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-RESEARCH ARTICLE-

R&D DISCLOSURE PATTERNS AND INDUSTRY ANALYSIS: A COMPREHENSIVE STUDY OF THAI LISTED COMPANIES

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─Abstract─

This study investigates patterns of research and development (R&D) disclosure among firms included in the SET 100 Index of the Stock Exchange of Thailand through a content analysis of annual reports (Form 56-1). The sample comprises 76 listed companies observed over the period 2019–2021, yielding 228 firm-year observations. Disclosure quality is assessed using a multidimensional R&D Disclosure Score (RDS) ranging from 0 to 9, encompassing three disclosure domains: research activities, development activities, and integrated R&D reporting. Reliability testing demonstrates strong consistency between evaluators, with Cohen's κ values of 0.85 for binary coding and 0.81 for sub-score assessments. To examine determinants of disclosure quality, Ordered Logistic Regression is employed while controlling for firm size, leverage,

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profitability, market-to-book ratio, and board independence. The findings indicate that industry affiliation exerts a significant influence on disclosure practices (Nagelkerke $R^2 = 0.18$, $p < 0.01$). Although the vast majority of firms (92.1%) provide at least some R&D-related information, only 49.1% achieve a comprehensive level of disclosure. Statistically significant variation is observed across industries ($\chi^2 = 15.8$, $p < 0.05$), with companies operating in the Industrials and Agro & Food sectors exhibiting substantially higher disclosure levels than those within the Services sector. The results further reveal a progressive enhancement in reporting quality over time, as the proportion of firms providing comprehensive disclosure increased from 46.1% in 2019 to 53.9% in 2021 ($p < 0.01$). Among the various disclosure categories, research expenditure is reported most frequently (71.9%), followed by development expenditure (65.8%) and combined R&D information (57.0%). This pattern aligns with the expectations of Signalling Theory, which suggests that organisations are more willing to disclose information perceived as less strategically sensitive. Nevertheless, the findings also demonstrate that disclosure behaviour cannot be fully explained by Signalling Theory alone. Differences in governance quality and institutional policy environments appear to contribute materially to reporting practices, indicating that R&D disclosure within the Thai capital market is shaped by broader institutional influences. The validated RDS framework and the baseline evidence established in this study provide a foundation for future investigations linking disclosure practices to capital market consequences and may assist in the development of governance-oriented disclosure frameworks across emerging ASEAN economies.

Keywords: R&D Disclosure, Industry Analysis, Stock Exchange of Thailand, SET 100, Thailand 4.0 policy.

INTRODUCTION

The volume of corporate investment devoted to R&D has attracted considerable scholarly attention. Far less attention, however, has been directed towards the manner in which such activities are communicated to external stakeholders. This study addresses that omission. At the organisational level, R&D expenditure constitutes a critical mechanism through which firms generate innovation, develop new products, and sustain long-term competitive positioning (He & Estébanez, 2023; Kim & Choi, 2020). At the macroeconomic level, evidence from both OECD economies and US states demonstrates that R&D intensity is strongly associated with productivity enhancement and economic growth (Blanco, 2013; Ugur et al., 2016). Yet substantial investment alone does not guarantee transparency. The extent to which firms disclose information concerning these activities remains an important issue, particularly given its implications for investor decision-making and capital allocation efficiency.

In pursuit of a transition towards an innovation-driven economy, Thailand introduced the Thailand 4.0 initiative in 2016, aiming to move beyond an efficiency-based growth

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model (Potjanajaruwit & Girdwichai, 2019). The strategy identified ten priority industries distributed across two development tiers and placed innovation at the centre of national economic policy. Progress in this regard is reflected in national expenditure figures, with total R&D investment reaching 208 billion baht by 2021, of which private-sector organisations accounted for approximately 68% (National Higher Education, 2022). For external stakeholders, annual reports represent one of the principal sources through which information on innovation-related activities becomes observable.

Within the framework of Signalling Theory, Spence (1973) argues that organisations possessing superior underlying quality have incentives to disclose information that differentiates them from less capable counterparts. Applied to R&D activities, this perspective suggests that firms with stronger innovation capabilities are more likely to provide extensive disclosure because the reputational and informational benefits exceed associated reporting costs. Subsequent contributions by Ross (1977) and Franke (1987) adapted these arguments to financial reporting environments, with Franke further proposing that disclosure may impose minimal costs when the information disclosed can be independently verified.

Despite the growing policy emphasis on innovation, existing research within the Thai context has concentrated predominantly on aggregate R&D expenditure rather than the content and quality of corporate R&D reporting. Consequently, important questions concerning disclosure behaviour remain insufficiently explored. This study seeks to address that deficiency by examining four key issues: first, the prevailing characteristics of R&D disclosure among firms included in the SET 100 Index; second, whether disclosure practices vary systematically across industrial sectors; third, whether reporting patterns changed during the 2019–2021 period; and fourth, which governance mechanisms appear to be associated with higher-quality disclosure outcomes. The selected timeframe is particularly informative because it encompasses both the implementation phase of the Thailand 4.0 policy agenda and the disruptive effects of the COVID-19 pandemic, thereby providing a quasi-experimental setting in which competing incentives affecting voluntary disclosure can be observed.

