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The dynamic role of film and drama industry, green innovation towards the sustainable environment in China: fresh insight from NARDL approach

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ABSTRACT

The ongoing climate changes have put forth various challenges for each industry to achieve their sustainable environmental goals, in an orderly manner. Like the other extensively growing industries, China's Film and Drama industries are responsible for contributing effectively toward a sustainable environment. In order to validate the same, this study has applied the Nonlinear Autoregressive Distributed Lag (NARDL) technique, so as to identify the asymmetric association among the Film and Drama Industry, green innovation, and sustainable environment. The quarterly time-series data of the variables is assessed from January 2000 to December 2019. The outcomes of the study have revealed that the appreciation in the Film and Drama stock prices tends to increase the CO_2 emissions. Whereas, the depreciation of the Film and Drama stock prices improves the efforts towards a sustainable environment. On the other hand, the increase in green innovation tends to have an adverse impact on environmental degradation, while the decline in green innovation tends to increase the carbon emissions. In order to handle the grievous problem of environmental degradation, caused by the Film and Drama industry of China, this study suggests that adopting green practices in Film and Drama making, such as green filming, the use of hybrid vehicles, LED lights, and solar generator supplies, and perhaps Computer-Generated Imagery sets will ultimately contribute towards the improvement of the quality of the environment.

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1. Introduction

The challenges related to the sustainable environment, due to the ongoing climate changes, are the primary issue of each business on a global level (Su et al., 2021; Umar et al., 2020b; Yu et al., 2022). In the same context, the Paris Agreement has set

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out the global framework, in order to reduce greenhouse gas emissions by strengthening the industries' collective responses to climate change (Wei et al., 2019). Similarly, the United Nations has also set the agenda for the year 2030, with 17 Sustainable Development Goals that have been put into place (Ji et al., 2021; Umar et al., 2020a). Most of the industries still need to adopt to the new business models, in order to achieve the climate change goals that have been designed to minimize further deterioration of the environment. The top global economies must pivot away from the depletion and overconsumption of the fossil fuels, primarily in order to prevent the world from environmental degradation (Bibi et al., 2021; Umar et al., 2021a). In the same vein, the creative industries in the world can also reduce the social and environmental impact of climate change by collaborating on certain common goals (Guo et al., 2022).

In this context, this paper evaluates the Film and Drama industry's role in improving the environmental sustainability. With the rapid advancements and the high level of conceptualizations, the Film and mass media have arguably become one of the most influential industries of today's day and age. Moreover, it also plays a prime role in the leisure pattern of global societies (Hiebert & Gibbons, 2017). The European and American film and drama industries frequently get a significant amount of annual investments (Corbett, 2006). Moreover, the film and drama industry is a high energy-intensive industry that produces an immense amount of waste products and greenhouses gases during the production process. However, the environmental degradation that has taken place due to the large scale production, and high fossil fuel consumption can be controlled by adopting eco-friendly production strategies and technologies (Hu et al., 2021; Meilani, 2021; Tsaurai, 2019; Victory, 2014).

According to the European Broadcast Union, more than 2% of the global carbon emissions have been contributed by the information and communication technologies industry. In this regard, France's audio and visual sector is considered to be one of the major contributors to the amalgamation of greenhouse gas emissions every year (Mayers et al., 2015). Moreover, 95% of the material used in the production of the audio-video industry generates waste, which eventually ends up in the form of rubbish.

Environmentalism has a growing concern to make the film and drama industry more sustainable and respectful towards the ecosystem. However, very few researchers have highlighted the effects on the ecological system due to the operations of the film and drama industry (Meilani, 2021). In more specific terms, there is scant literature available on China's film and drama industry and its effects on the environmental factors. At the same time, the film and drama industry of China is on its track of a speedy development. The mainstream forms of entertainment have experienced an extensive amount of development and growth, primarily because the cross-industry cooperation and competition have continuously transformed the industry, and are providing more opportunities and challenges over time. Therefore, in order to provide a valuable contribution to the existing literature. Moreover, this study has also been conducted to precisely examine the role of China's film and drama industry, and its relationship with green innovation, in order to achieve the sustainable

