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A Triadic Competency Requirement Model for Successful Win-Win Optimization in Public–Private Partnerships: A Structural Equation Modelling

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Abstract: Public Private Partnership (PPP) initiatives are often promoted as a mechanism for achieving win-win outcomes. However, recent studies highlight the realisation as a hurdle due to gaps in public and private sector competencies. PPP studies have typically focused on specific competency areas and have typically overlooked assessing the interrelationships among various competency dimensions, although these interconnections reflect how competencies function in real-world projects. Therefore, this study sets the pace in the development and modelling of a holistic competency requirement model for the public and private sectors in PPP schemes. A comprehensive literature review coupled with expert validation through piloting identified and categorised the competencies while Structural Equation Modelling (PLS-SEM) was adopted in model development. Findings indicated that public and private sector competencies for win-win optimisation should capture functional requirements, which are PPP scheme and type dependent, organisational requirements which highlight the institutional build of the project parties and relational/behavioural competency requirements that capture the traits and alliancing attributes. The study recommends the strategic alignment of public and private sector roles, skills, and capabilities before initiating infrastructure development to cultivate an environment conducive to achieving win-win outcomes in PPPs. This study challenges the conventional isolated approaches to PPP competencies with an integrated approach that deepens the understanding of successful infrastructure development in PPP.

Keywords: competency requirements modelling; public private partnerships; win-win optimisation; Structural Equation Modelling (SEM)

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1. Introduction

Public–private partnerships (PPP), as compared to traditional infrastructure procurement, have been popularised to facilitate the achievement of a win-win situation amongst the stakeholders involved. PPPs have been adopted in both developed and developing economies, primarily for procuring energy and transport infrastructure [1,2] Consequently, PPP is perceived to permeate win-win achievement in its build-up. However, recent studies have questioned the practical realisation of this in project implementation [3–5]. These studies report the existence of issues like lop-sidedness in contracts, negotiation, power imbalances, and devious behaviours, amongst others, which do not reflect win-win pursuance in practice. A comprehensive review of PPP studies by Eshun et al. [6] emphasised the contention by McKeon [7] that the realisation of win-win remains a challenge in PPP practice. The study posited that apt public and private sector competencies are critical to successful project implementation and the optimisation of win-win desires of project stakeholders.

Competencies in PPP studies have mostly focused on individual traits, and the literature is deficient in a clear assessment of competencies of both the private and public actors as individual traits and also as a team or collaborative partners. Previous PPP studies on competencies have focused on traits and skills, hence addressing certain aspects such as trust [8] and other leadership skills [9]. However, project management studies accentuate that competency modelling should encapsulate technical skills, knowledge, capacities, and personal traits or behaviour.

Despite the importance of competency modelling and development in real-world practice, scholars have been sceptical about the concept of competencies and have, therefore, not fully explored it. Additionally, PPP studies that captured competencies focused solely on certain aspects without assessing the interrelations between the different competency requirements as an integrated approach, which is what happens in reality [10]. Hence, an integrative approach is required in competency development to bridge this gap in PPP infrastructure schemes toward win-win outcomes and project success.

The long-period nature of PPPs calls for sustainable collaborative partnering. The establishment of an integrating partnership model that highlights the roles of all parties is ideal [11]. To achieve this, unique capabilities and skills in managing PPP arrangements are essential, especially at the organisational level, which can be complex. However, little empirical research has been done on what represents the basis for management proficiency and competence in partnerships and alliances [12]. Several studies have stated that there are few empirical studies that explore the exact and needed skills, values, and attitudes (competencies) of the governing parties in PPP implementation [11,13,14]. Furthermore, competency facets in the overall management of PPP by the public and the private sector are lacking and need attention to address the uniqueness of PPPs for a more collaborative and win-win-oriented partnership [6,15].

Some PPP studies have identified various required competencies of parties involved in the partnership. For instance, Devkar et al. [16] developed PPP competencies and summarised a couple of technical capabilities required of project actors in the implementation of PPP. Soecipto and Verhoest [17] identified competencies focused on project governance and implementation capacities. Most studies were inclined to the behaviour and relationships among stakeholders [18–20]. Mistarihi et al. [12] identified competencies that captured technical capabilities and relational or behavioural competencies of the project actors. However, these do not present an all-inclusive model of public and private sector competencies as exists in practice. Also, they do not assess the relationships between these competencies towards critical criteria as win-win achievement despite being pivotal in PPPs.

The study by Eshun et al. [6] conceptualised a win-win scenario in PPP and highlighted critical enablers such as having a reasonable financial plan (concession period and price), fairly allocating risks, meeting project success criteria or objectives, practising flexible contracting and engaging in strategic win-win solicitation during negotiation for contract closing, constitute enablers for win-win achievement in PPPs. Given that the public and private sector competencies drive these win-win strategies, this study seeks to develop and model a holistic competency requirement model for the public and private sectors in PPP schemes. The modelling integrates individual and corporate level competencies as well as technical, organisational/governance, relational and behavioural competencies. This study becomes the first to close this gap and adopts a model development approach that deals with a fusion of various theoretical management concepts for desirable results in PPP implementation.

2. Literature Review

2.1. Competency Requirements Modelling in PPPs

Competence in project implementation is viewed in two dimensions from an epistemological standpoint, i.e., the individual approach, which is concentrated on individual behaviours, and the other required at the organisational level or collective approach [21]. A typical PPP scheme is characterised by a cluster of experts, and competencies are developed

in relation to their collective effort in the private and public sectors, respectively. To enhance the effective implementation and management of PPP projects, competency development should target both individual expertise and collective organisational capability. This dual focus ensures a comprehensive approach to skill-building that supports successful project outcomes across all levels [12]. Competency modelling should capture three core areas: the skills and abilities that individuals or organisations should possess, task-oriented actions that reflect current duties, and personal traits or characteristics that describe how individuals behave [12,22]. This study proposes organisational, functional, and relational competencies as essential for successful win-win achievement in PPP implementation. The integration of these competencies creates a more practical framework for establishing competency requirements, guiding both public and private entities in policy development, and enabling relevant, practice-oriented analyses to drive continuous improvement.

2.1.1. Organizational Competency Requirements

Organisational competency requirements encompass the capabilities of key project stakeholders, particularly in terms of institutional structure, to support mutually beneficial outcomes. Infrastructure PPPs employ diverse strategies, processes, and practices—such as joint ventures involving both national and international partners—which make robust administrative structures essential. This competency, as seen in Table 1, reflects the foundational abilities that organisations, including government and private sector entities, must possess to function effectively as unified entities in the PPP framework.

Table 1. Organisational Competency Requirements for win-win optimisation in PPPs.

