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SIMULATING COMPETING CUSTOMER RELATIONSHIP MANAGEMENT (CRM) MODELS: A PLS-SEM APPROACH TO IDENTIFYING THE BEST-FIT MODEL FOR ALUMNI CONTRIBUTION IN HIGHER EDUCATION

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Abstract:

Background: Higher education institutions (HEIs) are increasingly expected to maintain meaningful long-term relationships with alumni. Customer Relationship Management (CRM), particularly when integrated with social media, has emerged as a key strategy for fostering alumni engagement, satisfaction, and contribution.
Purpose: This study aims to identify the best-fit structural model that explains alumni contributions through CRM and social media interaction, while also investigating the role of social media as a moderator, mediator, or intervening variable in these relationships.
Design/methodology/approach: The study employed Partial Least Squares–Structural Equation Modeling (PLS-SEM) to simulate twelve alternative models using data from 271 alumni of IPB University. These models varied in CRM structure, the inclusion of satisfaction, and the positioning of social media within the pathway.
Findings/Result: Twelve structural CRM models were simulated to examine the effect of CRM and social media on alumni outcomes. Among them, Model 12 demonstrated the best fit, with strong explanatory power (R^2), predictive relevance (Q^2), and low prediction error (RMSE/MAE). The model reveals a sequential pathway: CRM → Customer Satisfaction → Customer Engagement → Customer Loyalty → Alumni Contributions. CRM also influences Social Media, which in turn enhances Satisfaction. All structural paths are statistically significant, indicating that both CRM and social media play a critical role in driving alumni contributions through a satisfaction-based relational process.
Conclusion: CRM in higher education is most effective when treated as a socially constructed process mediated by digital interaction. Social media strengthens institutional trust and emotional connection, playing a critical role in converting alumni satisfaction into sustained loyalty and contribution. Universities should implement social CRM strategies by leveraging digital platforms, personalizing alumni communication, and supporting long-term engagement programs.
Originality/value: This study contributes to CRM theory by applying social construction theory to alumni engagement and offering an empirically validated model of how social media enhances relational CRM in HEIs. The findings have practical implications for alumni management strategies in the digital era.

Keywords: CRM, social media, alumni engagement, higher education, social construction theory

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INTRODUCTION

In today's rapidly evolving digital landscape, higher education institutions (HEIs) are increasingly expected not only to deliver quality education but also to establish and maintain long-term, meaningful relationships with their alumni (Limani et al. 2019). These relationships are critical not just for fundraising or community building, but for enhancing institutional reputation, particularly employer reputation—which reflects how highly graduates are valued by employers (Plewa et al. 2016). A strong employer reputation influences a university's competitiveness in attracting prospective students, building industry partnerships, and improving global rankings(Kleinberg & Oren, 2015). For instance, the QS World University Rankings 2023 report shows that IPB University, one of Indonesia's premier institutions in agriculture, business, and environment, achieved an employer reputation score of 56, trailing behind national counterparts such as UI, ITB, and UGM. This gap suggests a need to strategically reinforce alumni engagement as a reputational asset, given the alumni's pivotal role in shaping industry perceptions through professional contributions and strategic collaborations (Drezner, 2018).

This study focuses on the School of Business at IPB University (SB-IPB), a faculty with strong accreditation and close industry alignment. SB-IPB represents an ideal case for investigating CRM effectiveness due to its active alumni engagement programs and the presence of strategic initiatives such as capstone projects, alumni career tracking, and tailored communication strategies (Karna et al. 2015). Nevertheless, opportunities remain to further optimize CRM by identifying the most effective structural configurations for driving alumni contribution

Customer Relationship Management (CRM) has emerged as a strategic tool to strengthen these institutional–alumni ties(Kleinberg & Oren, 2015). Traditionally used in enrollment and student services, CRM in higher education has evolved into a holistic framework encompassing the entire student lifecycle, including post-graduation engagement (Kosovac et al. 2022). As highlighted by Khashab et al. (2022), CRM systems enable more personalized and meaningful interactions, driving alumni loyalty and sustained support. By segmenting alumni based on behavioral and attitudinal data, institutions can tailor communication and engagement strategies, thereby deepening emotional connection and long-term institutional affiliation (Jordán et al. 2018).

A critical advancement in CRM strategy is the integration of social media platforms, often referred to as social CRM (Shalihati et al. 2025). Social CRM allows institutions to utilize digital platforms such as LinkedIn, Instagram, and WhatsApp to maintain real-time, two-way communication with alumni. According to Meyliana et al. (2016), social CRM not only facilitates communication but also reinforces alumni trust, emotional bonds, and a sense of belonging. Social media thus functions as more than a channel; it becomes a relational space where alumni identities and institutional loyalty are continuously co-constructed (Jordán et al. 2018; Khashab et al. 2022). This perspective aligns with the social construction theory of Berger and Luckmann (1966), which emphasizes that institutional relationships are shaped through shared meanings and social interactions not merely formal systems.

