Analyzing the Role of Environmental Technologies and Environmental Policy Stringency on Green Growth in China

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Abstract

This study aims to investigate the impact of environmental technological innovations and environmental policy stringency on green economic growth in China. The empirical analysis of the study is based on the ARDL model. The estimates from the ARDL model confirm that the estimate of environmental technology positively impacts green economic growth both in the short and long run. In the robust model, the estimates of all technologies appeared to be significantly positive in the short and long run. Conversely, the estimated coefficients of environmental policy stringency, in the basic and robust model, have only negatively impacted the green economic growth in China in the short run. In the long run, the environmental policy stringency has not shown any significant impact on green economic growth in China in the basic and robust model.

Introduction

Green growth depends on market-based technological innovations to enhance the efficiency of production, thus distinguishing the environmental effects and natural resource-based consumption from unlimited development (UNEP, 2011). Green environmental technologies are effective in boosting green growth (Sohag et al., 2019), and cleaner technological innovations result in significantly reducing CO2 emissions (Ullah et al., 2021). One strand of literature validates that for an effective and consistent reduction in carbon emissions, improvements in the efficiency of environmental technology are compulsory (Kwon et al., 2017; Du et al., 2017; Chen and Lei, 2018; Mensah et al., 2018). Other strands of the literature reveal that the simultaneous role of environmental-related technologies and renewable energy technologies is required for a sustainable reduction in carbon emissions and renewable energy technologies are vital for producing clean energy (Sarkodie and Adom, 2018; Gu et al., 2019). Thus, environmental technological innovation is an imperative determinant that increases energy efficiency and diminishes energy consumption (Sohag et al., 2015). In the meanwhile, worldwide economic development has raised environmental issues and resource scarcity and distracted the emphasis of the economies from outdated economic development towards sustainable growth.

In this regard, opposing outdated growth theories, the new economic development literature focused on the adoption of technological innovations to attain a green revolution (Acemoglu et al., 2016). Aghion et al. (2020) explored the query that whether technological change combats environmental change or not. The study highlights the significance of patents and environmental stringency policies to direct environmental-related technological changes to increase renewable energy consumption and to reduce non-renewable energy usage for mitigation of carbon emissions. Similarly, the increasing awareness of green growth has stimulated many economies to inaugurate the green economic growth infrastructure for environmental and resources protection especially for the transformation of energy (Herman & Xiang 2019 and Song et al., 2019). Consequently, renewable energy usage, non-renewable energy usage, and green technological innovations, environmental stringency policies contribute significantly in explaining the green growth path.
Zhu et al. (2014) reported that modern environmental theories highlighted that climatic issues can be solved by environmentally-related technological innovations and environment-related regulations/stringency policies. It has become imperative to investigate how to endorse environmental management practices like green growth management to combat environmental issues (Lorek and Spangenberg, 2019). A vast literature supports the argument that the green growth approach has become effective for attaining sustainable development (Grover, 2013; Ploeg and Withagen, 2013). Ploeg and Withagen (2013) examine the association between green growth practices and environmental stringency policy. The findings of the study suggest that carbon tax and research and development subsidies are effective tools to attain green growth. It is well-known fact that the capital development approach is useful for the attainment of sustainable development. The findings of Nielen et al. (2014) study reveal that incentive-based environmental stringency policies contribute to achieving green growth. Environmental technological innovation is a key determinant of green growth (Grover, 2013).

Based on the above discussion it is concluded that the main determinants of green growth include technological innovations, environmental policy stringency, and so on. However, the existing literature takes into consideration the association between one specific determinant and green growth. Although, few studies investigated the integration among technological innovation, environmental policy stringency, and green growth (Zhao and Sun, 2016). Chan et al. (2015) study demonstrated that environmental dynamics have a comparatively strong impact on the association between green technological innovations and cost-effectiveness, and a slightly moderate association between green technological innovations and profitability of firms. Zhao et al. (2020) explore the impact of environmental policy stringency on corporation competitiveness and innovation.