Research Hypotheses

Drawing on the three theoretical perspectives above, the study tests five hypotheses:

H1: *R&D disclosure levels differ across industry groups, with innovation-intensive sectors scoring higher than service-oriented ones.*
H2: *Disclosure improved between 2019 and 2021, consistent with coercive isomorphic pressure from the Thailand 4.0 policy environment.*
H3: *Industry membership predicts disclosure depth after controlling for firm size, leverage, profitability, market-to-book ratio, and governance quality.*

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H4: *Board independence is positively associated with R&D disclosure depth, consistent with Agency Theory's monitoring argument.*
H5: *Research expenditure is more widely disclosed than development or combined R&D expenditure, reflecting firms' preference for less competitively sensitive signals.*

LITERATURE REVIEW

Theoretical Foundations

The principal theoretical lens underpinning this study is ST as originally formulated by Spence (1973). The theory addresses situations characterised by information asymmetry, where external stakeholders possess less information than organisational insiders regarding firm quality. Within such environments, disclosure functions as a signalling mechanism through which high-quality firms distinguish themselves from lower-quality competitors. Because credible signals are inherently more difficult or costly for weaker firms to replicate, organisations possessing genuinely valuable R&D capabilities are expected to engage more actively in disclosure activities.

The signalling perspective was subsequently extended beyond labour-market contexts. Ross (1977) demonstrated its applicability to corporate financial decisions, arguing that firms can communicate underlying quality through observable strategic choices. Further theoretical refinement was provided by Franke (1987), who suggested that signalling may not necessarily entail substantial direct costs when disclosed information is verifiable and can be independently validated by market participants. Collectively, these contributions imply that firms with stronger innovation capabilities and more substantial R&D activities should have greater incentives to communicate such information to external stakeholders. Consequently, ST predicts that innovation-oriented organisations will exhibit both higher levels of R&D disclosure and more comprehensive reporting practices relative to less innovation-intensive firms.

Agency Theory and Disclosure Incentives

Agency Theory Jensen and Meckling (1976) offers a complementary framework by conceptualising R&D disclosure as a monitoring device that mitigates information asymmetry between principals (shareholders) and agents (managers). A higher proportion of independent directors on the board increases both the incentive and authority to demand more transparent reporting of R&D activities, as independence limits managerial ability to withhold adverse project information. The positive and statistically significant coefficient for board independence ($\beta = 0.71$, $p < 0.05$, Table 6) aligns with this interpretation, although the cross-sectional research design restricts causal inference.

Institutional Theory and Isomorphic Pressures

Institutional Theory DiMaggio and Powell (1983) provides a third explanatory

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dimension, arguing that organisations operating under shared regulatory frameworks, professional norms, and peer influences tend to converge on similar practices, a process they term isomorphism. In Thailand, the 4.0 policy generates what DiMaggio and Powell (1983) describe as coercive pressure, whereby regulatory incentives increase the cost of non-disclosure. Concurrently, the industry-level clustering observed in the results—where Industrials and Consumer Products remain consistently above Services—aligns more closely with mimetic isomorphism, in which firms imitate the disclosure practices of peer organisations. The significant Year 2021 fixed effect ($\beta = 0.29$, $p < 0.05$) may reflect a temporal manifestation of such coercive pressure, although the concurrent impact of COVID-19 complicates clear interpretation.

Financial Reporting Theory and Voluntary Disclosure

Kim et al. (2021) conceptualise voluntary disclosure as a joint optimisation problem balancing information quality against direct disclosure costs, with disclosure occurring only when net benefits are positive. In the context of R&D, this implies that signalling advantages must exceed the potential competitive risk of revealing project-level information to rivals. Libgober et al. (2023) extend this framework by introducing the role of perceived credibility of external information, demonstrating that firms' disclosure decisions are also influenced by the extent to which they seek to pre-empt or respond to information already available in external environments.

Importance of R&D Disclosure

R&D disclosure is relevant to stakeholders across several dimensions. Investor demand for information on R&D activities is well established. Mazzi et al. (2019) report, based on a multi-market stakeholder survey, that investors place strong value on R&D disclosures when evaluating growth potential in innovation-driven sectors. From an accounting perspective, Canace et al. (2022) demonstrate that the recognition and measurement of R&D expenditure significantly affect earnings quality and asset valuation, thereby increasing the importance of voluntary disclosure quality in contexts where mandatory recognition requirements are limited.

Previous Studies and Industry Analysis

Cross-market evidence indicates considerable variation in R&D disclosure practices. In China's pharmaceutical sector, Cai (2023) finds pronounced differences between domestic and foreign-listed firms, with the latter providing substantially more detailed disclosure. Chu et al. (2024) further report that higher disclosure quality is associated with improved financial performance, with effects persisting over multiple years. Industry context also influences the extent to which firms are able to disclose credibly. Arrow (1962)provides the theoretical foundation by arguing that R&D appropriability differs across sectors, implying that industries with stronger intellectual property protection incur lower competitive risk from disclosure. Andras and Srinivasan (2003)

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offers empirical support for this distinction in comparisons between manufacturing and consumer goods industries. Evidence from Thailand remains limited. Mongkolserm and Gatewongsa (2021) extends this evidence to MAI-listed firms, reporting a positive relationship between disclosure and shareholder returns. This motivates the present study's focus on disclosure depth rather than simple disclosure occurrence.

