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Strategic Alignment of Venture Innovation Portfolios, External Signals, and Early Growth Outcomes in Emerging Entrepreneurial Firms

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Abstract

Entrepreneurial firms routinely depend on innovation to justify valuation, attract follow-on funding, and preserve room for strategic experimentation. Yet early-stage ventures rarely present innovation through a single, easily interpreted dimension. Investors, employees, suppliers, and prospective customers observe bundles of signals that include technical investment, market-facing experimentation, commercialization progress, and the broader legitimacy cues attached to the innovation agenda. The present study examines whether the internal alignment of these signals, rather than their isolated levels, helps explain heterogeneous growth outcomes among entrepreneurial firms. I conceptualize this alignment as venture innovation coherence and test its association with financing, revenue growth, and downside risk in a panel of 286 U.S. entrepreneurial firms observed from 2016 to 2024, yielding 1,534 venture-year observations. The empirical design combines venture fixed effects, correlated random-effects Tobit estimation for censored financing outcomes, complementary log-log hazard models, mediation analysis, and a control-function correction for endogeneity. The results indicate that greater venture innovation coherence is associated with higher next-year external financing, faster revenue growth, and a lower likelihood of a downside event defined as a down round, severe revenue contraction, or shutdown. Commercialization efficiency partially mediates the financing and growth relationships. The positive association is strongest under moderate competitive intensity, is amplified by prior innovation reputation, and is weakened when the venture's inventive portfolio becomes excessively concentrated. The findings suggest that entrepreneurial ventures benefit not merely from innovating more, but from making distinct elements of their innovation architecture move in a mutually reinforcing direction.

1. Introduction

Entrepreneurship unfolds under conditions in which strategic quality must be inferred long before it can be fully verified. Young firms are typically resource constrained, organizationally fluid, and only partially legible to outsiders. Their products may still be evolving, business models may remain provisional, and performance histories are usually short. In such settings, innovation becomes more than an operational activity. It becomes a central basis on which stakeholders infer future potential [1]. Founders seek to convince external audiences that present experimentation will mature into future rents, while capital providers and exchange partners attempt to distinguish disciplined innovation from symbolic motion [2]. That distinction is not trivial. Many entrepreneurial firms appear promising because they exhibit one conspicuous innovation marker such as a patent, a prototype, an engineering-heavy team, or a burst of public attention. Yet those isolated markers do not always imply that the broader innovation system is internally consistent or capable of producing durable growth.

A recurring difficulty in empirical entrepreneurship research is that innovation is often represented as a single scalar quantity. Studies frequently emphasize patenting, research intensity, product introductions, platform releases, or founder technical credentials. Each of those indicators carries useful information, but each compresses a multidimensional process into one observable slice. Entrepreneurial ventures often diverge precisely because they

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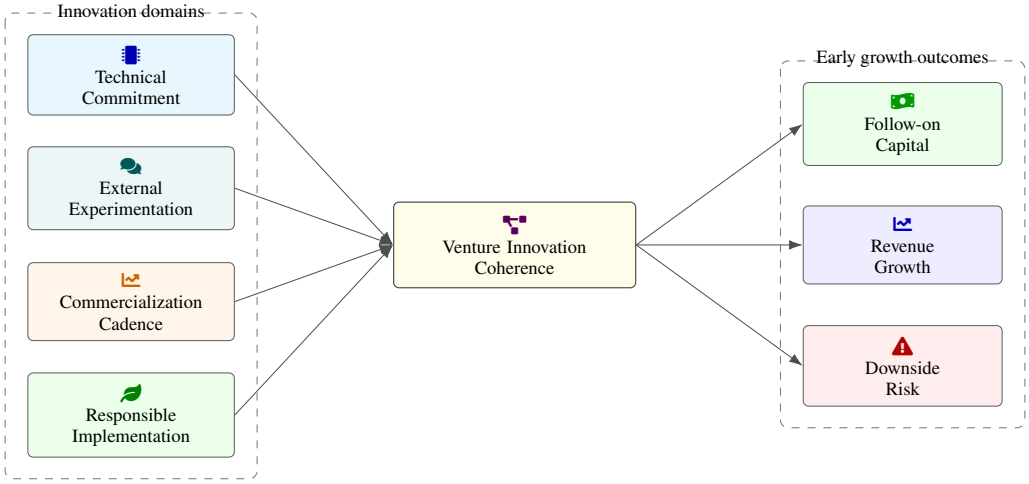


Figure 1: Conceptual architecture of the paper. The figure places venture innovation coherence between four observable innovation domains and three forward-looking outcomes, emphasizing that the paper studies alignment across domains rather than the isolated level of any single domain.

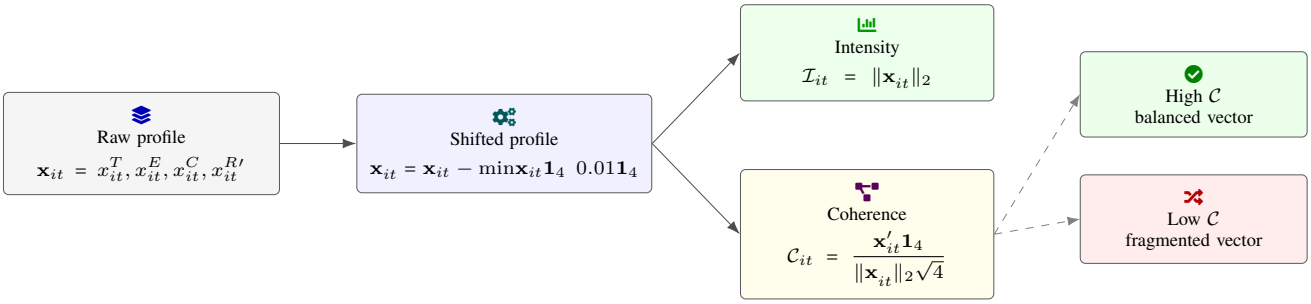


Figure 2: Measurement logic. The diagram separates innovation intensity from innovation coherence by first forming the four-dimensional standardized profile, then applying the positive shift, and finally computing level and alignment as distinct quantities.

differ in how these slices fit together. One venture may invest deeply in engineering but commercialize slowly. Another may conduct rapid market tests yet lack technical depth. A third may launch frequently while changing strategic direction often enough to make its trajectory difficult to interpret. A fourth may publicly emphasize responsible or efficiency-enhancing innovation but allocate little organizational attention to implementing it. In each case the venture is innovative in some sense, yet the overall architecture of innovation may remain fragmented.

This paper examines a simple but underdeveloped proposition: entrepreneurial firms perform better when their innovation activities are coherent. Venture innovation coherence refers here to the degree to which multiple innovation-related domains point in the same strategic direction. The domains are not interchangeable. They represent distinct organizational functions and stakeholder-facing signals: technical commitment, external market experimentation, commercialization cadence, and responsible innovation implementation. The argument is not that every young firm should display equal emphasis on each domain in an absolute sense. Rather, the argument is that a venture is more likely to secure favorable outcomes when these domains evolve in a mutually reinforcing pattern instead of pulling in divergent directions. Coherence should matter because young firms are judged as much by the structure of their signals as by the magnitude of any single signal.

The emphasis on structured signal bundles follows naturally from environments characterized by severe information asymmetry. External audiences do not observe the full internal logic of project selection, the quality of technical problem solving, or the reliability of commercialization routines. They instead observe traces and infer strategic intent. Cao et al. (2023) [3] show in the IPO context that innovation potential can mitigate adverse interpreta-

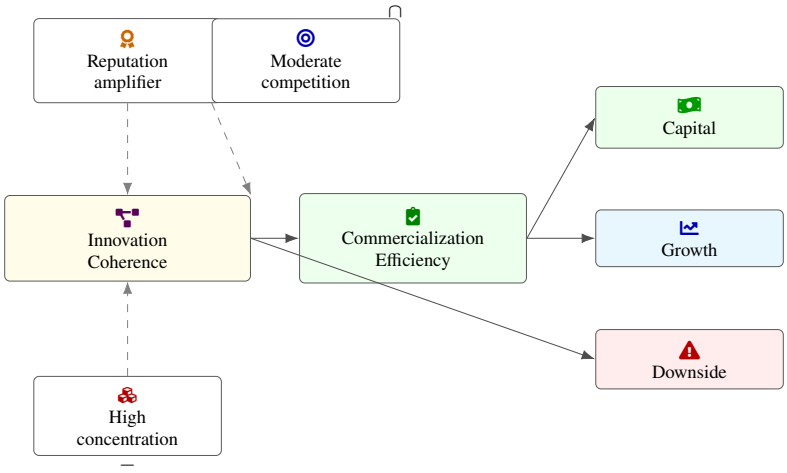


Figure 3: Mechanism and boundary conditions. The direct path from coherence to downside risk and the indirect path through commercialization efficiency sit alongside three contingencies: stronger effects under higher prior reputation, peak returns at moderate competition, and weaker gains under excessive portfolio concentration.

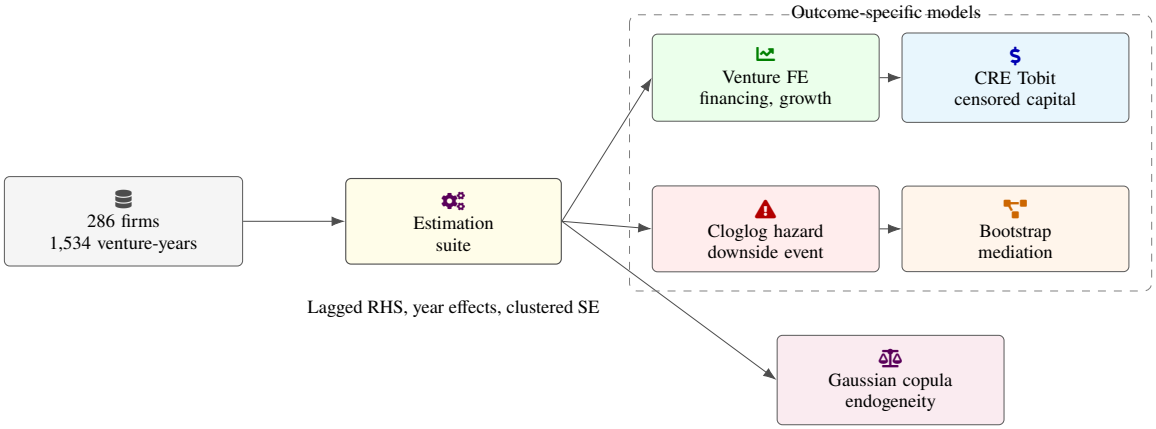


Figure 4: Econometric workflow. The empirical design combines fixed-effects panel estimation, a correlated random-effects Tobit check for censored financing, hazard modeling for downside risk, bootstrap mediation, and a copula-based endogeneity correction.

tions associated with insider selling, implying that market participants process innovation not as decorative language but as a probabilistic cue about the depth of future opportunities. The present paper extends that insight from a valuation event involving mature financing markets to the more persistent and uncertain setting of entrepreneurial growth. The relevant question is not only whether a venture emits favorable innovation cues, but whether the cues fit together tightly enough to alter stakeholder expectations regarding future performance.