Bel & Joseph (2018) study identified environmental stringency policy as an important determinant to enhance green growth in EU economies. It is argued that the increasing pressure of environmental regulations and environmental stringency policy directly influences green growth. For China, Zhao et al.’s (2015) study examine the influence of three measures of environmental regulations (i.e., market-based regulations, command and control regulations, and government subsidies) on carbon emissions reduction and efficiency improvement of power plants. The findings reveal that government subsidies and market-based regulations positively improve the efficiency of power plants and reduce carbon emissions, but command and control regulations exert no significant contribution. Porter and van der Linde (1995) report that environmental stringency policy can stimulate firm innovation, hence enhancing its effectiveness on green growth. Some researchers explored the association between environmental stringency policy and technological innovations (Lanoie et al. 2011 and Zhao et al., 2020). Castellacci and Lie (2017) examine different types of environmental innovations and reported that environmental stringency policies are more significant drivers of technological innovations and reduction in pollution emissions of firms. Furthermore, Tellis (2008) claimed that technological innovations play a significant role in viable green development in contemporary economies.

Based on the above discussion, understanding the influence of environmental-related technologies and environmental stringency policies on green growth is crucial for decision-making. Previous studies have
mostly focused on the influence of technological innovations and environmental stringency policies on CO2 emissions. However, the present study moves in a new direction and delivers a unique investigation on the simultaneous effect of environmental-related technologies and environmental stringency policies on green growth in the case of China. This study contributes to the existing literature in the following ways. Firstly, to the best of our knowledge, this study is the first one that investigates the simultaneous impact of environmental-related technologies and environmental stringency policy on green growth in China. The study will deliver imperative policy directions that help in stimulating green growth and reducing carbon emissions in China.

**Model And Methods**

Endogenous growth theory believes that technology innovation is the key important source of economic growth, and bulk of empirical research has proved that technology innovation has a significant and positive effect on economic growth (Pece et al. 2015 and Lopez-Rodriguez and Martinez-Lopez 2017). While, a newly emerging body of empirical studies paying attention to the influence of technology innovation on green growth (Mensah et al. 2019 and Danish and Ulucak, 2020). In formulating the green growth model, we follow the most recent theoretical and empirical literature in general (Hallegatte et al. 2012 and Jacobs 2012) and assume that green technology is the main determinant of green growth in China. As such, we begin with the following long-run green growth model specification:

\[
GG_t = \omega_0 + \varphi_2 GT_t + \varphi_2 EPS_t + \varphi_3 Internet_t + \varphi_4 RD_t + \varphi_5 Trade_t + \varepsilon_t \quad (1)
\]

Where green growth (GG) is dependent on green technology (GT), environmental policy stringency (EPS), internet users (Internet), research and development (RD), and trade openness (trade). While green technology affects green growth in the same way as standard green variables, thus expected sign is positive. Environmental policy stringency is one of the deep causes of green growth in the modern era, thus expected coefficient estimates of \( \varphi_2 \) is also positive. Internet and R&D plays an effective role in green growth, while trade openness is a key pillar of green growth, thus \( \varphi_3, \varphi_4 \) and \( \varphi_5 \) could be positive.

The basic model gives us only long-run estimates of concern variables. Next, we need to alter the equation (1) into error correction format for long-run as well short-run estimates as shown below:

\[
\Delta GG_t = \omega_0 + \sum_{k=1}^{n} \beta_{1k} \Delta GG_{t-k} + \sum_{k=0}^{n} \beta_{2k} \Delta GT_{t-k} + \sum_{k=1}^{n} \beta_{3k} \Delta EPS_{t-k} + \sum_{k=0}^{n} \beta_{4k} \Delta Internet_{t-k} + \sum_{k=0}^{n} \beta_{5k} \Delta RD_{t-k} + \sum_{k=0}^{n} \beta_{6k} \Delta Trade_{t-k} + \omega_1 GG_{t-1} + \omega_2 GT_{t-1} + \omega_3 EPS_{t-1} + \omega_4 Internet_{t-1} + \omega_5 RD_{t-1} + \omega_6 Trade_{t-1} + \lambda. ECM_{t-1} + \varepsilon_t \quad (2)
\]

After rewriting the equation (1) into error correction format, thus specification (2) can now be called as time series ARDL model of Pesaran et al. (2001). This equation can provide short and long-run estimates at the same time. Short-run results can be deduced from the estimates connected to the first difference variables, and long run results can be traced from the estimates of \( \omega_2-\omega_6 \) normalized on \( \omega_1 \). However, for the validity of long-run estimates, Pesaran et al. (2001) endorse two tests. The proposed test is F test to
determine the joint lagged level of significance of variables as a sign of cointegration. While the t-test is proposed to determine the cointegration if the estimate of $\lambda$ is negative and significant. This method can take integrating properties into account, and we can add combination I(0) and I(1) variables into our model. Lastly, this technique can provide efficient results in case of a small sample size. This method gives us short and long-run estimates in one step. We have confirmed the autocorrelation problem via Lagrange Multiplier (LM) test, but Breusch–Pagan (BP) test identify the Heteroskedasticity problem. Ramsey’s RESET test is employed which is used to identify model misspecification. The CUSUM and CUSUM-sq tests confirm the stability of coefficients estimates in the end.

