Journal of Scientific & Industrial Research
Vol. 85, January 2026, pp. 76-86
DOI: 10.56042/jsir.v85i1.18697

The Role of Water Cost in Corporate Performance: Is It Impacting Corporate Water Usage and Efficiency?

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Received 10 April 2025; revised 24 October 2025; accepted 05 January 2026

Corporations are increasingly exposed to water related challenges, including scarcity, pollution, and rising water costs. This study investigates the relationship between water costs and firm performance in food and beverages sector where water is a critical production input. Using panel data from 2014 to 2023 of 40 firms the analysis applies Generalized Method of Moments (GMM) to address profitability persistence and endogeneity. The key variable-water charges as a ratio to cost of production -captures firm's exposure to water related expenses. Results reveal a significant and positive association between water costs and Return on Assets (ROA), suggesting that firms currently translate water cost to their scale advantages. The study offers novel firm-level evidence from an emerging economy, demonstrating that for resource cost to act as a driver of profitability as well as efficiency, policymakers should consider integrative ecological service valuation and stricter disclosure norms to promote water efficiency and sustainable industrial growth.

Keywords: Broad money, Dynamic GMM, Food sector, Firm performance, Water charges

Introduction

In the beginning of 21st century, World Water Council labeled global statistics of water as 'the gloomy arithmetic of water',(1) 25 years down, the situation has worsened, with half the world suffering from water related illness at any given point of time, a quarter of population living in high water stress and over a billion without access to clean drinking water.[2] Water is the basis for our food, natural constancy, economic stability, and security. However, the state of water has changed over the years, owing to climate change, competition for natural resources, unregulated discharge of effluents etc. There is also a trend of rising water costs. This simply indicates widening demand and supply gap and significant strain on hydro-economic link. Just as other entities, water is crucial for survival and sustainability of firms. How do firms view it? Do water charges matter to firms and do they significantly impact on their performance? The discussion lay down the context of scarcity and natural resource dependence. It then draws the attention towards the necessity to focus on specific resources rather than combining all resources. Subsequently, it talks about the significant studies that have recently done around water and firm research, water cost and its impact in Indian context (extremely high-water stressed country[2]) in general and Food and Beverages (F&B) sector in particular.

Water is a finite resource and usable water is getting scarce. Its availability is getting unpredictable. The availability varies on spatial and temporal basis. The temporal variation is largely nature driven and beyond control. While spatial adequacies are marred by industrial and economic activities.[3] Further, water scarcity has both physical and economic dimensions. Physical scarcity (which is insufficient water for meeting the needs in a particular area) is generally measured with (a) 'water stress' implies consumption need in relation to the availability thus higher use will stress the resource; and (b) 'water shortage' indicates the low availability of water per capita. Economic water scarcity, on the other hand, is more towards inaccessibility, inadequate infrastructure, poor water management, and unaffordable prices. Quality aspects of water exacerbate the economics of water further.

Firms strategically look for locations with abundance of natural resources to gain competitive advantage. Also, through the theories on 'Natural resource dependence' it is acknowledged that natural environment imposes constraints and even sustainability challenges on corporations.[4] For instance, oil and minerals have long proved to create vulnerabilities such as, resource depletion or scarcity

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in terms of quantity and quality, economic instability, price fluctuation, market factors such as condemnation, and denial etc. Energy, in particular, considered crucial for all development, received greater research attention. Down the line, importance of other natural resources such as, air, soil and water are also coming under research microscope. Anthropogenic activities being the center of sustainability issues, valuation and monetization of water and other resources are being advocated on the lines of minerals and oils.[5,6] This is aimed to reduce ambiguity, acknowledgement for the value of the resource and better understanding of the cost.

There is an ongoing debate that whether investigation and reporting be standardized by using composite indicator of sustainability. Several firm level studies of the current period found to have covered water enveloped in the environmental factors along with energy, air quality, etc.[7–11] A distinct emphasis on the dependency on scarce natural resources is missing.[12] Disclosure of water information still remains high and dry. It is found to be low both in number of companies involved in reporting and also in the depth of information reported by each of the reporting companies. In this context, a review of 120 methodological frameworks done to assess sustainable water resource management in Industry and found only 22 to be applicable in industrial setting. Where 12 of them had reference for three axes of sustainability and only four were 100% replicable. Several water considerations found to be often omitted and only two had a metric for water consumption.[13] It's still rare that studies investigated the efficacy of firms in their use of natural resources. "It therefore, necessitate merely the fundamental societal agreement that reduced natural resource consumption is preferable."[14] While resource-specific indicator ensures clarity, depth and breadth, sustainability indicators need to be augmented for the same.

Water in business context is typically seen from risk perspective. Water related risks faced by firms are described under reputational, regulatory, physical, and financial.[15–20] No doubt, sustainability indicators are becoming updated and comprehensive, (e.g. BRSR last updated in Dec 2024) Yet, there are great variations in what is asked and getting reported as on date.[13,21,22] The issue has been often highlighted by researchers across the globe.[23,24] Whereas, in much cited works of Weber, where CDP water score (Carbon disclosure Project -Water) was used confirmed Corporate Water Performance (CWP) to have positive influence on firm performance. [25] Water footprint as a measurable tool to understand water use and to raise awareness for optimizing usage was also advocated.[26]

In a 2022 study using Difference-in-difference method a sample of 139 U.S. manufacturing industries between 2013 to 2016 is taken to find impact of good water management on firm's value. The sample was divided in two groups of good water management firms and bad water management firms. The result was found as good water management leads to increase in firm value.[27]

Thus, it can be observed that the importance of water is slowly getting recognized. The corporate water narrative is moving from risk & reputation management to Social and environment management, further leading to the performance and value of the firm.

