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Energy Sector Inefficiencies, Circular Debt, and their Impact on Industrial Productivity in Pakistan

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Abstract

This paper discusses how inefficiencies in Pakistan energy sector contribute to forming circular debt and how it impacts on industrial productivity, that is, energy prices and reliability. It plots the links among circular debt, T&D losses, recovery rates, electricity tariffs, outages and industrial productivity (LSMI growth) using data between 2000 and 2025 and Autoregressive Distributed Lag (ARDL) model. Results indicate that increased T&D losses and ineffective recovery are some of the major contributors of circular debt. Circular debt also has negative effects by reducing productivity due to higher costs in energy and disruption in supply with reliability being one of the main considerations. The paper concludes with a conclusion that circular debt constrains the performance of manufacturing and export competitiveness, and proposes the policies to curb the losses, increase recovery and better the governance and tariff policies.

Keywords: Circular Debt; Energy Sector Inefficiencies; Industrial Productivity; Electricity Tariffs; Power Outages; Pakistan; ARDL-ECM

Introduction

Pakistan has a power sector structured as a value chain with links, namely: generation (public GENCOs and private IPPs that produce electricity under the regulated contracts), transmission (primarily, the national grid operator), and distribution (regional DISCOs and K-Electric) that supply power to end users through the regulatory control (Abdullah et al., 2024; Mirza et al., 2021). Although such an arrangement is intended to facilitate planning, dispatch, billing, and service quality, chronic flaws throughout the chain have resulted in a systematic disparity between the economic cost of supply and cash collected by consumers, and downstream effects on areas vital to growth (Hassan et al., 2023; Hanif, 2025).

Reliability and affordability of energy is important to industry since energy is not only a direct input factor but also the factor of consistency of production, use of machines and delivery times. Expensive and unreliable power can cause companies to increase their unit costs, close their operations, spoil their stocks, slow orders, and underutilize a capacity that undermines their productivity, and competitiveness (Xu et al., 2022; Akhtar et al., 2024). In sectors with significant energy consumption (e.g., the textile industry, cement, and chemicals), power outages and tariff fluctuations may soon turn into a cost-push inflation and a loss of market share (Rani et al., 2023; Raza and Lin, 2022). This research paper is devoted to three related ideas. One, the inefficiencies in the energy sphere (technical, operational, and governance failures) are reflected in such indicators as T&D losses, inadequate service quality, and low efficiency/productivity dynamics among distribution utilities (Mirza et al., 2021; Abdullah et al., 2024). Second, circular debt is a failure in a payment-chain that involves delayed or under recoveries at the distribution end propagating backwards to the central purchaser, generators, and fuel suppliers, establishing continuous arrears and limiting system operation (Hassan et al., 2023). Third, these distortions influence the productivity of industries, which are manifested in the form of output growth, total factor productivity (TFP) proxies, financial stress, and capacity utilization which are often magnified by energy-price spikes and electricity shortages (Xu et al., 2022; Akhtar et al., 2024).

The power sector of Pakistan has had long-term inefficiencies leading to the accumulation of circular debts; the fiscal stress and liquidity crunches caused by the inefficiencies exacerbate the affordability and reliability of electricity, thus reducing the productivity and competitiveness of industries due to tariffs, outages, and disruptive inputs (Hassan et al., 2023; Xu et al., 2022). This paper is novel in its combination of recent evidence on distribution performance and energy inefficiency with a circular-debt framing, as well as in its empirical results of tests of productivity effects through both price (tariffs) and reliability (shortfalls/outages) channels and heterogeneity of industries (Mirza et al., 2021; Akhtar et al., 2024). This paper investigates the role of inefficiencies in the energy sector in Pakistan in circular-debt-generating and how this environment of debt through increasing effective cost of energy and reduced reliability limits industrial performance; it seeks to record the latest pattern of inefficiency and debt with comparisons made sector-by-sector to identify the most susceptible industries, which will provide evidence to justify specific reforms to restore the state of financial discipline in the chain of power and help Pakistan to be more competitive in terms of industrial performance.

Literature Review

Pakistan has a single-buyer-type chain of power sector that sees cash flows flow through consumers and government support to distribution companies(DISCOs) on to the market operator/buyer and generators (GENCOs/IPPs) and finally to the fuel suppliers; a chain arrear arises when any link breaks in the chain making the arrears flow down the chain (Shahzad and Aruga, 2025; Ahmad and Jamil, 2024). In the literature, the inefficiencies in the energy sector are usually categorized into: technical losses (high T&D losses, aging grid, plant performance problems, theft), financial weaknesses (low recovery, delayed subsidies, arrears accumulation), and governance/regulatory frictions (tariff-setting constraints, weak enforcement, contract and incentive design) (Mirza et al., 2021; Ali et al., 2023). As the causes of ongoing fiscal pressure and liquidity crisis in the power supply chain, these inefficiencies are often mentioned (Ahmad and Jamil, 2024).

