



New Quality Productive Forces and Firms' Cost Reduction and Efficiency Enhancement: Evidence from Chinese A-Share Listed Firms

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Abstract. This study examines whether firm-level new quality productive forces (NQP) are associated with cost reduction and efficiency enhancement in Chinese listed firms. Using an unbalanced panel of A-share listed companies from 2012 to 2024, we estimate firm- and year-fixed-effects models to test whether stronger NQP is linked to lower period-expense intensity and better operating efficiency. We conceptualize NQP as a multidimensional firm-level capability that combines human capital upgrading, innovation capability, digital transformation, green production, and data-factor utilization. The results show that higher NQP is significantly associated with a lower three-fee ratio, with the effect concentrated in management-expense intensity rather than sales-expense intensity. Mechanism-consistent evidence indicates that NQP is positively related to asset utilization, total asset turnover, and accounts receivable turnover, suggesting that the observed reduction in expense intensity is more consistent with efficiency-driven operating improvement than with simple expenditure compression. The association remains broadly stable across firm-size groups and is stronger in regions with more favorable digital and innovation environments. Robustness analyses confirm the stability of the baseline findings, although placebo-style and trend-based tests indicate that the evidence should be interpreted as strong panel associations rather than definitive causal effects. Overall, the study contributes to the literature by linking NQP to accounting-based operating outcomes that are closer to firms' internal managerial processes than broad measures of firm performance.

Keywords: new quality productive forces; period-expense efficiency; operating efficiency; digital transformation; Chinese listed firms

1 Introduction

1.1 Background and Motivation

As digital transformation diffuses across firms, sustained competitive advantage increasingly depends not on isolated technology adoption, but on whether digital, organizational, and knowledge-based inputs are translated into firm-wide capabilities that improve coordination, decision quality, and execution. Recent research shows that digital transformation can enhance firm performance, yet these gains depend heavily on complementary capabilities such as digital orientation, IT-enabled routines, organizational capital, and managerial adaptation. Against this background, the notion of new quality productive forces (NQP) has emerged as a useful lens for understanding how firms upgrade productive capabilities in the digital era. Recent evidence likewise shows that digital transformation practices can improve firms' operational efficiency, while stronger organizational capital and digital capability accumulation can shape the quality of these gains (Tian et al., 2023; Zhang & Deng, 2024; Zareie et al., 2024).^[1,2,3]

This issue is important because most existing studies evaluate transformation and upgrading through broad outcomes such as firm value, innovation output, or productivity growth. These indicators are informative, but they are relatively distal from the internal operating mechanisms through which performance gains are realized. By contrast, period-expense intensity, asset utilization, and turnover efficiency are closer to firms' day-to-day managerial processes and therefore provide a more direct test of whether capability upgrading improves organizational discipline and resource deployment. This question is especially relevant because digital upgrading may also entail adjustment costs, implementation frictions, and organizational tensions, making its net operating consequences an empirical rather than purely theoretical matter.

1.2 Research Gap and Study Positioning

This study addresses four gaps in the literature. First, prior research on digital transformation and firm upgrading has paid limited attention to accounting-based operating outcomes. Although existing studies document links with productivity, innovation, and investment efficiency, we know much less about whether upgrading is reflected in lower expense intensity and more efficient operating conversion at the firm level.

Second, mechanism evidence remains underdeveloped. A lower expense ratio may arise from direct spending compression, from efficiency-driven dilution through stronger revenue generation and asset utilization, or from both. Distinguishing among these explanations is important because the efficiency interpretation points to deeper process upgrading rather than short-term austerity. Third, boundary conditions remain insufficiently specified: the benefits of upgrading may depend on both internal organizational complements and external ecosystem conditions. Fourth, the construct distinctiveness of NQP is still not fully clarified at the firm level. Although NQP overlaps with measures such as R&D intensity, digital investment, and human-capital quality, it is broader in emphasizing the coordinated upgrading of multiple production-related factors. This study therefore positions NQP at the intersection of digital transformation,

accounting-based efficiency analysis, and firm-level operating outcomes. More recent evidence further suggests that business process digitalization can enhance working capital management efficiency by improving data accuracy, automating routine tasks, and strengthening operational synergies (Wang & Nie, 2025).^[4]

Third, the boundary conditions remain unclear. Recent studies emphasize that digital transformation depends on internal organizational complements and external ecosystem conditions, implying that its consequences may vary across firms and regional environments (Feliciano-Cestero et al., 2023; Elia et al., 2024).^[5,6] Fourth, the construct distinctiveness of NQP remains underexplored at the firm level. Although NQP overlaps with indicators such as R&D intensity, patent output, digital investment, and high-skill labor, it is broader in emphasizing the coordinated upgrading of multiple production-related factors. This study therefore positions NQP at the intersection of digital transformation, accounting-based efficiency analysis, and firm-level operating outcomes.

