POWER SECTOR

PIDE Working Papers
No. 2024:2

Pakistan Institute of Development Economics

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Designed, composed, and finished at the Publications Division, PIDE.

PIDE Working Papers
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PAKISTAN INSTITUTE OF DEVELOPMENT ECONOMICS
ISLAMABAD
2024

ABSTRACT

The electricity sector's financial stability is crucial for the smooth functioning of power systems. However, in Pakistan, circular debt is holding the sector and the entire economy hostage. To quantify the impact of this problem, a study is conducted using standard econometric techniques to investigate circular debt effects on the industrial sector at both the firm and macro levels. The study also measured the impact of circular debt on different sectors, sub-sectors, and factor inputs in the economy using a Computed General Equilibrium model through cost of production path. The study revealed that circular debt hurts real GDP and all sectors, increasing fiscal deficit and trade imbalance. The study also estimated a total public welfare loss of US$13 billion due to a 10 percent growth in circular debt. At the firm level, circular debt via an increase in tariffs is causing a reduction in profitability due to a significant increase in production costs. At the macro level, this is causing a decrease in industrial output and export competitiveness.

JEL Classifications: Q43, D22, C68
Keywords: Circular Debt, Electricity Tariff, Pakistan's Economy

1. INTRODUCTION

There is an abundance of reasonably priced energy supplies available worldwide. However, Pakistan's energy history has been characterised by erratic growth caused by energy shortages (Box 1). The most recent energy crisis, which emerged in 2005 and continued has led to exemplary increases in electricity tariffs, thus adversely affecting economic activities.

Box 1. Energy Crisis in Pakistan

- **First** crisis erupted before the commissioning of Mangla Dam in 1968.
- **Second**, it started in the early 1970s and continued till the commissioning of Tarbela Dam (four units of 700 MW) in 1977. Both Mangla and Tarbela dams led to a robust hydro-based energy generation that satisfied rising demand, but only for a few years.
- **Third**, energy demand soared in 1980s, leading to energy crises in 1984 and onwards. The crunch saw the unveiling of the 1994 power policy and the induction of IPPs.
- **Fourth**, it started in 2005 and continued.

Source: Cheema, et al. 2022.

It is widely recognised that a state's socio-economic development is closely linked to the performance of its energy sector. Electricity is a versatile form of energy that stimulates economic performance and is an essential driver of growth and development in the agricultural, industrial, and various services sectors and also affects domestic life. Any disruption in the supply of electricity can significantly impact the entire economic supply chain. Therefore, it is crucial to ensure that energy is available and at a reasonable cost to maintain a country's competitiveness in the global arena.

The electricity sector's financial viability is critical in electric power systems. But in Pakistan, circular debt (CD), a power sector financial deficit that originated in FY2006 to the tune of PKR 111 billion has reached now PKR 2.3 trillion (as of June 30, 2023) (Figure 2). The cumulative losses since FY2006 have crossed Rs 6 trillion (3 percent of current GDP).

The CD is affecting the power sector's health and further weakening Pakistan's already struggling economy. Maintaining macroeconomic sector efficiency has become challenging for fiscal and administrative managers; the industrial sector is adversely affected (Malik, 2012; Malik, et al. 2023).

Fig. 1. Circular Debt in Pakistan

- Contractual obligations ensure that outflows are guaranteed payments.
- Inflows are uncertain due to the possibility of delayed or absent tariff payments, subsidies, or discrepancies, such as system losses, not factored into tariffs.
- Result—receivables from the distribution sector to CPPA always fall behind payables to generators, creating a deficit, Circular Debt.

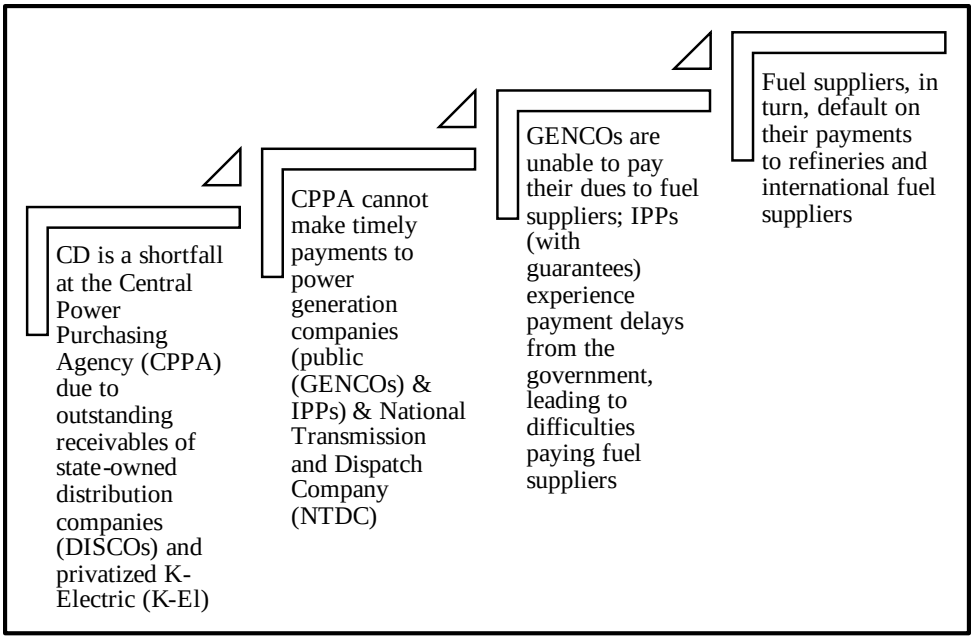
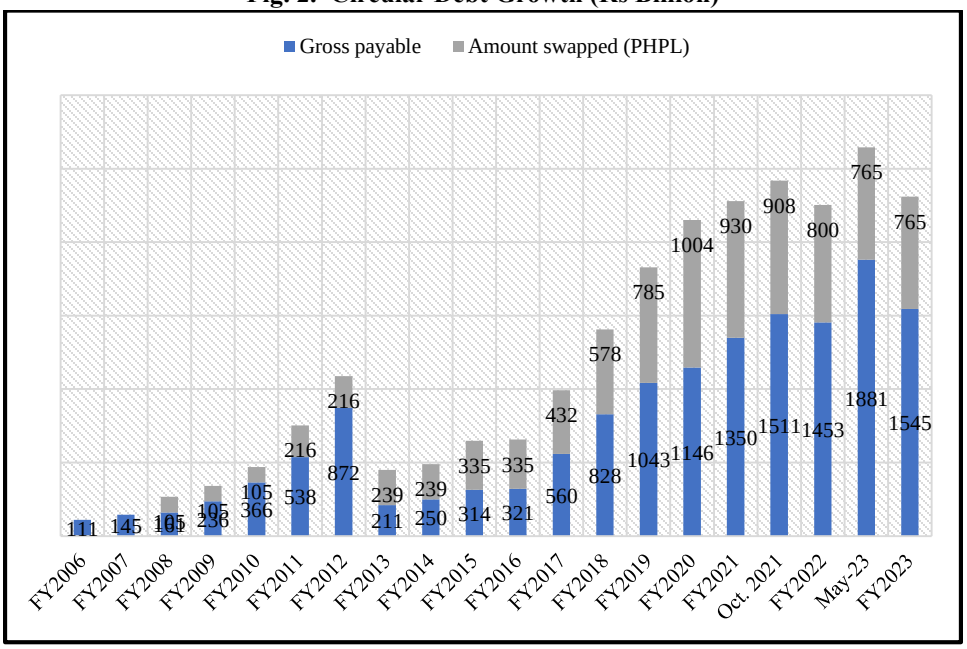


Fig. 2. Circular Debt Growth (Rs Billion)



Source: Malik (2020) and Power Division, Ministry of Energy.

Since its inception, CD's most immediate impact has been on utilising existing installed capacity. Consequently, most of the thermal power plants were forced to operate at a very low capacity factor; thus, there was a massive increase in power load-shedding. The country lost between 2000 MW to 2500 MW of potential thermal power generated by

private power companies as they remained off-grid due to the non-availability of fuel supply coupled with a lack of funds due to swelling dues in its early years (Malik, 2012). This trend continued. As a result of fuel shortages due to insufficient payables to power generation companies, power outages lasting 8 to 10 hours have occurred many times in recent years, leading to little capacity utilisation of thermal power plants and increased load-shedding.[1]

In FY2013, the circular debt was cleared using budgetary support and a direct liquidity injection of Rs 342 billion, which helped to improve capacity utilisation from 56 percent to 73 percent. Unfortunately, the improvement was short-lived, and the capacity utilisation dropped to 63 percent in less than a year due to the re-emergence of circular debt flows. This reduced cash flows to power generation companies (SBP, 2014). In FY2013, the circular debt was cleared using budgetary support and a direct liquidity injection of Rs 342 billion, which helped to improve capacity utilisation from 56 percent to 73 percent. Unfortunately, the improvement was short-lived, and capacity utilisation dropped to 63 percent in less than a year due to the re-emergence of circular debt flows. This reduced cash flows to power generation companies (SBP, 2014). Policymakers opted for a quick fix by settling payables but failed to address the root causes. As a result, circular debt re-emerged in 2013, amounting to Rs. 266 billion. After the 2013 power policy, there have been frequent power outages in loss-making areas__ and commercial load-shedding. This practice was implemented to reduce sector financial losses, but its adverse effects outweigh the benefits for the power sector. It has increased circular debt, putting more pressure on the economy.

The underutilisation or non-utilisation of available generation capacity and forced outages significantly impact the per unit cost of generation[2] and consumer-end tariff in the power sector[3]. This, in turn, has a cascading effect on economic activities, particularly in the industrial sector. The persistent shortage of electricity and its high tariffs in the country adversely affect the national economy, especially industrial production, and export earnings (Malik et al., 2023). Load shedding in the industrial sector costs the country in terms of loss in export earnings, and potential displacement of workers. The debt is expected to continue increasing if stringent measures are not taken to control it. Despite having enough installed and dependable capacity (as shown in Figure 3), energy shortages persist in the country due to rising circular debt.

