Analysis of the Structural Model of Financial Resilience in the Water Industry

Mehdi Habibzadeh Kalah Roudi
Department of Management and Economics, SR.C, Islamic Azad University, Tehran, Iran
Email: bardiyavaf1@yahoo.com
Fraydoon Rahnamay Roodposhti
Professor, Department of Accounting and Management, SR.C, Islamic Azad University, Tehran, Iran(Corresponding Author)
Rahnana.roodposhti@gmail.com
Ahmad Ebrahimi
Assistant Professor, Department of Industrial and Technology management, SR.C, Islamic Azad University, Tehran, Iran
Ahmad.ebrahimi@srbiau.ac.ir
Vahidreza Mirabi
Assistant Professor, Department of Business Administration, Department of Management, Tehran Central Branch, Islamic Azad University, Tehran, Iran
Vah.mirabi@iauctb.ac.ir
Reza Radfar
Professor, Department of management, SR.C, Islamic Azad University, Tehran, Iran
Radfar@gmail.com

Submit: 05/01/2025 **Accept:** 09/07/2025

ABSTRACT

The objective of the present study was to examine the structural model of financial resilience in the water industry. The research method employed was quantitative, and the target population consisted of financial managers, experienced specialists, experts in the water industry sector, policymakers, and university professors. A purposive sampling method was used to select 384 participants. In this study, to investigate the structural model of financial resilience in the water industry, questionnaires distributed among the sample were analyzed using structural equation modeling. The research findings present causal, contextual, and intervening factors, the core construct (financial resilience), smart water consumption behaviors, and a value creation framework contributing to the development of a financial resilience model in the water industry. Unlike previous models that focus solely on financial resilience in the water industry, the proposed model incorporates additional dimensions and interactions. Furthermore, the research model does not impose specific limitations on including various financial relationships that may be identified in future studies. In this regard, the examination of antecedents for the development of smart consumption behavior indicates that the appropriateness of water price and quality, social context, and social responsibility have a significant impact on the development of smart water consumption behavior.

Keywords: Structural Equation Modeling, Financial Resilience, Development, Water Industry

1. Introduction

Iran faces increasing water scarcity, driven by its arid climate, rapid urbanization, population growth, and the escalating impacts of climate change. These pressures have intensified the need for resilient water systems capable of adapting to unpredictable economic and environmental shocks. Among the various dimensions of resilience, financial resilience—the ability of water utilities and institutions to sustain services under financial stress—has become a critical factor in ensuring long-term water security.

Resilience is broadly defined as a system's ability to absorb disturbances, adapt to changing conditions, and recover efficiently. Unlike resistance, which focuses on preserving equilibrium, resilience emphasizes dynamic adaptation and transformation. This distinction is particularly important in the context of water systems, where financial stability must coexist with flexibility in the face of uncertainty (Holling, 1973; Rutter, 2006).

While resilience has been widely studied in ecological and social contexts, financial resilience in the water sector remains underexplored—especially in developing countries facing systemic infrastructure and governance challenges. Most existing studies address technical or operational dimensions, but few provide a structured model capturing the causal, contextual, and intervening factors that shape financial resilience in practice.

This study addresses this gap by developing a structural equation model (SEM) that conceptualizes financial resilience in the Iranian water industry. The model identifies key antecedents such as pricing adequacy, social context, and institutional responsibility, and examines their effects on adaptive behaviors like smart water consumption. By doing so, the research contributes a practical framework to guide policymakers and water managers in enhancing resilience through strategic financial planning.

The remainder of this article is structured as follows: Section 2 reviews relevant literature on resilience and its application in water systems; Section 3 explains the research design and SEM methodology; Section 4 presents the analysis and findings; and Section 5 discusses the implications and provides concluding remarks.

2. Theoretical Foundations and Literature Review

Conceptual Definitions of Resilience

Resilience is generally defined as a system's ability to adapt to disturbances and continue functioning under stress (Holling, 1973). In contrast to resistance, resilience emphasizes transformation and flexibility, which is especially relevant in financial systems within the water sector.

Financial resilience refers to the capacity of utilities to withstand economic shocks while maintaining service delivery. This involves short-term mechanisms (liquidity, cost recovery) and long-term strategies (investment, revenue diversification). Key drivers include pricing adequacy, transparency, and public engagement (Goldin et al., 2022).

This study develops a structural equation model (SEM) that integrates these variables and explains their interplay in shaping financial resilience in the context of the Iranian water industry.