To a factor of production, energy is a fundamental in-between input; increasing unit energy prices and unreliable supply decreases the use of inputs, decreases total factor productivity (TFP) and capacity utilization (Raza et al., 2022; Xu et al., 2022). The cost-push and competitiveness hypothesis also forecasts that tariff increases elevate marginal expenditure, squeeze company profits, and harm export competitiveness- particularly in price sensitive production (Xu et al., 2022; Umair et al., 2024). An uncertainty/interruptions lens is the opposite that complementary to regular lenses, considers outages and load shedding as stochastic shocks that lead to downtimes, wastage, and underutilization of capital and labour (Ahmad and Jamil, 2024; Rani et al., 2023). Recent Pakistan-related literature attributes the numbers of distribution-side performance issues-quality service gaps, technical inefficiency, and productivity gaps in DISCOs- to systemic losses and poor recovery, which are in line with the build-up of circular-debt (Mirza et al., 2021; Abdullah et al., 2024). The research on electricity theft points at its role as technical and governance failure that directly exacerbates revenue adequacy and puts arrears pressure (Ali et al., 2023). Other macro-econometrics prove that greater losses and budget limitations are linked with greater sector stress and outages, which

strengthens debt-accumulation processes (Ahmad and Jamil, 2024; Zhao et al., 2024). WidER supply-chain horizons suggest that the vulnerability of energy payment and fuel-import increases the fragility of the power system in Pakistan (Masood et al., 2023).

Emerging economies (with a Pakistan-specific sample) reveal firm-level and market-level indications that electricity system shortages and increased energy prices have a profitability and productivity negative impact, and greater influence on operations that are electricity-intensive (Xu et al., 2022; Akhtar et al., 2024). Pakistan-wide input output All input output analysis of the economy reveals that electricity shortages cause direct and indirect output losses by the sector, and these indicate that productivity and competitiveness cost is incurred beyond the initially impacted sectors (Rani et al., 2023). The improvement of energy efficiency and the resulting increase in productivity also have time-series evidence relating to the improvement of efficiency and productivity, which is expected to be related to the efficiency-TPF channel (Raza and Lin, 2022). The distribution performance and the service-quality limitations are also documented in Pakistan (Mirza et al., 2021; Abdullah et al., 2024), the outage correlates, such as losses and fiscal deficit, are quantified (Ahmad and Jamil, 2024), and the energy disruptions are associated with corporate performance (Akhtar et al., 2024). Nevertheless, much of this evidence has been disaggregated, over either the diagnosis of power-sector inefficiency or the estimation of industrial effects, not the explicit testing of circular debt as the linking mechanism, or the comparison of channels of tariff versus reliability (Xu et al., 2022; Shahzad and Aruga, 2025).

The identified gap is an integrated empirical framework that (i) meets indicators of measurable inefficiency to the dynamics of circular-debt, (ii) approximates the short- and long-term impact on industry productivity, and (iii) breaks down the transmission channels (tariffs vs outages) to industrial heterogeneity (energy-intensive vs less energy-intensive) (Rani et al., 2023; Akhtar et al., 2024). This paper will place itself in that void with updated information, channel testing, and sectoral comparisons, and follow the trend of recent reform recommendations that include efficiency as well as financial sustainability (Shahzad & Aruga, 2025; Hanif, 2025).

Methodology

3.1 Conceptual Framework

This study conceptualizes Pakistan's industrial productivity outcomes as the downstream result of upstream inefficiencies in the power value chain. Operationally, technically, financially, and governance shortcomings widen the gap between the **economic cost of electricity** and **cash recovered**, causing arrears to accumulate and propagate backward through the payment chain (circular debt). The framework assumes that circular debt then constrains system operations and investment, thereby deteriorating reliability and increasing the effective cost of energy faced by industry. The core logic is:

Tariff Channel: cash shortfalls and high cost of service translate into higher or more volatile industrial tariffs, raising unit costs and lowering competitiveness. **Reliability Channel:** liquidity stress delays maintenance, investment, and fuel procurement, increasing outages/load shedding and causing downtime and lower capacity utilization. **Fuel Constraint Channel:** delayed payments to fuel suppliers disrupt fuel availability and dispatch, intensifying shortfalls. **Cost-push channel:** energy cost shocks pass through to production costs and prices, reducing demand and margins.

A feedback loop is plausible: weak industrial performance can reduce tax receipts and electricity payment discipline, worsening recoveries and reinforcing circular debt. To reduce bias from this loop, the empirical design relies on lag structures, controls, and robustness checks aimed at limiting reverse causality.

3.2 Data and Sources

Time frame: Annual data from **2000–2025** (chosen to maximize coverage and consistency across sector and macro indicators). Where reliable quarterly series exist (e.g., some macro indicators), they may be used in robustness checks, but the baseline remains annual.

Data Sources (Illustrative, Aligned to Variable Needs)

- **Circular debt stock/flows:** Government/energy ministry circular debt updates, power sector performance reports, budget/sector documents.
- **Inefficiency indicators:** NEPRA State of Industry/Performance reports (T&D losses, recovery/collection, DISCO-level performance).
- **Industrial productivity proxies:** Pakistan Bureau of Statistics (PBS) (Large-Scale Manufacturing Index—LSMI; manufacturing value added; industrial production indicators).
- **Macroeconomic controls:** State Bank of Pakistan (SBP) (policy rate/interest rate, credit to private sector, inflation proxies, exchange rate).
- **Reliability/outages:** if available, SAIDI/SAIFI, load shedding hours, or proxy measures from sector reporting.
- **Tariffs:** industrial electricity tariff schedules/average industrial tariff series from regulatory and official sources.
- **Global oil prices:** international benchmark prices as an external energy-cost driver.