For a developing economy like India, which hinges on water intensive activities like agriculture, power generation, mining, manufacturing and so on, water is a critical resource. There is also a very high population load, urban and industrial growth. Though, India was known as one of the few water-rich countries in the world.[28] However, usable water is getting fast depleted both for surface water and groundwater. Ironically, some of the cities of India are among the top water-scarce cities globally.[29] This dichotomy unswervingly indicates that there is a great need to have a good water management system in the country.

For the Food and Beverages industry, water is a non-substitutable resource, which deserves prioritization in environmental issues.[30] The common processes of Food and Beverages industry such as cooking, constant heating, cooling, freezing, in cold storage, aerating and brewing etc. utilize water in its multiple forms.[31] Water then has the potential to demonstrate key resource feature as per "Resource-based view"(RBV).[32] Moreover, agriculture is still the means of livelihood for over half of the Indian population.[33] F&B sector of India has several factors to gain advantageous position competitively.[34]

The sector is among the largest industries in terms of employment generation, retail, production, consumption, & export. With a population of 1.4 billion, India presents a huge and varied market. This sector is home to the greatest number of firms.

The market is comprised of a wide spectrum of organizations, from large global corporations to minor local businesses. Consequently, the industry is characterized by rapid expansion, extensive water consumption, and is one of the top contributors to discharge and pollute water sources. Apart from consumers, regulators and investors' scrutiny of firms become crucial for survival.[35]

Water is also a complex economic good. Its vital nature for all life requires it to be judiciously allocated, efficiently used, well-regulated and suitably priced. In the industrial context, the terms, 'water withdrawal' (the total amount of water taken from a source), water use (the amount of water actually utilized) and water productivity (the ratio of output to the water used) becomes important. Owing to regulatory measures of recent years, variable water charges are applied based on volume used and categories of users such as, farmers, residential and industrial. There are further restrictions being imposed on extractions of groundwater.[36] The water charges on Industrial users are recommended to be several times higher and graded as per volumetric use. 'Full cost pricing' of water is also being advocated at multiple forums around the world.[37,38] The state of affairs is moving towards higher scrutiny, tighter regulations, cautious investors, aware customers and vigilant communities, etc. In such scenario, water charges on firms are set to increase significantly.[5,30]

Adequate selection and measurement are the main concerns of the industrial entities. Their selection criteria are majorly based on the direct production costs and size of the industry. Pricing being an effective tool from market perspective and taxes/tariffs from regulatory angle impact cost dynamism of water. It is also anticipated to rise substantially. Therefore, observing expenses incurred on water by a firm may be utilized for assessment. On the other side, firm performance has been viewed in these studies through Return on Equity (ROE), Return on Sales (ROS), Tobin's Q values or Return over Assets (ROA),[9,10,26] where ROA being the most commonly referred variable.

Knowledge Gap

Water is an essential resource, yet, its impact in Industrial context is less studied - in natural resource or even in ESG studies. Earlier research attempts have arrived at mixed results, calling for further investigation and more contributions in the field. From the contextual point of view, both water and food are the basic requisite for the most populous, developing and resource dependent country like India. However, more research has come from developed nations context, e.g. USA, Germany, UK, and Australia etc. Existing research have also not taken the route of water costs. For F&B industry, where usage and value of water cannot be denied, taking water expenditure is a unique proposition. Firms invariably see value in relating impact to their bottom line. Therefore, impact of water cost on firm's profitability is a pertinent Research enquiry.

CAGR of Variables Taken in the Study

Following are the graphs of consolidated figures of all the 40 companies over a decade for variables such as Water cost (WTR), Cost of Production (COP), Net Sales and Total Assets (TA) generated through MS Excel in Fig. 1.

As can be observed from the graph above, water charges, cost of production and sales for the F&B Industry has displayed consistent growth. Secondly, water charges and Total Assets have both increased for the industry.

The Compound Annual growth rate (CAGR) of the variables taken in current study were: Return on Assets (ROA) = 91%, Net Fixed Asset Utilisation Ratio (NFAT) = 12%, Cost of Production to Total Assets (COPTA) = (−1%), Liquid liability to Gross domestic Product[39] or Financial Depth (FD) = 1% and Water to Cost of Production WTRCOP = 4% for the firms in the data set.

Materials and Method

Resource Dependency Theory (RDT) emphasizes firm's vulnerability to external resource dependence. It is undeniable that for food sector water is a critical and non-substitutable resource, therefore rising water cost will constraint on profitability. In the contrary, Induced Innovation Theory (IIT) says that scarcity may triggers efficiency improvements and innovation. So, profitability may not necessarily be negative but context dependent. This need to be analysed in Indian Food firm's context. Therefore, this study is an attempt to investigate the impact of water charges on the firm's profitability or performance.

H1: Water cost intensity negatively affects firm's profitability.