That question has particular relevance for entrepreneurial firms because the liabilities of newness and smallness amplify the cost of mixed signals. When a venture's disclosed strategic direction is inconsistent with its technical staffing pattern, its launch tempo, or the nature of its external experimentation, investors may hesitate to supply capital at favorable terms. Commercial partners may treat the venture as tactically active but strategically unstable. Employees may find it difficult to infer which projects are durable priorities. Even when isolated innovation efforts are substantial, inconsistency can raise doubts about conversion efficiency, coordination quality, and the persistence of future cash flows [4]. Conversely, when innovation signals align, outsiders may perceive not only higher upside but lower interpretive noise. This reduces the inferential burden imposed on stakeholders who must commit resources before outcomes fully materialize.

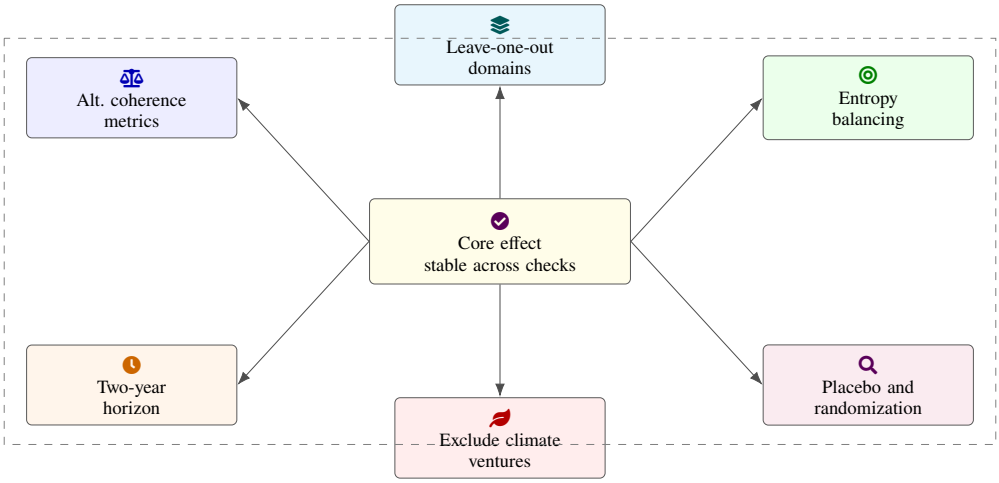


Figure 5: Robustness map. The main associations persist when the coherence construct is redefined, domains are omitted one at a time, high- and low-coherence observations are balanced on observables, climate ventures are excluded, the horizon is extended, and placebo-style checks are applied.

The empirical setting assembled for the study consists of 286 U.S. entrepreneurial firms founded within the prior twelve years and operating in software, digital health, climate technology, advanced manufacturing, frontier materials, mobility, and business services. The panel spans 2016 through 2024 and contains 1,534 venture-year observations after standard data cleaning and winsorization. The ventures are at different stages ranging from late seed to pre-IPO growth rounds, but all remain within the broader category of emerging entrepreneurial firms. The data integrate venture financing records, archived annual disclosures, founder and employee profiles, product release histories, customer pilot announcements, patenting information, and text-derived measures of responsible innovation implementation. This architecture allows the analysis to move beyond isolated innovation inputs and study how the pattern among several innovation-related domains predicts future outcomes [5].

Three outcomes are of particular interest. The first is next-year external financing because entrepreneurial firms rely heavily on periodic resource infusions to sustain search, hiring, and commercialization. The second is revenue growth because innovation ultimately matters only if it helps convert exploratory effort into market traction. The third is downside risk, defined here as a composite event that includes a down round, severe revenue contraction, or shutdown. Considering both upside and downside responses is useful because stakeholders may reward coherent innovation while also using it to screen for lower instability [6]. A venture can be impressive yet fragile; a central task is therefore to determine whether coherence affects expected growth, risk, or both.

The empirical findings indicate that it does. Controlling for venture fixed effects, year effects, innovation intensity, age, size, stage, prior financing, sectoral conditions, and founder characteristics, greater innovation coherence is associated with higher next-year financing and faster revenue growth. The same construct is associated with a lower hazard of a downside event. A venture moving from the twenty-fifth to the seventy-fifth percentile of coherence exhibits materially higher expected funding and measurably lower downside exposure, even when the overall level of innovation activity is held constant. This distinction is important because it indicates that coherence is not merely a disguised proxy for “more innovation.” It captures a patterned form of innovation organization that appears to affect stakeholders’ interpretation of venture quality.

The analysis further shows that the coherence effect operates partly through commercialization efficiency, defined as the venture’s ability to convert innovation activity into paid market adoption. The effect also depends on context. It is stronger when a venture has accumulated a credible stock of prior innovation reputation, weaker when the inventive portfolio becomes excessively concentrated, and nonlinear with respect to competition such that the returns to coherence peak at moderate competitive intensity. These boundary conditions suggest that coherent innovation matters because it simultaneously reduces interpretive ambiguity and improves internal conversion, but the benefits are not uniform across all strategic environments.

The paper is organized as follows. The next section develops the theoretical logic linking innovation coherence to entrepreneurial growth outcomes. The subsequent sections describe the data and variable construction, present the econometric framework, report the core empirical results, and examine additional analyses designed to probe alternative explanations. The final section discusses the implications of the findings for the study of entrepreneurial growth under uncertainty.

2. Theory and Hypotheses

Entrepreneurial ventures are distinctive not because they innovate more than established firms in every instance, but because they innovate under sharper informational and organizational constraints. Resource commitments are more consequential, sequencing mistakes are harder to absorb, and strategic narratives must perform a heavier legitimating role. Under these conditions, the venture's innovation profile is best understood as an interdependent system rather than as a collection of detached actions. Technical search, market experimentation, commercialization, and legitimacy-oriented design choices are linked through shared personnel, shared budgets, and shared expectations. A coherent innovation system exists when these domains evolve in ways that make the venture's overall direction easier to infer and easier to execute. Incoherence arises when domains move asynchronously, producing an innovation posture that is difficult to translate into stakeholder confidence or operational traction.

The first reason coherence should matter concerns the dual character of entrepreneurial innovation. New ventures seek not only intellectual assets such as knowledge, prototypes, and proprietary know-how, but also relational assets such as customer engagement, partner confidence, and visibility among resource providers. Cao et al. (2024a) [7] develop this distinction in the context of crowdsourced innovation initiatives by showing that investor reactions depend on whether a focal action appears capable of generating useful knowledge while also deepening stakeholder engagement. Applied to entrepreneurial firms more broadly, that logic implies that innovation signals should be interpreted jointly rather than separately [8]. A venture with strong technical work but weak external engagement may possess knowledge without market attachment. A venture with active external engagement but weak technical commitment may cultivate attention without substance. Coherence should increase value because it improves the likelihood that intellectual and relational assets accumulate together rather than at cross-purposes.

A second reason coherence should matter concerns inferential clarity. Stakeholders assessing entrepreneurial firms face an unusually noisy information environment. Venture reports are often selective, public data are fragmented, and many performance indicators remain private or hard to verify. In such environments, observers rely on patterns. If the venture's technical investment rises, its external experiments become more substantive, its commercialization cadence accelerates, and its responsible innovation claims appear in implemented form rather than only in rhetoric, stakeholders can infer a structured innovation path. The pattern is informative because it becomes increasingly difficult to explain away as accidental or purely symbolic. When the same strategic direction is visible in multiple domains, stakeholders may rationally assign greater probability to the venture's ability to generate future value.

A third reason coherence should matter concerns internal coordination. Entrepreneurial growth requires more than technological discovery. It requires that engineering, product management, customer development, compliance, operations, and capital acquisition occur in a sequence that preserves momentum without exhausting resources [9]. Coherence helps because aligned innovation domains reduce conflicts over prioritization. Technical teams are more likely to work on projects that external experiments can validate. Market experiments are more likely to produce learning that commercialization teams can use. Responsible innovation routines, when embedded in development rather than appended later, create fewer delays in scaling and partnership formation. Incoherence raises the coordination tax. Teams compete for scarce attention, product roadmaps shift more often, and the venture incurs friction in translating exploratory effort into market outcomes.

These arguments suggest that coherence should affect financing. Capital providers evaluating entrepreneurial firms care about upside potential, but they also care about whether a venture can convert exploratory effort into a credible growth path before the next financing need arises. Aligned innovation signals should make that path easier to project. They should also reduce concerns that the venture is overinvesting in search without developing routes to adoption. As a result, coherent ventures should attract larger or more timely follow-on rounds than ventures with comparable innovation intensity but weaker alignment. The implication is not that investors prefer sameness or balanced portfolios in an aesthetic sense. Rather, investors should reward coherent ventures because coherence de-

creases uncertainty about how current experimentation maps into future commercial milestones.

The same logic extends to revenue growth. Entrepreneurial revenues often increase unevenly because the venture alternates between periods of exploration and periods of commercialization. When innovation activities are coherent, those phases are less likely to be disconnected. Customer pilot programs yield information relevant to engineering priorities. Product launches leverage learning accumulated through prior experimentation. Responsible innovation choices can facilitate procurement, partnership formation, and enterprise adoption in settings where customers value traceability, efficiency, or compliance. Revenue growth should therefore reflect not only the level of innovative activity, but also the degree to which the venture organizes and sequences that activity coherently [10].

The possibility that coherence reduces downside risk also follows from the same framework. Downside events in entrepreneurial settings are frequently preceded by unstable strategic signaling, misaligned experimentation, or repeated difficulty converting technical work into recurring demand. Ventures that innovate intensively but incoherently may consume resources without stabilizing expectations among investors and customers. They may also become vulnerable to negative financing shocks because outsiders struggle to infer which projects are core and which are transitional. Coherence should mitigate such vulnerability by producing a more legible and reproducible innovation path. The predicted effect is not absolute protection from failure, but a lower likelihood that the venture experiences the specific kinds of reversal associated with unclear innovation conversion [11].

A further issue is whether coherence should always be beneficial or whether it can be undermined by the structure of the venture's search space. It is possible for a venture to appear coherent because it is narrowly concentrated in one technological corridor. Such concentration can reduce coordination burden and simplify communication, yet it can also restrict recombination and magnify exposure to leakage or strategic dead ends. Cao et al. (2024b) [12] show in the incubator setting that specialization can reduce startup R&D efficiency by narrowing useful knowledge inflows and intensifying the risks associated with close competitive overlap. The broader implication is that concentration and coherence are analytically distinct. A venture can be coherent without being narrowly concentrated, and a concentrated venture can be strategically brittle. Accordingly, the positive effect of coherence should weaken as the venture's inventive portfolio becomes excessively concentrated across domains or technological categories.