Under the Circular Debt Management Plan 2023 and IMF conditionalities, the electricity base tariff was increased twice in 2023, resulting in a 76 percent increase in the base tariff. The plan aimed to reduce untargeted subsidies, with no subsidy allocated for agriculture and zero-rated industry in the FY2024 budget. Revenue generation through tariff escalation is considered a major sector reform and an instrument to manage the circular debt flow, without realising that not only shortages, and rising tariffs, negatively impact economic sectors.

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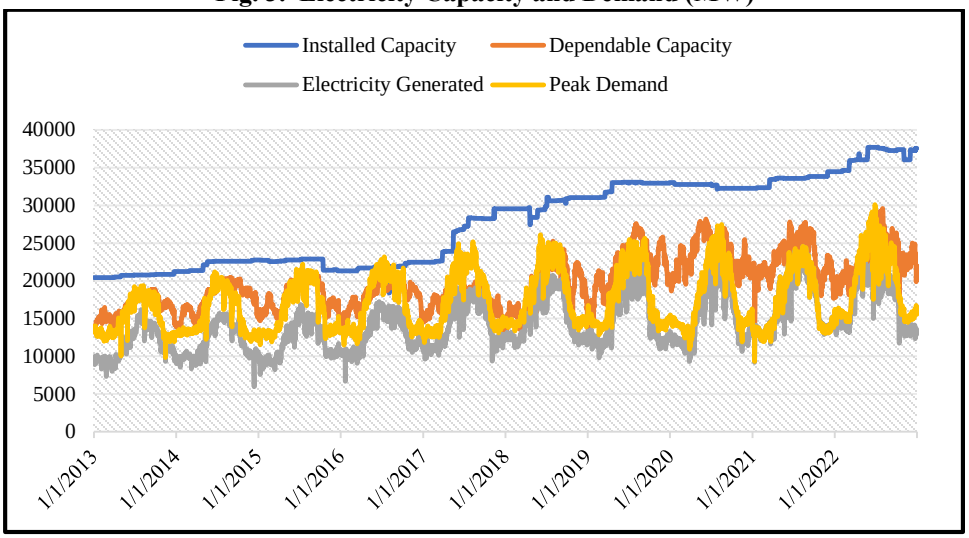
[1] Cited from Cheema et al., 2022.

[2] Limited energy use can lower energy costs but increases capacity payments. For instance, in FY2023, limited use of existing capacity led to a 22 percent decrease in energy costs, but this was offset by a 56 percent increase in capacity charges for the tariff projections for FY2024 (Malik, 2023).

[3] This is particularly true for 'Take or Pay' based thermal power plants and 'Must Run' renewable plants. In FY 2022, the most efficient RLNG plants couldn't operate at full capacity due to a shortage of RLNG. Due to non-payment by CPPA-G, some RFO and coal power plants couldn't maintain the desired fuel inventory. Additionally, renewable plants faced constraints in dispatching electricity due to system issues.

Fig. 3. Electricity Capacity and Demand (MW)



Source: NTDC.

This study is the first to measure the impact of circular debt (CD). It investigates the effects of CD both at the firm and macro levels using standard econometric techniques. At the firm level, the study examines how much CD affects firms' net profits by increasing overall costs. The macro-level investigation focuses on the effect of CD on the industrial sector's export earnings and competitiveness. The second part of the study attempts to quantify the impact of CD on Pakistan's economy through cost routes using a computed general equilibrium (CGE) model.

The remainder of the study is organised as follows: Section 2 provides the conceptual framework of the study, while Section 3 reviews the literature related to circular debt in Pakistan. Section 4 presents the methodology with data sources. Section 5 describes the findings and discusses them. Section 6 concludes the discussion with some recommendations.

2. CONCEPTUAL FRAMEWORK

The circular debt (CD) emerged in FY2006 when the cost of generating electricity surged due to a rise in international fuel prices. Tariffs began to increase from FY2008 onwards to counter the increase in electricity generation costs, but the circular debt persisted.

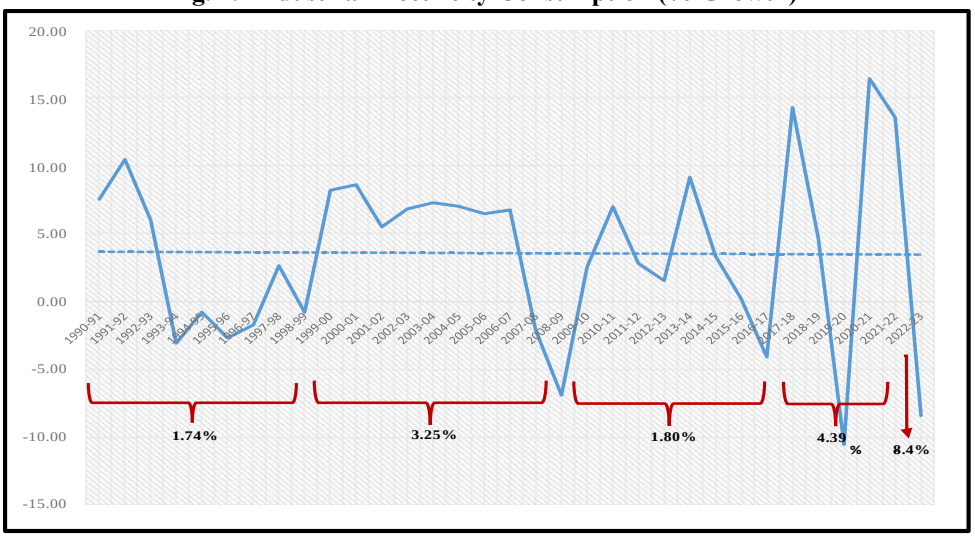
In the 1990s, the introduction of Independent Power Plants (IPPs) increased power generation capacity, mainly through imported fossil fuels such as furnace oil, RLNG, and imported coal. This move does help in reducing the public sector burden, but unplanned contracts with long-term agreements and sovereign guarantees have significantly raised the generation cost due to inflated capacity payments and costly fuel mix. Even when local fuels are utilised, payments are still made in US$. This trend has continued up to the present time, leading to entrapment of the sector and the economy. Thus, putting enormous pressure on consumer-end tariffs of electricity and its availability (Malik, 2020 and Malik, 2023a).

Another often overlooked while designing a circular debt management plan is increasing consumer-end tariffs, a strategy to counter rising circular debt, increasing the cost of production in economic activities, and decreasing human welfare. Furthermore, financial challenges (circular debt) often lead to shortages in (generation) supplies, resulting in power outages. Power outages can seriously affect daily life, productivity, and the economy. Circular debt limits consistent electricity generation, increasing the risk of blackouts and disrupting all sectors (Cheema et al., 2022; Malik, 2021).

The inconsistent power supply is a major problem for all sectors, in particular, industries, leading to reduced production and an economic slowdown. The industry faces a gap between demand and supply due to power outages, hindering daily production targets (PIDE, 2021). The circular debt issue exacerbates this problem, as funds are diverted away from developmental projects and towards addressing the debt. For a country to prosper economically, it is essential to have reliable and affordable energy. The circular debt issue disrupts the energy supply chain, causing industries to operate at less-than-optimal levels (Malik, 2012). This reduced production, affecting business revenue generation, hindering economic growth and development. Siddiqui et al., 2011 estimated that power outages have resulted in industrial output losses ranging from 12 percent to 37 percent. Xu, et al (2022) found the negative influence of electricity shortfalls on the profitability and productivity of Pakistani non-financial listed companies. A recent study by Haque et al. (2023) estimates a loss of PKR 1042 per hour load shedding cost. Likewise, another study estimated a significant loss in profitability, investment, exports, and employment in the various industrial sectors because of a rise in electricity tariffs (Malik, et al., 2023).

When the energy crisis started in FY2006, large industrial units either shut down their operations or moved to other countries. Some of them switched to their captive power plants (run on gas) and decreased their reliance on grid electricity. It was only in recent years, when the government introduced zero-rated industrial tariffs, that the consumption of bulk power consumers increased. The trend is reflected in Figure 4.

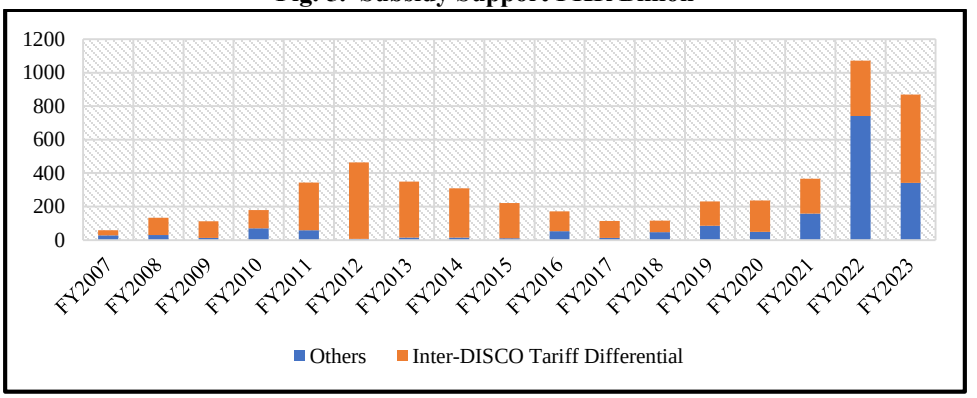
Fig. 4. Industrial Electricity Consumption (% Growth)



Source: Author's estimate based on NTDC data

Secondly, consumer-end tariffs have significantly risen in recent years, with average sale prices increasing by over 700 percent since 2007. Despite subsidy, the average tariff for industry has increased by about 640 percent in the same period (Figure 6). In Pakistan, electricity tariffs for industries are 30-50 percent higher than its regional competitors like India, Vietnam, Bangladesh, and China (Table 1). The Government of Pakistan provides several subsidies to the power sector. The largest portion of this subsidy is for inter-DISCO tariff differential4.