Despite the growing strategic role of CRM in higher education, several empirical challenges hinder its full potential. First, many institutions continue to struggle with fragmented alumni databases and the absence of an integrated tracking system, making it difficult to sustain long-term engagement strategies (Luciano et al. 2020). As highlighted in the study by Luciano et al. (2020), the lack of a centralized alumni tracking system significantly limits the effectiveness of CRM implementation. Second, the integration of social media within CRM practices remains underutilized (Ibrahim et al. 2022). Although digital communication channels offer immense opportunities for personalization and real-time interaction, institutions have yet to fully capitalize on their potential in alumni relations (Camilleri, 2020). Third, while previous studies have explored the adoption and perceived benefits of CRM, few have conducted comparative assessments of CRM model structures (Chien et al. 2015). There remains limited understanding of which CRM configurations particularly those incorporating social media are most effective in predicting alumni loyalty and contribution (Pedro et al. 2020). These gaps call for an empirical and structural evaluation of CRM models to identify the best-fit approach for enhancing alumni engagement in the digital era.

While CRM and social CRM have been widely discussed in higher education literature, most studies focus on implementation and perceived benefits rather than structural mechanisms (Jami Pour & Hosseinzadeh, 2021). The integration of social media into CRM systems has the potential to enhance engagement and foster more personalized communication. However, its strategic role in shaping alumni loyalty remains underexplored (Vohra & Bhardwaj, 2019). Prior studies have primarily examined the function of social media as a moderator or intervening variable influencing satisfaction. Therefore, this study seeks to investigate how social media operates within the CRM framework in the context of SB-IPB (Al-Rahmi et al. 2022; Arevin et al. 2024; Sabah, 2022). There is a notable lack of empirical investigation into how social media functions within CRM frameworks—particularly its role as a moderator, mediator, or intervening variable linking core CRM dimensions (e.g., trust, commitment, shared values) to key alumni outcomes (e.g., satisfaction, loyalty, contribution) (Juwitasary et al. 2022). Moreover, existing research seldom compares competing CRM model structures to determine which configuration most effectively predicts alumni contribution. This leaves a theoretical and empirical gap in understanding the optimal integration of social media within CRM strategies. To address these limitations, this study aims to answer three key questions: What is the structural relationship between CRM and alumni contribution?; How does social media function within this relationship?; Which conceptual model offers the most theoretically and empirically valid explanation of social media's role in CRM?.

This study proposes and tests twelve competing structural models using Partial Least Squares–Structural Equation Modeling (PLS-SEM), systematically varying the role of social media (as moderator or intervening), the construction of CRM (as latent or indicator-based), and the inclusion of customer satisfaction within CRM dimensions. By simulating and comparing these configurations, the research identifies the best-fitting model to explain alumni contribution behavior. In doing so, this study offers both theoretical insights into social CRM as a socially constructed engagement framework and practical guidance for universities seeking to enhance alumni relationships and institutional reputation through CRM strategies. These expected results will not only validate the theoretical assumptions of social CRM and social construction theory, but also provide empirical evidence for HEIs to adopt more interactive, personalized, and digitally-integrated alumni engagement strategies.

METHODS

This study adopts a quantitative survey design to test the hypotheses derived from the conceptual framework. A survey approach was chosen for its efficiency in collecting data from a relatively large sample within a short period. Primary data were collected through structured questionnaires distributed to alumni of the School of Business, IPB University, covering both undergraduate (S1) and postgraduate programs (including S2 and S3). A total of 271 valid responses were obtained, consisting of 144 undergraduate alumni and 127 postgraduate alumni. The data consist of primary sources. Primary data were obtained via online surveys measuring alumni perceptions of CRM, social media, satisfaction, engagement, loyalty, and contribution. The questionnaire instrument was tested for validity (to ensure it accurately measures the intended constructs) and reliability, with Cronbach's Alpha $\geq 0,8$ as the benchmark (Sugiyono, 2019).

The questionnaire was developed based on validated measurement scales from prior studies in CRM, social media engagement, and alumni loyalty (Jordán et al. 2018; Khashab et al. 2022). The sampling technique used was stratified random sampling, with alumni selected based on their academic level (undergraduate and postgraduate programs) to ensure balanced representation.

The data collection process consisted of the following steps:

1. Instrument Adaptation – Questionnaire items were carefully adapted from previous research to suit the higher education alumni context. Each item was reviewed for conceptual alignment, linguistic clarity, and relevance.
2. Expert Review – The questionnaire was evaluated by two academic experts in marketing and alumni engagement to ensure content validity and clarity of indicators before full deployment.
3. Digital Distribution – The finalized survey was distributed online using alumni mailing lists, institutional WhatsApp groups, and official social media platforms to maximize outreach and response rates.
4. Screening and Validation – Responses were

screened for completeness and internal consistency. Incomplete or inconsistent responses were excluded. A total of 271 valid responses were obtained, comprising 144 undergraduate and 127 postgraduate alumni.

Responses were recorded using a five-point Likert scale ranging from "strongly disagree" to "strongly agree." Anonymity was maintained throughout to ensure respondent confidentiality and data integrity.

This study employed Partial Least Squares–Structural Equation Modeling (PLS-SEM) using SmartPLS 4 to analyze the relationships among latent variables within the conceptual model. PLS-SEM is a variance-based approach well-suited for exploratory research involving complex structural models, including those with multiple latent constructs and potential mediating variables (Hair et al. 2022). It is particularly appropriate when the goal is to identify the most predictive and theoretically coherent model configuration.