Competitive conditions should also shape the value of coherence. In weakly competitive markets, even a diffuse venture may obtain time to experiment because imitation pressure and commercial urgency are limited [13]. In highly competitive markets, however, overly diffuse innovation becomes expensive because ventures must convert learning quickly while protecting their position against rivals. Yet competitive intensity may also eventually erode the private returns to coherent innovation if rivalry becomes so strong that imitation, price pressure, or customer switching reduce appropriation. Cao et al. (2025) [14] argue in the environmental innovation setting that the returns to innovation depend jointly on market-level competition and firm-level capabilities rather than increasing uniformly. Translated to entrepreneurial growth, that reasoning implies an inverted-U moderation: innovation coherence should matter most under moderate competition, where external pressure is strong enough to discipline execution but not so extreme that the venture cannot appropriate the gains from coherent experimentation.

Finally, prior innovation reputation should influence how coherence is interpreted. Reputation can be understood as a stock of accumulated belief regarding the venture's innovative credibility. Ventures with established records of meaningful prototypes, credible technical partnerships, patent quality, or prior successful launches may benefit more from current coherence because stakeholders interpret aligned signals as evidence of a durable capability rather than a temporary managerial campaign [15]. By contrast, ventures without such history may need repeated periods of coherent behavior before observers revise their priors. The expected implication is that prior innovation reputation amplifies the positive association between coherence and entrepreneurial outcomes.

Taken together, the theoretical logic yields a compact set of predictions. Venture innovation coherence should be positively associated with follow-on financing and revenue growth and negatively associated with downside risk. Part of the effect should operate through commercialization efficiency, because coherent systems convert exploratory activity into marketable outcomes more reliably [16]. The positive effect should strengthen with prior innovation reputation, peak at moderate competition, and weaken as the venture's inventive portfolio becomes too concentrated. These predictions guide the empirical design developed below.

3. Data and Measures

The empirical sample was constructed to capture entrepreneurial firms for which innovation is salient but whose histories remain short enough that external audiences still face meaningful uncertainty. The sampling frame began with U.S.-based firms founded in 2012 or later that had raised at least one institutional or organized angel round by the end of 2024 and operated in one of seven broad sectors: software, digital health, climate technology, advanced manufacturing, mobility, frontier materials, and business services. Financial intermediaries, real-estate vehicles, and firms whose business models depended primarily on passive asset ownership were excluded because their innovation processes differ materially from those of technology- and product-oriented ventures. Firms were also excluded if no year-level information could be assembled on product releases, customer pilots, or team composition, because the analysis requires observing multiple dimensions of innovation rather than only financing events.

After merging venture financing records with archived company materials, professional profiles, patent data, product announcements, and revenue estimates from audited disclosures or investor materials, the resulting unbalanced panel contained 1,534 venture-year observations from 286 firms over the period 2016–2024. The median venture appears in the sample for five years. Mean venture age is 6.8 years, median employee count is 79, and the median venture has completed three external financing rounds by the end of the observation window. Approximately 27% of the firm-years fall in software, 18% in digital health, 16% in climate technology, 14% in advanced manufacturing, 11% in mobility, 8% in frontier materials, and 6% in business services. These sector shares reflect the need to observe ventures for which innovation signals are visible in both technical and market-facing channels [17].

The dependent variable for the financing analysis is $\mathit{FollowOnCapital}_{i,t1}$, measured as the inverse hyperbolic sine of total new external capital raised by venture i during year t 1. This transformation retains zero observations while approximating a logarithmic interpretation at higher values. A parallel binary outcome, $\mathit{AnyRound}_{i,t1}$, equals one if the venture closes any new external financing round in the next year. Revenue performance is captured by $\mathit{RevenueGrowth}_{i,t1}$, computed as the log difference in annual revenue from year t to year t 1. Because revenue estimates for private firms can contain noise, all growth rates were winsorized at the 1% and 99% tails, and alternative classifications based on top-quartile growth are examined later as a robustness test. Downside exposure is measured by $\mathit{DownsideEvent}_{i,t1}$, a binary indicator equal to one if the venture experiences at least one of the following in year t 1: a down round, a year-over-year revenue contraction exceeding 30%, a workforce reduction exceeding 25%, or cessation of operations.

The central explanatory construct is venture innovation coherence [18]. Four dimensions were chosen to represent the core observable elements of entrepreneurial innovation. The first is *Technical Commitment*, measured as the standardized average of R&D intensity, engineering payroll share, and the proportion of employees in technical roles. The second is *External Experimentation*, measured through counts of paid pilots, beta programs, co-development trials, structured customer tests, and community-based product feedback initiatives. The third is *Commercialization Cadence*, measured as the standardized combination of major product launches, version releases with documented paying users, and the ratio of prototype-stage projects converted into revenue-generating offers within twelve months. The fourth is *Responsible Innovation Implementation*, measured through text analysis of venture communications and product materials identifying implemented design or process changes related to energy efficiency, waste reduction, traceability, safety transparency, lifecycle durability, or measurable operating-efficiency gains. The purpose of this fourth domain is not to recast entrepreneurship as an ESG-only setting [19]. It is included because responsible innovation has become a visible legitimacy channel in many venture sectors, especially where enterprise customers, regulators, and strategic investors evaluate technology alongside implementation standards.

To make the dimensions comparable across industries and years, each component was standardized within industry-year cells. Let $\mathbf{x}_{it}$ denote the vector of the four standardized dimension scores for venture i in year t. The empirical design distinguishes overall innovation intensity from coherence. Intensity captures how strongly the venture activates the four domains in aggregate, whereas coherence captures how aligned those domains are relative to a balanced directional profile [20]. The measurement system is defined as

$$\begin{aligned} \mathbf{x}_{it} &= \left[x_{it}^{T}, x_{it}^{E}, x_{it}^{C}, x_{it}^{R}\right]' \\ \mathbf{x}_{it} &= \mathbf{x}_{it} - \min \mathbf{x}_{it} \mathbf{1}_4 \;\; 0.01 \mathbf{1}_4 \\ \mathcal{I}_{it} &= \left\|\mathbf{x}_{it}\right\|_2 \quad \text{and} \quad \mathcal{C}_{it} = \frac{\mathbf{x}_{it}' \mathbf{1}_4}{\left\|\mathbf{x}_{it}\right\|_2 \sqrt{4}} \end{aligned} \tag{3.1}$$

where $\mathcal{I}_{it}$ is innovation intensity and $\mathcal{C}_{it}$ is innovation coherence. The positive shift by the minimum component plus a small constant prevents sign cancellation while preserving relative dispersion. The coherence term is therefore the cosine similarity between the venture's multidimensional innovation profile and a balanced reference vector. Values near one indicate that the four domains are strongly aligned; lower values indicate that the venture is overdeveloped in some domains and underdeveloped in others. This measure has two advantages in the present context. First, it separates the level of innovative activity from the pattern of alignment. Second, it respects the vector nature of innovation rather than collapsing all activity into one additive count.

Because ventures can be intense yet incoherent, the analysis includes both $\mathcal{I}_{it}$ and $\mathcal{C}_{it}$. This distinction is visible in the sample. The correlation between intensity and coherence is positive but moderate at 0.34, suggesting that more active ventures are somewhat more aligned on average, yet the constructs are far from identical. A venture can have a strong technical commitment and substantial experimentation while still lacking commercialization cadence or implemented responsible innovation, producing high intensity but middling coherence. Conversely, a smaller venture can display moderate but well-aligned activity, producing lower intensity yet relatively high coherence.

Commercialization efficiency, the proposed mediator, is measured as the fraction of innovation initiatives announced in year t that generate paying users, signed pilots, or contracted deployments by the end of year $t\,1$. This measure is conservative. Purely rhetorical announcements or informal interest signals do not qualify. The coding requires documentary evidence of conversion into economic engagement [21]. The mediator is designed to capture whether coherent innovation systems improve the rate at which exploratory effort becomes marketable output.

Several moderators and controls are included. *Innovation Reputation*$_{it}$ is a rolling three-year index composed of citation-weighted patent stock, recognized innovation awards, high-profile strategic development partnerships, and whether the venture had been featured in prominent industry rankings for technical leadership. *Competition*$_{it}$ is measured as the normalized density of closely comparable ventures in the same product market segment, adjusted for funding-weighted rival presence and the rate of comparable launches. A squared term is included to test for nonlinear moderation [22]. *Portfolio Concentration*$_{it}$ is a Herfindahl index computed across the venture's technological categories based on patent classifications, product modules, and project tags extracted from internal roadmaps or public descriptions. High values indicate that the venture's inventive efforts are concentrated in a narrow corridor [23].

The control set addresses both venture characteristics and environmental conditions. Venture-level controls include age, size, prior financing stock, prior revenue level, founder industry experience, founder serial entrepreneurship, founder technical depth, employee growth, cash burn intensity, gross margin, stage dummies, and whether the venture operates in a regulated market. Founder technical depth is measured as the fraction of founders with graduate STEM training or prior technical leadership roles [24]. Market-level controls include industry-year demand growth, investor sentiment in the venture's sector, regional venture capital supply, and a measure of technological munificence based on aggregate sector patenting [25]. Year fixed effects absorb macro shocks common to all ventures, including the pandemic period and the funding contraction observed in the later years of the sample [26].

The descriptive statistics indicate moderate variation across the central constructs. Mean coherence equals 0.741 with a standard deviation of 0.116. Mean innovation intensity is 2.31 with a standard deviation of 0.82. The average venture raises a new round in 38% of firm-years, and the average annual revenue growth rate is 21%, though the distribution is highly skewed. Downside events occur in 14% of firm-years. Pairwise correlations show that coherence is positively associated with follow-on capital and revenue growth and negatively associated with downside events. Variance inflation factors remain below 3.9 in the fullest specifications, indicating that multicollinearity is unlikely to drive the main estimates [27].

Considerable effort was devoted to coding reliability because some variables rely on textual or event-based information. Product launches, customer pilots, and responsible innovation implementation were independently coded by two trained research assistants following a detailed protocol. Inter-coder agreement exceeded 0.87 on all binary event classifications, and disagreements were resolved through review of the underlying source material. Text-derived measures were constructed with dictionary-augmented supervised classification and then manually validated on a random 12% holdout sample. These procedures do not eliminate measurement error, but they reduce the likelihood that the central coherence construct is merely a noisy reflection of publicity rather than a structured representation of venture innovation activity.