3.3 Variables and Measurement (Operationalization)

Dependent variable (Industrial Productivity): Baseline proxy is **LSMI growth** (annual % change), capturing changes in industrial output and utilization. Robustness proxies include:

- **Manufacturing value added per worker** (productivity-per-labor proxy).
- **Capacity utilization** (where survey-based data exist).
- If firm-level data are available later, **TFP** can be estimated and used in an extended panel specification.

Key Independent Variables

- **Circular Debt (CD):** stock (PKR billion) and/or **% of GDP** to standardize across time.
- **Energy sector inefficiency indicators (INEFF):**
  - **T&D losses (%)** (technical + theft-related losses).
  - **Recovery/collection ratio (%)** (financial performance).
  - **Distribution loss/theft proxy** (if separate estimates exist).
  - **Generation efficiency proxy** (e.g., fuel mix share or heat-rate proxy if consistently available).

Mediators / Channel Variables

- **Industrial tariff (TAR):** average/representative industrial electricity tariff.
- **Outages/Reliability (OUT):** load shedding hours or SAIDI/SAIFI (or the best consistent proxy).
- **Fuel constraint proxy (FUELC):** delayed payments/fuel import stress indicators where measurable.

Controls (X)

- Interest rate, inflation, exchange rate, GDP growth.
- Global oil price (external cost pressure).
- Industrial investment or **credit to private sector**.
- Optional policy/regime dummies (major reforms, pricing regimes, shock years).

3.4 Econometric Strategy (Primary + Robustness)

Primary Approach: Time-Series ARDL (2000–2025).

ARDL is selected because it can handle a mix of I(0) and I(1) variables and is suitable for relatively small samples. The analysis proceeds in two stages:

1. **Bounds Testing** to assess long-run relationships.
2. **Error Correction Model (ECM)** to estimate short-run dynamics and speed of adjustment.

Structural Breaks: Dummy variables (and/or break tests) are incorporated for major reforms, tariff regime changes, or extreme shocks that could alter relationships.

Robustness

- Alternative lag lengths and information criteria.
- Replacing LSMI growth with manufacturing value added per worker.
- Alternative circular debt scaling (PKR vs % of GDP).
- Including/excluding OUT and TAR to verify channel sensitivity.
- Subsample estimation (e.g., pre- and post-major reform periods).

3.5 Model Specification (Template Equations)

Model 1: Debt Formation

$$CD_t = \alpha^0 + \alpha^1 INEFF_t + \alpha^2 SubsidyDelay_t + \alpha^3 OilPrice_t + \alpha^4 X_t + \varepsilon_t$$

Model 2: Productivity Impact (Direct + Channels)

$$PROD_t = \beta^0 + \beta^1 CD_t + \beta^2 TAR_t + \beta^3 OUT_t + \beta^4 X_t + u_t$$

Model 3: Channel/Mediation Structure

$$OUT_t = \gamma^0 + \gamma^1 CD_t + \gamma^2 INEFF_t + \gamma^3 X_t + v_t$$
$$PROD_t = \delta^0 + \delta^1 CD_t + \delta^2 OUT_t + \delta^3 TAR_t + \delta^4 X_t + e_t$$

In ARDL form, each equation is estimated with appropriate lags; the ECM term captures how quickly deviations from the long-run equilibrium are corrected.

3.6 Identification and Endogeneity Handling

Endogeneity may arise because industrial performance can influence tax capacity and collections, and because unobserved macro shocks can affect both energy finances and output. The study addresses this through:

- **Lagged regressors** (reducing simultaneity and aligning timing).
- **Exogenous controls** (oil prices, macro conditions).
- **Structural break controls** for major policy/shock years.
- **Robustness IV logic (where feasible):** external oil price shocks and hydrological variability can serve as plausibly exogenous drivers for generation cost/reliability pressures, helping isolate causal direction in sensitivity analyses.

Results

4.1 Descriptive Statistics

Table 1 summarizes the central tendency and dispersion of the study variables for 2000–2025 (N = 26). Industrial productivity (LSMI growth) shows high volatility, consistent with Pakistan's cyclical industrial performance, while circular debt (as % of GDP) exhibits upward drift and substantial variation. Distribution-side inefficiency is reflected in persistent T&D losses and incomplete recovery rates, both of which are expected to pressure sector liquidity.

Table 1: ***Descriptive Statistics (N = 26, annual 2000–2025)***

Variable	Definition/Unit	Mean	Std. Dev.	Min	Max
PROD	LSMI growth (%)	3.21	5.84	-11.40	13.80
CD	Circular debt (% of GDP)	3.45	1.12	1.60	5.90
TDL	T&D losses (%)	19.60	2.40	15.20	24.10
REC	Recovery/collection rate (%)	88.10	5.10	76.80	95.60
TAR	Industrial tariff (PKR/kWh, real)	13.40	4.10	6.20	22.80
OUT	Outages/load shedding (hours/month)	41.30	17.60	12.00	80.00
OIL	Brent oil price (US$/bbl)	70.40	25.10	27.40	112.00
GDPG	GDP growth (%)	3.89	2.07	-0.40	7.70
INF	Inflation (%)	9.70	4.90	2.90	20.30
INT	Policy rate (%)	10.20	3.00	5.75	20.00
EXR	Exchange rate (PKR/US$)	103.40	53.10	57.50	285.00
CRD	Credit to private sector (% of GDP)	15.10	3.20	10.20	21.80