Concept of Resilience

The concept of resilience, particularly pertaining to places and communities, is increasingly prevalent across various domains, especially in relation to the resilience against shocks, economic collapse, climate change, globalization, and natural disasters. Some authors agree that resilience has become a common (prevalent) concept through a historical process. Resilience is a paradigm linked to communities, with resilience centers emerging from external shocks (Sarah Skerratt, 2013).

The concept of resilience has its roots in physics and mathematics and is used to describe the ability of a material or system to return to its equilibrium state after displacement or movement. In the context of social and ecological systems, resilience refers to the ability to absorb or confront disturbances or disruptions in such a way that the fundamental structures and functions, the capacity for reorganization, and the capacity for adaptation in the face of stresses and changes are maintained (Hanneman, 2001, p. 149; Gunderson & Holling, 2002).

Resilience represents a transformative advancement in risk management in the current decade. Today, perspectives and theories in disaster management and sustainable development aim to create resilient communities capable of withstanding natural hazards. Consequently, many researchers consider resilience to be one of the most critical topics for achieving sustainability. Currently, resilience is seen as a means to strengthen communities by leveraging their capacities, leading to the development of various definitions, approaches, indicators, and assessment models. Enhancing resilience and the level of adaptability and response to environmental changes and crises, while reducing vulnerability among local communities, enables the continuous and sustainable development of community residents amid threats from environmental hazards, preventing future disasters from disrupting people's lives (Sadeghloo & Sajasi-Qeidiari, 2014).

3. Research Methodology

Type and Objective of the Study

This study adopts a quantitative, applied research design aimed at developing and validating a structural model of financial resilience in the water industry. The research is explanatory in nature, using structural equation modeling (SEM) to examine causal relationships among key latent constructs.

3.1 Population and Sampling

The target population includes financial managers, water industry experts, policymakers, and academic researchers. A purposive sampling method was used to select 384 participants, in line with Cochran’s formula for large populations. The sampling ensured representation across diverse demographic groups relevant to financial decision-making in the water sector.

3.2 Data Collection Instrument

Data were collected using a structured questionnaire based on a 5-point Likert scale. The items were designed to measure constructs such as causal drivers or causal factors, contextual factors, mediating factors, core construct, and behavioral outcomes (e.g., smart water consumption).

3.3 Structural Equation Modeling Approach

To test the theoretical model, Partial Least Squares SEM (PLS-SEM) was employed using Smart PLS software. This method is well-suited for complex models with latent variables, especially when the sample size is relatively limited and the distribution of data is non-normal (Hair et al., 2021). PLS-SEM enables simultaneous assessment of both the measurement model (validity and reliability of constructs) and the structural model (hypothesis testing and path analysis).

The rationale for using Smart PLS over LISREL stems from:

its robustness in handling small to medium-sized samples, minimal assumptions regarding data distribution, and its ability to estimate complex hierarchical models involving both formative and reflective constructs.

The decision to use SmartPLS instead of LISREL was based on several factors. First, SmartPLS is more robust in handling data that deviate from normal distribution, which was confirmed through the Kolmogorov-Smirnov test. Second, it performs well with relatively small to medium-sized samples and allows for greater flexibility when dealing with complex models that include both formative and reflective constructs. Finally, it is particularly suitable for exploratory studies aiming to develop predictive models, which aligns with the objectives of this research.

3.4 Validity and Reliability

Convergent validity was evaluated using Average Variance Extracted (AVE), where values above 0.50 indicated adequate construct validity. Factor loadings for all items exceeded the acceptable threshold of 0.7, confirming that each item reliably measured its intended construct.

Reliability was confirmed through Composite Reliability (CR) and Cronbach’s Alpha, both of which exceeded 0.7 for all latent variables, indicating internal consistency.

Additionally, a Kolmogorov-Smirnov test confirmed that the data did not follow a normal distribution ($p < 0.05$), validating the appropriateness of using PLS-SEM.

Discriminant validity was assessed using the Fornell-Larcker criterion, which compares the square root of AVE for each construct with the correlations between constructs. All constructs met this criterion, confirming discriminant validity. In future research, complementary methods such as the HTMT ratio may be employed for more robust assessment.

Regarding the measurement items, they were adapted from existing validated instruments in the literature and refined through expert review involving academics and industry professionals in the water sector. This ensured both content relevance and contextual appropriateness for the study's setting.

3.5 Structural Model Evaluation

After validating the measurement model, the structural model was assessed using: Path coefficients (β values) to estimate relationships between constructs, t-values via bootstrapping to test statistical significance (threshold ±1.96 at 95% confidence), and R^2 values to determine the variance explained in each endogenous construct.

These metrics provided a comprehensive assessment of the theoretical model’s explanatory power and the significance of each hypothesized relationship.

It is noteworthy that the software used in this section is LISREL or Smart PLS.