Data

The study aims to analyze the role of environmental technologies and environmental policy stringency on green growth in China. In this regard, this research utilizes time-series data for time zone 1990-2019 for the Chinese economy. Table 1 provides information about symbols, definitions, and sources of data. The data on green growth, defined as pollution-adjusted GDP growth, is collected from OECD. The data for environmental-related technologies, all technologies (total patents), and environmental policy stringency index are collected from OECD. The study uses internet, research and development, and trade openness as control variables. Internet users is calculated as individuals using the internet in percent of total population. Research and development is measured into total R&D expenditures in percent of GDP. While trade openness is taken as total trade in percent of GDP. The data on these three control variables are obtained from the World Bank.

Table 1

| Variables                        | Symbol | Definitions                              | Sources   |
|----------------------------------|--------|------------------------------------------|-----------|
| Green growth                     | GG     | Pollution-adjusted GDP growth            | OECD      |
| Environmental technology         | ET     | Environment-related technologies         | OECD      |
| Total technology                 | AT     | All technologies (total patents)         | OECD      |
| Environmental Policy Stringency | EPS    | Environmental Policy Stringency index    | OECD      |
| Internet users                   | Internet | Individuals using the Internet (% of population) | World Bank |
| Research and development         | RD     | Research and development expenditure (% of GDP) | World Bank |
| Trade openness                   | Trade  | Trade (% of GDP)                         | World Bank |

Results And Discussion
Before exploring the long-run effects of environmental technologies and environmental policy stringency on green growth, the stationarity properties of variables have been checked by employing Augmented Dickey-Fuller (ADF) test and Phillips Perron (PP) test. The outcomes of these two unit root tests are displayed in Table 2. This table provides findings regarding the order of integration of variables. The findings of the table reveal that a few variables are level stationary while other variables become stationary after taking the first difference. Thus, it is confirmed that the study can employ ARDL approach because this technique is beneficial in the presence of I(0) and I(1) variables to obtain parameters that are unbiased. Literature supports that there is no objection to using ARDL approach in the presence of mixed order of integration.

### Table 2

**Unit root testing**

|       | ADF |       | PP |       |
|-------|-----|-------|----|-------|
|       | I(0) | I(1)  | Decision | I(0) | I(1)  | Decision |
| GG    | -2.967 |     | I(0) | -2.960 | I(0) |
| ET    | -0.884 | -3.428 | I(1) | -0.839 | -3.406 | I(1) |
| AT    | -0.973 | -3.071 | I(1) | -0.876 | -3.079 | I(1) |
| EPS   | -0.340 | -4.226 | I(1) | -0.464 | -4.228 | I(1) |
| Internet | 0.128 | -2.680 | I(1) | 0.254 | -2.690 | I(1) |
| RD    | -2.907 |     | I(0) | -2.921 | I(0) |
| Trade | -1.078 | -3.435 | I(1) | -1.346 | -3.426 | I(1) |

*Note: ***p<0.01; **p<0.05; and *p<0.1*

After confirming the order of integration of variables, the study employed ARDL approach in order to investigate the impact of environmental technologies and environmental policy stringency on green growth. The long-run and short-run results of ARDL approach are given in Table 3. The study finds that the environmental technologies' effect on green growth is statistically significant and positive at the 10 percent level of significance in the long-run. It is observed that a 1 percent increase in environmental technologies increases green growth by 4.932 percent. Our findings infer that promoting environmental technologies could be a fundamental policy tool to enhance green growth in China. Thus, environmental technologies in China can induce green growth, which tends to reduce environmental pollution.

Our findings are in line with Sohag et al. (2019), who reveals that environmental technology contributes significantly enhances green growth and significantly mitigates CO2 emissions. Thus, green innovation plays a vital role in explaining the path for green growth. Environmental innovation allows for
technological advancement that tends to green development. Advancement in environment-related technologies boosts the clean energy share in total energy and declines the share of energy intensity. However, initially, the technological advancement in energy exerts a harmful impact on CO2 emissions but later on, it improves environmental quality in China. The advancement in equipment related to technological progress improves production efficiency, thus increasing its sustainability by improving green growth. Due to technological advancement, the combustion of fossil fuels is substituted by new sources of energy that subsequently alleviate CO2 emissions. Green technologies encourage cleaner production that tends to be sustainable to green growth.

