An Econometric Assessment of the Effects of Electricity Market Reform on Bangladesh Economy

Sakib Amin, Rabindra Nepal, and Han Phoumin

Abstract The supply of reliable and affordable electricity has become imperative in most production and household activities in modern society. No country has progressed after subsistence extent without guaranteeing the least electricity level. Many developing and emerging countries have started implementing reform initiatives around the electricity market since the 1990s. The major developments in reforming countries are structural changes and privatisation of electricity and energy utilities. Bangladesh is also no exception to this trend. Realising the significance of the electricity sector as the lifeblood of industrial and economic development, the country also took multiple strides towards developing the sector by restructuring key power companies, creating independent regulatory bodies, and promoting private sector firms to enter the electricity market. However, to our knowledge, no literature focuses on the impact of the electricity market reform (EMR) in Bangladesh through the lens of privatisation, competition, and regulation. Addressing the research gap and discussing the reform initiatives critically, this chapter aims to empirically analyse the effects of the EMR on the energy sector development and macroeconomic stability of Bangladesh with the help of a time-series data set covering 1980–2019. We use standard and robust unit root and cointegration tests for empirical analysis. For the long-run estimation purpose, we use the dynamic OLS method. The results of our study can help policymakers adopt effective policies for sustainable development in Bangladesh.

Keywords Electricity · Reform · Bangladesh · Dynamic OLS · Market · Cointegration

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1 Introduction

Modern society is heavily dependent on affordable and reliable electricity in most household and production activities. Amin et al. (2020) argued that the least electricity level is mandatory for accomplishing progress after a subsistent amount. In his seminal work, Stern (2011) further discussed the importance of electricity as a precondition for meeting basic social needs. The necessity of electricity as a development instrument is unquestionable. Moreover, in developing and emerging economies, electricity greatly influences economic activities, the productivity of workers, and the overall improvement of living standards (Rehman et al. 2019). Therefore, a proper strategic plan for the electricity market is required for the long-run sustainable development of any nation.

Having realised the significance of the electricity sector as the economy's lifeblood, several developing and emerging countries across the world started initiating market-oriented reforms in the early 1990s (Jamasb 2002, 2006; Jamasb and Nepal 2011; Jamasb et al. 2016). The major reforms in these countries are restructuring and privatisation of electricity utilities. Zhang et al. (2008) also argued that electricity market reform (EMR) occurs through the combination of privatisation, regulation, and product market competition. The success of developed countries' EMR has been thoroughly documented (Pollitt 2008). Parker and Kirkpatrick (2005) examined the effect of EMR on the economic performance of developing countries at the sector and firm-level. They revealed that privatisation in the electricity market would be most effective in developing economies if it is accompanied by strategies that stimulate competitive behaviours and regulate the market effectively while simultaneously being integrated with the broader structural reform process.

The key reasons behind EMR programmes can be seen between 'push' and 'pull' factors. The 'push factors' are twofold. The first push factor implies the necessity of adopting a structural adjustment programme in the electricity sector as demanded by the donor agencies, such as the World Bank, the Asian Development Bank, and the International Monetary Fund. The second 'push factor' is linked to prevalent problems in the electricity sectors of different countries and a legitimate necessity for market reform (Sen 2014). These push factors include the weak performance of state-owned electric utilities, growth in power demand, the inadequate volume of investment, etc. The' 'pull' factors include a demonstration outcome following practices in Chile, England and Wales, and Norway in the 1980s and early 1990s (Zhang et al. 2008).[1]

Bangladesh, located in the north-eastern region of South Asia, is also no exception to this trend. Bangladesh has taken multiple strides towards developing the electricity sector since its independence. The reform programmes were initiated by restructuring the vertically integrated monopoly utility into different distribution and

[1] 'Power' and 'electricity' are used interchangeably in this chapter.

Table 1 An overview of socio-economic indicators in Bangladesh

Criteria	1972	1980	1990	2000	2009	2019
GDP growth (%)	−13.97	0.81	5.62	5.29	5.04	8.15
Foreign reserves (Current US$ billion)	0.20	0.33	0.65	1.52	10.34	32.70
Extreme poverty rate (%)	90.00	75.00	43.00	34.30	17.60	10.50
Literacy rate (%)	17.60	29.20	35.32	47.49	58.77	74.68
Life expectancy (Years)	46.51	52.90	58.21	65.45	69.49	72.32

Source World Bank (2020)

transmission utilities. Amin et al. (2021d) highlighted that the core reform initiatives in Bangladesh tend to include (i) unbundling the key power institutions, (ii) establishing independent regulatory bodies, (iii) promoting private firms to enter the electricity market, (iv) diversifying the fuel mix in electricity generation, and (v) ensuring large-scale investments in the power generation sector. These reform initiatives in the electricity market led the country to achieve landmark success over the last 5 decades.

Table 1 shows that the average gross domestic product (GDP) growth increased to around 7% in the 2010s compared to 3% in the 1970s. The country has maintained a GDP growth of 8% in pre-pandemic conditions. The Bangladesh Bureau of Statistics shows that extreme poverty decreased from around 90% in the early 1970s to around 10.50% in 2019.

However, to our knowledge, no literature focuses on the impact of EMR in Bangladesh through the lens of privatisation, competition, and regulation. Addressing the research gap, we aim to empirically analyse the assessment of EMR on the energy sector development and macroeconomic stability in Bangladesh with the help of a time-series data set covering 1980–2019. We use standard and robust unit root and cointegration tests for empirical analysis. We apply the dynamic ordinary least squares (DOLS) technique for the long-run estimation purpose. Additionally, model stability tests are used to examine the stability of the results.

The novelty of the chapter is threefold. First, no existing studies looked into the in-depth policy analysis of the Bangladesh electricity sector. Second, the chapter applies robust time-series econometric techniques based on data covering 1980–2019 to assess the long-run impacts of electricity sector reforms on the aggregate economy. Third, this chapter contributes to the literature with strategic policy options for Bangladesh to articulate its electricity policies to achieve its vision for 2041 of becoming a high-income country after having cleared the interim goal of becoming a middle-income country at its 50th anniversary of independence.[2]

The rest of the chapter is organised as follows. Section 2 highlights the relevant literature on EMR. Section 3 discusses stylised facts of the Bangladesh electricity market over the last 50 years, followed by a brief discussion on market reforms in the

[2] For more details, see http://oldweb.lged.gov.bd/UploadedDocument/UnitPublication/1/1049/vision%202021-2041.pdf.

electricity sector in Sect. 4. Section 5 presents and discusses the empirical modelling approach and results. Finally, Sect. 6 concludes the chapter with a robust policy discussion in line with Vision 2041.

2 Literature Review

This section summarises the existing literature surrounding the EMR. For better understanding, we divide the section into two subsections—theoretical and empirical discussions.

2.1 Theoretical Discussion

Fenglong (2011) applied a computable general equilibrium (CGE) analysis to understand the effect of competition policies on the electricity market in Singapore by stimulating a hypothetical regulatory condition. Compared to the regulated electricity market, simulation results show that deregulation greatly increases GDP and exchange rate and leaves the choice of higher national income and worse consumer welfare to implement government policies. If regulation is essential for political motives, a formal legal framework must ensure that the economy is free of regulatory constraints.

Yin et al. (2019) analysed the electricity market in China using a CGE analysis to understand the influence of liberalisation on the market by considering three subsectors of electricity: generation, transmission, and distribution. The current state is compared to a market reform of decreasing entry barriers on generation, increasing competition for distribution, and regulating the transmission sub-sector. The results show an increased efficiency in the market and a reduction in electricity prices.