4. Research Findings

In the present study, aimed at examining the structural model of financial resilience in the water industry, the distributed questionnaire was analyzed within the statistical sample. Accordingly, the demographic characteristics of the respondents and the comparison of the current status among different groups were examined as follows:

Among the respondents, 275 individuals (70%) are male and 116 individuals (30%) are female. Additionally, regarding educational attainment, 39 respondents (10%) hold a degree below a bachelor's degree, 70 respondents (18%) hold a bachelor's degree, 138 respondents (35%) hold a master's degree, and 144 respondents (37%) hold a doctoral degree. In terms of age distribution, 87 respondents (22%) are between 26 to 35 years old, 174 respondents (45%) are between 36 to 45 years old, and 130 respondents (33%) are over 45 years old.

Based on the analysis presented in Table 1, the significance level of the collected data for all research variables was less than 0.05. Consequently, at a 95% confidence level, the null hypothesis was rejected, indicating that all variables exhibit a non-normal distribution.

The use of the extracted Average Variance Extracted (AVE) is recommended as a criterion for assessing convergent validity. A minimum AVE of 0.50 signifies adequate convergent validity, meaning that a latent variable can, on average, explain more than half of the variance of its indicators (Azar et al., 2012).

Table 1: Kolmogorov-Smirnov Test

	Casual conditions	Contextual factors	Intervening conditions	Financial resilience phenomenon in the water industry	Main strategies and actions	Implications
Sample size	391	391	391	391	391	391
Mean	3.498	3.592	3.750	3.121	3.748	3.784
Standard deviation	0.717	0.683	0.764	0.907	0.702	0.788
Kolmogorov-Smirnov Test	0.081	0.090	0.212	0.285	0.186	0.225
Significance level	0.000	0.001	0.003	0.000	0.000	0.000

AVE	Variable
0.631	Intervening Conditions
0.577	Main Strategies and Actions
0.590	Causal drivers
0.645	Implications
0.552	Financial Resilience Phenomenon in the Water Industry
0.518	Contextual factors

Table 1 – Convergent Validity Assessment of the Measuremet ModelBased on the results of the confirmatory factor analysis, it can be concluded that all items or questionnaire questions possess acceptable validity; indeed, the factor loadings associated with each item or research question were significant at the 95% confidence level.

After testing the measurement model—namely, confirming the validity and reliability of the research's measurement models—the structural model, or the research's structural model, is evaluated. Using the structural model, the research hypotheses can be examined. The criteria of the t-statistic, the coefficient of determination (**R^2**), and the path coefficient are utilized to evaluate the model.

The tested conceptual model in standard mode using the PLS algorithm and the path coefficients are presented in Figure 4-2. The numbers displayed on the paths between constructs are referred to as **path coefficients**. These numbers represent the standardized beta coefficients in regression or the correlation coefficients between two constructs and are provided to assess the extent of the direct impact of one variable on another. The numbers displayed on the paths between constructs and indicators in reflective models represent the **factor loadings**, and the numbers within each circle indicate the **coefficient of determination (R^2)** of the primary construct, which always varies between zero and one. The larger the **R^2** value, the better the regression line explains the changes in the dependent variable in relation to the independent variable.

Figure 4-2. Structural model of financial resilience using PLS-SEM, displaying standardized path coefficients and R^2 values for each endogenous construct.

Most **R^2** values in PLS path models are described as significant (Azar et al., 2012). The **R^2** values for the latent variables of the model are presented in Table 2. As observed, **R^2** values are not provided for exogenous or independent latent variables.

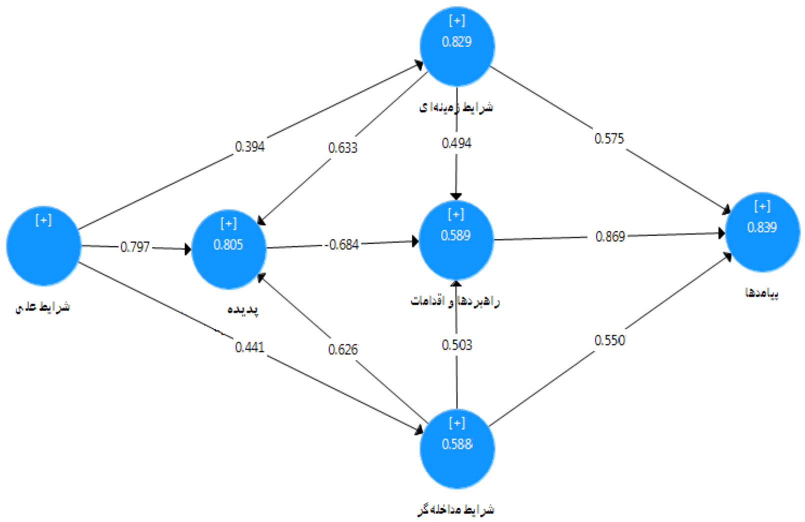
To evaluate the significance of the hypotheses, the Bootstrapping (BS) method was employed, utilizing the t-value as the partial indicator. The t-values for the research model are presented in Figure 2. Based on the pattern and magnitude of the significance coefficients, a t-value must exceed 1.96 or be less than -1.96 to either reject or accept the hypotheses. Therefore, any t-value falling within this range is considered statistically insignificant at the 95% confidence level.

