scisearch INTERNATIONAL PEER-REVIEWED JOURNALS

RESEARCH PAPER

Innovation Rhythm Fit and Portfolio Breadth as Determinants of Firm Value and New Product Revenue Growth Under Competitive Volatility

Ahmad Khalil[1] and Omar Haddad[2]

[1]Department of Business Information Systems, Faculty of Business, Tafila Technical University, Engineering College Street, Tafila 66110, Tafila, Jordan
[2]Management Information Systems Department, Faculty of Economics and Administrative Sciences, Al-Hussein Bin Talal University, Queen Rania Al Abdullah Street, Ma'an 71111, Ma'an, Jordan

Abstract

Innovation research has often emphasized the volume of inventive effort, the number of patents, or the frequency of new product launches. Yet firms rarely succeed through volume alone. In many settings, innovation creates value when the firm times its exploratory and exploitative activities in a way that is consistent with market turbulence, organizational absorption capacity, and the commercial horizon of the product portfolio. This study develops the concept of innovation rhythm fit, defined as the degree to which a firm's mix of exploratory and exploitative innovation and the temporal pacing of that activity correspond to the informational demands of its environment. Using a panel of 276 publicly listed U.S. firms from 2013 to 2024, representing 2,184 firm-year observations, the analysis combines patent data, product launch announcements, accounting variables, and text-derived disclosure measures. The findings indicate that innovation rhythm fit is positively associated with next-year Tobin's Q and the subsequent share of revenue generated by recently introduced products, while being negatively associated with idiosyncratic stock return volatility. The results are economically moderate rather than extreme. A movement from the first to the third quartile of rhythm fit is associated with a 5.9% increase in next-year firm value and a 2.3 percentage point increase in new product revenue share. The effect is stronger when portfolio breadth is broad but not excessive, when competitive pressure is moderate, and when commercialization efficiency is high. Mediation analyses suggest that rhythm fit improves market outcomes partly through more effective translation of innovation effort into market-facing outputs.

1. Introduction

Innovation is commonly framed as a strategic imperative, but the more difficult managerial problem is not whether to innovate. It is how to organize the timing and composition of innovative effort so that invention, product renewal, and commercialization reinforce one another rather than compete for attention. Firms often face a familiar tension. If they emphasize exploration too heavily, they may produce technically interesting projects that remain commercially distant, underdeveloped, or difficult to integrate into the existing portfolio. If they emphasize exploitation too heavily, they may become highly efficient at incremental refinement while permitting technological trajectories, customer expectations, and competitive standards to move beyond them. This tension is well known at a conceptual level, yet it is often measured in a static way, as if the same exploration share were desirable across firms, industries, and periods. That assumption is analytically restrictive. The value of innovation depends not only on what firms do, but also on whether they do it with a rhythm that fits their environment (1).

This paper develops an empirical account of innovation rhythm fit (2). The focal idea is that firms derive stronger economic gains when two alignment conditions hold simultaneously. First, the relative weight placed on exploratory and exploitative innovation should be appropriate for the firm's competitive and demand environment. Second, the timing of innovation output should be paced in a way that avoids both erratic bursts and excessively inert intervals. In practical terms, a firm benefits when it does not merely produce innovation, but produces it with a tempo that outside evaluators can understand, internal teams can absorb, and commercialization systems can convert into revenue. A firm that oscillates sharply between exploratory surges and long quiet periods may generate internal congestion, investor uncertainty, and inconsistent downstream execution. A firm with a more fitted rhythm may not innovate more in raw volume, but may innovate more effectively.

The need for such a perspective becomes especially apparent when one considers the limits of specialization as a universal answer to innovation management (3). Specialization can create focus, shared language, and concentrated expertise, but it can also narrow knowledge inflow and intensify internal or local competitive frictions. Cao et al. (2024b) (4) show that greater incubator specialization reduces startups' R&D efficiency and indirectly lowers venture capital funding, largely because specialized settings can amplify knowledge leakage concerns while

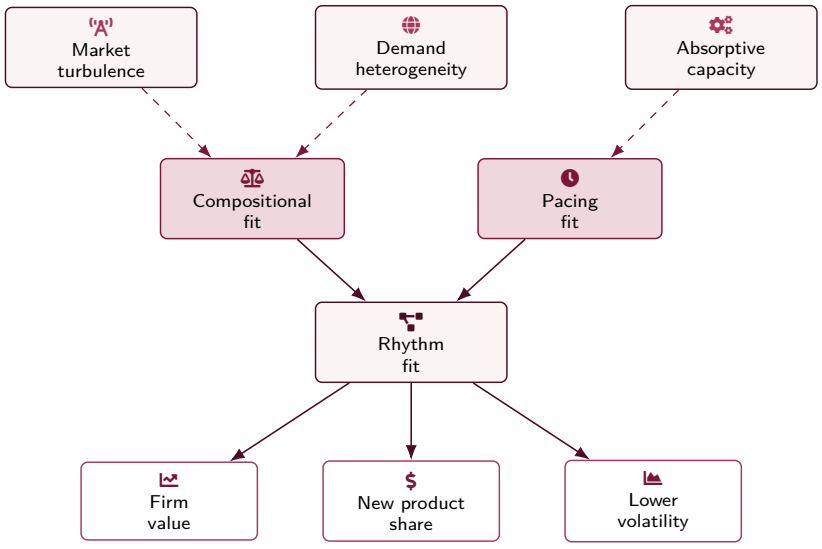

Figure 1. Conceptual architecture of innovation rhythm fit. Environmental conditions shape two distinct alignment layers: the fit between exploratory and exploitative innovation, and the fit in temporal pacing across the year. These two layers combine into a firm-level rhythm-fit construct that is expected to improve next-year firm value and new product revenue share while reducing firm-specific uncertainty.

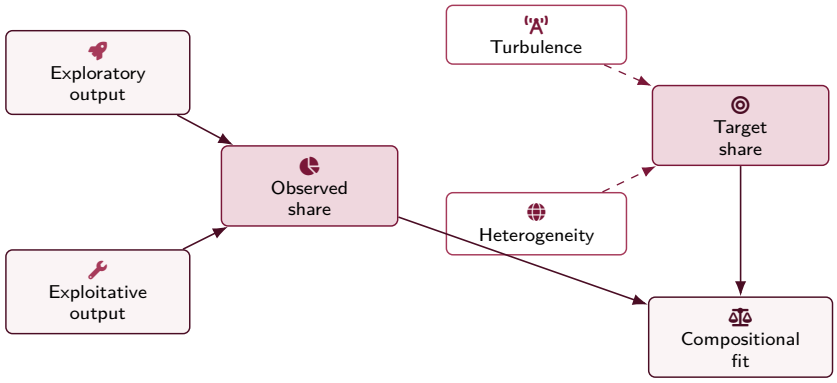

Figure 2. Compositional fit is formed by comparing the firm's realized exploration share with an adaptive benchmark implied by external conditions. The figure separates observed innovation mix from the market-implied target, emphasizing that balance is contingent rather than fixed.

limiting heterogeneous knowledge inflows. That insight is important well beyond the incubator context. It indicates that concentrated innovation structures do not automatically improve outcomes. The present study extends that logic by asking whether corporate innovation systems perform better when they preserve a fitted balance between exploratory novelty and exploitative refinement, rather than collapsing too far toward a narrow mode of innovation.

The argument pursued here differs from approaches that treat innovation as a stock of resources or a stock of outputs. Such measures remain useful, but they leave unresolved whether the firm's innovation pattern is strategically synchronized. A given R&D budget can support radically different rhythms. One firm may convert it into relatively smooth sequences of incremental and occasional breakthrough launches. Another may produce dense episodes of laboratory activity followed by weak commercialization. A third may generate frequent launches that overdraw product management, channel support, and manufacturing adaptation (5). These patterns are not equivalent, even if annual R&D intensity is the same. Investors, managers, and partners interpret them differently because they imply different levels of conversion efficiency, future continuity, and organizational control.