ID	Organizational Competence	Delineation	References
OC01	Well established regulatory and policy framework (including policies)	The existence of stringent working laws and policies that facilitate the development and implementation of PPPs. Good regulatory quality.	[23–26]
OC02	Effective dispute resolution mechanisms and rule of law	The existence of experts and well-developed process and structure for addressing conflicts, controversies and prevent corruption throughout the implementation of the project.	[23,24,27,28]
OC03	Well established public/local community engagement protocol	This refers to the existence of well-established procedures and the ability to engage users, community or the public to assess their level of interest and need for the project.	[28]
OC04	Politically stable environment	The ability to maintain a sound political environment that supports the continues development and operation of PPP projects i.e., PPP project continuity irrespective of political dynamics.	[17,23,26,28]
OC05	Standardized and well-defined administrative procedures	Having and efficient and standardized processes for approval and documentation activities in the development of the PPP	[26,28]
OC06	Effective contract administration procedures and experts	Having enough capacity to adequately draft and manage the contract arrangements of projects.	[17,24,26]
OC07	Well-built institutional/administrative capacity	This captures the entire composition of the organization, institution, or joint venture having well-established structures to run the day-to-day administrative procedures in delivering PPP projects.	[17,24,26]
OC08	Knowledge and technology transfer mechanisms	Existence of appropriate measures to enable the easy transfer and receipt of technology and knowledge to enable continuous running of the project beyond transfer	[17,26,29]

Table 1. *Cont.*

ID	Organizational Competence	Delineation	References
OC09	Strong bargaining techniques and capacity	Efficient experts and structural composition to poise them right to bargain effectively	[16,26,29,30]
OC10	Development and training culture and structure	The existence of routine exercises and procedures for training and development of personnel	[8,25]
OC11	Enterprise/Firm qualification, reputation and professional expertise	Commendable industrial qualification and certification of the firms	[8,26]
OC12	Efficient concessionaire (private partner) selection capacity	Having appropriate system for the selection of a reputable private sector with needed capacity to deliver as required. This includes selection criteria and procedures and experts involved in the process.	[20,31]
OC13	Commendable infrastructure PPP experience	Adequate firm and personnel's maturity in the development of infrastructure PPPs through planning, financing, constructing and operation	[8,12,23,25,26]
OC14	Adequate personnel/employee capacity	The appropriate number of workers or staff or experts required to effectively implement the PPP project.	[8,25]
OC15	Efficient subnational authorities (well established PPP unit)	A specialized PPP unit mainly and directly responsible for the overseeing the development and management of PPP projects.	[8]
OC16	Project conceptualization, identification and appraisal structures	The ability of the practitioners to sample out and select relevant projects which will be successful on PPP mode i.e., to select the right project at the right time to be executed at the right place which will yield success and improve its viability	[16,17,26]

2.1.2. Functional Competency Requirements

The functional competency category focuses on the skills and requirements necessary to meet performance metrics, objectives, and success criteria for PPP projects. These competencies depend on the type of infrastructure being delivered and the specific PPP model chosen, which defines the roles and responsibilities of project parties who must be equipped to execute the project effectively. This category (see Table 2) encompasses task-oriented competencies, outlining the immediate actions required for successful PPP implementation. Emphasising collective expertise, this competency category highlights the collaborative efforts of professionals within both public and private sectors, with specific skills adapted to the demands of each unique PPP project.

Table 2. Functional Competency Requirements for win-win optimisation in PPPs.

ID	Functional Competency	Delineation	References
FC01	Intellectual capacity with core technical knowledge and ability	This refers to the practitioners having the required level of skills, intellect, and equipment capacity for executing the type of project whether transport, energy, sewage, water treatment etc.	[8,12,25,28,32]
FC02	Financial capacity and planning efficiency	Project actors must have the needed funding with reliable financing facilities as well as develop efficient financial plans and models capable of handling the life cycle cost of the project.	[24,26]

Table 2. *Cont.*

ID	Functional Competency	Delineation	References
FC03	Efficient stakeholder management skills	Since PPP development involves engaging various stakeholders, the actors must be able to manage these stakeholders throughout the implementation of the PPP project.	[16,29]
FC04	Operational maturity and maintenance capacity	The ability to operate and maintain the project facility to meet required productivity and maintenance requirements	[12,16,25,28,32]
FC05	Construction technology capacity	This refers to the ability to execute the construction works efficiently to meet the desired project specification	[12,24,25,28,30–32]
FC06	Well prepared investment climate with stable microeconomic indicators	Existence of a good and stable economic environment that will enable the smooth operation of the project and meet the estimated cashflow	[8,17,24,25,30,32]
FC07	Project planning process management	The capacity to conduct effective planning such as feasibility studies and making sound project forecasts	[32]
FC08	Innovation oriented hallmark	Existence of innovative structures and conduct of parties in the development of the PPP project	[28,30]
FC09	Risk tolerance and control capacity	The tendency of exhibiting high-risk tolerance with highly specialized treatment strategies for managing project risks	[25,28]
FC10	Risk identification and evaluation ability	Practitioners must be able to effectively ascertain risks and uncertainties as well as evaluate their impact on the project to facilitate project planning.	[25,26,30,33]
FC11	Optimum risk allocation knowhow	Since risk allocation is very critical in PPPs practitioners must be able to effectively assign risk to the best party capable of preventing, controlling and managing the consequence of the risk during project delivery.	[8,24,26,28,32]
FC12	Environmental Sustainability Consciousness and management capacity	Practitioners must be able to exhibit concern to the environmental impact of developing the project	[26,32,33]
FC13	High technological capacity	The practitioners must be able to exhibit and use advanced technologies and be able to keep up with the global technological advancement and dynamics	[32]
FC14	Quality and Reliable service provision capacity	Project practitioners must be able to deliver consistent and good quality services to the public	[12,16,25,30]
FC15	Governmental guarantee/incentive provision capacity	The ability of the contracting party to support the PPP project with certain incentives like interest rate guarantee, price guarantee, tax rebates etc.	[12,23–25,32]
FC16	High Project commercialization expertise	The ability to successfully run the business component of the PPP project to facilitate the repayment arrangements.	[8,23,26,28]
FC17	Project management and governing skills	Exhibiting high level of project management and Different project types require different styles of efficient management	[25,26]

2.1.3. Relational Competency Requirements

These address the traits and self-concepts integral to a competency requirements model, focusing on the behavioural and synergistic attributes essential for fostering alliance and mutual goals among project stakeholders. Behavioural competencies, linked to personal motives and traits, are crucial for promoting cooperation and trust in PPPs. These competencies are among the most influential factors in project performance, outlining how public and private entities should interact to achieve a successful, mutually beneficial outcome in PPP projects [20]. This category, as listed in Table 3, encompasses the normative dimensions of the project actors as individuals and as teams.

Table 3. Relational/behavioural Competency Requirements for win-win optimisation in PPPs.

ID	Relational/Behavioural Competency	Delineation	References
RC01	Mutual accountability	The display of responsibility acceptance of obligations and willingness to give satisfactory reasons to each other (private and public partners)	[8,18,19,27,28,33]
RC02	Consensus-based decision-making custom	The practice of engaging and obtaining approval from all relevant stakeholders in decision-making.	[8,18,28,33]
RC03	Transparency and integrity virtues	The practice of demonstrating honesty and truthfulness in dealings especially in information sharing.	[31,34,35]
RC04	Equity principled project actors	The habit of ensuring that each stakeholder gets what is due them without cheating or utilizing power dominance/undue influence	[8,36,37]
RC05	High-level commitment ability to parties and project	This refers to both party's willingness and enthusiasm of both parties to offer or exert effort towards the or on behalf of the partnership relationship and the success of the project	[8,18,25,26,28]
RC06	Value appreciation	The tendency of individuals to understand, desire and thrive to ensure the value creation in dealings	[8,31,38]
RC07	Efficient Collaborative interactions between parties	The desire of both parties to obtain concerted effort and engage themselves through frequent and open discussion and communication of project matters to each other.	[18,37,39]
RC08	Mutual Respect	The recognition and reliance on the character and ability of each other (private and public actors) that they have valuable/vital contributions to make in the partnership	[19,40]
RC09	High ethical values and due diligence attitude	The existence of self-governing principles that projects a virtuous behaviour thus the conscious effort of parties to avoid committing an offense.	[20,31,41,42]
RC10	Emotional intelligence	The ability to comprehend and manage one's own emotions as well as that of others in a positive way.	[19,20,32,43]
RC11	Good leadership skills	This refers to the proactive and initiative-taking nature of practitioners to organize people towards achieving a goal	[18,19,25,26,28,30,43,44]