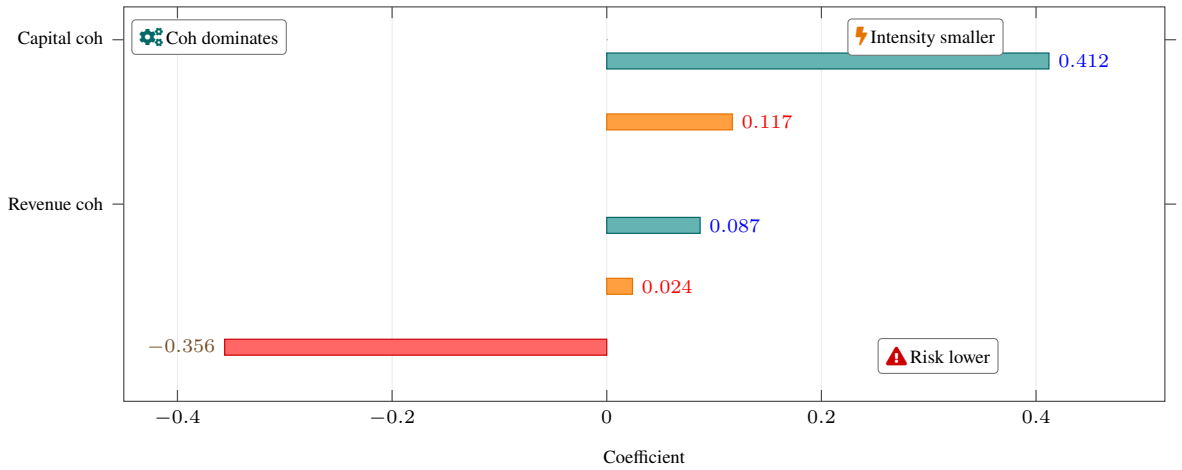


Figure 6: Baseline coefficient map for the venture results. Coherence is larger than innovation intensity in the financing equation (0.412 versus 0.117) and in the revenue-growth equation (0.087 versus 0.024), while the downside-hazard coefficient is negative at -0.356. The figure compresses the main result into a single coefficient view: aligned innovation is more strongly associated with next-year upside and with lower downside exposure than innovation level alone.

Table 1: Sample Composition by Sector

Sector	Share (%)	Firms	Obs.
Software	27	77	414
Digital Health	18	51	276
Climate Tech	16	46	245
Advanced Mfg.	14	40	215
Mobility	11	31	168
Frontier Materials	8	23	123

4. Empirical Strategy

The baseline empirical framework estimates whether coherence in year t predicts entrepreneurial outcomes in year t 1. This temporal ordering is essential because financing and growth outcomes can also influence innovation behavior. The first model uses venture fixed effects to absorb time-invariant heterogeneity such as founding quality, persistent sector niche, or unobserved organizational culture. Year fixed effects capture macroeconomic shifts, while industry-specific linear time trends are added in robustness checks. The principal continuous-outcome specification is

$$Y_{i,t1} = \alpha_i \ \tau_t \ \beta_1 \mathcal{C}_{it} \ \beta_2 \mathcal{I}_{it} \ \beta_3 R_{it} \ \beta_4 Q_{it} \ \boldsymbol{\gamma}' \mathbf{Z}_{it} \ \varepsilon_{it} \tag{4.1}$$

where $Y_{i,t1}$ denotes either $\mathit{FollowOnCapital}_{i,t1}$ or $\mathit{RevenueGrowth}_{i,t1}$, $\mathcal{C}_{it}$ is innovation coherence, $\mathcal{I}_{it}$ is innovation intensity, R_{it} is innovation reputation, Q_{it} is portfolio concentration, and $\mathbf{Z}_{it}$ is the vector of controls. Standard errors are clustered at the venture level to account for serial dependence.

Because financing has a large mass at zero, the linear fixed-effects model is supplemented by a correlated random-effects Tobit specification and a conditional logit model for the binary *AnyRound* outcome. The correlated random-effects formulation includes venture-level means of the time-varying regressors, allowing the random intercept to correlate with the covariates in the spirit of a Mundlak adjustment. This provides a useful check on whether censoring materially alters the financing results. For downside exposure, the analysis uses a complementary log-log hazard model because the event can occur once and the yearly panel is discrete. The hazard is specified as

$$\log\big[-\log\big(1 - h_{i,t1}\big)\big] \ = \delta_t \ \theta_1 \mathcal{C}_{it} \ \theta_2 \mathcal{I}_{it} \ \theta_3 R_{it} \ \theta_4 Q_{it} \ \boldsymbol{\lambda}' \mathbf{Z}_{it} \tag{4.2}$$

where $h_{i,t1}$ is the probability of a downside event in the next period conditional on survival through year t.

Table 2: Key Variables and Definitions

Variable	Type	Horizon	Description
FollowOnCapital	Dep.	$t1$	New external funding
RevenueGrowth	Dep.	$t1$	Log revenue change
DownsideEvent	Dep.	$t1$	Negative outcome indicator
Coherence ($\mathcal{C}$)	Main	t	Alignment across domains
Intensity ($\mathcal{I}$)	Control	t	Aggregate innovation level

Table 3: Innovation Dimensions

Dimension	Proxy	Source	Role
Technical Commitment	R&D, engineers	Profiles	Input depth
External Experimentation	Pilots, tests	Announcements	Market learning
Commercialization	Releases	Product logs	Conversion
Responsible Innovation	Implementation text	Documents	Legitimacy

Testing the contextual arguments requires interaction terms. Competition enters both linearly and quadratically, and both are interacted with coherence. Innovation reputation and portfolio concentration are each interacted with coherence as well. The interaction-rich specification is written as [28]

$$\begin{aligned} Y_{i,t1} = \alpha_i \;\; \tau_t \;\; \beta_1 \mathcal{C}_{it} \;\; \beta_2 \mathcal{I}_{it} \;\; \beta_3 Comp_{it} \;\; \beta_4 Comp_{it}^2 \\ \beta_5 Rep_{it} \;\; \beta_6 Conc_{it} \;\; \beta_7 \mathcal{C}_{it} \times Comp_{it} \\ \beta_8 \mathcal{C}_{it} \times Comp_{it}^2 \;\; \beta_9 \mathcal{C}_{it} \times Rep_{it} \;\; \beta_{10} \mathcal{C}_{it} \times Conc_{it} \\ \boldsymbol{\gamma}' \mathbf{Z}_{it} \;\; \varepsilon_{it} \end{aligned} \tag{4.3}$$

The competition effect is interpreted through marginal effects because the linear and quadratic interaction coefficients jointly determine the shape of the moderation.

Mediation through commercialization efficiency is examined with a sequential fixed-effects system. The first equation models the mediator as a function of coherence and controls. The second models the outcomes as functions of coherence, the mediator, and the same control set. The indirect effect is estimated through nonparametric bootstrap with 2,000 venture-level resamples. The mediation system is

$$\begin{aligned} M_{i,t1} &= \phi_i \;\; \omega_t \;\; a_1 \mathcal{C}_{it} \;\; a_2 \mathcal{I}_{it} \;\; \boldsymbol{\rho}' \mathbf{Z}_{it} \;\; u_{it} \\ Y_{i,t1} &= \eta_i \;\; \kappa_t \;\; c' \mathcal{C}_{it} \;\; b M_{i,t1} \;\; d \mathcal{I}_{it} \;\; \boldsymbol{\psi}' \mathbf{Z}_{it} \;\; v_{it} \end{aligned} \tag{4.4}$$

where ab is the indirect effect and c' is the direct effect of coherence after accounting for the mediator.

Endogeneity remains a serious concern. Ventures anticipating strong future financing may invest deliberately in more coherent signaling, and unobserved shocks to product-market fit could influence both coherence and subsequent outcomes. Several design choices aim to reduce these threats. First, all focal predictors are lagged. Second, venture fixed effects absorb stable latent quality differences. Third, the models control for prior revenue, prior financing stock, and stage. Fourth, a control-function correction based on a Gaussian copula is implemented for coherence because the measure is non-normally distributed and plausibly endogenous. The control function is constructed from the centered empirical distribution of coherence and entered as an additional regressor in the main equations. Fifth, a placebo analysis tests whether future coherence predicts past outcomes; a null finding would be consistent with the proposed temporal direction rather than reverse causality.

The Gaussian copula correction is particularly useful because a clean external instrument for coherence is difficult to justify. An instrument would need to shift the alignment of innovation domains without independently affecting future financing or growth, which is demanding in entrepreneurial settings. The copula approach is not a perfect substitute for exogenous variation, but it allows the analysis to model endogeneity flexibly when the endogenous regressor exhibits non-normality. In the present data, the coherence distribution is left-skewed and clearly non-normal, satisfying the basic condition for the approach to be informative.

The modeling strategy also recognizes that financing and growth may respond differently across venture stages. Seed and early Series A investors may rely more heavily on coherence because hard performance data are limited, whereas later-stage investors may place greater weight on realized revenue. To probe this possibility, heterogeneity analyses split the sample into early-stage and expansion-

Table 4: Descriptive Statistics

Variable	Mean	SD	Range
Coherence	0.741	0.116	0.41–0.96
Intensity	2.31	0.82	0.55–4.12
Revenue Growth	0.21	0.34	-0.60–1.20
Any Round	0.38	0.49	0–1
Downside Event	0.14	0.35	0–1

Table 5: Baseline Financing Results

Variable	Coef.	SE	Signif.
Coherence	0.412	0.103	***
Intensity	0.117	0.046	**
Reputation	0.089	0.031	**
Concentration	-0.064	0.028	*
Controls	Yes		

stage venture-years using the most recent financing round classification. These split-sample exercises are not used to establish the main result, but they help interpret whether coherence matters uniformly or primarily in the periods when inferential uncertainty is highest.

All continuous variables are mean-centered before interaction construction, and all monetary quantities are expressed in constant 2024 dollars [29]. Missing values in controls are limited and are handled using multiple imputation only for non-outcome variables with less than 5% missingness; complete-case analyses yield nearly identical estimates. Together, these design choices do not establish strict causality, but they provide a disciplined basis for assessing whether innovation coherence predicts entrepreneurial outcomes beyond the usual intensity-based representations of venture innovation [30].

5. Results

The descriptive patterns already suggest that coherence contains information distinct from innovation intensity. Ventures in the top quartile of coherence do not simply spend more. Relative to ventures in the bottom quartile, they exhibit more even profiles across technical commitment, external experimentation, commercialization cadence, and responsible innovation implementation. The high-coherence group raises more capital on average, grows faster, and experiences fewer downside events, but it is not the group with the highest intensity in every dimension. Some low-coherence ventures are technically intense but commercially delayed. Others commercialize rapidly but underinvest in technical depth or produce little evidence that responsible innovation choices are being implemented rather than merely advertised. These contrasts support the underlying premise that imbalance among innovation domains is substantively meaningful.