In view of Mensah et al. (2019), green innovations are somehow dependent on intellectual and patent rights, thus dissemination could be restricted. They claim that green technologies are key determinants of green growth. It is suggested that firms should introduce cleaner production-based technologies and environmental innovation to satisfy the needs of green growth that significantly boosts production competitiveness and efficiencies. Our finding is also consistent with Yao et al.'s (2018), who infer that environmental technology addresses the emissions of both demand-based and supply-based factors and confirms that these innovations significantly encourage green growth. The study suggests that the use of biotechnology reduces the combustion of fossil fuels significantly. Moreover, transport-based technologies are capable of enhancing green growth. A study done by Danish and Ulucak (2020) reveals that transmission and generation-related technological innovations are beneficial for enhancing green growth.

The relationship between environmental policy stringency and green growth is statistically insignificant in the long-run. However, the linkage between internet use and green growth is positive and statistically significant at 1 percent level in the long-run. We find that a 1 percent increase in internet use increases green growth by 0.293 percent in the long-run. It implies that the Chinese government focuses on digitalization products that increase internet use, which in turn increase green growth. However, the relationship between research and development and green growth is statistically insignificant in the long-run in China. However, trade openness is positively associated with green growth. Other things remaining the same, a 1 percent increase in trade openness causes green growth to increase by 0.210 percent in the long-run. We find that environmental policy stringency is negatively and significantly associated with green growth in the short-run at 5 percent level. However, internet use and trade openness are positively and significantly attached with green growth at 5 percent level in the short-run.

The study has used all technology variable in order to check the robustness of findings. The results of the robust model demonstrate that all technology's effect on green growth is statistically significant and positive at the 10 percent level of significance in the long-run. It is found that a 1 percent increase in all technologies increases green growth by 5.062 percent. The impact of environmental policy stringency on green growth is again statistically insignificant in the long-run in the robust model. Internet use adds to green growth significantly and positively at 5 percent level in the long-run. It shows that a 1 percent increase in internet use increases green growth by 0.175 percent. In line with original model, research and development impact on green growth is again statistically insignificant. Trade openness also adds to
green growth positively at 1 percent level of significance in the long-run. It shows that a 1 percent rise in trade openness increases green growth by 0.171 percent. In the short-run, robust model findings are quite similar to the findings of the original model.

In the end, findings of diagnostic tests are given in lower panel of Table 3. The statistically significant coefficient estimates of F-stat confirm that long-run cointegration exists among variables in both models. The coefficient estimates of ECT are statistically significant and negative in both models. These findings confirm the long-run association among variables of interest. The findings display that any short-run deviations will ultimately achieve a stable path in the long-run. There is no evidence of heteroskedasticity and autocorrelation found in both models. Both models are well-specified as confirmed by findings of Ramsey RESET test. The stability of both models is also confirmed by the findings of CUSUM and CUSUM SQ tests. The results from the linear causal empirical analysis are described in Table 4. The results show no causality between EPS and GG. In contrast, unidirectional causality exists from ET to GG, and from AT to GG.
Table 3
ARDL estimates of short and long-run