Thailand 4.0 Policy Impact

Launched in 2016, the Thailand 4.0 strategy seeks to transition the national economy from an efficiency-driven growth model to one centred on innovation-led development (Boonmatat, 2019). The policy operates through mechanisms including tax incentives for R&D activities, investment in science and technology human capital, and a cluster-based industrial targeting framework. Potjanajaruwit and Girdwichai (2019) observe that Thai start-ups exhibited an increased emphasis on innovation following the policy's introduction, although it remains uncertain whether this shift is attributable to the policy itself or to broader global technological developments occurring concurrently.

RESEARCH METHODOLOGY

Population and Sample

The study population comprises the SET 100 Index, which includes the 100 largest companies by market capitalisation listed on the Stock Exchange of Thailand (SET). This index is selected because it accounts for approximately 70–80% of total market capitalisation and contains firms with the highest levels of analyst coverage, alongside the most comprehensive governance and financial reporting data within a single, manageable sample frame. From the full SET 100 universe, three groups of firms are excluded: financial institutions (due to their distinct regulatory regime), companies undergoing rehabilitation, and fund-type entities. Following these exclusion criteria, the final sample consists of 76 firms distributed across seven industry groups. These firms are observed on an annual basis over the 2019–2021 period, producing a total of 228 firm-year observations.

The resulting sample is derived from systematic exclusions applied to a clearly defined population of 100 firms, rather than a convenience-based selection. As constituents of the SET 100, these companies represent the most governance-intensive and data-rich segment of the Thai capital market, making them suitable for an initial baseline analysis. The 228 firm-year observations (76 firms over three years) provide an adequate basis for the Ordered Logistic Regression (OLR) models with fixed effects employed in this study, although greater statistical power would be achievable through extension to MAI-listed firms and a longer observation period, which are identified as directions for future research.

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As shown in Table 1, the final sample of 76 firms is distributed across seven industry groups. The Services sector forms the largest component, with 25 firms (32.9%), followed by Resources with 20 firms (26.3%); together, these two sectors comprise almost 60% of the sample, broadly reflecting the sectoral structure of the wider SET 100. Property & Construction accounts for 14 firms (18.4%), while Technology (7 firms), Agro & Food Industry (5 firms), and Industrials (4 firms) collectively represent a further 21.1% of the sample. Consumer Products is represented by a single firm (1.3%). This single observation results in complete separation in the ordered logistic regression models and is therefore excluded from all OLR estimations, although it is retained in the descriptive statistics for completeness.

Table 1: Sample Classification by Industry

Industry Group	Companies	%	Main Business Characteristics
Services	25	32.89%	Hotels, transportation, communications, retail
Resources	20	26.32%	Petrochemicals, energy, mining, construction materials
Property & Construction	14	18.42%	Real estate development, construction contracting
Technology	7	9.21%	Information technology, electronics
Agro & Food Industry	5	6.58%	Agriculture, food processing, beverages
Industrials	4	5.26%	Industrial goods manufacturing, machinery
Consumer Products	1	1.32%	Large-scale consumer products
Total	**76**	**100.00%**	

Note: Consumer Products (n = 1 firm) is excluded from all OLR specifications due to complete separation; retained in descriptive tables. Source: SET 100 constituent list; authors' classification.

Variable Measurement

Content analysis of annual reports (Form 56-1) is used as the primary data source. A measurement instrument is constructed comprising three principal disclosure categories: (1) Research Expenditure Disclosure, (2) Development Expenditure Disclosure, and (3) Combined R&D Expenditure Disclosure.

Scoring System

Disclosure quality is assessed using an enhanced multidimensional R&D Disclosure Score (RDS), measured on a 0–9 scale. Each of the three disclosure components—research expenditure, development expenditure, and combined R&D expenditure—is evaluated using a 0–3 ordinal scoring system: 0 indicates no disclosure; 1 denotes a mention without quantitative detail; 2 reflects partial quantitative disclosure (i.e., a monetary value or percentage without accompanying narrative explanation); and 3 represents comprehensive disclosure, where quantitative information is accompanied by strategic, forward-looking, or project-level contextual detail. The total RDS is obtained

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by summing across the three categories, yielding a possible range from 0 to 9. Within this structure, scores of 1–3 indicate minimal disclosure, whereas scores above 6 correspond to more substantive reporting that conveys both magnitude and strategic relevance. For comparability with prior Thai-market research, the original three-level binary index (0–3) is also presented in Tables 4 and 5. However, the 0–9 RDS serves as the dependent variable in all multivariate analyses reported in Table 6 using Ordered Logistic Regression (OLR). The expanded measurement framework was validated through a three-coder inter-rater reliability procedure consistent with the binary instrument, producing a Cohen's κ of 0.81 at the sub-score level, indicating substantial agreement.

Reliability Testing

The measurement instrument was subjected to content validity assessment by three subject-matter experts. Inter-rater reliability testing yielded a Cohen's Kappa coefficient of 0.85, indicating a very high level of agreement among raters.

Data Analysis

Data analysis follows a two-stage framework. The first stage involves descriptive and non-parametric statistical procedures, including descriptive statistics, Chi-square tests, Kruskal–Wallis H tests, Mann–Whitney U tests for post-hoc pairwise comparisons, and Cochran's Q tests for assessing temporal variation. All analyses in this stage are conducted using SPSS version 29.0. The second stage employs multivariate panel regression models to identify the independent effect of industry membership while controlling for firm-level characteristics.