Table 3. *Cont.*

ID	Relational/Behavioural Competency	Delineation	References
RC12	Effective dialogue and communication skills	The ability to convey and express information and ideas effectively and openly. (Relevant in contract development and negotiation)	[20,27]
RC13	Good teamwork and interdependence ability	The ability to work effectively in an organized group where lies the belief in and reliance on each other's role play in the implementation of the project.	[20]
RC14	Creative thinking and learning abilities	The level of inventiveness and use of original ideas by project parties	[8,16,27,33]
RC15	Mutual Trust	The confidence that each party (private and public actors) will fulfil their obligations and behave as duly expected	[27,43]
RC16	Cultural intelligence	The ability to manage, relate and work with culturally diverse people and situations (i.e., the varying beliefs, language, value interpretation, etc. of both parties)	[8,17–19,26,27]
RC17	Conflict resolution and problem-solving skills	The ability of project actors when disagreements arise to discuss, manage and effectively resolve disputes. Thus, the practice of coming together and combining resources to solve project issues effectively.	[20]

Figure 1 presents the Triadic Public and Private Competency Requirement framework from the comprehensive literature review, detailing organisational, functional, and relational competency requirements that facilitate win-win realisation and overall PPP project success.

2.2. Hypothetical Modelling of PPP Competency Requirements

The development of competency requirements is extensive; therefore, studies achieve this feat by categorising them. The categorisation adopted in this study followed a theoretical ideology that describes the combination of knowledge, skills, and characteristics needed to effectively perform from the private and the public sector perspective. This enabled the siphoning of adequate and exhaustive variables or indicators to be measured. This study proposes that competency capability requirements fall into three main categories that must work collectively to support the public and private parties in achieving mutually beneficial outcomes in PPP schemes. This integrated approach strengthens the critical role of each party, enhancing the likelihood of a successful, win-win partnership.

Eshun et al. [6] evidencing a comprehensive literature review highlighted enablers of win-win achievement in PPP as the development of an equitable financial plan (WE01), attainment of project-specific success objectives/criteria (WE02), optimum assessment and allocation of project risks (WE03), effective engagement of project stakeholders (WE04), flexible contracting (WE05), and strategic contract negotiation and closing (WE06). The moderating role of private and public sector competencies in implementing these enabling strategies cannot be understated [45]. This underscores the concept that relational, functional, and organisational competencies collectively drive the achievement of win-win outcomes in PPPs. The identified variables were validated through expert interviews projecting the hypothesised model shown in Figure 2. The study engaged six experts in finalising the research framework. Research Hypothesis H1, H2 and H3 posit that organisational, relational/behavioural and functional competencies of the public and the private sectors have a positive influence on the win-win enablers/strategies. The study

further theorises the mediating role of the functional and organisational competencies to the relational/behavioural competencies, hence testing H4 and H5, as seen in Figure 2.

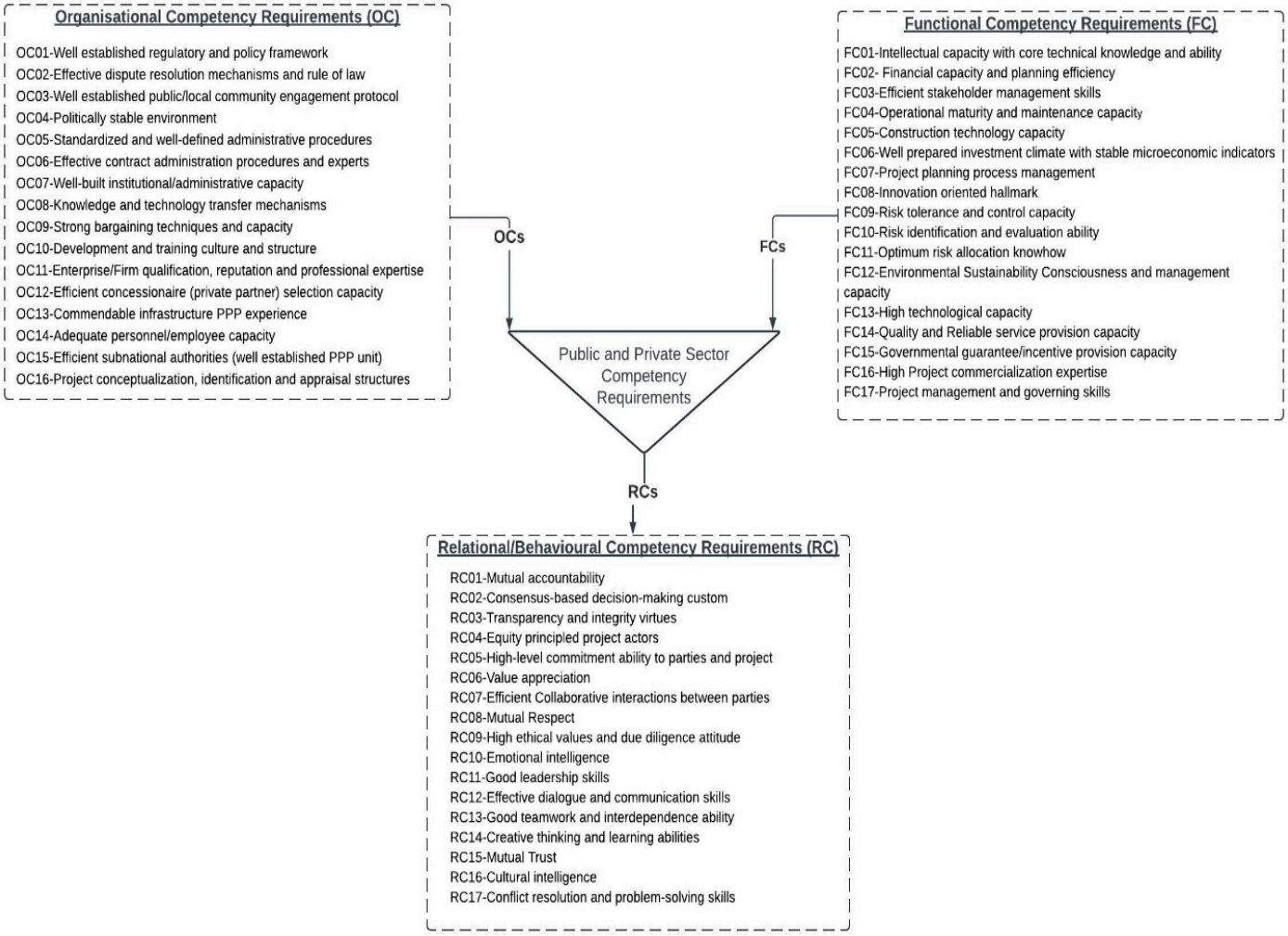

Figure 1. The Triadic Public and Private Competency Requirements Framework.

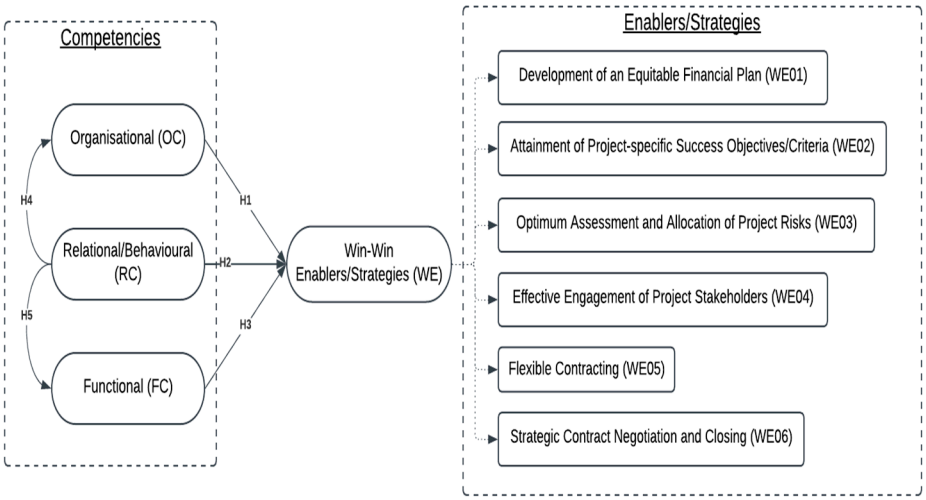

Figure 2. Hypothetical competency model for win-win optimisation in PPP.