The analytical process consisted of two stages: measurement model evaluation and structural model evaluation.

Measurement Model Evaluation (Outer Model): The reliability and validity of the constructs were assessed using: Average Variance Extracted (AVE) to confirm convergent validity (threshold > 0,50), Composite Reliability (CR) and Cronbach's Alpha to ensure internal consistency (threshold > 0,70), Cross-loading analysis to check discriminant validity.

Structural Model Evaluation (Inner Model): The main focus of this study was on comparing multiple structural models that differ in the positioning of social media (as a moderator, mediator, or intervening variable), the formation of CRM constructs (latent vs. indicator), and the inclusion of customer satisfaction. Following Hair et al. (2022), model comparison in PLS-SEM was guided by two core criteria: R^2 (Coefficient of Determination): to assess the model's in-sample explanatory power, indicating how well the independent constructs explain variance in the dependent variable (Alumni Contribution); Q^2 (Predictive Relevance): obtained through blindfolding, to evaluate the out-of-sample predictive capability of the model. A Q^2 value greater than zero indicates that the model has sufficient predictive relevance for the target construct.

These two metrics served as the primary basis for identifying the best-performing model among the twelve simulated configurations. Additional outputs such as path coefficients, t-statistics, and mediation tests were used to support interpretation, but not as primary criteria for model selection. This methodological approach ensures that the selected model not only fits the data well but also holds strong predictive value crucial for validating the dynamic, interaction-based assumptions of the social construction theory underpinning this research.

The formulation of hypotheses in this study is grounded in prior empirical literature on Customer Relationship Management (CRM), alumni engagement, and the role of social media in higher education, while incorporating a social constructionist perspective. Rather than positioning CRM as a fixed technological intervention, this study adopts the view that CRM is a socially constructed system, shaped by dynamic interactions, institutional narratives, and alumni responses in digital contexts (Berger & Luckmann, 1991; Hacking, 1999). Accordingly, twelve alternative model configurations were simulated to reflect the variability of CRM structures and social media roles, supporting the notion that CRM practices and their outcomes are not universal but context-dependent (Bourguignon & Hacking, 2000; Mallon, 2007). The hypotheses tested in this study are as follows:

H1: Trust positively affects customer satisfaction

Trust reflects the perceived reliability and credibility of the institution, which forms the foundation for positive alumni experiences (Sela et al. 2024).

H2: Commitment positively affects customer satisfaction.

Alumni who perceive a strong emotional and psychological bond with their alma mater are more likely to report satisfaction (Jordán et al. 2018).

H3: Shared values positively affect customer satisfaction.

Alignment between institutional and alumni values fosters relational harmony, which strengthens satisfaction.

H4: Social media influence mediates or intervening the relationship between CRM and customer satisfaction.

In the proposed structural model, social media is tested as a mediating construct linking CRM to satisfaction. The rationale follows prior findings indicating that real-time, interactive engagement via social platforms fosters trust and emotional connection, which in turn enhances satisfaction (Khashab et al. 2022; Meyliana et al. 2016).

H5: Customer satisfaction positively affects customer engagement.

Satisfied alumni are more likely to engage voluntarily in alumni activities and interactions (Dick & Basu, 1994).

H6: Customer engagement positively affects customer loyalty.

Engagement fosters a sense of belonging and emotional attachment, which leads to sustained loyalty (Amin, 2016; Prior et al. 2024)).

H7: Customer loyalty positively affects alumni contributions.

Loyal alumni are more likely to contribute financially, participate in events, and promote the university's reputation (Khashab et al. 2022).

These hypotheses were examined through a series of twelve structural models using PLS-SEM to determine the most explanatory and empirically valid configuration. Each model presented a variation in CRM structure and role of social media either as an intervening or moderating variable reflecting the flexibility and contextual dependence of CRM systems in higher education. This approach is consistent with the view that institutional relationships are not dictated by rigid frameworks, but co-produced through communication, shared meaning, and evolving expectations within socio-digital environments (Berger & Luckmann, 1991; (Mallon, 2007). The proposed hypotheses represent a core pathway tested across twelve structural models (Model 1–Model 12). These models differ in the placement and function of social media whether as a direct influence, moderating factor, or intervening construct as well as in how CRM is conceptualized, either as a latent multidimensional construct or a reflective system based on indicators. The models also vary in the directionality of relationships among constructs. This multi-model simulation approach aligns with the social constructivist perspective, which holds that CRM practices and their resulting outcomes are not fixed or universally applicable. Instead, they are context-dependent, shaped by how institutions and their stakeholders co-create meaning and relationships through socio-digital interactions.

The conceptual framework of this study is presented in Figure 1, illustrating the structural interaction between Customer Relationship Management (CRM) dimensions, social media, alumni satisfaction, engagement, loyalty, and contribution. This framework is grounded in the notion that alumni relationships are not formed merely through transactional interactions, but are socially constructed through trust, emotional engagement, and digital dialogue (Berger & Luckmann, 1991). Social media is embedded in the framework with flexible positioning either as a moderator, an intervening variable, or a direct influence highlighting its dual role as both a communication channel and a relational space.

