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Examining the Effect of Privatization on Renewable Energy Consumption in the Digital Economy under Economic Patriotism: A Nonlinear Perspective

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Abstract: This study is an effort to investigate the asymmetric effects of privatization and the digital economy on renewable energy consumption. The nonlinear quantile autoregressive distributed lag (QARDL) technique is used to estimate short and long-run analysis. Findings of the nonlinear QARDL model posit that the long-run positive shock in privatization promotes renewable energy consumption by increasing renewable energy consumption, while the long-run negative shock in privatization demotes renewable energy consumption by reducing renewable energy consumption. In the short run, the positive shock of privatization does not significantly impact renewable energy consumption, while the negative shock of privatization reduces renewable energy consumption. Moreover, information and communications technology (ICT), economic development, and financial development increase renewable energy consumption in the long run; however, in the short-run only financial development helps increase renewable energy consumption. The Wald test confirms the asymmetric impact of privatization on renewable energy consumption only in the long run. Based on these results, policymakers should thus take into account both positive and negative shocks in privatization when developing policies to encourage pro-environmental behavior.

Keywords: privatization; renewable energy consumption; nonlinear QARDL

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1. Introduction

Anthropogenic impacts are the primary cause of environmental issues; thus, they must be taken into account when trying to find solutions [1,2]. As the primary vectors of human activity, numerous institutions and organizations have implemented a wide range of environmental management practices in an effort to save the planet. In reality, nevertheless, the majority of these institutions and businesses only care about technological improvements and management improvement [3], rather than guiding and encouragement of workers' "green" or "pro-environmental behavior" (PEB). Employees' daily PEBs are especially helpful in reducing the negative effects of business operations in the commercial setting [4], since they invest approximately a third of their days working. This supports businesses' efforts to protect the effectiveness of the broader atmosphere and natural capital [5]. Recent research on China's smog issue appears to confirm this hope. Lu et al. [6] found that "corporate green" and pollution reduction were greatly aided by employees' personal environmental knowledge and actions at work (i.e., their personal environmental footprint, or PEB).

In a broader sense, there are two main types of organizations: private and government. Since private firms dominate the corporate sector, they can play a crucial role in promoting PEB in society. International financial institutions (IFIs) often enforce structural reform plans, including privatization initiatives in developing nations [7]. It has been stated that the superior resource distribution and more transparent principal-agent interactions at private companies explain why they have been more successful than their public sector counterparts. Experts in both high- and low-income nations have focused on the question of whether or not privatization boosts business effectiveness [8]. Research results have been inconsistent and contentious thus far. In the past, researchers have mostly looked at the financial implications of various performance metrics at both the macro and micro levels. Recent years have seen an increase in the number of studies examining social dimensions of success alongside traditional financial and non-financial metrics. Nevertheless, academics' narrow focus has prevented them from assessing the economic, cultural, and ecological consequences of privatization at the organizational level [9,10]. The research falls short, most obviously, in its failure to analyze how privatization affects PEB within the corporate framework.

In the early 1980s, the word "privatization" entered the general lexicon. Before this point, the selling of government companies was often described as "denationalization" [11,12]. As a key economic strategy, privatization refers to the transfer of entrepreneurship and/or control from the government to the private sector [13]. Since the 1980s, it has been extensively utilized throughout the globe to address a broad range of management, legal, cultural, and economic issues. The privatization of state-owned enterprises (SOEs) has been advocated by the World Bank, the IMF, and other foreign funders as a means of addressing economic woes and the distinctive troubles (such as wastefulness, bureaucratic red tape, political participation, and mismanagement) faced by least developed countries (LDCs) [14]. Structural adjustment plans that include privatization are a prerequisite for providing financial assistance to LDCs with failing economies [15].

Efficiency advantages in production and resource allocation are the basic theory for privatization's support. When compared to state-owned enterprises (SOEs), which typically have various competing goals (such as financial, cultural, and political), private sector businesses are thought to be significantly productive because their sole purpose is profitability, allowing them to implement efficiency-boosting technologies. To privatize, the government must agree to the organization's strategy (i.e., profitability) and the industry's behavior. Any other governmental goal that a public corporation could have been told to undertake should subsequently be addressed via taxation or subsidization measures, or abandoned entirely [16]. Furthermore, the administration of private enterprises seems to be more driven toward performance in comparison to the administration of SOEs, which is demotivated, low rewarded, and insufficiently overseen owing to the lack of understanding of the principal-agent link and property ownership. For this reason, proponents of ownership transfers expect an increase in productive and distributive efficiency as a result of tighter organizational control [17]. Innovation and productivity have benefited from the transition from public to private ownership. These changes are predicted to boost the economy, which in turn would benefit society and the environment and develop PEB in society [18].

Privatization can affect renewable energy consumption through several transmission mechanisms. Firstly, privatization can increase investment in renewable energy projects by creating opportunities for private sector participation. Private companies are generally more willing to invest in renewable energy projects because of the potential for long-term profitability. Privatization can also increase access to financing for renewable energy projects by allowing private companies to access capital markets [19]. Secondly, privatization can create competition in the renewable energy market, leading to lower prices and increased consumption. Competition can also encourage innovation and technological advancements in renewable energy, leading to increased efficiency and lower costs [20]. Thirdly, privatization can affect the regulatory framework for renewable energy consumption. Private companies may push for policies that favor renewable energy, such as feed-in tariffs or net metering, to encourage the growth of the market. Privatization can also lead to changes in regulatory frameworks that reduce barriers to entry for renewable energy companies. Lastly, privatization can impact energy security and reliability, which can in turn impact renewable energy consumption. Privatization can lead to improved energy security and reliability by promoting investment in new infrastructure and technologies [21].

