SCIENTIFIC OASIS

Decision Making: Applications in Management and Engineering

Journal homepage: www.dmame-journal.org
ISSN: 2560-6018, eISSN: 2620-0104

A Structural Equation Decision Model for ATM Cash Management and Routing: Balancing Cost and Customer Satisfaction in the Banking Sector

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ARTICLE INFO

Article history:
Received 5 January 2025
Received in revised form 16 March 2025
Accepted 19 April 2025
Available online 15 June 2025

Keywords:
ATM Cash Management, Operational Efficiency, Customer Satisfaction, Technological Readiness, Managerial Competence, PLS-SEM

ABSTRACT

This research explores the factors influencing ATM cash management and routing efficiency within the Palestinian banking industry, employing responses from 500 banking personnel and analysing the data using Partial Least Squares Structural Equation Modelling (PLS-SEM). The conceptual framework incorporates managerial competence, technological readiness, and both regulatory and environmental support as antecedents of operational performance and customer satisfaction. The findings indicate that these organisational elements significantly contribute to enhanced operational performance, which subsequently acts as a mediator in improving customer satisfaction. While cost management effectiveness does not exert a direct influence on satisfaction, it slightly moderates and strengthens the association between operational performance and satisfaction. This study contributes to the literature by integrating behavioural insights with operational outcomes and offers practical guidance for financial institutions and regulatory bodies aiming to enhance ATM-related services and customer value in developing economies.

1. Introduction

The banking industry plays a pivotal role in fostering economic progress and maintaining financial stability globally, a responsibility that becomes especially vital within the Palestinian context. Here, commercial banks, Islamic financial institutions, and microfinance entities are instrumental in sustaining monetary flow and supporting both personal and corporate financial needs [35]. Regulatory oversight is provided by the Palestine Monetary Authority (PMA), which ensures the implementation of effective monetary policies. Concurrently, banks have been advancing their digital infrastructure to meet increasing customer demands for accessible, dependable, and streamlined financial services. Among these digital innovations, Automated Teller Machines (ATMs) serve as a primary interface for customers, offering continuous, self-service access to cash and bridging the gap between conventional banking and modern user expectations [37].

As ATM networks have expanded, managing them has grown more complex. Financial

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https://doi.org/10.31181/dmame8120251468

institutions are required to navigate the dual challenge of maintaining high levels of customer satisfaction through consistent cash availability while simultaneously controlling the substantial operational costs tied to ATM replenishment, cash-in-transit (CIT) operations, and idle cash reserves [4]. In the pursuit of operational efficiency and financial prudence, optimising ATM logistics and replenishment strategies has become essential for strengthening competitive positioning and service delivery [25; 38]. Empirical evidence indicates that poor cash management in ATMs may lead to service disruptions, increased customer dissatisfaction, unnecessary expenditures, and missed investment opportunities for banks [12; 14]. In contrast, well-managed ATM operations can significantly improve service delivery and cost efficiency by reducing the frequency of cash-outs, optimising cash stock levels, and streamlining CIT routing processes [52; 55]. The success of ATM functionality is also reliant on key elements such as ATM location strategy, demand forecasting, utilisation of real-time analytics, and the competencies of personnel overseeing ATM operations [44; 57].

Recent developments in operational research and digital innovation have provided financial institutions with advanced methodologies for managing ATM cash logistics. Techniques such as optimisation algorithms, simulation modelling, and artificial intelligence have been widely applied to address challenges in replenishment and routing, typically aiming to reduce operational costs, enhance service reliability, or promote sustainability objectives [9; 48]. Nonetheless, these data-driven approaches often underrepresent the organisational and human factors—such as managerial skills, technological capacity, and regulatory frameworks—that are critical to the overall success of ATM systems. Within existing studies on Palestine's banking sector, scholarly focus has largely been directed at algorithmic and locational optimisation, with limited attention to how organisational and employee-level determinants affect the performance of ATM services and user satisfaction [44; 57]. There remains a pressing need for empirical investigations that comprehensively assess the interplay between human resources, technological infrastructure, regulatory context, and operational outcomes in ATM cash management.

To fill this research gap, the current study employs structural equation modelling through Partial Least Squares (PLS-SEM) to empirically identify the key determinants of effective ATM cash logistics and routing within the Palestinian banking environment. Based on first-hand data gathered from employees engaged in ATM-related roles, the study formulates and validates a conceptual framework incorporating managerial competence, technological readiness, and regulatory and environmental support as primary contributors to operational performance. The framework further explores how operational efficiency functions as a mediator between these organisational resources and customer satisfaction, and examines the moderating influence of cost management effectiveness in amplifying the operational efficiency–satisfaction linkage. By applying PLS-SEM, this study shifts the focus beyond algorithmic processes to explore the behavioural and organisational dynamics shaping ATM operations. The methodology is particularly well-suited to complex multivariate analyses, allowing for an in-depth assessment of both direct and mediated relationships, along with moderation effects. This yields a comprehensive view of how banks can optimise operational performance and enhance user experiences simultaneously.