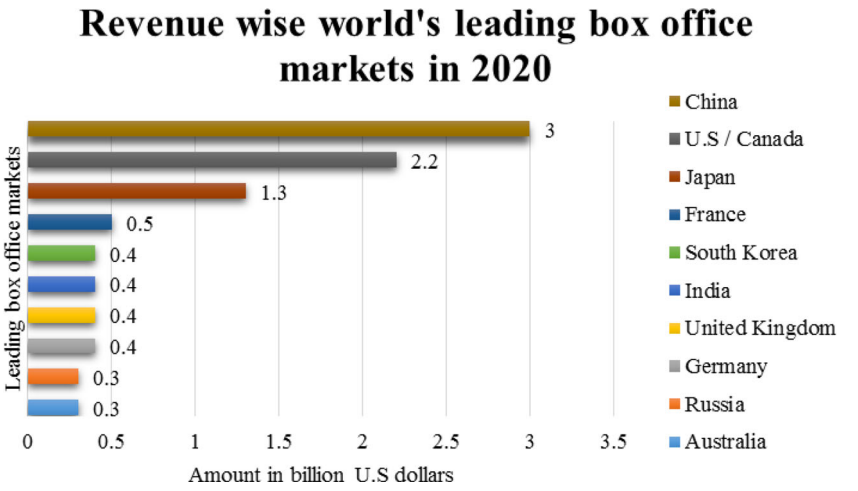

Figure 1. Revenue wise top ten leading world's box office markets in 2020.
Source: https://www.statista.com/statistics/243180/leading-box-office-markets-workdwide-by-revenue/

environmental goals. The study emphasizes the participation of the production manager as an eco-manager, so as to adopt the eco-friendly solution in order to improve the environment during the production process.

According to Statista 2021, China's film industry will be the world's leading revenue-generating film market in the year 2020. In this regard, Figure 1 shows the top 10 highest revenue generating film industries on a global level, in which the Chinese film industry stands on the top. In the same context, the novel COVID-19 pandemic has triggered a global recession, due to which there have been significant fluctuations in the investment returns and portfolios (Mirza et al., 2020; Rizvi et al., 2020a; Yarovaya et al., 2020), credit portfolios (Yarovaya et al., 2020), human capital efficiency (Mirza et al., 2020; Yarovaya et al., 2021), corporate solvency (Mirza et al., 2020b), and non-financial businesses (Rizvi et al., 2020b). However, like other countries of the world, China has also experienced its share of considerable losses in all the industries (Jiang et al., 2021; Song et al., 2021) during the COVID-19 pandemic. However though, the film industry has significantly contributed towards strengthening the economy. In addition to this, the availability of online forms and platforms has brought a novel change in the entertainment industry. So much so that the trend and transaction towards online platforms have improved, while the end-user's convenience level has reduced the overall costs related to distribution, screening, etc., and provided earning opportunities (García Leiva & Albornoz, 2021; Nieborg & Poell, 2018).

The most populated country in the world has the largest entertainment industry. The total global box office share of the Chines film and drama market is 25.4%, whereas cinemas have reached more than 11.3 thousand. Total box office revenue from 2012 to 2020 is approximately nearly 3 billion dollars or 20 billion yuan (As of January 2021. 1 CNY is equal to 0.15 USD). The industry has only produced more than 1037 films in 2019 (Hu et al., 2021). Moreover, the non-box office, film copyrights, and advertisement are also the other source of earning and provide continuous support to expand the industry.

Besides the booming revenue growth, this industry is also blamed for the substantial ecological adverse impact. The relevant issues of transportation, waste material (useless sets after production), catering, and high-energy demand in film and drama production are the reason for high carbon emission. There are various helping ways to achieve sustainable environmental goals to tackle this proactive issue of combatting environmental menace. For instance, green practices with green investments (Ji et al., 2021; Naqvi et al., 2021; Umar et al., 2021c) are essential to adopt in film and drama production to improve the quality of the environment. Similarly, green innovations are the most novel solution adopted by the world's developed countries for environmental up-gradation (Afrifa et al., 2020; Long et al., 2020). Green innovation is an essential factor in sustainable environmental development. It refers to all aspects of the innovations related to the green business and products such as nonrenewable energy savings, pollution management, circular economic activates, etc. (Chen, 2008; Song & Yu, 2018). Moreover, the green innovations have replaced the energy incentives production methods with more efficient and cost-effective reliable technologies to support the economic activities with fewer environmental issues (Murad et al., 2019; Saether et al., 2021).

