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Public–Private Partnerships as Innovation Ecosystems: A Boundary-Spanning Model of Knowledge Integration, Public Value, Risk Allocation, and Collaborative Adaptation

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Abstract

Public–private partnerships (PPPs) are commonly analyzed through contracts, financing, risk transfer, and project delivery, yet innovation-intensive partnerships increasingly depend on knowledge and resources distributed across organizations whose goals, authority, incentives, and time horizons differ. This article develops an original non-empirical boundary-spanning ecosystem model that reframes selected PPPs as innovation ecosystems when their functioning depends on complementarities, interdependence, continuing knowledge integration, and adaptive coordination beyond the bilateral contract. The synthesis distinguishes six connected but analytically separate elements: heterogeneous actor resources, boundary-spanning mechanisms, knowledge integration, public-value protection, risk–reward alignment, and collaborative adaptation. It argues that boundary spanning does not itself generate integration; translation devices, shared interpretive structures, and organizational integration capabilities are required, while excessive or poorly governed spanning can create attention and coordination costs. Public value is treated as a contested ecosystem-level outcome rather than a presumed consequence of collaboration, and risk allocation is recast as an evolving governance problem rather than a one-time contractual transfer. The proposed model also incorporates feedback, ecosystem failure, temporal change, and institutional contingencies. Its principal contribution is to connect PPP research with innovation-ecosystem and knowledge-integration theory without claiming that PPPs are inherently ecosystems or that the proposed relationships are empirically validated. The model is intended as a theoretically bounded basis for comparative, longitudinal, and multilevel testing across sectors and institutional settings.

Keywords: Public–private partnerships, Innovation ecosystems, Boundary spanning, Knowledge integration, Public value, Collaborative governance

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Introduction

Public–private partnerships are often justified through access to private finance, specialized expertise, risk sharing, and delivery capability, but these categories do not fully explain how innovation emerges when organizations must combine knowledge across contractual and institutional boundaries. Evidence from infrastructure PPP practice indicates that partnership arrangements can create opportunities for innovation while the contractual environment may also constrain innovation after award, making the relationship between PPP form and innovative activity conditional rather than uniformly



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positive [1]. This tension matters most where technological novelty, service redesign, data exchange, or evolving public needs require repeated recombination of knowledge after the initial transaction has been specified.

A second limitation of a narrow contractual view is that PPP performance cannot be reduced to cost, schedule, or commercial value. A systematic review of PPPs for government digitalisation shows that public-value considerations are plural and unevenly represented, indicating that evaluation must consider more than economic efficiency [2]. The argument developed here is therefore deliberately bounded: not every PPP is an innovation ecosystem. Rather, this article proposes that an ecosystem lens becomes analytically useful when innovation depends on interdependent actors, complementary resources, boundary-spanning knowledge processes, negotiated public value, evolving risk–reward arrangements, and adaptive governance. This reframing separates the formal partnership vehicle from the wider system through which knowledge, authority, benefits, and exposure are distributed. The contribution is conceptual integration, not empirical validation of a universal PPP form.

From contractual PPPs to innovation ecosystems

An ecosystem interpretation requires more than replacing “partners” with “actors.” Innovation-ecosystem research emphasizes interdependent participants, complementarities, and differentiated governance rather than an isolated organizational dyad [3-5]. This distinction is consequential for PPP analysis because contracts may establish bilateral rights and obligations while innovation can depend on additional participants—users, regulators, technical specialists, civic actors, suppliers, and knowledge intermediaries—whose contributions cannot be fully specified *ex ante*. Ecosystem arrangements can also generate coordination and distributional failures, so the label should not imply superior performance.

Complementarity provides the stronger theoretical bridge. Ecosystem theory treats actors as interdependent where the value of one contribution depends on other aligned activities and positions [6]. Applied cautiously to PPPs, this shifts attention from contract completeness toward the architecture within which specialized public and private capabilities become mutually usable. The contract remains important, but it becomes one governance device inside a wider relational system. The proposed ecosystem interpretation therefore applies only where cross-organizational complementarities materially shape innovation, value creation, or adaptation; conventional procurement relationships lacking such interdependence should remain outside the model.

