1)	Outcome	Cointegration
LNEF	3.8988	2.62	3.79	Reject H_o	Cointegration exist
LNTOR	640.1658	2.62	3.79	Reject H_o	Cointegration exist
LNTORS	662.1102	2.62	3.79	Reject H_o	Cointegration exist
LNEC	11.4367	2.62	3.79	Reject H_o	Cointegration exist
LNTR	3.8923	2.62	3.79	Reject H_o	Cointegration exist
LNUP	26.4109	2.62	3.79	Reject H_o	Cointegration exist

Null Hypothesis (Ho): There is no cointegrating equation.
Criteria: Reject the Ho if the F-statistic is above the I(O) value.

Since:
C(3) is statistically significant, then D(LNTOR(-1)) effects D(LNEF).
C(4) is statistically significant, then D(LNTORS(-1)) effects D(LNEF).
C(6) is statistically significant, then D(LNTR(-1)) effects D(LNEF).
C(7) is statistically significant, then D(LNUP(-1)) effects D(LNEF).

The results of Appendix 2b can be used for forecasting because C(1), which is the ECT coefficient for model 1, as represented by Eq. (6), is significant. Model 1 is the primary model of interest in this study. C(1) represents the speed of adjustment of EF to its long-run equilibrium. The 0.2196ECT_{t-1} means that a deviation from the long-run equilibrium level of EF in one year is corrected by 12.96% in the subsequent year. And so, for every deviation in the equilibrium condition, approximately 21.96% of such disequilibrium would be corrected back to its equilibrium state. While the significant error correction coefficient confirms the presence of a stable long-run relationship between the EF and the regressors, it also implies Granger causality among the variables. So, tourism activities, trade openness, and urban population have significant effect on the quality of the environment.

With reference to Appendix 2b, while tourism revenue and international trade lessen environmental degradation due to their negative relationship with EF, primary energy consumption and urban population increase environmental degradation due to their positive effect on the EF. The coefficient of primary energy consumption is not significant, but it contributes to environmental damage; it is positive as expected. In essence, a 1% increase in tourism revenue and international trade leads to 2.01% and 0.31%, respectively, decrease in EF. Likewise, a 1% increase in primary energy consumption and urban population leads to 0.086% and 7.86% increase of EF, respectively. Further, we observed that $\beta_{TOR} < 0$ and significant, and $\beta_{TORS} > 0$ and significant. Therefore, the test confirms the absence of the EKC hypothesis in Tanzania.

The ARDL bounds testing for cointegration confirmed cointegration among the variables in Eq. (3). To examine the causality among the variables, we implemented VECM Granger causality test and Wald Coefficients test. The VECM Granger causality results are already implied in Appendix 2b. It is affirmed that D(LNEF) is significantly explained by D(LNTOR), D(LNTORS), D(LNTR) and D(LNUP). To know if the significant coefficients have causal effect to the dependent variable i.e., D(LNEF), we carry out Wald Coefficient diagnostic test. Table 4 presents output of a joint significant test for ECT_{t-1} coefficients and then for coefficients of model one i.e., when D(LNEF) is the dependent variable.

Therefore, the VEC Granger Causality Test confirms a long-run causality between LNTOR and LNEF, LNTORS and LNEF, LNTR and LNEF, and LNUP and LNEF.

The serial correlation and normality tests were carried out and the results are summarized in Appendix 3. The Breusch-Godfrey Serial Correlation LM Test shows that for all lags, the p-values are greater than 0.05. This means that there are no residual autocorrelations. Further, the normality test, which seeks to test the null hypothesis that the residual values are multivariate normal, shows that the p-values for the two components as well as the Jarque-Bera test are greater than 0.05. In this case, we fail to reject the null hypothesis and so conclude that the residuals are multivariate normal. The serial correlation and normality test results are summarized in Appendix 3. In sum, the model diagnostic test results portray significant policy implications as detailed under the policy implication section of this research.