Akkemik and Oğuz (2011), using an applied CGE model and a counterfactual simulation, investigated the potential effects of full liberalisation on efficiency and competition in the Turkish electricity market. According to simulation results, the electric sector will be more efficient, home electricity prices will be lower, and output and welfare will increase by 0.5%–1.1% of GDP. They also discussed the various causes of discrepancies between estimated and real effects. Political considerations tend to dominate efficiency benefits when the institutional context and legal framework change.

Timilsina et al. (2019) employed The Integrated MARKAL-EFOM System (TIMES) model for the energy sector and a CGE model that examines the macroeconomic implications of a component of China's power sector reform initiative, which began in 2015. They revealed that if China uses the market principle to govern its power system, electricity prices will be roughly 20% cheaper than expected in 2020. As a result, electricity price reductions would have a ripple effect throughout the economy, leading to a 1% boost in GDP in 2020. It would also increase household income, economic opportunities, and international trade.

By developing a novel dynamic stochastic general equilibrium model, Amin et al. (2021a) examined the effect of captive power plants (CPPs) on the national grid. The model is calibrated and estimated by the Bayesian estimation technique. It is revealed that when the CPPs are connected, GDP, household consumption, and industrial output decline because of the prevailing distortions in the energy price. The result is closely associated with the notion of second-best theory. Finally, it is concluded that the CPPs should not be included in the national grid without reforms that can clear existing price distortions. In another theoretical analysis, Amin et al. (2021b) revealed that Bangladesh would be more exposed to the oil price shocks due to the sudden shutdown of the CPPs. Furthermore, industrial output and GDP would reduce by 1.5% and 1.2%, respectively, in the long run when the CPPs are completely shut down as a reform strategy. Therefore, as policy suggestions, alternative reforms, such as creating a pathway for advanced and efficient technologies and renewable-based CPPs, would be effective.

2.2 Empirical Discussion

Du et al. (2010) showed how regulatory reforms affect the productiveness of fossil-fired power generation plants based on the plant-level national survey data from 1995 and 2004. The impacts of the reforms on demand for fuel, non-fuel energy, labour, and other inputs are estimated by utilising a differences-in-differences econometric method. The findings reveal that the net efficiency improvement in labour input and non-fuel materials associated with the regulatory reforms is roughly 29% and 35%, respectively. On the other hand, these reforms showed no improvement in productivity in fuel input.

Zhang et al. (2008) examined an econometric analysis of the impact of competition, privatisation, and regulation on the electricity generation industry, conducting a panel study for 36 developing and transitional countries between 1985 to 2003. The study is depicted from a database developed from various international sources, measuring the effects of competition, privatisation, and regulation on electricity generation performance in emerging countries. They show that regulation and privatisation do not lead to significant economic performance benefits. Furthermore, competition among producers in the electricity market is more influential than privatisation or setting up independent regulations to increase generation and performance. The findings parallel those of Pollitt (1997), who ascertained that effective regulation is a vital component of the success of privatisation, especially when the market lacks competition.

Nakano and Managi (2008) assessed the performance of Japan's steam power–generation sector and analysed the productivity measures due to reforms from 1978 to 2003. Using a data envelopment analysis approach, they employed a Luenberger productivity indicator, a generalised version of the widely used Malmquist Productivity Index. The dynamic generalised method of moments estimation is used to investigate the factors associated with product performance changes. The results reveal that the regulatory reforms are instrumental for productivity growth in Japan's steam power–generation sector.

Kessides (2012) conducted an empirical survey of case studies across countries, mostly Latin American, for their respective electricity sector reforms. He revealed that when extensively planned and carefully applied, the synergy of adequate regulations, institutional reform privatisation, and unbundling results in a notable upgrade in levels of operational effectiveness around different scenarios and country settings. However, he pointed out that investment in transmission and generation capacity in the liberalised electricity market is yet a concerning aspect.

Khandker et al. (2012) examined the impact on the welfare of household grid connectivity by implementing a cross-sectional survey on 20,000 households in rural Bangladesh in 2005. They used rigorous econometric estimation techniques, such as Maximum Likelihood Probit Model IV Estimation and propensity score matching, and estimated that grid electrification has positively affected household income, expenditure, and educational outcomes. For instance, rural electrification has impacted total income to increase as much as 30% and as low as 9%. Other benefits also experience a steady improvement since household exposure to grid electrification increases and gradually reaches a plateau. They further discover that richer households gain more from electrification than poor households. The estimates also unveil that electrification generates income benefits that exceed cost by a wide margin on average.

Nepal and Jamasb (2012) used a panel data set covering 1990–2008 to investigate links between energy sector reforms and broader institutional criteria in 27 transitional economies. Applied bias–corrected fixed effect estimation and dynamic generalised method of moments estimation techniques are used for the empirical analysis. Their estimation results showed that energy sector reforms do not influence the selected countries' economic, operational, and environmental aspects. They also show that failure to synchronise inter-sector reforms ultimately leads to ineffective energy sector reforms implementation. As policy suggestions, they argued that successful energy sector reforms should depend on how they are synchronised with intra-sector reforms.

By analysing panel data (2002–2013) of 47 Sub-Saharan African countries, Imam et al. (2019) found that institutional deficiency, such as corruption, reduces the impact of electricity sector reforms for increasing access to energy and national income by increasing the loss of technical efficiency. However, they found that such an effect diminishes as the regulatory body can work without any externalities. On the other hand, Amin et al. (2021c), using the panel dynamic autoregressive distributed lag (ARDL) model, highlighted that power sector reforms such as privatisation and independent regulatory body – combined with political indicators – significantly influence the key components that predict energy demand in the South Asian context.

3 Electricity Market Scenario in Bangladesh

This chapter underlines some significant, stylised facts about the Bangladesh electricity sector connected to the reform activities undertaken by the government over the last 50 years to assure a steady base for sustainable development.

3.1 *Electricity Generation Capacity*

The electricity generation capacity was the lowest in Bangladesh around the 1970s, with the average generation capacity at 684.88 megawatts. This gloomy tendency continued to prevail until 2009. Mujeri et al. (2013) and Tamim et al. (2013) discussed that the primary reason behind the poor performance in the electricity market is the under-maintained condition of generation equipment; very few power plants; technical constraints; and insufficient operational, organisational, and maintenance regimes. Nevertheless, Bangladesh has effectively addressed the disequilibrium between supply and demand of electricity by profusely expanding its power generation capacity since 2009 (Fig. 1).

3.2 *Per Capita Electricity Consumption (PCEC)*

Previous literature suggests that sustained economic growth leads to increased use of technology and energy-intensive innovative appliances by households, higher industrialisation, and urbanisation, resulting in higher PCEC (Amin and Khan 2020;

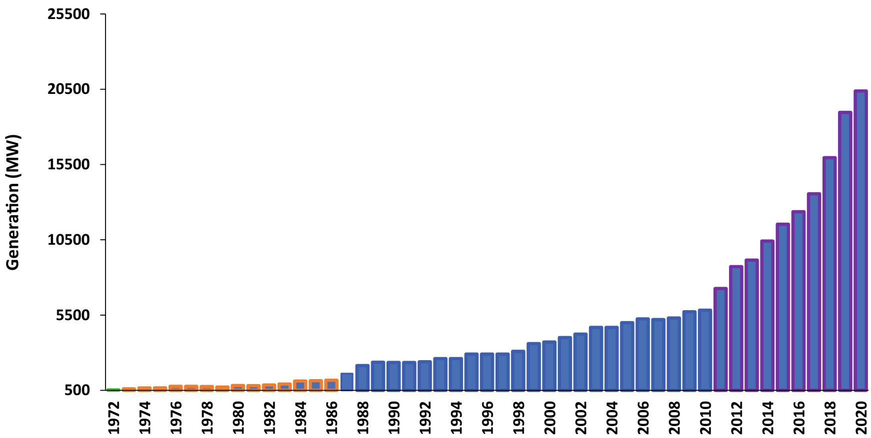

Fig. 1 Generation Capacity between 1972 and 2020. *Source* Various BPDB annual reports