The central claim of the paper is that innovation rhythm fit should predict both market-based and product-market outcomes. Specifically, firms with stronger rhythm fit should exhibit higher next-year Tobin's Q, a greater share of sales from recently introduced products, and lower idiosyncratic stock return volatility. The mechanism is not merely symbolic (6). Rhythm fit should improve the translation of innovation effort into market-facing outputs by reducing congestion in project selection, improving absorptive sequencing across functions, and preserving a portfolio structure that allows learning from both new and familiar knowledge domains (7). The concept is therefore meant to capture a joint organizational and interpretive advantage. It is organizational because coordinated timing supports execution. It is interpretive because external audiences use temporal patterns to infer whether the firm's innovation

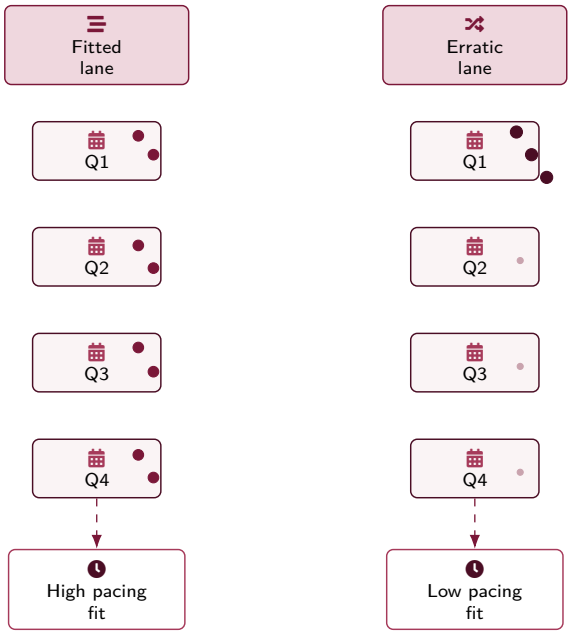

Figure 3. Temporal pacing fit distinguishes staged innovation activity from bursty, uneven release patterns. In the fitted lane, innovation events are distributed across quarters in a way that the organization can absorb; in the erratic lane, activity clusters into one period and leaves inactive intervals, lowering the pacing component of rhythm fit.

strategy is controlled and durable.

The paper also proposes that the benefits of rhythm fit depend on portfolio breadth (8). Broad portfolios create opportunities for recombination and lessen the fragility that accompanies narrow search paths, yet very broad portfolios can stretch managerial attention and slow conversion. Rhythm fit is therefore not expected to operate identically across all portfolio structures. Likewise, competitive pressure should matter. Under weak competition, fitted innovation rhythm may be less valuable because the cost of misalignment is lower. Under severe competition, the private returns to innovation may erode quickly as appropriation becomes more difficult. Between these extremes, fitted rhythm may be especially valuable because it allows firms to deploy innovation in a disciplined but responsive manner.

The study contributes to innovation research in three respects. First, it introduces an empirical construct that treats innovation as a temporal and compositional pattern rather than a volume count. Second, it links that pattern to both firm value and the revenue contribution of recently introduced products, thereby connecting financial evaluation and commercialization performance. Third, it identifies contingent conditions under which fitted innovation timing is more or less valuable. The broader implication is that innovation advantage may lie less in relentless intensity than in maintaining a strategically appropriate cadence that matches portfolio breadth, market turbulence, and competitive demand.

2. Conceptual Background

The concept of innovation rhythm fit begins from a simple observation: firms innovate under two kinds of uncertainty at once. One uncertainty concerns the substance of innovation, meaning whether new knowledge or product concepts will prove technically viable and commercially relevant. The second concerns timing, meaning whether the organization can stage exploration, development, launch, and post-launch learning at a pace consistent with its own absorptive capacity and with the evolution of external demand. Most empirical measures concentrate on the first uncertainty and abstract from the second. Yet timing can become a decisive source of variation in performance because innovative projects often compete internally for engineering resources, managerial attention, capital budgeting, product line support, and external communication bandwidth. Rhythm fit captures whether these activities occur in a pattern that is neither prematurely crowded nor strategically intermittent.

This perspective assumes that exploration and exploitation are not substitutes in a fixed proportion. Rather, they are complementary modes whose relative weight should vary with market turbulence, technological uncertainty, and the firm's position in the product cycle. Exploration extends the option set of the firm, creates fresh knowledge, and may unlock higher future rents. Exploitation refines routines, improves reliability, and converts prior learning into commercially digestible offerings. Problems arise when firms become trapped in a one-sided pattern. Excessive exploration can create a queue of projects whose technical promise exceeds the organization's capacity to evaluate and commercialize them. Excessive exploitation can produce efficient repetition, but reduce responsiveness when technologies, regulation, or customer standards shift. Rhythm fit is therefore not equivalent to a fifty-fifty balance. It refers instead to how closely a firm's observed innovation mix approaches the adaptive mix implied by its environment (9).

The environmental contingency is essential. Cao et al.

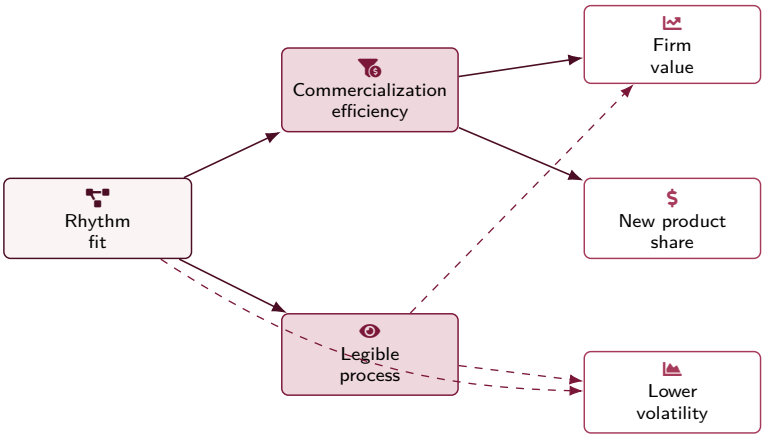

Figure 4. Mechanism structure linking rhythm fit to future outcomes. One route runs through commercialization efficiency, where a better-timed and better-balanced innovation pattern is translated into market-facing output. A second route operates through process legibility, which can stabilize interpretation and reduce firm-specific uncertainty in capital markets.

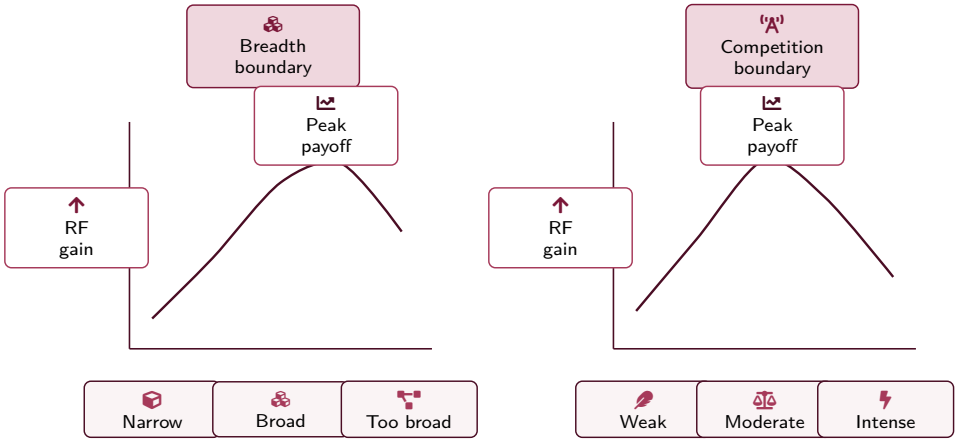

Figure 5. Nonlinear boundary conditions for rhythm-fit returns. The left panel depicts the idea that rhythm fit is most valuable when portfolio breadth is broad enough to support recombination but not so broad that coordination strain dominates. The right panel shows the analogous inverted-U logic for competition, where moderate pressure sharpens the value of disciplined innovation timing without fully eroding appropriation.

(2025) (10) show in the domain of environmental innovation that financial returns from innovation are shaped by market-level competition and firm-level characteristics such as reputation and innovation effectiveness. That result suggests a broader principle: innovative effort does not yield uniform financial consequences across contexts, because the same activity is interpreted and appropriated differently depending on competitive conditions and internal capability. The present paper builds on that idea by proposing that a fitted innovation rhythm should be most valuable in settings where market signals change enough to punish inertia but not so violently that disciplined sequencing loses relevance. When competition and turbulence are moderate, fitted rhythm should help firms update the portfolio without fragmenting it.