Wild bootstrap estimation results: The wild bootstrap estimation was carried out to confirm the accuracy of the VECM computed statistics (Enilov and Wang, 2021). The results show that the coefficients of LNTOR, LNTORS, LNEC and LNUP are all significant at 95% confidence interval. Thus, as observed under VECM estimation, the wild bootstrap test confirms that based on 95% biased corrected accelerated confidence

Table 4. Wald test – Coefficient Diagnostic Test.

	ECTt-1 coefficients	Model 1 coefficients
Null hypothesis (Ho):	C(1) = C(9) = C(17) = C(25) = 0	C(3) = C(4) = C(6) = C(7) = 0
Chi-square	58.4065	36.3352
P-values	0.0000	0.0000
Remarks	Reject Ho. Conclusion: The joint significant test is statistically significant	Reject Ho. Conclusion: The coefficients are jointly statistically significant

interval, tourism is an accurate and important predictor of environmental quality. These results corroborate the earlier VECM estimation in Appendix 2a and 2b.

5. Empirical findings and discussion

The key limitation in most of the previous literature in assessing income-environment nexus is that most of the previous studies employed data on CO_2 emissions when investigating income-environment relationship, while CO_2 represent only a small proportion of entire environmental damage. Therefore, the current research employed data on ecological footprint, which is a more representative proxy for environment damage. The VECM results show that urbanization and the primary energy consumption are the main factors that increase environmental damage because of their negative effect on ecological footprint, while tourism activities and international trade lessen it by its negative impact on ecological footprint. A 1% increase in urbanization and primary energy consumption leads to increase ecological footprint by 7.86% and 0.085% respectively. Likewise, a 1% increase in tourism activities and international trade leads to 2.01% and 0.31% decrease in ecological footprint, respectively. Further, the regression affirms positive relationship between the square of tourism revenue (TORS) and EF; a 1% increase in the TORS will lead to 0.18% increase in environmental damages due to its negative impact on EF.

In line with the VECM results, we observe that some of the urban environmental challenges experienced in Tanzania such as untreated domestic sewage disposal; poorly managed industrial and solid waste culminating into water and air pollution; excessive use of fossil fuel to meet increasing demand for transport, light and heating; emergence of shanty towns; etc., are ramifications of unchecked rapidly increasing urbanization especially in major cities such as Dar es Salaam, Arusha, and Mwanza. Currently, urban settings in Tanzania, unlike the rural counterparts, presents better means of livelihood opportunities, and so catalyze the rural-urban migration. These finding are consistent with the findings of Adedoyin et al. (2020) Al-mulali et al. (2015), Capps and Ramírez (2015), Maiti and Agrawal (2005), Ozturk and Al-Mulali (2015), Ozturk et al. (2016), Liu et al. (2021), etc. In sum, the rapidly increasing urban population in Tanzania are likely to culminate into a more serious environmental problems such as reduction of ground water re-charge due to excessive evapotranspiration and expanding paved surfaces. These will further lead to drying underground water wells and lead to acute environmental, health, and socioeconomic hazards.

In the case of Tanzania, the positive relationship between energy consumption and ecological footprints confirms that primary energy consumption causes environmental degradation. This is largely so due to Tanzania's high dependence on fossil fuel as source of domestic and industrial energy. About 70.9% of Tanzania's electricity draws from fossil fuel; a source well known as a major cause of pollution due to its huge contribution to CO_2 emission (AFREC, 2015). This statistic remains valid to date because since then there has not been major diversification of energy sources in Tanzania. Besides, road and air has remained as common means of transport across the country, which in turn generate a lot of CO_2 emissions. Thus, the booming tourist arrivals and tourism activities in Tanzania generates additional demand for gas, diesel, and motor gasoline, thereby putting additional pressure on the environment. The positive relationship between energy consumption and environmental quality has been also illustrated by several past studies (Ang, 2007; Farhani et al., 2014; Marrero, 2010; Ozturk and Al-Mulali, 2015; Saboori and Sulaiman, 2013).