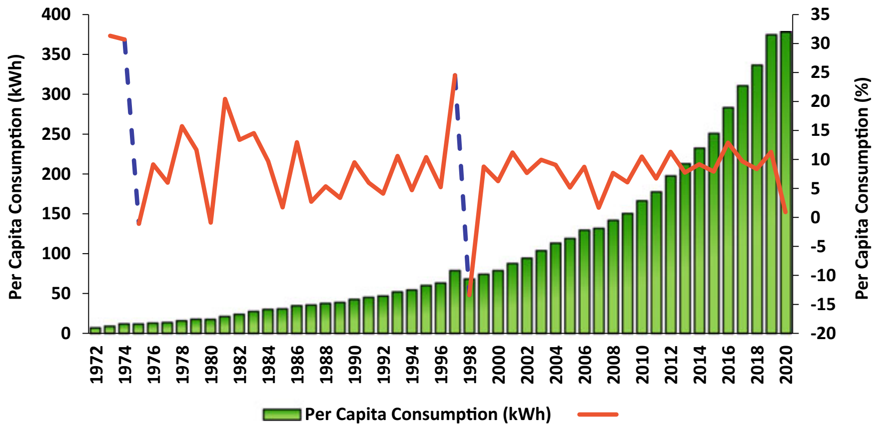

Fig. 2 Per capita electricity consumption between 1972 and 2020. *Source* Various BPDB annual reports

Pachauri 2012). Murshid (2020) also concluded that the escalated urbanisation and industrialisation rates promote rural non-agricultural activities, particularly in places networked to major urban hubs, thus increasing the PCEC. Figure 2 shows that the PCEC has gradually risen from 1972 to 2020 with an 8.9% growth rate. The average PCEC in 1970, 1980, and 2020 was 12.60 kWh, 30 kWh, and 378.16 kWh, respectively. The PCEC started rising dramatically in the 1990s as the Bangladeshi economy moved from an agrarian to an intensive industry sector.

3.3 Access to Electricity and System Loss

Bangladesh has experienced remarkable advancement in securing access to electricity across all groups among the entire population. However, the average electrification rate was less than 15% before the 1990s,[3] and only 20% of the nation had sourced electricity during the 1990s. The average share of the grid-connected population was 45% from 2000 to 2010, more than double since the 1990s. Presently, 100% electrification rate across the grid-covered regions has been realised because of the time-variant strategies initiated by the current government since 2009. Besides, Bangladesh has installed up to 6 million solar home systems to provide clean electricity in off-grid areas.

Moreover, the country successfully lowered the distribution system loss over a substantial volume. Due to heavy distribution system loss, the economy hurt from

[3] Only 3% of the population had access to electricity in 1971.

extensive load shedding between the 1990s and early 2000s. Nevertheless, the condition has developed steadily because of technical progress and prompt policy implementation since 2009. The 2020 annual report of the Bangladesh Power Development Board (BPDB) indicates that the distribution system loss exceeded 35% in 1992, which decreased to 8.99% in 2020.

3.4 Fuel Mix Options in Electricity Generation

Due to domestic availability, fuel mix options for electricity generation in Bangladesh have been governed historically by natural gas. Figure 3 shows the fuel mix from 1972 to 2020 for a grid-based generation. It is evident from the figure that the average share of natural gas in power generation increased in 2000–2006, and declined slowly onwards (2007–2013 and 2014–2020). In the 2000–2006 period, the average share was 86.69%. Besides, in 2007–2013 and 2014–2020, the average natural gas shares were 76.50% and 60.59%, respectively. However, due to the introduction of oil-based power plants to meet the increasing electricity demand, the shares of different oils such as furnace oil (FO) and high-speed diesel (HSD) increased rapidly after 2009. For instance, the share of FO in the 2007–2013 and 2014–2020 periods were 10.71% and 22.18%, respectively. On the other hand, the share of HSD in the same periods was 5.28% and 8.18%, respectively. However, the renewable energy share trend has been declining for the past 50 years, standing only at 1.65% in the electricity generation mix of the 2014–2020 period.

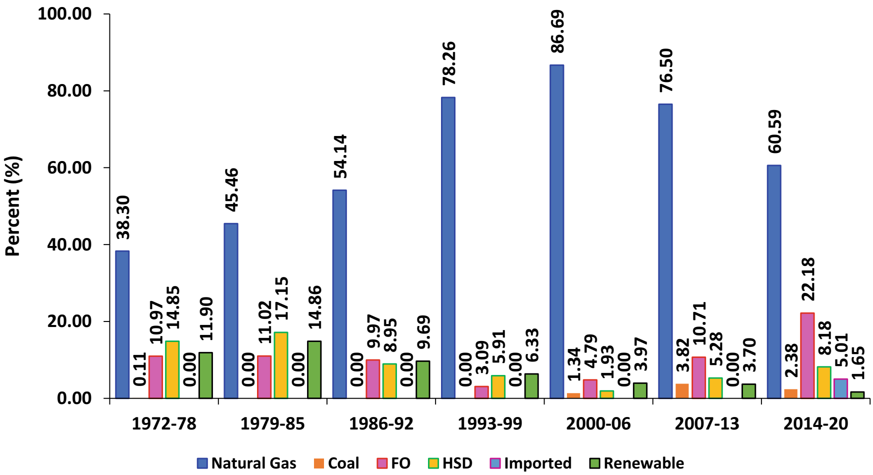

Fig. 3 Fuel mix in electricity generation in Bangladesh. *Source* Various BPDB annual reports

3.5 Move Towards Competitive Market Environment and Investment Trend

Despite the remarkable progress in the electricity generation capacity, Bangladesh has yet to go a considerable distance to make a competitive market environment since many power utilities are still controlled by the government and have little operational or financial independence. On many occasions, the state controls the regulatory commission to determine energy prices, which do not abide by the standard economic principles; however, they are based on political interests. Because of the imperfect or politically influenced pricing in the absence of economic costs, and operational inefficiencies in the lack of competition, government power utilities experience losses, obstructing investment in the energy sector. For example, the Bangladesh Petroleum Corporation's net loss due to the fuel subsidies was US$208.57 million in 2020.[4]

Besides, since the per-unit cost of electricity generation rose after 2009 due to the backing out from highly subsidised natural gas and using imported liquid fuels, the Bangladesh Energy Regulatory Commission (BERC) has made numerous adjustments to balance the wholesale and retail electricity markets.[5] Recently, BERC has implemented a benchmark pricing system to encourage private participation in electricity generation.[6] Moreover, since the administered prices of nationally sourced natural gas are set at levels considerably below world prices—and remain very low considering the opportunity cost in respect of imported fuel equivalence—the natural gas prices have also multiplied five times between 2009 and 2020, proceeding towards the competitive market environment.

Furthermore, it is argued that the government's attempts to ensure competition can be seen in the overall performance of the electricity sector in terms of generation availability, system losses, accessibility of service, non-technical losses, price levels and structures, investment, and service quality. The 6th, 7th, and 8th Five Year Plans of Bangladesh report an increasing trend in private investment in the generation sector because of the power and energy price adjustments in the past 10 years.