This investigation aligns with broader efforts to integrate quantitative modelling with organisational behaviour perspectives. It addresses the call in existing scholarship for contextually grounded, empirical research that mirrors the operational realities faced by financial institutions in developing markets. The theoretical foundation rests on resource-based and contingency frameworks, which posit that sustainable operational success is derived from a combination of tangible assets (such as technological tools and infrastructure) and intangible capabilities (such as managerial acumen and regulatory adherence). The empirical outcomes underscore that

managerial competence, technological readiness, and regulatory support substantially influence ATM operational performance. Furthermore, operational performance acts as a critical intermediary, converting these organisational assets into improved customer satisfaction. The findings also reveal that enhanced cost management contributes to strengthening this mediated relationship. These results offer concrete strategic insights for banking leaders and policymakers aiming to enhance the effectiveness and quality of ATM service provision in resource-constrained settings.

In conclusion, this study not only advances theoretical understanding but also offers practical relevance by presenting an empirically supported, multi-faceted model of ATM cash management and routing within the Palestinian banking system. It highlights the necessity of harmonising organisational, technological, and regulatory elements with operational and customer-centric goals. The adoption of PLS-SEM enables a robust analysis of these interconnected variables, ensuring that the study's insights are both methodologically rigorous and practically applicable for advancing banking operations.

2. Literature Review

The capability of contemporary banking institutions to deliver dependable and efficient ATM services in a cost-effective manner is fundamentally dependent on the integration of several organisational elements. These include managerial competence, technological adequacy, favourable regulatory frameworks, supportive environmental conditions, operational efficiency, and effective cost management. In various service-oriented and operational domains, prior research has underscored the relevance of these interconnected factors and their collective influence on customer satisfaction [3; 6; 21].

2.1 Managerial Competence and Its Impact

Managerial competence plays a critical role in shaping operational management and driving service innovation. Evidence from studies across the banking sector, supply chains, and various service industries consistently shows that organisational performance is closely linked to the expertise of managerial staff, their leadership capabilities, and their readiness to embrace change [18; 29; 36; 43]. In one organisational context, Radwan et al. [43] identified managerial and organisational preparedness as key predictors of non-financial outcomes, while [36] demonstrated that managerial competence contributes significantly to both operational outcomes and customer-related performance within the banking domain. Similarly, Barlan-Espino [3] highlighted how strategic managerial planning and leadership enhance operational efficiency and customer satisfaction in the restaurant industry, with implications for broader applicability across sectors.

In the context of Palestinian banks, Zıdan [57] argued that strong executive leadership and prudent asset management contribute to macroeconomic outcomes and the generation of customer value. Other research has emphasised the relevance of human capital and managerial skill in improving ATM replenishment processes and operational workflows [4; 48]. Further, Ekinci et al. [14] found that effective cash management practices, often led by competent managers, are instrumental in maintaining a balance between operational costs and customer satisfaction. Collectively, these findings [3; 4; 14; 43; 48; 57] establish a solid foundation for further empirical exploration into the link between managerial competence and operational efficiency.

2.2 Technological Readiness in Banking Operations

Technological readiness refers to an institution's willingness and capability to adopt and integrate digital technologies aimed at improving operational efficiency, reliability, and customer outcomes [21; 42; 47; 50]. One widely accepted tool for evaluating this construct is the Technology

Readiness Index (TRI 2.0), which has been validated across diverse sectors, ranging from logistics to financial services, for measuring how individuals and organisations engage with technological advancements [47; 50]. In the context of ATM-related functions, a strong degree of technological readiness is closely linked to the adoption of digital platforms, significantly influencing both the effectiveness and satisfaction associated with ATM service delivery [50].

Recent investigations [7; 9; 17; 21; 33; 40] have highlighted that employee preparedness for technological integration, alongside the depth of technology implementation, contributes to enhanced transactional stability. These studies, although often situated within logistics and cold chain management, carry transferable insights to banking contexts. For instance, Reyes-Mercado [46] emphasised that the deployment of forecasting tools, artificial intelligence, and route optimisation systems can simultaneously lower operational expenses and elevate service quality. ATM-specific research supports these conclusions, revealing that institutions with high technological readiness are more capable of employing machine learning and time series forecasting models to predict cash demand accurately and implement efficient replenishment strategies [2; 6; 8; 24; 48].

2.3 Regulatory and Environmental Support as Drivers

Extensive theoretical and empirical literature highlights the significance of both regulatory and environmental support in shaping operational efficiency and enhancing customer-related outcomes [4; 9; 26; 28]. Regulatory frameworks, particularly those governing ATM cash replenishment cycles, security protocols, and environmental compliance, provide both constraints and incentives that foster process innovation and facilitate risk management [26; 28]. Concurrently, environmental considerations and sustainability initiatives are gaining prominence within banking and logistics operations, further reinforcing their relevance to service delivery and operational performance [4; 9; 28]. Empirical findings from Hamzah and Shamsudin [21], Motamarri et al. [36], and Thanh et al. [53] indicate that regulatory systems support banks and service-oriented organisations in two main ways: by reducing operational uncertainty and by facilitating innovations in cash handling and routing. Additionally, environmentally supportive practices, such as the adoption of green fleets in cash logistics, contribute to increased operational efficiency and enhance public trust [4; 9].

2.4 Operational Efficiency: Concept and Measurement

A key component of ATM cash management is operational efficiency, which entails the strategic use of resources to deliver consistent, high-quality service while keeping costs to a minimum [3; 14; 21]. Prior studies have examined how financial institutions streamline the cash supply chain through forecasting techniques and secure replenishment protocols, thereby minimising downtime and enhancing the customer experience [2; 6; 8; 14; 24; 48]. Notably, Ekinci et al. [14] introduced robust optimisation strategies that integrate uncertainty into demand forecasting and replenishment decisions, demonstrating that such approaches result in reduced operational costs and higher customer satisfaction. Operational effectiveness is also associated with process design, procedural standardisation, and workforce training, as observed in the food service sector [3], hospitality industry [21], and other high-contact service environments. These operational strategies are equally applicable to ATM management, where improved efficiency leads to fewer replenishment cycles, reduced instances of cash shortages, and shorter waiting times—all of which contribute positively to customer satisfaction [3; 21; 40].