According to our results, the current effect of primary energy consumption on ecological footprint is not significant. This is because the overall amount of energy consumed is still low. Over 60% of the country's population have no access to grid electricity; they rely on unclean energy sources i.e., fossil fuel and wood (Felix and Gheewala, 2012). However, it is only a matter of time the expansion of tourism sector and other sectors will exert additional pressure on energy consumption to environmentally unsustainable level. For instance, Tanzania has a plan to enhance access to grid-connected electricity to realize her rural electrification initiative, thereby promote emergence of small-scale industries in rural areas for improved livelihood. Likewise, the country is aiming at becoming a semi-industrialized economy by 2025 and with an average annual GDP growth rate of at least 7%. However, these plans are not supported with a proportionate initiative to widen the access to clean and renewable energy. In particular, Tanzania's rural electrification initiatives comes with seeds for environmental degradation (Felix and Gheewala, 2012) because such initiatives are not proportional with efforts to create affordable access to clean and renewable energy. As greater proportion of the population gain access to the current grid electricity which hugely derives from unclean sources such as fossil fuel and gas, more environmental damages will be impending.

According to the World Bank (2020ed.), the trade sector in Tanzania contributed 21.82% of GDP in 2018 and 25.68% in 2017. The results of this study affirm that trade openness contracts the EF in Tanzania. Similar results were observed by Le et al. (2016), Shahbaz et al. (2013), etc. This means that the type of goods and services which Tanzania trades with the rest of the world are by and large environmental-friendly. It follows therefore, Tanzania can take advantage of international trade revenue to finance environmental protection strategies.

Likewise, tourism revenue displays negative relationship with EF, and so compact environmental damages. Therefore, although tourism-related activities such as construction can undermine the quality of natural environment (Ohl et al., 2007; Ozturk et al., 2016; Rahman, 2017), in the case of Tanzania, presupposing effective policies are in place; income from tourism can significantly be utilized to contain the country's environmental degradation. For instance, promoting community-based conservation by empowering the local community is one of the areas which the government must invest more (Robinson and Makupa, 2015). The negative relationship between tourism revenue and environmental degradation has also been reported by other researchers (Al-Mulali et al., 2016; Farhani et al., 2014; Li et al., 2006).

Contrary to the inverted U-shaped curve predicted by EKC hypothesis, we observed that β_{tor} is negative and significant, while β_{tors} is positive and significant. This implies that at the beginning tourism revenue compacts environmental damages, but as revenue increases over time it will have significant negative impact on the quality of the environment unless the country adapts sustainable tourism growth measures. Therefore, urbanization strategies, as depicted by measures to monitor the urban population growth, have not helped in forming an inverted U-shaped relationship between tourism revenue and environmental degradation in Tanzania. In the long-run, tourism growth, as projected by LNTORS, causes significant damages to the environment. In comparison with countries where the EKC hypothesis is established (Al-mulil et al., 2016; Ozturk et al., 2016), the levels of energy efficiency and renewable energy in Tanzania is very low.

As for the future research on tourism and environment the authors recommend use of panel data and assess the impact of tourism growth on the quality of the natural environment in Eastern Africa region. This is because international trade in the region, including tourism, among most of the eastern Africa countries especially Tanzania, Kenya, Uganda and Rwanda, is growing rapidly and country specific political and economic policies are gradually more dependent on the policies of the neighboring states, but so far no study has been carried to assess the reginal impacts of growth on the environment.