Fig. 5. Subsidy Support PKR Billion

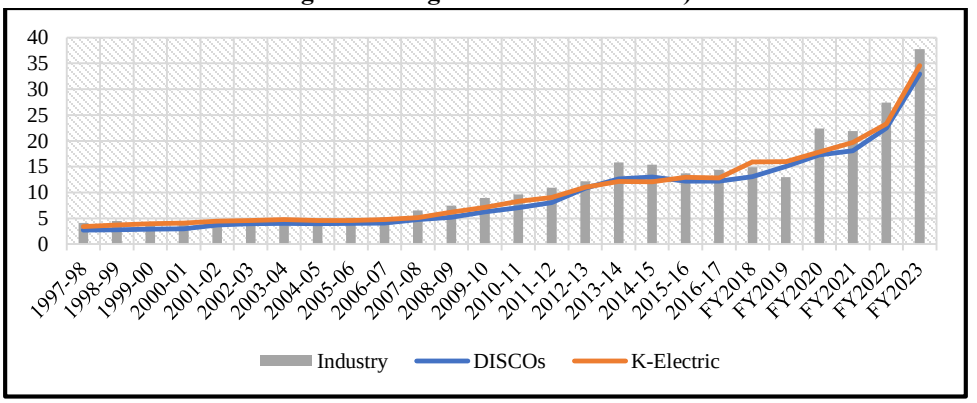


Source: Budget in Brief (Various Years)

Note: Subsidy support in 2022 includes paying IPPs Rs 434 billion and Rs 118 for servicing the debt parked in Power Holding Private Limited (PHPL)

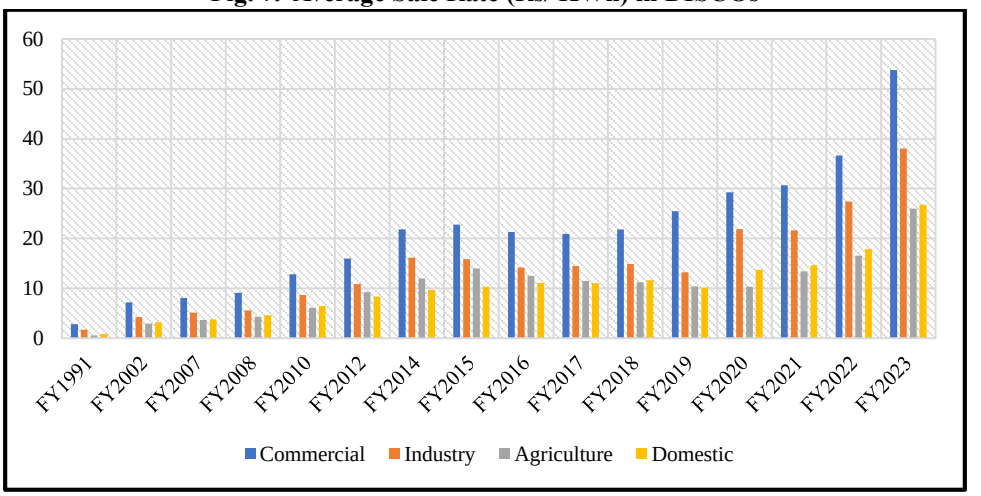
The government is pressured to reduce electricity subsidies and increase consumer tariffs as per IMF conditions. Additionally, various surcharges have been added to finance banks and other government liabilities, further driving up consumer tariffs. The financial cost surcharge has increased from PKR 0.43/kWh to PKR 3.23/kWh. Due to discrepancies in the subsidy structure, consumer-end tariffs are soaring, and government subsidies are rising (Malik & Urooj, 2022). This is causing a financial strain on all consumer categories, in particular, affecting production activities and export competitiveness.

Fig. 6. Average Sale Tariff Rs/KWh)



[4] It is the difference between government notified uniform tariff and the tariff determined by NEPRA.

Fig. 7. Average Sale Rate (Rs/ KWh) in DISCOs



Source: NEPRA State of Industry Report (Various years) and NTDC Electricity Marketing Data (Various Years).

Table 1

Industrial Electricity Tariff

Countries	Electricity Tariffs for Industries in KWh in US Cents
Pakistan	0.120
China	0.084
India (Maharashtra)	0.080
Vietnam	0.070
Bangladesh	0.080

Source: Official Websites.

It is important to note that the tariff for bulk power consumers has almost doubled due to two tariff rebasing.[5] This increase does not include taxes and surcharges, which comprise 40 percent of the consumer-end tariffs. This sudden increase will likely harm the industry's competitiveness and export gains from the last two years. Additionally, if electricity tariffs continue to rise, manufacturing costs will increase, resulting in a liquidity crisis due to decreased profitability. Ultimately, this will lead to a contraction of the sector, which will have negative implications for employment. This has been proven through empirical examination of firm-level data conducted by Malik et al. (2023).

Thirdly, the power sector consumes significant budgetary resources. The diversion of funds to address circular debt hinders crucial investments in infrastructure and social development projects. The power sector still depends on subsidy support, equity payments, and sovereign credit guarantees to sustain its operations. The build-up of circular debt has led banks to accumulate alarmingly high exposures on the energy sector. Continuous bank borrowing for energy sector deficit financing is also crowding out private borrowing, leaving little to be borrowed for productive activities expansion.

The stock of government guarantees is increasing non-stop.

[5] As per the news, another tariff rebasing is on the cards.

Table 2

Total Government Guarantees Stock_ Power Stock

	Total Govt. Guarantees Stock (Rs. Billion)
Jun-19	1,562
Jun-20	1,961
Jun-21	1,999
Jun-22	2238
Sep-22	2346

Source: Ministry of Finance: Debt Policy Statements (Various Years).

The coming section briefly reviews the available circular debt (CD) literature.

3. LITERATURE REVIEW

Since the introduction of circular debt (CD) in 2006, researchers, think tanks, and journalists have studied its existence, persistence, and impact on Pakistan's energy sector. The energy supply chain is struggling with multiple issues that lead to financial losses like CD and higher costs for electricity services. The issues include mismanagement, outdated governance structures, inefficiencies in generating and distributing electricity, irrational subsidy and tariff structures, slow progress in energy cost-side reforms, delays in tariff determinations, unprofessional handling of energy affairs, and weak regulatory infrastructure. Unfortunately, these structural issues, as has the circular debt, have been present for years.

Several studies have been conducted on the issue of circular debt in Pakistan's energy sector. These studies have identified its causes and suggested potential solutions. Some of the notable studies include Akram (2023), ADB (2021), Javed (2021), Hafeez (2019), Saleh (2019), Faraz (2018), PRIME (2016), USAID (2013), Kugelman (2013), Malik (2012), and Ali & Badar (2010). Circular debt remains a pressing issue in Pakistan's energy sector, with Cheema et al. (2022) and Malik (2020) emphasising the need for significant structural reforms to address the issue.

An in-depth analysis of the emergence, growth, and causes of circular debt is provided in Malik's (2020) research. In this study, Malik (2020) has provided a detailed account of how circular debt has evolved and expanded over time while also identifying the underlying structural problems and proposing viable solutions to address this issue.

In a study conducted by Tauhidi and Chohan (2020), the issue of circular debt using the public value approach is discussed. They found that developing economies often face non-natural energy crises, which can be attributed to the failure of national stakeholders (known as public value agents) to supply power services sufficiently. National stakeholders (public value agents) fail to provide power services, leading to a vicious cycle of debt that harms social and economic stability.

A study conducted by Awan et al. in 2019 evaluated the impact of tariff differential subsidies (TDS) on social welfare through a direct transfer mechanism using a computed general equilibrium framework. They compared the well-being of impoverished households that received TDS directly to the standard scenario. They also analysed the effects of subsidies targeting the country's circular debt and overall fiscal deficit.

However, the studies conducted so far have yet to attempt to measure the impact of circular debt on industrial and export competitiveness and the economy. Energy and economic growth theories emphasise the significance of energy consumption during production (Stern, 2004). Through electricity prices, its availability, and fiscal constraints, circular debt impacts various sectors. For this study, we will first focus on industry. This study examines how circular debt (CD) affects Pakistan's industrial sector, including output, export volume, and competitiveness. Secondly, using the cost channel, the impact of circular debt will be estimated for the whole economy. The research aims to address the knowledge gap and provide policy implications for industry, economy, and CD reduction.

4. METHODOLOGICAL FRAMEWORK

As explained in Section 2, circular debt (CD) affects the industry through three channels. The first two channels, directly (an increase in tariff) or indirectly (a decrease in availability and reliance on alternative sources), increase production costs. The third channel reduces the availability of bank credit for productive activities. All these factors lead to adverse impacts on the operational cost of businesses and their investment plans, thus a reduction in a firm's productivity and declining industrial output. Such adverse effects can reduce export competitiveness due to increased export prices resulting from the increased cost of production and supply chain disruptions caused by power outages (ADB, 2021; Malik, 2023).

4.1. Impact on Industry

To achieve the first study objective, we have modified the original model in the context of a standard microeconomic model that assumes firms aim to maximise profits (Varian, 2006). A firm that aims to maximise its profits seeks to achieve this by minimising its costs. This can be done by determining the conditional demand of each input factor, such as labour and capital, required to produce goods and services. We have introduced a third input factor to develop a model for this research: energy utilisation (e.g., electricity, gas, etc.) for producing goods and services.

The model's starting point is the formulation of a profit function, which is created based on the firm's revenue and costs. The costs are classified into four main categories: labour, capital, raw materials, and energy. To increase the firm's profits, it is necessary to increase revenues and minimise the cost of production. The objective function of a profit-maximising company is defined as:

$$maxpf(X1, X2, X3) - W1X1 - W2X2 - W3X3$$

Where, p denotes output prices, X1 denotes the labour cost, X2 denotes capital costs and X3 denotes the energy costs, of the firm. While input prices are denoted by W1= wages, W2 =capital, W3= energy prices.

By applying the first-order conditions on the objective function, we obtained the optimised conditional demand of inputs as: conditional demand of capital i.e., $X_1^* = \frac{aPy}{W1}$; conditional demand of labour i.e., $X_2^* = \frac{bPy}{W2}$; and the conditional demand of energy sources i.e., $X_3^* = \frac{cPy}{W3}$. This gives us the demand for the factors as a function of the optimal output choices, output prices, and own input prices. The optimal output which is driven through

cost minimisation is obtained by inserting the optimal factor demand into the Cobb-Douglas production function and its specification is presented as:

$$y = \left(\frac{Pay}{W1}\right)^{\frac{a}{1-a-b-c}}\left(\frac{Pby}{W2}\right)^{\frac{b}{1-a-b-c}}\left(\frac{Pcy}{W3}\right)^{\frac{c}{1-a-b-c}} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

Thus, Eq. (1) is the supply function of the profit-maximising firms, which is the function of optimum output produced, prices of goods and services being supplied, and input prices such as wages, return on capital, and energy prices. A detailed derivation of the Eq. (1) is presented in Appendix A.

