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An Analysis of Economic Real Variables' Impact on Renewable Energy Production (REP) Using the Autoregressive Distributed Lag (ARDL) Model

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Abstract

This paper tries to investigate the connections between renewable energy production and real economic factors such as gross domestic product (GDP), gross fixed capital formation (GFCF), and public-private partnership (PPP) based investment in energy in India. We use the autoregressive distributed lag (ARDL) model to examine the short- and long-term impacts of these factors. Data were obtained from the World Development Indicators covering 1991 to 2022. After reviewing previous literature, we use the ARDL model as the foundation for this study. The dataset compilation and empirical estimation have been conducted. The analytical evidence shows that in the short-run, present GDP has no effect, and PPP investment in energy and gross fixed capital formation lags have significant effects. The error correction model indicates a significant 51% short-run deviation that is adjusted in the long period. However, in the long run, GDP and PPP investment in energy have positive effects, while GFCF has a negative effect because it remains constant in the future. Our model fits and performs well on diagnostic tests, giving satisfactory and consistent results.

Categories: Sustainable Economic Development, Climate Change
Keywords: ardl, ppp investment in energy, post liberalization, gross fixed capital formation, renewable enrgy production
JEL Classifications: Q21, Q41, Q43

Introduction

Energy plays an essential component of a nation's economic and social development, determining its level of wealth. Deciphering the supply and consumption of energy at different levels of the Indian economy is a challenging task. With a population of 1.4 billion, India has an enormous demand for energy to power its fast-expanding economy. India confronts multiple energy difficulties, prompting industries to change their energy consumption patterns. However, one of the largest energy consumers, industry, must prioritize energy efficiency, cleaner fuels, renewable energy (RE), and decarbonization through Carbon Capture, Utilization, and Storage, and modern fuels such as green hydrogen to drive long-term transitions (Ministry of Power, 2021). The Indian government mostly generates energy using non-fossil fuel and renewable sources, such as major hydropower and nuclear reactors. Further, these sources are not without environmental concerns. Construction of megadams in the Himalayas has resulted in destabilization, ecological loss, and community dislocation. Radioactive power has caused forced displacement, curtailed civic values because it is covered with security, and the prospect of millennia of poisoning by incurable radioactive waste. These goals include attaining net-zero emissions of greenhouse gases by 2070, generating 500 GW from non-fossil fuels, and having the goal of converting 50% of the total production of electricity to clean energy by 2030. Any impediments to this, according to the judgment, result in more coal-based production, with disastrous effects for the environment (Kothari and Bajpai, 2024).

The United Nations Summit on Sustainable Development Goals (SDGs), held in New York on September 18-19, 2023, evaluated progress for obtaining them. The UN General Assembly developed Agenda 2030 in 2015, which included 17 SDGs and 169 specific targets to be fulfilled by 2030 (United Nations, 2015). The program is not legally enforceable on a worldwide basis, but every nation is dedicated to taking steps to achieve these goals because transitioning to a sustainable future is an international initiative. The UN SDG Report 2023 lists five priority areas for immediate action in light of the existing situation. Governments' pledges to take seven years of accelerated, sustained, and transformative actions to deliver on the ambitions of the SDGs; tangible, connected, and focused government strategies and initiatives to eliminate poverty, minimize inequality, and end the war on the natural world, with a focus on advancing the rights of women and girls and empowering the most vulnerable; and the strengthening of national and subnational capacity, accountability, and governmental agencies to deliver faster advancement (Chattopadhyay, 2024).

This implies that very small improvements in per capita income are likely to result in significant increases in renewable per capita energy consumption. Modern renewable energy consumption per capita in emerging economies is predicted to increase faster than real per capita income as the economy develops (Sadorsky, 2009). It is theoretically feasible to achieve UN climate stabilization goals by 2050 if energy demand is constrained to 25% or less above the current level, sources of clean energy are developed at 6 to 8 times the current rate, energy efficiency and conservation measures are much more aggressively applied, nuclear power is expanded by 30% or more, developed countries (especially the United States) reduce their per capita energy use by 40% or more, and carbon capture, utilization, and storage techniques are used (Holechek et al., 2022).