RBV on the other hand, highlights the importance of internal capabilities in sustaining performance and competitive advantage. While, firms that utilize their fixed assets efficiently gain higher profitability. Therefore,

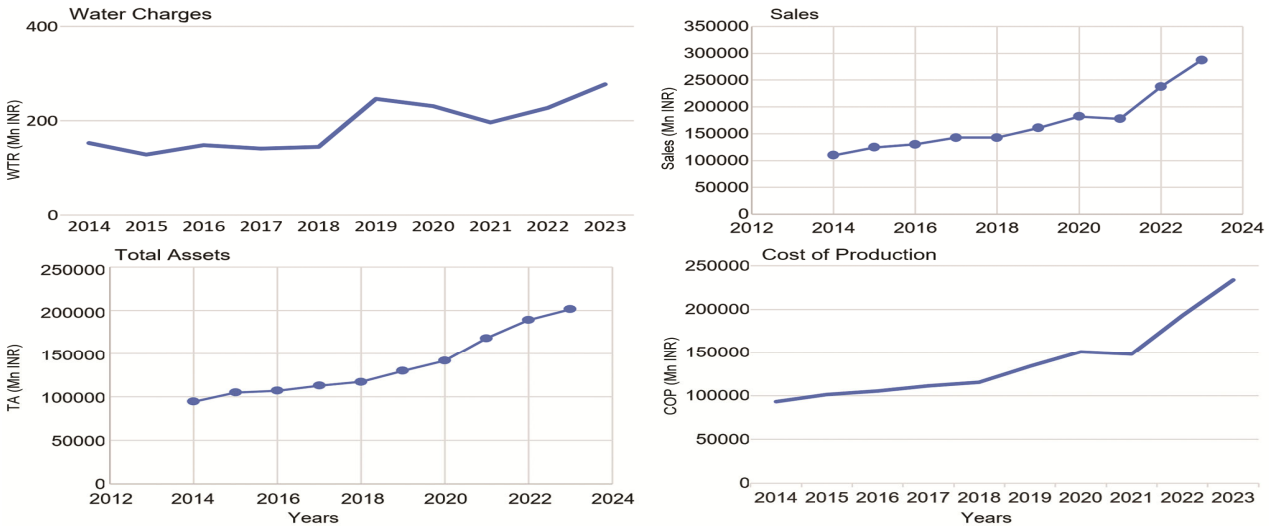

Fig. 1 — Trendlines of consolidated data of 40 Firms shown for Water charges, Cost of Production, Sales and Total Assets in Rs. Mn on Y-axis and Years on X-axis

Table 1 — Variables and theoretical and financial explanations

Variable	Theoretical basis	Financial Rationale
WTRCOP-Water Cost Intensity	RDT; water Dependence; IIT	Critical resource
NFAT- Asset efficiency	RBV; Captures Efficiency as capability	Captures capital efficiency, Firms
COPTA- Production intensity	Operational leverage	Implies larger direct cost relative to assets.
FD- Financial Depth	Macro-level liquidity and credit support	It shows the savings available from the banking sector to the industrial sector. A more developed financial system eases financial constraints.
ROA- Prior-year Profitability	Dynamic adjustment	Captures profit persistence and dynamic adjustment

H2: Capital efficiency positively affects firm's profitability

Financial development is considered a macro-level enabler of firm growth by making available credit and liquidity. Earlier studies have found the positive association.

H3: Financial Depth positively influence firm's profitability

High Production intensity reflects operational leverage. Whereas, theory points higher costs means reduced profitability. Evidence from prior studies provided mixed results. Therefore,

H4: Operating efficiency negatively influences firm's profitability.

Based on the review and theoretical basis, the following variables are framed for the present study in Table 1:

Generalized method of moments estimator was first explained by Lars Peter Hansen[40] for applications in the field of economics and finance. Later, this method has been worked upon by several authors.[41–44] In the current study, GMM approach explained by Roodman is applied.[45] Difference GMM estimator is proposed here because the DV or ROA exhibits dynamic behavior, Further, Difference GMM addresses potential endogeneity between firm performance and explanatory variables by (a) eliminating firm specific heterogeneity through first differencing. (b) Instrumenting endogenous regressors using lagged levels and (c) ensuring consistent estimation even in panels with a large cross-section (N) and shorter-time dimension (T), as in the present dataset (N-40 firms, T=10 Years). However, internal instruments can still be weak against persistent shocks etc.

As described above, Arellano-Bond Estimator is also recognized as the difference GMM estimator where first differences are used in the analysis. In a dynamic panel data model, the DV is reliant on its own historical values. Stated otherwise, there is a probability of correlation between the specific effect (μ i) and the lagged DV, or ROA (i, t-1).

$$ROA_{it} = \alpha 1\ ROA_{it-1} + \beta_{1i}X_{it} + \mu_i + \varepsilon_{it} \quad \ldots (1)$$

Further, Arellano-Bond Estimator makes use of extra moment constraints to increase the number of instruments available and resolves the issue of orthogonality which reportedly are impediment in even Anderson-Hsiao estimator.

$$E[ROA_{it-s}(\varepsilon_{it}-\varepsilon_{it-1})] = 0 \text{ for } s >/= 2 \quad \ldots (2)$$

$$E[X_{it-s}(\varepsilon_{it}-\varepsilon_{it-1})] = 0 \text{ for } s >/= 2 \text{ , } t= 3,\ldots\ldots\ldots\ldots T, \text{ and } f= 3,\ldots\ldots\ldots\ldots T \quad \ldots (3)$$