For the study objective, we align this optimised supply function with the channel of circular debt (CD) as discussed. Circular debt increases energy costs through electricity tariffs and costly electricity supplies to the firms and their supply chains. It also increases capital costs due to a need for more banking credit and high-interest rates. The study will explore these adverse impacts on the supply function of the firms, which consequently impacts the firms' profitability and supply of output to the local and international markets.

4.1.1. *Data and Variables*

We have used both firm-level and macro data sets to study the impact of circular debt (CD) on Pakistan's industrial sector. For firm-level analysis, we collected data from the annual reports of 114 firms belonging to significant exporting industries from 2012 to 2022. Due to some missing observations, an unbalanced firm-level panel is formed. For the macro-level analysis, we collected time series data on industrial output, exports, and other (control) macro variables from World Development Indicators (WDI), the Pakistan Economic Survey, and the Federal Board of Revenue reports from 1990 to 2022. Detailed descriptions of all variables used in the analysis are reported in Appendix B.

4.1.2. *Model Specification*

Micro-Level Analysis: an econometric model for firm-level impacts of circular debt (CD) on firms' net profit and cost of production. An optimised supply function has been derived for a profit-maximising firm through an optimisation approach (eq.1), where profits are maximised through conditional input demands, optimised revenues, and minimised cost of production; the econometric specification of firms' net profits is specified as:

$$logNP_{i,t} = \alpha_i + \beta_1 logCapital_{i,t} + \beta_2 logLabor_{i,t} + \beta_3 log\ Energy_{i,t} + \mu_{i,t} \quad \ldots (2)$$

Where log $logNP_{i,t}$ denotes the log of net profit of the firm i in time t, which is the function of capital employed ($Capital_{i,t}$), labour employed ($Labor_{i,t}$), and energy utilisation is measured through the share of the cost of energy utilisation ($Energy_{i,t}$), and $\mu_{i,t}$ is the error term. This specification assesses how the energy cost affects firms' net profits. Yet, our objective is to examine the impact of circular debt (CD) on firms' profits. To accomplish this, we incorporated circular debt and the interaction of CD and the energy cost share in the model (2). The final specification that meets the objective of the study is:

$$logNP_{i,t} = \alpha_i + \beta_1 logCapital_{i,t} + \beta_2 logLabor_{i,t} + \beta_3 log\ Energy_{i,t} + \beta_4 log\ CD_{i,t} + \beta_5 logCD_t * Energy_{i,t} + \mu_{i,t} \quad \ldots \quad \ldots \quad \ldots \quad (2a)$$

Where, an interaction of annual circular debt (CD) with a firm-specific time-variant share of energy costs is introduced to capture the impact of CD-induced energy costs on the net profits of industrial firms.

Likewise, to estimate the impact of CD on a firm's cost of good production, we have used the same specification as given in (2a). The specification of cost function is presented as follows: cost of production is the function of capital prices (CP), wage rate (Wage), net output (NO), and energy cost (Energy).

$$log\ Cost\ of\ Production_{i,t} = \alpha_i + \beta_1 log\ CP_{i,t} + \beta_2 log\ Wage_{i,t} + \beta_3 log\ NO_{i,t} + \beta_4 log\ Energy_{i,t} + \mu_{i,t} \quad \dots \quad \dots \quad \dots \quad (3)$$

In the cost function mentioned above, firms' energy cost is used as a substitute to reflect any electricity price increase. Electricity is the main component of firms' energy usage, and an increase in its price is expected to raise the cost of energy usage for the firms. The government of Pakistan determines the prices of electricity exogenously and are not part of the firm's production function. Furthermore, to investigate the effects of circular debt-induced firm energy costs on the firms' production costs, we have used an interactive term of circular debt with energy costs, which we can refer to as "circular debt-induced electricity prices." Its specification is outlined as follows.

$$log\ Cost\ of\ Production_{i,t} = \alpha_i + \beta_1 log\ CP_{i,t} + \beta_2 log\ Wage_{i,t} + \beta_3 log\ NO_{i,t} + \beta_4 \log Energy_{i,t} + \beta_5 log\ CD_{i,t} + \beta_2 log\ CD * Energy_{i,t} + \mu_{i,t} \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (3a)$$

Macro-Level Analysis: The study also aims to determine the effect of circular debt on industrial output and export competitiveness at the macro level using time series analysis. However, since the annual data of the CD is available for only 16 years, which is insufficient for time series analysis, a binary variable of the CD is generated to determine its causal impacts before and after its emergence. This binary variable interacts with industrial tariffs to capture its effect on tariffs.

Since we do not have macro-level data on firms' cost of energy for so long, we have used industrial tariffs as the proxy for cost of energy utilisation. The model specification of the macro-level impacts is specified as follows.

$$logZ_t = \alpha_0 + \beta_1 CD_t * IET_t + \sum \gamma_i logC_t + \mu_{i,t} \quad \dots \quad \dots \quad \dots \quad (4)$$

Where, Z indicates the dependent variable, which will be regressed for five separate dependent variables such as

(i) industrial value added (%) GDP,
(ii) manufacturing value added (%) GDP,
(iii) manufacturing export (%) total export,
(iv) export prices measured through export unit value index, which also demonstrates the export competitiveness, and
(v) revealed comparative advantage (RCA) of the industrial sector which is also an indicator of measuring export competitiveness.

CD is a dummy variable (equals to 1 2006 onwards, otherwise zero) for measuring circular debt, IET denotes industrial electricity tariff, and $CD_t * IET$ shows the interactive term

of CD and industrial electricity tariffs. Meanwhile, C is the vector of control variables such as real effective exchange rate, inflation, trade restriction, human capital, institutional quality, etc.

For the time series analysis, Fully Modified OLS (FMOLS) has been applied to estimate the five different specifications of the model (3) because all macro variables are stationary at the same level and first difference.

4.2. Impact on Economy

For determining the impact of circular debt on the economy and its various sectors, the study relies on the Computed General Equilibrium (CGE) model. The CGE model is a modern version of Walras' economic model. It is based on general equilibrium modeling and inspired by Walrasian equilibrium theory. The economy comprises agents interacting in different markets, each with goods and income distributions. As agents work towards their goals, they generate a set of supply and demand functions linked throughout the economy's markets. These functions represent the amounts of goods supplied and demanded at different prices.

The CGE model uses Walras' law to ensure a balanced economy with no imbalances. It connects income and expenditures, aligning total revenue earned with total spending on goods and services in the economy.

To understand how circular debt affects Pakistan's economy, we analysed its impact on electricity prices and power generation capacity. Circular debt (as discussed in the previous section) has an incremental effect on electricity tariffs and a decreasing impact on the electricity generation capability[6], affecting production costs. We have used the cost of production channel to assess macro and micro-level indicators of the economy. Specifically, we utilised the Social Accounting Matrix (SAM) for 2013-14 developed by International Food Policy Research Institute (IFPRI) Pakistan[7], to collect data on activity sectors, factors of production and various types of households. This information was then integrated into the GTAP Data Base Version 11, with the reference year 2014. The Walmsley and Minor (2013) study provided the methodology and tools for this integration. Details in Appendix C.

Limitation: There is no separate energy input-output model for Pakistan. The only version available is quite outdated (1979-80). Secondly, energy-based GTAB-E is also not accessible. Under these limitations, this study uses a production cost path to study the impact of circular debt, using the existing SAM (2013-14) integrated with the GTAP Database.

4.2.1. *Data Details*

CGE-based models usually require exhaustive data requirements, and most of the CGE models use social accounting matrixes to quantify the impact of particular policies. However, the GTAP made an excellent effort in obtaining and collecting all required data in input-output tables of 121 regions. GTAP Database Version 11 also provides data on bilateral trade for 65 commodities, services, and intermediate inputs among sectors. Furthermore, data on taxes and subsidies imposed by the Governments is also given. Other than that, the database presents data on consumption, production, and international trade

[6] The consumer will move to alternate energy sources, increasing production costs.

[7] A Social Accounting Matrix (SAM) is an extension of input-output tables commonly used to provide detailed information on the flow of goods and services and the structure of production costs in an economy (Cited from https://www.levyinstitute.org/pubs/UNDP-Levy/India/Appendix_B.pdf).

(including transportation and protection data), energy data, and carbon dioxide (CO2) emissions for three benchmark years (2004, 2007, 2011, and 2014). Moreover, the different economic flows are taken in millions of current US$.

4.2.2. Simulation Design

To estimate circular debt shocks through the cost of production path, we estimated the impact of circular debt on electricity prices and electricity generation separately using Fully Modified OLS. An increase of 1 percent in circular debt leads to an increase in the electricity tariff of about 0.8 percent and decreases grid electricity availability by about 0.3 percent. This results in higher production costs for all sectors of the economy (as discussed in Section 2). We assume that the cost of production will increase through these two channels by about 1.1 percent with a 1 percent increase in circular debt.

On the other hand, over the last five years, circular debt has grown by about 10 percent. Based on our calculations, we assume that this growth rate will increase the production cost of the economy roughly by 10 percent over the past five years. To assess the overall impact of the circular debt, we have simulated a 10 percent increase in the production cost for all sectors.