Given the current scenario, it is about the right time to access the transmission and distribution sectors for private investment.[7] Jamasb (2002) inferred that privatisation at the distribution and transmission utilities might be applied later in the reform initiatives, promoting further efficiency improvement for any country that has already significantly ensured private participation in the electricity generation sector. Since substantial progress has been made in private electricity generation over the last

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[4] For more details, see http://www.bpc.gov.bd/sites/default/files/files/bpc.portal.gov.bd/annual_reports/7c8c15d9_8aae_4168_89b5_8a2d5a862c28/2022-01-26-05-07-e2df1142db3df1a9ab702b4dd2ff5487.pdf.

[5] For more details, see http://plancomm.gov.bd/sites/default/files/files/plancomm.portal.gov.bd/files/68e32f08_13b8_4192_ab9b_abd5a0a62a33/2021-02-03-17-04-ec95e78e452a813808a483b3b22e14a1.pdf.

[6] Bangladesh becomes the first South Asian country to introduce benchmark pricing system.

[7] Amin et al. (2021c) report that private investment is better than government investment in increasing energy consumption in South Asia. = .

decade, it is now crucial for establishing effective competition through private sector participation in the distribution and transmission sector. Approximately US$216 billion will be required for the generation, transmission, and distribution sector by 2041[8] Given that the Power Grid Company of Bangladesh remains stand-alone for confronting all emerging challenges in the transmission sector, the Bangladesh government also plans to open up private investment.[9]

4 Electricity Reform Initiatives in Bangladesh

The socio-economic development of any economy is linked with electricity as a strategic input due to its impacts on economic stability and environmental sustainability. Therefore, powering up the nation remains a major policy agenda of the Bangladesh government since independence. The Father of the Nation, Bangabandhu Sheikh Mujibur Rahman, took several steps to develop the power sector, including restoring transmission and distribution lines, harnessing the country's mineral resources, and repairing power stations and bridges. He also included electricity in Article 16 of the constitution to ensure that all citizens have access to electricity.[10] Moreover, he also established Petro Bangla, nationalised the country's energy resources, acquired low-cost natural gas fields, and assured Bangladesh's long-term energy security. Due to the visionary and dynamic leadership of the Father of the Nation and his worthy daughter Prime Minister Sheikh Hasina, Bangladesh has achieved remarkable development in terms of access to electricity in the last 50 years.

Since 1990, most developing and emerging economies have begun considering the EMR as part of the broader strategies to create a more liberalised market (Erdogdu 2011; Jamasb 2006). In the past 50 years, Bangladesh has also introduced institutional reforms in the electricity sector by restructuring the electricity market. It unbundled the sector to create various government-owned utilities for generation, transmission, and distribution. The large-scale restructuring occurred through various policy measures, including inviting independent power producers, privatising the core power utility, implementing an independent regulatory authority, and establishing large-scale power generation plants.

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[8] For more details about investment potentials in the Bangladesh power sector (as of 13th June 2019), see http://www.powercell.gov.bd/site/page/8bf3f2bf-cdc8-4235-b2ca-1e8e39e3e7df/-.

[9] For more details, see https://ep-bd.com/view/details/article/NjAyMA%3D%3D/title?q=open+up+power+transmission+to+private+investment.

[10] Article 16 states: 'The State shall adopt effective measures to bring about a radical transformation in the rural areas through the promotion of an agricultural revolution, the provision of rural electrification, the development of cottage and other industries, and the improvement of education, communications and public health, in those areas, so as progressively to remove the disparity in the standards of living between the urban and the rural areas'. See http://bdlaws.minlaw.gov.bd/act-367/part-199.html.

4.1 Reform Policies

Since independence, EMR programmes have been experiencing a remarkable institutional shift and are claimed to be extremely successful. With the formation of the power sector reform in Bangladesh in 1993, the government outlined a reform process primarily focused on institutional issues. The National Energy Policy, adopted in 1996 and revised in 2004, was the first formal energy policy in Bangladesh to develop the infrastructure for the better achievement of this sector.

In 1996, the Private Sector Power Generation Policy[11] was implemented, which invited national and foreign private investment in electricity generation. Following this policy after 1996, the independent power producers entered the electricity market; in 1998, the policy guidelines for small power plants[12] were considered to mobilise private resources further. Besides, the Private Sector Infrastructure Guidelines[13] were adopted in 2004 to implement private infrastructure projects through institutional arrangements. Bangladesh also adopted policies for purchasing electricity from the CPPs in 2007.[14] The guidelines for remote area power supply systems were adopted in 2007.

Bangladesh undertook three major PSMP in 2005, 2010, and 2016 to meet the electricity demand goals and sustenance. The PSMPs were primarily adapted to shift to more mid to long term and comprehensive planning for meeting future electricity generation by augmenting the challenges in the interim period (Tamim et al. 2013). Initially, PSMP 2005 mainly focused on utilising domestically produced natural gas to increase the generation capacity. However, since natural gas stock was depleting at an unprecedented rate, PSMP 2010 tried to shift the focus towards the fuel diversification process for electricity generation by tapping all the possible fossil and non-fossil fuel sources. The plan called for the urgent commissioning of several oil-fired quick rental power plants (QRPPs) to meet demand in the short term. It emphasised solar home systems to boost the share of renewable energy in power generation and take cross-border electricity trading initiatives. Therefore, the government welcomed the QRPPs in 2010 under the Power and Energy Fast Supply Enhancement (Special Provision) Act 2010[15] as a quick solution to resolve the power crisis issue and provide 100% electrification by 2021. Finally, PSMP 2016 was articulated with a primary focus on infrastructure development for energy import, human capital development, and increasing renewable energy share in the electricity generation mix for a stable

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[11] For more details, see https://www.bpdb.gov.bd/bpdb_new/d3pbs_uploads/files/11%20March%202019/1.%20PSEPGPB.pdf.

[12] For more details, see https://berc.portal.gov.bd/sites/default/files/files/berc.portal.gov.bd/policies/9ddbabab_e084_464d_9511_46c0364d0ac4/Policy%20Guidelines%20for%20SPP.pdf.

[13] For more details, see https://berc.portal.gov.bd/sites/default/files/files/berc.portal.gov.bd/policies/bf23784c_4f48_4520_ace0_59667f00838f/Private%20Sector%20Infrastructure%20Guidelines.pdf.

[14] For more details, see: https://www.adb.org/sites/default/files/publication/692451/adbi-wp1238.pdf.

[15] https://www.dpp.gov.bd/upload_file/gazettes/18893_67482.pdf.

energy supply. Paltsev (2020) postulated that relevant stakeholders such as governments, industrial firms, and think tanks must prioritise research and development goals to achieve economic growth jointly with affordable and reliable energy.

The National Renewable Energy Policy[16] was formulated in 2008 to (i) recognise the significance of renewable energy and eliminate the discrepancy in electricity distribution between rural and urban areas, (ii) increase the contribution of renewable energy in the energy mix by setting targets, and (iii) develop a local authority to look after the dissemination of renewables. In 2008, a 3-year road map, the Power and Energy Sector Road Map,[17] was adopted and outlined new strategies for reconstructing the power and energy sector.[18] In 2013, Bangladesh and India also signed a memorandum of understanding on importing 500 MW of power from India. More recent policies included the Energy Efficiency and Conservation Master Plan up to 2030 in 2015,[19] the Electricity Act[20] in 2018, and the 8th Five Year Plan in 2020 for the next 5 years' energy sector development targets. Guidelines to further improve the power and energy sector and ensure energy security are also discussed in the 2nd Perspective Plan of Bangladesh 2021–2041 (GED 2020)[21] and Bangladesh Delta Plan 2021 (GED, 2018).