Public and private actors as heterogeneous knowledge holders

The public–private distinction captures differences in authority and ownership, but it is too coarse to explain innovation. Recent PPP evidence from digital-transformation and circular-economy settings shows that collaboration can combine complementary resources, interoperability capabilities, trust, governance arrangements, and organizational expertise [7]. These findings support a view of participating organizations as heterogeneous knowledge holders: public bodies may possess regulatory authority, mission knowledge, service-system understanding, and access to civic priorities, while private organizations may contribute technological, commercial, operational, or scaling capabilities. These role descriptions are analytical possibilities rather than universal attributes of each sector.

Heterogeneity also exists within collaboration forms. Empirically grounded research on public-sector collaborative innovation identifies distinct organizational archetypes rather than a single partnership configuration [8]. Accordingly, the proposed model does not assign fixed innovation roles on the basis of actor category. It treats contribution as relational: an actor matters because of the resource, knowledge, legitimacy, access, or implementation capacity it contributes and because other actors depend on that contribution. Innovation difficulty therefore arises not only from missing resources but from failures to translate, combine, authorize, or adapt resources that are already present across organizational boundaries.

Boundary spanning and knowledge integration

Boundary spanning concerns access across differentiated knowledge domains, whereas knowledge integration concerns the successful combination of what is accessed. Research on cross-disciplinary projects indicates that spanning disciplinary boundaries can be associated with technological impact [9]. Yet firm-level evidence also shows that boundary-spanning search can exhibit nonlinear returns, with excessive search creating costs that qualify the assumption that more external reach is always better [10]. For PPPs, this suggests that opening additional interfaces may expand problem-solving variety while simultaneously increasing interpretation, coordination, and attention demands.

Integration therefore requires mechanisms that make heterogeneous knowledge mutually intelligible and actionable. A systematic review identifies boundary objects as important devices for knowledge integration across organizational and cognitive interfaces [11], while empirical work links boundary-spanning objects and shared meaning with knowledge-integration capability [12]. Boundary-spanning activity is thus analytically distinct from knowledge integration: innovation-relevant cross-domain reach still requires mechanisms that translate and integrate heterogeneous knowledge [9, 11, 12]. The proposed model treats access, translation, integration, and feedback as separate functions. It does not assume a compulsory

sequence, because some interfaces may bypass formal boundary objects, recur iteratively, or fail before integration is achieved.

Public value as an ecosystem-level outcome

Innovation in a PPP can create commercial, operational, social, or public benefits simultaneously, but these forms of value should not be collapsed. Public-service ecosystem theory shows that public value can be contested, with actors differing over what constitutes a desirable outcome and how benefits and burdens should be distributed [13]. Public value is therefore positioned here as an ecosystem-level outcome requiring protection and negotiation rather than as an automatic by-product of successful collaboration. A technically innovative solution may still redistribute access, accountability, risk, or service quality in ways that different stakeholders evaluate differently.

The relevant actor set also extends beyond organizations signing the partnership agreement. Research on citizen engagement in public-sector innovation indicates that engagement varies with broader governance and innovation paradigms [14]. Consequently, partner collaboration and public inclusion are treated as distinct dimensions. Private and public organizations may integrate knowledge effectively while still excluding affected groups from defining the problem, evaluating trade-offs, or contesting distributional consequences. In the proposed model, public-value protection therefore depends on both interorganizational coordination and mechanisms that preserve visibility of affected interests, without assuming that participation itself guarantees legitimacy or value agreement.

Risk allocation beyond contractual transfer

PPP research commonly asks which party should bear particular risks, but innovation makes risk less stable than a one-time allocation metaphor suggests. Comparative evidence from capital projects shows that contractual flexibility interacts with stakeholder relationships, information, expertise, and the distribution of economic and social value [15]. This implies that an allocation that appears efficient at contract formation may become constraining when technology, stakeholder expectations, or implementation knowledge changes. Flexibility is not inherently beneficial; its usefulness depends on the capacity and authority to interpret and act on new information.

A systematic review of PPP risks likewise identifies multiple risk factors, impacts, and mitigation strategies rather than a single transferable risk category [16]. The model therefore distinguishes formal allocation from ongoing risk governance. Formal allocation specifies responsibility and exposure, whereas adaptive risk governance concerns detection, interpretation, mitigation, renegotiation, and learning as conditions evolve. This distinction allows risk to be linked to knowledge: an actor may formally bear a risk without possessing the information or capability needed to manage it. Risk–reward alignment is consequently proposed as a dynamic relationship among exposure, decision rights, information access, adaptive capacity, and value capture.