1.3 Theoretical Lens and Research Questions

To explain these relationships, this study combines Transaction Cost Economics (TCE) and Organizational Information Processing Theory (OIPT). TCE highlights how capability upgrading can reduce coordination, monitoring, and governance frictions by improving traceability, standardization, and process transparency. OIPT complements this view by emphasizing that firms with stronger information-processing capacity are better able to integrate operational information, coordinate across functions, and allocate resources under complexity. Taken together, these perspectives imply that NQP should matter not only for broad performance outcomes, but also for internal cost discipline and operating efficiency.

Accordingly, the study asks four questions: (1) Is firm-level NQP associated with lower period-expense intensity? (2) Is NQP associated with stronger operating efficiency, especially in asset utilization and receivables management? (3) Is the NQP–expense relationship consistent with an efficiency-related operating channel? and (4) Do these associations vary across firm and regional contexts?

1.4 Research Design Overview and Contributions

Using panel data for Chinese A-share listed firms from 2012 to 2024, this study estimates firm- and year-fixed-effects models to examine the relationship between NQP and cost-efficiency outcomes. The analysis begins with the baseline association between NQP and period-expense intensity, then decomposes the effect across expense categories, investigates mechanism-consistent operating channels through asset utilization and turnover indicators, and finally explores contextual heterogeneity and robustness under stricter specifications.

This paper makes four contributions. First, it shifts the discussion of NQP from broad performance narratives to accounting-based operating outcomes that are closer to internal managerial processes. Second, it sharpens the mechanism interpretation by distinguishing expense compression from efficiency-driven expense dilution and by

identifying the most relevant turnover channels. Third, it integrates TCE and OIPT to explain why NQP may influence both cost discipline and information-intensive operating routines. Fourth, it operationalizes NQP as a multidimensional firm-level construct that encompasses human capital, innovation capability, digital upgrading, green production, and data-factor utilization, thereby clarifying how NQP differs from narrower innovation or digitalization proxies.

1.5 Structure of the Paper

The remainder of this paper is organized as follows. Section 2 reviews the literature and develops the hypotheses. Section 3 presents the research design. Section 4 reports the empirical results. Section 5 discusses the main findings and implications. Section 6 concludes, notes the limitations, and suggests directions for future research.

2 Literature Review and Hypotheses Development

2.1 Digital Transformation, Firm Upgrading, and the Logic of NQP

Recent research increasingly conceptualizes digital transformation not as a discrete technological shock, but as a process of capability reconfiguration. Its economic effects depend less on technology investment per se than on the extent to which digital resources are embedded in managerial routines, process redesign, strategic alignment, and governance adaptation. From this perspective, new quality productive forces (NQP) can be understood as a firm-level manifestation of productive upgrading in the digital era. In this study, NQP is defined as a multidimensional composite construct capturing the coordinated upgrading of advanced labor, innovation capability, digital embedding, green production, and data-factor utilization, rather than a single technological or financial input. Recent studies also report that digital transformation practices improve operational efficiency, and that these efficiency gains are reflected in technical efficiency and operational routines rather than only in market-based performance indicators (Tian et al., 2023; Zhang & Deng, 2024).^[1,2]

This conceptualization is important because it connects NQP to observable operating outcomes rather than abstract narratives of modernization. If NQP captures stronger process visibility, information integration, coordination capacity, and resource quality, its economic relevance should be visible not only in market valuation or innovation output, but also in the efficiency with which firms control expenses and convert assets into operating activity. Accordingly, this study examines whether stronger NQP is associated with lower period-expense intensity and stronger operating efficiency.

2.2 Theoretical Foundation: TCE and OIPT

2.2.1. Transaction Cost Economics and the Cost-discipline Mechanism.

Transaction Cost Economics (TCE) posits that firms incur coordination, monitoring, and governance costs when internal processes are fragmented and information is

incomplete (Williamson, 1981).^[7] Under such conditions, firms rely on additional managerial and administrative inputs to sustain control, thereby increasing expense intensity. Capability upgrading associated with stronger NQP may mitigate these internal frictions by improving traceability, standardization, data transparency, and monitoring efficiency. As governance-related inefficiencies decline, firms should require fewer redundant managerial inputs and exhibit lower operating overhead.

This mechanism is more directly connected to internal governance and administrative coordination than to market-facing commercial activities. The cost-discipline implications of NQP should therefore be more salient in management-expense intensity than in sales-expense intensity.

2.2.2. Organizational Information Processing Theory and the Operating-efficiency Mechanism.

Organizational Information Processing Theory (OIPT) complements this perspective by emphasizing the fit between information-processing requirements and organizational information-processing capacity (Galbraith, 1974; Tushman & Nadler, 1978; Daft & Lengel, 1986).^[8,9,10] NQP-related capability upgrading may strengthen the firm's ability to integrate operational data, reduce information asymmetry, improve feedback quality, and coordinate cross-functional activities. These improvements should be particularly observable in turnover-based indicators that are sensitive to information timeliness, process control, and execution quality.