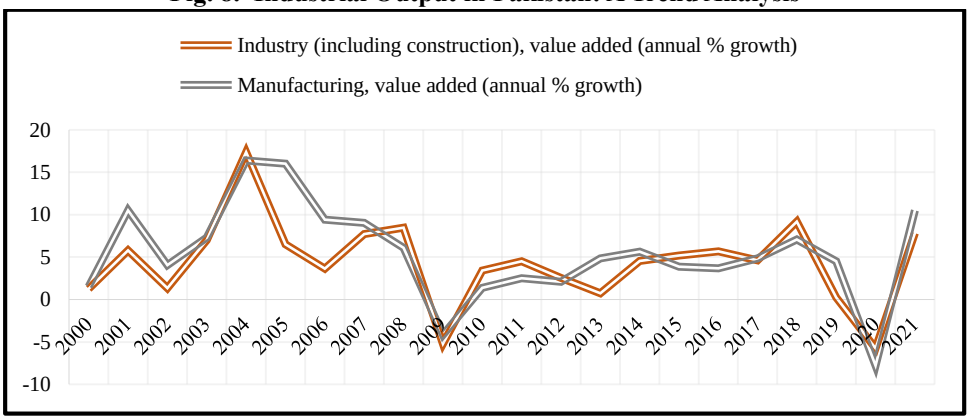
5. RESULTS AND DISCUSSION

5.1. Circular Debt and Industry

5.1.1. *Situational Analysis*

As previously discussed, the Circular Debt (CD) issue has been worsening since its emergence in 2006. This has impacted consumer-end tariffs for all categories of consumers. Despite Pakistan's government providing substantial subsidies to the power sector, the average consumer-end tariff has increased substantially. For the industry, it has increased by more than 640 percent, increasing the cost of production and leading to a decline in industrial output. Figure 8 illustrates the trend of declining growth rates in industrial and manufacturing sectors after 2006, while before 2006, an increasing trend can be observed from 2000 to 2005. CD's emergence after 2005 is linked to rising electricity prices and declining industrial and manufacturing output growth rates.

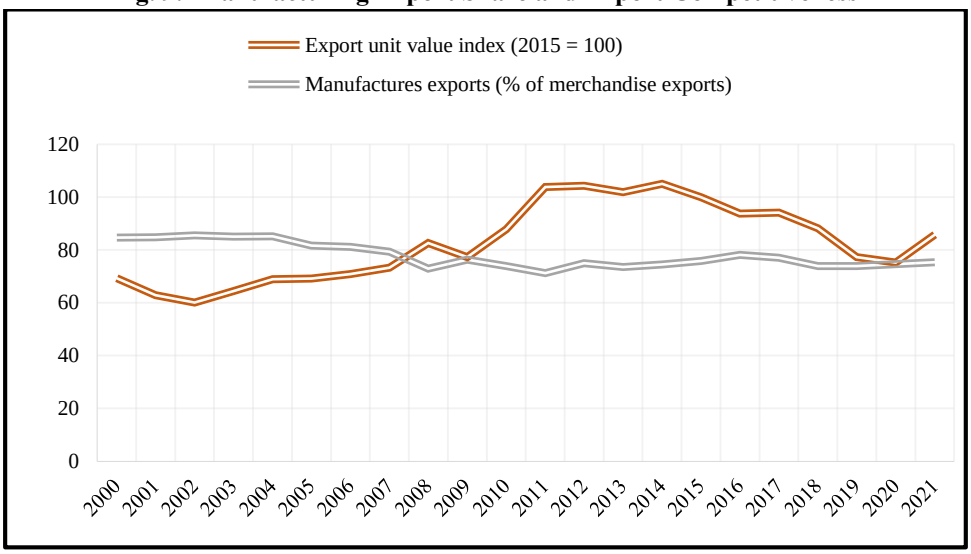
Fig. 8. Industrial Output in Pakistan: A Trend Analysis



Source: World Development Indicators (WDI).

Figure 9 indicates an upsurge in export prices post-2005, resulting in a decline in the international market's competitiveness and demand. The circular debt was accountable for the surge in electricity prices, leading to reduced industrial competitiveness. Before 2005, export prices were lower, and the manufacturing exports' share was comparatively higher. The circular debt, one of the primary reasons behind the rise in electricity prices and hindrances in electricity generation, has led to a hike in production costs for firms and the industrial supply chain. Consequently, it has led to decreased industrial competitiveness.

Fig. 9. Manufacturing Export Share and Export Competitiveness



Source: World Development Indicators (WDI).

5.1.2. *Impacts of CD on Industry: Regression Analysis*

In this section, we will have a detailed discussion about the estimated results obtained by applying the Fixed Effect model to measure the impact of CD on firms. On the other hand, we will use the Fully Modified OLS to measure the effects of CD on industry and export competitiveness at the macro level.

Firm Level Analysis

The specifications (2), (2a), (3), and (3a) have been estimated using a Fixed Effect model that fixes the heterogeneity across firms, such as their sector and location. This model is considered more appropriate and logical than the Random Effect model. Yet, to check results sensitivity, Random Effect model is also estimated. Results are reported in Table 3a and Table 3b. Hausman's test statistics are also presented, which confirms that the Fixed-Effect model is more suitable.

First, we estimated equation (3) and found that a 10 percent increase in electricity tariff (energy costs) increases firms' cost of production by about 7 percent (Column 3 in Table 3a). Next, we estimated equation (3a), and the interaction term (circular debt-induced energy costs) is introduced to the model (Column 5 in Table 3a); it gives the circular debt-

induced electricity tariffs impact on the firm cost of production. The coefficient is found to be positive and statistically significant. That is, with a 10 percent increase in circular debt-induced electricity tariffs, firms' cost of production increased by 2.8 percent.

These findings have significant implications for the business sector. With persistent circular debt, electricity tariffs rise, and power generation may be disrupted. This compels firms to resort to alternative power sources, such as captive power plants or expensive generators, leading to a rise in the overall production cost. However, firms that have invested in cheaper sources of energy like solar may experience a smaller impact.

Next, we estimated equation (2). We found that a 10 percent increase in electricity tariff (energy costs) decreases firms' net profits by 2.1 percent (Column 3 in Table 3a). However, when we estimated equation (2a) and the interaction term (circular debt-induced energy costs) is introduced to the model (Column 5 in Table 3a), it gives the impact of circular debt-induced electricity tariffs on firms' net profits. The interaction term is found to be negative and statistically significant. An increase in circular debt-induced energy costs raises the overall production cost; resultantly, it becomes challenging for firms and leads to a disruption in the industrial supply chain and, ultimately, a reduction in net profits. With a 10 percent increase in circular debt-induced electricity costs, the firm's net profit decreases by 1.6 percent.

Table 3a

Impact of Circular Debt (CD) Induced Energy Costs on Firms' Cost of Production

	(1) Fixed Effect	(2) Random Effect	(3) Fixed Effect	(4) Random Effect	(5) Fixed Effect	(6) Random Effect
Log Circular Debt Induced Energy Costs (Interaction Term)					0.282**	0.235*
					(0.125)	(0.124)
Log Energy Costs			0.714***	0.674***	-1.663	-1.356
			(0.130)	(0.128)	(1.987)	(0.980)
Log Circular Debt					-0.591	-0.4637
					(0.369)	(0.412)
Log Capital	0.210**	0.214***	0.202**	0.206***	0.197**	0.201***
	(0.0828)	(0.0774)	(0.0807)	(0.0760)	(0.0805)	(0.0756)
Log Wage	0.393***	0.406***	0.366***	0.385***	0.340***	0.363***
	(0.0843)	(0.0791)	(0.0872)	(0.0823)	(0.0903)	(0.0851)
Log Net Output	0.1030	0.267**	0.1020	0.273**	0.1250	0.296***
	(0.0995)	(0.119)	(0.0879)	(0.116)	(0.0782)	(0.112)
Log Net Output (square)	-0.00189*	-0.00520*	-0.00239*	-0.00581**	-0.00297*	-0.00640**
	(0.00103)	(0.00279)	(0.00105)	(0.00263)	(0.00171)	(0.00253)
Constant	12.06***	9.764***	10.83***	8.447***	11.83***	9.322***
	(2.245)	(1.954)	(2.112)	(1.898)	(2.126)	(1.915)
Observations	814	814	814	814	814	814
R-squared	0.344	0.351	0.398	0.409	0.406	0.414
Number of firms	108	108	108	108	108	108
Hausman's Test	98.263***		105.81***		123.80***	
	(14.180)		(11.320)		(9.201)	

Note: Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3b

Impact of Circular Debt (CD) Induced Energy Costs on Firms' Net Profits

	(1) Fixed Effect	(2) Random Effect	(3) Fixed Effect	(4) Random Effect	(5) Fixed Effect	(6) Random Effect
Log Circular Debt Induced Energy Costs (Interaction Term)					-0.1647** (0.078)	-0.229** (0.108)
Log Energy Cost			-0.211* (0.111)	-0.178* (0.103)	0.890 (0.623)	0.360 (1.491)
Log Circular Debt					-0.3397 (0.221)	-0.1682 (0.821)
Log Labour	0.611*** (0.217)	0.641*** (0.181)	0.651*** (0.222)	0.661*** (0.184)	0.620*** (0.220)	0.640*** (0.183)
Log Capital	0.0659 (0.0584)	0.0960 (0.0584)	0.113 (0.0789)	0.141* (0.0758)	0.105 (0.0794)	0.134* (0.0761)
Constant	14.57*** (2.052)	13.25*** (1.795)	12.73*** (2.330)	11.67*** (2.060)	13.08*** (2.301)	11.89*** (2.043)
Observations	827	827	784	784	784	784
R-squared	0.26	0.25	0.28	0.27	0.31	0.29
Number of firms	108	108	108	108	108	108
Hausman's Test	92.142*** (11.639)		101.265*** (10.320)		106.345*** (10.215)	

Note: Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Macro-Levels Analysis

This section explored the impact of CD on industrial output, export prices, revealed comparative advantage, and manufacturing export demand. Here, we have endeavored to quantify the magnitude of the CD effects on the development and competitiveness of the industrial sector.

Table 4 and Table 5 reports the results of our analysis. Using the interactive term of circular debt (CD) and energy tariff, we estimate its impacts before and after emergence. Our findings indicate that, on average, industrial output decreased significantly after the emergence of CD compared to before its emergence. Specifically, we found that industrial output declined by an average of 0.09 percent due to a 1 percent increase in the industrial tariffs caused by CD. On the other hand, the coefficient for industrial tariffs before the emergence of CD was statistically insignificant and had a low magnitude.

The manufacturing sector (within industry) is grappling more with the financial implications of circular debt. With a 1 percent increase in circular debt-induced electricity tariffs, the average reduction in manufacturing output is around 0.12 percent, a significant decline compared to the 0.04 percent drop before the emergence of circular debt. The firm-level results (explained above) also explain this financial strain. That is, circular debt leads to increased production costs and a decline in net profits. These findings underscore the detrimental effects of circular debt on the manufacturing sector's financial health, ultimately resulting in decreased output in the overall industrial and manufacturing sectors.