Figure 1 serves as the conceptual foundation for testing alternative structural assumptions regarding the formation and maintenance of alumni relationships within digital CRM ecosystems. To operationalize this framework, the study simulates twelve alternative structural models, each incorporating different theoretical assumptions about the role of social media and the formation of CRM constructs. The models are analyzed using Partial Least Squares–Structural Equation Modeling (PLS-SEM) to assess predictive accuracy, explanatory power, and theoretical coherence. Each of the twelve models is differentiated based on four core structural dimensions:

1. Role of Social Media: conceptualized either as a moderating variable (Models 1–4) or an intervening variable (Models 5–12);
2. CRM Dimension Type: operationalized as a latent construct or through indicator-based components;
3. CRM Composition: consisting of either three core dimensions (trust, commitment, and shared values) or expanded to include customer satisfaction;
4. Social Media Path Direction: with directional flows pointing either from CRM to social media or from social media to satisfaction.

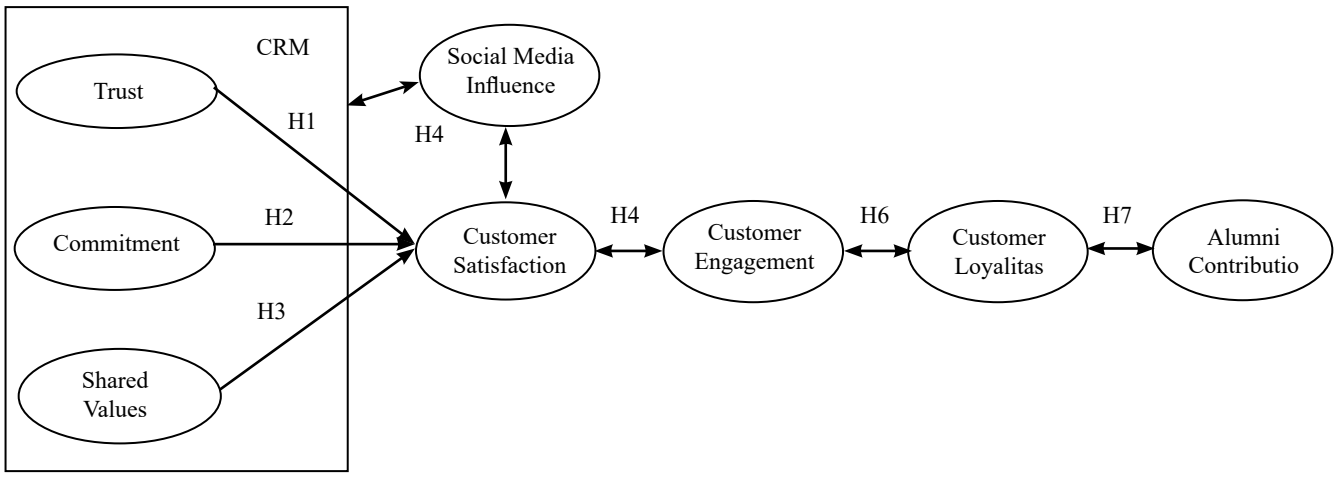

Figure 1. Research framework

Models 1 to 4 conceptualize social media as a moderator, with CRM operationalized both as a latent variable (Models 1 and 2) and as a reflective indicator model (Models 3 and 4). Customer satisfaction is included in the CRM construct in Models 2 and 4, extending the relational scope of the model. In these four models, social media has no explicit path direction but influences the strength of the relationships between CRM variables and satisfaction. In contrast, Models 5 to 12 position social media as an intervening variable, capturing its dynamic role in the causal flow of relational influence. Models 5 through 8 utilize a latent construct of CRM, with Models 7 and 8 incorporating customer satisfaction as a fourth dimension. These models differ in the directionality of social media—either as a consequence of CRM activities (from) or as a precursor to satisfaction (to). Models 9 to 12 employ an indicator-based CRM construct, consistently maintaining three core dimensions. Again, social media appears as an intervening variable, with directionality split between "from CRM" (Models 9 and 10) and "to satisfaction" (Models 11 and 12).

This multi-model approach enables a structured and theoretically grounded comparison of how different CRM and social media configurations impact alumni-related outcomes. The models are designed not to represent competing hypotheses but to reflect the fluidity and contextual nature of CRM processes in higher education, aligned with social construction theory (Hacking, 1999; Mallon, 2007). Table 1 summarizes the key structural distinctions among the models.

RESULTS

Measurement Model Evaluation

Before proceeding to structural model comparisons, an evaluation of the measurement model (outer model) was conducted to ensure the reliability and validity of all constructs across the twelve simulated models. This evaluation followed the recommended steps in PLS-SEM, including assessments of indicator reliability, internal consistency reliability, convergent validity, and discriminant validity (Hair et al. 2022).

Indicator reliability was confirmed through outer loading values, all of which exceeded the recommended threshold of 0,70, Table 2 presents the outer loading range for Model 12, which was identified as the best-fit model based on theoretical and empirical criteria. All values meet the minimum threshold for indicator reliability (≥ 0,70), except for one item in the Customer Engagement construct that was removed.