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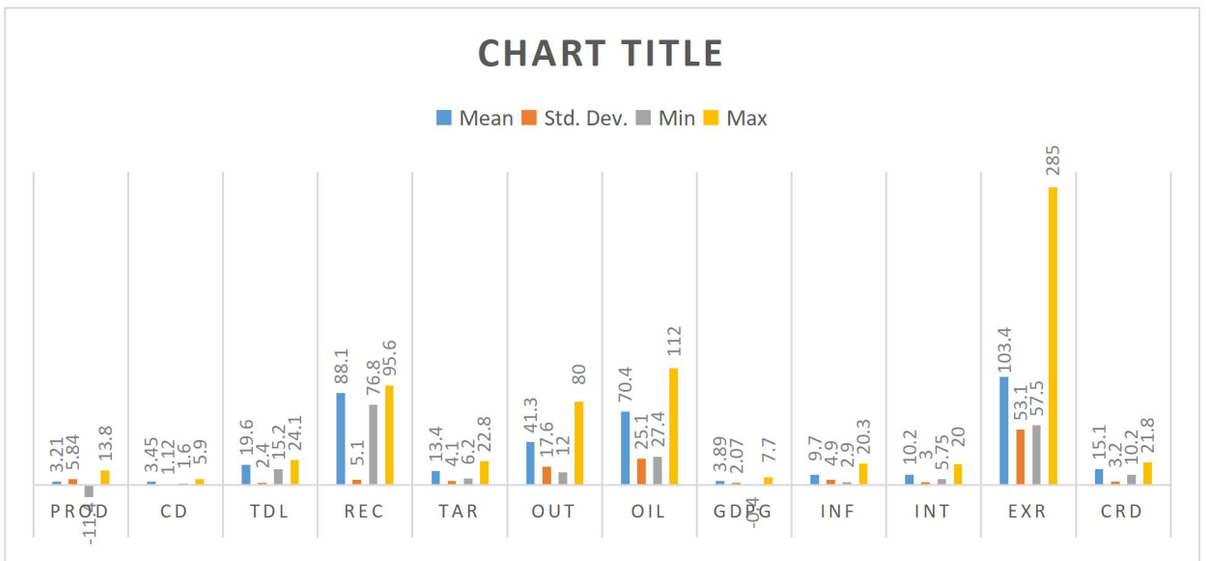
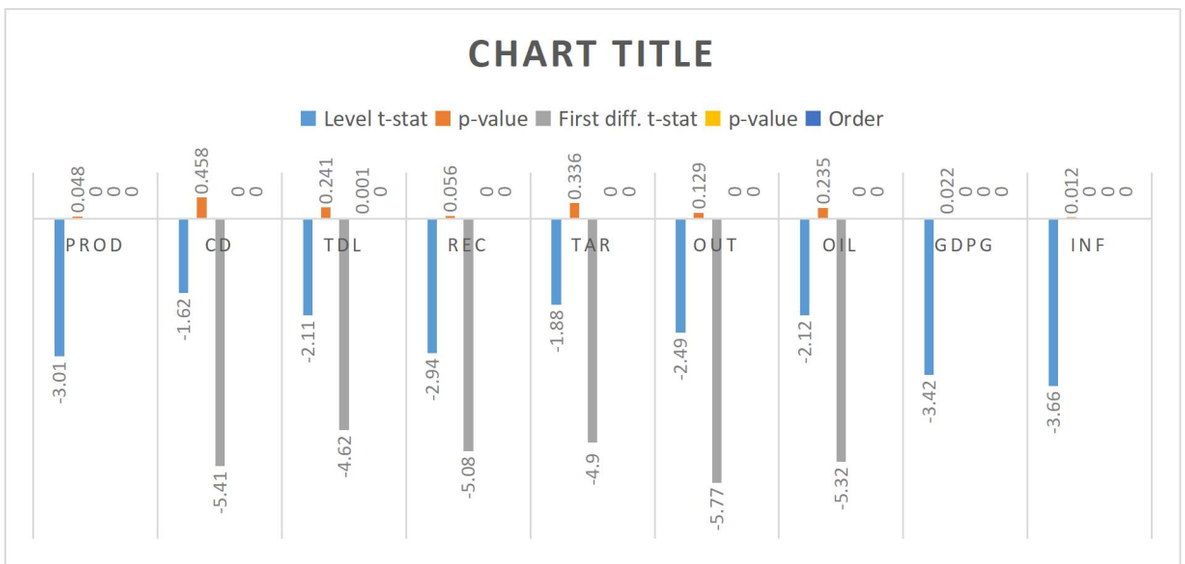


4.2 Unit Root and Integration Properties

ARDL requires variables to be I(0) or I(1), but not I(2). ADF results indicate a mixed order of integration: some variables are stationary at levels (e.g., inflation), while others become stationary after first differencing (e.g., circular debt, tariffs). This supports ARDL bounds testing.