The results pertaining to the research hypotheses are displayed in Table 3. It is important to note that, for the sake of clarity and enhanced visualization of the examined relationships, the coefficients of the research questions within the model are treated as latent variables. However, the factor loadings of the questions in this model are detailed in Table 4.

Although the path coefficient for the causal drivers construct is relatively strong (β = 0.797), the associated t-value (1.67) does not exceed the conventional significance threshold of 1.96. Therefore, the result should be interpreted with caution. This suggests a potential but statistically inconclusive relationship at the 95% confidence level. Future research may consider using bootstrapped confidence intervals to further assess this path's stability and significance.

جدول ۲- مقدار R2 در متغیرهای تحقیق

R^2	متغیر
0.5681	شرایط مداخله‌گر
0.5890	راهبردها و اقدامات اصلی
-	شرایط علی
0.8392	پیامدها
0.8053	پدیده تاب آوری مالی در صنعت آب
0.6291	شرایط زمینه‌ای



جدول ۱- ارزیابی روایی همگرای مدل اندازه گیری

5. Discussion and Policy Implications

The findings of this study have important implications for practitioners and policymakers in the water industry. The significant influence of factors such as pricing adequacy, institutional responsibility, and social context on financial resilience highlights the need for integrated planning.

Policymakers can enhance financial resilience by implementing flexible and transparent pricing strategies that reflect actual supply costs while promoting equitable access. Institutional leaders should also invest in public awareness programs that foster smart consumption behavior and build trust through transparency and accountability.

For water utility firms, financial planning must go beyond budgeting and cost recovery; it should incorporate adaptive mechanisms such as reserve funds, performance-based investment strategies, and customer engagement tools. These measures can help maintain financial health during economic downturns, droughts, or shifts in demand.

Additionally, promoting smart water consumption through targeted pricing incentives and community-level educational campaigns could simultaneously reduce water waste and improve revenue stability.
This study's SEM model offers a practical tool for evaluating how structural and behavioral elements interact, allowing decision-makers to prioritize interventions that maximize both economic and environmental outcomes.

6. Comparative Perspective

While this study focuses on the financial resilience of the water industry in a developing country context, its structural model shares commonalities with resilience frameworks in other infrastructure sectors such as energy and healthcare. For instance, key constructs such as institutional responsibility, financial planning, and consumer behavior are also central to resilience in electricity and public health systems.

In energy sectors, resilience frameworks often emphasize pricing mechanisms, demand-side management, and regulatory oversight—parallels that support the validity of including pricing adequacy and smart consumption in this study's model. Similarly, in the healthcare sector, resilience involves strategic resource allocation, transparency, and community trust—all of which align with the constructs of contextual and causal drivers presented here.

By drawing these parallels, the proposed model can be positioned as a generalized framework for financial resilience across public service sectors that rely heavily on stable resource flows, user cooperation, and institutional strength.

7. Conclusion and Recommendations

The findings of the present study can be precisely utilized to address the research question concerning the dimensions and components of the financial resilience model in the water industry. The results of this study indicate the objectives of managers regarding predictive behavior and the factors contributing to its emergence. Additionally, the implications for the water industry are delineated. In this context, financial managers, subsidiary companies within the water industry, and decision-makers must leverage the results obtained from this research to create competitive advantages based on financial resilience by identifying, prioritizing, eliminating, and mitigating the effects of each influential factor impacting financial resilience in the water industry.

Moreover, it is essential for these stakeholders to periodically evaluate and analyze their performance from both the perspective of consumers and human resources. Since this research focuses on financial resilience within the water industry, its outcomes can be applicable to subsidiary organizations. In today's competitive world, failing to respond to new needs and demands can lead to irreparable consequences. The practical recommendations provided aim to overcome existing challenges in financial management within the water industry. Various industries can utilize the current research model to address similar challenges within their respective sectors.