The NARDL approach is different from the traditional approaches to find the relationship among variables. According to (Lahiani et al., 2016), this approach is better for nonlinear relationship modeling in three ways. Firstly, this approach jointly analyzes asymmetries and cointegration. Moreover, this approach categorized the short-run and long-run nonlinearities and long-run equilibrium linkage between variables (Baloch, 2018; Hammoudeh et al., 2015).

Secondly, this approach is flexible to the integration order of variables and supports the multiple data series with I(0) or I(1) or the combination of all (Baz et al., 2019; Ullah et al., 2020). Thirdly, this approach evaluates the response of dependent variables against the positive and negative variation of each independent variable (Ahmad et al., 2018). Various studies have used NARDL to evaluate the existing literature's asymmetric linkage between variables for different economic determinants. Such as Agricultural (Baig et al., 2021), Commodity prices (Kumar, 2019; Umar et al., 2021b), real estate economy (Rehman et al., 2020). Moreover, several studies have also used NARDL to examine energy policy (Eissa & Al Refai, 2019; Kumar, 2019; Malik et al., 2020), environmental sustainability (Khan et al., 2020; Sarfraz et al., 2021), financial markets (Liang et al., 2020; Saidi et al., 2021), equity market (Kisswani & Elian, 2017; Raza et al., 2016), and technological innovation (Ahmad et al., 2019; Ullah et al., 2021) for the nonlinear associations.

A recent study by Hu et al. (2021) on the film and drama industry related to COVID-19 impact in China has also used nonlinear empirical analysis. However, to our knowledge, this study is the first study using the NARDL approach to examine the dynamic role of the film and drama industry, green innovation toward environmental sustainability in China. The NARDL method provides the details of the response of sustainable environment toward the positive and negative changes in the independent variables such as Film and drama, green innovation, and economic growth. The in-depth explanation of each variable relationship with the dependent variable assists the more desirable policies implication for the entertainment industry

to control the waste and CO_2 emission … The outcomes of the study revealed that the appreciation in the Film and drama stock prices increases the CO_2 emission. In contrast, the depreciation of the Film and drama stock prices improves the sustainable environment. On the other hand, the increase in green innovation has an adverse impact on environmental degradation, while the decline in green innovation increases carbon emission.

The remaining section of the study is organized as follows. The subsequent section provides the Literature review. Section 3 gives details of the data used in the study. Whereas Section 4 discusses the estimated methodology. However, Section 5 comprises outcomes and a discussion of statistical analysis. The conclusion and recommendations are present in Sections 6 and 7, respectively.

2. Literature review

The film and drama industry is one of the strategic locomotive industries of the economies, which significantly contributes to society's economic and moral development (İncekara et al., 2013). Filmmaking consists of various steps from the movie conceptualization and making to its marketing and distribution. Moreover, this industry needs high-energy resources and adequate time to conduct its operations (Meilani, 2021). Climate change is a big issue, and the greenhouse gasses, which accelerate global warming caused mainly by the industries, highly depend on fossil fuel consumption (Collins et al., 2013). During the production process of films and drama, an immense amount of waste is generated, along with the high consumption of energy resources causes air pollution and noise pollution. The film industry's environmental (carbon) footprint consists of raw material in sets, lighting equipment, photocopies, plastic bottles, gasoline, and other waste materials.

Moreover, with the enormous investments made in Europe, France, and the USA, the film and drama industry produces a heavy amount of greenhouse gases (Corbett, 2006). Therefore, according to the British Academy of Film and Television Art, it aims to reduce carbon emission through sustainable movie production by 2050. The existing literature provides very few studies to evaluate the film and drama industry impact on a sustainable environment. Victory (2014) conducted a qualitative study to highlight the importance of green practice in the filmmaking industry to minimize the environmental impact. The study emphasized the role of the production manager as an eco-manager responsible for taking a range of sustainable initiatives and implementing eco-friendly policies during production.

Malmodin and Lundén (2018) compared the carbon footprint of the entertainment & media industry with the previously forecasted footprint size. By employing the energy consumption and life cycle greenhouses gases emission data, the study found that the carbon footprint of the entertainment & media industry reduced in size with the passage of time due to the adoption of advanced information technologies globally. Tsaurai (2019) explained information and communication technology as the supporting variable for the media and entertainment industry. The study discovered that information and communication technology development helps the media and

entertainment industry reduce the obstacles to obtaining environmental sustainability in emerging countries.