Among such indicators, total asset turnover captures overall resource-utilization efficiency, whereas accounts receivable turnover reflects execution quality in an information-intensive operating domain involving customer information, billing coordination, and payment monitoring. Recent studies are broadly consistent with this argument, showing that digital transformation is associated with higher production efficiency, better labor investment efficiency, and innovation-related organizational adaptation (Wang et al., 2024; Wang & Shao, 2024; Merin-Rodriganez et al., 2024).^[11,12,13] More generally, the literature suggests that digital outcomes depend on the extent to which digital capabilities are embedded in managerial and operational processes (Feliciano-Cestero et al., 2023; Elia et al., 2024).^[5,6] Taken together, TCE and OIPT imply that stronger NQP should be associated with both tighter cost discipline and higher operating efficiency. This interpretation is also consistent with recent evidence that business process digitalization improves working capital management efficiency through better data quality and routine automation (Wang & Nie, 2025).^[4]

2.3 Research Gap and Analytical Focus

Despite this progress, three issues remain unresolved. First, extant research predominantly emphasizes aggregate outcomes such as firm value, innovation, or broad performance, leaving accounting-based indicators of internal operating discipline underexplored. Second, the underlying mechanism remains insufficiently specified: lower expense intensity may reflect expenditure compression, efficiency gains, or both. Third, contextual heterogeneity is rarely incorporated into an integrated framework,

even though the benefits of upgrading depend on complementary internal capabilities and external ecosystem conditions.

Accordingly, this study develops an accounting-and-operations perspective on NQP. It examines whether stronger NQP is associated with lower period-expense intensity, whether the effect is more pronounced for management expenses than for sales expenses, whether the observed pattern is consistent with an efficiency-related operating channel centered on asset utilization and selected turnover indicators, and whether the association varies across firm and regional contexts.

2.4 Hypotheses Development

2.4.1. NQP and Period-expense Intensity.

From a TCE perspective, firms with stronger NQP should face lower coordination, monitoring, and governance frictions (Williamson, 1981). ^[7]Capability upgrading may enhance process traceability, standardization, and organizational transparency, thereby reducing redundant managerial inputs and lowering the internal costs required to sustain coordination. OIPT further suggests that stronger NQP may improve the firm's capacity to process and utilize operational information, thereby reducing decision delays, communication losses, and resource misallocation. Collectively, these improvements should be reflected in a more efficient expense structure.

However, this relationship is unlikely to be homogeneous across expense categories. Because the underlying mechanism is more directly related to internal governance and administrative coordination, the effect of NQP should be more evident in management-related expenses than in sales-related expenses.

H1a. Higher NQP is associated with lower overall period-expense intensity.

H1b. The negative association between NQP and expense intensity is more pronounced for management-expense intensity than for sales-expense intensity.

2.4.2. NQP and Operating Efficiency.

If NQP reflects the upgrading of firms' digital and organizational capabilities, its implications should extend beyond expense outcomes. OIPT implies that firms with stronger information-processing capacity are better positioned to coordinate cross-functional activities, align resources with task requirements, and respond to operational complexity (Galbraith, 1974; Tushman & Nadler, 1978; Daft & Lengel, 1986).^[8,9,10] TCE complements this argument by suggesting that lower internal frictions improve the efficiency with which firms deploy and circulate resources.

Accordingly, stronger NQP should be associated with superior operating efficiency, particularly in indicators closely linked to information quality, execution discipline, and process coordination. Asset utilization efficiency is especially important because it captures the extent to which firms convert their asset base into operating activity. In addition, total asset turnover reflects system-level resource utilization, whereas accounts receivable turnover captures execution quality in an information-intensive operating segment. Relative to other turnover indicators, these

measures are theoretically more likely to respond to NQP-related capability upgrading.

H2a. Higher NQP is associated with stronger asset-utilization efficiency.

H2b. Higher NQP is associated with stronger turnover efficiency in key operating channels, particularly total asset turnover and accounts receivable turnover.

2.4.3. Efficiency-related Operating Channel.

A lower expense ratio does not necessarily imply that firms reduce costs solely through expenditure compression. It may also indicate that firms operate more efficiently and thereby dilute expense intensity by generating greater output or revenue from a given level of organizational and operating costs. This interpretation is particularly relevant when NQP enhances information-processing capacity, process coordination, and execution quality.

Among potential channel variables, asset turnover ability (ATO) is especially informative because it provides a parsimonious proxy for operating efficiency and serves as the primary channel indicator in the empirical analysis. If stronger NQP is associated with better asset utilization, and improved asset utilization is in turn associated with lower expense intensity, then the observed NQP-expense relationship can reasonably be interpreted as consistent with an efficiency-related operating pathway. Given the identification limits of panel data, this study does not frame this mechanism as strict causal mediation; rather, it advances a more cautious, mechanism-consistent hypothesis.

H3. The negative association between NQP and period-expense intensity is consistent with an efficiency-related operating channel, particularly through stronger asset utilization (ATO).