This can make it easier to integrate renewable energy into the grid, leading to increased consumption. Economic patriotism, which refers to the promotion of domestic industries and the protection of national interests, can also influence the adoption of renewable energy sources [22]. China encourages the use of domestically produced renewable energy sources, such as solar panels and wind turbines. Additionally, promoting renewable energy can reduce dependence on foreign oil and gas imports, which can help strengthen national security and reduce trade deficits. The Chinese government has provided significant financial and policy support to domestic renewable energy companies, such as solar panel manufacturers, wind turbine producers, and energy storage system providers [23].

Privatization has been widely discussed as a potential driver of renewable energy consumption. The argument is that privatization can bring new investments and competition to the energy sector, which can lead to more efficient and innovative renewable energy production [24]. While there is some disagreement about the specific impact of privatization on renewable energy consumption, many studies have examined this relationship. One such study by Torriti [25] investigated the impact of privatization on renewable energy consumption in Europe. The study found that privatization had a positive impact on renewable energy consumption in countries with well-established renewable energy policies, but the relationship was not significant in countries without such policies. The study concluded that privatization can play an important role in promoting renewable energy consumption, but only in the presence of effective policies. Similarly, a study by Nicolli & Vona [26] examined the impact of privatization on renewable energy consumption in emerging markets. The study found that privatization had a positive impact on renewable energy consumption in emerging markets, particularly in countries with strong regulatory frameworks and government support for renewable energy. Liza et al. [27] argued that privatization could lead to a focus on short-term profit maximization rather than long-term investment in renewable energy. The authors suggested that the government should maintain some level of control over the energy sector to ensure that renewable energy is prioritized. Despite significant efforts, we are unable to find a single study examining the impact of privatization on renewable energy consumption specifically in the context of China.

Progress in computing has been steady since the 1990s. New forms of economic activity, including the digital economy, have emerged as a result of developments in artificial intelligence (AI), blockchain, and 5G networks [28]. The detection, screening, processing, preservation, and application of big data constitutes the digital economy, an economic structure that leads and accomplishes speedy optimum distribution and rejuvenation of resources, attains “high-quality economic growth”, and promotes PEB not only within the corporate sector but in the whole society [29]. Entrepreneurs, customers, and authorities across all economic sectors all over the globe realize the importance of ICT. Most every large economy in the world has identified “green” and “digital” as the two buzzwords of important policy orientations for moving towards PEB. ICT and digitalization, in general, have opened up new doors for sustainable practices in the environmental and economic spheres and paved the way for business firms and the general public to follow PEB [30].

This research contributes to the literature by examining the impact of privatization on PEB in the age of the digital economy. Previous research on privatization’s effects often looked at either the broad economic effects or the specific financial and managerial results. In the wake of privatization, little is known about how private sector development has impacted PEB in the digital age. This study also includes an in-depth investigation of the effects of privatization on pro-environmental behavior in the digital economy. Thus, this study is a valuable addition to the current literature as it provides an empirical and theoretical base for upcoming studies. Another key contribution of this study is that it provides long-run and short-run dynamics under the QARDL approach. Lastly, the policy suggestions based on the results can prove vital for promoting renewable energy transitions in China. By understanding the impact of privatization on renewable energy consumption in China, this study seeks to provide insights that can inform future policy decisions in the country's efforts to combat air pollution and climate change. The study can be useful in practical applicability from the perspective of the three main pillars of sustainability: economic viability, environmental protection, and social equity. The study can help academics and policymakers to assess the economic and environmental benefits of the privatization of renewable energy.

2. Models and Methods

Renewable energy has emerged as a critical component of the energy mix due to its potential to mitigate climate change and promote sustainable development. The renewable energy sector has undergone significant transformation in recent years due to increased investment, technological advancements, and policy support. The relationship between privatization and renewable energy consumption has become a crucial research area for scholars and policymakers [31]. Several theoretical perspectives have been proposed to explain the relationship between privatization and renewable energy consumption. One theoretical perspective is the property rights theory, which argues that private ownership of energy assets leads to greater efficiency and investment in the energy sector [32]. According to this theory, private firms are better equipped to allocate resources efficiently, make long-term investments, and innovate in the renewable energy sector. Similarly, ICT has the potential to play a significant role in promoting the use of renewable energy sources and reducing reliance on non-renewable sources of energy [33]. The ecological modernization theory suggests that ICT and social change can be used to address environmental challenges and achieve sustainable development [34]. This theory suggests that the use of ICT can facilitate the integration and coordination of renewable energy technologies, such as solar and wind energy. Furthermore, this theory also suggests that ICT can play a role in facilitating the transition from fossil fuels to renewable energy sources.

