Journal of Information Systems Engineering and Management
2025, 10(42s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Indian Inorganic Chemical Industry: A Profitability Study

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ARTICLE INFO

Received: 30 Dec 2024
Revised: 12 Feb 2025
Accepted: 26 Feb 2025

ABSTRACT

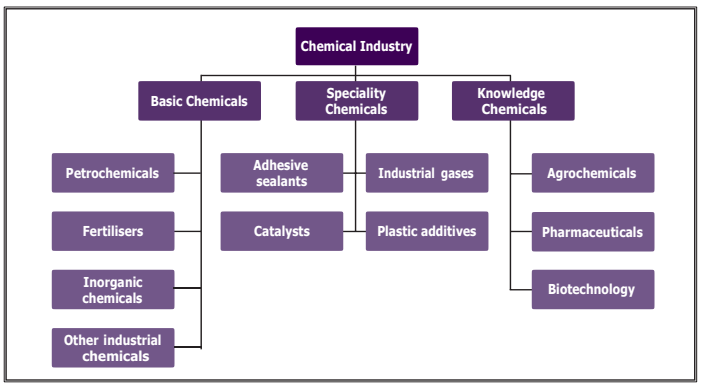
This study investigates the impact of operational and performance variables on the profitability (measured by Return on Assets) of the Indian manufacturing industry, focusing on the chemical industry. Utilizing financial data from 1988 to 2020, primarily due to challenges such as poor scale economies, balance of payments crises, and slow technology diffusion. Industry witnessed a significant structural transformation post-2013, becoming a net exporter of inorganic chemicals, albeit with reduced sales growth. The analysis explores relationships between R&D intensity (RDI), financial development (FD), fixed asset turnover (FAT), and cash conversion cycle (CCC). Employing cointegration techniques and Granger causality tests, results indicate that RDI and FAT negatively affect ROA in the short and long term. A ten-day increase in CCC raises ROA by approximately 0.06%. Studies indicate that higher investments in R&D and fixed assets, alongside improved sales realization, can positively impact profitability. The analysis highlights the need for effective managerial practices and intellectual property assets to enhance the industry's financial performance. The study underscores the significance of efficient working capital management and the strategic allocation of fixed assets in enhancing firm profitability. The findings provide valuable insights for policymakers and corporate managers aiming to optimize financial performance through targeted operational strategies.

Keywords: Cash Conversion Cycle, Profitability, Financial Development, Sales and Broad Money Ratio

INTRODUCTION

The chemical business is classified into three types: basic chemicals, specialized chemicals, and knowledge chemicals (figure 1). Basic chemicals have traditionally made up the majority of India's chemical sector. With greater R&D expenditure, the sector is expanding and developing. As a result, the market for specialized and knowledge chemicals has grown. These categories can be further separated into groups. Inorganic compounds are classed as basic chemicals (Speight, 2017).

Figure 1 Indian Chemical Industry Classification



(***Source***-Inorganic Chemicals: Market and Opportunities-Report by KPMG & IBEF, 17 July 2008)

Journal of Information Systems Engineering and Management
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https://www.jisem-journal.com/

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Inorganic compounds exclude carbon or its derivatives as fundamental elements. Some carbon-containing compounds are classed as inorganic and referred to as carbon-containing inorganics because their activity and properties are frequently comparable to those of inorganic compounds. These compounds are used in a variety of sectors, including paint, glass, automotive, detergent and soap, and paper & pulp as per the U.S. Environmental Protection Agency 2022.

Inorganic compounds are further classified into two subcategories (table 2).

Table 1 Classification of Inorganic Chemical Industry

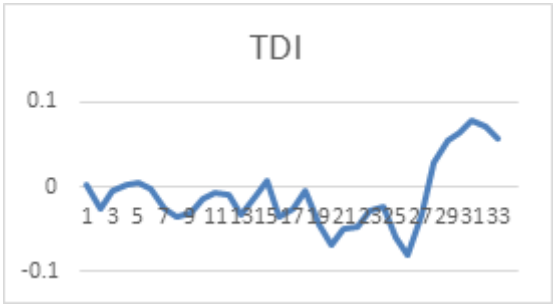
Basic Inorganic Chemicals	**Alkali Chemicals**
Aluminium fluoride	Soda ash
Calcium carbide	Caustic soda
Carbon black	Liquid chlorine
Potassium and sodium chlorate	
Titanium dioxide	
Red phosphorous	

(***Source***- Advantage India: inorganic Chemicals IBEF 2010)