2.4.4. Context dependence.

The effectiveness of capability upgrading is unlikely to be invariant across organizational and environmental contexts. Both TCE and OIPT suggest that firms differ in coordination complexity, resource endowments, and information-processing requirements, while external conditions such as digital infrastructure, innovation ecosystems, and institutional support may shape the extent to which NQP is translated into operating gains (Williamson, 1981; Galbraith, 1974; Tushman & Nadler, 1978; Daft & Lengel, 1986).^[7.8.10]

In particular, firms located in regions with more developed digital and innovation environments may benefit from stronger ecosystem complementarities, superior infrastructure, and more supportive institutional conditions, enabling NQP to translate more effectively into lower expense intensity and higher operating efficiency. By contrast, differences across firm-size groups are theoretically plausible but less directional a priori, because larger firms may enjoy greater resource endowments while simultaneously facing higher coordination complexity. Firm-size heterogeneity is therefore treated as a context-contingent empirical issue rather than a strong directional prediction.

H4a. The association between NQP and firms' cost-efficiency outcomes may vary across firm contexts, including firm-size groups.

H4b. The association between NQP and firms' cost-efficiency outcomes is stronger in more favorable regional digital and innovation environments.

2.5 Conceptual Framework

Figure 1 presents the conceptual framework of this study. At its core is the proposed association between firm-level NQP and overall period-expense intensity. Building on TCE and OIPT, the framework further posits that this relationship is linked to improvements in operating efficiency, particularly asset utilization and selected turnover channels. It also indicates that the effect should be more pronounced for management-expense intensity than for sales-expense intensity.

The framework additionally incorporates contextual heterogeneity. Firm context, including firm-size groups, may condition the strength of the focal associations, while regional digital and innovation environments are expected to strengthen the translation of NQP into lower expense intensity and higher operating efficiency. These propositions are examined as panel associations rather than strict causal effects, consistent with the empirical design of the study.

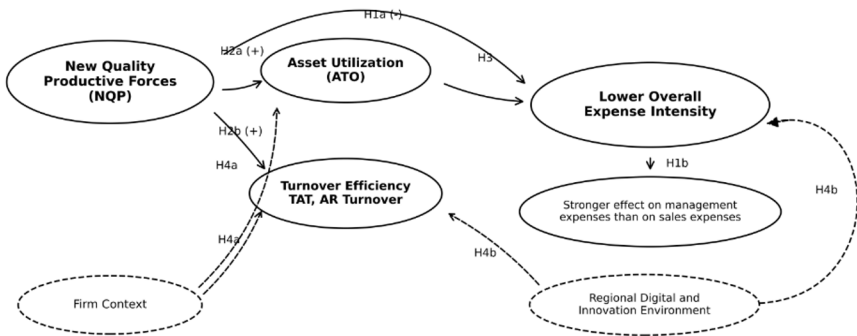


Fig. 1. Conceptual framework linking NQP to firms' cost reduction and efficiency enhancement

Notes: H1a denotes the baseline negative association between NQP and overall period-expense intensity; H1b denotes a stronger effect on management expenses than on sales expenses; H2a and H2b denote positive associations between NQP and asset utilization as well as turnover efficiency, respectively; H3 denotes an efficiency-related operating channel centered on asset utilization; and H4a and H4b denote contextual heterogeneity across firm context and the regional digital and innovation environment.

3 Research Design

3.1 Data and Sample

This study uses an unbalanced firm-year panel of Chinese A-share listed companies from 2012 to 2024. Data are mainly obtained from the CSMAR database, including the firm-level New Quality Productive Forces (NQP) index and financial statement variables. The sample covers firms listed on the Main Board and ChiNext. Financial firms are excluded because of their distinct asset structures, regulatory constraints, and reporting characteristics. ST and *ST firms are also excluded because abnormal operations and special regulatory treatment may distort expense-ratio and operating-efficiency measures. Observations with missing values in variables required for the baseline regressions are removed.

To reduce the influence of outliers, all continuous variables are winsorized at the 1st and 99th percentiles. Observations with undefined ratio variables are treated as missing and excluded from the relevant regressions. Standard errors are clustered at the firm level to account for heteroskedasticity and within-firm serial correlation. After screening and cleaning, the descriptive-statistics sample contains 37,498 firm-year observations, while the baseline regression sample contains 37,166 firm-year observations. Sample size varies slightly across specifications because of differences in variable availability.

3.2 Variable Definitions and Measurement

3.2.1. Main Variables.

The primary dependent variable is the three-fee ratio (*threefee_rate*), defined as the sum of selling, administrative, and financial expenses divided by operating revenue. A lower value indicates lower period-expense intensity and hence stronger period-expense efficiency:

$$\text{threefee_rate}_{i,t} = (\text{Selling Expenses}_{i,t} + \text{Administrative Expenses}_{i,t} + \text{Financial Expenses}_{i,t}) / \text{Operating Revenue}_{i,t}$$

Because operating revenue appears in the denominator, a decline in *threefee_rate* may reflect either direct expense compression or efficiency-driven dilution. To clarify this interpretation, the empirical design further examines mediation and turnover-channel mechanisms.