In this study, we use a technique called QARDL to analyze the data. To explore the long-run and short-run asymmetries among concerning variables, we have employed the QARDL technique proposed by Cho et al. [35]. The QARDL approach is dominant in linear models, for several reasons. The first advantage of adopting this technique is that it takes into account the locational asymmetries in which factors and findings may be conditional on the dependent variable. For this reason, QARDL is considered more appropriate, as the linear ARDL technique cannot capture the asymmetric association among variables. Another advantage is that the QARDL approach considers the long-run dynamics as well as short-run dynamics over different quantile ranges. The QARDL methodology is a scientifically sound approach to modeling non-stationary time series data with structural breaks. The latest literature uses QARDL to investigate a wide range of economic and financial phenomena [36]. The use of the nonlinear QARDL approach is a relatively new and advanced technique for analyzing time series data (see Figure 1). QARDL is considered a workhorse approach in energy economics; it has several advantages and potential applications. Depending on these trustworthy sets of data, it is shown that the QARDL approach is the most efficient at comprehending the asymmetric connection between renewable energy demand and its privatization, ICT diffusion, economic development, and financial development. The basic model is:

$$REC_t = \mu + \sum_{i=1}^{n1} \sigma_{REC_i} REC_{t-i} + \sum_{i=0}^{n2} \sigma_{PRIV_i} PRIV_{t-i} + \sum_{i=0}^{n3} \sigma_{ICT_i} ICT_{t-i} + \sum_{i=0}^{n4} \sigma_{ED_i} ED_{t-i} + \sum_{i=0}^{n5} \sigma_{FD_i} FD_{t-i} + \varepsilon_t \quad (1)$$

where ε_t is explained as REC_t-$E[RECt/Ft-1]$ with $Ft-1$ as the smallest σ–field made by ($PRIV_t$, ICT_t, ED_t, FD_t, $PRIV_{t-1}$, ICT_{t-1}, ED_{t-1}, FD_{t-1}}, and $n1 \ldots n5$ represents the lag orders for variables. In Equation (1), privatization, ICT diffusion, economic development, and financial development are represented by $PRIV_t$, ICT_t, ED_t, FD_t, respectively; while REC_t represents renewable energy consumption. Following the approach of Cho et al. [24], we have to reformat basic Equation (1) in the quantile ARDL format:

$$Q_{REC_t} = \mu(\tau) + \sum_{i=1}^{n1} \sigma_{REC_i}(\tau) REC_{t-i} + \sum_{i=0}^{n2} \sigma_{PRIV_i}(\tau) PRIV_{t-i} + \sum_{i=0}^{n3} \sigma_{ICT_i}(\tau) ICT_{t-i} + \sum_{i=0}^{n4} \sigma_{ED_i}(\tau) ED_{t-i} + \sum_{i=0}^{n5} \sigma_{FD_i}(\tau) FD_{t-i} + \varepsilon_t(\tau) \quad (2)$$

where $\varepsilon t(\tau) = RECt - QRECt(\tau/Ft - 1)$ and $Q_{RECt}(\tau/Ft - 1)$, and the level of quantile is represented by the range $0 < \tau < 1$. Given the possibility of serial correlation in Equation (2), a nonlinear QARDL model can be formulated, with our analysis being specifically geared towards examining the nonlinearity assumption, as previously indicated. The approach of Shin et al. [37] involves using the partial sum procedure to partition the PRIV variable into positive and negative components. We have decomposed only privatization (PRIV) for nonlinear analysis.

$$PRIV^{+}{}_t = \sum_{n=1}^{t} \Delta PRIV^{+}{}_t = \sum_{n=1}^{t} max\ (\Delta PRIV^{+}{}_t, 0) \quad (3a)$$

$$PRIV^{-}{}_t = \sum_{n=1}^{t} \Delta PRIV^{-}{}_t = \sum_{n=1}^{t} min\ (\Delta PRIV^{-}{}_t, 0) \quad (3b)$$

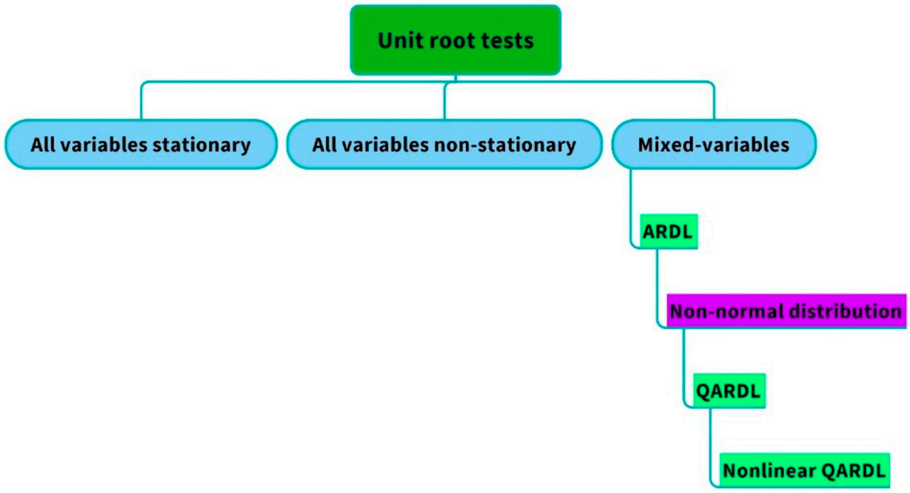

Figure 1. Methodology framework.