INDIAN INORGANIC CHEMICAL INDUSTRY

Alkali chemicals accounted for over 70% of the Indian basic chemical industry's output in 2021 (Industry-Specific Customs Bonded Warehouse 2022). This was a sharp decline from 88% in 2019, owing to the pandemic's stoppage of industrial activity (International Conference on Thinking 2021). According to Annual Report 2022, the CAGR output of alkali chemicals and inorganic chemicals between FY 2017 and FY 21 was 2.63% and -1.83%, respectively. The primary reasons were insufficient capacity utilization in aluminum fluoride, carbon black, and titanium dioxide. During the same time, the production of alkali chemicals gradually decreased. Even before the pandemic, these two fundamental chemical product categories had capacity utilization rates of 73-84% and 58-69%, respectively. India has long maintained a trade imbalance with these items (annual report 2020). Trade deficit intensity {(Export-Import)/Sales} in Indian chemical industry (ICI) (Figure 2) remained a consistent feature until 2014.

Figure 2 Trade Deficit Intensity



(Authors' calculation)

Sarbapriya Ray, (2011) observed that productivity growth in the Indian Chemical Industry (ICI) declined in the post-reform period of the 1990s compared to its level in the 1980s, both at aggregate and disaggregate levels. This decline was primarily due to poor scale economies in the 1990s, the balance of payments crisis, and slow technology diffusion. Even after considering capacity utilization, there was no evidence of productivity acceleration in the 1990s. Over the study period (1981–2004), productivity's contribution to output growth was negligible. While the

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ICI exhibited exceptional growth in material productivity, growth in capital and labor productivity fell sharply. The slow diffusion of technology was attributed to low investment in R&D. Additionally, due to low feedstock availability and cheaper imports, the output of main inorganic chemicals fell by 6%, compared to the XI (2006-2011) Plan goal of 7-8%, falling short of the sector's XI Plan growth targets (Indian Chemical Industry - XII Five Year Plan, 2012).

Between 1988 and 2020, the Indian Inorganic Chemical Industry (IICI) expanded at a sluggish pace in nominal terms (table 2).

Table 2 CAGR of Industry Parameters

Period	Sales	R&D	PAT	NFA	TA
1988-2020	11.00%	10.50%	17.00%	14.00%	14.21%

(Authors' Calculation)

After 2013, the Indian Inorganic Chemical Industry (IICI) underwent a structural transformation. Sales growth decreased dramatically, and the sector became a net exporter of inorganic chemicals. A structural break refers to an unexpected increase or decrease in an economic time series caused by shifts in regime, policy direction, or external shocks, among other factors (table 3). These breaks can occur in either the intercept or the trend (Bai & Perron, 2003). Evaluating industry performance and the factors affecting it is critical in this manufacturing industry. Until 2001, the industry experienced excess capacity and faced competitive imports (Indian Chemical Industry - XII Five Year Plan, 2012).

Table 3 Structural Break in Parameters

Variable	Financial Year	Type of structural break	Reason(s)
Sales	2012-13	Intercept. CAGR, till FY 13 was 13.22%. After that it became approx. 1%	General slowdown in industrial production according to Consumer Index 2017
ROA	2012-13	1st difference with intercept, Industry ROA went below 1%.	PAT was approximately 10% of preceding FY. Imports being more competitive.
Net Fixed Assets	2009-10	Trend and intercept. NFA increased by almost 25% in one FY	India and China lead the world in capital spending intensity (Capex as a percentage of profit) in the chemical space.
R&D	1997-98	Intercept. RDI went below 1%.	Reduced output, increased imports and increased sales in lower profitable intermediate products. In academia, research papers published in inorganic chemistry were lowest between 1995 and 2000 (Majumder et al., 2012; Raghavan, 2011).
CCC	2008-09	1st difference	Significant reduction in CCC length. From FY 2009, due to increasing the length of payables. CCC, remained negative thereafter.

(**Source**- Authors' calculation)

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Knowledge Gap

So far there has not been a study regarding profitability of the IICI. Most studies concentrate on specialty chemicals like pharmaceuticals, which have drawn bulk of attention. Inorganic compounds are essential inputs for contemporary living, and their availability is a key source of competitiveness (Mackay & Henderson 2017). In this paper, factors effecting profitability of IICI will be investigated.

Studying the profitability of the Indian inorganic chemical industry is critical for several reasons, including providing significant insights into the sector's economic health, competitiveness, and long-term viability. Here are some fundamental reasons why profitability analysis is important: -

- The profitability of the inorganic chemical sector acts as an important economic indicator.
- The financial performance of the inorganic chemical business is critical for investors to evaluate its attractiveness, possible risks, and returns, allowing them to establish successful investment plans.
- Domestic profitability of this sector has consequences for the sectoral trade balance.