The final model obtained demonstrates that a comprehensive perspective and attention to various aspects of the financial domain, particularly financial resilience in the water industry, are essential when considering Causal, Contextual, and Intervening Conditions. This study was conducted with the objective of examining the structural model. The research results include the identification of Causal, Contextual, Intervening Factors, Core Constructs, Optimal Consumer Consumption Behavior, and the development of Value Creation aimed at advancing the financial resilience model in the water industry, all of which are presented in the final research model. Contrary to the identified models limited to financial resilience in the water industry, this model also encompasses additional aspects. Furthermore, the research model does not impose specific restrictions on the inclusion of various financial relationships that may be identified in future studies. In this regard, the examination of antecedents to the development of Smart Water Consumption Behavior reveals that factors such as water price adequacy, quality, social context, and social responsibility significantly influence the development of intelligent water consumption behaviors.

7.1 Expanding Smart Consumption Strategies

Smart water consumption behavior plays a pivotal role in strengthening financial resilience in the water industry. To effectively promote these behaviors, policymakers should adopt a multi-faceted approach. First, implementing dynamic and incentive-based pricing structures—such as tiered rates or rebates for low-usage households—can financially motivate consumers to conserve water. Second, targeted educational campaigns in schools and communities can increase public awareness about the economic and environmental value of smart consumption. Third, regulatory measures such as mandating water-efficient appliances, leak detection technologies, and consumption monitoring tools can institutionalize responsible water use. These combined strategies not only reduce operational costs and waste but also build long-term consumer trust and system stability. The inclusion of smart consumption behavior in the structural model underscores its importance as both an outcome and a reinforcing factor of financial resilience.

References

FitzPatrick, B. (2019). Validity in qualitative health education research. Currents in Pharmacy Teaching and Learning, 11(2), 211-217

Holsti, O. R. (1969). Content analysis for the social sciences and humanities, Reading, MA: Addison-Wesley.

Kruckeberg, B. M., Chahla, J., Moatshe, G., Cinque, M. E., Muckenhirn, K. J., Godin, J. A., ... & LaPrade, R. F. (2018). Quantitative and qualitative analysis of the medial patellar ligaments: an anatomic and radiographic study. The American journal of sports medicine, 46(1), 153162.

Lemon, L. L., & Hayes, J. (2020). Enhancing trustworthiness of qualitative findings: Using Leximancer for qualitative data analysis triangulation. The Qualitative Report, 25(3), 604-614.

Mayring, P. (2014). Qualitative content analysis. A companion to qualitative research, 1, 159176.

McDonald, N., Schoenebeck, S., & Forte, A. (2019). Reliability and inter-rater reliability in qualitative research: Norms and guidelines for CSCW and HCI practice. Proceedings of the ACM on Human-Computer Interaction, 3(CSCW), 1-23..

Rose, J., & Johnson, C. W. (2020). Contextualizing reliability and validity in qualitative research: toward more rigorous and trustworthy qualitative social science in leisure research. Journal of Leisure Research, 51(4), 432-451.

Strauss, A. C., & Corbin, J. (1998).«Grounded Theory methodology: an over view».

Lincoln, Y, S.(Eds). (1985). Strategies of qualitative inquiry. Thousands Oaks, Sage, 158183.

Behboudian, M., & Kerachian, R. (2021). Evaluating the resilience of water resources management scenarios using the evidential reasoning approach: The Zarrinehrud river basin experience. Journal of Environmental Management, 284, 112025.

Corbin, J. (2021). Strauss's Grounded Theory. In Developing Grounded Theory (pp. 25-44). Routledge.

Creswell, J. W. (2002). Educational research: Planning, conducting, and evaluating quantitative (p. 676). Upper Saddle River, NJ: Prentice Hall.

Creswell, J. W. (2007). Qualitative Inquiry and Research Design: Choosing among five approaches Thousand Qaks CA: Sage.

Goldin, J., Nhamo, L., Ncube, B., Zvimba, J. N., Petja, B., Mpandeli, S., ... & Mabhaudhi, T. (2022). Resilience and Sustainability of the Water Sector during the COVID-19 Pandemic. Sustainability, 14(3), 1482.

Hair Jr, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2021). A primer on partial least squares structural equation modeling (PLS-SEM). Sage publications.

Hussain, M., & Papastathopoulos, A. (2022). Organizational readiness for digital financial innovation and financial resilience. International Journal of Production Economics, 243, 108326.

Kass-Hanna, J., Lyons, A. C., & Liu, F. (2022). Building financial resilience through financial and digital literacy in South Asia and Sub-Saharan Africa. Emerging Markets Review, 51, 100846.

Kirchhoff, C. J., & Dilling, L. (2016). The role of US states in facilitating ef