4.2 Energy Sector Reforms in Bangladesh

The primary reform initiatives in Bangladesh's electricity sector include privatisation, restructuring the core utilities, undergoing institutional reform, and establishing independent regulatory bodies (Fig. 4).

4.2.1 Institutional Reforms

The Power Cell was formed in 1995 to support the Power Division of the Ministry of Power, Energy, and Mineral Resources (MPEMR) in monitoring and implementing reform projects, helping different stakeholders for future sectoral activities, and attracting private investment. In 1998, to improve the efficiency of institutions, the MPEMR was divided into two divisions: the Energy and Mineral Resources Division

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[16] For more details, see http://policy.thinkbluedata.com/sites/default/files/REP_English.pdf.

[17] For more details, see https://policy.asiapacificenergy.org/sites/default/files/Roadmap_power_energy_2010.pdf.

[18] This power sector road map was further revised in 2011.

[19] For more details, see https://policy.asiapacificenergy.org/sites/default/files/EEC_Master_Plan_SREDA_2.pdf.

[20] For more details, see https://powerdivision.portal.gov.bd/sites/default/files/files/powerdivision.portal.gov.bd/page/18d2690b_f02f_4c35_8f90_79b70d333242/ELECTRICITY%20ACT,%202018.pdf.

[21] More details can be found at http://oldweb.lged.gov.bd/UploadedDocument/UnitPublication/1/1049/vision%202021-2041.pdf.

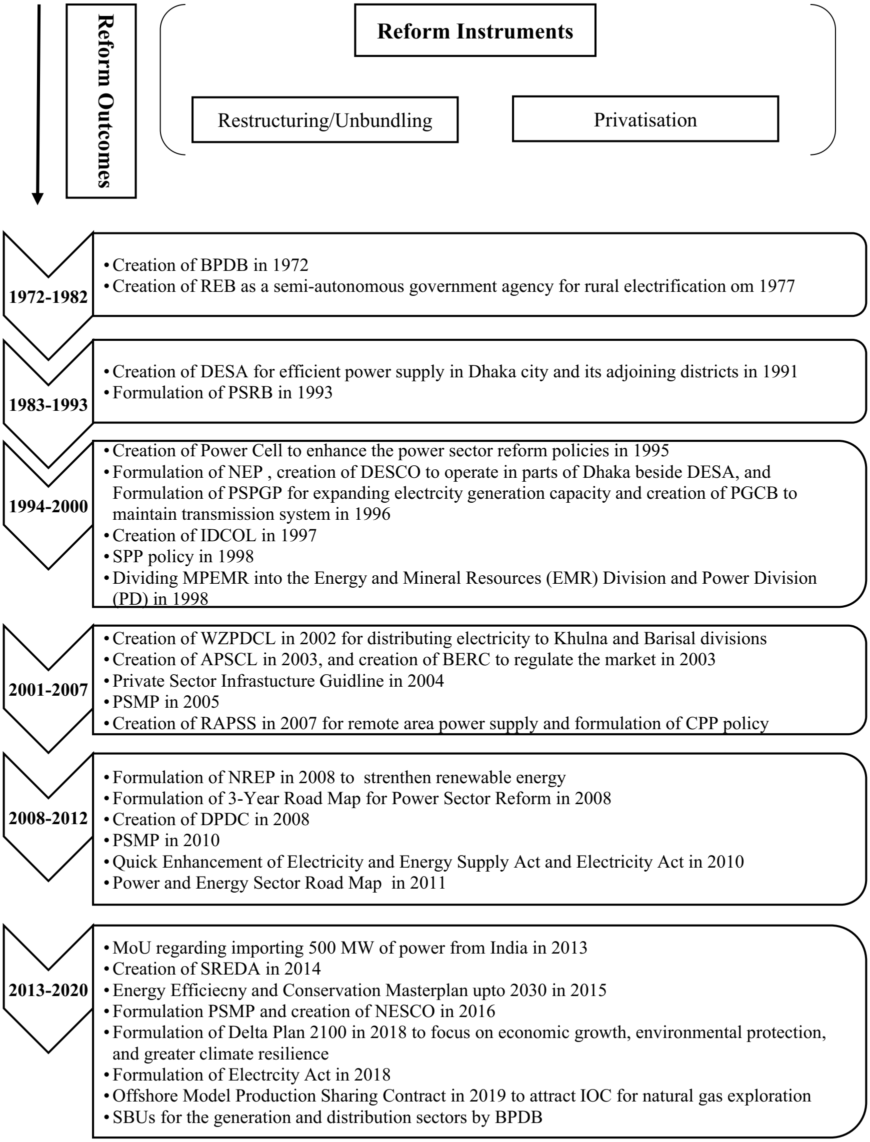

Fig. 4 Reform outcomes in Bangladesh. *Source* Amin (2015)

and the Power Division. The government also created the Sustainable and Renewable Energy Development Authority in 2014 as a nodal agency facilitating renewable energy development in Bangladesh.

4.2.2 Restructuring Core Utilities

Restructuring the core power and energy utilities has played a crucial role in Bangladesh's energy sector, briefly discussed below.

Generation Utilities

Bangabandhu Sheikh Mujibur Rahman, the Father of the Nation, emphasised the development of essential institutions and qualified human resources for a sustained and reliable energy sector. With Presidential Order 59 of 1972 (The Bangladesh Power Development Boards Order, 1972),[22] the Father of the Nation began a new era in the power sector by splitting the Water and Power Development Authority and establishing the Bangladesh Power Development Board (BPDB) and Bangladesh Water Development Board. As a result, the BPDB became the single entity in charge of electricity generation, transmission, and distribution. Moreover, the guidelines provided by Bangabandhu Sheikh Mujibur Rahman in 1977 also formed the Rural Electrification Board to share responsibility with the BPDB in promoting electricity in rural areas. In 1995, the importance of private companies in electricity generation was acknowledged, and some of the burden of electricity generation was shifted from the public utilities under the BPDB to private stakeholders. According to the 2020 BPDB annual report, the private sector generated 44.47% of the total electricity in 2019. The BPDB has been unbundling its utilities throughout the last 50 years to maintain adequate electricity generation while upholding administrative efficiency. For example, the Ashuganj Power Station Company Limited, North-West Power Generation Company Limited, BR Powergen Limited, and Rural Power Company Limited work as subsidiaries of the BPDB in power generation.[23]

Distribution Utilities

The Rural Electrification Board is responsible for distributing'electricity in the rural area as the first restructuring initiative in the distribution sector of Bangladesh. Until then, almost 80 collaborative organisations, commonly known as Palli Bidyut Samity, have contributed to creating additional connections and developing distribution channels for enhancing rural electrification and services. The BPDB was restructured further in 1991, leading to the creation of the Dhaka Electric Supply Authority (DESA), a public company facilitating power supply and services in Dhaka and its surroundings. After 5 years, a new company called the Dhaka Electric Supply Company emerged in 1996 to distribute electricity parallel with DESA, enhancing consumer satisfaction and achieving better management of resources. In 2002, the

[22] http://bdlaws.minlaw.gov.bd/act-392.html.

[23] For more details, please see https://www.bpdb.gov.bd/bpdb_new/index.php/site/page/13e9-2cc0-ce41-9c09-088d-94d5-f546-04a6-b4fa-1d18.

West Zone Power Distribution Company Limited was opened to distribute electricity in the Khulna and Barisal divisions. And in 2016, the Northern Electricity Supply Company Limited was established to distribute electricity in Rangpur and Rajshahi. Furthermore, in 2008, DESA was redefined as the Dhaka Power Distribution Company, with new directives of attaining and increasing the city's energy demand.