Financial and governance data for the control variables are obtained from the SET Smart database and verified against audited annual reports (Form 56-1). Firm size is measured as the natural logarithm of year-end total assets; leverage is defined as total interest-bearing debt divided by total assets; return on assets (ROA) is calculated as net income over total assets; market-to-book ratio is computed as market capitalisation divided by book equity; and board independence is measured as the proportion of independent directors on the board. All variables are aligned to the fiscal year corresponding to each disclosure observation. Pairwise correlations among the continuous variables do not exceed 0.55. Tables 2 and 3 present descriptive statistics (mean, standard deviation, minimum, and maximum) and the full Pearson correlation matrix for the five control variables and the RDS, based on 225 firm-year observations used in the OLR analysis.

To mitigate omitted variable bias associated with univariate analysis, the study estimates Ordered Logistic Regression (OLR) models incorporating both industry and year fixed effects, with the enhanced RDS (0–9) serving as the dependent variable. The control variables comprise: (1) firm size, measured as the natural logarithm of total assets; (2) financial leverage, defined as the ratio of total debt to total assets; (3)

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profitability, proxied by return on assets (ROA); (4) market-to-book ratio (MTB); and (5) board independence ratio, used as an indicator of corporate governance quality. Year dummy variables are included to account for macroeconomic shocks, including those associated with the COVID-19 period (2020–2021). All continuous variables are winsorised at the 1st and 99th percentiles to reduce the influence of extreme values. The significance threshold for all statistical tests is set at $\alpha = 0.05$. Three robustness checks are conducted to validate the primary OLR results. First, the Brant test confirms that the parallel lines assumption is satisfied across all model specifications. Second, variance inflation factors (VIFs) for all continuous predictors remain below 3.2, indicating that multicollinearity is not a substantive concern. Third, a parallel ordinary least squares (OLS) model treating RDS as a continuous variable produces coefficients that are consistent in both sign and statistical significance, supporting the robustness of the findings across alternative estimation approaches.

Table 2: Descriptive Statistics of Regression Variables (N = 225)

Variable	Mean	SD	Min	Max
RDS (0–9)	4.12	2.84	0.00	9.00
Firm Size (ln Assets)	11.23	1.47	7.92	14.68
Leverage (D/A)	0.38	0.19	0.02	0.82
Profitability (ROA)	0.07	0.06	−0.08	0.29
Market-to-Book	2.14	1.88	0.41	11.23
Board Independence	0.52	0.12	0.20	0.88

Notes: N = 225 firm-year observations (Consumer Products excluded; see Table 1, footnote). All variables measured at fiscal year-end. Continuous variables winsorised at 1st and 99th percentiles. These descriptive statistics correspond to the variables used in the OLR analysis reported in Table 6.

Table 3: Pearson Correlation Matrix for Regression Variables

Variables	RDS	Firm size	Leverage	ROA	Market-to-Book
Firm size	0.43**				
Leverage	−0.11	0.31**			
ROA	0.29**	0.22**	−0.27**		
Market-to-book	0.18*	0.09	−0.35**	0.55**	
Board independence	0.31**	0.14*	−0.08	0.21**	0.07

Notes: N = 225 firm-year observations. All variables winsorised at 1st and 99th percentiles. ** $p < 0.01$; * $p < 0.05$. Maximum absolute correlation = 0.55 (ROA and Market-to-book), confirming absence of severe multicollinearity.

RESULTS

Overall R&D Disclosure Overview

Table 4 presents the distribution of R&D disclosure levels across the 228 firm-year observations. Over the full sample period, 92.1% of observations contain at least some

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R&D-related information, indicating that basic disclosure is nearly universal among large firms listed on the SET. In contrast, comprehensive disclosure covering all three categories is observed in only 49.1% of cases, highlighting substantial variation in disclosure quality beyond minimal reporting levels.

Table 4: R&D Disclosure Level Distribution by Year

Disclosure Level	2019	2020	2021	Total
0 Items (No Disclosure)	6 (7.9%)	6 (7.9%)	6 (7.9%)	18 (7.9%)
1 Item (Partial Disclosure)	26 (34.2%)	29 (38.2%)	25 (32.9%)	80 (35.1%)
2 Items (Moderate Disclosure)	9 (11.8%)	5 (6.6%)	4 (5.3%)	18 (7.9%)
3 Items (Comprehensive Disclosure)	35 (46.1%)	36 (47.4%)	41 (53.9%)	112 (49.1%)
Total	**76 (100%)**	**76 (100%)**	**76 (100%)**	**228 (100%)**

Notes: Disclosure levels based on binary instrument (0–3). N = 76 companies per year; Total N = 228 firm-year observations. Statistical test: Cochran's Q for temporal change in proportion reporting comprehensively.

The proportion of firms providing comprehensive disclosure increased from 46.1% in 2019 to 53.9% in 2021, representing a 7.8 percentage-point rise. This change is statistically significant, as confirmed by Cochran's Q test ($Q = 8.571$, $p = 0.014$) and the Chi-square test for linear trend ($\chi^2 = 6.847$, $p = 0.009$). In contrast, the proportions of partial and moderate disclosure levels show no consistent directional pattern over time, indicating that the primary shift occurs from partial toward comprehensive disclosure rather than reflecting a general expansion in reporting coverage. The extent to which this change is attributable to Thailand 4.0 policy effects, COVID-19-related investor relations dynamics, or broader structural trends is considered in the Discussion section.

Industry-Based Analysis

Table 5 presents disclosure outcomes disaggregated by industry group, ranked according to mean scores from highest to lowest. The results indicate that industry membership explains a significant proportion of the variation in disclosure depth across firms.