2.5 Cost Management Effectiveness

Cost management effectiveness (CME) is recognised both as a crucial performance outcome and as a moderating variable in the relationship between operational efficiency and customer satisfaction. Insights from banking, logistics, and project management literature indicate that organisations demonstrating strong CME are able to optimise operations while maintaining or

enhancing profitability [6; 13; 29; 31; 48]. For instance, Le and Sutrisna [29] found that project environments characterised by advanced cost control mechanisms experienced fewer budget overruns and improved customer value delivery. Research specific to ATM operations highlights the relevance of cost-optimisation strategies that aim to balance cash holdings and replenishment frequency while managing the opportunity costs linked to excess or insufficient liquidity [4; 6; 8; 13; 14; 24; 48]. CME is typically conceptualised as an institution's ability to enhance efficiency—such as minimising the frequency of cash-outs and accelerating replenishment processes—without incurring additional costs. This capability is critical in establishing a robust and cost-effective cash supply chain [4; 14; 24].

2.6 Customer Satisfaction as Outcome

Customer satisfaction remains a central objective of both operational and strategic efforts within the banking sector. In the context of ATM services, this encompasses aspects such as user experience, transaction security, service dependability, and consistent cash availability [21; 36; 40]. Studies from the fields of service quality Bitner [5]; Froehle [17], logistics Chavez et al. [9], and banking operations [21; 36; 40] consistently reveal that satisfaction levels among customers are positively influenced by efficient processes, technological integration, and proactive managerial practices. Banking-specific investigations, including those by Hamzah and Shamsudin [21], Motamarri et al. [36], and Pandey et al. [40], further emphasise that improvements in customer satisfaction are largely driven by operational excellence and innovation. These, in turn, stem from the effective utilisation of managerial capabilities, technological resources, and environmental support mechanisms. Additionally, research focused on ATM operations [6; 24; 48] and broader cash management systems [13; 14] has consistently highlighted the negative impact of operational disruptions—such as cash shortages, extended waiting times, and transaction issues—on customer satisfaction.

2.7 Mediation and Moderation Mechanisms

A number of studies have adopted mediation and moderation frameworks to explore how organisational capabilities ultimately influence customer satisfaction [21; 40; 50]. Operational efficiency is frequently identified as a mediating factor linking managerial competence, technological readiness, and regulatory support to enhanced customer outcomes [6; 21; 36; 50]. Specifically, findings from Hamzah and Shamsudin [21] and Sriboonlue et al. [50] indicate that although management practices and technological infrastructure exert a direct influence on operations, their effect on customer satisfaction is primarily realised through improvements in operational performance. CME also plays a moderating role by shaping the strength of the relationship between operational efficiency and customer satisfaction [9; 29; 48; 56]. When cost management is effectively implemented, the positive link between efficiency and satisfaction is amplified, as the organisation not only utilises its resources efficiently but also exercises prudent financial control [6; 8; 13; 48; 55].

2.8 Additional Empirical Perspectives

Ongoing advancements in data-driven technologies and AI-based systems have significantly transformed ATM cash management, signalling a shift toward predictive analytics and evidence-based decision-making within the sector [2; 4; 8; 11; 14; 36; 50]. In banking and cash logistics operations, predictive forecasting techniques and neural network applications are now integral in reducing errors in cash replenishment, lowering operational costs, and improving customer satisfaction outcomes [14; 48]. The deployment of machine learning algorithms, time series models,

and multi-objective optimisation tools enables more accurate forecasting of cash requirements and optimised replenishment timing, thereby mitigating the risks of cash shortages and reducing unnecessary cash reserves [6; 13; 24].

Insights from the broader logistics and supply chain literature support these observations. Studies focusing on cold chain logistics and environmentally sustainable supply chains have demonstrated that customer-oriented strategies, such as bi-objective optimisation, can lead to simultaneous improvements in both operational efficiency and customer satisfaction [9; 46; 55]. Findings from Chavez et al. [9] and Yang and Tao [55] confirm that integrating data-informed decisions with environmental practices into logistics operations enhances both performance outcomes and user satisfaction. Complementary research on ATM placement and user accessibility further underscores the interconnected nature of ATM operations and customer experience [44]. Location optimisation models are employed to enhance cash availability and convenience, which positively shapes customer perceptions [57]. Simultaneously, research examining environmental performance under regulatory frameworks has highlighted that adherence to operational and environmental standards not only mitigates risk but also fosters public confidence and satisfaction [4; 28].

Accurate forecasting of cash flow and well-structured replenishment planning are also pivotal for ensuring operational effectiveness and meeting customer needs. Empirical studies demonstrate that predictive models—especially those utilising regression analysis, neural networks, and hybrid approaches—enable organisations to maintain balanced cash inventories and prevent ATM stock-outs [24; 45]. Regulatory and environmental considerations continue to play a crucial role in operational decision-making, as financial institutions increasingly integrate sustainability practices and compliance into their strategic agendas [9; 28]. Collectively, the literature confirms that a holistic, data-informed approach—incorporating managerial capability, technological readiness, supportive regulatory and environmental conditions, effective cost management, and operational excellence—is fundamental to achieving sustainable competitive advantage and delivering high levels of customer satisfaction within ATM and broader banking services. Drawing upon the insights derived from the reviewed literature, the subsequent hypotheses have been developed:

H1: Managerial competence (MC) positively affects operational efficiency (OE) in ATM cash management and routing.