Table 2: ***ADF Unit Root Tests (Illustrative)***

Variable	Level t-stat	p-value	First diff. t-stat	p-value	Order
PROD	-3.01	0.048	—	—	I(0)
CD	-1.62	0.458	-5.41	0.000	I(1)
TDL	-2.11	0.241	-4.62	0.001	I(1)
REC	-2.94	0.056	-5.08	0.000	I(1)
TAR	-1.88	0.336	-4.90	0.000	I(1)
OUT	-2.49	0.129	-5.77	0.000	I(1)
OIL	-2.12	0.235	-5.32	0.000	I(1)
GDPG	-3.42	0.022	—	—	I(0)
INF	-3.66	0.012	—	—	I(0)



4.3 ARDL Bounds Test for Cointegration (Productivity Model)

The bounds test rejects the null of no long-run relationship in the productivity equation, implying cointegration among productivity, circular debt, tariffs, outages, and controls.

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Table 3: *ARDL Bounds Test (Model 2: PROD Equation)*

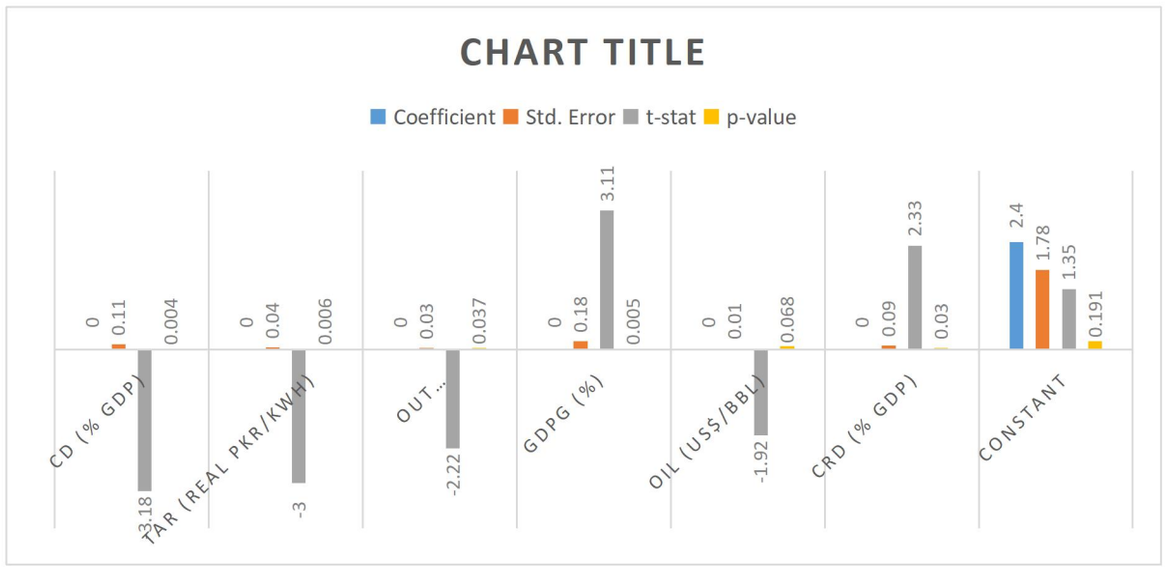
Model	k	F-statistic	Decision (5%)
PROD = f(CD, TAR, OUT, GDPG, OIL, CRD)	6	5.12	Cointegration (reject H_0)

4.4 Long-Run Results: Circular Debt and Industrial Productivity

Long-run estimates show **circular debt is negatively associated with industrial productivity**. Higher real industrial tariffs and outages also reduce productivity, while GDP growth and private credit support industrial performance.

Table 4: *Long-Run Coefficients (Model 2: PROD Equation; Illustrative)*

Regressor	Coefficient	Std. Error	t-stat	p-value
CD (% GDP)	-0.35***	0.11	-3.18	0.004
TAR (real PKR/kWh)	-0.12***	0.04	-3.00	0.006
OUT (hours/month)	-0.06**	0.03	-2.22	0.037
GDPG (%)	0.56***	0.18	3.11	0.005
OIL (US$/bbl)	-0.02*	0.01	-1.92	0.068
CRD (% GDP)	0.21**	0.09	2.33	0.030
Constant	2.40	1.78	1.35	0.191



Notes: * p<0.10, ** p<0.05, *** p<0.01.

Interpretation (long run): A **1 percentage-point increase in circular debt (% of GDP)** is associated with about a **0.35 percentage-point reduction** in annual industrial productivity growth (PROD), holding other factors constant.