However, existing research mainly focuses on the relationship between CO_2, GDP, renewable energy share, energy consumption, financial development, and economic growth rate, but this paper examines the public-private investment in infrastructure, GDP, and gross fixed capital formation interaction with renewable energy production post-liberalization to 2022 in India. The rest of the paper is structured as follows: the 'introduction' reviews research papers and finds a research gap for this paper. The 'research method' explains the data sources, variables, and methods for analysis. Following the presentation of our results and discussion, the final section addresses the conclusion and outlines the proposed policy recommendations.

Literature review

According to Sadorsky (Sadorsky, 2009), the two empirical models of renewable energy consumption and gross domestic product in the panel data of emerging economies were obtained from the International Energy Agency (IEA) and MSCI Barra by a panel cointegration test and fully modified ordinary least squares (FMOLS) and Ordinary Least Squares (OLS). It was found that an increase in GDP positively affects renewable energy consumption, and the long-run renewable energy consumption price elasticity is equal to -0.7. Further, the study by Ergun and Rivas (Ergun and Rivas, 2023) examines the U-shaped relationship between GDP per capita and the share of renewable energy consumption, employing the feasible generalized least squares on renewable energy share (RE%), GDP per capita, Financial Institution Development Index (FD), and gross capital formation from the database of World Development Indicators (WDI) and the International Monetary Fund.

They find a U-shaped relationship between income and RE share. Lyeonov et al. (Lyeonov et al., 2019) examine the effect of various indicators on GDP in European Union (EU) countries from 2008 to 2016, including greenhouse gas (GHG), Private investment, job and gross value added related to private investments in circular economy (PICE), and RE. They find that FMOLS and dynamic ordinary least squares (DOLS) have similar effects on GDP. Additionally, investments in green technology, PICE, can boost GDP per capita by 6.4% and reduce GHG emissions by 3.08% in spite of this further increase in renewable energy consumption by 5.6%. Furthermore, the investigation by Özden and Beşe (Özden and Beşe, 2021) using the ARDL model and the nonlinear autoregressive distributed lag (NARDL) model analyzes the Environmental Kuznets Curve (EKC) hypothesis and the relationship between GDP per capita, CO_2 emissions, energy consumption, and GDP squared. No asymmetric or symmetric link exists, suggesting that Australia should focus on reducing oil use and increasing renewable energy. Moreover, exploration of Kaya and Kaya (Kaya and Kaya, 2018) shows through an autoregressive distributed lag (ARDL) approach an analysis of the correlation between CO_2 emissions per capita, GDP per capita, energy consumption, and financial development in Turkey from 1975 to 2012. Their results exhibit that the EKC hypothesis does not apply to Turkey's economy and that energy consumption and financial development positively impact CO_2 emissions. Further, a study by Ntanos et al. (Ntanos et al., 2018) explores the correlation between renewable energy usage and GDP per capita in 25 European countries during the time period from 2007 to 2016. This study uses descriptive statistics, cluster analysis, and ARDL to show a stronger association between renewable energy consumption and economic growth in high-income countries.

The results are consistent with Radmehr et al. (Radmehr et al., 2022), who use panel simultaneous equations models and a generalized method of moments estimator for the association between ecological footprint, renewable energy consumption, and income in G7 nations from 1990 to 2018. Their result shows that there is a two-way association between renewable energy and GDP. Strengthening human capital positively impacts income, environmental quality, and renewable energy consumption. Economic globalization has a minimal impact. Therefore, the paper by Ghosh (Ghosh, 2002) tries to investigate the Granger causation between India's electricity consumption and GDP per capita, revealing a unidirectional relationship with no feedback effect, suggesting that electricity conservation strategies can be implemented without negative economic impacts, which indicates a long-run equilibrium between the variables. Further, Gautam et al. (Gautam et al., 2024) link post-1990 solar energy growth to India's economy, analyzing 2007-2022 trends using CAGR and regression methods. Similarly, Verma (Verma, 2021) analyzes how to overcome unsustainability through the adoption of renewable energy.

Research Method

Data collection and sample

For this study, a dataset was constructed using yearly time series information for the post-liberalization period from 1990 to 2022. Data were utilized from the World Development Indicators (WDI) (World Development Indicators, 2022) and Our World in Data (Our World in Data, 2024). They provide an extensive amount of energy-related data in the world on a country-wise and timely basis. The variable details are shown in Table *1*.