3. Research Methods

The research methods included a comprehensive literature review, expert validation, pilot and questionnaire survey to provide a detailed understanding and modelling of the competency requirements prior to modelling and testing. The study adopted a mixed method to allow the complementing strengths of both methods for a plausible research outcome [46,47].

3.1. Data Collection

An initial literature review was conducted to explore a wide range of studies in PPP and project management studies. Journal articles and books accessed through Scopus, Web of Science, and Google Scholar were analysed for the study. The review explored concepts of competencies, the role of the public and private actors, success factors and enablers of win-win achievement in project implementation. Studies on competency requirement modelling were analysed to understand the categorisation and ensure theoretical consistency [48]. The review identified 50 comprehensive competencies, which were categorised and validated by experts, resulting in 17 functional competency requirements, 16 organisational competency requirements, and 17 relational/behavioural competency requirements. The pilot and expert validation survey conducted allowed for the refining of identified factors, improving validity and ultimately enhancing the reliability of the final research outcomes [49]. The study adopted an open-ended survey tool to elicit expert views on the final elements, and these were used in the main survey.

The finalised factors were structured into a questionnaire and distributed to PPP experts and practitioners in Ghana and Nigeria. The study adopted the non-probability sampling technique using purposive and snowballing to obtain a representative sample of practitioners. The respondents were tasked to indicate agreement on the factors posited as competency requirements and strategies for win-win optimisation in PPP. These measurement items were evaluated on a five-point Likert scale to prevent data fatigue and reluctance from respondents to expand choices. Moreover, the five points are commonly adopted for most PPP and construction management studies that use Structural Equation Modelling (SEM) [50,51]. The pre-screening data available were hundred and eighty-nine; however, after rigorous sorting and screening, the suitable dataset used in the study was one hundred and seventy-six. Additionally, concerning country datasets, eighty-five and ninety-one were from Ghana and Nigeria, respectively. This makes a good representation as Sub-Saharan countries like Nigeria and Ghana have a strong need and high potential for leveraging PPP models [52].

Table 4 captures details of the professionals engaged in the survey as well as some general information and perspectives in relation to their experience with the implementation of infrastructure PPPs. These respondents include both practitioners from the public and the private sector, as well as some academics who have been involved in these dealings through research and consultancy. The professionals classified under the others include other administrative workers such as contracts managers, finance and accounts officers, administrative assistants, facilities managers, administrative consultants, and procurement officers. These professionals were purposively sampled to ensure plausible association with these projects and to ensure the reliability of the findings produced by the study.

3.2. Data Analysis

The competency model developed utilised Structural Equation Modelling (SEM) to measure and analyse relationships between observed and latent variables, allowing for the assessment of complex multivariate causal interactions. SEM examines the relationships between variables by integrating factor analysis, multiple regression analysis, and path analysis [53]. Specifically, the study employs Partial Least Squares Structural Equation Modelling (PLS-SEM), which is well-suited for evaluating these relationships within the model. Most studies have adopted this method in modelling complex relationships, eluding the previously used covariance-based modelling to understand and make plausible

interpretations of PPP infrastructure delivery [50,54,55]. PLS-SEM is a causal-predictive approach to SEM that emphasises prediction in estimating statistical models whose structures are designed to provide causal explanations [56]. Moreover, the ability to analyse mediating and moderating variables within a model enhances its rigour and makes it more suitable than regression analysis, aligning well with this study's goals for hypothesis testing [57].

Table 4. Respondents profile.

Demographics	Category	Frequency	Percentage
Profession	Researcher/Professor	16	9
	Engineer	31	18
	Quantity surveyor	28	16
	Project Manager	34	19
	Architect	12	7
	Construction Manager	23	13
	Others	32	18
Years of Experience	Below 5 years	26	15
	5 to 10 years	45	26
	11 to 15 years	43	24
	16 to 20 years	33	19
	Above 20 years	29	16
Type/Job Affiliation	Central Govnt/Ministries	21	12
	Public sector consultant	28	16
	Private sector consultant	13	7
	Private Corporation	61	35
	Sub-Govnt Contracting Authority	37	21
	Academia	16	9
Number of Projects	1 to 5	17	10
	6 to 10	29	16
	11 to 15	35	20
	16 to 20	30	17
	21 to 30	42	24
	over 30	23	13

PLS path models consist of two linear equations: the inner and outer models, also known as the structural and measurement models, respectively. The outer (measurement) model represents the relationship between an observed variable and its corresponding latent variable, while the inner (structural) model captures the relationships between latent (unobserved) variables [58]. PLS-SEM involves three main steps: (i) Preliminary planning, which addresses factors like sample size, potential use of secondary data, distribution assumptions, statistical power, and model fit; (ii) Assessment of the measurement model, where reflective indicators (e.g., loadings, reliability measures) and formative indicators (e.g., VIF, redundancy analysis, indicator weight significance and relevance) are analysed to strengthen model reliability; and (iii) Assessment of the structural model, which evaluates the model's explanatory and predictive power [57].

3.2.1. Reflective Measurement Model Assessment

Composite Reliability (CR) and Cronbach's Alpha (CA) are the most commonly used metrics for assessing the internal reliability and consistency of constructs. CR accounts for the varying loadings of indicators, allowing for differing reliability contributions across items, while CA assumes equal reliability across all indicators, which can result in an underestimation of the internal consistency of a latent variable [59]. A satisfactory coefficient for internal consistency reliability is typically considered to be around 0.7 in the early stages of research and 0.8 or higher in more advanced stages. Values below 0.6 indicate weak consistency. Indicator reliability describes the extent to which a latent variable explains the variance in its associated indicators. This reliability is assessed by examining the loadings of

reflective indicators, with a target of at least 50% of the indicator's variance being explained by the latent variable. Indicator loadings should exceed 0.7, be significant at the 0.05 level, and differ from zero to confirm reliability [60]. Fornell and Larcker [61] suggest using the Average Variance Extracted (AVE) as a measure for assessing convergent validity. To meet this criterion, the latent variable should explain at least 50% of the variance in its indicators, indicated by an AVE value of 0.5 or higher. Additionally, discriminant validity ensures that constructs are distinct from one another; hence, each latent variable's AVE should be greater than the highest squared correlation with any other latent variable [57].

3.2.2. Assessment of the Structural Model

The multiple determination coefficient (R^2) is a key criterion for evaluating each dependent construct within PLS-SEM. R^2 indicates the proportion of total variance in the dependent variable that is explained by the latent variables. In path models within PLS-SEM, R^2 values of 0.19, 0.33, and 0.67 are generally interpreted as weak, moderate, and substantial, respectively. Following this, the regression coefficient is examined as the next step in assessing the structural model's validity. Research hypotheses are unsupported if the direction of the path in the hypothesised relationship contradicts the model's specified sign. To be impactful, some researchers suggest setting the regression coefficient, which measures the strength of the relationship between latent variables, at a threshold of 0.1 or higher [57]. Additionally, resampling techniques such as bootstrapping or jackknifing are used to test significance, typically at a 0.05 level, to assess robustness [62].