A second theoretical element concerns temporal legibility. External audiences do not observe project-level deliberations directly. Instead, they infer quality from patterns that can be seen: the spacing of launches, the persistence of inventive activity, the relation between disclosed priorities and realized outputs, and the stability of the product renewal process. These patterns create beliefs about whether innovation is being governed deliberately or reactively. If a firm exhibits extreme bursts of innovation followed by long inactive periods, observers may infer episodic managerial attention, unstable opportunity screening, or weak downstream integration. A smoother pattern is not always better, but a fitted pattern should increase the predictability of innovation-related cash flows and the perceived reliability of the firm's strategic process.

The internal mechanism of rhythm fit is likely to operate through conversion efficiency. Innovation is rarely constrained only by upstream knowledge generation. It is also constrained by the organization's ability to absorb new knowledge across engineering, operations, marketing, channel coordination, legal review, and service support. When the rhythm of innovation is poorly matched to organizational capacity, several forms of inefficiency may arise. Some promising projects remain delayed because internal interfaces are overloaded. Other projects are pushed forward before enough downstream readiness exists (11). Launch clusters may compete for the same market attention and dilute one another (12). Still other projects are delayed so long

that they lose novelty or market relevance. Rhythm fit reduces these problems by creating a more workable relation between upstream inventive activity and downstream commercialization routines.

Portfolio breadth conditions these effects because the benefits of fit depend on what the portfolio makes possible. A broader portfolio supports cross-domain recombination and reduces dependence on a single knowledge trajectory. It may also buffer the firm against shocks in a particular technological or product domain (13). However, breadth is not unconditionally beneficial. Beyond a point, the combinatorial possibilities of broad search impose integrative burdens on managers, evaluators, and platform owners. A portfolio that is too broad can slow selection, amplify coordination costs, and weaken product line coherence. The implication is not that rhythm fit requires narrow focus. Instead, it requires enough breadth to sustain recombination, but not so much breadth that pacing loses operational traction (14). The most favorable outcomes should occur when breadth is substantial yet governable.

Another implication concerns market valuation (15). Financial markets often reward firms not merely for current earnings, but for credible narratives of future opportunity. Innovation rhythm can shape that credibility because it reveals how the firm renews itself over time. A firm whose innovation behavior is erratic may still generate occasional successes, but the market may apply a discount because future outcomes appear hard to forecast. A firm with more fitted rhythm may generate somewhat lower peaks in any one period, yet be valued more highly because the stream of future innovation-based cash flows appears more plausible and less noisy. The argument is therefore not that smoothness is prized for its own sake. It is that adaptive rhythm fit can reduce avoidable uncertainty and improve the expected conversion of innovation into future revenue (16).

These arguments motivate three expectations (17). First, rhythm fit should increase next-year firm value and the subsequent share of sales derived from recently introduced products. Second, rhythm fit should reduce idiosyncratic stock return volatility by making the innovation process more legible and less episodic. Third, commercialization efficiency should mediate part of the effect, because fitted rhythms should improve the conversion of innovation resources into market-facing outputs. The moderation expectations follow naturally (18). Rhythm fit should be more valuable when portfolio breadth is broad but not excessive and when competitive pressure is moderate rather than minimal or extreme. These are not claims of universal superiority (19). They are conditional predictions about how temporal and compositional organization influences the returns to innovation.

3. Research Design

The empirical setting consists of publicly listed U.S. firms in sectors where innovation is visible, strategically consequential, and observable in both technological and commercial data. The sampling frame begins with all firms appearing in Compustat between 2013 and 2024 in software, medical technology, industrial equipment, specialty chemicals, mobility solutions, business services, consumer durables, and electronic components. Financial firms, utilities, and regulated infrastructure businesses were excluded because their innovation profiles, disclosure patterns, and valuation structures are less comparable to the focal sectors. A firm entered the sample if it had at least four consecutive years of financial data, available annual reports, identifiable product launch announcements, and patent or product innovation records sufficient to classify innovation type. After eliminating cases with missing core variables and winsorizing the continuous measures at the 1% and 99% levels, the final panel contains 276 firms and 2,184 firm-year observations.

Multiple data sources were integrated at the firm-year level. Financial variables were taken from standardized accounting databases and verified against annual reports where necessary. Patent data were compiled from U.S. patent records and assigned to firms using assignee matching and manual verification for major mergers and name changes. Product innovation outputs were identified through firm press releases, investor presentations, earnings transcripts, and archival product databases. To avoid treating minor packaging or cosmetic changes as substantive innovation events, only launches with a discernible functionality, platform, feature, performance, or service change were retained. Innovation disclosure data were collected from annual report narratives and shareholder letters using a supervised text approach that distinguished innovation-related passages from general growth language. Industry demand turbulence and heterogeneity were measured using segment-level sales volatility and cross-segment demand dispersion.

The central explanatory construct is innovation rhythm fit. The measure combines two dimensions (20). The first is compositional fit, meaning the distance between the firm's realized exploration share and a market-implied target share (21). Exploratory innovation is measured through a composite of originality-weighted patents, patents in novel technological classes relative to the firm's own history, and product launches classified as new platforms or materially new categories. Exploitative innovation is measured through incremental patents that extend existing classes, product refinements, line extensions, and performance-improving revisions to established offerings. The second dimension is temporal pacing fit, meaning the regularity with which innovation events are distributed across quarters. A firm that clusters most innovation activity into one quarter and remains quiet for long intervals receives a poorer pacing score than a firm whose activity is staged more evenly, unless the former pattern is explicitly consistent with the firm's industry cycle (22). To allow for industry differences, pacing variance is standardized within industry-year cells before being incorporated into the composite measure.

Formally, let exploratory output be denoted by E_{it} and exploitative output by X_{it}, both strictly nonnegative. Let the observed exploration share be $s_{it} = E_{it}E_{it}\ X_{it}\ 1$. The target share is modeled as an adaptive benchmark based on market turbulence and demand heterogeneity, and the temporal component is based on the standardized within-year dispersion of innovation events across quarters. The resulting index increases when the firm's exploration share approaches the adaptive benchmark

and when innovation activity is paced in a more fitted manner. The purpose of the measure is not to reward stability alone. A firm with low activity in all quarters does not receive a high rhythm-fit score because the compositional and intensity terms remain distinct from the pacing term. In other words, rhythm fit is defined conditionally on meaningful innovation activity rather than on inactivity disguised as smoothness.

Portfolio breadth is measured separately to preserve conceptual distinction. It is calculated from the normalized entropy of the firm's patent-class distribution and launch-category distribution (23). High breadth indicates that the firm's innovation activity spans multiple technological and product domains. This breadth measure is not folded into the rhythm-fit index because a firm can display a highly fitted rhythm with either narrow or broad portfolios. The moderating logic instead treats breadth as a conditioning structure that can either support or overextend the benefits of fitted timing. Breadth is therefore entered linearly and quadratically in the models to allow the data to indicate whether moderate or high breadth strengthens the focal effect.

The outcome variables cover both market evaluation and commercialization performance. The first dependent variable is next-year Tobin's Q, logged to reduce skewness. The second is next-year new product revenue share, defined as the percentage of firm revenue attributable to products or services introduced during the prior thirty-six months. This measure is assembled from segment disclosures, investor materials, and product-level revenue commentary; where exact proportions were unavailable, ranges were converted into interval midpoints and checked manually. The third outcome is next-year idiosyncratic stock return volatility derived from daily returns net of common risk factors. This variable captures whether fitted innovation rhythms are associated with less firm-specific uncertainty in capital markets (24).

The choice of market-based outcomes is motivated by the idea that innovation is a credible external signal rather than only an internal process variable. Cao et al. (2023) (25) show that innovation potential can mitigate the negative effect of insider selling on IPO performance, indicating that investors use innovation cues to revise the interpretation of otherwise adverse information. This supports the use of firm value and return volatility as meaningful outcomes in the present setting (26). If outside audiences infer future opportunity, controllability, and quality from innovation-related patterns, then the temporal organization of innovation should influence not just product outcomes but also market valuation and uncertainty (27).