Log Form	Details	Source
LnREP	Modern Renewable Energy Production (Twh)	Our World in Data
LnGDP	Gross Domestic Product (Current International US $)	WDI
LnPPIE	Public-Private Partnership Investment in Energy (Current US $)	WDI
LnGFCF	Gross Fixed Capital Formation (Current US $)	WDI

TABLE 1: List of variables

Methodology

For investigation of the paper, Equation (1) is grounded on the mathematical functional form shown below, offering a preliminary concept for structuring a model to support subsequent modelling efforts.

$$REP_t = f(GDP_t + PPPIE_t + GFCF_t) \quad (1)$$

Here, REP refers to modern renewable energy production in TWh, GDP refers to gross domestic product in US $, PPPIE refers to public-private partnership investment in energy in US $, and GFCF refers to gross fixed capital formation in US $. To avoid multicollinearity, convert data to natural log form and then model what it looks like.

$$LnREP_t = \alpha_o + \alpha_1 GDP_t + \alpha_2 PPPIE_t + \alpha_3 GFCF_t + \varepsilon_t) \quad (2)$$

After designing the econometric model, the first step is to test data stationarity using the method of Dickey and Fuller (Dickey and Fuller, 1981). The second step is to test the bounds cointegration, which involves identifying the presence of a level correlation between an explained variable and a group of explanatory variables, where it is not known with certainty whether the explanatory variables are trend- or first-difference (Pesaran et al., 2001). The third step is to run the Autoregressive Distributed Lag (ARDL) model to explore the short and long-run relationship between REP and GDP, PPP investment in energy, and GFCF in India. In the analysis of time series, the ARDL method was developed by Pesaran et al. (Pesaran et al., 2001). This model is suitable when variables are set to I(1), I(0), or both; thus, the ARDL model can be run lacking complexity. Here, Equation (2) is rewritten in the ARDL form in Equation (3).

$$\Delta LnREP_t = \gamma_o + \gamma_1 REP_t{-1} + \gamma_2 GDP_t{-1} + \gamma_3 PPPIE_t{-1} + \gamma_4 LnGFCF_t{-1} + \sum_{i=1}^{p} \lambda_1 \Delta LnREP_t{-1} + \sum_{i=1}^{p} \lambda_2 \Delta LnGDP_t{-1} + \sum_{i=1}^{p} \lambda_3 \Delta LnPPPIE_i{-1} + \sum_{i=1}^{p} \lambda_4 \Delta LnGFCF_t{-1} + \varepsilon_t) \quad (3)$$

Where Δ represents the difference between lag values for all of the other variables expressed previously in the equation. When analyzing the ARDL bound approach, start from estimating Equation (3) using OLS, and then observe the F-test for the joint significance of the model coefficients of the lagged levels of the variables to test for the presence of a long-run cointegration relationship. For not accepting the null hypothesis that there is no cointegration relationship among variables, express it as H0 = γ1 = γ2 = γ3 = γ4 = 0. And H1: γn ≠ 0, n = 1, 2, ..., 4.

The Akaike Information Criteria (AIC) is used to determine the lag length. So the outcome of the lag length determination and the existence of long-run association are identified; the error correction model (ECM) is like that.

$$\Delta LnREP_t = \beta_0 + \sum_{i=1}^{p} \Theta_1 \Delta LnREC_t{-1} + \sum_{i=1}^{p} \Theta_2 \Delta LnGDP_t{-1} + \sum_{i=1}^{p} \Theta_3 \Delta LnPPPIE_i{-1} + \sum_{i=1}^{p} \Theta_4 \Delta LnGFCF_t{-1} + \delta ECM_t{-1} + \varepsilon_t) \quad (4)$$

In this study, we also incorporate some diagnostic tests to establish the appropriate model functionality through Ramsey's RESET test, variance consistency by Heteroskedasticity Test (BP Test), Breuch-Godfrey Serial Correlation LM Test (B Test), Normality Test of Jarque-Bera, and CUSUM and CUSUM Square Tests for coefficients stability (Figure *1* and Figure *2*).