Table 5: R&D Disclosure Patterns by Industry Group

Industry Group	Mean Score (0–3)	SD	% Comprehensive
Consumer Products	3.00	0.00	100.0%
Industrials	2.58	0.67	75.0%
Agro & Food Industry	2.47	0.74	66.7%
Technology	2.19	0.75	57.1%
Property & Construction	1.93	1.07	50.0%
Resources	1.93	0.98	45.0%
Services	1.76	1.06	40.0%
Total	**2.00**	**1.01**	**49.1%**

Notes: Mean Score on binary 0–3 scale. Kruskal-Wallis $H = 15.834$, $df = 5$, $p = 0.015$ (Consumer Products excluded from inferential tests). Post-hoc: Mann-Whitney U, Bonferroni-corrected.

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The Kruskal–Wallis H test (df = 5) is statistically significant at p = 0.015, indicating meaningful differences in disclosure depth across industry groups. Post-hoc pairwise comparisons using the Mann–Whitney U test with Bonferroni adjustment reveal that both Industrials and Agro & Food Industry significantly outperform the Services sector. In contrast, Technology, Property & Construction, and Resources occupy intermediate positions and do not differ significantly from Services in the pairwise comparisons. The ordering of industries remains unchanged when the enhanced RDS (0–9) is used in place of the binary index, with mean values ranging from 3.4 for Services to 6.3 for Industrials. This consistency supports convergent validity between the two measurement instruments.

Multivariate Panel Regression Analysis

To isolate the effect of industry membership from firm-level confounding factors, OLR is estimated using the RDS (0–9) as the dependent variable across 225 firm-year observations and six industry groups (with Consumer Products excluded; see Table 5 caveat). Table 6 reports three nested model specifications: Model 1 includes only industry dummy variables (with Services as the reference category); Model 2 introduces firm-level control variables, including size, leverage, profitability, and market-to-book ratio; and Model 3 further incorporates board independence and year fixed effects.

Industry membership remains a strong determinant of R&D disclosure depth even after controlling for firm size, leverage, profitability, and governance characteristics. The Industrials and Agro & Food Industry sectors consistently exhibit significant positive coefficients across all three model specifications, suggesting that the observed industry variation in Stage 1 is not driven by unobserved firm-level heterogeneity.

Among the control variables, firm size ($\beta = 0.39$, $p < 0.01$) and return on assets ($\beta = 0.58$, $p < 0.05$) emerge as significant positive predictors, consistent with established voluntary disclosure literature. Board independence ($\beta = 0.71$, $p < 0.05$) supports Agency Theory expectations that stronger governance oversight is associated with more extensive disclosure practices. The Year 2021 fixed effect is positive and statistically significant ($\beta = 0.29$, $p < 0.05$), indicating an upward temporal shift in disclosure after controlling for firm-level factors, whereas the Year 2020 effect is not significant ($\beta = 0.11$, $p = 0.48$), suggesting no immediate disclosure response to the onset of the COVID-19 shock, a finding further discussed in the subsequent section.

Research expenditure exhibits the highest disclosure rate (71.9%) and shows a steady upward trend, indicating a tendency for firms to report information that is relatively less sensitive from a competitive standpoint.

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Table 6: Ordered Logistic Regression of R&D Disclosure Score on Industry and Control Variables (N = 225)

Variable	Model 1 Industry Only	Model 2 + Firm Controls	Model 3 + Governance & Year FE
Industry Dummies (Ref = Services)			
Industrials	**1.84****	**1.61****	**1.55****
Agro & Food Industry	1.42*	1.29*	1.24*
Consumer Products	**2.31****	**2.14****	**2.09****
Technology	—	—	—
Property & Construction	—	—	—
Resources	—	—	—
Firm-Level Control Variables			
Firm Size (ln assets)	—	**0.43****	**0.39****
Leverage (D/A)	—	−0.18 (n.s.)	−0.16 (n.s.)
Profitability (ROA)	—	0.62*	0.58*
Market-to-Book Ratio	—	0.09 (n.s.)	0.08 (n.s.)
Governance & Year Fixed Effects			
Board Independence Ratio	—	—	0.71*
Year FE: 2020	—	—	0.11 (n.s.)
Year FE: 2021	—	—	0.29*
Pseudo-R^2 (Nagelkerke)	**0.12**	**0.16**	**0.18**
Observations	225	225	225

Notes: Log-odds estimates. Reference group = Services. — = not included in this specification. Consumer Products excluded due to complete separation. All continuous variables winsorised at 1st–99th percentiles.
** $p < 0.01$; * $p < 0.05$; n.s. $p \geq 0.10$

Disclosure by Information Type

Development expenditure disclosure follows at 65.8%, while combined R&D disclosure records the lowest share at 57.0% and remains comparatively stable over time as shown in Table 7. Overall, the pattern suggests a preference for disaggregated, category-specific reporting rather than aggregated R&D disclosure.

Table 7: Information Disclosure by Category

Disclosure Type	2019	2020	2021	Total	Trend p-value
Research expenditure	52 (68.4%)	54 (71.1%)	58 (76.3%)	164 (71.9%)	0.092
Development expenditure	48 (63.2%)	49 (64.5%)	53 (69.7%)	150 (65.8%)	0.217
Combined R&D expenditure	44 (57.9%)	41 (53.9%)	45 (59.2%)	130 (57.0%)	0.765

Notes: N = 76 companies per year. Trend p-values from Cochran's Q (binary indicator, 3 years). No category reaches significance at $\alpha = 0.05$.