Literature Review and Theoretical Framework

R&D investment is an important attribute for enhancing firm value (Johnson & Pazderka, 1993) and economic growth (Alam et al., 2019; Brown &Peterson, 2009). The study by Arif Khan et al., (2023)observed for Chinese listed businesses from 2000 to 2020, that increasing R&D costs, negatively impact company performance. Boiko, (2021) concluded a strong correlation between research and development (R&D) activity and export sales, emphasizing its crucial role in business expansion and innovation. Between 1995 and 2014, EU lost competitiveness to Asian manufacturers due to rising input costs and distance from emerging Asian markets. Gain in competitiveness among EU exporters was postulated to arise from product innovation (Gladkykh, 2015). Brenner & Rushton, (1989) 15-year analysis of fifty-four chemical industry companies of US revealed that businesses with faster sales growth invest more in R&D, while those with slower growth invest less. Inconsistent R&D spending can weaken companies and lead to acquisitions. Success requires strong engineering, manufacturing, marketing, and financial management. The non-causality between R&D intensity and profitability was also proven by Morbey & Reithner, (1990) in a study of industrial firms for the period 1978-87. The route for profits was found to be through increased productivity in these firms during the period. A larger selection of firms confirms the same with lower profitable firms having a negative relationship between RDI and profitability. Highly profitable firms although showed positive association with a five-year lagged period (Karna et al., 2022). A study of UK firms for the period 1992-2014, showed that R&D investments require the mediating power of effective managerial practices and presence of IP assets to effect profitability favorably (Nemlioglu & Mallick, 2017). There seems to be a consensus on impact of R&D on profitability. Foster's S curve suggests that in initial low levels of R&D spending, profitability is negatively affected, followed by positive gains and higher stages resulting in diminishing marginal returns (Foster, 1986).

The chemical industry in Singapore is a case study that has important ramifications for urban and regional development (Wang & Yeung, 2000). Because of ideal location and governmental policy, Singapore's chemical business has been a regional hub since the 1970s. Leading chemical companies have made Singapore their strategic home, proving Singapore's ability to compete for overseas investment.

Profitability of Greek chemical firms for the period 2008-11, showed a positive association with FAT and an inverse relationship with total assets. Smaller firms were able to use their asset more efficiently (Voulgaris & Lemonakis, 2014). Inorganic chemicals fall in the category of true commodities, accompanied with drawbacks like – high capital costs, government regulations, depressed prices etc. Being a buyers' market, the producers happen to be price takers. The bigger producers take advantage of scale and dominate the market globally (Linn, 1984). In the Indian context, lack of scale along with high cost of capital ensured that investments in physical capital was insufficient creating a competitively disadvantageous position (Chaudhuri et al., 2010).

Sharma & Kumar, (2011) investigated the association between working capital management (WCM) and profitability in 263 Indian firms from the BSE 500 index across 15 industrial sectors during 2000–2008,

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uncovering a negative correlation with accounts payables and inventory period, but a positive one with accounts receivables. Talonpoika et al., (2014) analyzed the effect of advance payments on working capital among firms on the Helsinki Stock Exchange between 2010 and 2012, noting improvements in profitability and financial performance. Malm & Sah, (2019) explored the relationship between the Cash Conversion Cycle (CCC) and litigation risk among S&P 1500 firms from 1996 to 2008, concluding that efficient WCM reduces litigation risk even in periods of easy credit. Bhatia & Srivastava (2016) examined 179 BSE 500 listed firms from 2000 to 2014 using panel data, found a negative relationship between CCC and financial performance. Collectively, these studies underscore the nuanced impact of WCM on a firm's financial health and risk management, highlighting the importance of efficient working capital strategies.

Tyagi et al., (2018) noticed that net profit showed positive growth as an outcome of investment in R&D, with a one-year lag from 2000 to 2013. A significant association was also seen between the increase in Net Profit (NP) and R&D. An increase in Net Fixed Assets (NFA) for medium-sized enterprises was offset by a decrease in Research and Development Intensity (RDI). The findings suggested that there were the consequences of modifying the Indian patent regime, which took effect on January 1, 2005. Chowdhury and Chatterjee, (2020) investigated factors such as labor and capital productivity, fixed asset turnover, and net profit margin as significant determinants of growth in the Indian automobile industry from 1998 to 2016, underscoring the importance of these variables in driving firm performance. Das & Das, (2015) found that RDI within a firm remains constant despite fluctuations in sales. From 1991 to 2008, the size of an enterprise never had any influence on research and development investment, which goes against previous studies. Small enterprises in the pharmaceutical industry had no impact on their R&D practices. Significant beneficial effects of lagged profitability on RDI were only detected in big and medium-sized enterprises.