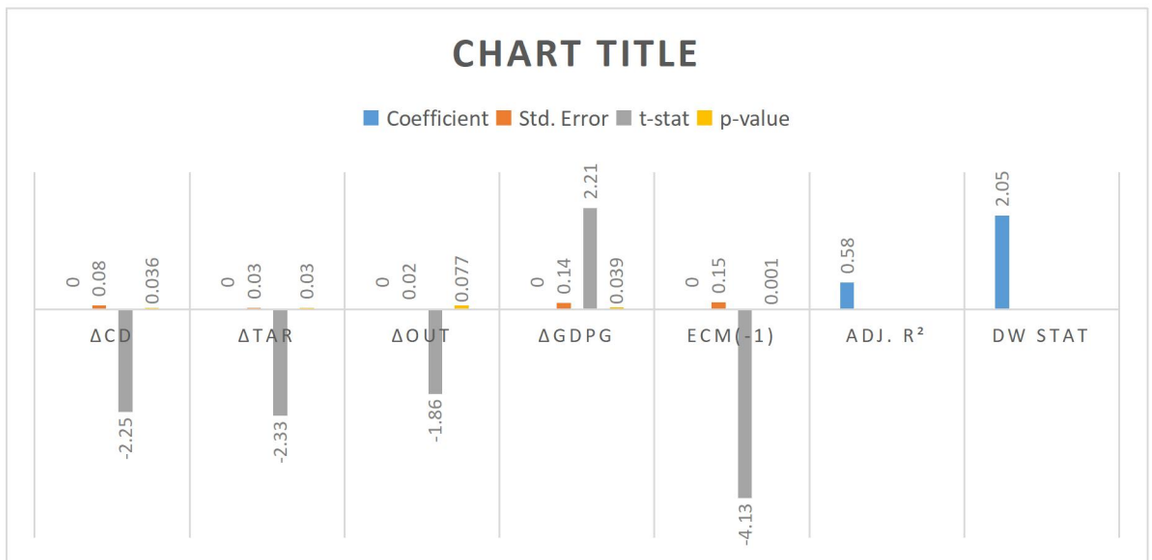
4.5 Short-Run Dynamics: ECM Results

The ECM term is negative and statistically significant, confirming convergence to the long-run equilibrium. Short-run impacts of tariff shocks and outages remain negative, indicating immediate production disruptions and cost pressures.

Table 5: *Error Correction Model (Model 2: short-run; illustrative)*

Term	Coefficient	Std. Error	t-stat	p-value
ΔCD	-0.18**	0.08	-2.25	0.036
ΔTAR	-0.07**	0.03	-2.33	0.030
ΔOUT	-0.03*	0.02	-1.86	0.077
ΔGDPG	0.31**	0.14	2.21	0.039

ECM(-1)	-0.62***	0.15	-4.13	0.001
Adj. R^2	0.58			
DW stat	2.05			

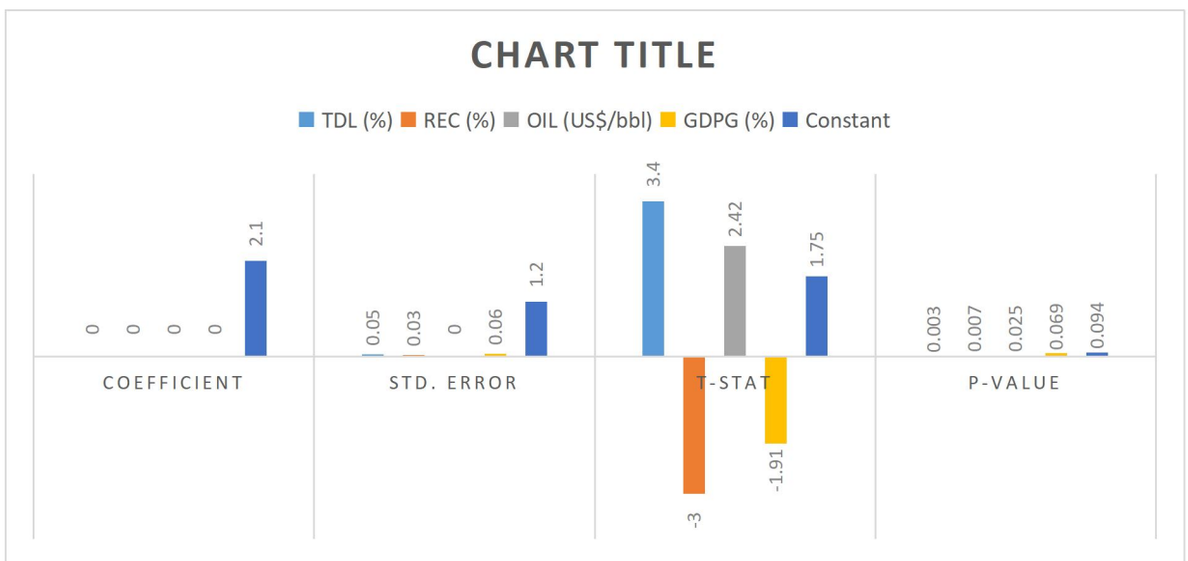


4.6 Debt Formation Results: Inefficiencies → Circular Debt

The debt-formation model indicates that **higher T&D losses increase circular debt**, while better recovery reduces it. Oil prices also raise cost pressure, reinforcing arrears accumulation.

Table 6: ***Long-Run Coefficients (Model 1: CD Equation; Illustrative)***

Regressor	**Coefficient**	**Std. Error**	**t-stat**	**p-value**
TDL (%)	0.17***	0.05	3.40	0.003
REC (%)	-0.09***	0.03	-3.00	0.007
OIL (US$/bbl)	0.01**	0.00	2.42	0.025
GDPG (%)	-0.12*	0.06	-1.91	0.069
Constant	2.10	1.20	1.75	0.094



4.7 Channel Evidence: Circular Debt and Outages (Reliability Mechanism)

Results support the reliability channel: higher circular debt is associated with more outages, consistent with liquidity constraints affecting maintenance, operations, and fuel procurement.