We then move back to Equation (2) and replace the positive and negative changes of PRIV to arrive at:

$$Q_{\Delta REC_t} = \mu + \rho REC_{t-1} + \beta^{+}{}_{PRIV} PRIV^{+}{}_{t-1} + \beta^{-}{}_{PRIV} PRIV^{-}{}_{t-1} + \beta_{ICT} ICT_{t-1} + \beta_{ED} ED_{t-1} + \beta_{FD} FD_{t-1} + \sum_{i=1}^{n1} \pi_{REC_i} \Delta REC_{t-i} + \sum_{k=0}^{n2} \pi^{+}{}_{PRIV_i} \Delta PRIV^{+}{}_{t-i} + \sum_{k=0}^{n3} \pi^{-on\ GE\ een\ ods.\ Contrariwise,}{}_{PRIV_i} \Delta PRIV^{-}{}_{t-i} + \sum_{i=0}^{n4} \pi_{ICT_i} \Delta ICT_{t-i} + \sum_{i=0}^{n5} \pi_{ED_i} \Delta ED_{t-i} + \sum_{i=0}^{n4} \pi_{FD_i} \Delta FD_{t-i} + \varepsilon_t(\tau) \quad (4)$$

Extending Equation (2) to conform to the QARDL-ECM format within the context of nonlinear QARDL can eliminate prior correlations by projecting ε_t onto relevant variables. Thus, the model can be expressed in its nonlinear QARDL-ECM version as follows:

$$Q_{\Delta REC_t} = \mu(\tau) + \rho(\tau)(REC_{t-1} - \beta^{+}{}_{PRIV}(\tau)PRIV^{+}{}_{t-1} - \beta^{-}{}_{PRIV}(\tau)PRIV^{-}{}_{t-1} - \beta_{ICT}(\tau)ICT_{t-1} - \beta_{ED}(\tau)ED_{t-1} - \beta_{FD}(\tau)FD_{t-1}) + \sum_{i=1}^{n1} \pi_{REC_i} \Delta REC_{t-i} + \sum_{i=0}^{n2} \pi^{+on\ GE\ een\ ods.\ Contrariwise,}{}_{PRIV_i}(\tau)\Delta PRIV^{+}{}_{t-i} + \sum_{i=0}^{n3} \pi^{-on\ GE\ een\ ods.\ Contrariwise,}{}_{PRIV_i}(\tau)\Delta PRIV^{-}{}_{t-i} + \sum_{i=0}^{n4} \pi_{ICT_i}(\tau)\Delta ICT_{t-i} + \sum_{i=0}^{n5} \pi_{ED_i}(\tau)\Delta ED_{t-i} + \sum_{i=0}^{n6} \pi_{FD_i}(\tau)\Delta FD_{t-i} + \varepsilon_t(\tau) \quad (5)$$

The cumulative short-run effect of the lag of renewable energy consumption (REC) on current emanation is measured by $\pi * \sum_{j=1}^{n} \pi_j$. Regarding cumulative short-run dynamics of $PRIV^{+}{}_t$, $PRIV^{-}{}_t$, ICT_t, ED_t, and FD_t are represented by $\pi * \sum_{j=1}^{n2} \pi_j$, $\pi * \sum_{j=1}^{n3} \pi_j$, $\pi * \sum_{j=1}^{n4} \pi_j$, $\pi * \sum_{j=1}^{n5} \pi_j$, $\pi * \sum_{j=1}^{n6} \pi_j$, respectively. Similar, the cointegration among the long-run variables of privatization, ICT diffusion, economic development, and financial development are described with the help of $\beta^{+}{}_{PRIV}* = -\frac{\beta^{+}PRIV}{p}$, $\beta^{-}{}_{PRIV}* = -\frac{\beta^{-}PRIV}{p}$, $\beta_{ICT}* = -\frac{\beta ICT}{p}$, $\beta_{ED}* = -\frac{\beta ED}{p}$, and $\beta_{FD}* = -\frac{\beta FD}{p}$, correspondingly. In Equation (5), a substantial negative estimation is necessary for the parameter (ρ) that is linked to the REC variable. Using the Wald test, we examined the nonlinear effects of the PRIV variable on REC in both the short and long run. If the Wald test rejects the null hypothesis of $\beta^{+}{}_{PRIV} = \beta^{-}{}_{PRIV}$ ($\pi^{+}{}_{PRIV} = \pi^{-}{}_{PRIV}$), then we can establish the presence of asymmetric effects in the long run (or short run).