Singla & Prakash, (2021) emphasized the significance of R&D investment, net fixed assets, and sales in enhance firm performance in the construction sector. Findings revealed that increasing R&D activities and investments in net fixed assets lead to performance improvement. Teng et al (2021) highlighted the role of net profit margin in driving sustainable growth in manufacturing firms using data from listed firms in Taiwan. The sustainable growth rate measures a company's sustainability by showing the amount of revenue it can grow without diminishing financial resources. Long-term objective growth rates assist managers planning of finances and avoid insolvency by preventing negative cash flows. Setiawan & Prawira, (2018) found that intellectual capital positively affects return on assets, return on equity, and market-to-book value, indicating its impact on firm performance in the manufacturing industry.

The shift from a trade deficit to a trade surplus industry can greatly affect the profitability of manufacturing firms in India. This change in trade balance can impact various aspects of the economy, including the financial constraints faced by firms. (Hoang et al., 2019) revealed the inverted U-shaped association between trade credit receivable (TCR), trade credit payable (TCP), and profitability. small and medium-sized enterprises (SMEs) have to sustain trade credit level that balances Income and expenditures to maximise profitability. A Pakistan study suggested that utilizing trade credit can have an unusual impact on firm profitability, with a U-shaped relationship between trade credit and profitability (Asif & Nissar, 2023)

A study using 13,243 firm-year observations from 2004 to 2016 found that firms using trade credit positively impact future access to bank loans in China, with a stronger relationship for firms with higher perceived agency costs. Finally, utilizing trade credit can improve financial performance, potentially increasing firms' access to bank loans (Ma & Ma, 2020).

M3 as a percentage of GDP (Broad Money ratio, BMR) has become a common measure of Financial Depth (FD) and an indication of the quantum of financial intermediary activity (Dawson, 2010). The relationship between financial development and economic growth in India has been an issue of discussion since the contributions of Goldsmith, McKinnon, and Shaw. An analysis conducted on India between 1970 and 1999 revealed that M3, which represents the level of financial sector development, significantly impacts the country's GDP (Bhattacharya & Sivasubramanian, 2003). Some economists contend that the financial system inherently adjusts to the requirements generated by economic expansion. The study employed unit root and cointegration analysis on GDP

Journal of Information Systems Engineering and Management
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e-ISSN: 2468-4376
https://www.jisem-journal.com/

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and M3 data from Indian sources. The Granger causality test findings indicated a positive relationship between short-term fluctuations in M3 and GDP, with an annual correction of 3.7% of the GDP gap. M3/GDP indicates the assets and liabilities (or savings) of the financial sector available to the corporate sector for investments.

Knowledge Gap

The role of physical capital and its utilization efficiency along with Working Capital Management (WCM) have not been depicted in any of the studies. WCM has become a variable of interest, especially during the post the Great Financial Crisis (GFC) of 2007-09. This study investigates the impact of operational and performance variables on profitability in the IICI. R&D investment in the Indian corporate sector was minimal till the entry into TRIPS regime by force in 1995 (Banerji & Suri, 2019). Does R&D Intensity and Innovative Activities drive Indian Pharmaceutical Exports? Increasing R&D intensity is crucial for the growth of technology-driven industries, such as chemicals, and promotes innovation. In turn, innovation creates novel items that may generate income, hence increasing R&D intensity. The study would look at the function of fixed assets in profitability evaluation, especially their funding via fixed asset turnover ratio. So far, no work has been reported in the same matter. Greater formalization of the economy also impacts performance. Interaction of BMR (or FD) with working capital management measure and utilization on fixed assets will be studied. Rising banking liquidity leads to greater investments in fixed assets and credit supply from financial sector (Tu et al., 2012).

Data and Methodology

Financial data has been taken from CMIE Prowess. To remove fluctuations in the value of currency, the variables are taken into ratio. Data for the years 1988 to 2020 has been taken. The variables were scaled by the median, enabling control for unobserved heterogeneity at industry levels (Chauhan, 2021). Scaled variables are depicted as FAT, CCC, RDI and ROA. The objective of this study is to investigate the impact of these operational variables on the profitability (ROA) of the Indian industry. Most financial and economic data are non-stationary, i.e., I (1), they possess unit root. Ordinary Least Square regression may generate spurious results. In such instances, the variables (series) may exhibit long-run relationships and may be cointegrated. Cointegrating techniques- Vector Error Correction Method (VECM) and Auto Regressive Distributed Lag (ARDL) are used to understand these long-run relationships. The choice of either of these techniques is subject to the presence or absence of unit root in the variables (series). To establish causation and direction of causation, Granger Causation (GC) is used. Lag length have been selected using VAR Lag Order Selection Criteria (Winker, 1998). Only successful and relevant iterations will be mentioned and discussed. EViews 10 has been used for analyses.