The main efficiency indicator is asset turnover ability (ATO), measured as operating revenue divided by total assets:

$$\text{ATO}_{i,t} = \text{Operating Revenue}_{i,t} / \text{Total Assets}_{i,t}$$

A higher value indicates stronger asset utilization and operating efficiency.

The channel variables include accounts receivable turnover (*ar_turnover*), inventory turnover (*inv_turnover*), working capital turnover (*wc_turnover*), fixed asset turnover (*fa_turnover*), and total asset turnover (*ta_turnover*). These variables are

used to identify the operating pathways through which NQP-related efficiency gains may be reflected.

The key explanatory variable is the firm-level NQP index. Rather than treating NQP as a single technological or financial input, this study conceptualizes it as a multidimensional composite construct that captures firms' coordinated upgrading in advanced labor, innovation capability, digital transformation, green production, and data-factor utilization. The baseline NQP index is constructed from five dimensions—human capital, innovation capability, digital upgrading, green upgrading, and data-factor utilization—using standardized indicators and the entropy-weighting method. In robustness tests, alternative forms such as $\ln(1+NQP)$ and lagged NQP are also employed.

3.2.2. Variable Classification.

To improve transparency, variables are classified into dependent variables, the key independent variable, mechanism/channel variables, and control variables, as shown in Table 1.

Table 1. Variable classification, definitions, and roles in the study

Variable Category	Variable Symbol	Definition / Measurement	Role in the Study
Dependent variable	threefee_rate	(Selling expenses + Administrative expenses + Financial expenses) / Operating revenue	Measures cost reduction performance (period-expense efficiency)
Dependent variable / Mechanism variable	ATO	Operating revenue / Total assets	Measures overall operating efficiency; used in mediation analysis
Key independent variable	NQP	CSMAR firm-level New Quality Productive Forces index (weighted composite of substantive and permeative factors)	Core explanatory variable
Channel variable	ar_turnover	Operating revenue / Accounts receivable	Identifies the receivables collection and credit-management efficiency channel
Channel variable	inv_turnover	Operating revenue / Inventory	Identifies the inventory management efficiency channel

Variable Category	Variable Symbol	Definition / Measurement	Role in the Study
Channel variable	wc_turnover	Operating revenue / Working capital	Identifies the working capital management efficiency channel
Channel variable	fa_turnover	Operating revenue / Fixed assets	Identifies the fixed-asset utilization efficiency channel
Channel variable	ta_turnover	Operating revenue / Total assets	Identifies the overall resource allocation efficiency channel
Control variables	CFO_rate, lnSize, Lev, Growth, Age, PPE_TA, Cash_TA, OPM, NPM, GM	Cash flow, firm size, leverage, growth, firm age, asset structure, cash holdings, and profitability measures	Mitigates omitted-variable bias

Notes. (1) *NQP* is a multidimensional firm-level composite index covering human capital, innovation capability, digital upgrading, green production, and data-factor utilization. (2) *threefee_rate* is the primary proxy for period-expense efficiency; a lower value indicates lower expense intensity relative to revenue. (3) *ATO* serves both as an outcome variable and as a mechanism variable in mediation tests. (4) All continuous variables are winsorized at the 1st and 99th percentiles.

3.3 Empirical Model Specification

3.3.1. Baseline Model.

To examine the association between *NQP* and firm-level cost-efficiency outcomes, this study estimates two-way fixed-effects (TWFE) models:

$$Y_{i,t} = \alpha + \beta_1 \cdot NQP_{i,t} + \gamma \cdot X_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t}$$

Here, $Y_{i,t}$ denotes the dependent variable; $NQP_{i,t}$ is firm-level new quality productive forces; $X_{i,t}$ is a vector of control variables; μ_i and λ_t represent firm and year fixed effects, respectively; and $\varepsilon_{i,t}$ is the error term. The coefficient β_1 captures the association between *NQP* and firm-level cost reduction/efficiency outcomes.

3.3.2. Mediation Model.

To assess whether operating efficiency mediates the NQP–expense relationship, a stepwise mediation framework is estimated using ATO as the mechanism variable:

$$(a) \text{ATO}_{i,t} = \alpha + \beta_1 \cdot \text{NQP}_{i,t} + \gamma \cdot X_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t}$$

$$(b) \text{threefee_rate}_{i,t} = \alpha + \beta_2 \cdot \text{NQP}_{i,t} + \gamma \cdot X_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t}$$

$$(c) \text{threefee_rate}_{i,t} = \alpha + \beta_3 \cdot \text{NQP}_{i,t} + \delta \cdot \text{ATO}_{i,t} + \gamma \cdot X_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t}$$

If β_1 in equation (a) is statistically significant, δ in equation (c) is statistically significant, and the absolute magnitude of β_3 is smaller than that of β_2 , the evidence is interpreted as consistent with an efficiency-related mediation pattern. Given the observational panel setting, this is not interpreted as definitive causal mediation.