3. Data and Descriptive Analysis

Table 1 describes the details of the variables to be used in the regression. The dependent variable in our model is pro-environmental behavior, which is captured through renewable energy consumption (REC). The total consumption of energy from all sources is taken to measure this variable and the data series is collected from the energy information administration (EIA). Privatization and digitalization are the main focused variables in our model. Privatization (PRIV) is measured through gross fixed capital formation from private sector as % of GDP. The digital economy impact is measured through ICT users as % of total population. The data series for PRIV and ICT are assembled from the world development indicators (WDI). Following existing literature, we have included economic development (ED) and financial development (FD) as control variables in our model. ED is measured by GDP per capita, while an index is used to measure financial development. Data series for ED are collected from the WDI and data series for FD are collected from the International Monetary Fund (IMF). The data assembling procedure has two stages. In the first stage, annual time series data is collected for the period 1993–2020. In the next stage, the annual data series are transformed into quarterly data series by employing the quadratic match-sum method. Table 1 also displays the summary of descriptive statistics. Descriptive statistics provide results for the following tests: mean, median, skewness, Jarque–Bera (J-B) stat, and kurtosis. The mean and standard deviation tests provide positive values for REC, PRIV, ICT, ED, and FD. The J–B test rejects the null hypothesis of normality for all series confirming the applicability of the nonlinear QARDL regression technique.

Table 1. Definations and results of descriptive statistics.

Variables	Definations	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque–Bera	Prob.	
REC	Total energy consumption from nuclear, renewables, and other (quad Btu)	1.702	1.603	3.063	0.512	0.876	0.108	1.538	9.833	0.007	EIA
PRIV	Gross fixed capital formation, private sector (% of GDP)	3.533	3.550	3.687	3.333	0.109	−0.227	1.766	7.781	0.020	WDI
ICT	Individuals using the Internet (% of population)	1.544	2.775	4.292	−7.401	3.133	−1.363	3.698	35.617	0.000	WDI
ED	GDP per capita (current US$)	7.867	7.899	9.260	6.071	1.020	−0.070	1.493	10.302	0.006	WDI
FD	Financial development index	0.484	0.486	0.638	0.337	0.104	0.135	1.556	9.711	0.008	IMF

4. Empirical Results and Discussion

4.1. Empirical Results

Table 2 outlines the results of unit root tests. Our study used the ADF test and the ZA test for checking the unit root properties for REC, PRIV, ICT, ED, and FD series. Both tests produce similar outcomes. The stationarity of the ICT series at level is confirmed by both unit root tests, while the stationarity of REC, PRIV, ED, and FD is confirmed at first difference. Nonetheless, no series exhibits stationarity at the second difference. Thus, the findings of the Augmented Dickey–Fuller (ADF) and Zivot–Andrews (ZA) unit root tests are fulfilling the pre-requisite for using a nonlinear QARDL approach for regression analysis. The regression results of the nonlinear QARDL model is provided in Table 3. Table 3 also provides the results of the speed of adjustment parameter that confirm the convergence possibility among variables. The speed of adjustment parameters are found significant at all quantiles. The negative sign associated with error correction model (ECM) parameters confirm the convergence of concerned variables in the long run.

Table 2. Results of unit root test.

	ADF			ZA				
	I(0)	I(1)	Decision	I(0)	Break Date	I(1)	Break Date	Decision
REC	−1.546	−3.452 **	I(1)	−3.021	2003 Q1	−6.302 ***	1997 Q3	I(1)
PRIV	−1.658	−3.235 ***	I(1)	−3.014	2007 Q2	−5.324 ***	1997 Q3	I(1)
ICT	−9.325 ***		I(0)	−11.25 ***	1997 Q2			I(0)
ED	−0.854	−2.758 *	I(1)	−3.189	2003 Q1	−4.857 ***	1995 Q1	I(1)
FD	−0.721	−2.873 *	I(1)	−2.854	2005 Q1	−5.542 ***	1996 Q1	I(1)

Note: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

Table 3. Results of nonlinear QARDL.