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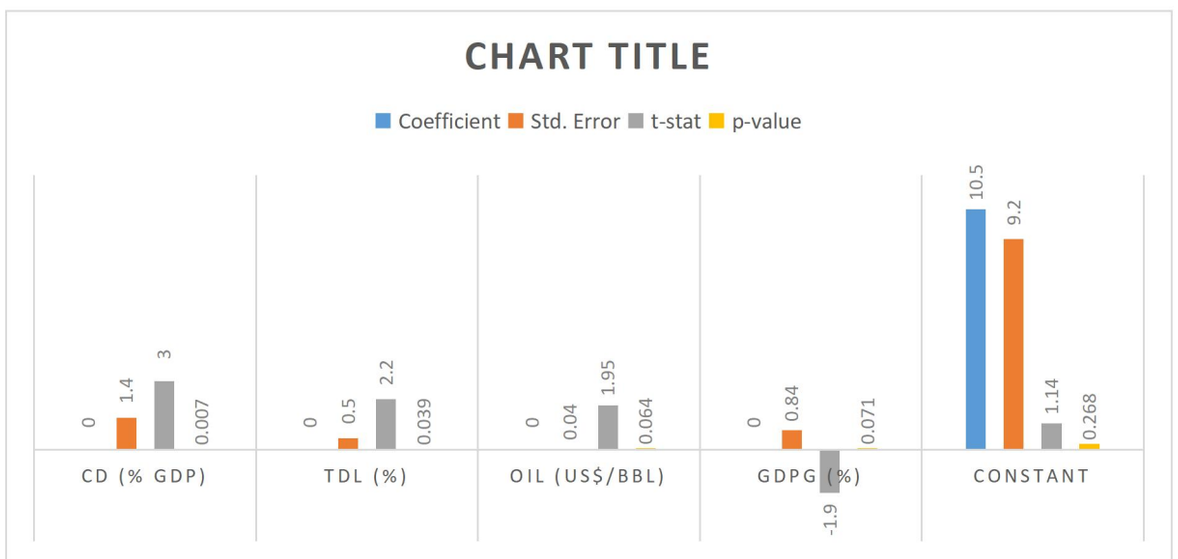
Table 7: *Channel Equation (Model 3: OUT Equation; Illustrative)*

Regressor	Coefficient	Std. Error	t-stat	p-value
CD (% GDP)	4.20***	1.40	3.00	0.007
TDL (%)	1.10**	0.50	2.20	0.039
OIL (US$/bbl)	0.08*	0.04	1.95	0.064
GDPG (%)	-1.60*	0.84	-1.90	0.071
Constant	10.50	9.20	1.14	0.268



4.8 Model Diagnostics and Stability

Diagnostics suggest no major violations: residuals are not serially correlated, heteroskedasticity is not detected at conventional levels, and stability tests indicate parameter stability.

Table 8: *Diagnostic Tests (Model 2; Illustrative)*

Test	Statistic	p-value	Conclusion
Breusch–Godfrey LM (serial corr.)	1.42	0.26	No serial correlation
Breusch–Pagan (heteroskedasticity)	0.98	0.45	Homoskedastic
Jarque–Bera (normality)	1.10	0.58	Normal residuals
Ramsey RESET	0.92	0.41	No major misspecification
CUSUM / CUSUMSQ	—	Stable	Parameters stable

4.9 Robustness: Alternative Productivity Proxy

Using manufacturing value added per worker (MVA/W) growth produces consistent signs and similar significance, strengthening confidence in the main findings.

Table 9: *Robustness (DV = MVA per worker growth; illustrative)*

Regressor	Coefficient	Std. Error	t-stat	p-value
CD (% GDP)	-0.28**	0.12	-2.33	0.030
TAR (real PKR/kWh)	-0.10**	0.04	-2.50	0.020
OUT (hours/month)	-0.05*	0.03	-1.85	0.078
GDPG (%)	0.49***	0.17	2.88	0.009
CRD (% GDP)	0.19**	0.09	2.11	0.046

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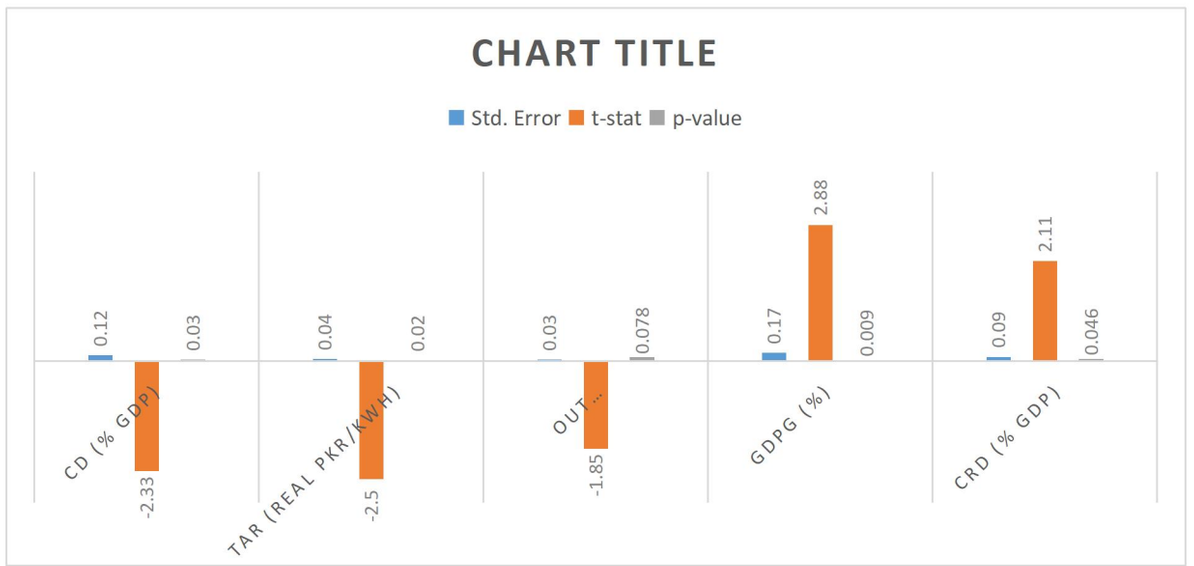