3.3.3. Channel Decomposition Model.

To identify the operating channels through which NQP affects cost-efficiency outcomes, this study uses a two-step channel decomposition strategy. First, separate TWFE regressions are estimated with turnover variables—*ar_turnover*, *inv_turnover*, *wc_turnover*, *fa_turnover*, and *ta_turnover*—as dependent variables. Second, the more responsive channel variables are incorporated into the *threefee_rate* equation while retaining NQP. This design helps identify the more economically meaningful transmission channels.

3.3.4. Heterogeneity Analysis.

To examine contextual dependence, heterogeneity analyses are conducted across firm size and the regional NQP environment. The main analyses rely on subgroup regressions under the baseline specification. In extended analyses, interaction models may also be estimated:

$$Y_{i,t} = \alpha + \beta_1 \cdot \text{NQP}_{i,t} + \beta_2 \cdot \text{Moderator}_{i,t} + \beta_3 \cdot (\text{NQP}_{i,t} \times \text{Moderator}_{i,t}) + \gamma \cdot X_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t}$$

where *Moderator*_{*i,t*} denotes a grouping or moderating variable. The interaction coefficient β_3 captures heterogeneous associations across contexts.

3.3.5. Inference and Identification Boundary.

All regressions include firm and year fixed effects and use firm-clustered standard errors. Lagged NQP specifications are treated both as robustness checks and as a dynamic extension of the baseline model, because innovation, digital upgrading, and organizational change may require time to affect operating routines and accounting outcomes.

The empirical strategy is designed to identify robust within-firm associations rather than definitive causal effects. To probe potential identification threats, the study further considers lagged specifications, province-by-year fixed effects, and firm-specific linear trends. These supplementary tests help evaluate the extent to which the baseline estimates may reflect persistent firm trajectories or broader time-varying confounding.

Accordingly, the results are interpreted as strong panel associations with mechanism-consistent support, rather than as clean causal estimates.

4 Results

4.1 Descriptive Statistics and Variable Relationships

This section examines the association between New Quality Productive Forces (NQP) and firms' expense ratios using panel regressions with firm fixed effects and year fixed effects. The analysis proceeds in six steps: descriptive statistics, baseline regressions, mechanism tests, heterogeneity analysis, robustness checks, and a brief chapter summary.

Table 2 reports the descriptive statistics of the main variables. The sample consists of 37,498 firm-year observations. The dependent variable, *threefee_rate*, has a mean of 0.1710 and a standard deviation of 0.1317, indicating substantial cross-sectional variation in expense ratios across firms. The core explanatory variable, NQP, has a mean of 0.0005, a standard deviation of 0.0007, and a maximum of 0.0035, exhibiting a clear right-skewed distribution. With respect to efficiency variables, ATO has a mean of 0.6569, while accounts receivable turnover (*ar_turnover*) has a mean of 26.5321 and a very large standard deviation of 96.0429, suggesting heavy-tailed distributions for some turnover measures. To mitigate the influence of outliers, all continuous variables are winsorized at the 1st and 99th percentiles.

The correlation matrix likewise shows that NQP is negatively correlated with *threefee_rate* and positively correlated with ATO, offering preliminary descriptive evidence that higher NQP tends to coincide with lower expense intensity and stronger operating efficiency. Overall, the descriptive patterns are consistent with the baseline expectation, while also indicating substantial cross-firm variation that warrants multivariate analysis.

Table 2. Descriptive Statistics of Main Variables (Winsorized at 1/99)

Variable	Obs.	Mean	Std. Dev.	Median	Max
<i>threefee_rate</i>	37498	0.1710	0.1317	0.1350	0.7076
SA_rate	37498	0.0762	0.0931	0.0426	0.4900
GA_rate	37498	0.0855	0.0651	0.0692	0.3949
NQP	37498	0.0005	0.0007	0.0002	0.0035
ATO	37498	0.6569	0.4378	0.5594	2.6850
ROA	37495	0.0474	0.0637	0.0449	0.2318
lnSize	37498	22.0349	1.2111	21.8608	25.8693
Lev	37498	0.3809	0.1942	0.3671	0.8480

Notes. All continuous variables are winsorized at the 1st and 99th percentiles.

4.2 Baseline Regression Results

Table 3 reports the baseline estimates. In column (1), the coefficient on NQP is negative and statistically significant at the 1% level, indicating that firms with stronger NQP exhibit lower overall period-expense intensity. Columns (2) and (3) show that this relationship is not evenly distributed across expense categories: the coefficient is strongly negative for GA_rate but statistically insignificant for SA_rate. This pattern is economically meaningful because it suggests that the relevance of NQP lies primarily in internal administration, coordination, and managerial control rather than in outward-facing selling activities.

The magnitude is also nontrivial. Given a sample standard deviation of 0.0007 for NQP and a mean threefee rate of 0.1710, the baseline estimate implies that a one-standard-deviation increase in NQP is associated with an approximately 0.77 percentage-point reduction in the expense ratio, equivalent to about 4.5% of the sample mean. For firms operating with relatively thin margins, such an effect is economically meaningful rather than merely statistically detectable.