Transmission Utilities

Through the unbundling of the BPDB in 1996 under the Companies Act 1994, the Power Grid Company of Bangladesh was formed to act as a separate transmission utility in the energy sector. This was primarily done to increase efficiency in operational activities and maintenance while simultaneously improving the transmission infrastructure all over the country.

4.2.3 Independent Regulatory Body

A major reform initiative taken by Bangladesh was establishing an independent regulatory authority in 2003 known as the Bangladesh Energy Regulatory Commission (BERC) through a legislative act of the Government of Bangladesh. Currently, BERC is responsible for regulating the tariff rate for electricity and other natural resources like coal and natural gas. Moreover, the commission guides policy formulation and implementation by other entities in the energy industry and promotes a competitive market environment while also protecting consumer rights.

5 Econometric Estimation

This section aims to empirically analyse the effect of major reform initiatives on the Bangladesh electricity market. The econometric analysis is mainly designed to reveal reform effects on three major blocks: the electricity market, welfare, and the environment. The electricity market block captures the direct effect of reforms on electricity consumption and generation. On the other hand, the welfare and the environment blocks capture the possible influence of EMR on aggregate welfare and environmental aspects. Following Amin et al. (20162021c), Amin and Khan (2020), Imam et al. (2019), and Sen et al. (), the general expression of the models from each block is expressed by the following Eqs. (1–7).

Electricity Market Block

$$lnE_t = \alpha_1 + \beta_1 lnY_t + \beta_2 lnP_t + \beta_3 PRI_{t-2} + \beta_4 REG_{t-1} + \varepsilon_t \quad (1)$$

$$lnG_t = \alpha_2 + \mu_1 lnY_t + \mu_2 lnP_t + \mu_3 PRI_{t-2} + \mu_4 REG_{t-1} + \varepsilon_t \quad (2)$$

Welfare Block

$$lnHDI_t = \alpha_3 + \vartheta_1 lnY_t + \vartheta_2 PRI_{t-2} + \vartheta_3 REG_{t-1} + \vartheta_4 POL_t + \varepsilon_t \quad (3)$$

$$lnGINI_t = \alpha_4 + \lambda_1 lnY_t + \lambda_2 lnY_t^2 + \lambda_3 PRI_{t-2} + \lambda_4 REG_{t-1} + \lambda_5 POL_t + \varepsilon_t \quad (4)$$

$$lnGINI_t = \alpha_5 + \pi_1 lnY_t + \pi_2 lnY_t^2 + \pi_3 PRI_{t-2} + \pi_4 REG_{t-1} + \pi_5 PRI * POL_{t-2} + \varepsilon_t \quad (5)$$

Environment Block

$$lnCO_{2,t} = \alpha_6 + \psi_1 lnY_t + \psi_2 lnY_t^2 + \psi_3 PRI_{t-2} + \psi_4 REG_{t-1} + \varepsilon_t \quad (6)$$

$$lnCO_{2,t} = \alpha_7 + \phi_1 lnY_t + \phi_2 lnY_t^2 + \phi_3 PRI_{t-2} + \phi_4 REG_{t-1} + \phi_5 RE_t + \varepsilon_t \quad (7)$$

In the above equations, E_t = electricity consumption per capita (kWh), Y_t = real GDP per capita (US$), Y_t^2 = squared real GDP per capita (US$), P_t = electricity price (proxy by an aggregate price index), PRI_{t-2} = privatisation dummy with two-period lag, REG_{t-1} = introduction of regulatory body with one period lag, HDI_t = human development index (proxy of welfare), POL_t = political stability index, $GINI_t$ = Gini coefficient (proxy of welfare), $PRI * POL_{t-2}$ = interaction of privatisation and political stability with two-period lag, $CO_{2,t}$ = CO_2 emissions (tonne), RE_t = renewable energy consumption (tonnes of oil equivalent), α_i = constants, and ε_t = error terms. Data of the variables are obtained from the World Bank (2020), BPDB (2020), Standardised World Income Inequality Database (2020), and Amin et al. (2021c). The data set covers data from 1980 to 2019. It is worth noting that reform variables are entered into the models with the lagged time period. One main reason for such design is that these reform initiatives are subject to a time lag to be observed (i.e. delayed effect). It implies that the effects of the planned reform initiatives are not observed in the market as soon as the government adopts them. Rather, the effects become visible after some time. Numerous reasons can cause this delay. For emerging countries like Bangladesh, some reasons are the fragmented nature of the institutional set-up, bureaucracy, market rigidity arising from supply and demand, political economy aspects, etc. Additionally, the time needed for observing the privatisation effect is expected to be higher than that of the regulatory effect due to underlying structure and implementation strategies. Accordingly, lag 2 is considered in the equations.

Before performing any dynamic long-run estimations, it is standard to run some pre-testing techniques such as stationarity and cointegration tests to confirm robust results. We perform the Augmented Dickey-Fuller and the Dickey-Fuller-GLS (DF-GLS) stationary tests. For the stationary properties, Table 2 shows that all the concerned variables are stationary at the first difference form.

Then, we examine the existence of a long-run relationship among the variables through the ARDL bound test. Table 3 illustrates that the F-statistics exceed the upper bound critical values, confirming the long-run cointegrating relationship among the model variables.

Since the sample size is relatively small (1980–2019) in the models, we use the DOLS method to estimate the coefficient values (Stock and Watson, 1993). Table 4 shows the results of the DOLS estimation of the variables of interest from the proposed blocks. According to the electricity market block results, it is evident that

Table 2 Stationary properties of the variables

ADF				
Variable	Level		First difference	
	Intercept	Intercept and trend	Intercept	Intercept and trend
Y	1.90	−0.43	−3.69***	−6.12***
Y^2	2.15	−0.33	−3.74***	−3.51***
E	0.85	−3.07	−4.38***	−4.35***
G	−0.70	−2.04	−4.50***	−4.40***
P	0.19	−2.75	−2.96**	−3.47**
RE	−0.09	−1.61	−3.12***	3.52*
CO_2	2.53	0.06	−4.19***	−6.49***
GINI	−2.53	−2.27	−2.49	1.55
HDI	−1.22	−5.21***	−5.38***	−5.18***
POL	−1.44	−3.33*	−4.09***	−4.13**
DF-GLS				
Y	1.32	−2.12	−2.70***	−4.23***
Y^2	1.29	−2.06	−2.63**	−4.22**
E	2.49	−2.88	−2.10**	−4.26***
G	1.10	−1.41	−2.60**	−2.94*
CO_2	0.33	−1.81	−1.95**	−4.18***
P	2.56	−2.04	−4.65***	−5.25***
RE	−0.88	−1.49	−2.97***	3.74**
GINI	−1.41	−1.89	−1.95**	−2.43
HDI	−1.53	−3.13**	−3.10***	−3.83***
POL	−1.86	−4.22***	−1.17	−4.34***

Note ***, **, and * denote significance level at 1, 5, and 10%, respectively
Source Authors' own calculation

Table 3 ARDL Bounds Cointegration Test with Surface Regression Results

Model	Value	10%		5%		1%		P-Value	
		I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
Model 1	5.42	2.63	4.03	3.24	4.85	4.73	6.87	0.005	0.031
Model 2	5.22	2.63	4.11	3.25	4.98	4.83	7.16	0.007	0.042
Model 3	4.14	2.64	4.03	3.24	4.85	4.74	6.87	0.019	0.091
Model 4	5.48	2.47	3.89	3.02	4.66	4.37	6.53	0.003	0.024
Model 5	5.18	2.66	3.94	3.25	4.65	4.65	6.55	0.006	0.033
Model 6	4.00	2.68	4.00	3.29	4.87	4.83	6.91	0.026	0.100
Model 7	3.99	2.48	3.98	3.05	4.80	4.51	6.84	0.017	0.099