The control set includes firm size, leverage, cash holdings, capital intensity, advertising intensity, R&D intensity, profitability, firm age since listing, analyst coverage, prior stock return, and year and firm fixed effects. A text-based control for general strategic assertiveness was also included to distinguish innovation timing from broad managerial optimism. Further controls account for acquisition intensity, because acquisitive firms may exhibit different innovation timing patterns and product renewal profiles. Because rhythm fit and new product revenue share may both be influenced by time-varying industry conditions, industry-year medians for segment growth and input-cost volatility are included as additional controls in the main specifications.

4. Empirical Specification

The empirical model is designed to separate the effect of rhythm fit from the level of innovative effort. For this reason, the regressions include both the rhythm-fit index and an innovation intensity control built from the mean standardized level of exploratory and exploitative outputs. The basic structure for each outcome is a firm and year fixed-effects model with one-year-ahead dependent variables (28). Using future outcomes reduces the mechanical simultaneity that would arise if innovation timing and performance were measured within the same year.

The observed exploration share, adaptive target, and rhythm-fit index are defined as follows:

$$
\begin{aligned}
s_{it} &= \frac{E_{it}}{E_{it} \;\; X_{it} \;\; 1}, \\
b_{it} &= \Lambda\left(\omega_0 \;\; \omega_1 Turb_{it} \qquad \omega_2 Hetero_{it}\right), \\
RF_{it} &= 1 - \sqrt{\alpha\left(s_{it} - b_{it}\right)^2 \qquad 1 - \alpha\widetilde{\sigma}^2_{it}},
\end{aligned}
\tag{4.1}
$$

where $\Lambda\cdot$ denotes the logistic mapping, $Turb_{it}$ is market turbulence, $Hetero_{it}$ is demand heterogeneity, and $\widetilde{\sigma}^2_{it}$ is standardized quarterly pacing variance. The parameter α governs the relative weight on compositional and temporal fit. In the main specification $\alpha = 0.6$, reflecting the view that balance between exploratory and exploitative innovation is somewhat more fundamental than pacing regularity, though alternative weights are examined in robustness tests.

The baseline fixed-effects model for firm value is

$$
\begin{aligned}
\ln Q_{i,t1} = \mu_i \;\; \tau_t \;\; \beta_1 RF_{it} \qquad \beta_2 INT_{it} \\
\beta_3 Breadth_{it} \qquad \beta_4 Comp_{it} \\
\gamma' Z_{it} \;\; \varepsilon_{i,t1},
\end{aligned}
\tag{4.2}
$$

where INT_{it} is innovation intensity, $Breadth_{it}$ is portfolio breadth, $Comp_{it}$ is product-market competition, and Z_{it} is the vector of controls. Analogous models are estimated for new product revenue share and idiosyncratic volatility (29). The coefficient on RF_{it} captures whether a better-fitted innovation rhythm predicts future outcomes after conditioning on the overall level of innovative activity and the main observable confounds.

To test moderation by breadth and competition, the model is expanded to include both linear and quadratic interactions: (30)

$$
\begin{aligned}
Y_{i,t1} = \mu_i \;\; \tau_t \;\; \beta_1 RF_{it} \qquad \beta_2 INT_{it} \\
\beta_3 RF_{it} Breadth_{it} \qquad \beta_4 RF_{it} Breadth^2_{it} \\
\beta_5 RF_{it} Comp_{it} \qquad \beta_6 RF_{it} Comp^2_{it} \\
\beta_7 Breadth_{it} \qquad \beta_8 Breadth^2_{it} \\
\beta_9 Comp_{it} \qquad \beta_{10} Comp^2_{it} \\
\gamma' Z_{it} \;\; \varepsilon_{i,t1}.
\end{aligned}
\tag{4.3}
$$

This structure allows the data to indicate whether rhythm fit becomes more valuable at intermediate levels of breadth and

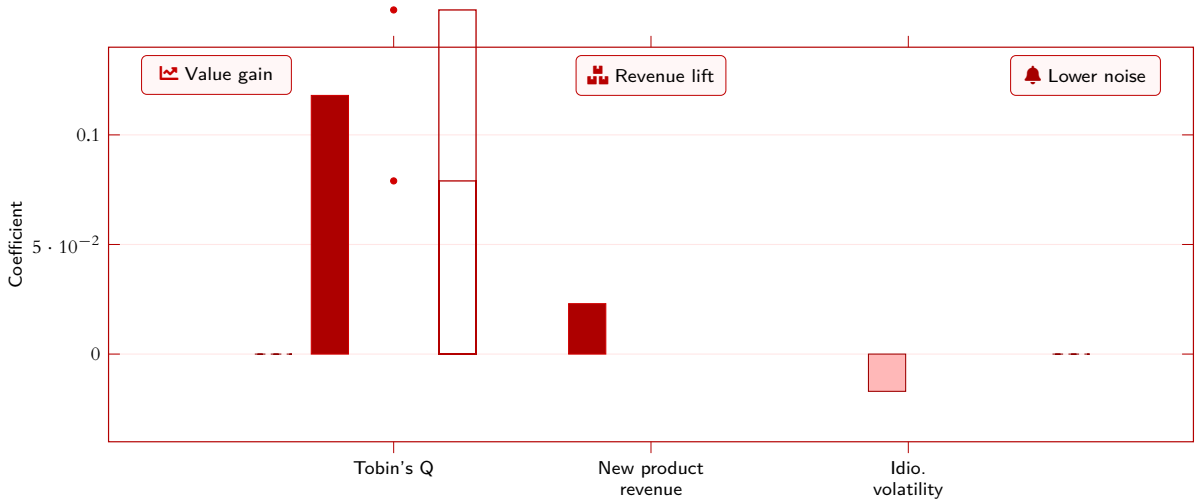

Figure 6. Baseline fixed-effects results. Innovation rhythm fit is positively associated with next-year Tobin's Q (0.118) and new product revenue share (0.023), while being negatively associated with idiosyncratic stock-return volatility (-0.017). The vertical interval on the Tobin's Q bar marks the reported clustered standard-error band around the baseline estimate.

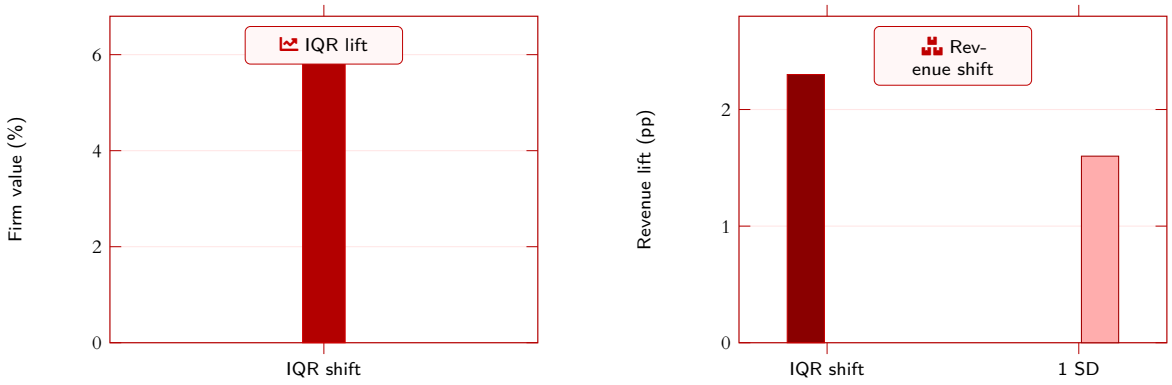

Figure 7. Economic magnitude of the main findings. The left panel shows that moving from the first to the third quartile of rhythm fit is associated with a 5.9% increase in next-year firm value. The right panel reports the lift in new-product revenue share: 2.3 percentage points for the interquartile movement and 1.6 percentage points for a one-standard-deviation increase in rhythm fit.

competition rather than assuming monotonic moderation. Because breadth and competition may be correlated with persistent sectoral differences, firm and year fixed effects remain in all specifications.