Collaborative adaptation under technological and institutional change

Innovation ecosystems operate under changing technological, regulatory, and political conditions, making adaptation a governance problem rather than an incidental response. Configurational evidence from collaborative governance for green transition shows that collaboration can be supported by different combinations of conditions rather than one universally sufficient driver [17]. This finding is consistent with an equifinal view of adaptation: partnerships may preserve coordination through different mixes of authority, facilitation, trust, participation, resources, and institutional support depending on context. Adaptation also occurs across portfolios of collaborative activity. Work on public-sector co-creation argues that multiple projects create coordination demands at a level above the individual initiative [18]. Collaborative adaptation is therefore modeled here as configurational and portfolio-level rather than reducible to a single governance lever [17, 18]. For PPPs, the implication is that contractual modification is only one adaptive mechanism. Others may include boundary-role redesign, revised interfaces, new information-sharing arrangements, altered decision rights, or changes in stakeholder participation. These mechanisms remain proposals within the integrated model; the selected literature does not establish a universal adaptation sequence or demonstrate that any one configuration will be effective across PPP sectors.

The PPP innovation-ecosystem model

The proposed PPP innovation-ecosystem model combines a structural and an evolutionary view. Ecosystem scholarship distinguishes ecosystem-as-structure from ecosystem-as-coevolution, indicating that a static map of participants cannot fully represent changes in relationships, capabilities, and dependencies over time [19]. Structural ecosystem analysis further directs attention to activities, actors, positions, and links organized around an interdependent value proposition [20]. Taken together, these ideas support a PPP model that specifies who contributes what, how knowledge crosses boundaries, where value and risk are distributed, and how these relationships can change.

The model centers boundary spanning as a linking function rather than a guaranteed performance mechanism. Heterogeneous actor resources remain analytically separate from the processes that translate and integrate them; public value remains separate

from private value capture; contractual risk assignment remains separate from adaptive risk governance; and collaborative adaptation is conditioned by institutional and sectoral context. Feedback is essential because integration can reveal new uncertainties, value conflicts can trigger renegotiation, and technological change can alter resource dependencies. Failure can therefore arise through misalignment, exclusion, boundary-spanning overload, unresolved value conflict, or rigid allocation, not simply through absence of collaboration. These relationships jointly constitute the proposed synthesis and require direct empirical testing rather than being treated as established PPP mechanisms.

Figure 1 visualizes this architecture and makes the distinction between evidence-supported relationships and proposed PPP-specific integrations explicit.