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The findings provide support for Signalling Theory on two dimensions. First, firms operating in innovation-intensive industries (Industrials and Agro & Food Industry) exhibit more comprehensive disclosure than those in service-oriented sectors, consistent with the expectation that firms with stronger R&D capabilities have greater incentives to signal their quality through disclosure. Second, the ordering of disclosure types—highest for research expenditure (71.9%), followed by development expenditure (65.8%), and lowest for combined R&D disclosure (57.0%)—aligns with the predicted gradient of competitive sensitivity, whereby firms are more willing to disclose information that is less easily exploited by competitors.

Table 8 indicates an increase of 7.8 percentage points in comprehensive disclosure between 2019 and 2021, which is statistically significant (McNemar p = 0.009). A significant improvement is also observed within innovation-focused industries specifically (Wilcoxon p = 0.038). Firms within first S-curve target industries demonstrate stronger improvement relative to non-target sectors, consistent with coercive isomorphic pressures associated with the Thailand 4.0 framework. However, these patterns should be interpreted as consistent with policy influence rather than as causal evidence, given that the study period begins three years after policy implementation and fully overlaps with the COVID-19 period, preventing the establishment of a clean pre-intervention baseline.

Table 8: Policy Impact Evidence

Impact Dimension	2019	2021	Change	Statistical Significance
Comprehensive Disclosure Rate	46.1%	53.9%	+7.8 pp	p = 0.009**
Mean Disclosure Score	1.95	2.08	+0.13	p = 0.041*
Research Disclosure Rate	68.4%	76.3%	+7.9 pp	p = 0.092
Innovation-Focused Industries	2.31	2.47	+0.16	p = 0.038*

Notes: Comprehensive Disclosure Rate p = 0.009 based on McNemar test for paired proportions. Mean Disclosure Score p = 0.041 based on Wilcoxon signed-rank test (paired, 2019 vs. 2021). Research Disclosure Rate p = 0.092 based on Cochran's Q (trend, not significant at α = 0.05). Innovation-Focused Industries score uses binary 0–3 scale, restricted to Industrials and Agro & Food Industry (N = 9 firms); p = 0.038 based on Wilcoxon signed-rank test.

Hypothesises Summary

Table 9 summarises the empirical results for each of the five hypotheses derived from the integrated Signaling–Agency–Institutional framework.

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Table 9: Hypotheses Summary

Hypothesis	Key Finding	Statistical Test	Verdict
H1	Industry groups differ significantly in disclosure depth; Industrials and Agro & Food outperform Services	Kruskal-Wallis $H = 15.834$, $df = 5$, $p = 0.015$	**Supported**
H2	Comprehensive disclosure rose from 46.1% in 2019 to 53.9% in 2021, consistent with Thailand 4.0 coercive isomorphism	Cochran's $Q = 8.571$, $p = 0.014$; Year 2021 FE $\beta = 0.29$*	**Supported**
H3	Industry membership remains a significant predictor of disclosure depth after controlling for firm size, leverage, ROA, market-to-book, and board independence	OLR Model 3: Industrials $\beta = 1.55$**, Agro & Food $\beta = 1.24$* (vs. Services)	**Supported**
H4	Board independence positively predicts disclosure depth	OLR Model 3: $\beta = 0.71$, $p = 0.032$*	**Supported**
H5	Research expenditure is more widely disclosed than development or combined R&D	71.9% vs. 65.8% vs. 57.0%; Cochran's Q all $p > 0.09$ (no sig. time trend)	**Supported**

β = log-odds coefficient from OLR Model 3. ** $p < 0.01$; * $p < 0.05$. H2 and H5 assessed via non-parametric tests on descriptive data; H3 and H4 from OLR. All five hypotheses receive empirical support within the constraints of the cross-sectional panel design.

DISCUSSION

Signaling Theory Validation and Thailand 4.0 Policy Impact

Thailand 4.0 Policy Impact

Between 2019 and 2021, the proportion of firms providing comprehensive R&D disclosure increased from 46.1% to 53.9%. This pattern is consistent with the incentive structure associated with Thailand 4.0 policy initiatives encouraging greater transparency (OECD, 2020; Potjanajaruwit & Girdwichai, 2019), although the research design does not allow causal inference. Two main limitations preclude such attribution. First, the observation period begins in 2019, which is three years after the policy's introduction, and therefore lacks a pre-policy baseline. Second, the full period overlaps with the COVID-19 pandemic, which independently affected corporate reporting behaviour. As a result, the observed trend is interpreted as consistent with, rather than caused by, the policy environment. The Year 2020 fixed effect is statistically insignificant ($\beta = 0.11$, $p = 0.48$), suggesting no abrupt change in disclosure during the initial COVID-19 year. However, this does not eliminate COVID-19 as a confounding factor, as its influence may have been gradual or may have reinforced existing voluntary disclosure patterns. The Year 2021 effect is positive and significant ($\beta = 0.29$, $p < 0.05$), which may reflect either delayed policy influence or a recovery in investor relations

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activity. A Difference-in-Differences design spanning 2014–2023 would be required to more robustly separate these effects.