	ECM	Constant	Long-Run Estimates					Short-Run Estimates							
Quantiles	$\rho(\tau)$	τ	$\beta^{+}{}_{PRIV}(\tau)$	$\beta^{-}{}_{PRIV}(\tau)$	$\beta_{ICT}(\tau)$	$\beta_{ED}(\tau)$	$\beta_{FD}(\tau)$	$\pi^{+}{}_{PRIV}(\tau)$	$\pi^{-}{}_{PRIV}(\tau$	$\pi0_{ICT}(\tau)$	$\pi1_{ICT}(\tau)$	$\pi_{ED}(\tau)$	$\pi0_{FD}(\tau)$	$\pi1_{FD}(\tau)$
0.05	−0.526 **	3.761 **	0.789	0.949	0.014	0.519 **	1.733	0.050	0.206	0.072	0.060	0.029	0.079	0.500
	(−2.256)	(2.502)	(0.642)	(0.943)	(0.927)	(2.376)	(1.308)	(0.165)	(1.120)	(0.220)	(0.193)	(1.348)	(0.113)	(0.750)
0.10	−0.358 ***	3.665 **	0.868	1.331	0.014	0.505 **	1.577	0.023	0.232	0.030	0.037	0.024	0.212	0.833
	(−3.194)	(2.366)	(0.662)	(1.196)	(0.893)	(2.107)	(1.005)	(0.002)	(1.583)	(0.636)	(0.822)	(1.241)	(0.666)	(0.982)
0.20	−0.330 **	4.275 ***	0.863*	1.055	0.022	0.663 ***	0.522	0.014	0.359	0.022	0.032	0.013	0.524	0.976
	(−2.473)	(8.085)	(1.731)	(1.576)	(1.284)	(6.523)	(0.699)	(0.764)	(1.633)	(0.390)	(0.586)	(1.018)	(1.187)	(1.372)
0.30	−0.280 **	4.392 ***	0.740 **	1.912 ***	0.021	0.722 ***	0.460	0.135	0.425 **	0.008	0.003	0.005	0.738	1.040
	(−2.092)	(13.13)	(2.369)	(4.380)	(1.265)	(9.261)	(0.602)	(0.156)	(2.379)	(0.133)	(0.047)	(0.635)	(1.350)	(1.170)
0.40	−0.264 **	4.545 ***	0.777 **	2.071 ***	0.037 **	0.766 ***	0.846	0.137	0.373 ***	0.002	0.011	0.007	0.922 *	1.284 **
	(−2.242)	(13.33)	(2.449)	(5.633)	(1.988)	(10.24)	(1.244)	(0.318)	(4.045)	(0.025)	(0.215)	(1.065)	(1.795)	(2.406)
0.50	−0.267 **	4.512 ***	0.807 **	2.182 ***	0.047 ***	0.772 ***	1.006 *	0.198	0.304 ***	0.004	0.007	0.002	0.935 *	1.173 **
	(−2.470)	(11.71)	(2.446)	(7.251)	(4.885)	(10.14)	(1.843)	(0.485)	(3.206)	(0.037)	(0.153)	(0.356)	(1.906)	(2.289)
0.60	−0.264 **	3.939 ***	1.167 ***	2.245 ***	0.042 ***	0.684 ***	0.953 *	0.257	0.261 **	0.009	0.017	0.001	1.043 **	1.235 **
	(−2.549)	(10.32)	(3.242)	(7.800)	(4.419)	(9.397)	(1.915)	(0.612)	(2.416)	(0.203)	(0.378)	(0.190)	(2.002)	(2.261)
0.70	−0.264 **	3.772 ***	1.405 ***	2.170 ***	0.050 ***	0.662 ***	0.974 *	0.379	0.280 **	0.038	0.046	0.005	1.309 ***	1.472 ***
	(−2.573)	(9.806)	(3.493)	(7.244)	(5.508)	(9.152)	(1.843)	(0.764)	(2.040)	(0.776)	(0.949)	(0.873)	(3.102)	(5.036)
0.80	−0.269 **	3.681 ***	1.809 ***	2.225 ***	0.072 ***	0.660 ***	1.245 **	0.597	0.228 *	0.070	0.076	0.007	1.429 ***	1.576 ***
	(−2.579)	(7.429)	(2.780)	(6.060)	(6.368)	(7.719)	(2.158)	(1.074)	(1.813)	(1.045)	(1.020)	(1.444)	(4.437)	(4.932)
0.90	−0.298 *	3.579 ***	1.867 ***	2.263 ***	0.074 ***	0.642 ***	1.172 **	0.426	0.050 *	0.071	0.073	0.010 *	1.491 ***	1.585 ***
	(−1.717)	(8.565)	(3.391)	(7.378)	(8.240)	(8.949)	(2.447)	(1.142)	(1.758)	(1.203)	(1.294)	(1.912)	(4.649)	(5.101)
0.95	−0.378 ***	3.531 ***	1.869 ***	2.384 ***	0.078 ***	0.630 ***	1.107 ***	0.667	0.053*	0.081	0.092	0.046 **	1.419 ***	0.902 ***
	(−2.695)	(9.859)	(4.328)	(8.849)	(9.414)	(10.22)	(2.793)	(1.546)	(1.682)	(1.389)	(1.637)	(1.973)	(3.010)	(3.179)

Note: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

The long-run results show that the coefficient estimates of the positive shock of PRIV are found positive and significant at quantiles 0.20 to 0.95. This shows that positive shock in PRIV positively enhances REC in the long run, but the nexus between the positive shock of PRIV and REC is reported as insignificant at quantiles 0.05 and 0.10. The coefficient estimates of the negative shock of PRIV are found negative and significant at quantiles 0.30 to 0.95. This shows that negative shock in PRIV tends to reduce REC in the long run. However, the negative shock of PRIV reports no impact on REC at quantiles 0.05 to 0.20 in the long run. These results display that positive shock in PRIV enhances REC while negative shock in PRIV declines REC in the long run. In short, our main findings suggest that a positive shock in privatization promotes pro-environmental behavior. In the long run, the coefficient estimates for ICT are significant and positive across quantiles ranging from 0.40 to 0.95. It shows that an upsurge in ICT positively enhances REC in the long run. However, the connotation between ICT and REC is observed insignificant at quantiles 0.05 to 0.30 in the long run. Our findings suggest that digitalization is crucial in promoting pro-environmental behavior.