6. Conclusion and policy implications

This study investigated the relationship between ecological footprints and tourism revenue, primary energy consumption, trade openness and urbanization in Tanzania for the period 1995–2017. The VECM Granger causality test confirm that in the case of Tanzania, while urbanization and primary energy consumption accelerate accelerates environmental degradation, international tourism revenue and trade openness compacts it. Besides, the results confirm long-run relationship among the variables and absence of the EKC hypothesis. The absence of EKC hypothesis implies that Tanzania's efforts to safeguard the environment are still below the desired threshold. If Tanzania, and by extension the sub-Saharan Africa, is to attain sustainable development, more proactive scientific research on environmental degradation to inform formulation and implementation of environmental policies and regulations, are inevitable.

The study also affirmed that proceeds from international trade and tourism activities can be used to alleviate environmental damages. Thus, ceteris puribus, promoting sustainable tourism will ultimately lead to improved environmental quality if good governance is nurtured and policymakers formulate and implement effective tourism policies. In the case of Tanzania, urban population control and enforcing compliance with environmental regulations are basic tools for reducing country's pressure on the natural environment. Such compliance can only come about if effective policies and good governance exists. For improved governance, improved democracy and public-private partnerships are crucial to empower residents to take responsibility for improved environmental quality. At present, freedom of expression and public-private partnership in Tanzania are impeded by the prevailing underlying unhealth sociopolitical conditions such as closing civic space, increasingly overgrown executive branch, inadequate political competition, underdeveloped civil society, unhealthy barriers to accessing information, low public accountability, etc (USAID, 2020). Timely access to information and existence of effective civic society are some of necessary preconditions for effective advocacy in favor of environmental quality.

Following the preceding analysis, the following are some key policy and managerial implications. First, to improve environmental quality, Tanzania needs to adopt a scale-up strategy to enhance access to clean and renewable energy thereby alleviating excessive dependence on fossil fuels. For example, policies to improve public transport infrastructures, will reduce the demand for motor gasoline to operate private vehicles. Similarly, imparting an environmental safeguarding awareness to the tourists and the public will help reduce energy usage. Such environmental protection awareness campaigns covering best practices on the use of environmental resources such as electricity and water, avoiding unnecessary private drive, garbage disposal, littering, etc. can be imparted to the public by means of leaflets, video clips, recorded briefs, etc. They should also be made a compulsory welcome package to tourists, as well as a non-optional component in the curriculum of secondary and primary education. The same strategy can be adopted by most sub-Saharan African countries which share similar experience with Tanzania.

Second, in the case of Tanzania, in the short-run, trade compacts ecological footprints and hence alleviates the natural environment. Appropriate and effective trade-related policies, guidelines, and regulations such as prohibiting industries with obsolete technologies; regulating the importation of used motor vehicles and unnecessary and obsolete plastics and electronic items; and continued public environmental awareness will further strengthen the current positive contribution of international trade on environmental conservation efforts in Tanzania, and by extension in sub-Saharan Africa. Such efforts should be accompanied with more deliberate strategies for channeling greater part of tourism and trade revenue to support environmental safeguarding programs.

Third, Tanzania needs turn-around policies to alleviate the impacts of the missing strong urban governance: the unplanned rapid urban population growth changes the quality of the natural environment due to unsustainable consumption patterns. For instance, the rapidly increasing urban population is associated with unsustainable demand for energy, durable commodities, water and sanitation, and an excessive built environment. This in turn pollutes the natural environment. Also, urbanization in major cities such as Dar es Salaam, Arusha and Mwanza is associated with flooding leading to downstream water pollution because the unplanned city expansion interferes with the natural water runoff patterns. Since the government lacks adequate resources and expertise to manage urbanization, we recommend policies promoting public-private partnership to help form priorities that are shared and implemented broadly by the public, the private institutions, and individuals. Strong and participatory urban governance is critical for sustainable environmental progress.

Fourth, for a sustainable environment Tanzania needs to set strategies to promote timely and accurate data collection, research, and publications. Lack of robust statistical data and scientific publications is a chronic problem across sub-Saharan Africa (Kyara et al., 2021b). Building a big and accessible public database for vital statistics will promote scientific research and publications which is a basis for good policy formulation. The current lack of good statistics implies that urban indicators that would inform sustainable environment decisions are missing.