Results And Discussion

The results of this analysis are summarized in Table 2, which displays the descriptive statistics of the data, including mean, standard deviation, skewness, kurtosis, and Jarque-Bera test results. For normally distributed data, the skewness value should be 0 and the kurtosis value should be 3. The Jarque-Bera test is employed to identify whether a series was symmetrically distributed or not.

Variables	Mean	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	P-value
LnREP	2.117164	0.236111	0.409981	1.862935	2.620342	0.2697
LnGDP	3.505307	0.253344	-0.06194	1.695855	2.288191	0.3185
LnPPPIE	9.198572	0.752797	-1.04538	5.069669	11.53974	0.003 ***
LnGFCF	11.44645	0.400064	-0.22783	1.486837	3.329719	0.1892

TABLE 2: Descriptive statistics

In our null hypothesis, the skewness value is equal to 0, and kurtosis is equal to 3. In the descriptive statistics results display, the data variables are not normally distributed.

Therefore, in the statistical descriptive analysis of the data, the first step in the ARDL model is to evaluate the variable stationarity test condition: the explained variable must be integrated at the first difference I(1) and all explanatory variables must be either level I(0) or first difference I(1) stationary. For this test, we use the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) stationarity tests.

Variables	ADF (constant and trend)		PP (constant and trend)	
Black	Level	First Difference	Level	First Difference
LnREP	0.93392	-5.5425 ***	1.9678	-5.5741 ***
LnGDP	-0.6155	-5.2015 ***	-0.7537	-5.2747 ***
LnPPPIE	-2.9514 **		-2.8448 *	
LnGFCF	-0.7537	-6.0965 ***	-0.8879	-6.1738 ***

TABLE 3: Augmented Dicky-Fuller and Phillips-Perron unit root test

* Critical value for ADF and PP are *** for 1%, ** for 5%, * for 10%

Moreover, Table 3 explains that REP, GDP, and GFCF are not unit root at level but are unit root at first difference I(1) using ADF and PP tests at a 1% significance level, and PPPIE is stationary at level I(0) at 5% in ADF and 10% in PP significance level. After identifying a suitable lag number based on the AIC and SC criteria, the next step is to decide whether there is a co-integration relationship between variables in the long run. To evaluate this, the F-statistic is used (Pesaran et al., 2001).

Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	4.814787	10%	2.37	3.2
K	3	5%	2.79	3.67
		2.5%	3.15	4.08
		1%	3.65	4.66

TABLE 4: Bounds cointegration test

Asymptotic: n = 1000

Table 4 shows the result of the F statistic value for the co-integration test. As shown in the table, the F statistic value was greater than the the critical value at the 1% significance level. Hence, it shows a long-period relationship between the variables. Further, the long-run and short-run coefficients are examined to evaluate the effects of the regressors on renewable energy consumption. For this long-run ARDL model, the selected lag structure is (1, 1, 4, 1).

Dependent Variable: Renewable Energy Consumption				
Variable	Coefficient	S.E.	t-Statistic	P-value
Gross Domestic Product	2.523	0.824	3.064	0.007 ***
Gross Fixed Capital Formation	-1.134	0.625	-1.814	0.087 *
PPP Investment in Energy	0.046	0.026	1.767	0.095 *
Constant	-13.779	0.994	-6.911	0.000 ***
* Critical value for ADF and PP are *** for 1%, ** for 5%, * for 10%				

TABLE 5: Short-run regression model

In Table 5, the results show that if India's GDP increases by 1%, renewable energy consumption increases by 2.5%, significant at the 1% level. Therefore, if investment increases 1% on gross fixed capital formation, then there is a 1.1% decrease in REP, significant at the 10% level. If PPP investment in energy increases by 1%, REP increases by 0.04%, significant at the 10% level; if other factors remain constant, there is a 13% increase in non-REP in the Indian economy. After analyzing the long-run results, we examine the short-run results. Here, the error correction form shows that lagged values have an effect on REP.