The baseline fixed-effects estimates show a positive relationship between coherence and next-year financing. In the simplest specification including coherence, intensity, venture fixed effects, and year fixed effects, the coefficient on coherence is 0.463 with a clustered standard error of 0.119. After adding the full set of controls, the coefficient attenuates to 0.412 with a standard error of 0.103 and remains significant at conventional levels. Innovation intensity is also positive, but its coefficient is smaller at 0.117 with a standard error of 0.046. The substantive interpretation is that a one-standard-deviation increase in coherence is associated with approximately 11.8% higher expected follow-on capital in the next year, holding constant the overall level of innovative activity and the venture's prior resource base. The correlated random-effects Tobit estimates produce a very similar marginal effect, and the binary *AnyRound* model indicates that the same change in coherence corresponds to a 4.7 percentage-point higher probability of closing any round in the following year.

These magnitudes are economically meaningful in the entrepreneurial context because financing thresholds are often discontinuous. Ventures do not merely benefit from marginally cheaper capital. They may cross the threshold required to retain key employees, enter enterprise procurement cycles, or complete regulatory milestones. The estimated coherence effect is especially pronounced among early-stage ventures. In the seed-through-Series A subsample, the standardized effect on follow-on capital is about 18% larger than in later stages. This pattern is consistent with the theoretical expectation that coherence matters most when hard performance histories

Table 6: Revenue Growth Results

Variable	Coef.	SE	Signif.
Coherence	0.087	0.028	***
Intensity	0.024	0.013	*
Reputation	0.041	0.019	**
Concentration	-0.032	0.014	**
Controls	Yes		

Table 7: Downside Risk Hazard Model

Variable	Coef.	SE	Signif.
Coherence	-0.356	0.145	**
Intensity	-0.071	0.052	
Reputation	-0.118	0.061	*
Concentration	0.092	0.043	**
Controls	Yes		

are short and stakeholders rely heavily on structured signal bundles to assess quality [31].

Revenue growth results tell a related story. In the fully controlled fixed-effects model, coherence predicts next-year revenue growth with a coefficient of 0.087 and a standard error of 0.028. Innovation intensity remains positive but smaller at 0.024 and is only marginally significant. Translating the estimate into levels, a one-standard-deviation increase in coherence is associated with 3.6 percentage points higher annual revenue growth. The top-quartile growth specification yields a marginal effect of 3.9 percentage points. The association is strongest in digital health, advanced manufacturing, and climate technology, sectors in which converting technical work into customer adoption usually requires more cross-functional coordination than in purely digital products. In software, the effect remains positive but somewhat smaller, perhaps because commercialization frictions are lower and experimentation cycles are faster.

The downside-risk models indicate that coherence is not merely an upside predictor. In the complementary log-log hazard estimates, the coefficient on coherence is -0.356 with a standard error of 0.145 in the fully controlled model. At the sample mean hazard, this implies that a one-standard-deviation increase in coherence lowers the predicted probability of a downside event by roughly 2.9 percentage points. This is not a trivial effect given the 14% base rate. The result survives when the downside event is redefined more narrowly as only down rounds and shutdowns. Ventures with coherent innovation systems appear less likely to experience the kinds of reversal that indicate stakeholder confidence has deteriorated or internal conversion has stalled.

One alternative explanation is that coherence is simply capturing a favorable publicity cycle. Ventures receiving attention might produce more announcements in multiple domains, which could inflate the apparent alignment of signals without reflecting genuine organizational structure. Several results cut against this interpretation. First, the models include direct controls for announcement volume and sector-level investor sentiment. Second, coherence remains predictive even when the analysis excludes ventures in the top decile of media visibility. Third, commercialization efficiency and downside risk are less easily explained by publicity alone. If coherence merely reflected attention, its association with later paid conversion and reduced hazard would be harder to rationalize [32].

The mediation results provide evidence on the mechanism. In the first-stage mediator model, coherence predicts commercialization efficiency with a coefficient of 0.231 and a standard error of 0.054. In the second-stage financing equation, commercialization efficiency enters positively with a coefficient of 0.271 and a standard error of 0.082, while the direct effect of coherence remains positive but falls from 0.412 to 0.349. The implied indirect effect is 0.063, with a bootstrap 95% confidence interval of [0.021, 0.116]. This suggests that approximately 15% of the total financing association operates through improved conversion of innovation initiatives into paying engagements. For revenue growth, the mediation is somewhat stronger. The indirect effect equals 0.019 with a confidence interval of [0.007, 0.036], accounting for roughly 22% of the total coherence association. The mechanism results are therefore consistent with the idea that coherence improves entrepreneurial outcomes not only because it makes the venture easier to interpret, but also because

Table 8: Mediation via Commercialization Efficiency

Path	Coef.	SE	Effect
Coherence → Efficiency	0.231	0.054	***
Efficiency → Financing	0.271	0.082	**
Indirect Effect	0.063		
Direct Effect	0.349	0.097	***

Table 9: Moderation Effects

Interaction	Coef.	SE	Signif.
Coherence × Reputation	0.203	0.086	**
Coherence × Concentration	-0.154	0.061	**
Coherence × Competition	0.268	0.117	**
Coherence × Competition^2	-0.191	0.082	**

it helps the venture translate experimental activity into marketable output.

The moderation by innovation reputation is positive and statistically meaningful. In the full financing model, the interaction between coherence and prior innovation reputation is 0.203 with a standard error of 0.086. The marginal effect of coherence on follow-on capital is about twice as large for ventures at the seventy-fifth percentile of reputation as for those at the twenty-fifth percentile. The interpretation is not that unreputed ventures receive no benefit from coherence; they do [33]. Rather, stakeholders appear more willing to extrapolate from coherent current behavior when it is attached to an existing stock of credible innovation achievements. Reputation functions as an interpretive amplifier [34]. It increases the likelihood that aligned innovation signals are read as evidence of enduring capability rather than short-run orchestration.

Portfolio concentration weakens the coherence effect, as predicted. The interaction coefficient between coherence and concentration is -0.154 with a standard error of 0.061 in the financing model and -0.032 with a standard error of 0.014 in the revenue-growth model [35]. Ventures that appear coherent because they are narrowly concentrated in one technological corridor do not capture the same gains as ventures whose coherence is achieved through disciplined alignment across a broader search space. This distinction matters empirically. Among ventures in the top quartile of concentration, the funding benefit of coherence is materially smaller, and the predicted reduction in downside risk is close to zero at the extreme upper tail of concentration. The pattern supports the argument that coherence and narrowness should not be conflated. A venture can be strategically aligned without becoming overdependent on a single inventive path.

The competition moderation is nonlinear in the expected direction. In the financing model, the linear interaction between coherence and competition is positive at 0.268 with a standard error of 0.117, while the quadratic interaction is negative at -0.191 with a standard error of 0.082. Marginal-effect calculations show that the financing benefit of coherence rises from the low-competition tail to roughly the sixtieth percentile of competition and then declines. At very low competition, coherent innovation is helpful but not strongly differentiating. At moderate competition, coherent ventures gain the most because the environment rewards disciplined conversion without making appropriation impossible. At very high competition, the benefit narrows, likely because rivals imitate quickly, price pressure intensifies, or customers disperse attention across many comparable offers. The same inverted-U pattern appears in revenue growth, though the quadratic term is somewhat smaller in magnitude.

A useful interpretive question is whether coherence dominates intensity or complements it. The estimates indicate complementarity rather than substitution. Innovation intensity remains positively associated with financing in most models, though its effect is smaller and less stable than coherence. When both are high, predicted outcomes are strongest. A venture with low intensity but high coherence performs better than a venture with similar low intensity and low coherence, but it does not outperform the most intense and coherent ventures [36]. Coherence therefore appears to raise the productivity of innovation effort rather than replace the need for innovation effort itself. This is theoretically plausible. Alignment improves the translation of activity into value, but it does not eliminate the underlying need for technical and commercial work.

Further heterogeneity analysis explores whether founder technical depth conditions the concentration result. The

Table 10: Robustness Checks

Test	Result	Direction	Stable
Alt. Coherence Measure	Similar	+	Yes
Leave-one-out	Slight drop	+	Yes
Entropy Balancing	Consistent	+	Yes
Exclude Climate	Minor drop	+	Yes
Two-year Horizon	Attenuated	+	Yes

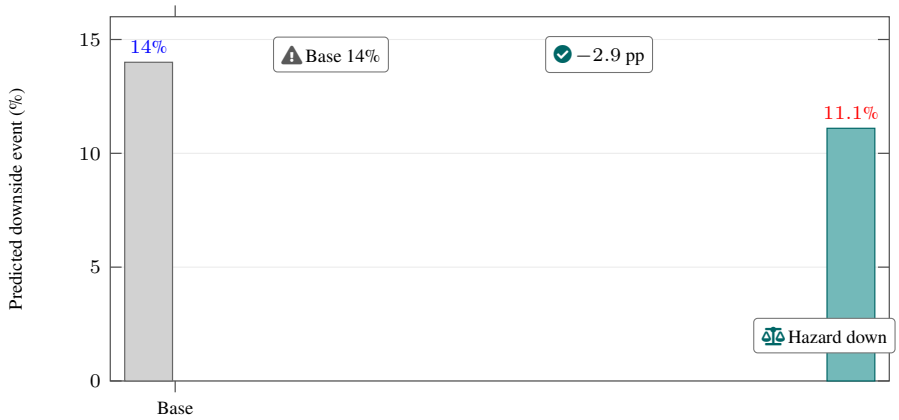


Figure 7: Downside-risk effect translated into probability terms. Starting from the reported 14% base rate, a one-standard-deviation increase in innovation coherence corresponds to an approximate 2.9 percentage-point decline in predicted downside-event probability, yielding about 11.1%. This makes the negative hazard estimate more interpretable by showing that the result is not merely statistical sign reversal but a visible reduction in downside exposure.

penalty associated with high concentration is weaker when a larger share of founders possess advanced technical training or prior technical leadership experience. In a supplemental specification, the three-way interaction among coherence, concentration, and founder technical depth is positive and modestly significant in the financing equation [37]. This suggests that deep technical human capital can buffer some of the brittleness associated with concentrated inventive search, likely because technically sophisticated founders manage narrower search paths more deliberately. Still, the buffering effect is incomplete. Even technically strong teams experience diminishing returns when coherence is achieved primarily through excessive concentration [38].

The control variables behave largely as expected. Prior revenue and prior financing stock predict future financing positively. Cash burn intensity is positive in early-stage financing models but negative in later-stage ones, reflecting different interpretations of aggressive spending across stages. Founder serial entrepreneurship is positively associated with financing but less so with revenue growth once venture fixed effects and stage are included. Ventures in regulated markets exhibit lower baseline revenue growth but not lower financing once milestones and technical depth are controlled [39]. These patterns do not drive the coherence results, but they increase confidence that the models are capturing reasonable entrepreneurial dynamics.