The tool used for the statistical analysis were 'SPSS 26', 'Eviews12' and 'Gretl'. The stationarity properties of all the variables were examined through the ADF- Fisher Chi-square, PP-Fisher Chi-square, Im, Pesaran and Shin W-Statistics and Levin, Lin & Chu -test. For the residual diagnostics, the Arellano-Bond Test was performed.

$$ROA_{it} = \alpha 1 ROA_{it-1} + \sum I = 2n\ \beta_{1i} X k_{it} + \mu_I + \varepsilon_{it} \quad \ldots (4)$$

$$ROA_{it} = \alpha 1 ROA_{it-1} + \beta_{1i} X_1 k_{it} + \beta_{2i} X_2 k_{it} + \beta_{3i} X_3 k_{it} + \beta_{4i} X_4 k_{it} + \mu_I + \varepsilon_{it} \quad \ldots (5)$$

Also employed a 2-step GMM estimator suggested by Arellano -Bond,[41] where 2nd step is found to be more efficient in case of large samples.

Determinants of the Water Variable

The Water Variable (WTRCOP) is taken as the ratio of Water cost to Cost of production. Please refer to Table 2, for the derivation process of WTRCOP used here. Since, the Food and Beverages firm has water as an important role as an input component, process, and peripheral activities of the firm.

Data Sources

40 companies' data for 10 years (from 2014 to 2023), could be obtained from the Center for Monitoring Indian Economy (CMIE).

Constructing the Model

Firm performance has been a constant quest for management researchers. The analysis focuses on why firms take certain actions and whether water charges (or its savings) enhance their performance. Theoretically, water influences the profitability of food and beverage companies through a variety of pathways, which can be investigated using panel data or time series data. However, as the profit of food and beverage businesses is a continuous, dynamic process, economic concept indicate that the profitability of the previous period would have some impact on the current one. As a result, a lag DV would be utilized, which would more truly reflect both theory and reality. The initial static model becomes a dynamic model when the lag DV is included in the calculation. Control factors that impact the firm's profitability are also introduced to the model, along with a phase-1 lag term for ROA, taking into account the fact that ROA is influenced by a number of factors not only in the present period but also in the past. Therefore, the following dynamic panel model:

$$ROA_{it} = \alpha 1\ ROA_{it-1} + \sum i=2n\ \beta_{1i} X_1 k_{it} + \beta_{2i} X_2 k_{it} + \beta_{3i} X_3 k_{it} + \beta_{4i} X_4 k_{it} + \mu_i + \varepsilon_{it} \quad \ldots (6)$$

$$ROA_{it} = \alpha 1 ROA_{it-1} + \beta_{1i} WTRCOP k_{it} + \beta_{2i} NFAT k_{it} + \beta_{3i} COPTA k_{it} + \beta_{4i} FD k_{it} + \mu_I + \varepsilon_{it} \quad \ldots (7)$$

In this case, $X_1 k_{it}$ is the IV or the 'ratio of water cost to cost of production' (WTRCOP), $X_2 k_{it}$ is the second IV or the 'ratio of Net Fixed Assets to total Assets'(NFAT), $X_3 k_{it}$ is the third IV or the 'ratio of Cost of Production divided by Total Assets' (COPTA), and $X_4 k_{it}$ is acting as the control variable the financial depth (FD). Also, β_{1i}, β_{2i}, β_{3i} and β_{4i} are the coefficients of IVs respectively, μ_i denotes individual effects, and ε_{it} is a random error term. ROA_{it} is the DV, and ROA_{it-1} is the lagged DV in phase-1.

The individual effect and the lagged value of the DV are expected to be correlated, which will lead to endogenous issues. Since the least squares approach cannot be employed for regression in this model, the Generalized Method of Moments (GMM) is used for estimate in this work. There exist both short and long-run relationships between IVs and DV and Water variable has some impact on the performance of the firm. However, GMM provides short run results and for the long run results are found to be inconsistent.

Table 2 — Description of water variable

Terms	Explanation	Abbreviation
Water charges (in monetary terms reported annually)	Total expenses on water incurred during the year in INR	WTR
Water charges (incurred by the firm adjusted)	Water charges (incurred by the firm adjusted with respective Wholesale Price Index of India)	WTRWPI
Water Efficiency	Ratio of Water charges over Cost of Production	WTRCOP

Table 3 — Descriptive statistics

Variables	N	Minimum	Maximum	Mean	SD	Jarque-Bera Statistics	Probability	Sum	Sum Sq Dev.
WPI	400	110.30	151.30	123.81	15.47	65.64	0.00	49524	95511.56
FD	400	0.75	0.85	0.79	0.03	27.40	0.00	317.02	0.48
WTR	400	0.10	83.60	4.72	9.54	13659.60	0.00	12.54	36324.80
WTRCOP	394	0.00	8.24	0.03	0.42	2129975.00	0.00	1889.87	70.43
ROA	400	−36.23	0.93	−0.13	1.89	1846124.00	0.00	−50.96	1432.80
NFAT	400	0.02	523.70	1.78	26.23	2568456.00	0.00	711.55	274621.60
COPTA	400	0.00	19.8	1.976	2.19	3933.305	0.00	788.6	1912.737

Results and Discussion

The descriptive statistics used to summarize data distribution and central tendencies are presented in Table 3, which reports mean, maximum, minimum and variability characteristics of all variables. In addition, correlation matrix and Generalised Method of Moments estimation, done to achieve the research objectives.