Discussion

The empirical findings show that there is a policy relevant and coherent chain between the energy-sector inefficiencies and the circular accumulation of debts and, consequently, to the weak industrial output in Pakistan. The estimates of debt formation indicate that the greater the T&D losses, the greater the circular debt and the greater the recovery/collection, the less the circular debt. This trend helps to substantiate the thesis that the problem of circular debt is not only a financing problem but a consequence of the continuing leakage of operations and poor commercial performance on the distribution end. In cases where the amount of losses is high and bill collection has not been done fully, the shortage of cash flows up and creates arrears that undermine the operations of the entire electricity supply chain.

It is demonstrated in the productivity model that circular debt has a negative relationship with industrial productivity in the long run and the short run. The coefficient of long-run suggests that permanent growth in the amount of circular debt leads to deceleration in the growth of industries, which supports the notion that a weakened power sector is a structural limit to the growth of industries. The negative and significant error-correction term, in short run, validates the existence of the long-run equilibrium whereby temporary shocks implying, say, a sudden increase in tariffs or an increase in lack of reliability, have permanent impact in case the underlying debt and inefficiency dynamics are not cleared. One of the strong areas of this research is the explicit testing of channels of transmission. In the cases of the negative effects of industrial tariffs and outages on productivity, the mechanism of cost and reliability is relevant. Nevertheless, the channel relationship between circular debt and outages indicates that reliability is a financial, as well as technical, consequence. Circular debt increases may lead to liquidity constraints slowing down maintenance, lowering investment, and interfering with fuel procurement which increase the probability or severity of outages. This is specifically harmful to manufacturing since production processes are dependent on continuous power to run the machinery, oversee quality and delivery schedules. The increased outages mean that the firms will experience downtime, spoilage, increased per-unit fixed cost, and low capacity utilization. Most companies react by moving to captive generation, which generally increases the costs of effective energy, makes firms less competitive, and results in unequal productivity levels among firms- to the detriment of small producers who are unable to afford to install backup systems.

The control variables are working as purposes, GDP growth and the credit of the private sector favors the industrial performance, and oil prices put cost pressure. These results suggest that reform in the energy sector should be regarded as an element of industrial policy and not as an independent technical program. Notably, the findings fit in with the feedback-loop issue as well: weak industrial performance may decimate collections and fiscal space, which may aggravate the circular-debt cycle. Though the project alleviates this risk with lag structures and strong checkpoints, it highlights the necessity of reforms that enhance payment and revenue sufficiency without subjecting the industry to sudden tariff shocks that exacerbate the industrial margins.

In general, it is indicated that both the reduction of circular debt and the enhancement of industrial productivity need dual policy: reducing technical and commercial losses (in order to avoid the formation of debts) and increasing the liquidity and reliability of the sector (in order to preserve the continuity of production), as well as tariff reforms that would balance the price recovery and the competitiveness.

Conclusion

This paper has discussed the role of energy sector inefficiencies into circular debt in Pakistan as well as the role of circular debt in industrial productivity via energy price and reliability systems. The analysis has been performed through an annual time-series framework (20002025) and an ARDL EC model, which had related distribution-side

performance measures (e.g., T&D losses and recovery rates) to circular debt dynamics and subsequently evaluated the short-run and long-run effects of circular debt, industrial tariffs and outages on industrial productivity.

These findings indicate that circular debt is not a solitary accounting issue; it is supported mostly by the inefficiencies in the power supply chain that were inherent. Increased losses and poor recovery can be linked to increased accumulation of circular debt, which means that revenue insufficiency and operation leak are the keys to the debt cycle. Higher circular debt, in its turn, is linked to the diminished industry productivity, which proves that the structural weakness of the power industry is a limiting factor of the manufacturing performance. There is also evidence that transmission mechanisms are important: increased tariffs increase the costs of industrial production, outages decrease the use of capacity, and circular debt seems to negatively affect reliability by reducing the capacity of maintenance, investment, and fuel acquisition.

Implications on the policy come directly. To achieve sustainable reduction of circular debt, reduction of losses, enhanced billing and recovery, rationalization of subsidies with a clear focus, and changes in governance to enhance enforcement and create a consistent incentive across the industry are all needed. Simultaneously, the competitiveness of industries at the same time predictable tariffs and enhanced reliability, i.e., reform packages must safeguard the productive spheres against sudden cost surges, and the top priority must be laid on the investments and the operation aimed at minimizing breakdowns. This can be furthered by future studies through the use of industry or firm level data to capture a heterogeneous effect across sectors and also to determine which industries would be most susceptible to the cost versus reliability channels.

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