Note The test is run for both no trend and intercept configuration
Source Authors' own calculation

Table 4 DOLS long-run estimation results

Model	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
VAR	E	G	HDI	GINI	GINI	CO_2	CO_2
Y	0.75[a] (0.12)	1.47[a] (0.18)	0.16[a] (0.02)	11.18[a] (0.91)	9.43[a] (0.62)	60.40[a] (11.51)	58.04[a] (9.39)
Y^2				−0.54[a] (0.04)	−0.47[a] (0.03)	−2.83[a] (0.56)	−2.17[a] (0.45)
P	−0.26[a] (0.12)	−0.02 (0.13)					
PRI_{t-2}	0.20[a] (0.03)	0.18 [b] (0.06)	0.02[b] (0.10)	0.004 (0.01)		−0.10 (0.07)	−0.07 (0.27)
REG_{t-1}	0.17[a] (0.04)	0.33[b] (0.08)	0.05[b] (0.02)	−0.08[a] (0.12)	−0.09[a] (0.004)	−0.35[a] (0.08)	−0.30[a] (0.07)
POL			0.03[b] (0.01)	0.001 (0.01)			
$PRI^{*}POL_{t-2}$					−0.02[a] (0.005)		
RE							−0.27 (0.17)
N	34	32	35	34	34	34	34
Adj-R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99
J-B	3.56	5.35[c]	1.12	2.73	1.83	2.46	0.70
Q-Stat (AC)	2.45	3.96	0.59	4.30	1.15	0.21	2.72

Note Standard errors are in parenthesis. a, b, and c show significance at 1%, 5%, and 10%, respectively. J-B and AC refer Jarque–Bera and Autocorrelation tests. Both tests are done in the residuals of the regressions. Model 1 uses a time trend. The F-statistics show that the time trend is significant at a 1% confidence level (F = 14.76 and Prob = 0.0023)
Source Authors' own calculation

electricity consumption depicts the characteristics of an inelastic normal good in the long run (model 1). A 1% increase in income increases electricity consumption by 0.75%. Besides, electricity consumption is also negatively related to price. Moreover, our results indicate that electricity consumption reduces by 0.26% due to an increase in price by 1%. Such a level of inelasticity shows the degree of consumer reluctance since, without access to electricity, it is nearly impossible to complete any activity in the current context. The overall result is consistent with Amin and Khan (2020). On the other hand, results suggest that generation capacity is positively associated with income but not price (model 2).

We also find that reform initiatives significantly impact electricity consumption and generation capacity (models 1 and 2). It is evident from the results that privatisation positively impacts electricity consumption and generation by 20% and 18% in the long run, respectively, compared to a situation of no privatisation. Similarly, introducing a regulatory body increases electricity consumption and generation capacity by 17% and 33%, respectively, in the long run. These findings are expected as privatisation initiates, more private firms enter the market competitively, and, as a result, generation capacity increases and meets the growing demand from consumers. The growing demand is well explainable through the transformation of Bangladesh as the country that entered into an industrialised regime from the mid-1980s (Amin et al. 2020).

One key aspect to notice from the results is that the effects of regulatory reform on electricity consumption and generation are significantly different, even though the variation in effects is expected to be minimal. This finding reflects the issue of power theft[24] as evident in Bangladesh, like any other emerging country. Finally, both models show no autocorrelation problem per the model diagnostic tests. Although the electricity consumption model (model 1) residual term is normally distributed, the residual term of the electricity generation model has trivial irregularity (model 2).

From the welfare block, it is evident that the HDI has a positive association with the reform initiatives (model 3). According to the estimation, privatisation and regulatory bodies increase the HDI by 2% and 5%, respectively. We also find that political stability is another determinant of the HDI in Bangladesh. Inequality (i.e. Gini coefficient) reduces with the introduction of a regulatory body (model 4: 8% and model 5: 9%). These results are consistent with the earlier literature. From the theoretical perspective, induction of electricity sector reforms can improve the efficiency of the electricity sector and alleviates poverty, reduces inequality, increases healthcare, facilitates education services, and improves environmental aspects, leading to overall economic development (Newbery 2002; Jamasb 2006; Sen and Jamasb 2012; Jamasb et al. 2014). However, there is also evidence that the reform initiatives sometimes alone may not lead to such developments (Nepal and Jamasb 2012; Amin et al. 2021c). Our analysis also finds a similar indication since privatisation influences inequality negatively when interacting with institutional variables such as political stability (model 5: −2%). Therefore, following Jamasb et al. (2014) and

[24] This can be simply referred to as unregistered consumption of electricity.

Sen et al. (2016), we argue that the EMR could reduce income inequality through several channels when implemented and maintained through good governance, given political stability. Examples of these channels are access to quality infrastructure, job creation, and increased generation capacity that leads to the desired level of electricity to improve the standard of living, etc. We also observe that income has a long-run non-linear effect on the Gini coefficient of Bangladesh, and it is an inverted U-shape. In other words, in the beginning, as income increases, Gini rises but falls after a certain threshold. On the contrary, HDI has a linear relationship with income in the long run. Also, model diagnostic tests do not show autocorrelation and residual irregularity problems.

Following Nepal and Jamasb (2012), we analyse the impact of reforms on environmental aspects. As highlighted in the previous studies, we also find that CO_2 emissions have a non-linear relationship with income per capita in the long run (models 6 and 7). The relationship is more widely known as the environmental Kuznets curve (Kacprzyk and Kuchta 2020). Also, an increase in renewable energy consumption may not significantly reduce long-run CO_2 emissions (model 7). This outcome of the low share of renewable energy in electricity generations in Bangladesh is immensely poor compared to the fossil fuel counterpart. According to the recent statistics of SREDA (2020), the share of renewable energy in electricity generation is only about 3% (considering off-grid and on-grid). So, a change in the consumption pattern of renewable energy may not bring any progressive alteration in the CO_2 emissions path unless its share in electricity generation reaches an adequate level.

On the other hand, no significant relationship is found between privatisation and CO_2 emissions. A key reason behind such a result is that private companies mostly invest in Bangladeshi generators that use fossil fuels like natural gas and imported oil to generate electricity. It also implies that the country is slowly transitioning to renewable energy and energy efficiency programmes. The regulatory reform also shows the expected sign on CO_2 emissions. It is because the presence of a regulatory body influences behavioural patterns of the stakeholders with regulative and monitoring authority. Regulatory reform can reduce CO_2 emissions by 35% and 30%, respectively, in the long run (models 6 and 7). Finally, post-estimation diagnostics tests reveal no residual irregularity and autocorrelation in both models.

Lastly, we check the stability of the variables used in the model by using the novel CUSUM test in Fig. 5. All the variables are stable considering exogenous effects (systematic and sudden movements).