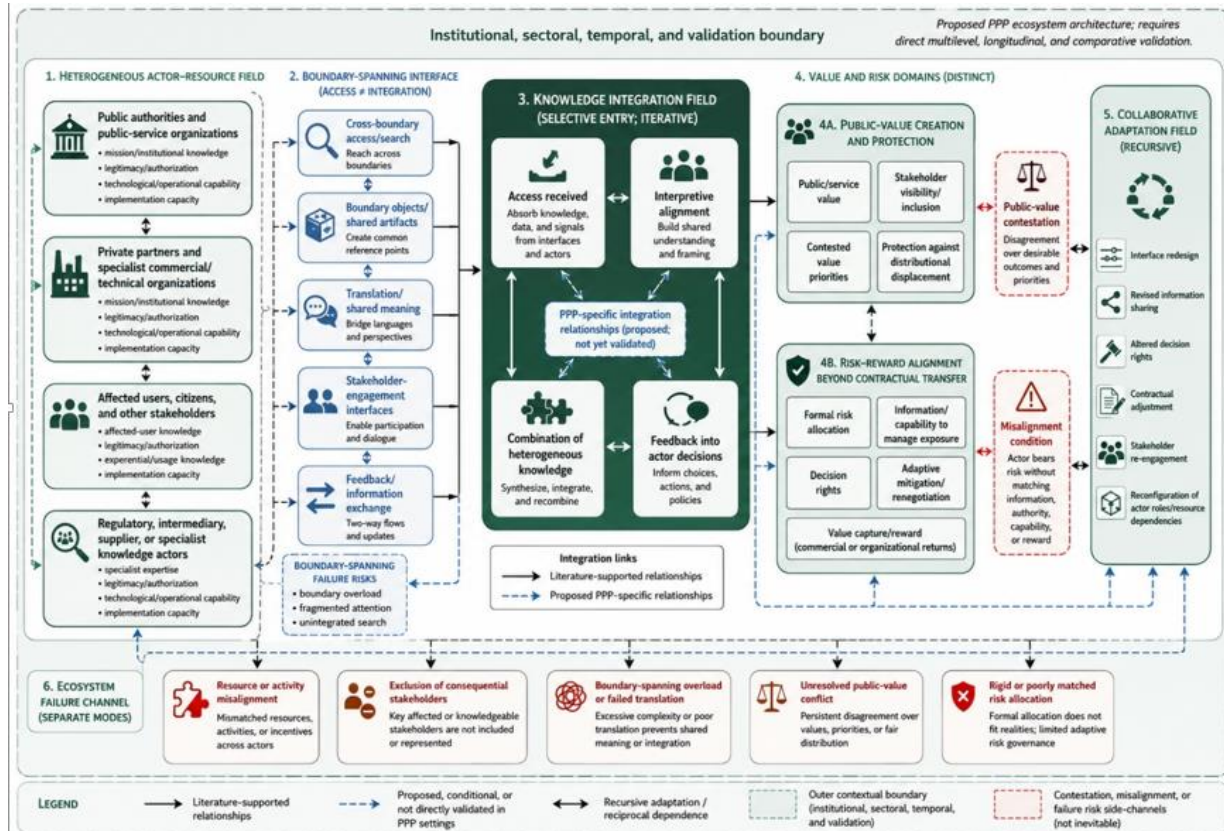


Figure 1. Boundary spanning conditions how heterogeneous PPP resources become integrated knowledge, public-value protection, and adaptive capacity

Actor roles and complementary resources

The proposed ecosystem model assigns roles through contribution and dependence rather than ownership category. Ecosystem-legitimacy theory indicates that legitimacy can emerge through collective action among participants rather than being created solely by a focal organization [21]. In PPP settings, this matters because public authority may authorize action without possessing all technical or operational knowledge, while private organizations may possess implementation capabilities without independently defining legitimate public purposes. Complementarity therefore creates both productive possibility and reciprocal dependence. Actor roles should be specified by what knowledge, resource, authorization, access, or implementation capacity each actor contributes and what it requires from others.

Stakeholder engagement further complicates this architecture. Public-sector innovation research shows that engagement is enacted through procedural, material, relational, and cognitive practices rather than represented adequately by a binary participation indicator [22]. The model therefore distinguishes formal presence from boundary-spanning contribution. A stakeholder may be consulted yet remain weakly connected to problem definition, interpretation, or adaptation, while an intermediary may have little contractual authority but perform critical translation work. **Table 1** organizes these asymmetries as interdependencies rather than a static stakeholder inventory.

Table 1. Who contributes, depends, and remains exposed in PPP innovation ecosystems

Actor class	Distinctive resource	Critical dependency	Spanning need	Value created/ captured	Public-value exposure	Risk borne	Proposed governance implication
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Public authority	Mission knowledge, regulation, authorization	Technical/delivery capability	Translate public purpose	Service and policy value	Access, accountability, legitimacy	Fiscal, political, service	Retain learning access and decision rights
Private partner	Technical, commercial, scaling capability	Authorization and demand definition	Contextualize technology	Commercial return, innovation opportunity	Service consequences	Investment, technology, delivery	Match exposure with controllability
Specialist/intermediary/oversight actors	Expertise, standards, assurance	System access and information	Bridge or verify interfaces	Problem resolution, legitimacy	Accountability	Interface or regulatory failure	Preserve access and independent scrutiny
Users/civic stakeholders	Lived and consequence knowledge	Meaningful decision access	Make use knowledge actionable	Service benefit, voice	Direct	Exclusion, inequitable burden	Enable consequential participation

Note: Governance implications are proposed rather than validated prescriptions.