Declarations

Author contribution statement

Valensi Corbinian Kyara: Conceived and designed the experiment; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Mohammad Mafizur Rahman, Rasheda Khanam: Analyzed and interpreted the data; Wrote the paper.

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Data availability statement

Data used in this research were extracted from international databases which can be accessed by the public. These include World Development Indicators database, International Energy Commission database, and the Global Footprint Network. Please refer to the uploaded data availability statement for a more detailed information.

Declaration of interest's statement

The authors declare no conflict of interest.

Additional information

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Appendix 1: Optimal lag determination

Lag	LogL	LR	FPE	AIC	SC	HQ
0	37.55078	NA*	0.001477	-3.711856	-3.417781	-3.682625
1	39.11304	1.837956	0.001410*	-3.778005	-3.434917*	-3.743901*
2	39.68041	0.600738	0.001527	-3.727106	-3.335006	-3.688131
3	40.34545	0.625925	0.001652	-3.687700	-3.246587	-3.643853
4	41.79908	1.197108	0.001652	-3.741068	-3.250943	-3.692349
5	41.88789	0.062690	0.001978	-3.633870	-3.094732	-3.580278
6	44.26991	1.401185	0.001858	-3.796460*	-3.208309	-3.737996

* Indicates lag order selected by the criterion.
LR: sequential modified LR test statistic (each test at 5% level).
FPE: Final prediction error.
AIC: Akaike information criterion.
SC: Schwarz information criterion.
HQ: Hannan-Quinn information criterion.

Appendix 2a: Vector Error Correction Estimates

Cointegrating Eq:	CointEq1					
LNEF(-1)	1.000000					
LNTOR(-1)	5.990301					
	(1.18330)					
	[5.06237]					
LNTORS(-1)	-0.571768					
	(0.08872)					
	[-6.44479]					
LNEC(-1)	-2.331396					
	(0.60508)					
	[-3.85303]					
LNTR(-1)	0.630597					
	(0.10661)					
	[5.91513]					
LNUP(-1)	4.118325					
	(0.63764)					
	[6.45874]					
C	-91.59235					
Error Correction:	D(LNEF)	D(LNTOR)	D(LNTORS)	D(LNEC)	D(LNTR)	D(LNUP)
CointEq1	0.219642	0.457661	6.041383	0.263892	0.305456	-0.002564
	(0.03744)	(0.20172)	(2.53208)	(0.07276)	(0.19811)	(0.00310)
	[5.86619]	[2.26876]	[2.38594]	[3.62689]	[1.54187]	[-0.82693]
D(LNEF(-1))	-0.137147	-0.756966	-9.602880	0.037669	0.135779	0.007026
	(0.20553)	(1.10731)	(13.8992)	(0.39940)	(1.08747)	(0.01702)
	[-0.66729]	[-0.68361]	[-0.69089]	[0.09431]	[0.12486]	[0.41283]
D(LNTOR(-1))	-2.012528	-5.136495	-65.43757	0.259964	-0.291734	0.041440
	(0.64490)	(3.47446)	(43.6123)	(1.25321)	(3.41220)	(0.05340)
	[-3.12069]	[-1.47836]	[-1.50044]	[0.20744]	[-0.08550]	[0.77603]
D(LNTORS(-1))	0.180167	0.420862	5.387790	0.004745	0.037013	-0.003438
	(0.05197)	(0.27997)	(3.51426)	(0.10098)	(0.27495)	(0.00430)
	[3.46705]	[1.50324]	[1.53312]	[0.04699]	[0.13462]	[-0.79904]
D(LNEC(-1))	0.085958	0.195709	2.780088	-0.508873	0.381892	-0.001844
	(0.12666)	(0.68237)	(8.56527)	(0.24612)	(0.67014)	(0.01049)
	[0.67867]	[0.28681]	[0.32458]	[-2.06754]	[0.56987]	[-0.17584]
D(LNTR(-1))	-0.310294	-0.190384	-2.892341	-0.188022	-0.075069	0.004742
	(0.07267)	(0.39153)	(4.91457)	(0.14122)	(0.38451)	(0.00602)
	[-4.26978]	[-0.48626]	[-0.58852]	[-1.33140]	[-0.19523]	[0.78799]
D(LNUP(-1))	7.861684	14.86865	210.6155	10.48322	12.37798	0.818159
	(1.84876)	(9.96040)	(125.025)	(3.59262)	(9.78191)	(0.15309)
	[4.25241]	[1.49278]	[1.68458]	[2.91798]	[1.26540]	[5.34445]