In addition to increasing impact on electricity tariffs, circular debt often leads to disruptions and constraints in energy supply, thus impeding industrial and manufacturing activities, hindering production capacities, causing operational inefficiencies, and increasing costs.

Table 4

Impact of Circular Debt (CD) on Industry and Manufacturing Sector

Variables	Log Industrial Output	Log Manufacturing Output
Interaction Circular Debt (CD) and Electricity Tariff		
Before the Emergence of CD	-0.00252	-0.0407***
	(0.0112)	(0.0141)
Since the Emergence of CD	-0.0894***	-0.123***
	(0.0129)	(0.0164)
Log of Industrial Employment	0.255***	0.256***
	(0.0605)	(0.0768)
Log of Real Effective Exchange Rate (REER)	-0.187***	-0.118***
	(0.0358)	(0.0454)
Log of Capital Formation	0.0131	0.0366*
	(0.0178)	(0.0225)
Constant	2.929***	1.690***
	(0.483)	(0.613)
Observations	32	32
R-squared	0.757	0.672

Note: Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table 5 illustrates how circular debt (CD) affects export competitiveness and manufacturing exports. The study analysed two indicators of export competitiveness: export prices and revealed comparative advantage (RCA) of industrial exporting commodities. The results show that there has been a 0.33 percent increase in export prices due to CD-induced industrial tariffs, which is higher compared to the period without CD.

Table 5

Impact of Circular Debt on Export Competitiveness and Manufacturing Exports

Variables	Log Export Prices	Log RCA	Log Manufacturing Export
Interaction Circular Debt (CD) and Electricity Tariff			
Before the Emergence of CD	0.257***	-0.0495**	-0.0944***
	(0.0246)	(0.0236)	(0.0116)
Since the Emergence of CD	0.335***	-0.0751***	-0.141***
	(0.0250)	(0.0238)	(0.0107)
Log Real GDP	-0.262***	0.132**	0.123***
	(0.0533)	(0.0594)	(0.0177)
Log Trade Restriction	0.0761***	-0.0064	-0.0393***
	(0.0107)	(0.0158)	(0.0036)
Log Nominal Exchange Rate	-0.428***	0.195***	0.122***
	(0.0734)	(0.0706)	(0.0297)
Log Industrial Employment	-0.257***		
	(0.0620)		
Log Term of Trade (relative prices)		-0.173***	
		(0.0250)	
Log Inflation			-0.0321***
			(0.0024)
Log Institutional Quality			0.301***
			(0.0193)
Constant	9.643***	-2.313	0.879**
	(1.278)	(1.564)	(0.441)
Observations	32	32	31
R-squared	0.715	0.85	0.86

Note: Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Likewise, CD leads to a 0.07 percent adverse effect on the industrial sector's comparative advantage (as estimated by the Revealed Comparative Advantage (RCA)) due to increased electricity tariff after the emergence of circular debt. The impact of tariff on RCA was 0.05 percent prior to the emergence of circular debt.

Finally, we have estimated the impact of CD on manufacturing exports. On average, there has been a 0.14 percent decrease in the share of manufacturing exports due to a 1 percent increase in CD induced electricity tariff. This decline can be attributed to the decline in export competitiveness.

To summarise, the negative impact of circular debt (CD) on Pakistan's manufacturing exports can be attributed to disruptions in operations and increased production costs. These factors directly affect the export prices and competitiveness of Pakistan's manufactured goods in international markets. The findings of this section depict a deteriorating situation in Pakistan's industrial landscape following the emergence of circular debt.

5.2. Circular Debt and Economy: CGE Results

The results presented in this section are based on a 10 percent increase in production cost shocks (due to circular debt) on various segments of the economy. Our estimated production cost shock for the industry was slightly lower. But this 10 percent shock is assumed to cover all economic sectors.

5.2.1. *Impact of Circular Debt on Macro Variables*

Based on the CGE model estimates, an increase in circular debt results in decreased power generation and increased electricity prices. This ultimately leads to rising production costs for all sectors, adversely affecting crucial macroeconomic indicators. Results are reported in Table 5. Let's examine macro variables in greater detail below.

After simulating a 10 percent increase in production costs due to rising electricity prices caused by circular debt, there was a 4.61 percent decrease in real GDP. This suggests that Pakistan has experienced a substantial loss in real GDP due to power sector losses (circular debt) over time. Due to circular debt-induced production costs, the government loses 5.4 percent of revenues (both taxes and non-taxes), leading to a 7.5 percent wider budget deficit. On the expenditure side, a significant portion of government resources are allocated towards the power sector through subsidies, as previously mentioned. In addition to providing tariff differential subsidies to the domestic sector, the government also offered tariff support packages to industry and agriculture until the last fiscal year. The government also pays interest payments on debt parked in PHPL and IPPs under the subsidies head (Figure 5).

Simulated data further shows a 5.06 percent decrease in investment returns at the macro level. Understandably, circular debt has a negative impact, leading to increased supply chain costs or higher production costs and lower returns on investment, which may discourage investors from investing more. The decrease in profits also contributes to investor reluctance. Furthermore, circular debt is severely affecting the creditworthiness of the country or sector in the eyes of investors (Malik, 2020).

In addition, circular debt's effects on production costs are also modeled in the external sector. The results show a decrease in export volume of 3.8 percent. The impact on export volume is due to decreased overall output/real GDP caused by the increased electricity prices and energy shortages. The results are similar to what are reported for manufacturing exports in Section 5.1.2.

When energy tariffs increase, it can hurt industries by causing an increase in production costs. This can lead to decreased domestic and international competitiveness, resulting in reduced demand for products, lower profits, and fewer job opportunities. The higher energy prices will impact companies in two ways. Firstly, there will be an immediate impact on production costs due to the increased energy tariffs. Secondly, larger firms that survive will pass on the cost impact to their customers. As a result, customers will face higher costs, decreasing their purchasing power. They may switch to cheaper products from other producers or reduce their spending, leading to a decreasing impact on the overall GDP (cited from Malik et al., 2023).

With the decline in exports, there will be limited foreign exchange reserves, limiting import volume. However, our results indicate an increase in the import volume of 2.5 percent. It could be due to a decline in domestic output and increased reliance on imports to meet the needs of domestic buyers of goods and services. The implication of a decrease in export volume and an increase in import volume suggests a widening of the trade imbalance by 6.4 percent and a decline in terms of trade by 3.2 percent, as reported in Table 6.

Table 6

Impact of Increase in Cost of Production on Macro Indicators

Macro Indicators	(%) Change
Real GDP	-4.61
Government Revenues (Tax and Non-Tax)	-5.4
Budget Deficit	7.5
Return on Investment	-5.06
Export volume	-3.8
Import Volume	2.5
Trade Balance	-6.4
Term of trade	-3.2
Loss of Overall Public Welfare	US$13250.2 Million

Source: Model's Simulation.

In addition to the previously mentioned indicators on a larger scale, we have also run simulations to determine the negative effect of circular debt on public welfare. This includes the impact of increased electricity prices and electricity shortages on the real GDP, loss of government revenue, and negative trade balance. Based on our findings, there is a significant loss in public welfare, totaling US$13,250 million, as a result of circular debt in the power sector of Pakistan.

5.2.2. *Sector-wise Analysis*

This section provides a circular debt impact at the sectoral level. Results are reported in Table 7.

Table 7

Circular Debt Induced Cost of Production and Sectoral Analysis

Sectors	Output (%)	Domestic Supply Prices (%)	Domestic Sale (%)	Export Volume (%)	Import Volume (%)
Overall Agriculture	-3.67	2.13	-4.15	-0.61	1.46
Grains Crops	-3.88	1.8	-4.29	-0.45	1.82
Vegetable & Fruit	-3.66	1.8	-4.01	-0.38	1.18
Meat & Livestock	-3.83	0.90	-4.06	-0.76	1.72
Extraction (Minerals)	-3.34	4.02	-4.25	-0.87	1.14
Overall Manufacturing	-6.23	3.73	-6.29	-4.98	3.23
Processed Food	-3.95	2.03	-4.17	-1.44	1.26
Textile & Apparels	-5.86	3.92	-5.60	-6.27	2.26
Light Manufacturing	-7.79	4.20	-7.76	-8.07	3.50
Heavy Manufacturing	-7.34	4.80	-7.63	-4.15	5.89
Overall Construction	-6.79	2.89	-6.80	-4.48	4.56
Overall Services	-6.54	2.80	-6.64	-2.75	1.77
Transport & Communication	-6.35	2.59	-6.44	-2.40	2.16
Other Services	-6.73	3.01	-6.85	-3.11	1.39

Source: Model's Simulation.

5.2.3. *Impact on Sectoral Output*

The model simulation shows that circular debt negatively impacts all major economic sectors. In terms of GDP, the findings indicate that the construction sector is bearing a loss of 6.79 percent, the services sector is losing 6.54 percent, the manufacturing sector is losing 6.23 percent, and the agriculture sector is facing a loss of 3.67 percent. Furthermore, the estimates suggest that the power sector debt severely affects light, heavy, and textile manufacturing. These results are consistent with our firm-level and macro level analysis in the previous sub-section.

5.2.4. *Impacts on Sectoral Domestic Supply Prices*

According to the results shown in Table 7, the manufacturing sector has experienced a 3.73 percent increase in domestic supply prices compared to other sectors. Further examination of the manufacturing sector reveals that heavy manufacturing saw an average increase of 4.8 percent in domestic supply prices, while light manufacturing and textile and wearing apparel experienced increases of 4.2 percent and 3.92 percent, respectively.

Similarly, there has been a rise in agricultural supply prices by 2.13 percent, and construction sector prices have increased by 2.89 percent. On average, the services sector sees a 2.80 percent increase in domestic supply prices.

5.2.5. Impacts on Domestic Sale by Sectors

When there is an increase in circular debt, it causes a decrease in domestic sales. The research findings indicate that the construction sector, on average, experiences a decline of 6.80 percent in domestic sales. The overall services sector also observes a decline

at a rate of 6.64 percent, while the manufacturing sector sees a decline in domestic sales at a rate of 6.29 percent. The agricultural sector is experiencing a decline in domestic sales at a lower rate of 4.15 percent, less than the other three sectors.