The variability in distribution can be observed in standard deviation values which is scattered around the center and less than the mean value such as 15.47% for WPI, 0.03% for FD. Whereas, it is larger for Water (WTR), Ratio of Water to cost of Production (WTRCOP) Return on Assets (ROA), Net Fixed Assets Turnover (NFAT) and Ratio of Cost of Production to Total assets. This means that firm data has great variations over time.

As shown in Table 4, water to the Cost of production ratio (WTRCOP) has a high negative relationship with the Profitability ratio or ROA. ROA is also negatively related to FD and NFAT. Between WTRCOP and NFAT, there may exist some collinearity. However, the value is below the threshold of 0.7 and tolerable as per Naval Bajpai.[46]

As per in Table 5, Unit root test of all the variables were conducted using eviews confirming that the data series are stationary. The process also helped in selecting variables for the study.

As per the guidelines suggested[41] based on Arellano Bond Estimator, pooled Ordinary Least Square (POLS) and the Fixed Effect (FE) approaches should be used to estimate the AR model in the beginning. The higher bound estimate should be determined by taking the coefficient of the lag DV estimated by the POLS, and the lower bound estimate should be determined by taking the corresponding FE estimate. The System GMM estimator should only be used when the coefficient produced by the Difference GMM estimator is less than the lower bound or the FE estimate. It can be seen from Table 6 that the value of the coefficient of difference GMM estimator is above FE estimate and falls in between POLS and FE estimates. The results of residual diagnostics are presented in Table 7. Therefore, the difference GMM is preferred taken as more suitable.

Table 4 — Correlation table

−0.082	ROA	WTRCOP	FD	NFAT	COPTA
ROA	1				
WTRCOP	−0.959**	1			
FD	−0.011	0.029	1		
NFAT	−0.59**	0.579**	−0.019	1	
COPTA	0.056	−0.065	00.03	−0.234	1

Validity Tests

1. Coefficient of Difference GMM falls between FE and POLS, i.e. (0.11>**0.08**>0.06)
2. The results indicate significant ROA and WTRCOP for both FE and POLS whereas, ROA, WTRCOP, NFAT, COPTA and FD are all significant in the Difference GMM estimator.
3. ROA is directly affected by its past values which reflects the suitable use of a dynamic estimator.
4. The P-value of AR (2) is estimated as 0.59 which is insignificant. This highlights that 2nd order autocorrelations do not exist there.
5. Hansen J statistic is 0.42 or insignificant, which also overrides the overidentification of the data as per David Roodman.[44]

Substituted Coefficients:
@DADJ(ROA)=0.076*@DADJ(ROA(−1)) + 0.78*@DADJ(WTRCOP) − 0.46*@DADJ(NFAT) − 0.02*@DADJ(COPTA) − 0.095*@DADJ(FD)

Short run coefficient of determinants turned out as 0.78 for X_1 on Y, −0.46 for X_2 on Y, −0.02 for X_3 on Y, and −0.095 for X_4 on Y.

Table 5 — Stationarity test results

Variable	Tests Passed	Probability	Cross section	No. of observation	Test Results	Data Model
ROA	ADF- Fisher Chi-square, PP-Fisher Chi-square, Im, Pesaran and Shin W-Statistics and Levin, Lin & Chu -t	0.00	40	320	Stationary	(i, 0, 0)
WTRCOP	PP-Fisher Chi-square	0.00	40	354	Stationary	(i, 0, 0)
NFAT	PP-Fisher Chi-square	0.00	40	360	Stationary	(i, 0, 0)
COPTA	ADF- Fisher Chi-square, PP-Fisher Chi-square, Im, Pesaran and Shin W-Stat. Levin, Lin & Chu -t	0.00		359	Stationary	(i, 0, 0)
FD	PP-Fisher Chi-square	0.00	40	360	Stationary	(i, 0, 0)

Table 6 — OLS, FE and Difference GMM regression results for 40 companies (N = 40, T-10; Dependent Variable = Return on Assets (ROA))

Variable	Simple OLS Coefficient	P-Value	POLS with lagged DV Coefficient	P-Value	Fixed Effect with lagged DV Coefficient	P-Value	Difference GMM with lagged DV Coefficient *Higher than FE Coefficient	P-Value
			Upper Bound		Lower Bound			
ROA(-1)			0.11	0.00**	0.06	0.00**	0.08*	0.00**
WTRCOP	−1.24	0.00	−1.24	0.00**	−1.14	0.00**	0.78	0.00**
NFAT	0.14	0.20	0.12	0.25	0.38	0.18	−0.46	0.00**
COPTA	0.004	0.15	−0.005	0.10	−0.04	0.00**	−0.02	0.00**
FD	0.23	0.26	0.24	0.20	0.04	0.76	−0.09	0.00**
R -Squared	0.922		0.933		0.947			
Overall P-Value		0.00**		0.00**		0.00**		
D-W Statistics	0.843		1.11		1.16			
Mean Dep. var	0.005	S.D. Dep.var	0.07	S.E. of Regression	0.06	Sum Sq. resid	1.49	
Note:	** = Significant; J-Statistics: 36.035 P-Value-0.42*; Instrument Rank: 40							

Table 7 — Residual diagnostics

Test	Statistic	p-Value	Interpretation
Hansen J-test	36.03	0.42	Instruments are valid
Arellano-Bond AR(1) test	−2.91	0.03	Significant, Ist order autocorrelation expected
Arellano-Bond AR(2) test	0.54	0.59	No 2nd order autocorrelation-confirms model specification
Number of instruments	40	—	Within acceptable range.