Table 4: Variables Description

Variable	Acronym	Formula	Measure
Return on Assets	ROA	Net Profit/ Total Assets	Profitability
Cash Conversion Cycle (Trade Cycle)	CCC	Account Receivable Period + Inventory Turnover Ratio – Account Payable Period	Efficiency of WCM
Financial Development	FD	M3/GDP (Broad Money/Gross Domestic Product)	Savings available to borrowers
Fixed Assets Turnover ratio	FAT	Sales /Fixed Assets	Efficiency measure of usage of fixed assets
Research & Development Intensity	RDI	R&D Expenditure/Sales	R&D commitment

Source: Authors' compilation

Journal of Information Systems Engineering and Management
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e-ISSN: 2468-4376
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Results and Discussion

The correlation matrix showed the relationships between ROA, RDI, CCC, and FAT. The correlation coefficient between ROA and RDI is -0.339, suggesting a moderate negative correlation (table 5). This implies that as RDI increases, ROA tends to decrease. Week negative correlation is observed between FAT and Trade Cycle. These negative correlations suggest that ROA tends to decrease as CCC and FAT increase. Overall, these correlation coefficients show the financial and operational metrics interact.

Table 5: Correlation Matrix

Variables	ROA	RDI	CCC	FAT
ROA	1.000			
RDI	-0.339	1.000		
CCC	-0.142	-0.338	1.000	
FAT	-0.175	0.084	-0.195	1.000
Source: Authors' compilation. Note: - All variable significance levels below 5%.				

Low correlation between the independent variables, indicates absence of multi-collinearity.

Unit Root Tests

In econometric analysis, conducting a unit root test is crucial to determine the stationarity of time series data. The Augmented Dickey-Fuller (ADF) test is necessary to check the presence of unit root. The results in Table 6 show the ADF test statistics for four variables: ROA, RDI, CCC and FAT. The tests were conducted at both levels and first differences, with the 1% significance level. Only RDI is stationary at levels, meaning it does not require difference to achieve stationarity. ROA, CCC, and FAT are non-stationary at levels, indicating the presence of unit roots ROA, CCC, and FAT become stationary after taking the first difference, implying they are integrated of order I (1).

Table 6: Unit Root Test

Variable	**Augmented Dickey-Fuller Test**	
	Levels	**First Difference**
ROA	−0.610	−7.745***
RDI	−5.154***	
CCC	−1.105	−5.985***
FAT	−0.956	−6.612***
Source: Authors' compilation. Note: - 1% significance level indicated by ***		

1.1. Granger Causality Tests

The Granger Causation (GC) test is a statistical method used to determine the causal relationship among the given variables. Specifically, it assesses whether the unidirectional and bi-directional association with variables is statistically significant. Table 7 result shows the unidirectional relationship with the variables. GC was done at levels (stationary variables) at one lag and two lags depicted.

The null hypothesis that RDI $_{t-1}$ does not GC ROA $_{t-1}$ is rejected. Similarly, CCC $_{t-1}$ does not GC ROA $_{t-1}$ is also rejected. The results further indicate that past RDI, CCC, and FAT×FD values provide significant information for predicting future values of ROA.

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e-ISSN: 2468-4376
https://www.jisem-journal.com/

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Table 7 Granger Causation

Null Hypothesis:		Obs	F-Statistic	Prob.
RDI_{t-1} →	ROA_{t-1}	32	5.125	0.02
CCC_{t-1} →	ROA_{t-1}	32	6.114	0.00
ROA_{t-2} →	FAT_{t-2}	31	7.745	0.00
$FAT \times FD_{t-2}$	ROA_{t-2}	31	7.056	0.00
Source: Authors' compilation.				

The rejection of the null hypothesis of no cointegration indicates that ROA and its determinants (table 8) have a short and long-term equilibrium relationship. Prior to establishing an Error Correction Model (ECM), it is essential to specify the appropriate lag length, using the lag length criteria and the VAR Granger Causality/Block Exogeneity Wald test causation is shown from RDI, FAT, and CCC to ROA at lag two. Positive F-statistic value is more than the critical values for the upper and lower bound of the models. Cointegration is found when the ARDL method is used.