Upon conducting a more thorough analysis, it has been determined that the domestic sales of several sub-sectors have been more adversely affected, particularly heavy and light manufacturing, transport & communication, and other services (more than 6 percent). However, the sub-sectors within the agriculture sector, including grains crops, vegetables & fruit, meat & livestock, and extraction sectors, are observing a decrease of nearly 4 percent in domestic sales.

5.2.6. Impacts on Sectoral Export & Import Volume

When looking at the export and import volumes of different sectors, the simulation shows that manufacturing exports are more negatively impacted by circular debt than other sectors. The manufacturing sector's exports decreased by 5 percent. Light manufacturing, textiles, and apparel among the manufacturing group are most severely impacted. On the other hand, the agricultural sector's exports are estimated to be the least affected by the increased production costs caused by circular debt.

In addition, the study also examined the negative impacts on sectoral imports. The results show that overall, the construction sector saw a 4.48 percent increase in import volume due to decreased domestic output and a greater reliance on imports to meet their needs. Similarly, there was an average increase in import volume of 3.23 percent for the manufacturing sector. When looking at specific sub-sectors of manufacturing, there was a 5.89 percent increase in import volume for heavy manufacturing, 3.5 percent for low manufacturing, and 2.26 percent for textile and apparel imports (refer to Table 7).

5.3. Impacts on Returns on Factors of Production

This section discusses how circular debt affects the returns on factors of production, including land, labour, capital, and natural resources. The results show an average decrease of 5.63 percent in returns on overall factor production due to the increased cost of production caused by circular debt. Further analysis reveals that returns on land decreased by 4.67 percent. At the same time, unskilled labour, skilled labour, capital, and natural resources experience declines of 5.19 percent, 5.59 percent, 5.39 percent, and 7.33 percent, respectively (refer to Table 8). Due to the limited backward flow of funds in the supply chain, refineries or exploration and production companies are most adversely affected.

Table 8

Percentage Change in Returns on Factor of Production

Factor of Production	Returns (%)
Land	-4.67
Unskilled Labour	-5.19
Skilled Labour	-5.59
Capital	-5.39
Natural Resources	-7.33
Overall, All Factors of Production	-5.63

Source: Model Simulation.

5.4. Impacts on Households' Real Income

While looking at the impact on households' real income, as it has already been indicated, circular debt brings about an increase in the domestic supply prices, loss of output, and decrease in real wages, which ultimately bring about a loss of households' real income. The findings show that all income-earning families experience similar adverse effects on their income. However, rural workers seem to have a less severe impact on their income loss than urban workers (refer to Table 9). This could be because over 40 percent of rural workers reside in areas without access to the national grid, as the World Development Indicators reported in 2019. Whatever impact these households have could be due to the negative effect on agriculture.

Table 9

Circular Debt Impact on Household Real Income

Household Types	(%) Change in Real Income	Household Types	(%) Change in Real Income
Small farmer (Quantile 1)	-4.76	Rural Non-Farm Worker (Quantile 1)	-4.75
Small farmer (Quantile 234)	-4.83	Rural Non-Farm Worker (Quantile 2)	-5.08
Medium farmer (Quantile 1)	-4.69	Rural Non-Farm Worker (Quantile 3)	-5.27
Medium farmer (Quantile 234)	-4.74	Rural Non-Farm Worker (Quantile 4)	-5.42
Landless Farmer (Quantile 1)	-4.63	Urban Worker (Quantile 1)	-4.9
Landless Farmer (Quantile 234)	-4.77	Urban Worker (Quantile 2)	-5.03
Rural Farm Worker (Quantile 1)	-4.94	Urban Worker (Quantile 3)	-5.18
Rural Farm Worker (Quantile 234)	-5.19	Urban Worker (Quantile 4)	-5.26

6. CONCLUSION AND WAY FORWARD

Pakistan's economy is struggling due to low foreign exchange reserves, high debt, rising inflation, and increased energy prices. To achieve sustainable economic growth, a stable macroeconomic environment is necessary. One of the significant issues affecting the economy is the circular debt in the power sector, which is exacerbating the existing struggles. The circular debt poses challenges for fiscal and administrative managers, as it reduces the efficiency of the macroeconomic sector. This study is conducted to estimate the impact of circular debt on the economic supply chain.

Circular debt substantially increases electricity tariffs and power outages, raising the cost of production in all sectors across the economy. For industry, it is disrupting its supply chains. The study found that the average impact of a circular debt on a manufacturing firm's production costs is 2.8 percent due to a 10 percent increase in CD-induced electricity tariffs. Additionally, these firms are losing an average of 1.6 percent of their net profits with a 10 percent increase in CD-induced electricity tariffs.

The study further estimates that the CD has caused a 0.09 percent to 0.12 percent decrease in industrial and manufacturing output at the macro level. Additionally, it has caused a considerable surge in export prices, ultimately reducing export competitiveness in foreign markets. The estimates suggest an increase in export prices of around 3.3 percent, with a 10 percent increase in circular debt. Furthermore, the CD has led to a 0.75 percent drop in the global market's comparative advantage for industrial commodities.

The study estimated the effect of circular debt on the economy using a Computed General Equilibrium model. It followed the cost of production path and simulated the

impact of a 10 percent increase in production costs on all sectors due to circular debt. The findings indicate that the 10 percent increase in production cost adversely affects the real GDP (-4.6 percent) and all major economic sectors. It is increasing fiscal deficit (7.5 percent) and trade imbalance (6.4 percent) and decreasing human welfare. The total public welfare loss due to circular debt is estimated at US$13 billion.

In short, the simulations of the model indicate that urgent corrective actions are needed to address the increasing problem of circular debt. The measures taken thus far have proved to be counterproductive.

Interestingly, circular debt's causes and consequences are the same. The accumulation of circular debt is primarily due to distribution companies' high transmission and distribution losses (DISCOs), lower recovery of the billed amount, and delays in payment of subsidies. Raising tariffs to counter CD leads to higher theft rates, lower payment recovery chances, and increased government subsidies, which the government could not pay in time, all adding to the circular debt.

Sector managers and decision-makers often seek advice from donor organisations like the World Bank, the Asian Development Bank, or the USAID. Unfortunately, these donors and our bureaucracy may not fully understand the realities on the ground, leading to a prolonged issue. Most attempts to reduce the power sector deficit have focused on raising consumer tariffs but have increased receivables and added to the circular debt.

Furthermore, frequent outages, voltage fluctuations, poor service quality, and rising tariffs can all negatively impact consumer sentiment, causing payment delays or no payments at all, which only worsens the circular debt crisis.

In FY2023, despite increasing tariffs, the financial gap reached nearly PKR 403 billion due to lower recoveries and unaccounted transmission and distribution losses. This amount was PKR 110 billion in FY2021 and PKR 292 billion in FY2022. Government officials need to understand the negative impact of tariff increases on the power system. It increases commercial losses. Although increasing consumer-end tariffs is a strategy to counter rising circular debt, it increases the production cost for various economic sectors.

The term "circular debt" has led policymakers to believe that it is simply an accounting issue when, in fact, it is a complex problem stemming from structural issues that require careful analysis.

Improvement in decision-making processes to establish a sustainable electricity sector is essential. The Power Division (bureaucracy) manages Pakistan's power sector but lacks professional management. As a result, the sector experiences operational, financial, and commercial inadequacies, inappropriate policies, and a suboptimal energy mix. The power sector has suffered significantly because of wrong decisions, approving investments in unsuitable projects, or jeopardising critical projects for personal gain or due to incompetence. Similarly, the focus is on increasing consumer tariffs (and not changing its design) without considering its potential negative impact on the sector's financials.

The suggestions below are primarily drawn from Cheema et al. (2022), Malik (2020) and Malik (2023).

The study suggests:

- Reduce the government footprint in the power sector.

- Decentralisation of power for better operational and financial management is vital. Make companies accountable for their decisions.
- Companies require innovative leadership with a commercial-minded strategy. They must be adaptable to new technologies, like pre-paid smart meters, to increase transparency in billing and manage demand while decreasing reliance on meter readers.
- Rather than privatisation, management contracts for selected areas with a defined timeline can be considered.
- The corporatisation and commercialisation should be earnestly pursued through the compulsory disclosure of not only distribution companies but also state-owned generation companies and the NTDC in the stock exchange, with a limit of 5 percent share for each shareholder. Institutional investors (pension funds) must come and run the business, and not the private conglomerates.

Although renewable energy is the way forward, more than 90 percent of power plants, regardless of whether they generate electricity or not, require capacity payments, making immediate energy transition unfeasible. Capacity payments are rising. The capacity payments have already surpassed PKR 2 trillion. Not utilising the available capacity contributes to the circular debt. Several factors limit the use of existing capacity, including fuel shortages, increased electricity prices, revenue-based load shedding, transmission constraints, and reduced economic activity. Consumers are charged for capacity through their bills, but only if they consume this energy.

- Using this capacity in productive activities (where payment is relatively more certain, e.g., industry) is crucial to prevent this amount from being added to the circular debt. That is, by offering tariffs to the productive sectors without any cross-subsidy.
- Instead of relying on revenue-based load shedding, it is essential to use technology and management with innovative ideas to address non-compliant areas and integrate them into the mainstream.
- Transmission capacity has not improved much over the years, resulting in a financial loss of PKR 20.26 billion due to system limitations in FY2023. Addressing transmission inadequacies requires immediate action.
- There is also a need to verify IPPs' claims regarding their ability to supply power. IPPs may be receiving compensation for electricity they cannot generate. It is necessary to impose a complete moratorium on new IPPs. Let the market decide about new capacity additions through competition.
- Instead of following a policy of increasing tariffs, there is a need to eliminate a uniform tariff policy. Tariffs should be non-discriminatory (without cross-subsidy) and based on total cost recovery. A flat rate is the most efficient way to maximise revenue.
- The development of a competitive electricity market and an effective regulatory framework is the ultimate solution to all problems in the power sector.