The proposed process mechanism is commercialization efficiency. This mediator is defined as the ratio of recent market-facing output to lagged innovation resource deployment. Specifically,

$$CE_{it} = \log\left(1 \frac{LaunchValue_{it} \quad 0.5\, PatQual_{it}}{1 \quad R\&D_{i,t-1} Sales_{i,t-1}}\right). \qquad (4.4)$$

LaunchValue is a weighted measure of substantive product and service introductions, and PatQual is a quality-adjusted patent count based on originality and forward relevance. The first-stage mediation model regresses $CE_{i,t1}$ on rhythm fit and controls, and the second-stage model adds commercialization efficiency to the outcome regressions. Indirect effects are evaluated using clustered bootstrap procedures at the firm level.

Several additional estimators address endogeneity and persistence. A dynamic panel specification includes the lagged dependent variable to account for valuation persistence. A control-function model uses lagged regional engineering labor tightness and industry-level disclosure seasonality as shifters of innovation timing costs and salience. The identifying idea is that changes in local specialized labor tightness and disclosure seasonality may influence how firms sequence innovation work without directly determining the focal firm's next-year valuation after fixed effects and the full control set. These procedures do not eliminate all concern about endogeneity, but they materially reduce the likelihood that the main results are driven by omitted stable traits or purely contemporaneous anticipation.

5. Results

The baseline regressions show that innovation rhythm fit is positively associated with next-year Tobin's Q. In the main firm and year fixed-effects specification, the coefficient on rhythm fit is 0.118 with a clustered standard error of 0.039 (31). The corresponding estimate is statistically distinguishable from zero

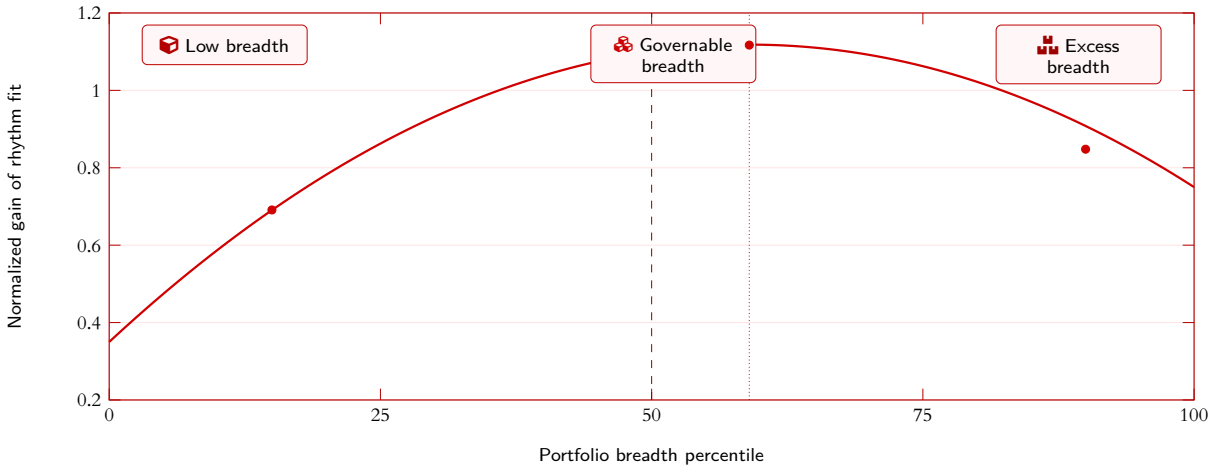

Figure 8. Moderation by portfolio breadth. This curve is a normalized visual rendering of the reported positive linear and negative squared interaction between rhythm fit and breadth. The gain from rhythm fit rises from low to moderate breadth, peaks slightly above the sample median, and then softens once breadth becomes very large. The vertical guides mark the sample median and the approximate turning point described in the results.

and economically moderate. Moving from the first quartile to the third quartile of rhythm fit is associated with a 5.9% increase in next-year firm value, holding innovation intensity and other controls constant. Innovation intensity itself is also positive, but its coefficient is smaller and less stable across alternative specifications. This difference is noteworthy because it suggests that the timing and composition of innovation matter beyond how much innovation the firm generates in aggregate.

The new product revenue share regressions yield a similar pattern. Rhythm fit carries a coefficient of 0.023 in the preferred specification, implying that firms with more fitted innovation rhythms derive a meaningfully greater fraction of their subsequent revenue from recently introduced products (32). The magnitude is not extreme. A one-standard-deviation increase in rhythm fit predicts approximately 1.6 percentage points higher next-year new product revenue share, and the interquartile movement corresponds to roughly 2.3 percentage points. In industries where annual new product revenue shares are often in the low double digits, this is not trivial, yet it remains well within a plausible range. The result indicates that rhythm fit is tied to commercialization outcomes rather than merely to financial market sentiment.

The volatility models provide additional evidence. Rhythm fit is negatively associated with next-year idiosyncratic stock return volatility, with a coefficient of -0.017. This suggests that firms exhibiting more fitted timing and compositional balance face slightly lower firm-specific uncertainty in capital markets. The magnitude should not be overstated. Rhythm fit does not transform risky innovators into safe utilities. Instead, it appears to reduce one portion of uncertainty associated with episodic or poorly staged innovation behavior (33). The pattern is consistent with the interpretive argument developed earlier: when innovative activity appears more deliberately paced, outside audiences may assign less firm-specific noise to the future stream of innovation-based outcomes.

Moderation by portfolio breadth reveals a nonmonotonic pattern. The linear interaction between rhythm fit and breadth is positive, while the squared interaction is negative. The estimates indicate that the gains from rhythm fit become stronger as breadth rises from low to moderate levels, but begin to flatten and then weaken at high levels of breadth (34). The turning point lies slightly above the sample median. Substantively, this means that rhythm fit benefits from a reasonably broad search space because breadth supports recombination and reduces dependence on a single innovation channel. However, once breadth becomes very large, the pacing advantages of rhythm fit are partly offset by the integrative strain of coordinating across too many domains. The result fits the theoretical expectation that governable variety is beneficial, while excessive dispersion can dilute temporal discipline.

Competition exhibits a similar inverted pattern. The linear interaction of rhythm fit and competition is positive and the squared interaction negative. The strongest gains from rhythm fit occur under moderate competitive pressure. When competition is weak, timing fit matters less because firms can afford slower adjustment and can appropriate returns even with relatively loose innovation sequencing. When competition is intense, the returns to fitted rhythm diminish because appropriation becomes harder and rivals compress the duration of advantage. In the middle range, fitted innovation rhythm seems especially beneficial because it helps firms update and commercialize quickly enough to matter while still preserving a meaningful portion of the resulting value.

The mediation analysis supports commercialization efficiency as one meaningful channel. Rhythm fit is positively associated with next-year commercialization efficiency, with a coefficient of 0.102. Commercialization efficiency, in turn, is positively associated with both firm value and new product revenue share after rhythm fit remains in the model. The bootstrapped indirect effect on firm value is 0.021, and the indirect effect on new product revenue share is 0.006 (35). These estimates suggest that roughly one-fifth of the total firm-value effect

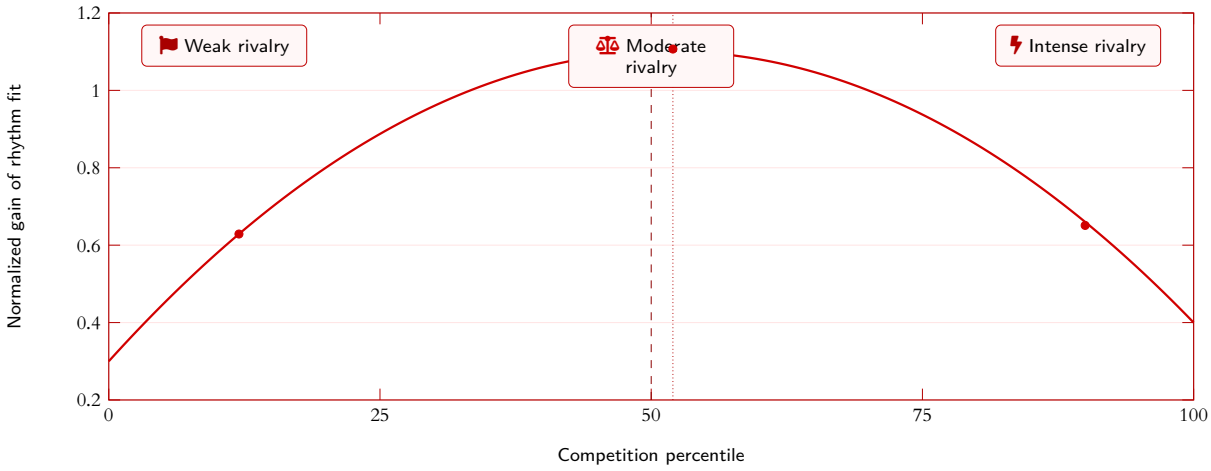

Figure 9. Moderation by competitive pressure. The plot visualizes the reported inverted-U pattern: rhythm fit contributes less when competition is very weak, peaks under moderate competition, and then loses force once rivalry becomes intense enough to compress appropriation and shorten the duration of advantage. The levels are normalized to represent the reported shape rather than a separately re-estimated marginal-effects schedule.