6 Conclusion and Policy Recommendations

Bangladesh was approved for graduation from the least developed country status list by the United Nations General Assembly in 2021. The country has satisfied

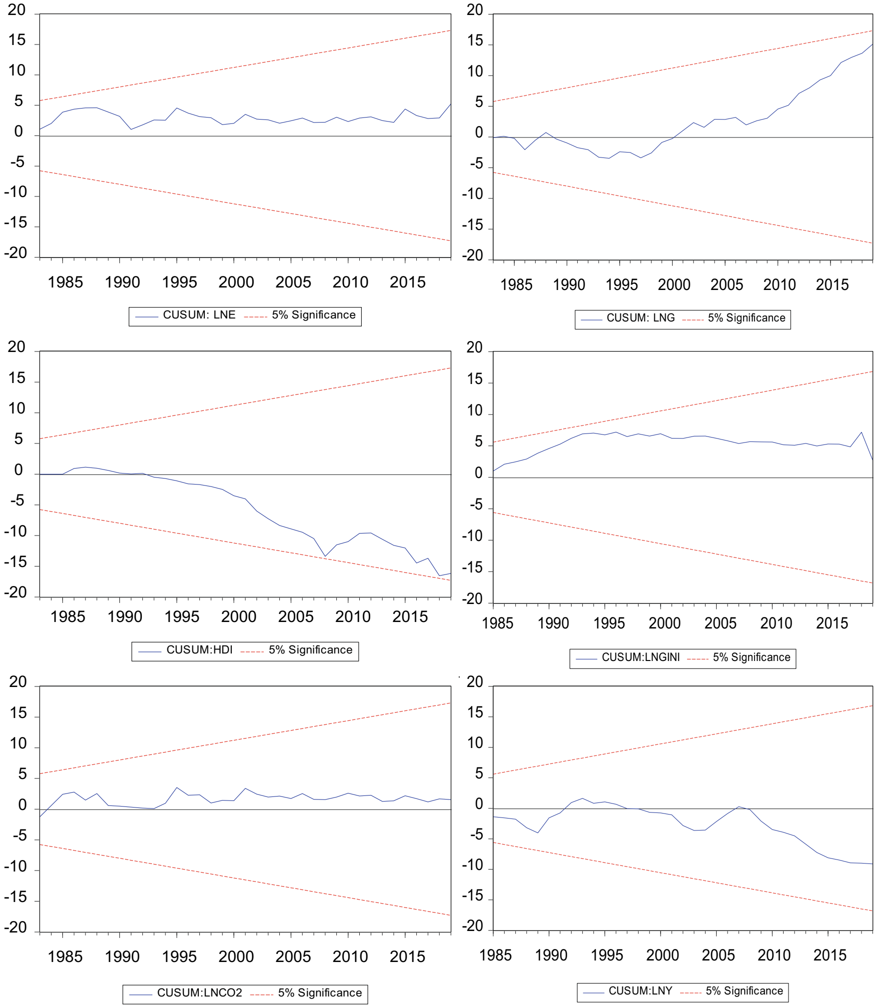

Fig. 5 The CUSUM tests. *Source* Authors' own calculation

the necessary criteria of per capita income, economic and environmental vulnerability, and human resources for the second consecutive time since 2018.[25] With the aspiration of a futuristic Bangladesh as a high-income country by 2041 with reduced extreme poverty by 2030, the focus of the present Awami League government is sustaining economic growth by employing more people, enhancing structural growth by promoting health and education standards, accelerating the growth

[25] For more details, see https://www.thedailystar.net/business/news/bangladesh-gets-un-recommendation-graduating-ldc-status-2051857.

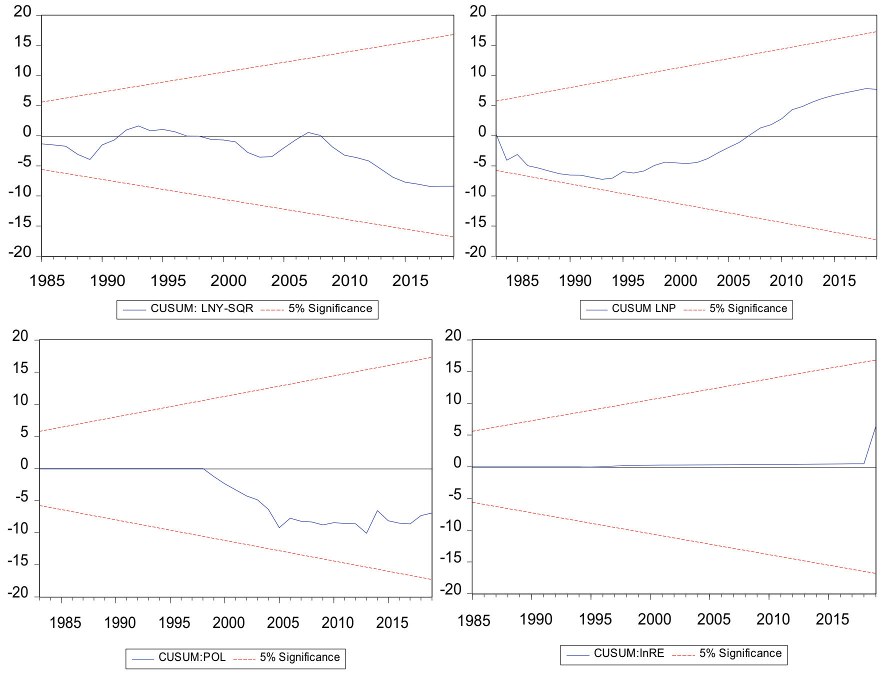

Fig. 5 (continued)

of energy and transport infrastructure, and maintaining good governance while reinforcing anti-corruption policies and regulations (GED 2020). Hence, the electricity sector has been recognised as imperative for sustainable future growth. It is also vital to critically and empirically review the overall assessment of the electricity reform initiatives in Bangladesh. This chapter, therefore, thoroughly discusses electricity reform initiatives in Bangladesh.

Moreover, highlighting the literature review, we also conduct an empirical exercise to assess the policy's effectiveness. The empirical results indicate that reform initiatives, such as privatisation and regulation, significantly impact electricity consumption and generation capacity in Bangladesh. Electricity sector reform initiatives can also affect the economic indicators significantly.

We recommend that the government continue with energy price reform. It will enable the country to progress to a competitive and environmentally sustainable least-cost power generation, transmission, and distribution system, with increased private participation and own-resource mobilisation, reducing reliance on limited financial resources and meeting Bangladesh's environmental goals, including its commitment to the Paris Accord on Carbon Emission Reduction.

Bangladesh could also build large-scale power transmission and distribution systems to secure network voltage fluctuations and frequency issues, establish uninterrupted quality power distribution, and develop more high-power transmission lines to cater to the rising demand from new power generation hubs. Attracting large-scale private investment on a global and domestic scale and bringing new newer innovative solutions could be given top priority in the coming years to develop the transmission and distribution sectors. To meet the energy efficiency targets, the government may look into implementing well-articulated demand-side management to help ensure cost-effective ways to reduce peak demand and curb load shedding while simultaneously encouraging consumers to use energy-efficient appliances and equipment and introducing better energy-efficient technologies and new building insulation standards.[26]

Institutional reforms are crucial, as decentralised institutions' lack of organisational power within a centralised system hinders policy implementation and private investments (Vijay et al. 2015; Ghafoor et al. 2016; Cai and Aoyama 2018). Furthermore, several administrative issues delay the speed of ongoing power and energy projects in emerging countries. As a result, the policy may be strengthened to implement synchronised institutional reforms in natural gas exploration for power generation, increase investment opportunities, ensure demand-side management, and negotiate cross-border electricity trade and power dissemination projects (Jamasb et al. 2016). Finally, the government could reckon with implementing plans to improve the skills of the current labour force in the power sector to minimise managerial bottlenecks and redistribute existing subsidies to develop renewable energy energies.

Since electricity consumption keeps increasing, energy efficiency programmes must be enhanced to promote the sale of high-efficiency household appliances awareness campaigns to evoke behavioural changes in individuals to save electricity. Furthermore, welcoming research and development initiatives can focus on the development of energy storage systems.

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