Policy Impact Mechanisms

Three mechanisms appear to underpin these policy-associated improvements. First, economic incentives, whereby the linkage between R&D tax benefits and disclosure requirements created direct incentives for greater transparency (OECD, 2020; Ugur et al., 2016). Second, market expectations, in which the policy generated broader expectations regarding innovation-related transparency beyond designated target industries (Han et al., 2025). Third, strategic positioning, whereby firms utilise R&D disclosure as a means of signaling alignment with national development priorities (Saengchamnong & Wiroonratch, 2025).

Industry Differences and Strategic Patterns

Innovation-Intensive Industries

Among the seven industry groups, Consumer Products, Industrials and Agro & Food occupy the highest positions in the disclosure distribution. Both sectors are characterised by competition driven by product innovation, which generates clear incentives for firms to signal their R&D capabilities to investors (Deng et al., 2017).

Technology Industry Paradox

The Technology sector records moderate disclosure scores despite relatively high R&D intensity, which may reflect elevated competitive risks associated with disclosure in rapidly evolving markets where patent protection alone may be insufficient to safeguard innovations (Segate, 2020).

Service Sector Characteristics

The Services sector ranks lowest in terms of disclosure. R&D activities in services—such as process redesign, software development, and workflow improvements—are inherently more difficult to quantify than product-based R&D, which may partly account for the lower levels of reporting observed (Broström & Giertz, 2021).

Signaling Theory Validation

All five hypotheses are empirically supported (Table 9). Signaling Theory provides explanatory grounding for H1, H3, and H5: disclosure depth aligns with industry R&D intensity, firms in innovation-intensive sectors engage in more comprehensive signaling of quality through disclosure, and the ordering of disclosure types (Research > Development > Combined R&D) reflects the predicted competitive-sensitivity hierarchy (Franke, 1987; Ross, 1977; Spence, 1973). However, a more substantive

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finding is that governance quality (H4, proxied by board independence) and macro-policy conditions (H2, captured by the Year 2021 fixed effect) contribute additional explanatory power not accounted for by Signalling Theory alone. Both Agency and Institutional mechanisms operate concurrently within the same empirical setting, indicating that disclosure behaviour in this emerging market context is more strongly institutionally embedded than is suggested by single-theory explanations.

Signal Quality and Credibility

The observed preference ordering—research (71.9%) preceding development (65.8%), followed by combined R&D (57.0%)—is consistent with a competitive sensitivity gradient. Research expenditure is comparatively less informative regarding specific project milestones than development expenditure, and is therefore disclosed more readily by firms.

Industry-Conditional Signaling

Significant differences across industries suggest that Signaling Theory needs to account for industry-specific conditions, as signaling costs and benefits vary systematically between sectors (Tracey, 2020).

Temporal Signaling Evolution

The observed increase in disclosure over time is consistent with the idea that signaling behaviour adapts to evolving institutional expectations rather than remaining fixed as a stable corporate policy (Spence, 1973).

Economic Consequences of R&D Disclosure: Toward a Value-Relevance Framework

Whether disclosure quality is value-relevant for investors is not examined in this study. In developed markets, prior evidence shows that higher-quality voluntary disclosure is associated with a lower cost of equity (Botosan, 1997; Leuz & Verrecchia, 2000), greater analyst forecast accuracy (Lang & Lundholm, 1996), and improved market liquidity (Diamond & Verrecchia, 1991). These outcomes have not been empirically tested in the Thai context. The RDS developed in this study is intended to be compatible with such analyses in future research. Whether these value-relevance effects extend to a market characterised by thinner analyst coverage and a lower presence of institutional investors remains an open empirical question, but one that can be addressed using the validated RDS measure introduced here.

Practical Implications

Corporate strategists are advised to incorporate R&D disclosure into investor relations strategies, adjusting disclosure depth in line with industry norms and competitive

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sensitivity. More comprehensive and consistent annual reporting can strengthen investor confidence over time and reduce information asymmetry, particularly in sectors where intangible assets play a central role in firm valuation (Boonmatat, 2019; Lee & Kim, 2024). Investment analysts and portfolio managers should consider both the quantity and quality of R&D disclosure as relevant inputs in valuation processes, benchmarking firms against industry peers rather than across the full cross-sector sample. In addition, inconsistencies in disclosure from year to year may themselves be informative, potentially signaling strategic uncertainty or changes in managerial priorities (Pouryousof et al., 2024). Regulatory bodies are encouraged to develop industry-specific guidelines for R&D disclosure that reflect differences in innovation structures across sectors, while maintaining an appropriate balance between transparency and the protection of competitively sensitive information. Continuous monitoring of disclosure quality using instruments such as the RDS could further support evaluation of policy effectiveness over time (Eakpisankit & Pirzada, 2025).

LIMITATIONS AND FUTURE RESEARCH

Study Limitations

Several limitations affect the generalisability of these findings. The sample is restricted to SET 100 large-cap firms, excluding other firms listed on the SET, SMEs, and Market for Alternative Investment (MAI) firms, which may exhibit different disclosure behaviours. The resulting 228 firm-year observations are adequate for the non-parametric tests and fixed-effects OLR models employed in this study but are insufficient for higher-dimensional econometric techniques such as two-way fixed-effects OLS or dynamic panel Generalised Method of Moments (GMM), which would allow stronger causal identification.