A recent study by Hu et al. (2021) has discussed the importance of the film and drama industry's contribution to China's economic growth and the COVID-19 pandemic impact on the industry. During the slow economic activities in COVID-19, the film and drama stock returns also face a significant decline in the long run and observed less investment. In contrast, digital technology has boosted Film and drama stock returns and viewership in the short run. However, during the economic uncertainty, China's film and drama industry have a less environmental impact from the ecological perspective.

Furthermore, Meilani (2021) discussed the film and drama industry's contribution to the carbon footprint and found that the film and drama industry has a high contribution to carbon emission. However, by collecting the data from various sustainable production literature and reports, the study also explored that the eco-friendly movements in movie production, such as the green production movement, play a significant role in reducing carbon emissions.

In the same vein, to find a better solution to control and mitigate the detrimental effect of waste on the environment, this study explores green innovation's role in achieving sustainable environmental goals. Green innovations have motivated and converted most industries from the consumption of nonrenewable energy resources to renewable energy resources (Khan et al., 2020). Moreover, the existing literature widely discusses the role of technological advancement in the form of green innovations to support the fewer energy incentives productions (Afrifa et al., 2020; Long et al., 2020; Murad et al., 2019; Saether et al., 2021; Tao et al., 2021; Wang et al., 2021; Yue et al., 2021). According to (Song & Yu, 2018), green innovation enhances the organizations' creativity and green identity. The high level of creativity in waste management, energy savings, and green practices enhances the industry's capabilities to adopt sustainable practices and improve environmental quality.

Moreover, Afrifa et al. (2020) explored ways to control the harmful effects of environmental pollution and carbon emissions with the country level is green innovations. The study results revealed that the high investments in green innovation play a significant role in improving environmental sustainability. At the same time, the countries with low investment strategies in green innovation face more challenges of environmental degradation. Shahbaz et al. (2020) studied the influence of green innovation in reducing greenhouse gasses in China by using the BARDL method of cointegration. The study's outcomes were consistent with the majority of the studies that technological innovation is getting prime importance because it plays a vital role in supporting the carbon mitigation function in china. Similarly, Saether et al. (2021) investigated the relationship of green innovation with carbon emission in the Norwegian maritime sector. The study found that green innovations are a reliable, cost-effective way to support economic activities and reduce greenhouse gas emissions.

Furthermore, Tao et al. (2021) also investigated the effects of green innovation on carbon emissions in the emerging seven economies from 1995 to 208 using advanced panel data estimates. The study explored those green innovations play a prime role in

Table 1. Variable's description and data source.

Variable name	Variable symbol	Description	Measurement	Data source
Sustainable environment	CO_2	Consumption-based carbon emission	Metric tone	WDI
Film and Drama industry	F&D	Stocks of Film and drama production companies	Index prices	DataStream Database
Green- Innovations	GIN	green patent	Number of a patent registered (World Intellectual Property Organization)	OECD
Economic growth	GDP	Genuine Gross Product per Capita	US Dollar	WDI

controlling carbon emissions in these emerging countries. Yue et al. (2021) have also investigated the relationship of green innovations and tourism with carbon neutrality in Thailand. The study employed the ARDL bound test to find the cointegration among variables. With the dynamic model of explanatory variables, the study explored that green innovation negatively correlates with carbon emission. By making more investments in green innovation, the environmental damages due to the carbon emission can be reduced.

3. Data

To evaluate the role of the film and drama stock prices, green innovation toward environmental sustainability in China, this study uses the consumption-based carbon emission as the proxy of the sustainable environment (dependent variable). At the same time, the independent variable of China's Film and drama industry stock price is explained through Film and Dram Index. However, the other independent variable green innovation represents the number of green patents registered in a year—the quarterly time-series data of the variables employed from January 2000 to December 2019. The variable details and data source are mentioned in Table 1. The data of all variables have transformed into a log form.

4. Estimated methodology

This study uses the NARDL model to discover the asymmetric association between film and dram stock prices, green innovation, and a sustainable environment. The Film drams stock prices and green innovation play a significant role in sustaining the attainable climate by reducing carbon emissions. For the empirical calculation of the sustainable environment, the following linear equation has been postulated:

$$CO_{2t} = \alpha_1 + \alpha_2(F\&D_t) + \alpha_3(GIN_t) + \alpha_4(GDP_t) + \alpha_5\left(GDP^2{}_t\right) + \mu_t \quad (1)$$

where CO_2 demonstrates the sustainable environment, F&D is a stock price of film and drama industry, GIN is a green innovation, GDP is economic growth, GDP^2 is Environmental Kuznets Curve (EKC) hypothesis effect, and α_i represent the coefficient vectors. At the same time, μ_t presents the error term.