4. Model Development and Interpretations

This section reports the results of the PLS-SEM analysis for the competency requirement modelling. The study aims to effectively model competencies required of the private sector and the public sector in typical PPP schemes to drive win-win-oriented goals and overall project success. Hence, the systematic report of the PLS-SEM analysis is key to building the model.

4.1. Initial Measurement Model Specification

The initial model assumes a reflective structure, as indicated in the hypothetical model in Figure 2. Featuring a triadic categorisation of competency requirements, namely organisational (org_comp_req), relational/behavioural (rel_beh_comp_req), functional competency requirements (func_comp_req), and win-win enablers or strategies (win_win_enbs). The model consists of fifty-six observed variables, of which seventeen evaluate relational and behavioural aspects, sixteen focus on organisational elements, and another seventeen assess functional factors. The remaining six variables serve as enablers for the win-win construct shown in Figure 3.

4.2. Initial Measurement Model Evaluation

Measurement model evaluation usually involves assessing indicator reliability, convergent validity, and internal consistency. Reflective indicators are often deemed reliable with standardised loadings above 0.7, though some suggest a threshold of 0.4 may also be acceptable [63]. To ensure item reliability, each construct should explain at least 50% of the variance in its items [57]. This study, therefore, applied a criterion of 0.7 for reliability. Tables 5–7 display the patterned matrix, showing the loadings for each variable construct reliability and validity evaluations of the initial measurement model. The results reveal that some loadings fall below the threshold of 0.7, and these will be excluded from further analysis. The evaluation of internal consistency reliability is carried out using three approaches: Cronbach's alpha [64], composite reliability (CR) [65], and Dijkstra-Henseler's rho (rho_A) [66]. The use of rho_A is particularly recommended as it addresses the limitations and conservative tendencies associated with Cronbach's alpha [67]. In assessing discriminant validity, the average variance extracted (AVE) for a construct is compared to the squared shared variance between that construct and all other constructs within the

reflective framework [57]. Ideally, the square root of the AVE should exceed the correlation with any other factor [61]. Additionally, the Heterotrait-Monotrait (HTMT) ratio serves as another metric for evaluating discriminant validity, with correlations ideally remaining below 0.9 [68].

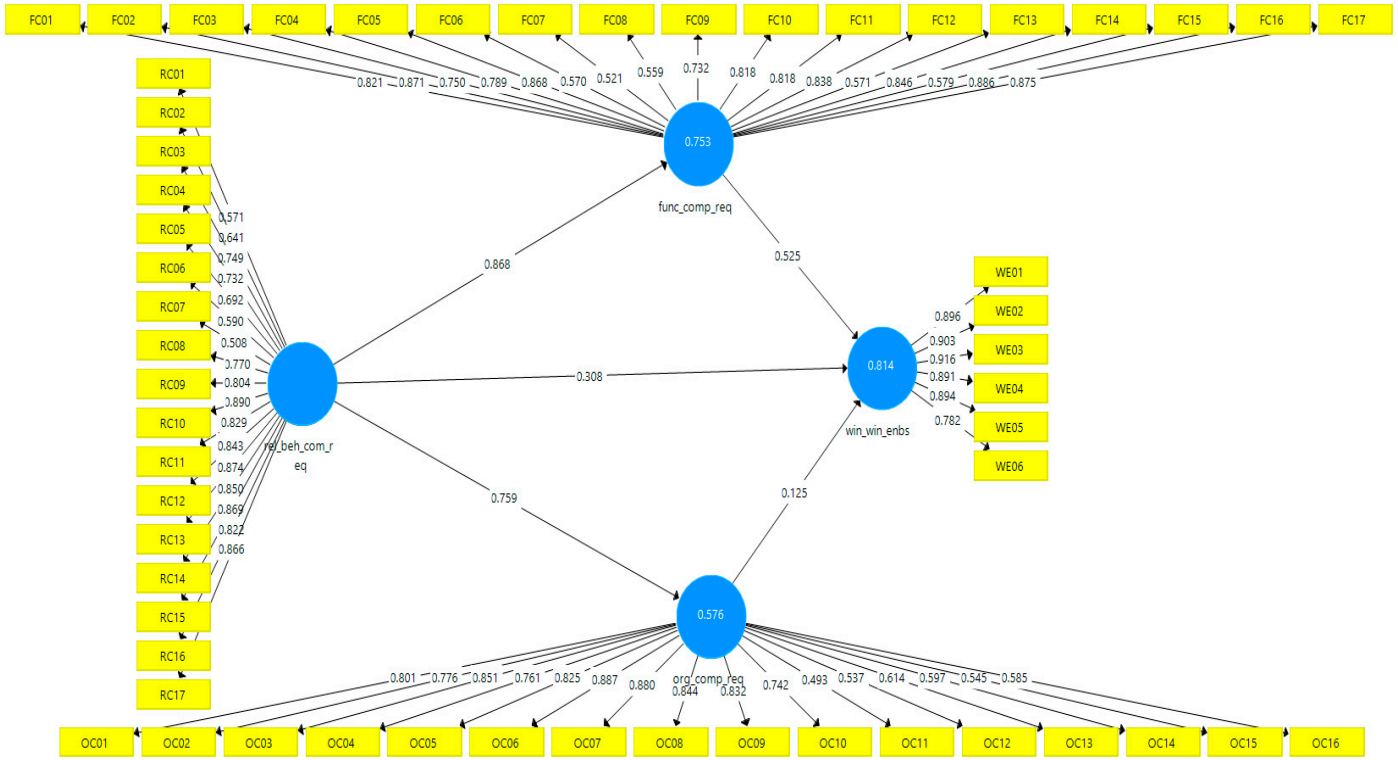

Figure 3. Initial Measurement Model.

Table 5. Initial outer loadings of the measurement model.

Code	func_comp_req	org_comp_req	rel_beh_com_req	win_win_enbs
FC01	0.821			
FC02	0.871			
FC03	0.750			
FC04	0.789			
FC05	0.868			
FC06	0.570 *			
FC07	0.521 *			
FC08	0.559 *			
FC09	0.732			
FC10	0.818			
FC11	0.818			
FC12	0.838			
FC13	0.571 *			
FC14	0.846			
FC15	0.579 *			
FC16	0.886			
FC17	0.875			
OC01		0.801		
OC02		0.776		
OC03		0.851		
OC04		0.761		
OC05		0.825		

Table 5. *Cont.*

Code	func_comp_req	org_comp_req	rel_beh_com_req	win_win_enbs
OC06		0.887		
OC07		0.880		
OC08		0.844		
OC09		0.832		
OC10		0.742		
OC11		0.493 *		
OC12		0.537 *		
OC13		0.614 *		
OC14		0.597 *		
OC15		0.545 *		
OC16		0.585 *		
RC01			0.571 *	
RC02			0.641 *	
RC03			0.649 *	
RC04			0.632 *	
RC05			0.692 *	
RC06			0.590 *	
RC07			0.508 *	
RC08			0.770	
RC09			0.804	
RC10			0.890	
RC11			0.829	
RC12			0.843	
RC13			0.874	
RC14			0.850	
RC15			0.869	
RC16			0.822	
RC17			0.866	
WE01				0.896
WE02				0.903
WE03				0.916
WE04				0.891
WE05				0.894
WE06				0.782

Notes: * Reflective loadings of variables below 0.7 criterion.

Table 6. Construct reliability and validity of the initial measurement model.