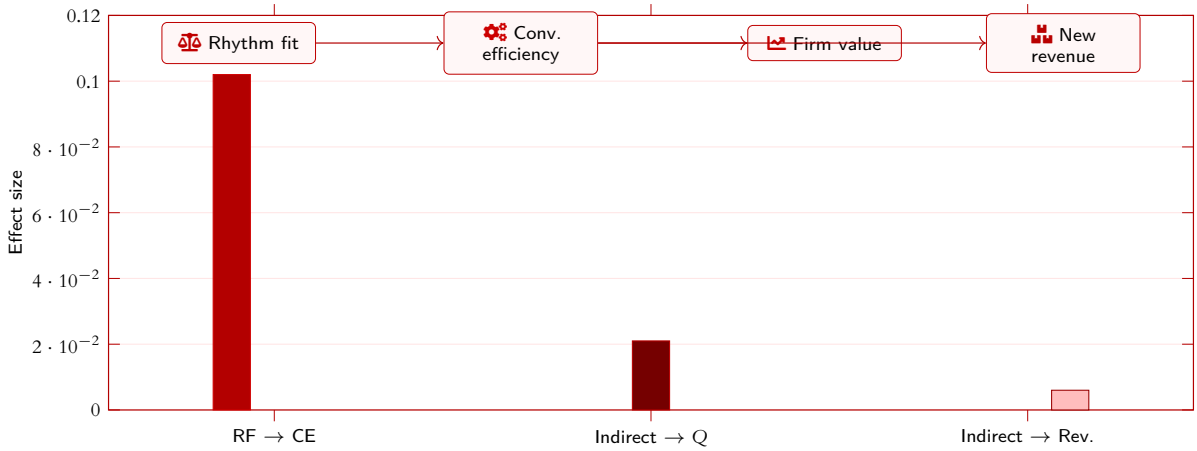

Figure 10. Mediation through commercialization efficiency. The bars report the first-stage coefficient of rhythm fit on next-year commercialization efficiency (0.102), together with the bootstrapped indirect effects on firm value (0.021) and new-product revenue share (0.006). The path sketch emphasizes that conversion efficiency explains a meaningful but partial share of the total effect, leaving room for additional channels such as interpretive credibility and lower expectation instability.

and slightly more than one-quarter of the product-revenue effect operate through improved conversion of innovation effort into market-facing output. The remainder likely reflects interpretive credibility, expectation stability, and improved project selection beyond what the mediator captures.

The dynamic panel results leave the main picture largely intact. After including the lagged dependent variable in a system-GMM estimator, rhythm fit continues to exhibit a positive relation with future firm value, though the coefficient falls somewhat to 0.094 (36). The persistence parameter on firm value is strong, as expected, which makes the remaining rhythm-fit effect more difficult to obtain by chance. The Hansen and serial-correlation tests do not indicate obvious specification failure. The control-function estimates tell a similar story. The residual term from the first-stage rhythm-fit equation is small and statistically unstable, while the rhythm-fit coefficient remains positive and comparable to the fixed-effects estimate. Together these results suggest that the baseline findings are not likely to be driven entirely by reverse causality or omitted stable traits.

To probe economic interpretation more deeply, the rhythm-fit index was decomposed into compositional fit and pacing fit. Both are positively associated with firm value, but compositional fit is somewhat stronger. This indicates that matching the exploration-exploitation mix to the environment matters slightly more than smooth staging alone (37). Nevertheless, pacing fit remains independently informative, especially for new product revenue share. The decomposition implies that innovation tempo and innovation mix are complementary rather than interchangeable. Firms seem to benefit when they not only choose an appropriate innovation composition, but also release and renew in a staged pattern that the organization can absorb.

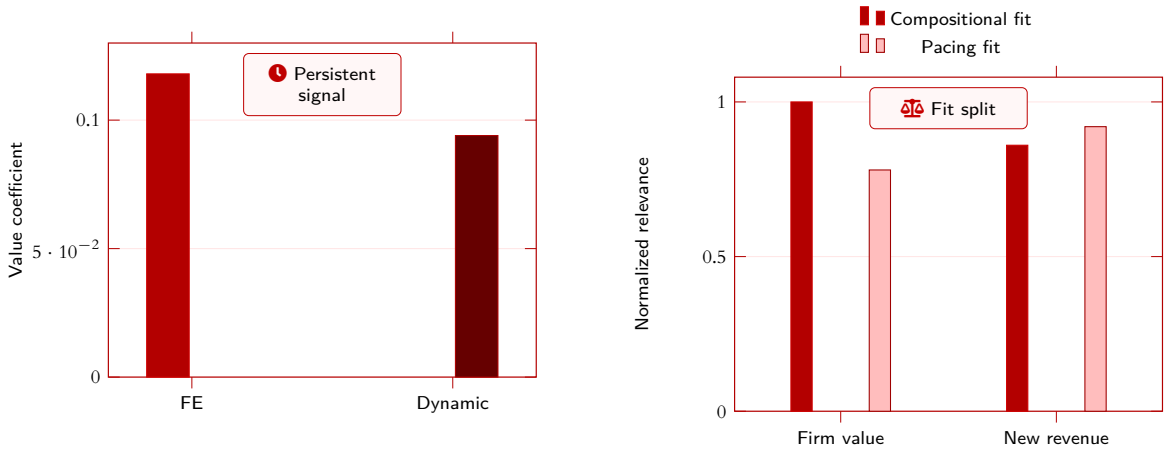

Figure 11. Persistence and decomposition. The left panel shows that the value effect remains positive after dynamic adjustment, though it attenuates from 0.118 in the baseline fixed-effects model to 0.094 in the system-GMM specification. The right panel is a normalized visual summary of the decomposition result: compositional fit is somewhat stronger overall, while pacing fit remains independently informative and is especially salient for new-product revenue share.

The market-facing interpretation of the results receives further support from an additional analysis of abnormal returns around major innovation-related announcements. Firms in the upper half of rhythm fit receive somewhat more favorable market responses to major launch and technology announcements than firms in the lower half, after controlling for announcement type and firm characteristics. The difference is modest, yet consistent. This pattern resonates with the logic that investor response depends on whether innovation signals appear embedded in a broader credible process. Cao et al. (2024a) (38) show that investors react more favorably to marketing ideation crowdsourcing contests when the contest design signals stronger knowledge generation and relational engagement. The present evidence is analogous in spirit. Innovation events appear to be interpreted more favorably when they are situated within a fitted and legible temporal pattern rather than an episodic one.

6. Robustness and Additional Analyses

A series of additional checks were conducted to assess whether the main findings were sensitive to measurement or specification choices. First, the rhythm-fit index was reconstructed using alternative weights for exploratory and exploitative components, alternative definitions of breakthrough launches, and alternative standardizations of pacing variance. Across these variants, the direction and approximate magnitude of the main effect remained stable. The coefficient on rhythm fit in the firm-value model ranged from 0.101 to 0.126 across the alternative definitions. This range suggests that the central result does not hinge on one narrow operationalization of innovation rhythm.

Second, alternative outcome windows were estimated. When new product revenue share was measured over a two-year forward window rather than a one-year window, the rhythm-fit effect remained positive but attenuated slightly. When firm value was measured contemporaneously rather than at t 1, the coefficient became somewhat larger, which is plausible because contemporaneous specifications may absorb a portion of immediate market interpretation. The choice to emphasize one-year-ahead outcomes in the main analysis is therefore conservative. It prioritizes temporal sequencing and reduces the risk that rhythm fit simply proxies for the market's same-period response to managerial communication.