Equation (1) specifies the long-run coefficients only, whereas the error correction approach provides both the predictor's long-run and short-run effects. Therefore, Equation (1) restates in the ARDL model under the error correction approach.

$$\begin{aligned}\Delta CO_{2t} &= \vartheta_1 + \sum_{j=1}^{n} \vartheta_{2j}\ \Delta F\&D_{t-j} + \sum_{j=1}^{n} \vartheta_{3j}\ \Delta GIN_{t-j} + \sum_{j=1}^{n} \vartheta_{4j}\ \Delta GDP_{t-j} \\ &+ \sum_{j=1}^{n} \vartheta_{5j}\ \Delta GDP^2{}_{t-j} + \gamma_1\ CO_{2t-1} + \gamma_2\ F\&D_{t-1} + \gamma_3\ GIN_{t-1} \\ &+ \gamma_4\ GDP_{t-1} + \gamma_5\ GDP^2{}_{t-1} + \mu_t \end{aligned} \tag{2}$$

where the short-run parameters are shown as the change (Δ) in variables and long-run parameters present as γ1, γ2, γ3, γ4, and γ5.

Equation (1) shows the linear association among the variables; however, the study's objective is to explore the nonlinear relationship among variables; therefore, Equation (3) presents the model's functional form and splits the variables into positive and negative.

$$CO_2 = f(F\&D^+, F\&D^-, GIN^+, GIN^-, GDP, GDP^2) \tag{3}$$

The function in Equation (2) is further stipulated as under:

$$\begin{aligned} CO_{2t} &= \beta_1 + \beta_2(F\&D^+{}_t) + \beta_3(F\&D^-{}_t) + \beta_4(GIN^+{}_t) + \beta_5(GIN^-{}_t) + \beta_6(GDP_t) \\ &+ \beta_7\left(GDP^2{}_t\right) + \mu_t \end{aligned} \tag{4}$$

Here, β_t defined the coefficient vector for the long run. In Equations (5–8), the F&Dt + and GIN_t^+ are present as the partial sum of positive changes, and $F\&D_t^+$, GIN_t^- are the partial sum of negative changes in F&D and GIN, respectively.

$$F\&D^+{}_t = \sum_{i=1}^{t} \Delta F\&D^+{}_t = \sum_{i=1}^{t} \max(\Delta F\&D_t, 0) \tag{5}$$

$$F\&D^-{}_t = \sum_{i=1}^{t} \Delta F\&D^-{}_t = \sum_{i=1}^{t} \min(\Delta F\&D_t, 0) \tag{6}$$

$$GIN^+{}_t = \sum_{i=1}^{t} \Delta GIN^+{}_t = \sum_{i=1}^{t} \max(\Delta GIN_t, 0) \tag{7}$$

$$GIN^-{}_t = \sum_{i=1}^{t} \Delta GIN^-{}_t = \sum_{i=1}^{t} \min(\Delta GIN_t, 0) \tag{8}$$

To formulate the nonlinear ARDL promoted by Shin et al. (2014), the variable F&D and GIN in Equation (2) are replaced by $F\&D^+$, $F\&D^-$, GIN^+, and GIN^- respectively, followed by

Table 2. Results of descriptive statistics.

Variables	F&D	GIN	GDP	CO_2
Mean	2.558	3.489	5.621	2.914
Minimum	1.641	2.721	4.954	1.086
Maximum	2.976	5.623	6.057	3.552
Std. Dev.	0.548	1.025	0.875	1.128
Jarque-Bera	12.535	27.367	19.485	18.943
Probability	0.000	0.000	0.000	0.000

Source: Author Estimation.