Constructs	CA	rho_A	CR	AVE
func_comp_req	0.951	0.962	0.957	0.576
org_comp_req	0.941	0.955	0.948	0.541
rel_beh_com_req	0.954	0.960	0.960	0.589
win_win_enbs	0.942	0.943	0.954	0.777

Notes: CA—Cronbach's Alpha, CR—Composite reliability, AVE—Average Variance Extracted.

Table 7. Discriminant validity of the initial measurement model (HTMT).

Constructs	func_comp_req	org_comp_req	rel_beh_com_req	win_win_enbs
func_comp_req	-	-	-	-
org_comp_req	0.695	-	-	-
rel_beh_com_req	0.897	0.793	-	-
win_win_enbs	0.917	0.744	0.900	

Notes: HTMT—Heterotrait-Monotrait.

4.3. Final Measurement Model Evaluation

The evaluation of the initial model revealed that several observed variables failed to meet the required loading thresholds of 0.7. To enhance the model and ensure optimal

results, these variables were removed, and the analysis was conducted iteratively while carefully monitoring both construct and scale reliability criteria [67]. The final measurement is illustrated in Figure 4, demonstrating acceptable factor loadings (see Table 8), along with confirmed construct reliability and validity (Table 9) and discriminant validity (Table 10). The results indicate that all reflective loadings exceeded the 0.7 threshold. Specifically, the highest and lowest loadings recorded were 0.903 and 0.736 for functional competency requirements, 0.917 and 0.763 for organisational competency requirements, 0.912 and 0.803 for relational behavioural competency requirements, and finally, the win-win enablers had loadings of 0.917 and 0.781. Furthermore, the reliability results—measured by Cronbach's Alpha, rho _A, and composite reliability (CR)—were all above 0.7, indicating strong reliability. Additionally, convergent validity was confirmed, as the average variance extracted (AVE) for each component exceeded the largest squared correlation with any other latent component [67]. The HTMT correlations also fell within the acceptable range based on the criteria established for the study. The final model, after thorough scrutiny and iterative eliminations that met all necessary specifications, demonstrates that the constructs adequately measure their intended variables. Therefore, it is deemed suitable for further analysis within the structural model [68].

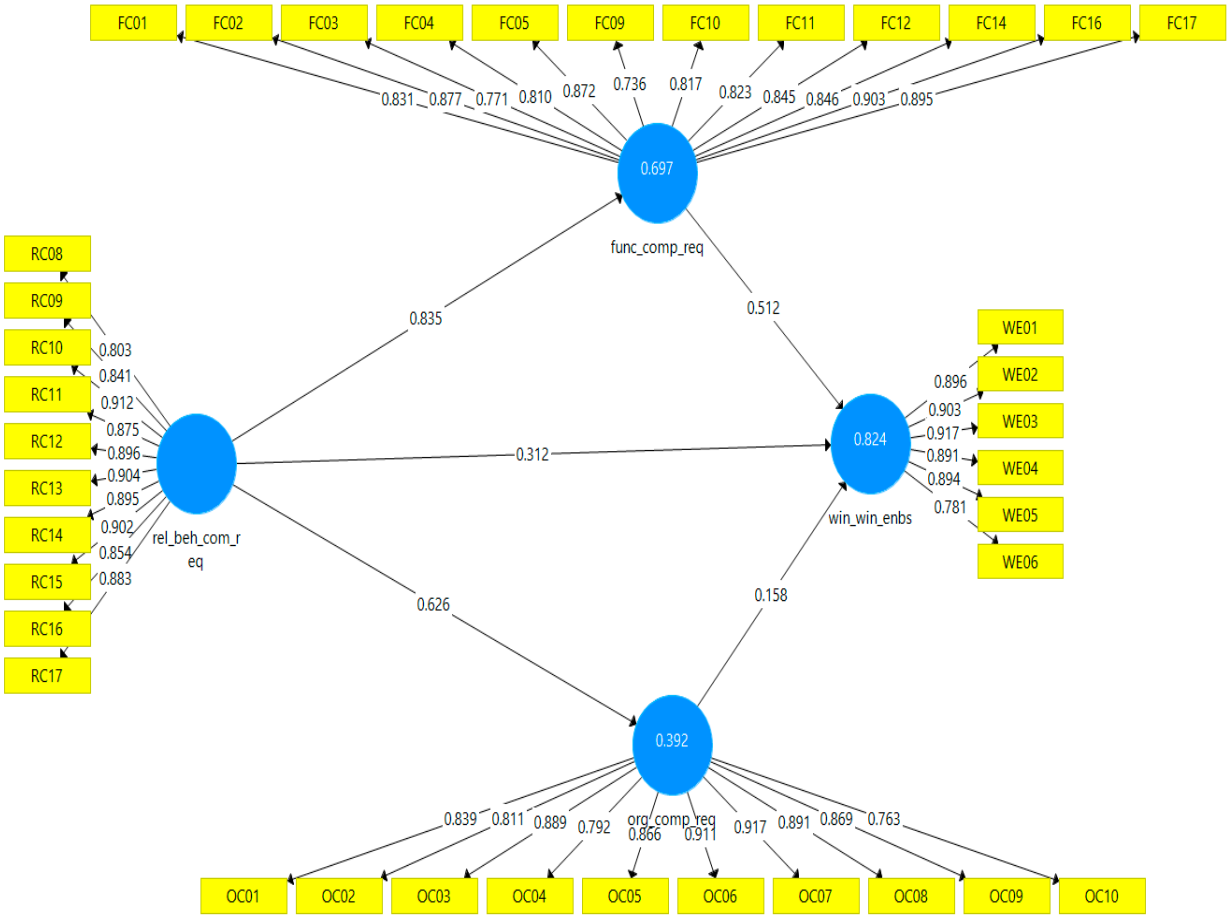

Figure 4. Final Measurement Model.

The final measurement model encapsulates 10 relational/behavioural competencies, 12 functional competencies, 10 organisational competencies, and all 6 win-win enablers/strategies.

Table 8. Final outer loadings of the measurement model.

Code	func_comp_req	org_comp_req	rel_beh_com_req	win_win_enbs
FC01	0.831			
FC02	0.877			
FC03	0.771			
FC04	0.810			
FC05	0.872			
FC09	0.736			
FC10	0.817			
FC11	0.823			
FC12	0.845			
FC14	0.846			
FC16	0.903			
FC17	0.895			
OC01		0.839		
OC02		0.811		
OC03		0.889		
OC04		0.792		
OC05		0.866		
OC06		0.911		
OC07		0.917		
OC08		0.891		
OC09		0.869		
OC10		0.763		
RC08			0.803	
RC09			0.841	
RC10			0.912	
RC11			0.875	
RC12			0.896	
RC13			0.904	
RC14			0.895	
RC15			0.902	
RC16			0.854	
RC17			0.883	
WE01				0.896
WE02				0.903
WE03				0.917
WE04				0.891
WE05				0.894
WE06				0.781

Table 9. Construct reliability and validity of the Final Measurement model.

Constructs	CA	rho_A	CR	AVE
func_comp_req	0.961	0.962	0.965	0.700
org_comp_req	0.959	0.964	0.965	0.733
rel_beh_com_req	0.966	0.968	0.971	0.769
win_win_enbs	0.942	0.943	0.954	0.777

Notes: CA—Cronbach's Alpha, CR—Composite reliability, AVE—Average Variance Extracted.

Table 10. Discriminant validity of the initial measurement model (HTMT).

Constructs	func_comp_req	org_comp_req	rel_beh_com_req	win_win_enbs
func_comp_req	-	-	-	-
org_comp_req	0.841	-	-	-
rel_beh_com_req	0.826	0.845	-	-
win_win_enbs	0.720	0.742	0.856	

Notes: HTMT—Heterotrait-Monotrait.