The control-function estimates indicate that endogeneity is present but does not overturn the main conclusions. The Gaussian copula term enters significantly in the financing and revenue-growth equations, suggesting that unobserved factors do indeed affect both coherence and outcomes. Yet after including the correction, the coherence coefficient remains positive and statistically significant, shrinking only moderately [40]. In the financing model, for example, the coefficient moves from 0.412 to 0.366 [41]. The persistence of the effect after the correction is consistent with the view that coherence is not merely a byproduct of favorable unobserved shocks.

The placebo analysis offers another check [42]. Future coherence, measured in year t 1, does not predict financing already raised in year t, nor does it predict prior-year revenue growth once current coherence and controls are included. This lack of reverse temporal association does not prove causality, but it weakens the claim that the results are entirely driven by omitted factors that operate symmetrically through time. Likewise, when the

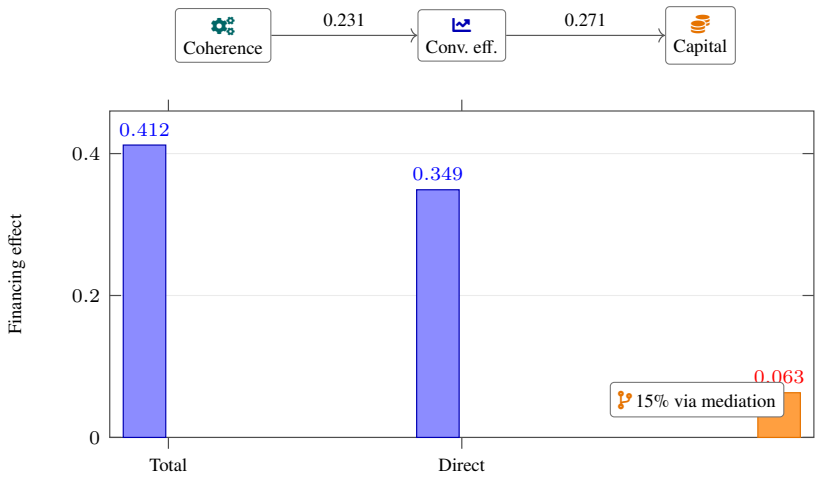


Figure 8: Mediation through commercialization efficiency in the financing model. The lower bars decompose the total coherence effect on follow-on capital (0.412) into a direct component (0.349) and an indirect component (0.063). The upper path sketch adds the reported first-stage and second-stage coefficients: coherence increases commercialization efficiency (0.231), and commercialization efficiency raises follow-on capital (0.271). Together they indicate that roughly 15% of the financing association flows through improved conversion into paying engagement.

venture-level innovation dimensions are randomly reassigned within industry-year cells and a pseudo-coherence measure is recalculated, the resulting placebo variable is unrelated to the outcomes. The substantive predictive content therefore appears to reside in the actual alignment of a venture's own innovation domains rather than in mechanical properties of the formula.

A final descriptive interpretation is helpful. Ventures at the high end of coherence are not necessarily the most visible or the most specialized. They tend to show steadier technical staffing, a clearer link between pilot activity and product releases, and more concrete implementation of efficiency or accountability-oriented design choices. Low-coherence ventures often oscillate across narratives. They may emphasize sophisticated technical architecture while releasing products slowly, or they may engage customers actively without making commensurate technical commitments. Such ventures may still survive and sometimes grow, but the empirical results suggest that they do so under less favorable expectations and greater downside exposure.

6. Robustness and Interpretation

A first robustness exercise replaces the cosine-based coherence measure with two alternatives. The first is an inverse dispersion index computed as the negative standard deviation of the four standardized innovation dimensions plus the mean innovation level. The second is a principal-component alignment measure based on the proportion of variance in the four-dimensional innovation vector explained by the first principal component [43]. Both alternatives retain the core idea that aligned multidimensional innovation should matter independently of raw intensity. Across these alternatives, the main results remain intact. Coherence continues to predict follow-on financing and revenue growth positively and downside risk negatively. The cosine-based metric yields the strongest and most stable estimates, likely because it more directly captures directional alignment relative to a balanced reference profile rather than only dispersion [44].

A second robustness check addresses the possibility that one specific innovation domain is doing all the work. To examine this, each domain is omitted in turn from the coherence calculation [45]. The financing and growth effects remain positive in every leave-one-out specification, but the estimates weaken most when commercialization cadence or external experimentation is omitted. This suggests that the coherence mechanism is especially dependent on market-facing translation rather than solely on internal technical commitment. Omitting the responsible innovation implementation dimension reduces the magnitude but does not eliminate the effect. Thus the results are not driven only by ventures operating in environmentally sensitive sectors, though the responsible innovation domain contributes incremental explanatory power.

A third test uses stage-matched entropy balancing so that high- and low-coherence venture-years are compared among observations with similar age, size, prior financ-

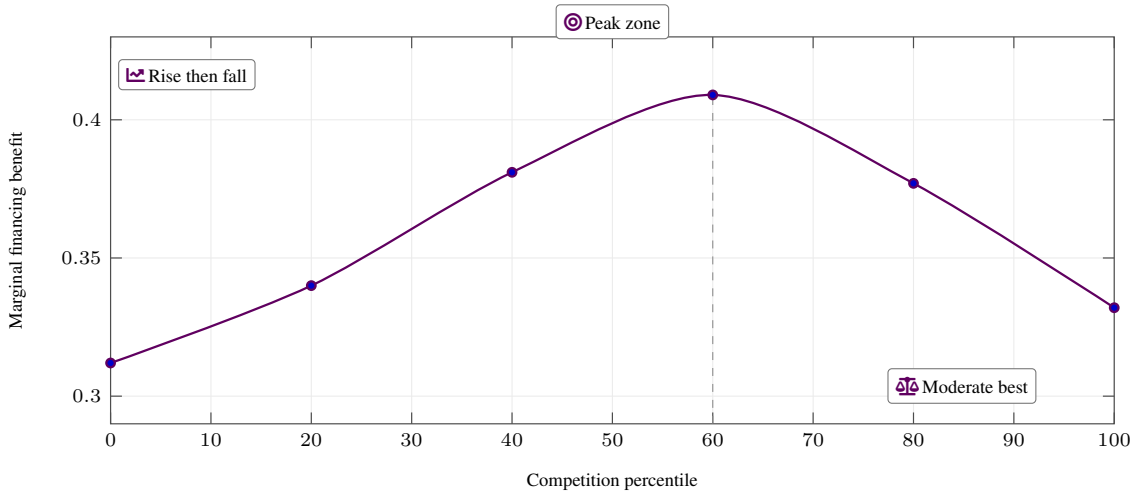


Figure 9: The curve is drawn to match the reported inverted-U pattern in which the financing benefit of coherence rises from the low-competition tail, peaks around the middle-to-upper-middle portion of the observed competition distribution, and then declines as rivalry becomes very intense. This visual corresponds to the positive linear interaction and negative quadratic interaction reported for competition, and it conveys the central result that coherence pays off most when pressure is strong enough to discipline execution but not so strong that appropriation collapses.

ing, sector, and prior revenue. After balancing, the mean differences in all matching covariates fall below 0.03 standard deviations [46]. The treatment-effect estimates remain positive and close to the main model magnitudes. High-coherence venture-years exhibit 9.6% more next-year financing on average and a 3.1 percentage-point lower downside-event rate relative to balanced low-coherence venture-years. Matching does not resolve all endogeneity concerns, but it reduces reliance on functional-form assumptions and shows that the main association is not obviously driven by extreme covariate imbalance.

A fourth analysis excludes climate-technology ventures, which are the sector most likely to exhibit high scores on responsible innovation implementation. This is useful because one might worry that coherence is simply rewarding sectoral fashion rather than general entrepreneurial discipline. Excluding climate ventures lowers the mean responsible innovation score substantially, yet the coherence coefficients on financing and revenue growth remain significant. Their magnitudes decline by roughly 12%, indicating that the responsible innovation domain is informative but not decisive. The construct therefore appears portable across sectors rather than specific to environmentally oriented venture markets [47].

A fifth analysis shifts the outcome horizon [48]. Instead of one-year-ahead financing and revenue growth, the models are estimated with two-year cumulative financing and two-year average revenue growth [49]. The positive coherence effect persists but attenuates modestly. The financing coefficient falls by about one-fifth, and the revenue-growth coefficient by about one-sixth. This pattern is sensible. In entrepreneurial settings, current coherence should be most informative over horizons in which the same strategic system remains in place. Over longer periods, pivots, team turnover, and market shocks can weaken the continuity between present alignment and later outcomes. The continued though smaller association nonetheless suggests that coherence is not only a short-lived signaling phenomenon [50].

A sixth exercise examines whether the coherence effect is stronger when ventures face high milestone dependence. Milestone dependence is proxied by the need to secure regulatory approvals, enterprise integration, or hardware validation before meaningful revenue can scale. In these subsamples, the coherence effect on financing is stronger than in low-milestone ventures. This is consistent with the argument that coherence matters especially when multiple organizational functions must remain aligned for external audiences to believe the venture can navigate a complex commercialization path. Simpler products with shorter feedback cycles still benefit from coherence, but the premium is smaller because incoherence is easier to correct quickly.

Interpreting the results also requires distinguishing coherence from consistency of narrative alone. A venture might tell a stable story without changing how it allocates resources or commercializes products. The empirical measure used here requires more than rhetorical consistency.

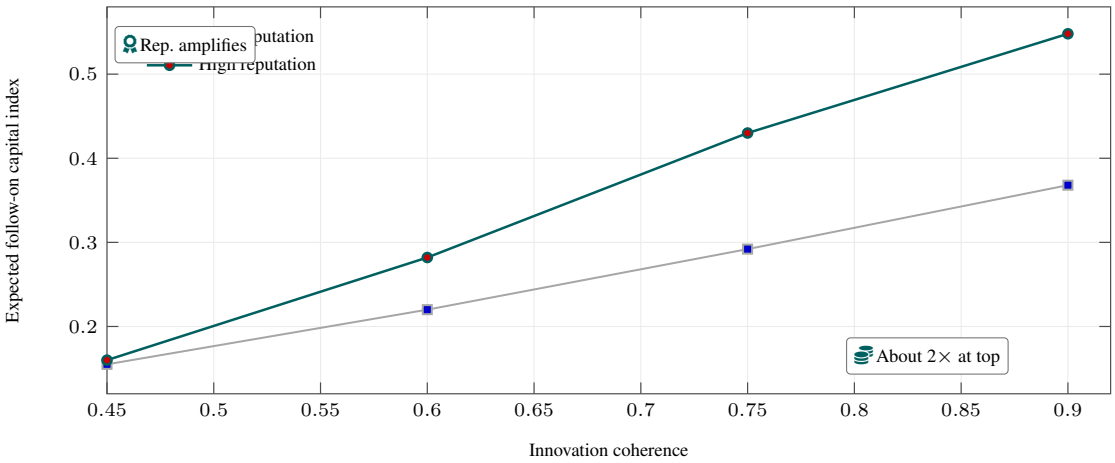


Figure 10: Amplification by prior innovation reputation. The higher-slope line represents ventures with stronger prior innovation reputation, for which the marginal financing payoff to coherence is substantially larger. The visual reflects the reported positive interaction between coherence and innovation reputation and the interpretation that the coherence effect on follow-on capital is about twice as large near the upper reputation quartile as near the lower one. Reputation therefore does not replace coherence; it makes coherent behavior easier for outsiders to believe and reward.