$$\begin{aligned}\Delta CO_{2t} = {} & \omega_1 + \sum_{j=1}^{no} \omega_{2j} \Delta F\&D^{+}{}_{t-j} + \sum_{j=1}^{np} \omega_{3j} \Delta F\&D^{-}{}_{t-j} + \sum_{j=1}^{nq} \omega_{4j} \Delta GIN^{+}{}_{t-j} \\ & + \sum_{j=1}^{nr} \omega_{5j} \Delta GIN^{-}{}_{t-j} + \sum_{j=1}^{ns} \omega_{6j} \Delta GDP_{t-j} + \sum_{j=1}^{nu} \omega_{7j} \Delta GDP^{2}{}_{t-j} + \gamma_1 CO_{2t-1} \\ & + \gamma_2 F\&D^{+}{}_{t-1} + \gamma_3 F\&D^{-}{}_{t-1} + \gamma_4 GIN^{+}{}_{t-1} + \gamma_5 GIN^{-}{}_{t-1} \\ & + \gamma_6 GDP_{t-1} + \gamma_7 GDP^{2}{}_{t-1} + \mu_t \end{aligned} \tag{9}$$

where no, np, nq, nr, ns, and nu represent the respective lag order. On the other hand, the long-run coefficient is defined by γ_1, γ_2, γ_3, γ_4, γ_5, γ_6 and γ_7. At the same time, short-run parameters are shown as the change (Δ) in variables.

Moreover, the nonlinear ARLD model present in Equation (9) is feasible for the bond test to check the cointegration among variables. Pesaran et al. (2001) introduced the bond testing approach and suggested by Pesaran et al. (2001) to evaluate the long-run relationship among variables. The NARDL incorporates the possibility of the asymmetric effects due to the positive and negative changes in the segregated components of the independent variables.

5. Empirical results and discussions

The descriptive statistics of variables presented in Table 2 show that F&D varied between 1.641 to 2.976 with a mean value of 2.558 and standard deviation of 0.548. Similarly, the green innovation (GIN) maximum and minimum values are 2.721 to 5.623, respectively, whereas the variable's mean value is 3.489 with a standard deviation of 1.025. Moreover, the CO_2 has the highest value of the standard deviation of 1.28 among all the variables, which shows that the other factors and more volatile highly influence this variable. The mean value of CO_2 is 2.914, with the maximum and minimum range of 1.086 to 3.552. However, the variable GDP has the highest mean of 5.621 varies among 4.956 and 6.057 with the standard deviation of 1.025. From the descriptive statistics in Table 2 from the Jarque-Bera results, it is evident that all the variables are not generally distributed at a 5% level of significance which confirms that there is a nonlinearity present among the variable; therefore, nonlinear estimations are suitable (Anwar et al., 2021; Chien et al., 2021; Godil et al., 2021; Umar et al., 2021c).

Any estimate model with the unit root presence in variables yields spurious outcomes (Granger & Newbold, 1974). Therefore, it is mandatory to perform some pre-

Table 3. Results of Unit root test.

	ADF unit root test				PP unit root test			
	I(0)		I(1)		I(0)		I(1)	
Variables	C	C&T	C	C&T	C	C&T	C	C&T
F&D	−0.368	−0.452	−8.056***	−7.685***	−0.455	−0.421	−6.625***	−6.058***
GIN	−1.059	−1.328	−6.365***	−6.412***	−1.215	−1.282	−5.985***	−6.156***
GDP	−0.892	−0.742	−3.985***	−4.059***	−0.952	−1.056	−5.889***	−5.217***
CO_2	−1.217	−1.298	−4.673***	−4.241***	−1.699	−1.726	−8.059***	−7.368***

Note: *** represents the level of significance at 1%.
Source: Author estimations.

tests before estimating the results with the NARDL technique. One limitation of this technique is that not any of the variable series should have the inclusion of I(2). In the case where the series becomes stationary at a second difference will give the invalid value of cointegration F-statistics (Ibrahim, 2015; Meo et al., 2018). Therefore, to find out this potential issue of second difference stationary, this study employs the unit root test of augmented Dickey-Fuller (ADF) and (Phillips & Perron, 1988). The outcomes of the unit-roots trial illustrated in Table 3 revealed that all the variable series are stationary at the first difference and confirm that none of the variables is stationary at I(2).

Moreover, the ADF and PP tests outcomes may deceptively prove the integration order in the presence of an unknown structural break. Therefore, the (Zivot & Andrews, 2002) structural break test is used to handle this issue. Table 4 shows the Zivot and Andrews test results and endorsed that all the variables are integrated at order one. In addition, the study also employs the Schwarz information criteria (SIC) for the optimal lags in the Zivot and Andrews structural break unit root test (here, maximum optimal lags are two based on SIC).