4.4. Specification and Evaluation of Structural Model

The assessment of the structural model demonstrates both the strength and significance of the hypothesised relationships (See Figure 2). This study employs a two-stage approach to derive path values within the structural model. This method not only surpasses other techniques in parameter recovery but also enhances statistical power [69], making it widely recommended for use at the structural modelling stage [57]. The initial phase of this technique is similar to the repeated indicators method [69]. It entails running the PLS path model to derive latent variable values for the constructs. These latent variable scores are saved and subsequently used to specify the model for further evaluation, with the higher-order construct forming the structural model in the second phase [56]. Additionally, the hypothesised mediating effect is assessed at this stage. The study employs a complete bootstrapping method with five thousand samples, as larger sample sizes are recommended for achieving more stable and reliable results. A significance level of 95% was applied to all computations. For estimating confidence intervals, the study utilised the bias-corrected and accelerated bootstrap method, recognised for its stability and efficiency in computing time [56]. Figure 5 shows the structural model with the path coefficients and *p* values to the specified criteria for the model.

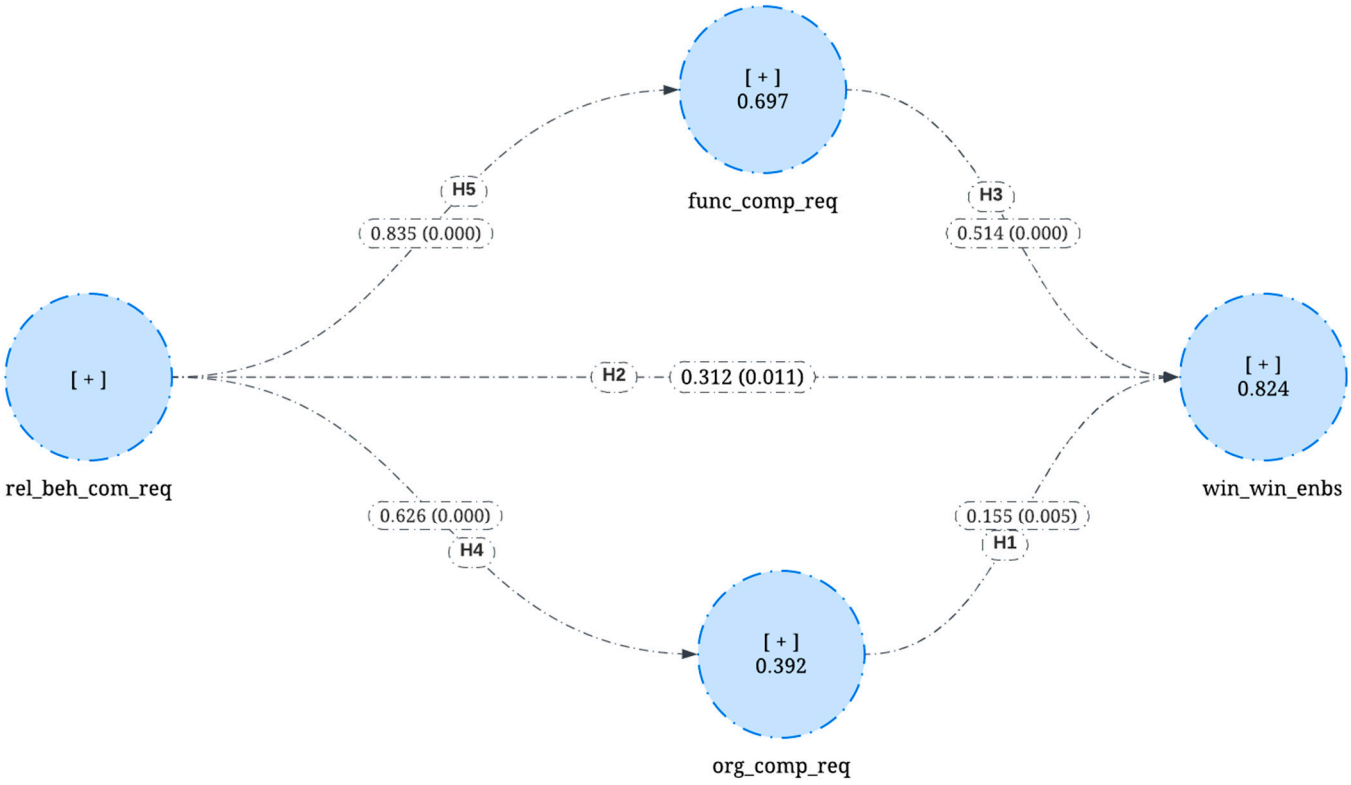

Figure 5. Structural Model with path coefficients and *p*-values.

This study utilised the coefficient of determination (R^2) and the significance of the path coefficients to evaluate the structural model. The R^2 value indicates the total variance explained by each input feature, and its interpretation can vary by context. For example, an R^2 value of 0.10 in stock predictions is considered satisfactory [70]. Similarly, Hair et al. [71] notes that while high R^2 values can be reasonable in certain contexts, they may also suggest overfitting, particularly in terms of out-of-sample predictions. Several factors may contribute to this phenomenon, prompting Henseler and Sarstedt [72] to recommend caution in interpretations, as theoretical concepts often justify higher values. The robust theoretical and practical foundations of this model produced acceptable R^2 values, as illustrated in Table 11. Although these values are satisfactory and do not exceed 0.90—which could raise concerns about overfitting [57]—the R^2 value is influenced by

the number of exogenous factors included in the model; generally, more factors lead to higher R^2 values [57]. Notably, the coefficients are significant at the 95% confidence interval, indicating the structural model's soundness.

Table 11. R-square statistics.

Factors	Coef	Stdev	T-Statistics	*p*-Values	95% CI	
					Lower	Upper
func_comp_req	0.697	0.055	12.659	0.000	0.595	0.808
org_comp_req	0.392	0.067	5.876	0.000	0.272	0.535
win_win_enbs	0.824	0.028	29.019	0.000	0.774	0.884

Notes: CI—confidence interval, Coef—coefficients, Stdev—standard deviation.

Further evaluation of the structural model confirmed that the hypotheses were supported. The results indicate that the path coefficients reflect the strength of regression among the latent variables in the model. According to Hair et al. [71], coefficients exceeding 0.1 demonstrate influence and can be categorised by strength. Sarstedt et al. [56] classifies these coefficients as follows: a weak influence is indicated by values from 0.1 to 0.3, a moderate influence is from 0.3 to 0.5, and a strong influence is represented by values above 0.5. However, the acceptance of the structural model is contingent upon the *p*-value and t-statistics, with values above 1.67 deemed acceptable for t-statistics and below 0.05 acceptable for *p*-values [57].

From the modelling results on the three clusters identified as competency requirements for PPPs, it is evident that relational/behavioural, functional, and organisational competencies positively influence the achievement of win-win enablers. However, the extent of these positive relationships among the constructs varies. These findings broadly support the theoretical perspectives of numerous studies, indicating that the realisation of the win-win principle relies significantly on both the private sector and the public sector competencies at the individual and corporate levels [6]. The model validated the win-win enablers and strategies, as all components successfully passed the rigorous analytical process of PLS-SEM modelling.

Additionally, the findings reveal that relational/behavioural competencies have a strong, positive influence on both organisational and functional competencies, emphasising their mediating role in reaching a win-win outcome. As shown in Table 12, this hypothesis is supported, highlighting that the relationship dynamics and behaviours between parties are crucial to the successful implementation and win-win realisation of the partnership. These relational competencies are essentially channelled through organisational and functional competencies in practice, reinforcing their interconnected role. The mediation effects were statistically significant, lending further credibility to these relationships as key enablers in achieving the partnership goals of the PPP scheme.