Internal consistency reliability was established based on: Cronbach's Alpha and Composite Reliability (CR) values above 0,70, indicating sufficient internal consistency (Hair et al. 2019), and Average Variance Extracted (AVE) values above 0,50, confirming convergent validity (Fornell & Larcker, 1981; Hair et al. 2022).

Table 1. Structural characteristics of CRM Model Simulations

Model	Role of Social Media	CRM Dimension Type	CRM Dimensions	Social Media Direction
Model 1	Moderator	Latent Variable	3 (Trust, Commitment & Shared Value)	-
Model 2	Moderator	Latent Variable	4 (Trust, Commitment, Shared Value & Customer Satisfaction)	-
Model 3	Moderator	Indicator	3 (Trust, Commitment & Shared Value)	-
Model 4	Moderator	Indicator	4 (Trust, Commitment, Shared Value & Customer Satisfaction)	-
Model 5	Intervening	Latent Variable	3 (Trust, Commitment & Shared Value)	From
Model 6	Intervening	Latent Variable	3 (Trust, Commitment & Shared Value)	To
Model 7	Intervening	Latent Variable	4 (Trust, Commitment, Shared Value & Customer Satisfaction)	From
Model 8	Intervening	Latent Variable	4 (Trust, Commitment, Shared Value & Customer Satisfaction)	To
Model 9	Intervening	Indicator	3 (Trust, Commitment & Shared Value)	From
Model 10	Intervening	Indicator	3 (Trust, Commitment & Shared Value)	From
Model 11	Intervening	Indicator	3 (Trust, Commitment & Shared Value)	To
Model 12	Intervening	Indicator	3 (Trust, Commitment & Shared Value)	To

These results indicate that all constructs in every model demonstrate acceptable convergent validity and reliability, making them appropriate for further structural evaluation. Additionally, discriminant validity was assessed using the Fornell-Larcker Criterion, which compares the square root of each construct's AVE with its correlations to other constructs. In all models, the square roots of AVE were higher than the inter-construct correlations, indicating that discriminant validity is achieved (Fornell & Larcker, 1981; Henseler et al. 2015).

With both measurement model requirements satisfied, the analysis proceeds to the structural model evaluation (inner model). Here, the focus shifts to assessing the strength and predictive relevance of relationships among constructs using coefficient of determination (R^2) for explanatory power and Stone-Geisser's Q^2 for predictive relevance (Hair et al. 2022). These values serve as the foundation for comparing model configurations and identifying the most theoretically and empirically robust structural model.

Summary of Statistical Results

To address the research objectives, twelve structural models were simulated using PLS-SEM, with social media positioned in various roles moderator, intervening, or direct influencer on alumni engagement pathways. To evaluate the predictive strength of each simulated CRM model, both in-sample explanatory power (R^2) and out-of-sample predictive relevance (Q^2) were examined for key endogenous variables: Customer Satisfaction, Customer Engagement, Customer Loyalty, and Alumni Contributions. According to Hair et al. (2022), a good model should exhibit high R^2 for dependent variables and $Q^2 > 0$ to ensure predictive relevance.

Coefficient of Determination (R^2): Evaluating Explanatory Power Across Models

The coefficient of determination (R^2) is a key metric in structural equation modeling that reflects the proportion of variance in the dependent variable explained by the independent variables. In PLS-SEM, higher R^2 values indicate better explanatory power

of the model (Hair et al. 2022). Table 3 summarizes the R^2 values across fourteen simulated models for four core outcome variables: Customer Satisfaction, Customer Engagement, Customer Loyalty, and Alumni Contributions.

Among all models, Model 1 and Model 3 exhibit the strongest ability to explain customer satisfaction, each with an R^2 value of approximately 0,60, This suggests that the dimensions of CRM—particularly trust, commitment, and shared values—are effective in accounting for alumni satisfaction when structured as latent variables. These models suggest that nearly 60% of the variance in satisfaction can be attributed to the predictors used. In contrast, customer engagement is most effectively explained in Model 2, with an R^2 value of 0,341. This finding highlights the important role of social media as a moderating factor, enhancing the relationship between CRM constructs and engagement. The relatively higher explanatory power in this model suggests that alumni engagement is more sensitive to the way CRM strategies are delivered through digital platforms. Interestingly, alumni contributions maintain a consistent R^2 of 0,279 across all models, reflecting the fixed structure in the final outcome pathway of the simulation. Although the explanatory power is moderate, the consistency of this value indicates that upstream constructs regardless of their configuration converge similarly on this outcome.

Taken together, these findings underscore that different models excel in explaining different aspects of the alumni relationship lifecycle. Model 1 and Model 3 are more effective in explaining satisfaction, whereas Model 2 performs better in explaining engagement. These results offer a foundation for evaluating model performance using predictive relevance (Q^2), which will be discussed in the following section to determine the most suitable model not only based on explanatory power but also on out-of-sample predictive validity. Model 1 and Model 3 show the highest R^2 for Customer Satisfaction (0,599 and 0,600 respectively), suggesting that the constructs in these models—such as trust, commitment, and shared values—collectively explain approximately 60% of the variance in satisfaction.