In this case, where all the variables are integrated in the first order. The most appropriate test for cointegration is a bond test. Table 5 demonstrates that the F-statistics value for the nonlinear ARDL is 58.694, more significant than the all-critical values of the upper bond of 1%, 5%, and 10% significance level. The high F-statistic value provides enough evidence to reject the null hypothesis of no integration among variables. In other words, it has been proven that there is a long-run relationship between F&D, GIN, GDP, GDP^2, and CO_2.

Table 6 shows the long-run coefficients for the asymmetric relationship among independent variables and dependent variables. The study results suggest that economic growth (GDP) positively influences the sustainable environment (CO_2) at the 1% significance level. It indicates that high economic growth causes environmental degradation by emitting more greenhouse gases into the atmosphere. The increase in economic development or per capita income accelerates economic activities, nonrenewable energy consumption, global warming, and environmental pollution, thus increasing the risk of potential losses of environmental habitats. On the other hand, the GDP^2 shows the inverse relationship with the sustainable environment CO_2 that endorses the EKC hypothesis of income inequality and economic development.

Moreover, essential outcomes presented in Table 6 are the asymmetric effects of F&D and GIN on CO_2 emission. According to the NARDL estimates, CO_2 is highly influenced by the GIN_NEG, which implies that reducing green innovation will

Table 4. Zivot-Andrews structural break trended unit root test.

	At level		At 1st difference	
Variable	T-statistics	Time break	T-statistics	Time break
F&D	−0.596 (1)	2005	−5.227 (1)***	2015
GIN	−1.034 (1)	2017	−6.365 (1)***	2019
GDP	−0.567 (1)	2008	−8.671 (1)***	2007
CO_2	1.257 (1)	2012	−5.802 (1)***	2018

Note: Lag order shown in parenthesis.
***Represents significance at 1% level.
Source: Authors' estimation.

Table 5. Results of NARDL bound testing cointegration.

Model	F-statistics	Upper bond	Lower bond
CO_2/(F&D_POS, F&D_NEG, GIN_POS, GIN_NEG, GDP, GDP^2)	58.694		
Critical values			
10%		4.463	1.735
5%		5.433	2.231
1%		6.873	2.802

Source: Author estimations.

Table 6. Findings of long-run coefficients.

Variables	Coeff.	t-stats	Prob.
GDP	0.368	8.056	0.000
GDP^2	−0.168	−5.356	0.000
F&D_NEG	0.255	4.684	0.000
F&D_POS	−0.186	−6.039	0.000
GIN_NEG	0.307	−5.571	0.000
GIN_POS	−0.285	−11.059	0.000

Dependent variable: CO_2 emission.
Source: Author estimation.

increase CO_2. However, the positive changes in the GIN_POS significantly decrease the CO_2. Green innovations are playing a significant role in controlling environmental degradation by implementing new technology. Therefore the increase in the number of green patents enhances environmental sustainability. The cumulative effect of these outcomes is consistent with the findings of (Afrifa et al., 2020; Tao et al., 2021).

Furthermore, according to Table 5, the film and drama stock positive change F&D_POS negatively and significantly affect the sustainable environment. Whereas the film and drama negative change F&D_ NEG mitigate the detrimental effects of carbon emission. Thus, it has been proven that the film and drama industry consumes more energy in indoor and outdoor production, traveling, and post-production activities such as distribution and launching and, therefore, cause high carbon emissions. These results endorse the study results of the European Broadcast Union, which states that the world's audio-video sector is responsible for more than 2% of the total carbon emission yearly (Ecopord.com). The adequacy of the estimates has been evaluated with various diagnostic tests. Table 7 illustrates the outcomes of the diagnostic tests, such as the Breusch–Godfrey test, also known as the Lagrange Multiplier (LM) test, which was employed to investigate the autocorrelation or serial correlation residuals. At the same time, the Breusch-Pagan-Godfrey test is used to diagnose the presence of heteroscedasticity in the regression model. Moreover, the

Table 7. Findings of diagnostic tests.

Diagnostic test	Problem	P-value	Status
LM test	Serial correlation	0.597	Serial correlation does not exist
Breusch-Pagan-Godfrey	Heteroscedasticity	0.462	There is no issue of heteroscedasticity
Ramsey RESET test	Model specification	0.409	Model specification is correct
VIF	Multicollinearity	3.085	There is no problem with multicollinearity

Source: Author estimation.