Variable	Coefficient	S.E.	t-Statistic	P-value
ΔGDP_t	-0.203	0.506	-0.402	0.693
$\Delta GFCF_t$	0.377	0.278	1.357	0.193
$\Delta GFCF_{t-1}$	0.348	0.198	1.760	0.096 *
$\Delta GFCF_{t-2}$	-0.478	0.191	-2.496	0.023 **
$\Delta GFCF_{t-3}$	0.581	0.210	2.762	0.013 ***
$\Delta PPPIN_t$	0.041	0.011	3.886	0.001 ***
ECM Term	-0.519	0.095	-5.453	0.000 ***

* Critical value for ADF and PP are *** for 1%, ** for 5%, * for 10%

TABLE 6: Long-run regression model

ECM, Error Correction Model

Table 6 shows that the differentiated lag value of GDP at present and GFCF have inverse and direct effects on REP, and they are insignificant. Therefore, previous year lags 1 and 3 of GFCF value have a positive and significant effect, and lag 2 has a negative effect. PPP investment in energy has a positive and substantial effect on REP, and the ECM has a negative and significant effect, meaning that 51% of short-run disequilibrium is adjusted monotonically toward the long-run equilibrium.

Test Name	P-value	Null Hypothesis	Decision
Ramsey's RESET Test	0.8956	No Problem of functional form	Do not Reject H_0 Hypothesis
Heteroskedasticity Test (BP Test)	0.5024	No Problem of heteroskedasticity	Do not Reject H_0 Hypothesis
Serial Correlation LM Test	0.9074	No Problem of serial correlation	Do not Reject H_0 Hypothesis
Normality test of Jarque-Bera	0.7474	Data is normally spread	Do not Reject H_0 Hypothesis

TABLE 7: Diagnostic test

However, many diagnostic tests were run for the ARDL model; these were used to ensure our estimated results are consistent and efficient for unbiased estimation. In Table 7, we present the Ramsey's RESET Test, Heteroskedasticity Test, Serial Correlation Test, and Normality Test.

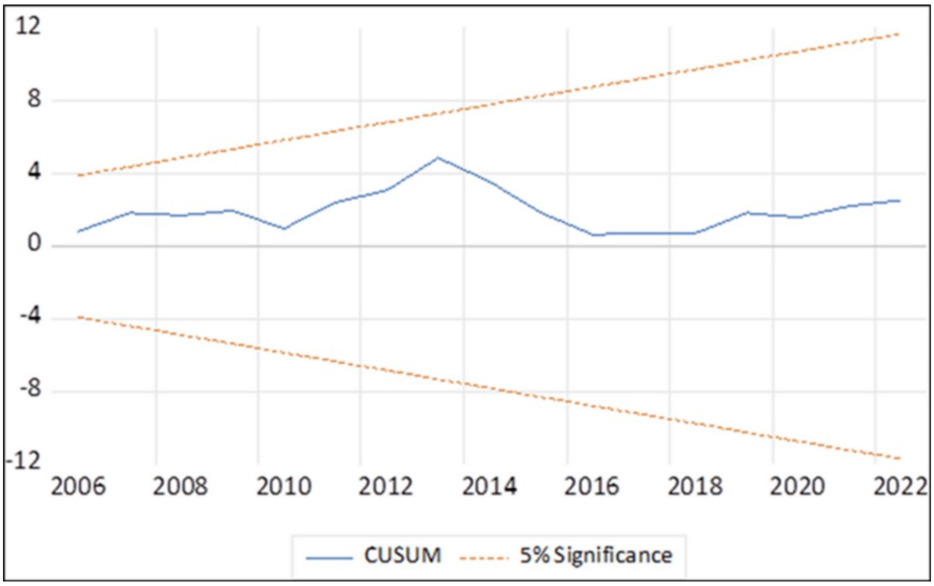

FIGURE 1: CUSUM test

X axes indicate time period and Y axes show cumulative sum.