Third, matched-sample comparisons were constructed. Firms in the top tercile of rhythm fit were matched to firms in the bottom tercile on size, age, leverage, profitability, innovation intensity, and industry-year. In the matched sample, high-rhythm-fit firms still exhibited higher next-year Tobin's Q and higher new product revenue share. The magnitudes were somewhat smaller than in the full fixed-effects models, which is expected once the comparison set is compressed, but the differences remained meaningful. This exercise is useful because it compares firms with similar scale and innovation volume but different temporal and compositional organization.

Fourth, placebo tests were used to distinguish rhythm fit from general managerial steadiness. A placebo index was created from the temporal regularity of non-innovation corporate events such as governance announcements, routine financing notices, and ordinary operational updates. That placebo measure showed little systematic relationship with the focal outcomes. A second placebo based solely on the regularity of innovation wording in annual reports likewise exhibited unstable and weak coefficients. These results indicate that the main findings are unlikely to be explained simply by firms that communicate more evenly or produce more regularly scheduled announcements in general (39). The relevant feature appears to be the fitted organization of innovative activity itself.

An additional analysis examined whether the effect of rhythm fit differed across firms with stronger or weaker environmental innovation profiles. The positive relation remained present in both groups, but was modestly larger among firms with stronger environmental innovation activity. This pattern is plausible because such firms must often coordinate technological development, stakeholder expectations, and regulatory

timing simultaneously, making rhythm fit especially valuable. Another split by analyst coverage showed somewhat stronger valuation effects among highly followed firms, suggesting that temporal legibility matters more when the firm is subject to more continuous outside scrutiny.

Finally, the possibility that acquisitions mechanically generate both broad portfolios and more frequent launches was considered carefully. After excluding firm-years with major acquisitions or adding finer controls for acquisition intensity and integration spending, the main results were materially unchanged (40). This helps reduce the concern that the rhythm-fit effect merely captures acquisitive firms that buy rather than build innovation (41). The evidence instead points toward a pattern rooted in how firms sequence and balance their own innovation efforts across time.

7. Discussion

The results suggest a different way of thinking about innovation performance. Many studies ask whether more innovation is associated with higher value. The present analysis indicates that this question is incomplete because it ignores how innovation is organized over time. Firms appear to benefit when their exploratory and exploitative activities are not only substantial, but also adapted to the volatility and heterogeneity of their markets and paced in a way that the organization can absorb. The advantage of rhythm fit is visible in both market valuation and new product revenue contribution, which indicates that the effect is not purely financial-market symbolism (42).

The findings also sharpen the distinction between breadth and timing. Broad portfolios are often treated as inherently beneficial because they enable recombination and reduce dependence on a single path (43). Yet the data suggest that breadth is most helpful when it remains governable. Rhythm fit becomes more valuable as breadth rises from low to moderate levels, but the benefit weakens when breadth grows too large. This matters because firms frequently respond to uncertainty by widening the search portfolio, even when internal coordination routines are not prepared for such dispersion. The evidence presented here suggests that breadth without fitted pacing may be less productive than a moderately broad portfolio managed with more deliberate timing.

Another implication concerns how managers stage innovative activity. The empirical pattern does not reward constant activity for its own sake. It rewards a rhythm that is adapted to conditions. A firm in a stable environment need not force a relentless stream of exploratory moves merely to appear dynamic. A firm in a turbulent environment should not rely too heavily on long product cycles and sparse renewal intervals simply because those patterns are operationally comfortable. Rhythm fit therefore offers a more contingent normative guide. It implies that managers should calibrate the exploration share and the pacing of launches to both the opportunity structure of the market and the conversion capacity of the organization.

There is also a governance implication (44). Boards and investors frequently evaluate innovation using annual spending, patent totals, or showcase launches. Those indicators remain useful, but they may miss whether the innovation system is temporally disciplined. A board observing high inventive volume should still ask whether innovation is arriving in surges that overload downstream functions or whether exploratory initiatives are crowding out systematic exploitation (45). Likewise, investors assessing firm quality may need to consider whether repeated innovation signals represent a durable rhythm or a succession of disconnected events. The present results suggest that the distinction is meaningful and may help explain why firms with similar levels of innovative effort can produce noticeably different economic outcomes.

8. Conclusion

This study examined whether firms benefit from organizing innovation with a rhythm that fits market conditions rather than merely maximizing innovation intensity. The central finding is that innovation rhythm fit, defined by the correspondence between the exploration-exploitation mix and environmental demands together with the pacing of innovation activity across time, is positively associated with next-year firm value and the share of revenue derived from recently introduced products. It is also associated with lower idiosyncratic stock return volatility. These effects remain after accounting for innovation intensity, firm fixed effects, year effects, and a broad set of controls.

A further contribution is the demonstration that commercialization efficiency explains part of the observed association. Firms with more fitted innovation rhythms appear better able to convert their innovative effort into market-facing output. This suggests that rhythm fit is not only a matter of how outsiders interpret the firm. It is also a matter of how the organization sequences work internally. Better-timed innovation reduces congestion, supports more selective project progression, and improves the coordination of launch-related activities across functions.

The study also qualifies the conditions under which rhythm fit is most useful. Its gains are strongest when portfolio breadth is substantial but not excessive and when competition is moderate rather than weak or extreme. These contingent findings matter because they caution against universal prescriptions. Neither intense specialization nor indiscriminate breadth emerges as a general solution. Likewise, neither relentless exploratory pressure nor heavy reliance on incrementalism appears uniformly desirable. What matters is the fitted relationship between innovation composition, innovation tempo, and the firm's context.

Several limitations remain. The analysis is confined to public firms in sectors where innovation data are comparatively visible, so the findings may not map directly onto private firms or very young ventures. The product revenue measure, while carefully assembled, necessarily relies on partial public disclosure in some cases. The adaptive target for exploration share is also modeled rather than observed directly, which means that some part of the estimated fit measure reflects theoretically guided approximation. These limits suggest that future work could benefit from project-level internal data and richer process tracing.

Even with these qualifications, the results point toward a

useful shift in emphasis. Innovation should be evaluated not only by how much inventive activity firms undertake, but also by whether that activity unfolds in a rhythm that matches strategic conditions and organizational capacity. Firms do not appear to be rewarded simply for innovating more (46). They are rewarded, more modestly but consistently, for innovating with a pattern that is adaptive, legible, and commercially absorbable.

References

[1] P. J. Buckley and M. Casson, "The internalization theory of the multinational enterprise: Past, present and future," *British Journal of Management*, vol. 31, pp. 239–252, 1 2019.

[2] H. E. Aldrich, "Who wants to be an evolutionary theorist?: Remarks on the occasion of the year 2000 omt distinguished scholarly career award presentation," *Journal of Management Inquiry*, vol. 10, pp. 115–127, 6 2001.

[3] U. Stephan, M. Patterson, C. Kelly, and J. Mair, "Organizations driving positive social change a review and an integrative framework of change processes," *Journal of Management*, vol. 42, pp. 1250–1281, 2 2016.

[4] 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.

[5] A. Jiménez, F. F. Mtango, and S. Cairncross, "What role for local government in sanitation promotion? lessons from tanzania," *Water Policy*, vol. 16, pp. 1104–1120, 5 2014.

[6] M. Sud, C. V. VanSandt, and A. M. Baugous, "Social entrepreneurship: The role of institutions," *Journal of Business Ethics*, vol. 85, pp. 201–216, 9 2008.

[7] L. Pinto, "A qualitative analysis of corporate social responsibility in saudi arabia's service sector-practices and company performance," *Sustainability*, vol. 15, pp. 9284–9284, 6 2023.

[8] F. Haleem, "Planning change in an organization; mcb bank limited, pakistan," *Journal of Central Banking Theory and Practice*, vol. 4, pp. 75–107, 5 2015.

[9] J. Wiklund, H. Patzelt, and D. A. Shepherd, "Building an integrative model of small business growth," *Small Business Economics*, vol. 32, pp. 351–374, 12 2007.

[10] 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.

[11] X. Xiang, G. Yang, and H. Sun, "The impact of the digital economy on low-carbon, inclusive growth: Promoting or restraining," *Sustainability*, vol. 14, pp. 7187–7187, 6 2022.