Table 8 Bound Test

K	N	F-statistic	Upper (1%)	Lower (1%)	Decision
3	30	7.127	4.29	5.61	Cointegration
Source: Authors' compilation.					

The long- and short-term results of the ARDL approach are reported in Table 9. The findings reveal that RDI, FAT and CCC have a negative impact on ROA in both long term and short term. In the long term, a 1% decline (rise) in RDI and FAT will reduce (increase) ROA by 1.375% and 0.425 (respectively), ceteris paribus. R&D expenditure results increase in innovation and technology upgrades, which may impact profitability. Over time, a competitive disadvantage as the firm may lag in new product development in spite of high investments in R&D. In the chemical industry, where the fixed assets expenditure can be high due to the cost of equipment and compliance with safety and environmental regulations, a higher FAT indicates utilization of surplus (profit) in creation of fixed assets.

On the other hand, a ten-day increase in CCC raises ROA by around 0.06%, *cetris paribus*. Padachi (2006) and García-Teruel & Martínez-Solano, (2007) found that retaining cash contributes more to a firm's value than investments in working capital. They observed that firms that increased their investments in CCC experienced reduced excess profitability. Additionally, firms with restricted access to external financing faced more significant difficulties. The counterfactual relationship between CCC and ROA suggests a trade-off between accounts receivables and profitability. Granting longer sales credit days resulting in increased profitability is probably the reason for this inverse relation.

Table 9 ARDL Lags (2,1,0,0)

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.***
Estimated long run coefficients				
RDI	− 1.375	0.345	− 3.987	0.000
FAT	− 0.425	0.201	− 2.114	0.032
CCC	− 0.006	0.002	− 2.568	0.017
Estimated short run coefficient				
ROA_{t-1}	0.513	0.180	2.846	0.009
ROA_{t-2}	0.278	0.210	1.324	0.199
RDI	−0.485	0.229	−2.117	0.027
RDI_{t-1}	−0.665	0.282	−1.564	0.131
FAT	−0.356	0.199	−1.788	0.095

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CCC	−0.005	0.002	−2.400	0.025
C	−3.506	1.681	−2.085	0.047
R^2	0.799			
Adj. R^2	0.736			
F-statistic	12.551			
Prob(F-statistic)	0.000			
Durbin-Watson stat	2.339			
Residual diagnostics				
LM (Prob.)	1.802 (0.190)			
Heteroskedasticity Test (Prob.)	0.176 (0.987)			
Jarque-Bera (Prob.)	0.660 (0.718)			
Source: Authors' compilation.				

ARDL with lags (2,1,0,0) is given in table 9. The model is as per Eq.2, (R^2 =79.97%, no autocorrelation) with the cointegrating equation as Eq1-

ROA = 0.513*SROA (−1) + 0.278*SROA (−2) − 0.628*SROA (−3) − 0.485*SRDI − 0.665*RDI (−1) −0.356*FAT − 0.005*SCCC + 2.466**.....Eq1**

Cointegrating Equation:

D(ROA) = 2.466 − **0.836***ROA (− 1) − 1.151*RDI (− 1) − 0.356*FAT** − 0.005*SCCC** + 0.350*(SROA (− 1)) + 0.628*(ROA − (− 1.375*RDI (− 1) −0.425*SFAT (− 1) − 0.006*CCC (−1)) −0.485*D(RDI))**.....Eq2**

Long run equation: - EC = ROA − (− 1.375*RDI − 0.425*FAT − 0.006*CCC) **...Eq3**

In the short-run coefficient (table 9), the positive coefficient of ROA_{t-1} suggests that lagged profitability significantly impacts it. The findings primarily reflect the model's autoregressive characteristic. RDI, FAT and CCC cause a negative and significant impact on ROA, 1% change in RDI, FAT and CCC increase (decrease) by −0.48%, −0.35% and −0.005% in ROA respectively.

In the long term, around 83.6% of the variance in ROA is corrected within fourteen months (Eq. 2), indicating its returns to its long-run equilibrium.

The model passed all residual tests, including no autocorrelation, a normal residual distribution, and no heteroskedasticity. The Wald coefficient diagnostic test indicates that the independent variables are collectively significant in the model. Due to parsimony, results are not reproduced here. Model stability tests (CUSUM of squares), within the 5% (+/−) range, do not show any instability of the model and its coefficients in the sample period (figure 3).

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Figure 3 Caption: - Plot of the cumulative sum of squares of residuals

Interaction Term

M3/GDP (Broad Money, referred to as BMR) indicates the financial development (FD) of an economy. An increasing BMR suggests greater formalization of a developing economy. It also shows how much of the liquid liabilities of the banking system are available to the business sector for investments. In the case of India, BMR has been steadily increasing over the past three decades and more. Interaction with CCC and FAT will illustrate the impact of these variables on the formalization of the Indian economy.