|               | Basic model |               | Robust model |               |
|---------------|-------------|---------------|--------------|---------------|
|               | Coefficient | S.E          | t-Stat       | Prob.         | Coefficient | S.E          | t-Stat       | Prob.         |
| **Short-run** |             |              |              |               |             |              |              |               |
| D(ET)         | 2.015       | 5.338        | 0.378        | 0.715         | D(ET)       | 4.580*       | 2.403        | 1.906         | 0.081         |
| D(ET(-1))     | 4.795*      | 2.779        | 1.725        | 0.119         | D(EPS)      | -2.238*      | 1.215        | -1.842        | 0.090         |
| D(AT)         |             |              |              |               | D(EPS(-1))  | -3.303**     | 1.444        | -2.288        | 0.041         |
| D(EPS)        | -3.253**    | 1.493        | -2.178       | 0.057         | D(INTERNET) | 0.483**      | 0.208        | 2.320         | 0.039         |
| D(EPS(-1))    | -3.466**    | 1.765        | -1.963       | 0.081         | D(INTERNET(-1)) | -0.491*** | 0.177        | -2.783        | 0.017         |
| D(INTERNET)   | 0.685**     | 0.348        | 1.966        | 0.081         | D(RD)       | 1.353        | 4.874        | 0.278         | 0.786         |
| D(INTERNET(-1)) | -0.528*** | 0.186        | -2.837       | 0.020         | D(RD(-1))   | 4.896        | 7.058        | 0.694         | 0.501         |
| D(RD)         | -2.663      | 7.193        | -0.370       | 0.720         | D(RD(-1))   | 7.101        | 5.188        | 1.369         | 0.196         |
| D(RD(-1))     | 5.807       | 6.066        | 0.957        | 0.363         | D(TRADE)    | 0.154***     | 0.048        | 3.195         | 0.008         |
| D(TRADE)      | 0.180**     | 0.092        | 1.966        | 0.081         |             |             |              |               |               |
| **Long-run**  |             |              |              |               |             |              |              |               |               |
| ET            | 4.923*      | 2.931        | 1.679        | 0.127         | AT          | 5.062*       | 2.770        | 1.828         | 0.093         |
| AT            |             |              |              |               | EPS         | -0.400       | 1.967        | -0.204        | 0.842         |
| EPS           | -1.636      | 2.005        | -0.816       | 0.436         | INTERNET    | 0.175**      | 0.070        | 2.518         | 0.027         |
| INTERNET      | 0.293***    | 0.073        | 4.001        | 0.003         | RD          | 4.896        | 7.058        | 0.694         | 0.501         |
| RD            | 1.983       | 7.772        | 0.255        | 0.804         | TRADE       | 0.171***     | 0.036        | 4.748         | 0.001         |
| TRADE         | 0.210***    | 0.030        | 7.003        | 0.000         | C           | 53.59        | 26.27        | 2.039         | 0.064         |
| C             | 39.77       | 19.58        | 2.031        | 0.073         |             |             |              |               |               |
| **Diagnostics** |           |              |              |               |             |              |              |               |               |
| F-test        | 5.895***    |             |              |               |             | 4.262***     |             |               |               |
| CointEq(-1)   | -1.270**    | 0.517        | -2.458       | 0.036         |             | -0.905***    | 0.227        | -3.981        | 0.002         |
| LM            | 1.589       |              |              |               |             | 0.712        |              |               |               |
| BP            | 2.023       |              |              |               |             | 0.215        |              |               |               |

**Note:** ***p<0.01; **p<0.05; and *p<0.1
|                      | Basic model | Robust model |
|----------------------|-------------|--------------|
| RESET                | 1.023       | 1.536        |
| CUSUM                | S           | S            |
| CUSUM-sq             | S           | S            |

**Note:** ***p<0.01; **p<0.05; and *p<0.1
| Null Hypothesis: | F-Stat | Prob. | Null Hypothesis: | F-Stat | Prob. |
|-----------------|--------|-------|-----------------|--------|-------|
| ET → GG         | 2.949  | 0.075 | AT → GG         | 3.294  | 0.056 |
| GG → ET         | 0.879  | 0.431 | GG → AT         | 0.318  | 0.732 |
| EPS → GG        | 0.280  | 0.759 | EPS → GG        | 0.280  | 0.759 |
| GG → EPS        | 0.071  | 0.932 | GG → EPS        | 0.071  | 0.932 |
| INTERNET → GG   | 0.470  | 0.632 | INTERNET → GG   | 0.470  | 0.632 |
| GG → INTERNET   | 1.698  | 0.209 | GG → INTERNET   | 1.698  | 0.209 |
| RD → GG         | 2.270  | 0.129 | RD → GG         | 2.270  | 0.129 |
| GG → RD         | 8.037  | 0.003 | GG → RD         | 8.037  | 0.003 |
| TRADE → GG      | 1.565  | 0.234 | TRADE → GG      | 1.565  | 0.234 |
| GG → TRADE      | 2.500  | 0.107 | GG → TRADE      | 2.500  | 0.107 |
| EPS → ET        | 0.047  | 0.954 | EPS → AT        | 0.602  | 0.558 |
| ET → EPS        | 2.837  | 0.082 | AT → EPS        | 3.567  | 0.047 |
| INTERNET → ET   | 0.830  | 0.450 | INTERNET → AT   | 0.517  | 0.604 |
| ET → INTERNET   | 3.212  | 0.062 | AT → INTERNET   | 3.292  | 0.058 |
| RD → ET         | 4.178  | 0.031 | RD → AT         | 6.831  | 0.006 |
| ET → RD         | 1.451  | 0.258 | AT → RD         | 0.367  | 0.698 |
| TRADE → ET      | 0.966  | 0.398 | TRADE → AT      | 0.021  | 0.979 |
| ET → TRADE      | 0.746  | 0.487 | AT → TRADE      | 1.064  | 0.364 |
| INTERNET → EPS  | 5.298  | 0.014 | INTERNET → EPS  | 5.298  | 0.014 |
| EPS → INTERNET  | 0.750  | 0.485 | EPS → INTERNET  | 0.750  | 0.485 |
| RD → EPS        | 2.692  | 0.092 | RD → EPS        | 2.692  | 0.092 |
| EPS → RD        | 2.526  | 0.105 | EPS → RD        | 2.526  | 0.105 |
| TRADE → EPS     | 0.195  | 0.825 | TRADE → EPS     | 0.195  | 0.825 |
| EPS → TRADE     | 0.674  | 0.521 | EPS → TRADE     | 0.674  | 0.521 |
| RD → INTERNET   | 2.948  | 0.076 | RD → INTERNET   | 2.948  | 0.076 |
| INTERNET → RD   | 3.413  | 0.053 | INTERNET → RD   | 3.413  | 0.053 |