The results in Table 3 report that ED estimates are observed significantly positive at all quantiles in the long run. This portrays the positive role of ED in enhancing REC in the long run at all intensities of ED. FD estimates are observed significantly positive at quantiles 0.50 to 0.95 in the long run. This shows that enhancement in FD escalates REC in the long run at quantiles 0.50 to 0.95, but the association between FD and REC is observed as insignificant at quantiles 0.05 to 0.40 in the long run. In the short run, the coefficient estimates for positive shock in PRIV are observed statistically insignificant at all quantiles, revealing that positive shock in PRIV produces no influence on REC. However, the estimates of the negative shock of PRIV are found negative and significant at quantiles 0.30 to 0.95 in the short-run. This shows that negative shock in PRIV significantly declines REC in the short run. The coefficient estimates for ICT are found to be statistically insignificant across all quantiles in the short run, indicating that digitalization has no immediate impact on REC. However, in the short run, ED estimates are significant and positive at the highest quantiles, specifically at 0.90 and 0.95. The association between ED and REC is observed as insignificant at remaining quantiles in the short run. FD estimates are found significant and positive at quantiles 0.40 to 0.95 in the short-run, depicting that increase in FD enhances REC in the short-run at these quantiles.

The results of the Wald test are given in Table 4. This test confirms the asymmetries of variables. The linearity hypothesis is rejected for positive and negative shock in privatization in the long run at all quantiles. This confirms the nonlinear dynamics of the positive and negative shock of privatization for pro-environmental behavior. However, the linearity hypothesis is rejected for positive and negative shock in privatization in the short-run at 0.95th quantile only. This shows that the dynamic of the positive and negative shock of privatization are linear in nature in the short-run at remaining quantiles i.e., 0.05 to 0.90.

Table 4. Results of Wald test.

	Long-Run	**Short-Run**
	(H0: $\beta^{+}=\beta^{-}$)	**(H0: $\pi^{+}=\pi^{-}$)**
0.05	6.125 ***	0.254
0.10	7.689 ***	0.321
0.20	17.65 ***	0.356
0.30	28.25 ***	0.412
0.40	31.03 ***	0.231
0.50	35.65 ***	0.072
0.60	39.65 ***	0.061
0.70	41.02 ***	0.051
0.80	31.05 ***	1.302
0.90	28.39 ***	2.031
0.95	25.12 ***	3.452 *

Note: *** $p < 0.01$; * $p < 0.1$.

4.2. Results Discussion

This study's main findings suggest that a positive shock in privatization promotes pro-environmental behavior. This result is not surprising because, recently, there has been a widespread phenomenon of privatizing government businesses. The goals of governments in promoting privatization are also obvious: to boost economic efficiency while easing the financial pressure of owning loss-making businesses. What is less well known is that privatization may produce economic and environmental advantages within the right circumstances, and offers the chance to adopt intentional choices that impact a sustainable environment [18,27]. Observation and empirical analysis suggest that private businesses function better in most industries and regions than public organizations in terms of economic efficiency, capacity to keep up with the changing business environment and technical hurdles, and capability to join new markets [21]. Numerous advancements have been initiated to impact the environment through improved resource administration, enhanced access to credit, continued spending of low-carbon technologies, evolutionary development, prominence of cutting-edge management methods, and enhanced access to markets for eco-friendly products and services, and thus promote pro-environment behavior [38].

Our findings imply that privatization can lead to increased investment in renewable energy projects by creating opportunities for private sector participation. Private companies are generally more willing to invest in renewable energy projects because of the potential for long-term profitability. This increased investment can lead to the development of more renewable energy infrastructure and an increase in renewable energy consumption. Our finding is supported by McGreevy et al. [24], who infers that privatization can create competition in the renewable energy market, which can lead to lower prices and increased consumption. Competition can encourage innovation and technological advancements in renewable energy, leading to increased efficiency and lower costs. This can make renewable energy more accessible and attractive to consumers. Privatization can lead to changes in regulatory frameworks that promote the growth of renewable energy [39]. This means that privatization creates a more favorable environment for renewable energy consumption and encourages the development of more renewable energy projects. Moreover, privatization can lead to improved energy security and reliability by promoting investment in new infrastructure and technologies. This can make it easier to integrate renewable energy into the grid, leading to increased consumption [40]. Additionally, the diversification of energy sources can reduce the dependence on traditional fossil fuels, leading to a more sustainable energy system.

Next, our findings suggest that digitalization is crucial in promoting pro-environmental behavior. The substitution effect that comes into play as a result of increased use of ICT eases the shift to environmentally friendly modes of consumption and manufacturing. Dematerialization, demobilization, and decarbonization are some of these impacts. To reduce trash, dematerialization converts printed books into digital books, postal mail into emails, and newspapers into online papers. Demobilization also lowers outdoor activities, conserves carbon fuels used in automobiles, and cuts carbon pollution. It promotes working from home instead of coming to the office and enables video conferencing instead of in-person meetings. The impacts of replacement aid in streamlining industrial procedures, enhancing energy effectiveness, and achieving decarbonization. It is also claimed that ICT has more positive net effects than negative ones since its indirect effects outweigh its direct ones [41]. All these factors are responsible for promoting pro-environment behavior in society. Moreover, our findings are in line with the studies of Chao et al. [25] and Deshuai et al. [42].

The results of Xu & Ullah [33] show that ICT can enable the development and implementation of energy management systems that optimize the use of renewable energy sources. This can lead to more efficient and effective use of renewable energy sources, leading to increased renewable energy consumption. Chang et al. [43] infer that ICT can enable the development and integration of energy storage systems that increase the flexibility and reliability of renewable energy sources. These systems use software and hardware solutions to manage the flow of energy to and from the grid, ensuring that renewable energy is stored and used efficiently. This can help to overcome the variability and intermittency issues associated with some renewable energy sources, leading to increased renewable energy consumption. Chao et al. [36] assert that ICT can enable the development and integration of distributed energy resources that increase the availability and accessibility of renewable energy sources. ICT can help to optimize the management and operation of these resources, leading to increased renewable energy consumption.