Knowledge flows and boundary-spanning mechanisms

Knowledge movement in a PPP is not a single transfer event. Cross-boundary search can enlarge the pool of ideas and expertise, but its value depends on whether information is selected, translated, and incorporated into joint problem solving [9]. Evidence of nonlinear search effects also cautions that expanding interfaces can increase coordination burdens when organizations lack sufficient analytical or absorptive capacity [10]. Boundary objects can stabilize communication across heterogeneous communities [11], while knowledge-integration capability helps convert common meaning and shared interests into innovation-relevant use [12]. These mechanisms are related but non-equivalent.

The proposed model therefore separates boundary type from spanning mechanism. Technical boundaries may require shared specifications or prototypes; organizational boundaries may require liaison roles and common routines; institutional boundaries may require translation between legal, commercial, and service logics; stakeholder boundaries may require engagement practices that make affected-user knowledge visible [22]. The same spanning mechanism may also perform different functions at different interfaces, so mechanism labels should not be treated as fixed indicators of integration quality. **Table 2** differentiates these mechanisms by the integration problem they are intended to solve. The resulting architecture permits feedback and bypasses rather than imposing a universal sequence.

Table 2. Boundary-spanning mechanisms matched to the knowledge problem they address

Boundary	Mechanism	Integration function	Interface	Failure risk	Enabling condition	Potential adaptation
Technical	Shared specification/prototype	Make expertise comparable	Engineers–users–public experts	False common meaning	Interpretable representation	Revised design
Organizational	Liaison role	Translate priorities	Public–private teams	Brokerage overload	Authority plus access	Recombined response
Cognitive	Joint sensemaking	Build shared interpretation	Expert communities	Assumption mismatch	Repeated interaction	Reframed problem
Institutional	Legal–commercial–mission translation	Reconcile logics	Contract–policy–delivery actors	Logic conflict	Clear constraints/rights	Governable redesign
Stakeholder	Structured engagement	Introduce consequence knowledge	Partners–users–civic actors	Tokenism	Consequential participation	Revised safeguards

Note: Mechanism use does not guarantee integration.

Value creation, value capture, and public-value protection

Ecosystem language can obscure a fundamental distributional question: value may be jointly created without being jointly captured or publicly protected. Ecosystem theory identifies externalities and complementarities that can produce distributional as well as functional failures [4]. Public-service ecosystem research likewise treats public value as potentially contested rather than consensual [13]. In a PPP, an innovation may improve operational performance while shifting benefits, costs, access, or control among taxpayers, users, public agencies, and commercial partners. Evaluating ecosystem performance therefore requires distinguishing the existence of new value from its allocation and from the preservation of public purposes.

This distinction becomes sharper in mission-intensive sectors. Research on low-carbon and climate-resilient infrastructure PPPs shows that sustainability objectives introduce governance requirements extending beyond conventional delivery and

financial considerations [23]. The model consequently proposes public-value protection as an ongoing governance function: actors must retain visibility over who benefits, who bears residual exposure, and whether adaptation changes the original public-purpose balance. Protection is not synonymous with preventing private value capture. Private reward may be necessary to mobilize capability and investment. The relevant theoretical problem is whether value-capture arrangements remain compatible with public obligations as knowledge, risks, and ecosystem dependencies evolve.

Risk–reward alignment

Risk–reward alignment extends the earlier distinction between contractual allocation and actual capacity to manage exposure. Formal contracts can assign responsibility, but the practical consequences of that assignment depend on information access, decision rights, expertise, stakeholder relationships, and the ability to respond when assumptions change [15]. A risk-bearing actor that cannot observe or influence the source of uncertainty may be formally accountable but operationally unable to manage it. Conversely, an actor with substantial adaptive discretion may influence outcomes without bearing corresponding exposure. The proposed model treats these asymmetries as potential sources of ecosystem instability rather than as evidence of a single optimal allocation.

Institutional context further qualifies alignment. Comparative analysis across PPP markets indicates that institutional variables interact differently as market maturity changes [24]. Thus, governance arrangements feasible in mature PPP systems may not transfer unchanged to settings with different legal, professional, financial, or administrative infrastructures. Risk–reward alignment is therefore conceptualized as contingent correspondence among exposure, authority, information, adaptive capability, and expected value capture. The model does not prescribe quantitative sharing ratios. Instead, it identifies a testable proposition: persistent mismatch among these dimensions should be examined as a possible mechanism linking contractual architecture to adaptation difficulty, opportunistic behavior, or withdrawal.