H2: Technological readiness (TR) positively affects operational efficiency (OE).

H3: Regulatory and environmental support (RES) positively affects operational efficiency (OE).

H4: Operational efficiency (OE) positively affects perceived customer satisfaction (PCS).

H5: Managerial competence (MC) positively affects PCS.

H6: Technological readiness (TR) positively affects PCS.

H7: Regulatory and environmental support (RES) positively affects PCS.

H8: Cost management effectiveness (CME) positively affects PCS.

H9: Operational efficiency (OE) mediates the relationship between managerial competence (MC) and perceived customer satisfaction (PCS).

H10: Operational efficiency (OE) mediates the relationship between technological readiness (TR) and perceived customer satisfaction (PCS).

H11: Operational efficiency (OE) mediates the relationship between regulatory and environmental support (RES) and perceived customer satisfaction (PCS).

H12: Cost management effectiveness (CME) moderates the relationship between operational efficiency (OE) and perceived customer satisfaction (PCS), strengthening the positive effect at higher levels of CME.

3. Methodology

3.1 Research Design

This study adopts a quantitative approach under an explanatory research framework, employing Partial Least Squares Structural Equation Modelling (PLS-SEM) to examine the factors influencing the effectiveness of ATM cash management and routing within the Palestinian banking sector. PLS-SEM is particularly appropriate for analysing complex models that include multiple constructs, as well as mediating and moderating variables. It is widely recognised for its robustness in management and social science research, especially in contexts where the emphasis is on theoretical development and predictive accuracy [19].

3.2 Sampling and Data Collection

The study targeted employees from commercial banks in Palestine who were directly involved in ATM operations, logistics, or cash management functions. A purposive sampling strategy was employed to reach individuals with direct operational knowledge and practical experience related to the management of ATM networks. A total of 500 valid responses were collected through survey instruments, satisfying the minimum sample size guidelines for PLS-SEM, which require a sample size of at least ten times the number of indicators associated with the most complex construct in the model [27]. The data collection relied on structured, self-administered questionnaires that were disseminated via the internal communication systems of participating banks. Participants were assured of their anonymity and were given the freedom to participate voluntarily. The questionnaire was constructed using measurement items adapted from previously validated scales in the literature. Responses were recorded using a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). To ensure the instrument's face validity, clarity, and reliability, a pilot test was conducted with a small group of banking professionals before the main data collection phase.

3.3 Measurement of Constructs

This study employed multi-item measurement scales for all constructs, drawing from established and validated sources. Managerial Competence (MC) was evaluated using three indicators related to managerial skills, domain expertise, and decision-making capabilities, adapted from the works of [51; 54]. Technological Readiness (TR) was assessed using five items derived from the Technology Readiness Index [42], along with contemporary empirical insights into digital integration within the banking sector [39; 47], capturing an institution’s preparedness to implement advanced technology in ATM management.

Regulatory and Environmental Support (RES) was measured using three components that reflected compliance with banking regulations, organisational support structures, and alignment with environmental policies. These items were adapted from prior studies by [23; 30; 49]. Operational Efficiency (OE) was evaluated using three dimensions based on [18; 41], which included the timeliness of cash replenishment, process optimisation, and minimisation of ATM service disruptions. Cost Management Effectiveness (CME), following the frameworks proposed by Le and Sutrisna [29], Lee and Shin [30], and Love et al. [31], was measured using three items: adherence to budgeting practices, efficiency in cost control, and resource allocation for ATM-related logistics. Finally, Perceived Customer Satisfaction (PCS) was gauged through four items reflecting user views on ATM service quality, reliability, accessibility, and overall satisfaction with banking services. These were adapted from [1; 15; 32].

3.4 Data Analysis Procedure

The analysis of the data was conducted using SmartPLS version 4.0. To assess the reliability and

validity of the measurement model, several statistical indicators were employed, including Cronbach's alpha, composite reliability, and average variance extracted (AVE). Discriminant validity was evaluated through the Heterotrait-Monotrait (HTMT) ratio and the Fornell-Larcker criterion. The structural model was assessed by estimating path coefficients and examining both mediating and moderating effects, utilising the bootstrapping technique as recommended in PLS-SEM research guidelines [20].

3.5 Ethical Considerations

The study received ethical clearance from the institution's ethics committee, which reviewed and approved all procedural elements. Participation was entirely voluntary, and informed consent was obtained from all respondents. Throughout the research process, data were handled with strict confidentiality, and the treatment of participants adhered fully to the principles outlined in the Declaration of Helsinki, as well as all relevant national ethical regulations.

4. Results

This section details the empirical outcomes generated through the application of PLS-SEM, based on responses gathered from 500 personnel directly engaged in ATM-related responsibilities within the Palestinian banking sector. The results are systematically presented to encompass a complete assessment of the measurement and structural models, including reliability, construct validity, discriminant validity, and the outcomes of hypothesis testing. The analysis initiates with an evaluation of the psychometric properties of the measurement items, followed by a comprehensive presentation of the structural model's findings. This includes the significance of direct paths, mediating mechanisms, and moderating influences within the conceptual framework. These results offer valuable insights into the organisational, technological, and regulatory-environmental factors that critically shape service efficiency and customer satisfaction in the domain of ATM cash handling and routing.