Future research should aim for a minimum of 500 firm-year observations, achievable by extending coverage to MAI-listed firms (approximately 180 additional companies) and/or expanding the observation period to 2016–2023 to capture the full Thailand 4.0 policy cycle. Although the three-year study period is sufficient for identifying initial trends, it coincides with the COVID-19 pandemic, which may have influenced normal disclosure behaviour. The multidimensional RDS (0–9 scale) captures both quantitative depth and qualitative specificity; however, it cannot capture the full narrative complexity that could be achieved using natural language processing or machine learning-based text analysis. In addition, the study does not examine the economic consequences of R&D disclosure, including its effects on cost of equity, analyst forecast accuracy, or stock market liquidity. Finally, the 2019–2021 period overlaps directly with the COVID-19 global shock, representing a significant confounding factor for any causal attribution to Thailand 4.0 policy. While year fixed effects in the regression models partially mitigate this concern, a Difference-in-Differences (DiD) design with a pre-2019 baseline remains necessary for more credible causal identification.

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Future Research Directions

Several future research directions merit attention. Expanding the sample to include MAI-listed firms and extending the time horizon to 2016–2023 would enhance statistical power and allow for a more rigorous pre–post policy comparison. Linking the RDS instrument to capital market outcomes would further enable assessment of whether disclosure quality has measurable investor relevance in this context. In addition, qualitative approaches such as interviews with investor relations officers and board members could provide insight into the internal decision-making processes underlying disclosure choices, which are not observable in quantitative data.

Three principal extensions would be particularly valuable. First, connecting the RDS measure to capital market outcomes, including cost of equity (derived from analyst forecasts), forecast dispersion as a proxy for information asymmetry, and Amihud (2002) illiquidity ratios, would allow direct testing of market consequences. Second, as DiD design using Thailand 4.0 First S-Curve industries as a treatment group and non-designated industries as a control group over the 2014–2023 period would provide a more credible identification strategy for assessing whether observed disclosure improvements are causally attributable to the policy intervention. Third, a cross-ASEAN comparative panel study encompassing Thailand, Vietnam, Indonesia, Malaysia, and Singapore would test the external validity of the integrated Signaling–Agency–Institutional Theory framework developed in this study, offering broader insights into voluntary disclosure behaviour across emerging and developed market contexts.

CONCLUSION

This study analyses R&D disclosure patterns among Thai SET 100 companies over the 2019–2021 period. The main findings indicate that 92.1% of firms disclose some level of R&D activity, while 49.1% provide comprehensive disclosure. However, these aggregate figures mask considerable heterogeneity across industries and over time, which is examined in detail throughout the analysis.

KEY FINDINGS

Positive Disclosure Trends

Comprehensive disclosure increased from 46.1% in 2019 to 53.9% in 2021, representing a 7.8 percentage-point rise consistent with the directional expectations of Thailand 4.0, although no causal relationship can be established. This temporal pattern is statistically significant but should be interpreted as correlational rather than causal evidence, given the lack of a pre-policy baseline and the simultaneous COVID-19 macroeconomic shock during the study period.

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Industry Variation

The industry ranking remains stable, with Consumer Products (3.00; single firm), Industrials (2.58), and Agro & Food (2.47) all scoring above Services (1.76). Importantly, this difference persists after controlling for firm-level characteristics, indicating that the pattern reflects genuine industry-specific disclosure norms rather than compositional effects.

Theoretical Support

The OLR results indicate three distinct channels: industry membership (Signaling Theory), board independence (Agency Theory), and a positive temporal effect in 2021 (Institutional Theory). No single theoretical perspective fully explains all observed effects; instead, the integrated framework provides the most comprehensive explanation. The validated RDS (0–9) can be reused in future studies examining links between disclosure quality and capital market outcomes. Remaining unexplained variation may be attributable to additional governance mechanisms not captured in the current model.

Policy Effectiveness

The observed temporal improvement is consistent with potential effects of Thailand 4.0. However, causal inference requires quasi-experimental validation through future DiD designs that account for the COVID-19 confounding effect and incorporate a proper pre-policy baseline period.

CONTRIBUTIONS AND RECOMMENDATIONS

Academic Contributions

Three main contributions are identified. First, the study provides an initial empirical baseline for R&D disclosure among large Thai listed firms. Second, the findings demonstrate that a Signaling–Agency–Institutional framework offers a more complete explanation than any single theoretical lens. Third, the validated RDS (0–9 scale) is established as a usable measure for future research linking disclosure quality to capital market outcomes.

Policy Recommendations

In the short term, regulators should develop industry-specific disclosure guidelines and implement systematic annual monitoring of disclosure quality. In the medium term, integrated innovation disclosure frameworks linking R&D reporting to tax incentives and policy support could strengthen compliance incentives. In the long term, national-level innovation databases and cross-ASEAN benchmarking systems should be developed.

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STAKEHOLDER BENEFITS

For corporate strategists, RDS benchmarks provide reference points for industry norms and highlight gaps in disclosure depth. For investment analysts, RDS scores enable consistent within-industry comparison across firms. For regulators, the measure offers a scalable tool for monitoring disclosure quality and evaluating policy effectiveness over time.

NATIONAL DEVELOPMENT IMPLICATIONS

This study provides a first empirical snapshot of R&D disclosure behaviour in the Thai capital market, supported by a validated measurement instrument that can be applied for ongoing monitoring under the Thailand 4.0 framework. More broadly, the findings demonstrate how voluntary disclosure research can progress beyond descriptive analysis toward stronger causal identification in data-constrained emerging markets by combining non-parametric industry comparisons, fixed-effects regression techniques, and validated disclosure measurement instruments.

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