**Note:** ***p<0.01; **p<0.05; and *p<0.1
Null Hypothesis: | F-Stat | Prob. | Null Hypothesis: | F-Stat | Prob. |
|-----------------|-------|-------|-----------------|-------|-------|
| TRADE → INTERNET | 2.597 | 0.099 | TRADE → INTERNET | 2.597 | 0.099 |
| INTERNET → TRADE | 0.578 | 0.570 | INTERNET → TRADE | 0.578 | 0.570 |
| TRADE → RD | 0.845 | 0.444 | TRADE → RD | 0.845 | 0.444 |
| RD → TRADE | 2.824 | 0.083 | RD → TRADE | 2.824 | 0.083 |

Note: ***p<0.01; **p<0.05; and *p<0.1

Conclusion And Implications

Green economic growth has recently got popularity, representing the economic growth achieved with the help of green technological innovations energy-efficient and carbon-free production techniques. Green growth has been widely recognized as a major factor in mitigating carbon emissions and preserving energy. In recent times policymakers and economists advocated using environmental-related rules and regulations as a crucial complementary factor in decoupling economic growth and carbon emissions. They argued that economic factors alone are not enough to attain green and sustainable economic growth, but strictness in environmental policy stringency is also very important to increase the efficacy of other mitigating measures. The literature suggests that countries with strictness in environmental policy stringency complement other mitigating measures enjoy a more clean environment. As an emerging economy, China heavily relies on energy, particularly non-renewable energy sources, for long-term economic growth. However, the pressure on China is mounting worldwide to decouple economic growth and carbon emissions. Therefore, the focus of policymakers in China has shifted to green economic growth. Hence, this study aims to investigate the impact of environmental, technological innovations, and environmental policy stringency on green economic growth in China. The empirical analysis of the study is based on the ARDL model.

The estimates from the ARDL model confirm that the estimate of environmental technology positively impacts green economic growth both in the short and long run. In the robust model, the estimates of all technologies appeared to be significantly positive in the short and long run. Conversely, the estimated coefficients of environmental policy stringency, in the basic and robust model, have only negatively impacted the green economic growth in China in the short run. In the long term, the environmental policy stringency has not shown any significant impact on green economic growth in China in the basic and robust model. The estimates of Trade and Internet also appeared to be significantly positive in the short and long run in both models.

The results are essential to draw some policy guidelines. Policymakers in China should focus on implementing environmental rules and regulations with great caution because strictness in environmental policy can correct the environment but can increase the manufacturing cost of the firms and reduce their productivity that will eventually negatively impact the economic growth. To achieve green economic
growth government should try to increase the role of environmental technologies in manufacturing and energy sectors that can decouple economic growth and carbon emissions. Environmental technologies can reduce production-driven carbon emissions, a significant factor in achieving economic growth. Therefore, policymakers should encourage investment in environmental technologies, research and development, and renewable energies.

Declarations

Ethical Approval: Not applicable

Consent to Participate: I am free to contact any of the people involved in the research to seek further clarification and information

Consent to Publish: Not applicable

Authors' Contributions: This idea was given by Li Chen. Li Chen and Papel Tanchangya analyzed the data and wrote the complete paper. While Li Chen read and approved the final version.

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Availability of data and materials: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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