5. Conclusions

Researchers, energy professionals, and environmentalists have all recently acknowledged that climate change presents a major threat to mankind. If the world's behavior as a whole would not change, the threat of climate change and global warming will also remain a serious challenge in the coming years. Therefore, to deal with the issues of global warming and environmental degradation, it is very important for people worldwide to change their behavior to make it more environmentally friendly. In this regard, increasing renewable energy consumption at household and business levels would be a big step toward pro-environment behavior. Therefore, identifying the elements that might influence pro-environmental behavior is essential to preventing additional ecosystem damage. The two key factors that have revolutionized society and affected every area of the economy are privatization and digitization. However, empirical evidence on the impact of privatization and the digital economy on pro-environment behavior is missing. Therefore, this study was an effort to investigate the effects of privatization and the digital economy on pro-environmental behavior. This research also made use of the asymmetry assumption, which enabled us to explore the effects of privatization's positive and negative shocks on pro-environmental behavior.

As a prerequisite for time series data, we examined the variables' stationary qualities before moving on to the empirical analysis. The ADF and ZA findings show that every variable in the study is either I(0) or I. (1). As a result, we used the nonlinear QARDL model, which is capable of handling these kinds of the mixed ordering of variables. Findings of the nonlinear QARDL model posit that the long-run positive shock in the privatization promotes pro-environmental behavior by increasing renewable energy consumption, while the long-run negative shock in the privatization demotes pro-environmental behavior by reducing renewable energy consumption. In the short run, the positive shock of privatization does not significantly impact pro-environmental behavior, while the negative shock of privatization reduces pro-environmental behavior. Moreover, ICT, economic development, and financial development develop pro-environmental behavior in the long run; however, in the short-run only financial development help increase pro-environmental behavior. The Wald test confirms the asymmetric impact of privatization on pro-environmental behavior only in the long run.

5.1. Policy Implications

These results allow us to make some significant policy recommendations. According to the study's results, pro-environment behavior reacts differently to privatization's positive and negative shocks. Policymakers should thus consider both positive and negative shocks when developing policies to encourage pro-environmental behavior in the context of privatization and the pro-environmental nexus. Since the positive change in privatization promotes pro-environmental behavior, increasing the volume of the private sector is a viable solution to increase pro-environmental behavior. Thus, the transformation of the overall structure of the economy away from the government sector is the most viable option to develop more environmentally-responsible behavior. The government can also invest in renewable energy infrastructure, research and development, and capacity building. The government can facilitate competition by ensuring that the market is open and transparent, and that there are no barriers to entry for new firms. This can encourage private firms to adopt renewable energy technologies to gain a competitive advantage. Public-private partnerships can play a vital role in promoting renewable energy. The government can work with private firms to develop renewable energy projects, sharing the risks and benefits of the projects. This can help overcome the financing barriers that private firms may face in investing in renewable energy technologies.

The positive impact of privatization on renewable energy consumption suggests that policies aimed at promoting private sector participation in renewable energy projects could be effective in increasing economic viability. Governments could provide incentives for private companies to invest in renewable energy projects, such as tax breaks, subsidies, or loan guarantees. This could lead to increased investment and job creation in the renewable energy sector, boosting economic viability. Renewable energy consumption can help to reduce greenhouse gas emissions and mitigate the effects of climate change. Policymakers could implement policies that promote the development and use of renewable energy sources, such as feed-in tariffs or renewable portfolio standards. Additionally, policies aimed at reducing the use of traditional fossil fuels, such as carbon taxes or emissions trading schemes, could help to protect the environment and promote sustainability. Policymakers could implement policies aimed at promoting social equity in the renewable energy sector. For example, policies could be implemented to ensure that the benefits of renewable energy projects are distributed fairly among all members of society, including low-income households and marginalized communities. Additionally, policies could be implemented to promote access to renewable energy technologies for all members of society, regardless of socioeconomic status. Additionally, expanding ICT usage in the economy may hasten the dematerialization and digitalization processes, which are essential for transforming the nation's economy into one that is less dependent on capital resources, and as a result, encouraging pro-environmental behavior. Governments should promote the use of digital technologies in the energy sector to further enhance the uptake of renewable energy sources.

5.2. Limitations and Directions

This study relied on data for China at the national level, which may not be representative of the provincial renewable energy landscape. Future studies should conduct this analysis for provinces of China. The model used in this study only included a limited number of variables, which may not fully capture the complexity of the relationship between privatization, ICT, and renewable energy consumption. Future research could include additional variables, such as government policies and regulations, to better understand the factors that influence renewable energy consumption. This study only focused on the effect of privatization on renewable energy consumption and did not consider other factors that may influence sustainability in the renewable energy sector. Future research could investigate the impact of other variables on renewable energy consumption. Future research could also investigate the role of public-private partnerships in promoting sustainability in the renewable energy sector. Additionally, research could investigate the impact of renewable energy consumption on other sustainability outcomes, such as social and economic development.

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