ARDL bounds test examines the cointegration between the Variables. To obtain that, AIC will estimate the lag length of the considered variables to examine the long-run association between the time series. After selecting lag 2 the Bound's test is used to check the presence of cointegration. Table 10 shows the F-statistic value is greater than the critical values for the upper and lower bound of all the model values.

Table 10 Bound Test

K	N	F-statistic	Upper (1%)	Lower (1%)	Decision
3	30	6.858	4.29	5.61	Cointegration
Source: Authors' compilation.					

The null hypothesis of no cointegration stands rejected, indicating that ROA and its determinants have a long-term relationship. The appropriate lag length must be specified before establishing an Error Correction Model (ECM). VAR Granger Causality/Block Exogeneity Wald test showed causation from RDI, FAT×FD, and CCC×FD to ROA at 2 lags.

Table 11 Short-Run ARDL Lags (2,1,0,0)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
ROA_{t-1}	0.555	0.176	3.140	0.004
ROA_{t-2}	0.257	0.211	1.215	0.237
RDI	−0.509	0.232	−2.188	0.037
RDI_{t-1}	−0.617	0.277	−2.220	0.037
CCC×FD	−0.004	0.001	−2.390	0.025
FAT×FD	− 0.165	0.076	− 2.170	0.034
C	2.226	0.468	4.477	0.000
R^2	0.795			
Adj. R^2	0.730			
F-statistic	12.217			

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Prob(F-statistic)	0.000			
Durbin-Watson stat	2.324			
Residual diagnostics				
LM (Prob.)	1.786 (0.193)			
Heteroskedasticity Test (Prob.)	0.144 (0.993)			
Jarque-Bera (Prob.)	0.770 (0.818)			
Source: Authors' compilation.				

In the short run (table 11), the coefficient indicates a 1% increase in ROA $_{t-1}$ associated with a 0.55% increase in ROA, holding other variables constant. RDI and RDI $_{t-1}$ negative and significant relation with ROA. In interaction variables CCC×FD and FAT×FD showed a negative and significant association with ROA.

Overall, the model has a high R-square value of 0.795, indicating that the independent variables explain 79.5% of the variation in the dependent variable. The F-statistic is significant at the 5% level, suggesting that the overall model is statistically significant. In the long term, around 82.7% of the variance in ROA is corrected within fourteen months (Eq. 5), indicating that it has returned to its long-run equilibrium.

ARDL with lags (2,1,0,0) is given in table 12, with the cointegrating equation as Eq4-

ROA = 0.555*ROA (– 1) + 0.257*ROA (– 2) – 0.639*ROA (– 3) – 0.509*RDI – 0.617*RDI (– 1) – 0.004* CCC×FD – 0.165* FAT×FD + 2.226**.....Eq4**

Cointegrating Equation:

D(ROA) = 2.226 – **0.827*ROA (– 1)** – 1.126*RDI (– 1) – 0.004*CCC×FD** – 0.165* FAT×FD ** + 0.382*D (ROA (– 1)) + 0.639*(ROA – (– 1.362*RDI(– 1) – 0.005*CCC×FD (– 1) – 0.200* FAT×FD (– 1)) – 0.509*D(RDI))**.....Eq5**

In the long run (table 12), a 1% fall (rise) in RDI decreases (increases) ROA by 1.362%, *ceteris paribus*. On the other hand, 1% increase in CCC×FD and FAT×FD decreases ROA by approximately 0.005% and 0.2% respectively, *ceteris paribus*. The change in behaviour of CCC after interacting with FD is in line with extant work, wherein greater overall liquidity leads to negative relation with profitability (Howells, 2007). It can be inferred that firms with higher FAT×FD require less WC due to the substantial investment in fixed capital. In financial constraints, the investment in fixed assets is higher, automatically reducing the funds available for WC. Thus, firms need to follow an aggressive WC approach.

There is a marked decrease in the negative coefficient of FAT upon interaction with FD.

Table 12 Long-Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RDI	– 1.362	0.351	– 3.879	0.000
CCC×FD	– 0.005	0.002	– 2.561	0.017
FAT×FD	– 0.200	0.095	– 2.568	0.017
EC = ROA – (– 1.362*RDI – 0.005* CCC×FD – 0.200* FAT×FD) **...Eq3**				

The model passed all residual tests, demonstrating the absence of autocorrelation, adherence to a normal distribution of residuals, and the lack of heteroskedasticity. The Wald coefficient diagnostic test further validated the collective significance of the independent variables within the model.