Ecosystem evolution and failure

PPP ecosystems should be expected to evolve because technologies, stakeholder priorities, institutions, and interorganizational dependencies change over time. Evidence from infrastructure PPP development shows that project characteristics and relationships can change across development phases [25]. A static governance description may therefore conceal when a previously workable division of responsibilities becomes misaligned with new information or capability demands. Ecosystem coevolution adds a second temporal layer: actors can modify their own capabilities and positions in response to changes elsewhere in the system [19]. Adaptation is consequently both episodic and relational.

Failure in this model is not a single terminal state. It can appear as stalled knowledge integration, exclusion of consequential stakeholders, unresolved public-value conflict, risk without corresponding control, excessive spanning burdens, or rigid governance that blocks necessary reconfiguration. Ecosystem theory similarly cautions that complementarities can generate endogenous failures rather than automatically solving coordination problems [4]. **Table 3** traces proposed risk–reward states through which an innovation-oriented PPP might move. These states are analytical devices, not empirically validated lifecycle stages; projects may skip, revisit, or combine them.

Table 3. How risk, value capture, and adaptation can shift as a PPP ecosystem evolves

Ecosystem state	Dominant uncertainty	Risk pattern	Value/public-value tension	Adaptation	Governance response	Failure signal	Transition condition
Formation/alignment	Capability and requirements	Broad ex ante allocation	Viability versus public purpose	Joint specification	Clarify roles/interfaces	Hidden dependency	Workable shared framing
Contract stabilization	Delivery/coordination	Responsibilities formalized	Capture terms harden	Learning routines	Preserve information channels	Experimentation narrows	New evidence challenges assumptions
Adaptive reconfiguration	Technological/institutional change	Exposure-design mismatch	Benefits/costs redistribute	Renegotiation, role redesign	Rebalance authority/exposure	Blocked response	Fit restored
Conflict/misalignment	Persistent asymmetry	Risk without capability	Contested capture/public-value loss	Re-engagement/escalation	Corrective scrutiny	Distrust, repeated dispute	Resolution or fragmentation
Renewal/exit	Long-term viability	Redistribution or termination	Residual obligations	Renewal/reconstitution/exit	Preserve continuity/accountability	Lock-in, unmanaged legacy	New configuration or closure

Note: States and transitions are proposed, non-universal analytical devices.

Institutional and sectoral boundary conditions

The proposed model is deliberately conditional. PPPs differ across countries in legal authority, procurement institutions, administrative capability, professional communities, financial markets, and accumulated partnership experience. Evidence from developing-country digital and circular-economy PPPs highlights the importance of governance, trust, interoperability, and institutional context [7]. Cross-market evidence further indicates that relationships among PPP institutional variables vary with market maturity [24]. These findings caution against treating a governance arrangement observed in one institutional environment as a transportable design rule.

Sector and time impose additional boundaries. Capital-project evidence concerning flexibility arises from a small number of infrastructure cases [15], while collaborative-governance configurations identified in green transitions come from local public settings [17]. Climate-resilient infrastructure introduces distinctive sustainability obligations [23], and development-phase research shows that PPP relationships can change as projects progress [25]. Accordingly, the model should be tested separately across infrastructure, digital, health, environmental, and service contexts rather than assuming sectoral equivalence. Its mechanisms also operate at different levels: individual boundary spanners, organizational capabilities, interorganizational arrangements, ecosystem relations, and institutional structures should not be collapsed into a single causal level. Cross-level relationships therefore require measurement and testing rather than inference from evidence collected at only one level.

Contributions to innovation and ppp research

The first contribution is to PPP research. Rather than treating innovation as an attribute delivered by the private partner or produced by contractual incentives alone, the article proposes a relational explanation in which innovation depends on how heterogeneous capabilities become accessible, translated, integrated, and adaptively governed. This retains the importance of contracts while locating them inside a larger architecture of interdependence. The model thereby links PPP innovation evidence [1] with ecosystem complementarity [6] and knowledge-integration mechanisms [11] without claiming that those literatures already constitute a validated unified theory.