Ramsey RESET (regression equation specification error test) is used to check the goodness of fit of the explanatory variables of the nonlinear model to explain the response variable. Whereas the Variance inflation Factor (VIF) is used to diagnose the existence of multicollinearity among the variables.

According to the diagnostic test results, the LM test accepts the null hypothesis of no serial correlation of any order up top. Similarly, the Breusch-Pagan-Godfrey test fails to reject the null hypothesis of no heteroscedasticity (all the error variances are equal). Moreover, the Ramsey RESET test results state that the model is correct. The VIF value is less than 10, indicating no multicollinearity among variables (Hair et al., 2010).

6. Conclusion and policy recommendations

6.1. Conclusion

Each industry of the world has to contribute to achieving the sustainable development goals agenda proposed by United Nations. Like the other extensively growing industries, China's film and drama industries are also responsible for contributing effectively toward a sustainable environment. Therefore, it is essential to evaluate the existing impact of the film and dram industry, green innovation on carbon emission in China. The study employed the quarterly time-series data of variables from January 2000 to December 2019. No prior researches have examined the film and drama industry's impact on environmental degradation. However, the audio and visual industry is very well known for waste production and excessive energy resources. This study has covered the gap by applying the NARDL techniques to identify the asymmetric association among the F&D, GIN, and CO2. Before using the NARDL technology study, stationary tests of ADF and PP and Zivot and Andrews test with a structural break to find the integration order of the variables. The test results show that all the variables are stationary in first-order. Therefore, the bond test can be used to identify the existence of cointegration among variables. The result of the bond test endorses the presence of a long-run association among F&D, GIN, GDP, GDP^2, and CO_2.

Moreover, the NARDL long-run asymmetric approach results show the response of the dependent variables against the positive and negative variation of each independent variable. According to the outcomes, the positive changes in green innovation positively influenced the sustainable environment, whereas the decline in green innovation increases the CO_2 emission. The green innovations support green processing in the business; therefore, it adversely impacts environmental degradation. However, the Film and drama stock prices with the positive change impose a

detrimental effect on the environment, while with the decline in stock prices, the F&D boosts environmental sustainability. The film and drama industry consumes more fossil fuel and produces more wastes, increasing greenhouse gas levels. Moreover, the high stock prices encourage more film and drama production that ultimately causes damages to the environment in the ecological sense.

6.2. Recommendations

Based on the results, this study suggests that China's film and drama industry should implement green practices to handle the cause of environmental deterioration. The green methods include green filming, a resource-efficient concept to provide a sustainable contribution to climate change. Green filming controls the transport, waste, catering, and energy supply efficiently. The government needs to encourage green filming by introducing specific production houses and providing funding to fulfill the sustainable criteria. Moreover, there is a need for proper training and knowledge sharing to create awareness in this industry to control carbon emissions.

Feature films production is a time-consuming and resource-consuming process; therefore, the green screen production process is highly recommended at every stage of production. The sustainable production method is challenging to manage. However, by adopting the greenfilm.com system guidelines introduced by Italy to rate green production, filmmakers can reduce the ecological impact of production activities. Such as the filmmakers need to put more emphasis on paperless production planning, selection of the closed sites and locations, reusable production material, and minimum consumption of water and energy.

Furthermore, technological advancements such as using hybrid vehicles for transportation, using green screens or GGI sets to reduce waste, and using LED and solar energy supply generators at production houses will positively impact the environment. Thus, the growing awareness and the government's common laws initiatives to promote a sustainable environment will make the film and drama industry green. In the future, the cumulative study on the world's all-leading film and drama industries will provide more detailed countermeasures and recommendations for their combined contribution to achieve sustainable environmental development goals.

6.3. Study limitations and future research directions

The current study is limited to the film and media industry effect on the environmental sustainability of China and employed the quarterly data from the year 2000 to 2019 due to the unavailability of the data of selected variables. Moreover, the other crucial economic factor which can highly influence the Film and drama stock returns are not incorporated in the current study, such as political and economic uncertainty and availability of green financing. For future research, it has been suggested that the same topic be carried out with the panel data of the top film and drama industries from all over the world with advanced panel data estimations to evaluate the collective effects of the entertainment industry on environmental sustainability.

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