Water charges to cost of production ratio (WTRCOP) has a positive relationship with Return on Assets (ROA). However, it is found to have a negative relationship with Net Fixed Assets Turnover (NFAT), the ratio of Cost of Production to Total assets (COPTA), and the ratio of Liquid Liability to Gross Domestic Product (FD). The analysis clearly exhibits the fact that past profitability has an impact on the next year's profitability.

The water variable or the ratio of 'Water charges to Cost of production' (WTRCOP) gives the idea of the contribution of water consumption to the cost of production. The cost of production involves all the cost elements in both direct and indirect incurrence.

The GMM estimation suggested a 10% increase in WTRCOP will increase profitability or ROA by 7.8%. This can be inferred from the fact that more consumption of water is basically translating into more profits for the firm. Although, the study further conducted by creating 4 quartiles based on 'sales-values' depicted through Fig. 2. It was observed from the graph of WTRCOP that firms of last quartiles displaying unusual fluctuations. Therefore, on removing the outliers or the firms in last quartile, the following results could be obtained.

Coefficient of Difference GMM falls closer to POLS and higher than FE, i.e. (**0.38**>0.32>0.26)

Substituted Coefficients: @DADJ(ROA) = 0.38*@DADJ(ROA(−1)) + 1.78*@DADJ(WTRCOP) − 0.046*@DADJ(NFAT) − 0.002*@DADJ(COPTA) − 0.027*@DADJ(FD)

Short run coefficient of determinants in second case turned out as 1.78 for X_1 on Y, 0.046 for X_2 on Y, −0.002 for X_3 on Y, and −0.027 for X_4 on Y.

Here as per Table 8, water variable is found to be positively linked to ROA. The result is in line with the findings of Sudha.[10] The current analysis suggests a

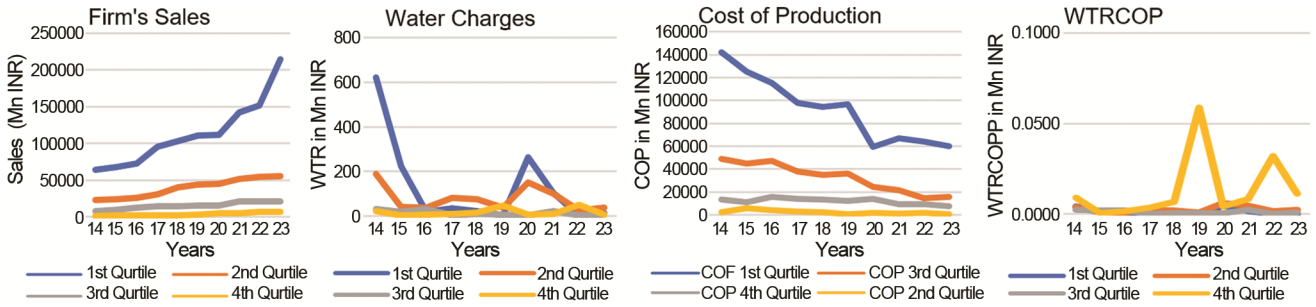

Fig. 2 — Quartiles trend of 10 years shown of 40 firms divided in 4 groups on sales basis for Water charges to cost of production (in Mn INR on Y-axis and Years on X-axis)

Table 8 — OLS, FE and Difference GMM regression results for 30 companies
(Dependent Variable = Return on Assets (ROA); N=30, T-10)

Variable	Simple OLS Coefficient	P-value	POLS with lagged DV Coefficient Upper bound	P-value	Fixed Effect with lagged DV Coefficient Lower bound	P-value	Difference GMM with lagged DV Coefficient *Close to POLS	P-value
ROA(-1)			**0.32**	0.00**	**0.26**	0.00**	**0.38***	0.00**
WTRCOP	1.89	0.0**	1.899	0.0**	1.91	0.0**	1.78	0.0**
NFAT	−0.002	0.52	−0.001	0.66	−0.001	0.51	−0.046	0.00**
COPTA	0.0007	0.001**	0.001	0.0**	0.001	0.51	0.002	0.0**
FD	−0.02	0.187	−0.02	0.16	−0.02	0.19	−0.027	0.00**
R -Squared	0.974		0.978		0.981			
Overall P-Value		0.00**		0.00**		0.00**		
D-W Statistics	1.23		1.41		1.55			
Mean Dependent var	0.004	S.D. Depvar	0.06	S.E. of Reg.	0.01	Sum Sq resid	0.03	
Note	(** = Significant); J-Statistics: 22.62, P-Value - 0.59* Instrument Rank: 30							

10% increase in 'water charges to cost of production' will increase profitability or ROA by 17.8%. It can be inferred from the analysis that for firms with larger operations, water has a significant impact on the performance of the firm. It is a noteworthy point considering water's role in the cost of production. However, by the second analysis it can be said that bigger the firm, higher the consumption of water. While heuristics say that it should be negative, the results obtained are opposite. Earlier study informed that firms often set less aggressive future water efficiency goals largely due to declining marginal returns on efficiency expenses and aversion to address supply chain water hazards.[16] Secondly, Food sector is generally considered a rather crisis-proof sector, where profitability is driven by industry growth.