The second contribution is to innovation-ecosystem research. Ecosystem theory explains complementarity, alignment, and potential failure [4], but PPPs foreground issues that market-centered ecosystem accounts can understate: public authority, contested public value, explicit risk allocation, political accountability, and institutional variation. Public-value conflict [13], multidimensional PPP risk [16], and market-maturity effects [24] are therefore not peripheral contingencies in the proposed synthesis. They define governance conditions under which ecosystem coordination must be evaluated.

Policy and governance implications

For policy and governance, the model suggests that contract design should preserve the capacity to learn after award rather than attempt to eliminate all uncertainty *ex ante*. Evidence on PPP flexibility indicates that formal adaptability has value only in relation to stakeholder resources, information, and authority [15]. Configurational governance research similarly cautions against searching for one universally sufficient collaboration lever [17]. Portfolio-level work further suggests that multiple collaborative initiatives can generate metagovernance demands beyond the focal project [18].

These implications are conditional rather than prescriptive. Governance actors may need to protect boundary interfaces, public-value visibility, and mechanisms for revisiting mismatched risk and decision rights, but the appropriate institutional form should vary by sector and setting. Sustainability-oriented PPP research illustrates how mission requirements can alter governance priorities [23], while PPP market maturity changes the institutional environment in which arrangements operate [24]. The model therefore supports diagnostic questions, not an implementation-ready template.

Future research agenda

The central empirical task is to test whether the proposed links are distinguishable in PPP settings. Studies should measure boundary-spanning access separately from translation and knowledge integration, because evidence from adjacent innovation contexts indicates that spanning can be beneficial yet nonlinear [10]. Process tracing and network analysis could examine who carries knowledge across technical, organizational, institutional, and stakeholder boundaries, while multilevel designs could test whether individual boundary-spanning activity becomes an organizational integration capability rather than assuming cross-level transfer. Boundary-object mechanisms identified in innovation research [11] should be tested against plausible alternatives such as pre-existing trust, contractual clarity, or common professional background.

A second agenda concerns time and context. Longitudinal research should observe changing resource dependencies, public-value disputes, risk allocation, and adaptive responses across PPP development phases [25]. Comparative designs across institutional maturity [24] and sectors should test whether the same mechanisms recur or whether alternative configurations explain adaptation. Strong tests should permit rejection of the model—for example, by showing that knowledge integration is unnecessary, that public-value conflict is orthogonal to adaptation, or that contractual variables explain outcomes without ecosystem mechanisms.

Limitations

This article integrates evidence produced at different levels, in different sectors, and with different methods. Several boundary-spanning and knowledge-integration studies concern firms or research projects rather than PPPs, while some PPP evidence is qualitative, sector specific, or based on limited cases. The proposed architecture therefore cannot establish causal pathways, prevalence, effect magnitude, or universal ordering. Construct boundaries may also overlap empirically: flexibility can operate simultaneously as a contractual feature, relational capability, and institutional permission, while public value may be interpreted differently by different stakeholder groups.

A further limitation is motivational. PPP adoption should not be assumed to arise from innovation or public-value considerations alone. Recent evidence indicates that governmental decisions to use PPPs can also reflect political motivations under particular fiscal, legal, and institutional conditions [26]. Political incentives, procurement constraints, path dependence, bargaining power, and sector regulation may therefore rival or modify the mechanisms proposed here. These possibilities should be incorporated into empirical tests rather than treated as residual noise.

Conclusion

This article proposes a boundary-spanning ecosystem interpretation for PPPs whose innovation depends on interdependent organizations, complementary resources, and continuing adaptation. Its central claim is not that PPPs are inherently innovation ecosystems, but that an ecosystem lens becomes useful when contractual relationships alone cannot explain how knowledge is accessed and integrated, how public value is protected, how risks and rewards remain aligned, and how governance responds to change. The model keeps these processes analytically distinct while connecting them through recursive feedback and explicit failure possibilities. Actor roles remain relational rather than fixed by ownership, and institutional context remains a boundary rather than background noise. Its contribution is therefore an evidence-bounded architecture for theory development and testing. Validation requires longitudinal, multilevel, cross-sector, and comparative institutional research capable of distinguishing the proposed mechanisms from contractual, political, and contextual alternatives.

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