Table 1 presents the results supporting the convergent validity of the constructs used within the measurement model.

Table 1
Convergent Validity Test

Constructs	Items	Loading	Alpha	CR	AVE
MC	MC1	0.82	0.758	0.861	0.674
	MC2	0.814			
	MC3	0.828			
OE	OE1	0.815	0.757	0.86	0.672
	OE2	0.856			
	OE3	0.787			
PCS	PCS1	0.747	0.775	0.855	0.597
	PCS2	0.805			
	PCS3	0.781			
	PCS4	0.755			
RES	RES1	0.748	0.768	0.862	0.677
	RES2	0.876			
	RES3	0.838			
TR	TR1	0.789	0.814	0.87	0.572
	TR2	0.75			
	TR3	0.755			
	TR4	0.746			
	TR5	0.742			
CME	CME1	0.971	0.961	0.974	0.926
	CME2	0.961			
	CME3	0.956			

All item loadings fall within the range of 0.742 to 0.876, surpassing the commonly accepted

threshold of 0.70 for indicator reliability [20]. The Cronbach's alpha values for all constructs exceed 0.75, while composite reliability scores are above 0.85, reflecting strong internal consistency. In addition, each construct demonstrates an AVE above the minimum required level of 0.50, confirming that the underlying variables sufficiently represent their indicators [16]. Among all constructs, CME displays the strongest reliability, with loading values reaching 0.95, a Cronbach's alpha of 0.961, and an AVE of 0.926, indicating that this construct is particularly well-represented. Overall, the findings confirm that the measurement model is both reliable and valid, and that the constructs are suitable for subsequent use in the structural model analysis.

As illustrated in Table 2, the HTMT values provide strong evidence of discriminant validity across all construct pairings. Each HTMT ratio remains well below the conservative threshold of 0.85, which suggests that the constructs are statistically distinct from one another [22]. The highest HTMT value observed is 0.54, occurring between OE and PCS, which still lies considerably beneath the accepted cut-off point. This further confirms the presence of discriminant validity. These results reinforce the assertion that each construct represents a unique conceptual domain, thereby strengthening the overall robustness and measurement integrity of the PLS-SEM model.

Table 2
HTMT Ratio

	CME	MC	OE	PCS	RES	TR
CME						
MC	0.054					
OE	0.046	0.472				
PCS	0.042	0.38	0.54			
RES	0.046	0.059	0.31	0.321		
TR	0.051	0.076	0.307	0.357	0.101	

Table 3 presents the Fornell-Larcker criterion used to evaluate discriminant validity. As outlined by Fornell and Larcker [16], the square root of each construct's AVE, positioned along the diagonal, must exceed its correlations with other constructs, which are represented by the off-diagonal values. In this analysis, the diagonal entries—for instance, 0.963 for CME, 0.821 for MC, and 0.82 for OE—are all higher than their respective correlations with other constructs. This outcome confirms that each construct is more strongly related to its own indicators than to any other construct within the model. The results affirm the presence of discriminant validity and support the conceptual clarity and empirical distinction of the constructs, further validating the reliability of the measurement model for continued structural assessment.

Table 3
Fornell Larcker

	CME	MC	OE	PCS	RES	TR
CME	0.963					
MC	0.043	0.821				
OE	-0.033	0.361	0.82			
PCS	-0.01	0.294	0.417	0.772		
RES	-0.04	-0.045	0.25	0.256	0.823	
TR	0.013	-0.027	0.245	0.286	0.083	0.757

Table 4 outlines the cross-loading values for all measurement items across their assigned constructs and other constructs in the model, offering an additional evaluation of discriminant validity. In every case, each item loads most strongly on its designated construct, with noticeably weaker associations observed with unrelated constructs. For instance, all indicators related to CME

exhibit high loadings on their own construct (each exceeding 0.95), while their loadings on other variables remain minimal. Similarly, the indicators for MC, OE, PCS, RES, and TR show the highest associations with their respective constructs, confirming that each item is most aligned with its theoretical domain. This loading structure is consistent with the criteria outlined by Hair et al. [19], which state that each measurement item should display a stronger loading on its intended construct than on any other. These results offer further confirmation of discriminant validity within the measurement model, indicating that the constructs are empirically distinct and that the allocation of items is appropriate for robust analysis using PLS-SEM.

Table 4
Cross Loadings

	CME	MC	OE	PCS	RES	TR
CME1	0.971	0.050	-0.027	-0.012	-0.032	0.007
CME2	0.961	0.033	-0.024	-0.009	-0.036	0.032
CME3	0.956	0.037	-0.049	-0.008	-0.052	0.000
MC1	-0.007	0.820	0.267	0.243	-0.040	-0.085
MC2	0.058	0.814	0.302	0.239	-0.043	-0.003
MC3	0.050	0.828	0.318	0.241	-0.029	0.015
OE1	-0.068	0.264	0.815	0.350	0.198	0.239
OE2	-0.010	0.354	0.856	0.370	0.224	0.186
OE3	-0.003	0.264	0.787	0.300	0.192	0.178
PCS1	-0.046	0.174	0.296	0.747	0.212	0.176
PCS2	0.011	0.259	0.348	0.805	0.205	0.219
PCS3	0.026	0.238	0.331	0.781	0.180	0.256
PCS4	-0.029	0.229	0.310	0.755	0.196	0.229
RES1	0.005	-0.032	0.125	0.157	0.748	0.026
RES2	-0.045	-0.042	0.255	0.255	0.876	0.061
RES3	-0.046	-0.036	0.208	0.199	0.838	0.109
TR1	0.021	-0.027	0.215	0.230	0.062	0.789
TR2	0.044	-0.016	0.205	0.210	0.108	0.750
TR3	0.029	0.018	0.200	0.233	0.071	0.755
TR4	0.005	-0.039	0.120	0.212	0.029	0.746
TR5	-0.060	-0.048	0.172	0.196	0.035	0.742