Though, the data series is also examined through a line graph and Cumulative sum of squares a structural break (Fig. 3) was identified in the year 2016 for contextual understanding. In an economic time series, a structural break is a sudden alteration that can be the result of a variety of factors, such as changes in policy direction, regime, or external disruptions. The intercept, trend, or both may be influenced by structural fractures as per Bai & Perron.[47]

Post 2014–15, Indian corporations had to submit ESG data which include Water information in the format of Business Responsibility and Sustainability reports as a regulatory requirement. The Government also brought the Model Groundwater Bill draft after 1970 in India. However, as per the Indian Constitution, water is a matter included in Entry 17 of List-II, i.e., the State List of subjects and water charges being decided by the respective states. There have been directions from the center to differentiate the charges among Industrial, domestic, and agricultural users. Globally, in 2016 GRI transitioned from providing guidelines to setting the first global standards for sustainability reporting – the GRI Standards. The GRI standards included the water parameter as 'GRI 303: Water and Effluents' also in the comprehensive reporting system.

In Fig. 4, the variable 'Cost of Production to Total assets' (COPTA) gives the idea of the efficiency of the firm in generating sales. The cost of Production

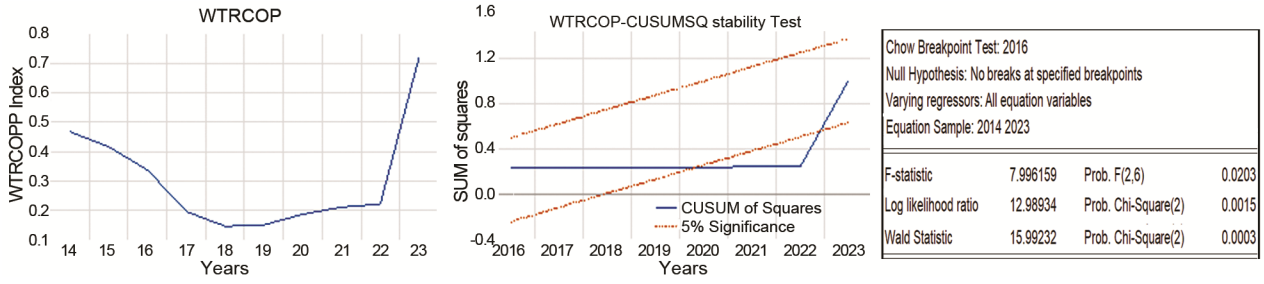

Fig. 3 — Structural break and CUSUMSQ -plot, Residuals calculations of water charges to cost of Production (WTRCOP) (Source: Author's compilation)

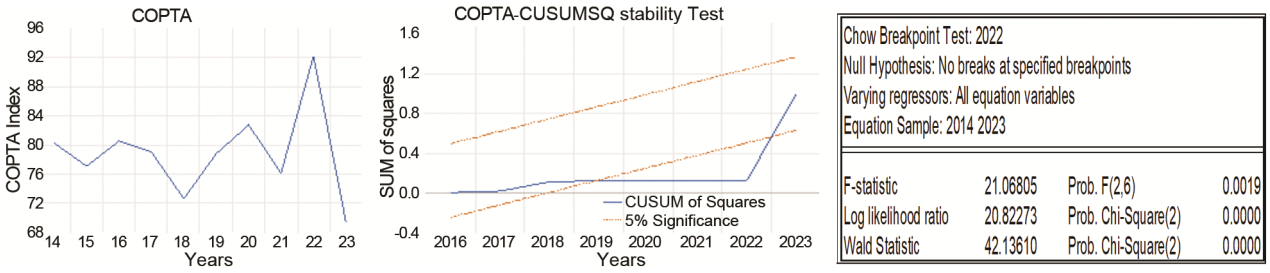

Fig. 4 — Structural break and CUSUMSQ -plot, Residuals calculations of Cost of Production to Total assets (COPTA) (Source: Author's compilation)

covers all the direct costs involved in production such as Raw materials, labour costs and, storage costs etc. Therefore, the ratio takes into account the revenue consumed in producing the good. Theoretically, it reduces the profitability of the firm and hence the result of analysis, a 10% increase in COPTA decreases the Return on Assets by 0.2% is consistent with the fact that costs incurred in production has negative impact on the profitability. Also, as shown below, a structural break was identified in 2022.

Then in Fig. 5, the variable 'Net Fixed Assets Turnover' (NFAT) is taken here as the ratio of net fixed assets to Total assets. Here net fixed assets mean the fixed assets value net of depreciation and other liabilities. They are non-current assets or tangible parts. The ratio in the study gives the idea of the stockholder's equity in the firm. The study suggested that a 10% rise in NFAT decreases the profitability of the firm by 4.6%. The data was consistent over the ten-year period reflecting the stability of the sector.