Q^2 Predictive Relevance (Stone-Geisser)

The Q^2 value, also known as Stone-Geisser's Q-square, is used to evaluate the predictive relevance of a structural model. Unlike R^2, which reflects in-sample explanatory power, Q^2 assesses the model's ability to predict data not used during parameter estimation. In the context of PLS-SEM, Q^2 values above zero indicate that the model has predictive relevance for a particular endogenous construct (Hair & Alamer, 2022). Specifically, Q^2 values are interpreted as follows: values above 0,35 indicate high predictive relevance, values between 0,15 and 0,35 reflect moderate predictive relevance, and values between 0,02 and 0,15 indicate low predictive relevance.

Table 2. Outer loading ranges of retained indicators in model 12

Latent Variable		Dimension	Indicator		Model 12
Code	Variable		Initial	Final	
TR	Trust	-	7	7	0.711-0.84
CM	Commitment	-	8	7	0.703-0.82
SV	Shared Values	-	8	8	0.762-0.843
SM	Social Media	-	11	6	0.81-0.875
CS	Customer Satisfaction	Reliability	4	4	0.774-0.802
CS	Customer Satisfaction	Tangibles	4	2	0.711-0.781
CS	Customer Satisfaction	Responsiveness	4	0	-
CS	Customer Satisfaction	Assurance	2	2	0.75-0.799
CS	Customer Satisfaction	Empathy	2	2	0.773-0.802
CE	Customer Engagement	-	11	4	0.84-0.909
CL	Customer Loyalitas	-	8	5	0.791-0.872
AC	Alumni Contribution	-	13	4	0.756-0.849

Table 3. Comparative R^2 values across models

Variable	1	2	3	4	5	6	7	8	9	10	11	12
Alumni Contributions	0.279	0.279	0.279	0.279	0.279	0.279	0.279	0.279	0.279	0.279	0.279	0.279
Customer Engagement	0.173	0.341	0.173	0.305	0.173	0.173	0.307	0.308	0.173	0.173	0.173	0.173
Customer Loyalty	0.214	0.206	0.214	0.207	0.214	0.214	0.206	0.206	0.214	0.214	0.214	0.214
Customer Satisfaction	0.599	–	0.600	–	0.585	0.585	0.415	–	0.581	0.575	0.581	0.575
Commitment	–	–	–	–	0.291	–	0.295	–	–	–	–	–
Shared Values	–	–	–	–	0.231	–	0.232	–	–	–	–	–
Trust	–	–	–	–	0.209	–	0.208	–	–	–	–	–
CRM	–	–	–	–	–	–	–	–	0.295	0.288	–	–
Social Media	–	–	–	–	–	0.308	–	0.455	–	–	0.295	0.288

Table 4 presents the Q^2 values for each endogenous construct across all 14 model configurations. A comparison of these values shows that while several models demonstrate predictive relevance for individual constructs, Model 12 stands out for its consistent and moderately high Q^2 values across multiple core variables. Specifically, Model 12 achieved Q^2 = 0,453 for Customer Satisfaction, 0,137 for Customer Engagement, and 0,140 for Customer Loyalty, indicating a moderate-to-high level of predictive relevance. The model also maintained a solid predictive value for Social Media (Q^2 = 0,242) and a positive Q^2 = 0,045 for Alumni Contributions.

The relative stability of Q^2 across constructs in Model 12 suggests that it is not only effective in explaining alumni-related outcomes but also reliable in predicting unseen data across different stages of the CRM-alumni relationship pathway. This makes Model 12 a strong candidate for the best-fit model when balancing both explanatory and predictive performance.

RMSE and MAE

Root Mean Square Error (RMSE) and Mean Absolute Error (MAE) are used to assess the predictive accuracy of a model by quantifying the discrepancy between observed and predicted values. In the context of PLS-SEM, lower RMSE and MAE values indicate that the model is more accurate in predicting specific outcomes (Hair et al. 2022). While Q^2 values assess predictive relevance, RMSE and MAE serve as complementary indicators that highlight the magnitude of prediction error.

Table 5 presents the RMSE and MAE values for key constructs across all simulated models. Particular attention is given to Customer Satisfaction and Social Media, as these variables play central roles in influencing downstream outcomes such as engagement and alumni contribution. Among the tested models, Model 12 yields the lowest prediction error for Customer Satisfaction (RMSE = 0,747; MAE = 0,547) and a competitive error level for Social Media (RMSE = 0,880; MAE = 0,665). These values suggest that Model 12 not only demonstrates strong predictive relevance (as discussed in Q^2) but also minimizes the prediction error, reinforcing its robustness as the most accurate and reliable configuration. Therefore, the combination of low RMSE and MAE values, particularly in core constructs, supports the selection of Model 12 as the best-fitting model in terms of both predictive accuracy and theoretical alignment.

Path Analysis and Interpretation

After identifying Model 12 as the most robust structural model based on its consistent performance across R^2, Q^2, RMSE, MAE, and reliability measures this section elaborates on the significant direct and mediated relationships found within the model. The goal is to interpret how key constructs such as CRM, social media, satisfaction, engagement, loyalty, and alumni contributions are interconnected through statistically significant paths.