Table 12. Assessment of the structural model.

Relationship	PCoef	Stdev	T-Stat	*p*-Values	95% CI		Decision
Direct Effects					Lower	Upper	
func_comp_req -> win_win_enbs	0.514	0.124	4.153	0.000	0.272	0.756	Accept
org_comp_req -> win_win_enbs	0.155	0.056	2.795	0.005	0.051	0.269	Accept
rel_beh_com_req -> func_comp_req	0.835	0.033	25.283	0.000	0.771	0.899	Accept
rel_beh_com_req -> org_comp_req	0.626	0.053	11.793	0.000	0.522	0.731	Accept
rel_beh_com_req -> win_win_enbs	0.312	0.123	2.530	0.011	0.089	0.566	Accept
Mediation effects							
rel_beh_com_req -> org_comp_req -> win_win_enbs	0.197	0.037	2.643	0.008	0.032	0.176	Accept
rel_beh_com_req -> func_comp_req -> win_win_enbs	0.429	0.106	4.064	0.000	0.228	0.638	Accept

Notes: CI—confidence interval, PCoef—Path coefficients, Stdev—standard deviation.

5. PPP Competency Model Discussion and Implications

The PPP competency requirement model developed in this study sets the pace for a holistic partnership model that highlights the roles of the project actors towards the achievement of the win-win, integrating organisational, functional, and relational/behavioural competencies of the project actors.

5.1. PPP Organisational Competencies

In a typical PPP, the private and the public sectors are multi-stakeholder in composition; hence, the administrative capacity and build-up of each sector must be adequate to adopt the PPP route. These competencies exist irrespective of the type of PPP or the infrastructure project, be it transport, energy, water ICT, etc. The existence of a well-established regulatory and policy framework with a politically stable environment is a necessary competency for the public sector [25,73]. Moreover, the public sector should have a well-structured public/local community engagement protocol for project needs assessment and public cooperation in the project [28]. It is imperative for both the public and the private sectors to have effective contract administration procedures and experts with standardised and well-defined managerial procedures and capacity to enhance PPP implementation [26]. Effective dispute resolution mechanisms, strong bargaining techniques and capacity, as well as efficient knowledge and technology transfer mechanisms, are necessary competencies for win-win optimisation and overall PPP success [16,17].

5.2. PPP Functional Competencies

It is essential to emphasise competencies specific to the roles of project stakeholders in infrastructure development, particularly the technical skills that are influenced by the type of PPP model and the nature of the infrastructure involved [12]. Project actors must possess the intellectual and technical expertise necessary to manage the specific project requirements, ensuring that each project milestone is met with precision and alignment with overarching objectives [8]. Additionally, they should prioritise delivering infrastructure that meets both quality and service standards, continuously enhancing their skills and competencies to fulfil these standards effectively [25]. Risk management capacity is a critical competency for project actors [74]. The technical abilities for the identification, assessment, and, most importantly, the allocation of project risks are key for the establishment of a win-win scenario in PPPs [6]. Additionally, the private sector should ensure and continually enhance its competencies in construction technology, project operations, and commercialisation [28]. Project actors' awareness and management skills in environmental sustainability are essential for integrating sustainable practices effectively throughout project implementation [33]. Efficient stakeholder management skills are essential functional competencies for successful PPP.

5.3. PPP Relational/Behavioural Competencies

The study identified competencies designed to fulfil relational and behavioural requirements that project actors should demonstrate to support win-win strategies. These capture relationship and behavioural competencies, i.e., intra and inter-attributes from the individuals to the team level. These competencies foster the goals of alliance and mutual benefit sought by the project parties. Gruden and Stare [20] highlight these traits as particularly influential for project performance, as they cultivate collaboration and positive dynamics among partners. Studies have captured issues of corruption, conflict of interests, poor leadership skills, disputes, lack of trust and transparency, and cultural and communication inefficiencies [18,19]. It is key for the public and private actors to be more conscious of the development of certain behavioural and relationship competencies to eliminate these problems. Mutual respect among project participants, coupled with a strong sense of accountability, is essential for successful PPP alliances. This approach promotes responsibility, acknowledgement of roles, and mutual recognition within the partnership [40]. Transparency among stakeholders promotes the achievement of a win-

win agreement with Brogaard [8]. In addition, cultural and language differences among project stakeholders should not pose barriers to the effective delivery of infrastructure. It is crucial for project actors to intentionally exhibit cultural intelligence and possess strong communication skills to ensure seamless implementation of the project [19,26]. PPP implementation has sometimes led to conflicts among stakeholders, highlighting the importance of emotional intelligence and effective problem-solving skills among project participants to achieve the win-win objective [20,43]. The study emphasises that effective leadership skills, the demonstration of strong ethical values, and the ability to think creatively and learn continuously are essential for successfully delivering public infrastructure projects [33,41].

6. Conclusions

The implementation of PPP infrastructure projects typically involves multiple stakeholders and is complex; hence, it requires special expertise and strategies to manoeuvre the intricacies and obstacles. Infrastructure development through PPPs must optimise the realisation of win-win to foster continued alliancing. The study underscores the defining elements of win-win and the pivotal role of aptness in the public and private sector competencies. The robust modelling approach adopted in the study presented an integrated approach to sculpting the interactions amongst competencies, exposing implementation realities. Most studies have attributed the failures and impediments to successful PPP to strained relationships, lack of mutual trust and respect, financial constraints, meagre risk management, and weak PPP formation or structure, amongst others, typically in developing countries. The model implies that while PPP experts develop enablers within the PPP framework to meet project needs and achieve performance metrics, the successful realisation of these goals relies heavily on the seamless integration of capabilities, specialised expertise, and the cultivation of healthy stakeholder relationships. The study highlights the criticality of relational/behavioural, functional and organisational competencies of the private and public sectors for win-win optimisation. The model emphasises the interdependence of competencies, demonstrating that these elements cannot function effectively in isolation. Instead, they must integrate seamlessly to optimise outcomes and achieve a win-win scenario for all stakeholders involved.

Additionally, given that PPPs are multi-stakeholder in nature, it is essential that relational competencies, both at the inter and intra-sector levels, are highly developed. These competencies significantly influence the distribution of organisational and functional responsibilities. Effective communication, collaboration, and trust-building between diverse parties are critical for the successful execution of PPP projects, as they shape how teams function collectively. Thus, the model depicts the practical scenario of underscoring the mediating effect of the organisational and functional competencies towards win-win optimisation.

For PPP practice, the model offers a comprehensive framework for evaluating competencies, detailing specific parameters that assess the readiness of both the private and public sectors in undertaking a given PPP project in infrastructure development. This framework helps ensure that the stakeholders involved have the necessary organisational, functional, and relational capabilities to successfully implement the scheme. Additionally, practitioners and policymakers can identify project-specific dimensions such as transport, energy, health, or education to align their capabilities with the unique requirements and orientation of the project. This allows them to adapt to sector-specific conditions and the PPP framework in use, ensuring effective implementation and alignment with project goals. Further studies capturing project-specific scenarios and PPP models can be explored to ascertain more dimensions that inform policy and practice.

The study's theoretical contributions extend the existing body of knowledge by proposing a holistic competency model, which may serve as a foundation for future research and practice in the field of infrastructure development. Ultimately, this study highlights that achieving win-win outcomes in PPPs is not merely a theoretical ideal but a practical necessity, requiring intentional actions to align competencies and foster collaboration among all

project participants. The insights gained from this research will be instrumental in guiding future initiatives aimed at optimising the impact of PPPs on infrastructure development.

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