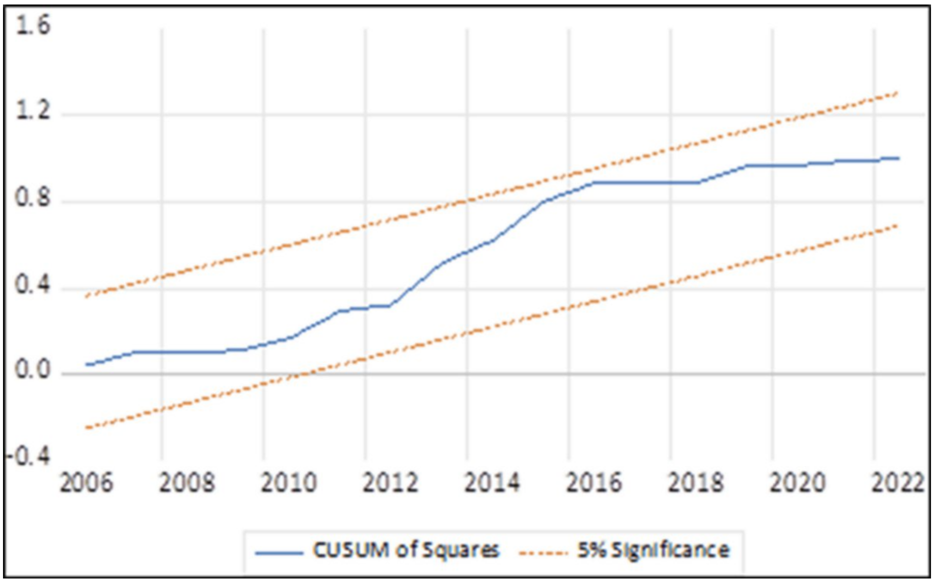

FIGURE 2: CUSUM square test

X axes indicate time period and Y axes show cumulative sum square.

Here, results show that there is no functional disturbance, error variance is constant or homoscedastic, there is no serial correlation of its lags, and data are normally distributed.

Finally, the coefficients stability test and its goodness of fit on our test tool are CUSUM and CUSUM-Q. Here, residuals of the model are plotted at the 5% significance level across the time frame. In both figures, from post-liberalization to 2022 in India, there is no structural fluctuation of the coefficients on the bounded limit at 5% in both the CUSUM and CUSUM-Q plots.

Figure *1* and Figure *2* results are aligned with the Kaya and Kaya (Kaya and Kaya, 2018) outcome.

This study was used to analyze future green energy production from renewable sources with the help of GDP growth pattern, public-private partnership investment in energy and gross fixed capital formation in the economy. Therefore, these variables are affected through monetary and fiscal dynamics decisions taken by policy makers of the economy. Although in this study, limitations most likely arise from the difficulties in obtaining accurate values for the model due to the errors and uncontrolled variables.

These study findings align with Ergun and Rivas (Ergun and Rivas, 2023) outcome that an increase in economic growth leads to the production of green energy for household consumption demand.

This study does not align with the Ghosh (Ghosh, 2002) findings, exploring unidirectional relationship between electricity consumption and per capita GDP but here we invest in renewable energy leads to adopt more energy efficient technology for production and consumption.

Conclusions

In the current scenario of resource consumption for energy utilization in countries' economic development, the post-industrialization world has rapidly exploited fossil fuel-based energy sources such as crude oil and coal. When the world faced climate change problems, it moved toward renewable energy sources to sustain future energy needs. Here our paper tries to investigate short-run and long-run modern renewable energy production with respect to economy indicators like GDP, GFCF, and PPP investment in energy. Our findings aim to explore both short-run and long-term trends with a significant level. In short-run results, we simulate the long-run equilibrium condition for energy needs from renewable sources in India. As per the Ministry of Environment, Forest, and Climate Change During the 26th session of the United Nations Framework Convention on Climate Change (UNFCCC) Conference of Parties 26 in November 2021, India announced its objective of achieving net zero emissions by 2070. According to Paragraph 19 of Article 4 of the Paris Agreement, India's long-term low-carbon development policy, submitted to the UNFCCC, reiterates the goal of achieving net-zero emissions by 2070. The ideas of equity and climate justice, also common but differentiated responsibilities and respective capabilities, underpin India's long-term low-carbon development strategy. To achieve this target, India seeks to enhance its renewable energy production and investment patterns.

Appendices

Table *8* presents the raw yearly data for India from 1991 to 2022.