Figure 1 presents the measurement model, illustrating both the associations among latent variables and the linkages between these constructs and their corresponding observed indicators. All indicator loadings exceed the recommended threshold of 0.70, which reflects strong item reliability and confirms that each observed variable appropriately represents its underlying construct [19]. MC, TR, and RES each display significant direct effects on OE, with MC also exerting a notable direct influence on PCS. Furthermore, OE demonstrates a direct impact on PCS, highlighting its mediating function within the model. The moderating role of CME on the relationship between OE and PCS is also depicted, in line with established PLS-SEM approaches for modelling interaction effects [10]. Overall, the model visualised in Figure 1 demonstrates sound specification, as the relationships among constructs are coherent and the observed indicators consistently reflect their latent dimensions.

Table 5 summarises the results of the path analysis derived from the PLS-SEM framework, capturing both direct and indirect associations among the key constructs in the study. The findings reveal that MC and TR have a significant positive influence on OE, with path coefficients of 0.379 and 0.235, respectively. These relationships are supported by robust t-statistics, affirming their statistical validity [19]. Similarly, RES exerts a positive and significant effect on OE, as evidenced by a path coefficient of 0.248 and a strong t-value. Moreover, MC, TR, RES, and OE each demonstrate significant direct effects on PCS, reinforcing the notion that improved managerial capacity, technological advancement, regulatory engagement, and operational excellence all contribute meaningfully to enhanced customer satisfaction. These outcomes align with earlier research within banking and service-related domains [1; 21].

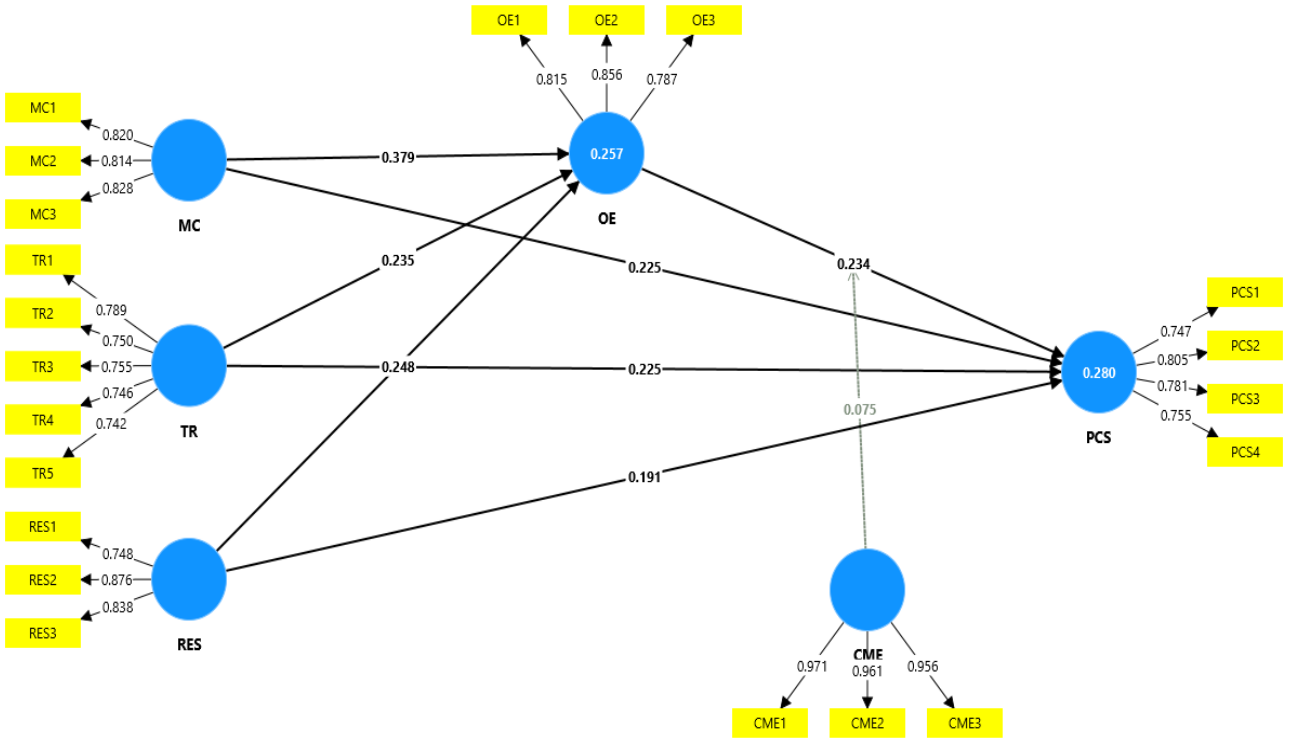

Fig.1: Measurement Model

The analysis further indicates that OE mediates the relationships between MC, TR, and RES and their impact on PCS, as shown through substantial indirect effects (e.g., MC → OE → PCS = 0.089, t = 4.665), consistent with models that position OE as a critical intermediary in shaping customer-related outcomes [18]. The moderating role of CME in the OE–PCS relationship is positive but marginally significant (β = 0.075, p = 0.075), suggesting that while cost control may enhance the influence of OE on satisfaction, its effect is not particularly strong. Additionally, the direct impact of CME on PCS is minimal, indicating that cost strategies alone do not meaningfully alter customer perceptions unless accompanied by operational improvements. Overall, the model supports the hypothesised relationships and highlights the strategic relevance of integrating managerial, technological, and regulatory dimensions to maximise efficiency and improve customer outcomes within ATM service management.