Column (4) further indicates that NQP is positively associated with ATO. Although the estimate is less precise than the expense-ratio result, its sign is consistent with the view that NQP is associated not only with cost discipline but also with more efficient asset utilization. This result provides the first indication that the baseline effect may be linked to operating conversion rather than simple expenditure compression.

Table 3. Baseline Regression Results

Variable	(1) threefee_rate	(2) GA_rate	(3) SA_rate	(4) ATO	(5) ROA
NQP	-11.003*** (1.287)	-7.610*** (0.921)	-0.555 (0.898)	10.394* (5.615)	-1.748** (0.692)
CFO_rate	-0.034***	-0.021***	-0.018***	0.049***	0.010***
lnSize	-0.015***	-0.015***	-0.002**	-0.073***	-0.005***
Lev	0.037***	-0.021***	-0.007*	0.226***	-0.021***
Growth	-0.026***	-0.016***	-0.006***	0.197***	0.018***
PPE_TA	0.051***	0.025***	0.007	-0.157***	-0.028***
Cash_TA	-0.020***	0.018***	-0.008**	-0.011	0.010***
OPM	-0.437***	-0.199***	-0.171***	0.504***	0.059***
NPM	0.164***	0.080***	0.063***	-0.235***	0.190***
GM	0.452***	0.151***	0.253***	-0.633***	0.060***
N	37166	37166	37166	37166	37163
Adj. R2	0.851	0.745	0.898	0.814	0.820

Notes. All regressions include firm fixed effects and year fixed effects. Standard errors clustered at the firm level are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

4.3 Mechanism Analysis: The Efficiency Channel

The mechanism analysis evaluates whether the negative NQP-expense association is consistent with an operating-efficiency channel. The evidence broadly supports this interpretation. First, the baseline results show that NQP is positively related to ATO. Second, Table 4 indicates that ATO is negatively associated with *threefee_rate* after controlling for NQP and the full set of covariates. Third, once ATO is added to the expense equation, the absolute magnitude of the NQP coefficient declines. Taken together, these results are consistent with the view that part of the reduction in expense intensity is associated with stronger asset utilization rather than simple expense compression alone.

Table 4. ATO Mechanism Test

Variable	(1) ATO	(2) <i>threefee_rate</i>
NQP	10.394* (5.615)	-10.432*** (1.279)
ATO		-0.055*** (0.003)
Controls	Yes	Yes
Firm FE	Yes	Yes
Year FE	Yes	Yes
N	37166	37166
Adj. R2	0.814	0.857

Notes. Standard errors clustered at the firm level are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table 5 refines this interpretation by decomposing the operating channel. Among the turnover measures, the clearest and most stable evidence appears for total asset turnover and accounts receivable turnover: NQP is positively associated with both variables, and both are negatively associated with *threefee_rate* in the second-stage specifications. By contrast, the evidence for inventory turnover, working-capital turnover, and fixed-asset turnover is weaker or less stable. This asymmetry is theoretically informative because it suggests that NQP is most closely linked to system-level operating conversion and information-intensive receivables processes, rather than to a uniform improvement across every operating link.

Table 5. Summary of Turnover-Channel Tests

Channel Variable	NQP -> Channel	Channel -> <i>threefee_rate</i>	Conclusion
<i>ta_turnover</i>	11.958**	-0.049***	Supported
<i>wc_turnover</i>	300.386	-0.000***	Only second-stage significant
<i>ar_turnover</i>	3269.071***	-0.000***	Supported

Channel Variable	NQP -> Channel	Channel -> threefee_rate	Conclusion
inv_turnover	435.655	-0.000	Not supported
fa_turnover	234.812	-0.000***	First-stage insignificant

Notes. Entries summarize the sign and significance pattern from the two-stage turnover-channel tests. 'Supported' indicates that NQP is significantly associated with the channel variable and that the channel variable is significantly associated with threefee_rate in the expected direction.

4.4 Heterogeneity Analysis

The heterogeneity analysis examines whether the NQP-expense relationship depends on organizational or regional context. The results point to a clearer environmental boundary condition than an internal size-based one. Specifically, the interaction between NQP and the high-NQP province indicator is significantly negative, indicating that the baseline association is stronger in regions with more developed digital and innovation environments. By contrast, the size-based interaction does not reveal meaningful differences across the three firm-size groups.

Table 6 reinforces this interpretation. The estimated NQP coefficients for small, medium, and large firms are all negative, similar in magnitude, and significant at the 1% level, suggesting that the baseline relationship is not driven by a single size segment. For the regional split, however, the coefficient is more negative in high-NQP provinces, consistent with the idea that ecosystem complementarities help firms convert internal capability upgrading into operating gains more effectively.