(continued on next page)

(continued)

Cointegrating Eq:	CointEq1					
C	-0.405476	-0.707486	-9.977387	-0.434991	-0.561154	0.009575
	(0.09101)	(0.49032)	(6.15461)	(0.17685)	(0.48153)	(0.00754)
	[-4.45537]	[-1.44291]	[-1.62112]	[-2.45961]	[-1.16535]	[1.27053]
R-squared	0.756183	0.405337	0.418311	0.719202	0.264007	0.879570
Adj. R-squared	0.624897	0.085134	0.105094	0.568003	-0.132297	0.814724
Sum sq. resids	0.010982	0.318764	50.22415	0.041470	0.307442	7.53E-05
S.E. equation	0.029065	0.156590	1.965552	0.056480	0.153783	0.002407
F-statistic	5.759811	1.265875	1.335532	4.756662	0.666172	13.56384
Log likelihood	49.54065	14.17447	-38.95343	35.58890	14.55421	101.8573
Akaike AIC	-3.956252	-0.588045	4.471755	-2.627514	-0.624211	-8.938795
Schwarz SC	-3.558339	-0.190132	4.869669	-2.229601	-0.226297	-8.540882
Mean dependent	-0.003812	0.074583	1.035537	0.054757	0.083001	0.049725
S.D. dependent	0.047456	0.163713	2.077763	0.085933	0.144520	0.005591
Determinant resid covariance (dof adj.)		1.94E-17				
Determinant resid covariance		1.09E-18				
Log likelihood		255.4759				
Akaike information criterion		-19.18819				
Schwarz criterion		-16.50227				

Appendix 2b: Summary of Vector Error Correction Estimates with p-values

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.219642	0.037442	5.866192	0.0000
C(2)	-0.137147	0.205529	-0.667289	0.5066
C(3)	-2.012528	0.644897	-3.120694	0.0025
C(4)	0.180167	0.051966	3.467050	0.0009
C(5)	0.085958	0.126655	0.678675	0.4994
C(6)	-0.310294	0.072672	-4.269784	0.0001
C(7)	7.861684	1.848758	4.252414	0.0001
C(8)	-0.405476	0.091009	-4.455366	0.0000
C(9)	0.457661	0.201723	2.268756	0.0260
C(10)	-0.756966	1.107310	-0.683608	0.4962
C(11)	-5.136495	3.474461	-1.478357	0.1433
C(12)	0.420862	0.279971	1.503237	0.1368
C(13)	0.195709	0.682369	0.286808	0.7750
C(14)	-0.190384	0.391529	-0.486258	0.6281
C(15)	14.86865	9.960402	1.492776	0.1395
C(16)	-0.707486	0.490319	-1.442910	0.1530
C(17)	6.041383	2.532081	2.385936	0.0195
C(18)	-9.602880	13.89924	-0.690893	0.4917
C(19)	-65.43757	43.61232	-1.500438	0.1375
C(20)	5.387790	3.514264	1.533121	0.1293
C(21)	2.780088	8.565274	0.324577	0.7464
C(22)	-2.892341	4.914574	-0.588523	0.5579
C(23)	210.6155	125.0255	1.684580	0.0961
C(24)	-9.977387	6.154610	-1.621124	0.1090
C(25)	0.263892	0.072760	3.626892	0.0005
C(26)	0.037669	0.399397	0.094314	0.9251
C(27)	0.259964	1.253206	0.207439	0.8362
C(28)	0.004745	0.100983	0.046992	0.9626
C(29)	-0.508873	0.246124	-2.067544	0.0420
C(30)	-0.188022	0.141221	-1.331400	0.1869
C(31)	10.48322	3.592625	2.917984	0.0046
C(32)	-0.434991	0.176854	-2.459611	0.0161
C(33)	0.305456	0.198108	1.541865	0.1272
C(34)	0.135779	1.087467	0.124858	0.9010