In Fig. 6, the variable 'Financial Depth' (FD) is used in the analysis to have a fair idea of the impact of national financial strength on the industry. While liquid liability refers to the presence of the currency and other liquid instruments at a given period in the country, GDP is the measurement of the total value of all the finished goods and services produced in the country.[39] The present analysis suggests that a 10% increase in FD also decreases the firm profitability by 0.95%. This inference is a surprise element and inconsistent with general economic assumptions. As shown below, a structural break was identified in 2022, a COVID-effect and can be taken as outlier.

Water affects lives and practically every facet of a business's daily operations, therefore its efficiency is linked to operational efficiency, energy efficiency, and even firm consciousness. The study aimed to investigate the relationship between water charges and firm performance for 40 food firms from 2014 to 2023 taken from the CMIE Prowess database. In this study instead of water usage as a direct variable the ratio of Water charges to cost of production is used. The dynamic panel estimator-GMM estimation (Hansen[39] to Blundell and Bond estimator[43]) was used to analyze the panel data. It was observed that WTRCOP displayed significant and negative relationship in POLS, POLS with lagged ROA and Fixed effect analysis with lagged ROA. However, it reversed in GMM estimation. Similar second analyses of 30 firms (removing the outliers) suggested that, WTRCOP has a positive and significant effect on return over assets. While the effect of NFAT, FD remained same, except the COPTA which also turned positive. Finally, it can be concluded that the ratio of water to cost of production has a positive and significant effect on ROA.

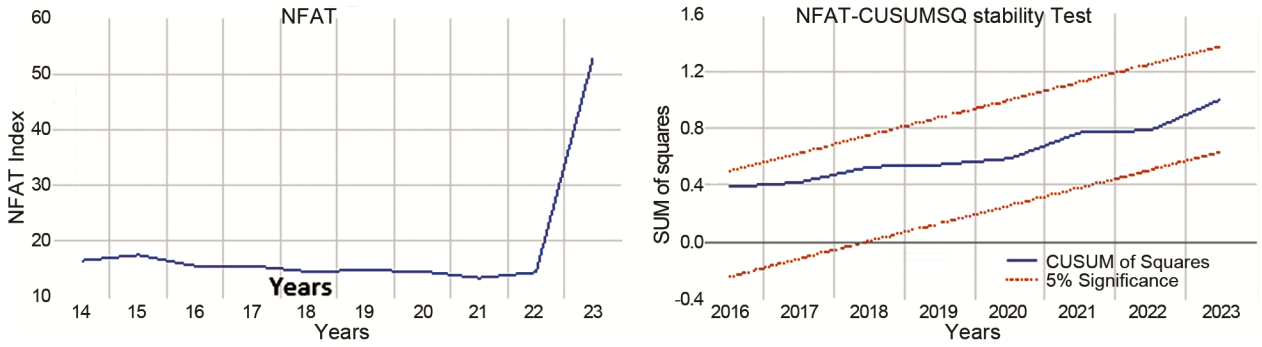

Fig. 5 — Structural break and CUSUMSQ -plot of Net Fixed Assets Turnover (Source: Author's compilation)

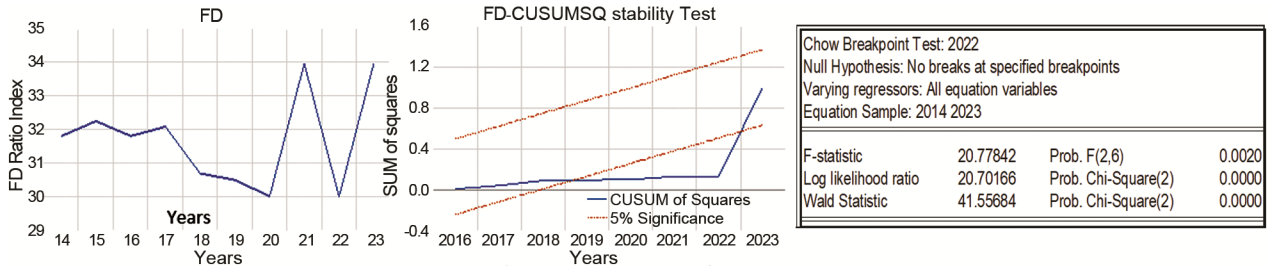

Fig. 6 — Structural break and CUSUMSQ -plot, Residuals calculations of Broad Money to Gross Domestic Product; (FD ratio) (Source: Author's compilation)

Conclusions

Water has emerged as a critical determinant of corporate survival and sustainability. This study provides attempted linking water costs and profitability in Indian Food and beverage sector. The findings suggest that as long as profitability remains positively associated with water consumption, firms have little incentive to improve water efficiency. Policymakers should therefore introduce a disincentive to minimize water consumption, like surcharges and differential pricing (covering value of ecological services etc.) aimed towards a negative relationship between water consumption and profitability and mandate more rigorous disclosure of water information by firms. Firms in turn must adopt systematic measures for optimizing water usage, discharge, reuse, benchmarking and spending on water. While this study focuses on single sector, it added fresh evidence on how water management intersects with corporate performance. Future research could extend the narrative across industries and include listed firms to build a more comprehensive picture of water's role in corporate sustainability.

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