Table 5
Path Analysis

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
CME -> PCS	-0.007	-0.008	0.041	0.173	0.862
MC -> OE	0.379	0.380	0.036	10.610	0.000
MC -> PCS	0.225	0.226	0.041	5.451	0.000
OE -> PCS	0.234	0.234	0.043	5.417	0.000
RES -> OE	0.248	0.249	0.036	6.905	0.000
RES -> PCS	0.191	0.192	0.039	4.954	0.000
TR -> OE	0.235	0.237	0.036	6.569	0.000
TR -> PCS	0.225	0.227	0.038	5.934	0.000
CME x OE -> PCS	0.075	0.071	0.042	1.780	0.075
MC -> OE -> PCS	0.089	0.089	0.019	4.665	0.000
RES -> OE -> PCS	0.058	0.058	0.014	4.159	0.000
TR -> OE -> PCS	0.055	0.055	0.013	4.156	0.000

Figure 2 illustrates the structural model developed for this study, displaying both the path

coefficients and corresponding t-values that define the relationships among the latent constructs. The diagram shows that MC, TR, and RES each exert statistically significant positive effects on OE, with all associated path coefficients supported by t-values exceeding the critical threshold of 1.96. These results underscore the pivotal role of these organisational dimensions in enhancing operational performance, as noted in previous literature [19]. OE is also found to have a strong and statistically significant impact on PCS, reinforcing its function as a mediator in the overall framework [18].

Moreover, the direct effects from MC, TR, and RES to PCS are also confirmed as significant, illustrating that improvements in management capability, technological infrastructure, and regulatory alignment each contribute directly to customer satisfaction in the context of ATM service delivery [21]. The moderating role of CME in the relationship between OE and PCS is depicted using a dashed line, indicating a conditional influence that, while present, reflects only marginal statistical significance. Taken together, Figure 2 offers visual confirmation of a coherent and theoretically grounded structural model, consistent with contemporary PLS-SEM applications in the field of banking operations.