It depends on observable activity across multiple domains. Indeed, when the analysis substitutes a pure text-based strategic consistency score for the coherence variable, the outcome associations are weaker and less stable. Narrative discipline matters, but it does not appear sufficient. Stakeholders respond more strongly when the venture's technical, market-facing, and implementation choices align in observable behavior.

An additional interpretive issue concerns whether coherence might simply proxy for managerial quality. High-quality teams may be both more coherent and more successful. Venture fixed effects reduce this concern by absorbing time-invariant managerial differences, but quality can still evolve. To probe this, the analysis includes changes in senior leadership structure, hiring of experienced operating executives, and board professionalization as controls. The coherence coefficient remains robust. This suggests that while evolving managerial quality likely contributes to venture performance, the specific alignment of innovation domains carries incremental information beyond general improvements in governance or staffing.

The results also clarify an ambiguity about entr - epreneurial specialization. It is common to view focus as unambiguously positive in early-stage ventures because resources are scarce and founders are urged to avoid strategic diffusion. The present findings imply a more careful distinction. Focus on a market problem or technical challenge can be beneficial, but excessively concentrated inventive portfolios weaken the gains from an otherwise coherent innovation system. The issue is not that ventures should diversify indiscriminately. Rather, they should avoid deriving coherence solely from narrowness [51]. Disciplined alignment works best when it preserves some recombinative breadth and does not make the venture overly dependent on one knowledge trajectory.

From a methodological standpoint, the findings point to the value of representing entrepreneurial innovation as a multidimensional vector [52]. Scalar measures remain useful, but they are incomplete in settings where external interpretation and internal sequencing jointly determine outcomes. A venture with moderate levels of innovation across aligned domains may outperform a venture with higher aggregate innovation but stronger imbalance [53]. This possibility is difficult to detect with conventional single-dimension indicators. The coherence approach does not replace existing measures; it reorders them into a structure that better reflects how entrepreneurial systems function under uncertainty [54].

The broader interpretation is therefore restrained but consequential [55]. The evidence does not imply that coherence is a universal or sufficient condition for entrepreneurial success. Many coherent ventures will still fail because markets shift, technologies disappoint, or financing windows close [56]. Nor does it imply that all ventures should emphasize the same innovation mix. The effect identified here is relational rather than prescriptive. What seems to matter is that the venture's chosen innovation domains move in a mutually reinforcing direction and that stakeholders can observe that reinforcement with enough clarity to update expectations favorably. Under

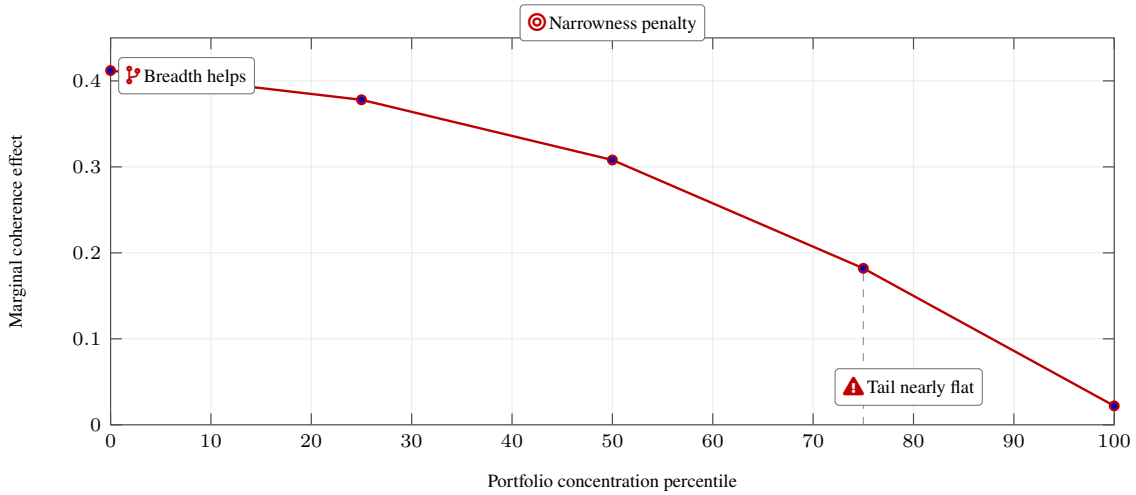


Figure 11: Weakening of the coherence payoff as inventive portfolios become excessively concentrated. The downward trace reflects the reported negative interaction between coherence and portfolio concentration in the financing model and the interpretation that the reduction in downside risk nearly disappears at the extreme upper tail of concentration. The figure makes the paper's distinction visually clear: disciplined alignment is beneficial, but coherence achieved mainly through narrowness becomes brittle and yields much smaller gains.

entrepreneurial uncertainty, alignment itself appears to be a resource.

7. Conclusion

This study examined whether entrepreneurial ventures benefit when distinct elements of their innovation system align rather than develop unevenly. Using a panel of 286 U.S. entrepreneurial firms over 2016–2024, the analysis found that venture innovation coherence is positively associated with next-year external financing and revenue growth and negatively associated with downside risk. These associations remain after accounting for venture fixed effects, innovation intensity, financing history, founder attributes, market conditions, and a control-function correction for endogeneity. The evidence also indicates that commercialization efficiency explains part of the relationship, suggesting that coherence matters not only because it affects external interpretation but also because it improves internal conversion from exploratory activity to economic engagement.

The conditional results help narrow the interpretation. Coherence is most valuable when competition is neither too weak nor too intense, when the venture has accumulated a credible innovation reputation, and when alignment is not achieved through excessive concentration of the inventive portfolio. These findings imply that coherence should be treated as an organizing property of entrepreneurial innovation rather than as a synonym for focus, publicity, or simple innovativeness. Ventures appear to benefit when technical commitment, external experimentation, commercialization cadence, and implementation-oriented legitimacy cues reinforce one another in a way that stakeholders can recognize.

Several implications follow for the study of entrepreneurship [57]. First, innovation in young firms is often assessed through isolated dimensions, yet the present results indicate that the pattern among dimensions can carry independent predictive content. Second, the conversion of exploratory effort into growth depends partly on whether stakeholders can interpret the venture's activities as belonging to a coherent path. Third, downside outcomes in entrepreneurial settings may reflect not only insufficient innovation, but also imbalanced innovation architectures that raise uncertainty about conversion and strategic direction [58]. These implications do not eliminate the role of product-market fit, team quality, or financing conditions. They suggest that those factors interact with the structure of innovation signals in ways that deserve more direct empirical attention [59].

The analysis has limitations. The sample is U.S.-based and concentrated in sectors where innovation leaves relatively visible traces, so the results may not transfer directly to quieter entrepreneurial settings or to regions with different disclosure norms. Some measures, especially those based on textual coding and private-firm disclosures, inevitably contain error. The endogeneity strategies reduce but do not eliminate concerns about omitted shocks.

It is also possible that coherence operates differently in founder-led lifestyle ventures, nonprofit ventures, or platform ecosystems where growth logic and stakeholder interpretation follow different patterns from those observed here.

Within the limits of the present design, the evidence supports a straightforward conclusion. Entrepreneurial firms do not appear to benefit only from innovating more. They benefit when the main domains through which innovation is enacted and observed move in a coordinated direction. Under uncertainty, alignment becomes part of what stakeholders value. For emerging ventures attempting to sustain growth while preserving strategic flexibility, the structure of innovation may therefore matter nearly as much as its absolute scale.

References

[1] J. Denrell, C. Fang, and S. G. Winter, "The economics of strategic opportunity," *Strategic Management Journal*, vol. 24, pp. 977–990, 9 2003.

[2] L. Xiao and A. R. Anderson, "The evolution of chinese angels: Social ties and institutional development," *British Journal of Management*, vol. 33, pp. 69–87, 3 2021.

[3] Z. Cao, R. Song, A. Sorescu, and A. Chua, "Innovation potential, insider sales, and ipo performance: how firms can mitigate the negative effect of insider selling," *Journal of Marketing*, vol. 87, no. 4, pp. 550–574, 2023.

[4] R. Ferlito and R. Faraci, "Sustainable hybrid business model of benefit corporation: The case of an italian film production company," *Sustainability*, vol. 14, pp. 5836–5836, 5 2022.

[5] M. Johnson, E. Monsen, and N. MacKenzie, "Follow the leader or the pack? regulatory focus and academic entrepreneurial intentions," *Journal of Product Innovation Management*, vol. 34, pp. 181–200, 10 2016.

[6] J. Haltiwanger, "Entrepreneurship in the twenty-first century," *Small business economics*, vol. 58, pp. 1–14, 10 2021.

[7] Z. Cao, H. Feng, and M. A. Wiles, "When do marketing ideation crowdsourcing contests create shareholder value? the effect of contest design and marketing resource factors," *Journal of Marketing*, vol. 88, no. 2, pp. 99–120, 2024.

[8] V. F. He, C. Sirén, S. Singh, G. Solomon, and G. von Krogh, "Keep calm and carry on: Emotion regulation in entrepreneurs' learning from failure," *Entrepreneurship Theory and Practice*, vol. 42, pp. 605–630, 6 2018.

[9] A. Steiner, S. Jack, J. Farmer, and I. Steinerowska-Streb, "Are they really a new species? exploring the emergence of social entrepreneurs through giddens's structuration theory," *Business & Society*, vol. 61, pp. 000765032110530–1961, 11 2021.

[10] E. Hudcová, T. Chovanec, and J. Moudrý, "Social entrepreneurship in agriculture, a sustainable practice for social and economic cohesion in rural areas: The case of the czech republic," *European Countryside*, vol. 10, pp. 377–397, 9 2018.

[11] H. Aguinis, R. S. Ramani, and W. F. Cascio, "Methodological practices in international business research: An after-action review of challenges and solutions," *Journal of International Business Studies*, vol. 51, pp. 1593–1608, 8 2020.

[12] Z. Cao, L. F. Cunningham, W. Gao, and Y. Liu, "The downsides of specialization: the impact of business incubator's specialization on startups' r&d efficiency and venture capital financing," *R&D Management*, vol. 54, no. 1, pp. 39–59, 2024.

[13] C. Harrison, K. Burnard, and S. Paul, "Entrepreneurial leadership in a developing economy: a skill-based analysis," *Journal of Small Business and Enterprise Development*, vol. 25, pp. 521–548, 12 2017.