Journal of Information Systems Engineering and Management
2025, 10(42s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

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Due to parsimony, results are not reproduced here. Moreover, the model stability tests, specifically the CUSUM of squares analysis conducted within the 5% (+/−) margin, indicated no signs of instability in both the model and its coefficients throughout the sample period, as illustrated in Figure 4.

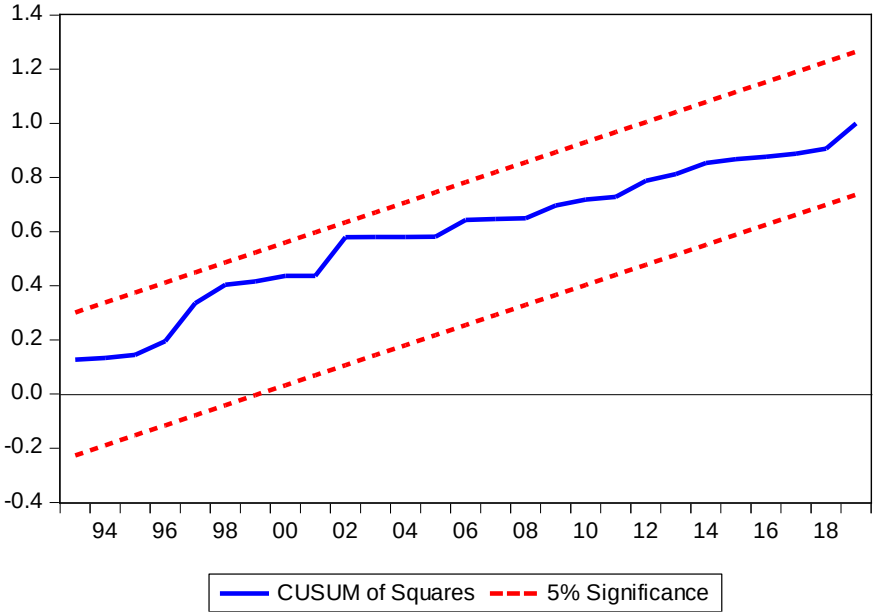

Figure 4 Caption: - Plot of the cumulative sum of squares of residuals

CONCLUSION

The research on the profitability of the Indian Inorganic Chemical Industry (IICI) provides several critical insights into the impact of various operational and performance variables. The findings underscore the nuanced relationships between profitability and factors such as R&D intensity (RDI), fixed asset turnover (FAT), and the cash conversion cycle (CCC). Firstly, the negative contribution of R&D intensity (RDI) and Fixed Asset Turnover (FAT) on profitability suggests a U-shaped relationship with profits. This indicates that only higher investments in R&D and higher sales realization can positively impact profitability. In other words, moderate levels of investment may not be sufficient; substantial and sustained investments are required to realize the benefits in profitability. Secondly, the negative relationship between the trade cycle (Cash Conversion Cycle, CCC) and profitability aligns with expectations. This relationship suggests that reducing the length of the trade cycle by 10% could potentially increase profits, as firms can better manage their working capital and improve efficiency. Thirdly, as the economy grows, it is likely that Broad Money (BMR) will also rise. This growth is expected to translate into a lower negative impact of FAT. Therefore, in the near future, the IICI may start realizing the positive impact of FAT as the economy expands and firms optimize their fixed asset investments. Furthermore, the role of imports on the industry's performance remains a critical area for future inquiry. Investigating how imports affect the profitability and competitiveness of the IICI could provide valuable insights for policymakers and industry stakeholders.

RECOMMENDATIONS

Increase investments in R&D and fixed assets (technology) to realize the benefits of a growing economy. Higher R&D investments can drive innovation and technological advancements, while strategic investments in fixed assets can enhance operational efficiency and profitability. Reducing the length of the CCC by improving working capital management practices can significantly boost profitability. Firms should focus on reducing inventory levels, speeding up accounts receivable collections, and optimizing accounts payable processes. Firms should strategically position themselves to benefit from the expected economic growth and financial development. By aligning their operational practices with the broader economic trends, they can mitigate the negative impacts of FAT and enhance their financial performance.

Acknowledgments: - we are grateful to the anonymous reviewers for dedicating their valuable time to

reading and reviewing our research work.

Author contributions: - Nirbhay Mahor: writing, review, editing, analysis, and interpretation. Amit Banerji: review and editing, methodology and supervision.

Funding: -There is no funding information available.

Declarations: - Competing interests the authors have no competing interest to disclose.

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