[12] R. Hanage, J. M. Scott, and M. A. P. Davies, "From "great expectations" to "hard times": A longitudinal study of creative graduate new ventures," *International Journal of Entrepreneurial Behavior & Research*, vol. 22, pp. 17–38, 3 2016.

[13] A. V. D. Massis, J. Kotlar, F. Frattini, J. J. Chrisman, and M. Nordqvist, "Family governance at work: Organizing for new product development in family smes," *Family Business Review*, vol. 29, pp. 189–213, 1 2016.

[14] A. Gunasekaran, N. Subramanian, and S. Rahman, "Supply chain resilience: role of complexities and strategies," *International Journal of Production Research*, vol. 53, pp. 6809–6819, 11 2015.

[15] A. M. Fadeev, S. S. Vopilovskiy, S. V. Fedoseev, K. S. Zaikov, N. M. Kuprikov, M. Y. Kuprikov, and N. S. Avdonina, "Industrial support of the energy projects as a part of the blue economy development in the arctic," *Sustainability*, vol. 14, pp. 15346–15346, 11 2022.

[16] V. Bamiatzi, S. Jones, S. Mitchelmore, and K. Nikolopoulos, "The role of competencies in shaping the leadership style of female entrepreneurs: The case of north west of england, yorkshire, and north wales," *Journal of Small Business Management*, vol. 53, pp. 627–644, 7 2015.

[17] L. Galloway and D. Refai, "Introduction to volume 22 of international journal of entrepreneurship and innovation," *The International Journal of Entrepreneurship and Innovation*, vol. 22, pp. 3–4, 2 2021.

[18] B. Bird, H. Welsch, J. H. Astrachan, and D. Pistrui, "Family business research: The evolution of an academic field:," *Family Business Review*, vol. 15, pp. 337–350, 12 2002.

[19] A. Adamik, V. M. Ghinea, M. Ghinea, and M. Nowicki, "Mapping the maturity of smart world trends as a tool for developing business excellence and reducing organizational complexity," *Management & Marketing. Challenges for the Knowledge Society*, vol. 17, pp. 193–219, 6 2022.

[20] L. Craiut, C. Bungau, T. Bungau, C. Grava, P. Otrisal, and A.-F. Radu, "Technology transfer, sustainability, and development, worldwide and in romania," *Sustainability*, vol. 14, pp. 15728–15728, 11 2022.

[21] M. Dabić, J. Maley, L. P. Dana, I. Novak, M. M. Pellegrini, and A. Caputo, "Pathways of sme internationalization: a bibliometric and systematic review," *Small Business Economics*, vol. 55, pp. 705–725, 6 2019.

[22] A. M. Dy, L. Martin, and S. Marlow, "Emancipation through digital entrepreneurship? a critical realist analysis," *Organization*, vol. 25, pp. 585–608, 6 2018.

[23] J. Strengers, L. Mutsaers, L. van Rossum, and E. Graamans, "The organizational culture of scale-ups and performance," *Journal of Organizational Change Management*, vol. 35, pp. 115–130, 9 2022.

[24] S. Abaddi, "A novel framework for analyzing the impact of covid-19 on entrepreneurial financial firms in jordan," *Journal of Entrepreneurship and Public Policy*, vol. 13, pp. 414–440, 5 2024.

[25] 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.

[26] D. Rae and N. R. Woodier-Harris, "International entrepreneurship education: Postgraduate business student experiences of entrepreneurship education," *Education + Training*, vol. 54, pp. 639–656, 11 2012.

[27] G. D'Amico, K. Szopik-Depczyńska, R. Beltramo, I. D'Adamo, and G. Ioppolo, "Smart and sustainable bioeconomy platform: A new approach towards sustainability," *Sustainability*, vol. 14, pp. 466–466, 1 2022.

[28] A. Newman, C. Neesham, G. Manville, and H. H. M. Tse, "Examining the influence of servant and entrepreneurial leadership on the work outcomes of employees in social enterprises," *The International Journal of Human Resource Management*, vol. 29, pp. 2905–2926, 7 2017.

[29] C. Albert, A. Caggese, B. González, and V. Martin-Sanchez, "Income inequality and entrepreneurship: Lessons from the 2020 covid-19 recession.," *Journal of banking & finance*, vol. 149, pp. 106779–106779, 1 2023.

[30] O. Ogundana, A. Simba, L. P. Dana, and E. W. Liguori, "Women entrepreneurship in developing economies: a gender-based growth model," *Journal of Small Business Management*, vol. 59, pp. S42–S72, 7 2021.

[31] S. B. Choi and C. Williams, "Entrepreneurial orientation and performance: mediating effects of technology and marketing action across industry types," *Industry and Innovation*, vol. 23, pp. 673–693, 7 2016.

[32] T. F. Ramukhithi, K. A. Nephawe, T. J. Mpofu, T. Raphulu, K. Munhuweyi, F. V. Ramukhithi, and B. Mtileni, "An assessment of economic sustainability and efficiency in small-scale broiler farms in limpopo province: A review," *Sustainability*, vol. 15, pp. 2030–2030, 1 2023.

[33] M. M. Tun and D. Juchelková, "A preliminary approach toward development of the tvet research and development (r & d) sector for sustainable development in myanmar," *Sustainability*, vol. 14, pp. 5474–5474, 5 2022.

[34] C. Forliano, L. B. Orlandi, A. Zardini, and C. Rossignoli, "Technological orientation and organizational resilience to covid-19: The mediating role of strategy's digital maturity.," *Technological forecasting and social change*, vol. 188, pp. 122288–122288, 12 2022.

[35] H. L. Smith, D. Chapman, P. R. Wood, T. Barnes, and S. Romeo, "Entrepreneurial academics and regional innovation systems: The case of spin-offs from london's universities," *Environment and Planning C: Government and Policy*, vol. 32, pp. 341–359, 1 2014.

[36] M. A. Roomi and G. Parrott, "Barriers to development and progression of women entrepreneurs in pakistan," *The Journal of Entrepreneurship*, vol. 17, pp. 59–72, 5 2008.

[37] N. Arshed, S. Carter, and C. Mason, "The ineffectiveness of entrepreneurship policy: is policy formulation to blame?," *Small Business Economics*, vol. 43, pp. 639–659, 2 2014.

[38] 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.

[39] M. Crescimanno, C. Mirabella, V. Borsellino, E. Schimmenti, D. Vrontis, S. Tinervia, and A. Galati, "How organizational resources and managerial features affect business performance: An analysis in the greek wine industry," *Sustainability*, vol. 15, pp. 3522–3522, 2 2023.

[40] D. de Lange, "Sustainable transportation for the climate: How do transportation firms engage in cooperative public-private partnerships?," *Sustainability*, vol. 15, pp. 8682–8682, 5 2023.

[41] M. Fahreza, D. T. Alamanda, U. Zuhdi, G. Anggadwita, D. M. Kurniati, and E. S. Soegoto, "Enhancing startup business performance through iterative strategies and lean programs: Insights from capital cities in indonesia to unlock central asia's potential," *Australasian Accounting, Business and Finance Journal*, vol. 18, 10 2024.

[42] Z. Zhu and H. Xie, "What do we know and what do we need to know about covid-19's implications on business economics? from bibliometric analysis to a conceptual framework," *Sustainability*, vol. 14, pp. 6396–6396, 5 2022.

[43] R. Brown and S. Mawson, "The geography of job creation in high growth firms: The implications of 'growing abroad'," *Environment and Planning C: Government and Policy*, vol. 34, pp. 207–227, 11 2015.

[44] I. Grabel, "The rebranding of capital controls in an era of productive incoherence," *Review of International Political Economy*, vol. 22, pp. 7–43, 1 2014.

[45] C. Williams and S. van Triest, "Product launch performance in hi-tech smes: Newness to the firm and the role of management controls," *International Journal of Innovation Management*, vol. 21, pp. 1750022–, 3 2017.

[46] N. K. Kakabadse, A. Tatli, K. Nicolopoulou, A. Tankibayeva, and N. Mouraviev, "A gender perspective on entrepreneurial leadership: female leaders in kazakhstan," *European Management Review*, vol. 15, pp. 155–170, 8 2017.