Year	REP_(Twh)	LnPRP	GDP (Current International $)	LnGDP	PPP_Invest	LnPPPEI	GFCF	LnGFCF
1991	74.12686532	1.869976	4.7016E+11	11.67225	613600000	8.787885	5.24681E+12	12.7199
1992	70.26860689	1.846761	4.95936E+11	11.69543	13400000	7.127105	5.80298E+12	12.76365
1993	71.07931954	1.851743	5.19496E+11	11.71558	1047700000	9.020237	5.75503E+12	12.76005
1994	80.7836753	1.907324	5.54089E+11	11.74358	314800000	8.498035	6.08647E+12	12.78437
1995	76.98215113	1.88639	5.96059E+11	11.77529	1008300000	9.00359	6.82415E+12	12.83405
1996	70.69812925	1.849408	6.41058E+11	11.8069	1553100000	9.191199	7.1451E+12	12.85401
1997	72.18673331	1.858457	6.6702E+11	11.82414	1019200000	9.008259	7.79519E+12	12.89183
1998	86.01031841	1.934551	7.08271E+11	11.8502	922300000	8.964872	8.62295E+12	12.93566
1999	85.38758941	1.931395	7.70923E+11	11.88701	2235400000	9.349355	1.00665E+13	13.00288
2000	80.26551351	1.904529	8.00534E+11	11.90338	1828900000	9.26219	9.88594E+12	12.99502
2001	76.18822511	1.881888	8.39152E+11	11.92384	240000000	8.380211	1.20797E+13	13.08205
2002	72.78292201	1.862029	8.71073E+11	11.94005	10500000	7.021189	1.1993E+13	13.07893
2003	74.62937132	1.87291	9.39543E+11	11.97292	844770000	8.926738	1.26066E+13	13.1006
2004	109.193975	2.038199	1.01398E+12	12.00603	2362270000	9.37333	1.40505E+13	13.14769
2005	107.4643178	2.031264	1.09432E+12	12.03915	579100000	8.762754	1.63606E+13	13.2138
2006	127.54883	2.105676	1.18253E+12	12.07281	4798980000	9.681149	1.86305E+13	13.27022
2007	141.7579	2.151547	1.27313E+12	12.10487	9344850000	9.970572	2.16726E+13	13.33591
2008	138.91222	2.14274	1.31242E+12	12.11807	12415880000	10.09398	2.2366E+13	13.34959
2009	134.32603	2.12816	1.41561E+12	12.15094	21222600000	10.3268	2.4083E+13	13.38171
2010	142.608495	2.154145	1.5359E+12	12.18636	29608760000	10.47142	2.67433E+13	13.42721
2011	173.6209	2.239602	1.6164E+12	12.20855	21011250000	10.32245	2.99773E+13	13.47679
2012	165.243975	2.218126	1.7046E+12	12.23162	8904400000	9.949605	3.14579E+13	13.49773
2013	187.90142	2.27393	1.81345E+12	12.25851	2952700000	9.470219	3.19492E+13	13.50446
2014	202.03619	2.305429	1.94783E+12	12.28955	2816630000	9.44973	3.2781E+13	13.51562
2015	203.207632	2.30794	2.10359E+12	12.32296	2086940000	9.31951	3.49218E+13	13.5431
2016	208.207255	2.318496	2.27727E+12	12.35741	1686930000	9.227097	3.78757E+13	13.57836
2017	234.905346	2.370893	2.43202E+12	12.38597	1311630000	9.117811	4.08308E+13	13.61099
2018	263.61972	2.420978	2.58897E+12	12.41313	1639510000	9.214714	4.54051E+13	13.6571
2019	303.159756	2.481672	2.68921E+12	12.42962	856350000	8.932651	4.59258E+13	13.66206
2020	315.67	2.499233	2.5324E+12	12.40353	3321000000	9.521269	4.25569E+13	13.62897
2021	333.493221	2.523087	2.76159E+12	12.44116	1621240000	9.209847	4.87877E+13	13.68831
2022	380.872376	2.580779	2.96152E+12	12.47151	2503340000	9.39852	5.43469E+13	13.73517

TABLE 8: Raw table data

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Concept and design: Ajay K. Gautam, NMP Verma

Acquisition, analysis, or interpretation of data: Ajay K. Gautam, NMP Verma

Drafting of the manuscript: Ajay K. Gautam, NMP Verma

Critical review of the manuscript for important intellectual content: Ajay K. Gautam, NMP Verma

Supervision: NMP Verma

Disclosures

Human subjects: All authors have confirmed that this study did not involve human participants or tissue. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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