APPENDIX A

Derivation of Optimised Supply Function of a Firm

We know a profit-maximising firm wants to maximise its profits through cost minimisation by putting up a conditional demand of each input factor such as capital, and labour to produce concerned goods and services. The profit function is specified as $\pi = Revenue - costs$, while the objective function of the profit-maximising firm is outlined as follows i.e. $maxpf(X1, X2, X3) - W1X1 - W2X2 - W3X3$

Where p denotes output prices, X1 denotes the labour cost (labour implied), X2 denotes capital costs and X3 denotes the energy cost of the firm, while input prices are denoted by W1= wages, W2 =capital, W3= energy prices.

By applying the first-order conditions to obtain the optimisation conditions which are given as follows: $P\frac{\partial(X1^*, X2^*, X3^*)}{\partial X1} - W1 = 0$, $P\frac{\partial(X1^*, X2^*, X3^*)}{\partial X2} - W2 = 0$, and $P\frac{\partial(X1^*, X2^*, X3^*)}{\partial X3} - W3 = 0$. By replacing the Cobb Douglas function is given by $f(X1, X2, X3) = X_1^a X_2^b X_3^c$, we obtain the following F.O.Cs.

$$Pa\ X^{a-1}X_2^b X_3^c - W1 = 0 \ldots\ldots\ldots\ldots\ldots\ldots (3.1)$$
$$Pb\ X_1^a X_2^{b-1} X_3^c - W2 = 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.2)$$
$$Pc\ X_1^a X_2^b X_3^{c-1} - W3 = 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.3)$$

Multiplying Eq (1) by X1, Eq (2) by X2 and Eq (3) by X3.

$$Pa\ X_1^a X_2^b X_3^c - W1X1 = 0 \ldots\ldots\ldots\ldots\ldots (3.4)$$
$$Pb\ X_1^a X_2^b X_3^c - W2X2 = 0 \ldots\ldots\ldots\ldots\ldots (3.5)$$
$$Pc\ X_1^a X_2^b X_3^c - W3X3 = 0 \ldots\ldots\ldots\ldots\ldots (3.6)$$

Using $y = X_1^a X_2^b X_3^c$ to denote the level of output of the firm we write these expressions as; $Pay = W1X1$, $Pby = W2X2$, $Pcy = w3X3$. Moreover, by solving for $X1, X2, X3$ and we obtained: $X_1^* = \frac{aPy}{W1}$, $X_2^* = \frac{bPy}{W2}$, $X_3^* = \frac{cPy}{W3}$. These are the optimum level of conditional input demands which leads a firm to cot-minimisation. To obtain the optimum level of supply function, we insert these input demands into the CD production function.

$$(\frac{Pay}{W1})^a (\frac{Pby}{W2})^b (\frac{Pcy}{W3})^a = y$$

By solving it further for supply function

$$y = (\frac{Pay}{W1})^{\frac{a}{1-a-b-c}} (\frac{Pby}{W2})^{\frac{b}{1-a-b-c}} (\frac{Pcy}{W3})^{\frac{c}{1-a-b-c}}$$

The above equation shows the optimum level of output supplied which leads a firm to profit maximisation.

APPENDIX B

Variable Description and Correlation Matrix

Table B1

Variable Description

Micro-Level Variables	**Description of Variables**	**Unit**
Net profit	Total revenue minus all sorts of the costs paid by firms	Thousand PKR
Labour employed	Average number of employed people	number
Capital employed	Total expenditures on capital goods and services by a firm in the production process	Thousand PKR
Cost of goods produced	Total cost of producing goods and services by firm	Thousand PKR
Cost of energy utilisation	Share of cost of all types of energy utilisation	Ratio
Interaction of circular debt and energy cost	To see through the impacts of circular debt (CD), an interaction term of the share of cost of energy utilisation with CD is calculated.	Ratio
Macro-Level Variables	**Description of Variables**	**Unit**
Industrial output	Industrial value added (%) GDP	(%)
Manufacturing output	Manufacturing value added (%) GDP	(%)
Manufacturing export	Share of manufacturing export to total export	(%)
Export prices	Export unit value index (2015=100). It can be taken as a proxy of export competitiveness as well	Index
Comparative advantage	Revealed Comparative Advantage (RCA) for the industrial sector is taken from UNCTD, which is the proxy of export competitiveness as well. If RCA >1, it means the country has a comparative advantage, and vice versa.	Index
Industrial tariffs	Industrial electricity tariffs is collected from the government reports	PKR
Circular debt (CD)	Binary variable conceding value 1 for the period of persistence of circular debt (since 2006 to 2022), while 0 for having on circular debt (before 2006 such as 1990 to 2005).	Binary
Other macro variables	It includes, real GDP, inflation, real exchange rate, term of trade, and trade restriction. These variables are collected from WDI and UNCTD.	

Pairwise Correlation Matrix

According to the pairwise correlation analysis, circular debt (CD) has a strong and statistically significant correlation with overall average electricity tariff, industrial tariff, industrial output, export prices, and manufacturing export. The signs of all correlation coefficients align with the earlier discussion. These findings provide insight into the negative impact of CD on industrial development, such as the reduction of industrial and manufacturing output and a decline in export competitiveness.

Table B2

Correlations Matrix: Circular Debt, Electricity Tariff, and Industrial Development

	CD	Average Elect. Tariff	Industrial Elect. Tariff	Industrial Output	Manufac. Output	Export Prices	Manufac. Export
CD	1.000						
Average Elect. Tariff	0.930*	1.000					
Industrial Elect. Tariff	0.909*	0.966*	1.000				
Industrial Output	-0.642*	-0.707*	-0.647*	1.000			
Manufac. Output	-0.699*	-0.752*	-0.643*	0.960*	1.000		
Export Prices	0.407*	0.553*	0.478*	-0.553*	-0.473*	1.000	
Manufac. Export	-0.570*	-0.605*	-0.623*	0.579*	0.499*	-0.711*	1.000

Note: * p<0.1: all coefficients are statistically significant at less than or equal to 10 percent significance level.

APPENDIX C

GTAP Model

The Global Trade Analysis Project (GTAP) framework is a structured global economy model that depicts various economic agents and sectors. It includes households, governments, industrial sectors, and a global sector. Together, they represent the complex interactions among countries and regions in the global economy through international trade (Hertel, 1997).

Both factor and goods markets carefully track prices and quantities. Skilled and unskilled labour, capital, natural resources, and land are the major factors of production in the GTAP model. Firms working under this system follow the rule of constant returns to scale, meaning their production processes remain consistent no matter the size of their operations. Technological factors are determined through established mathematical functions like the Leontief and CES functions. The production process in these companies happens in two distinct phases.

Initially, firms determine the optimal combination of intermediate inputs and primary factors of production to minimise costs. They follow the principles of a Leontief production function, a fundamental concept in production theory. During the later production stage, imported and domestic goods are used as intermediate inputs to create

final goods. Policy changes can affect the prices of imported and domestically produced commodities, impacting the overall economic landscape (Birur et al., 2015).

Central to the GTAP model is the concept of the Armington elasticity, a critical relationship for analysing the model. The Armington structure posits that locally produced and imported goods are not perfect substitutes, capturing the idea that consumers may prefer one. This assumption plays a critical role in understanding how changes in a policy or external factors affect the choices made by economic agents.

As mentioned in Corang et al. (2017), the GTAP model is based on an input-output accounting framework, which accounts for all sources and uses of each economic good and all inputs used in production. Every cost incurred or benefit obtained is also considered as the usage of specific products or primary factors. It is important to note that the completeness of the framework refers to its theoretical model rather than its representation of the world. GTAP is thriving as a generic broad-based general equilibrium model.

GTAP is a general equilibrium model different from partial equilibrium models as it does not focus on one specific sector or a small group of sectors. Also, it differs from macroeconomic models as it does not treat all production and consumption as a single good or a few stylised goods. Instead, it represents an economy of multiple goods produced by various sectors (Corang et al., 2017).

MyGTAP model

The multi-sector and multi-region CGE model has been adapted using a newly developed MyGTAP model (Walmsley & Minor, 2013), an extension of a standard GTAP model. This model captures the interlinkages of factors, prices, and markets (Minor & Mureverwi, 2013). The standard GTAP model features a single regional household that represents both private households and government entities. However, a notable limitation of this standard model is its inability to discern the distinct impacts of a policy on the income and expenditure of the government and private households separately. There is a potential scenario where a policy might increase government income while simultaneously decreasing private household income. In such cases, the reported increase or decrease in regional household income may be misleading. The MyGTAP model addresses this gap by allowing the separation of government identity from private households. Additionally, it offers the flexibility to incorporate multiple household and factor types, thereby enabling a more nuanced analysis of the comprehensive linkages between various households and the government within the economic standard model, (Corong *et al.,* 2017).

Model Closure and Decomposition of Regional Welfare

The study used the equivalent variation method to measure welfare decomposition, documented in Huff and Hertel's (1996) research. Rather than relying on the expenditure function of regional households, the method involves analysing changes in terms of trade and various sources of efficiency. The following equation can express the equivalent variation measure as:

$$EV_s = (\Psi_s)\begin{Bmatrix} \sum_{i=1}^{N} \sum_{r=1}^{R}(\tau_{Mirs}\, PCIF_{irs}\, dQMS_{irs}) \\ +\sum_{i=1}^{N}(\tau_{CDis}\, PD_{is}\, dQD_{is}) \\ +\sum_{i=1}^{N}(\tau_{CMis}\, PM_{is}\, dQM_{is}) \\ +\sum_{i=1}^{N}(\tau_{Ois}\, PD_{is}\, dQO_{is}) \\ +\sum_{i=1}^{N} \sum_{r=1}^{R}(\, QMS_{irs}\, dPFOB_{irs}) \\ -\sum_{i=1}^{N} \sum_{r=1}^{R}(\, QMS_{irs}\, dPCIF_{irs}) \end{Bmatrix}$$

The first four expressions on the right side of the equation represent the variations in resource utilisation efficiency across different sectors. These changes result from the interplay between tariffs/subsidy distortion and the corresponding quantities. The last two terms relate to the impact of terms of trade (ToT) on the regions.

To solve the model, the exogenous variable must match the endogenous variables. The model is considered closed when all markets are balanced, with no real profits being made by firms and consumers staying within their budget constraints. It is also assumed that employment is at full capacity. If scenarios change, the model parameters will shift from their original state to a new equilibrium level. This shift in equilibrium level indicates the impact of a specific shock (circular debt shock).

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