(continued on next page)

(*continued*)

	Coefficient	Std. Error	t-Statistic	Prob.
C(35)	-0.291734	3.412198	-0.085497	0.9321
C(36)	0.037013	0.274954	0.134617	0.8933
C(37)	0.381892	0.670141	0.569868	0.5704
C(38)	-0.075069	0.384513	-0.195232	0.8457
C(39)	12.37798	9.781909	1.265395	0.2095
C(40)	-0.561154	0.481532	-1.165350	0.2474
C(41)	-0.002564	0.003100	-0.826928	0.4108
C(42)	0.007026	0.017019	0.412832	0.6809
C(43)	0.041440	0.053400	0.776026	0.4401
C(44)	-0.003438	0.004303	-0.799042	0.4267
C(45)	-0.001844	0.010488	-0.175840	0.8609
C(46)	0.004742	0.006018	0.787992	0.4331
C(47)	0.818159	0.153086	5.344455	0.0000
C(48)	0.009575	0.007536	1.270526	0.2077
Determinant residual covariance		1.09E-18		
Observations: 21				
R-squared	0.756183	Mean dependent var		-0.003812
Adjusted R-squared	0.624897	S.D. dependent var		0.047456
S.E. of regression	0.029065	Sum squared resid		0.010982
Durbin-Watson stat	2.090179			

Appendix 3: Model Diagnostic tests

[3.1] Vector Error Correction Residual Normality Tests

Null Hypothesis: residuals are multivariate normal

Component	Skewness	Chi-sq	Df	Prob.	Component	Kurtosis	Chi-sq	Df	Prob.
1	1.393147	6.793006	1	0.009	1	5.499217	5.46532	1	0.019
2	0.181019	0.114687	1	0.735	2	3.611500	0.32719	1	0.567
3	0.554692	1.076890	1	0.299	3	2.738554	0.05981	1	0.807
4	-0.335247	0.393366	1	0.531	4	2.565540	0.16516	1	0.684
5	0.438139	0.671881	1	0.412	5	4.545450	2.08986	1	0.148
6	-0.070764	0.017527	1	0.895	6	2.579327	0.15485	1	0.694
Joint		9.067357	6	0.170	Joint		8.26219	6	0.220

Component	Jarque-Bera	Df	Prob.
1	12.25833	2	0.002
2	0.441877	2	0.802
3	1.136700	2	0.566
4	0.558527	2	0.756
5	2.761745	2	0.251
6	0.172372	2	0.917
Joint	17.32955	12	0.138

[3.2] Serial Autocorrelation LM Test
Null Hypothesis(H0): no serial correlation

F-Statistic	0.704565	p-value F-statistic	0.4154
Obs R-squared	1.054123	p-value Chi-square	0.3046
Decision:	Failed to reject H_0 because all p-value $>$ 0.05		

[3.3] White's Heteroscedasticity Test
Null hypothesis (Ho): The residuals are homoscedastic

F-Statistic	0.668627	p-value F-statistic	0.6765
Obs R-squared	4.642323	p-value Chi-square	0.5904
Decision:	Failed to reject H_0 because all p-value $>$ 0.05		

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