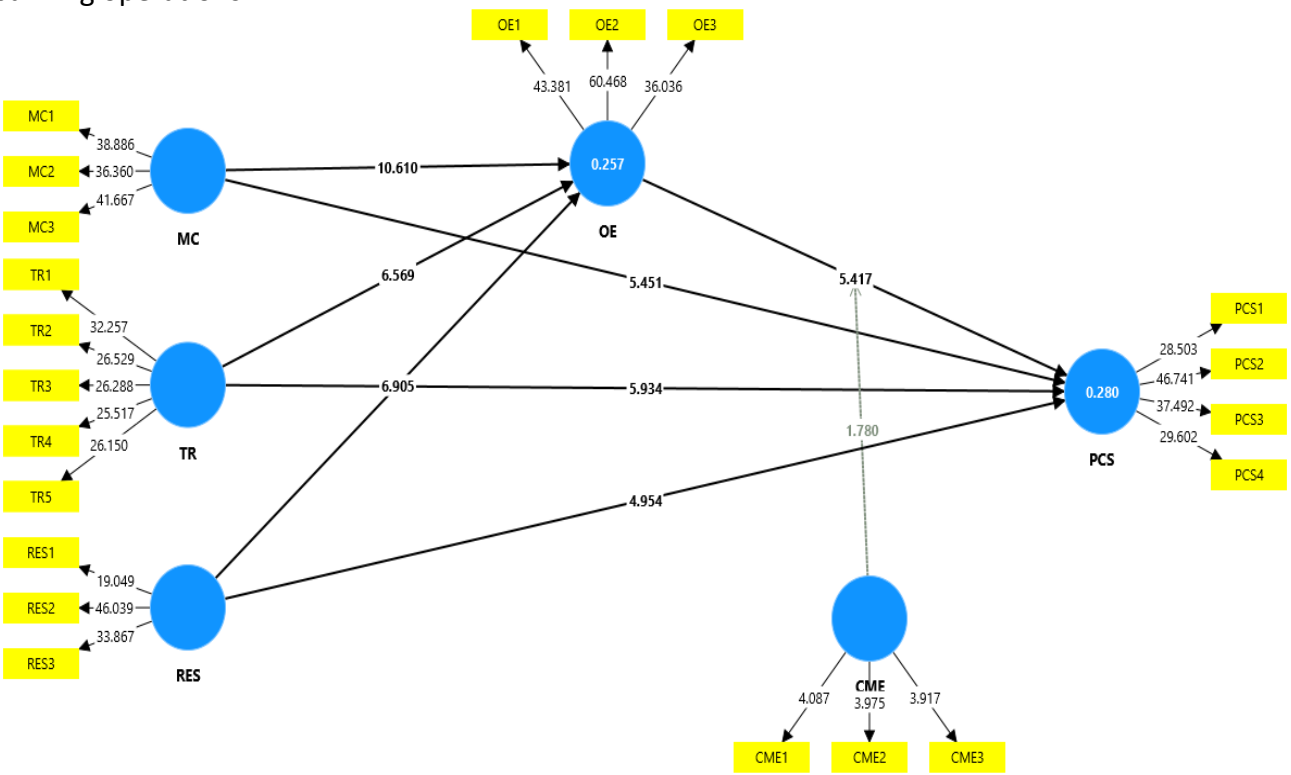

Fig.2: Structural Model

5. Discussion

This study aimed to empirically examine the key determinants influencing ATM cash management and routing effectiveness within the Palestinian banking sector, employing PLS-SEM to assess how MC, TR, and RES shape OE and PCS. The findings provide robust empirical support for most of the hypothesised relationships, while also revealing certain divergences between theoretical expectations and practical realities. With regard to the first hypothesis, MC was found to exert a strong and statistically significant positive influence on OE (H1). This aligns with earlier findings that underscore the value of managerial expertise, leadership, and decision-making in facilitating timely cash replenishment and optimising ATM operations [51; 54]. Additionally, MC also had a direct positive effect on PCS (H5), suggesting that competent leadership not only enhances internal efficiency but also improves the overall customer experience, as also indicated by [1; 15].

Similarly, high levels of TR significantly influenced both OE (H2) and PCS (H6), supporting the assertion that banks with advanced digital capabilities and innovation-oriented cultures are better positioned to deliver consistent, high-quality ATM services [39; 42; 47]. These findings are consistent with the conclusions of Hamzah and Shamsudin [21], who argued that technological integration improves service reliability, transactional accuracy, and customer satisfaction. The role of RES was also substantiated, demonstrating a positive impact on both OE (H3) and PCS (H7). This result validates the perspective that regulatory clarity and environmental support create a conducive atmosphere for service innovation and operational optimisation in banking operations [23; 30; 49].

OE itself emerged as a critical determinant of PCS (H4) and served as a mediating factor between MC, TR, and RES and customer satisfaction (H9–H11). These outcomes reinforce previous research that positions OE as the mechanism through which internal capabilities are transformed into enhanced service quality and customer satisfaction [18; 41]. The significant indirect effects reported further highlight OE as essential for sustaining competitive advantage and fostering customer loyalty. Interestingly, CME did not exhibit a statistically significant direct effect on PCS (H8), which diverges from some prior studies that identified cost control as a primary driver of customer perceptions [29; 34]. However, the observed moderating influence of CME on the OE–PCS relationship, although marginally significant, suggests that effective cost practices may enhance the ability of operational gains to be translated into improved customer experiences [31]. In summary, the study contributes to existing literature by validating an integrated model that links organisational, technological, and regulatory enablers to both operational and customer-related outcomes in ATM cash management. The evidence advocates for a holistic strategy, where MC, TR, and RES jointly promote OE, which subsequently acts as the primary conduit for enhancing PCS within the modern banking environment.

6. Conclusion and Policy Recommendations

This research empirically assessed the critical factors influencing ATM cash management and routing effectiveness in the Palestinian banking sector, applying a rigorous PLS-SEM methodology and drawing on data collected from 500 professionals directly involved in ATM-related functions. A theoretically grounded conceptual model was formulated and validated, encompassing MC, TR, and RES as the principal antecedents influencing both OE and PCS. The empirical results confirmed that these three organisational drivers significantly and positively impact OE, which, in turn, plays a central mediating role in strengthening PCS. Additionally, direct influences from MC, TR, and RES to PCS were also substantiated, suggesting that organisational capabilities and external institutional support contribute through multiple pathways to the enhancement of service delivery and consumer experiences within ATM operations. Interestingly, although CME did not present a statistically significant direct influence on PCS, its modest yet notable moderating effect on the OE–PCS relationship suggests that when cost control is effectively implemented, operational improvements are more likely to generate higher customer value. This indicates that CME may amplify the benefits of OE when aligned with broader operational goals. These findings contribute meaningfully to existing literature by integrating operational and behavioural dimensions of ATM service delivery, offering a more comprehensive view of how aligned internal capabilities and supportive regulatory structures jointly enhance customer satisfaction, particularly within developing financial markets.

The policy implications derived from these outcomes are multifaceted. Firstly, banking institutions are advised to strengthen managerial competencies across all ATM-related departments by investing in structured capacity-building programmes and continuous professional development.

Secondly, the prioritisation of digital transformation through the adoption of sophisticated technological systems is essential to improving service dependability and responsiveness. Thirdly, regulatory bodies are encouraged to formulate enabling policies that incentivise innovation, operational transparency, and environmental accountability. A collaborative approach between banks and regulators can help to mitigate systemic inefficiencies and align institutional strategies with broader goals such as financial inclusion and customer-centric service design.

Future investigations could build on the present study by incorporating customer-centric datasets to capture perceptions directly from service users, thereby allowing a dual-perspective analysis. Moreover, longitudinal studies tracking changes over time in response to technological upgrades or regulatory adjustments may reveal dynamic trends and causality. Cross-country comparative studies could also provide insights into the contextual applicability of these findings. Lastly, the integration of environmental sustainability indicators and the deployment of predictive analytics may advance the understanding of ATM management in increasingly data-driven and sustainability-oriented banking environments.

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