The model conceptualizes CRM as a latent construct influencing alumni behavior through two primary pathways: (1) a direct influence on Customer Satisfaction, and (2) an indirect channel through Social Media. All major paths in the model show statistically significant results, indicating the soundness of the structural relationships.

Table 4. Q^2 predictive relevance for all constructs across models

Construct	1	2	3	4	5	6	7	8	9	10	11	12
Alumni Contributions	0.061	0.107	0.061	0.102	0.053	0.044	0.092	0.088	0.053	0.053	0.045	0.045
Customer Engagement	0.219	0.257	0.216	0.269	0.196	0.135	0.246	0.191	0.197	0.193	0.136	0.137
Customer Loyalty	0.184	0.305	0.186	0.293	0.147	0.139	0.251	0.263	0.148	0.142	0.141	0.140
Customer Satisfaction	0.531	–	0.570	–	0.404	0.439	0.406	–	0.405	0.391	0.454	0.453
Commitment	–	–	–	–	0.271	–	0.275	–	–	–	–	–
Shared Values	–	–	–	–	0.209	–	0.209	–	–	–	–	–
Trust	–	–	–	–	0.183	–	0.182	–	–	–	–	–
CRM	–	–	–	–	–	–	–	–	0.266	0.260	–	–
Social Media	–	–	–	–	–	0.247	–	0.396	–	–	0.247	0.242

Table 5. RMSE and MAE Across Models

Model	AC (RMSE/MAE)	CE (RMSE/MAE)	CL (RMSE/MAE)	CS (RMSE/MAE)	SM (RMSE/MAE)
Model 1	0.983 / 0.760	0.894 / 0.724	0.911 / 0.775	0.691 / 0.524	–
Model 2	0.959 / 0.735	0.871 / 0.679	0.841 / 0.718	–	–
Model 3	0.983 / 0.760	0.895 / 0.722	0.910 / 0.775	0.662 / 0.511	–
Model 4	0.962 / 0.741	0.864 / 0.694	0.848 / 0.725	–	–
Model 5	0.988 / 0.761	0.906 / 0.729	0.932 / 0.796	0.780 / 0.623	–
Model 6	0.992 / 0.768	0.940 / 0.755	0.936 / 0.792	0.757 / 0.556	0.878 / 0.655
Model 7	0.967 / 0.743	0.878 / 0.694	0.873 / 0.744	0.779 / 0.622	–
Model 8	0.969 / 0.741	0.909 / 0.703	0.866 / 0.730	–	0.787 / 0.604
Model 9	0.988 / 0.761	0.906 / 0.729	0.931 / 0.796	0.779 / 0.623	–
Model 10	0.987 / 0.761	0.909 / 0.730	0.934 / 0.798	0.788 / 0.633	–
Model 11	0.992 / 0.767	0.940 / 0.753	0.935 / 0.792	0.746 / 0.547	0.878 / 0.652
Model 12	0.992 / 0.767	0.940 / 0.753	0.935 / 0.792	0.747 / 0.547	0.880 / 0.665

A strong direct effect is observed from CRM → Customer Satisfaction ($T = 6.949$, $p < 0{,}001$), confirming that alumni's perception of trust, commitment, and shared values directly contributes to their satisfaction with the institution. Similarly, Social Media → Customer Satisfaction ($T = 4.707$, $p < 0{,}001$) indicates that digital interactions significantly shape satisfaction, positioning social media as a key touchpoint in alumni relationship management. Satisfaction then strongly predicts Customer Engagement ($T = 6.319$, $p < 0{,}001$), which subsequently drives Customer Loyalty ($T = 8.724$, $p < 0{,}001$), and ultimately leads to Alumni Contributions ($T = 9.290$, $p < 0{,}001$). This sequence highlights the cumulative mediating role of satisfaction, engagement, and loyalty in the CRM framework. The full pathway from CRM to contributions, mediated through these constructs, showcases a theoretically coherent and empirically supported mechanism that aligns with customer lifecycle models in CRM literature (Hair & Alamer, 2022; Prior et al. 2024).

In addition, the path CRM → Social Media ($T = 6.432$, $p < 0{,}001$) confirms that CRM-related values and interactions also influence social media dynamics, further enhancing alumni engagement via digital channels. This underscores the dual role of CRM—both as a driver of satisfaction and as a stimulator of social engagement.

Importantly, this model does not rely on interaction (moderation) terms. Paths such as Social Media × Trust or Social Media × Shared Values—which were significant in other models—are excluded here, reinforcing that direct and sequential mediation pathways offer greater explanatory power and stability than moderated effects. The results support the argument that social media is best conceptualized as an integral communication channel rather than a conditional moderator (Vohra & Bhardwaj, 2019).

Model 12 provides a well-fitting, theoretically grounded structure where CRM and social media independently and jointly shape satisfaction, which then cascades through engagement and loyalty to influence alumni

contributions. All major paths are statistically significant, supporting the model's robustness for explaining post-graduation alumni behavior.