[14] Z. Cao, N. Amrouche, and Z. Pei, "Environmental innovation for competing firms: Key esg dimension shaping strategies and profitability," *Journal of Environmental Management*, vol. 392, p. 126716, 2025.

[15] S. Estrin, D. Gozman, and S. Khavul, "The evolution and adoption of equity crowdfunding: entrepreneur and investor entry into a new market," *Small Business Economics*, vol. 51, pp. 425–439, 2 2018.

[16] Y. Cho, D. A. Robalino, and S. Watson, "Supporting self-employment and small-scale entrepreneurship: potential programs to improve livelihoods for vulnerable workers," *IZA Journal of Labor Policy*, vol. 5, pp. 1–26, 4 2016.

[17] T. K. Darwish, S. Singh, and G. Wood, "The impact of human resource practices on actual and perceived organizational performance in a middle eastern emerging market," *Human Resource Management*, vol. 55, pp. 261–281, 2 2015.

[18] E. Rasmussen, S. Mosey, and M. Wright, "The evolution of entrepreneurial competencies: A longitudinal study of university spin-off venture emergence," *Journal of Management Studies*, vol. 48, pp. 1314–1345, 3 2011.

[19] S. Kumar, D. Sharma, S. Rao, W. M. Lim, and S. K. Mangla, "Past, present, and future of sustainable finance: insights from big data analytics through machine learning of scholarly research.," *Annals of operations research*, vol. 345, pp. 1–1104, 1 2022.

[20] J. Bachtler and I. Begg, "Eu cohesion policy after brexit: the economic, social and institutional challenges," *Journal of Social Policy*, vol. 46, pp. 745–763, 7 2017.

[21] H. Xiao, J. Xiao, and F. Xie, "Impact assessment of farmland lease-out on rural households' livelihood capital and livelihood strategy," *Sustainability*, vol. 14, pp. 10736–10736, 8 2022.

[22] Z. Gródek-Szostak, J. Adamczyk, M. Luc, M. Suder, J. Tora, K. Kotulewicz-Wisińska, W. Zysk, and A. Szeląg-Sikora, "Hard cash in hard times—the effect of institutional support for businesses shaken by covid-19," *Sustainability*, vol. 14, pp. 4399–4399, 4 2022.

[23] C. Gonzales-Gemio, C. Cruz-Cázares, and M. J. Parmentier, "Responsible innovation in smes: A systematic literature review for a conceptual model," *Sustainability*, vol. 12, pp. 10232–, 12 2020.

[24] Y. Aksoy, H. S. Basso, R. Smith, and T. Grasl, "Demographic structure and macroeconomic trends," *American Economic Journal: Macroeconomics*, vol. 11, pp. 193–222, 1 2019.

[25] K. Greve, R. D. Vita, S. Leminen, and M. Westerlund, "Living labs: From niche to mainstream innovation management," *Sustainability*, vol. 13, pp. 791–, 1 2021.

[26] A. F. Constant and Y. Shachmurove, "Entrepreneurial ventures and wage differentials between germans and immigrants," *International Journal of Manpower*, vol. 27, pp. 208–229, 4 2006.

[27] X.-Q. Chen and J. K. Musango, "A conceptual approach to the stakeholder mapping of energy lab in poor urban settings," *Sustainability*, vol. 14, pp. 6233–6233, 5 2022.

[28] O. Dada and A. Watson, "Entrepreneurial orientation and the franchise system : Organisational antecedents and performance outcomes," *European Journal of Marketing*, vol. 47, pp. 790–812, 5 2013.

[29] A. Lindholm-Dahlstrand, M. Andersson, and B. Carlsson, "Entrepreneurial experimentation: a key function in systems of innovation," *Small Business Economics*, vol. 53, pp. 591–610, 7 2018.

[30] C. B. Gibson, L. L. Gilson, T. L. Griffith, and T. A. O'Neill, "Should employees be required to return to the office?," *Organizational dynamics*, vol. 52, pp. 100981–100981, 4 2023.

[31] W. R. Kerr and R. Nanda, "Financing innovation," *Annual Review of Financial Economics*, vol. 7, pp. 445–462, 12 2015.

[32] T. Fuller and Y. Tian, "Social and symbolic capital and responsible entrepreneurship: an empirical investigation of sme narratives," *Journal of Business Ethics*, vol. 67, pp. 287–304, 9 2006.

[33] R. Ajates, "Reducing the risk of co-optation in alternative food networks: Multi-stakeholder cooperatives, social capital, and third spaces of cooperation," *Sustainability*, vol. 13, pp. 11219–, 10 2021.

[34] Y. Zhu, G. He, and K. Bao, "Driving path and system simulation of green innovation capability of science and technology enterprises in yangtze river delta," *Sustainability*, vol. 14, pp. 13031–13031, 10 2022.

[35] J. Stankevičienė, G. G. Noja, M.-G. Pirtea, A.-M. Ţăran, A. Gînguţă, and A. Giovanis, "Technological innovations for sustainable business success: enhancing processes and performance," *Business Process Management Journal*, vol. 31, pp. 1884–1907, 5 2025.

[36] M. Guerrero and J. Espinoza-Benavides, "Does entrepreneurship ecosystem influence business reentries after failure?," *International Entrepreneurship and Management Journal*, vol. 17, pp. 211–227, 8 2020.

[37] P. Chen, "The effect of value creation on startups performance in the digital environment: Evidence

from chinese digital startups," *Sustainability*, vol. 15, pp. 4116–4116, 2 2023.

[38] B. Akkaya, C. Popescu, and S. Üstgörül, "How can we remove psychological entrepreneurship barriers on entrepreneurship intention for health organizations in the future?," *Sustainability*, vol. 16, pp. 3503–3503, 4 2024.

[39] N. J. Foss and P. G. Klein, "Reflections on the 2016 nobel memorial prize for contract theory (oliver hart and bengt holmström)," *Erasmus Journal for Philosophy and Economics*, vol. 9, pp. 167–180, 12 2016.

[40] C. Berry, "Industrial policy change in the post-crisis british economy: Policy innovation in an incomplete institutional and ideational environment," *The British Journal of Politics and International Relations*, vol. 18, pp. 829–847, 9 2016.

[41] B. Hagen, A. Zucchella, J. Larimo, and P. Dimitratos, "A taxonomy of strategic postures of international smes," *European Management Review*, vol. 14, pp. 265–285, 2 2017.

[42] I. Okhmatovskiy, O. Suhomlinova, and L. Tihanyi, "Legacy of the state: Prior shared experience and survival of spin-offs from restructured state enterprises:," *Journal of Management*, vol. 46, pp. 503–529, 11 2018.

[43] N. Culkin, "Entrepreneurial universities in the region: the force awakens?," *International Journal of Entrepreneurial Behavior & Research*, vol. 22, pp. 4–16, 3 2016.

[44] J. Du and Y. Temouri, "High-growth firms and productivity:evidence from the united kingdom," *Small Business Economics*, vol. 44, pp. 123–143, 5 2014.

[45] M. G. Colombo, C. Fisch, P. P. Momtaz, and S. Vismara, "The <scp>ceo</scp> beauty premium: Founder <scp>ceo</scp> attractiveness and firm valuation in initial coin offerings," *Strategic Entrepreneurship Journal*, vol. 16, pp. 491–521, 1 2022.

[46] C.-T. Lee, J.-L. Hu, and M.-H. Kung, "Economic resilience in the early stage of the covid-19 pandemic: An across-economy comparison," *Sustainability*, vol. 14, pp. 4609–4609, 4 2022.

[47] C.-H. Yang, Y.-C. Chen, W. Hsu, and Y.-H. Chen, "Evaluation of smart long-term care information strategy portfolio decision model: the national healthcare environment in taiwan.," *Annals of operations research*, vol. 326, pp. 1–536, 4 2023.

[48] M. F. Halim, C. Barbieri, D. B. Morais, S. Jakes, and E. Seekamp, "Beyond economic earnings: The holistic meaning of success for women in agritourism," *Sustainability*, vol. 12, pp. 4907–, 6 2020.

[49] W. Fu, "Spatial mobility and opportunity-driven entrepreneurship: the evidence from china labor-force dynamics survey," *The Journal of Technology Transfer*, vol. 45, pp. 1324–1342, 7 2019.

[50] J. G. York, I. O'Neil, and S. D. Sarasvathy, "Exploring environmental entrepreneurship: : Identity coupling, venture goals, and stakeholder incentives," *Journal of Management Studies*, vol. 53, pp. 695–737, 3 2016.

[51] J. Li, B. Liang, and Z. Yan, "Too much of a good thing? the impact of government subsidies on incubator services: Empirical evidence from china," *Sustainability*, vol. 14, pp. 14387–14387, 11 2022.

[52] K. Nicolopoulou, I. Lucas, A. Tatli, M. Karatas-Ozkan, L. Costanzo, M. Özbilgin, and G. Manville, "Questioning legitimacy of social enterprises through gramscian and bourdieusian perspectives : the case of the british social enterprises," *Journal of Social Entrepreneurship*, vol. 6, pp. 161–185, 11 2014.

[53] J. E. Meador, D. J. O'Brien, M. L. Cook, G. Grothe, L. Werner, D. Diang'a, and R. M. Savoie, "Building sustainable smallholder cooperatives in emerging market economies: findings from a five-year project in kenya," *Sustainability*, vol. 8, pp. 656–671, 7 2016.

[54] E. C. Tortia, M. Gago, F. Degavre, and S. Poledrini, "Worker involvement and performance in italian social enterprises: The role of motivations, gender and workload," *Sustainability*, vol. 14, pp. 1022–1022, 1 2022.

[55] F. do Adro, C. I. Fernandes, and P. M. Veiga, "The impact of innovation management on the performance of <scp>npos</scp>: Applying the tidd and bessant model (2009)," *Nonprofit Management and Leadership*, vol. 32, pp. 577–601, 1 2022.

[56] G. A. Afrifa, J. Amankwah-Amoah, A. Acquaye, F. A. Yamoah, and F. G. Mwiti, "Small sums,

big impact: Corruption and microfinance institutions," *Economic and Industrial Democracy*, vol. 45, pp. 164–199, 12 2022.

[57] P. M. Kreiser, D. F. Kuratko, J. G. Covin, R. D. Ireland, and J. S. Hornsby, "Corporate entrepreneurship strategy: extending our knowledge boundaries through configuration theory," *Small Business Economics*, vol. 56, pp. 739–758, 5 2019.

[58] M. Dost and W. A. Umrani, "Managerial proactiveness, frugal innovation and firm performance," *The Journal of Entrepreneurship*, vol. 33, pp. 393–417, 5 2024.

[59] C. Parkinson and C. Howorth, "The language of social entrepreneurs," *Entrepreneurship & Regional Development*, vol. 20, pp. 285–309, 4 2008.