Best-Fit Model Determination

The evaluation of the twelve simulated models was conducted using a combination of statistical indicators, including R^2 (explanatory power), Q^2 (predictive relevance), RMSE and MAE (prediction errors), and the number of significant path coefficients. Among all configurations, Model 12 emerged as the best-fitting model, offering a balanced structure that integrates strong predictive performance with theoretical consistency. Although some models exhibited higher R^2 or Q^2 for specific variables—such as Model 4 with high Q^2 for Customer Satisfaction—Model 12 displayed consistently moderate-to-high Q^2 values across key endogenous constructs (e.g., Q^2 = 0,453 for Satisfaction, 0,242 for Social Media) while maintaining the lowest RMSE and MAE values for Satisfaction and Social Media, indicating strong predictive accuracy.

In addition, Model 12 shows full significance across all its direct paths, including those from CRM to Satisfaction ($T = 6.949$, $p < 0{,}001$), from Satisfaction to Engagement ($T = 6.319$, $p < 0{,}001$), and ultimately to Alumni Contributions through Loyalty ($T = 9.290$, $p < 0{,}001$). The outer model also demonstrated high validity and reliability, with AVE > 0,5 and CR > 0,7 for all constructs. Furthermore, social media is optimally positioned as both a direct influence on satisfaction and an outcome of CRM, rather than a moderator, which is supported by higher statistical stability and conceptual clarity.

Thus, Model 12 is selected as the optimal configuration due to its predictive strength, theoretical alignment, significant structural paths, and empirical stability, making it the most appropriate representation of CRM dynamics in the context of alumni engagement in higher education.

Interpretation through Social Construction Theory

These results align with social construction theory (Berger & Luckmann, 1966), which argues that institutional relationships are socially co-produced through shared interactions and meaning-making processes. The structural pathways in Model 12, particularly the mediating role of social media, reinforce the idea that alumni loyalty and contribution are outcomes of dynamic, digitally mediated interactions not merely transactional touchpoints (Bailey, 2015).

Compared to previous studies, this model expands the CRM framework by emphasizing the social nature of alumni relationships. While studies such as Hrnjic (2016) have established that CRM enhances student satisfaction and loyalty in higher education, few have positioned social media as an intervening construct that shapes these outcomes. This study goes beyond transactional CRM frameworks by integrating socially constructed digital interactions, supporting the findings of Jordán et al. (2018) and Meyliana et al. (2016) that social CRM fosters a sense of belonging and shared values among alumni. CRM and social CRM initiatives enable institutions to craft digital spaces that nurture emotional resonance, shared identity, and sustained commitment (Yawised & Marshall, 2015). For instance, alumni may construct their affiliation and loyalty through consistent engagement with institutional narratives, community participation, and recognition, especially on platforms such as LinkedIn and Instagram (Khashab et al. 2022; Ibrahim et al. 2022).

Managerial Implications

This research contributes to CRM theory in HEI contexts by validating that alumni behavior is shaped by a chain of socially mediated constructs: CRM → Social Media → Satisfaction → Engagement → Loyalty → Contribution. Prior models (Helgesen & Nesset, 2007) demonstrated CRM's link to loyalty via satisfaction. Our findings extend these frameworks by integrating alumni engagement and social CRM as active mediators, aligning with recent structural works by (Mater et al. 2024; Wu et al. 2022). This model affirms that alumni loyalty is not just driven by service quality, but by emotional connection and sustained interaction—a perspective consistent with relationship marketing and social construction paradigms.

For HEIs, this model recommends positioning CRM as a relational strategy, not just an administrative tool. Institutions should strengthen social CRM systems—e.g., alumni LinkedIn groups, responsive Instagram accounts, and gamified digital events—to build emotional bonds and shared values. Moreover, alumni engagement must be nurtured as a long-term journey, using satisfaction and trust as entry points to mobilize loyalty and contributions (Baumann & Halpern, 2024).

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

This study was designed to explore the dynamic relationship between Customer Relationship Management (CRM) and alumni contribution in the context of higher education, with a particular emphasis on the mediating and structural role of social media. In response to this objective, the findings affirm that CRM relationships are not simply transactional processes, but are socially constructed and mediated through digital interactions that foster satisfaction, engagement, and loyalty. The evaluation of multiple structural models revealed that Model 12 offers the most balanced configuration, demonstrating both statistical robustness (in terms of R^2, Q^2, RMSE, MAE) and practical relevance, as all path relationships in this model were significant. Furthermore, the positioning of social media as a mediator between CRM and satisfaction underscores its role as a relational infrastructure in the digital era.

In light of these findings, institutions of higher education are encouraged to reconceptualize CRM not as a purely technical system, but as a socially embedded process. Alumni relationship management should leverage social media as a strategic communication and engagement platform. Specifically, efforts should be made to enhance shared values through consistent messaging and digital events, strengthen satisfaction through personalized content, and foster long-term loyalty through interactive alumni experiences.

Recommendations

The findings provide clear guidance for university policymakers to align alumni engagement strategies with institutional missions and efforts to enhance reputation. This includes developing integrated CRM systems and alumni databases that are connected to official social media platforms, enabling more personalized and sustained communication. Investment in digital infrastructure and skilled personnel is essential to support this integration. Furthermore, alumni engagement should be institutionalized as a key performance indicator (KPI), measured through metrics such as employer reputation, alumni giving, and graduate employability, to reflect the university's long-term value and societal relevance.

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