Table 6. Summary of Heterogeneity Analysis

Group	NQP Coef.	Std. Err.	Significance
Small firms	-8.104	(2.583)	***
Medium firms	-8.357	(2.514)	***
Large firms	-8.188	(2.293)	***
Low-NQP regions	-9.534	(2.661)	***
High-NQP regions	-11.162	(1.466)	***

Notes. Coefficients are from grouped regressions estimated separately by firm-size terciles and regional digital environment. Standard errors clustered at the firm level are shown in parentheses. *** denotes significance at the 1% level.

4.5 Robustness and Identification Boundaries

This section evaluates whether the baseline finding survives alternative specifications and, equally importantly, where its identification boundary begins (Table 7). The purpose of the robustness analysis is therefore twofold: first, to test whether the main association is stable across reasonable alternative specifications; and second, to clarify which interpretations remain defensible once more demanding controls are introduced.

The stricter specifications are especially informative for interpretation (Table 7). Lagged NQP remains negatively associated with the period-expense ratio, and the estimate is also stable when NQP is log-transformed or when province-by-year fixed effects are added (Table 7). These patterns suggest that the main result is not an artifact of one particular functional form or broad regional time shocks. However, future-NQP placebo terms are also significant in simpler specifications, which is more consistent with persistence or trending confounding than with a sharply identified treatment effect. Once firm-specific linear trends are introduced, the contemporaneous coefficient becomes much smaller and statistically weak, while the lagged specification remains negative and significant (Table 7). These patterns reinforce a cautious reading of the evidence.

Table 7. Summary of Robustness Tests

Specification	Core Variable	Coefficient	Std. Err.	Conclusion
Lagged one period	L1_NQP	-13.601	(1.376)	Robust
Log transform	ln(1+NQP)	-11.020	(1.289)	Robust
Excluding 2020	NQP	-10.822	(1.322)	Robust
Province x Year FE	L1_NQP	-13.542	(1.380)	Robust
Province x Year FE	ln(1+NQP)	-10.973	(1.286)	Robust
Firm linear trends	NQP	-2.530	(1.643)	Insignificant
Firm linear trends	L1_NQP	-5.781	(1.739)	Significant

Notes. The table summarizes the direction and statistical significance of the core coefficient across alternative specifications. Section 4.5 explains the identification concern addressed by each design and the appropriate interpretation of the resulting coefficient pattern.

Overall, the robustness tests strengthen confidence that the negative NQP-expense relationship is economically meaningful and not purely mechanical, while also making clear that the evidence falls short of definitive causal identification. Rather than weakening the paper, this boundary strengthens its credibility by distinguishing robust panel evidence from stronger causal claims that the current design cannot yet fully support.

4.6 Chapter Summary

Based on 37,498 firm-year observations, this section examines the association between new quality productive forces and firms' expense ratios. Four main findings emerge. First, higher NQP is consistently associated with lower expense ratios, with the strongest association appearing in management expense intensity. The effect on sales expense intensity is weaker and not statistically significant. Second, higher NQP is positively associated with ATO, and turnover-based evidence points to asset utilization and receivables management as the most plausible channels through which improved operating efficiency is linked to lower expense intensity.

Third, the baseline association is broadly stable across firm-size groups, suggesting that the result is not confined to a particular segment of firms. At the same time, the

association is stronger in regions with more favorable digital conditions, indicating that the local environment may shape the extent to which NQP is translated into cost discipline. Fourth, the main result remains negative across the principal robustness checks, including lagged specifications, alternative functional forms, and stronger fixed effects. Overall, the evidence is most consistent with the view that higher NQP is associated with lower expense intensity at the firm level, while the interpretation should remain within the bounds of panel-association evidence rather than strict causal identification.

5 Discussion

The findings support interpreting NQP as an operating capability rather than a symbolic modernization label. Stronger NQP is associated with lower period-expense intensity, and this association is concentrated in management expenses rather than sales expenses. The mechanism analyses further indicate that the relationship is more closely related to stronger asset utilization and receivables management than to broad-based improvements across all turnover measures. Overall, the evidence suggests that NQP matters most when capability upgrading strengthens internal coordination, information processing, and operating conversion.

5.1 Interpretation of Period-expense Intensity

Because threefee_rate scales period expenses by operating revenue, a lower ratio may reflect expense compression, revenue expansion, or both. The empirical pattern is more consistent with efficiency-driven dilution than with pure cost cutting. The evidence is concentrated in ATO, total asset turnover, and accounts receivable turnover, and the NQP coefficient attenuates after these variables are added to the expense equation. This pattern indicates that stronger NQP is associated with improved operating conversion—especially in receivables routines and system-level resource utilization—rather than merely with short-term retrenchment in administrative spending.

5.2 Theoretical Implications

The results strengthen the joint TCE-OIPT explanation. Under OIPT, NQP enhances the firm's capacity to process operational information, improve cross-functional coordination, and support higher-quality execution. Under TCE, NQP reduces coordination and monitoring frictions, thereby lowering the internal governance burden reflected in management expenses. Taken together, these findings suggest that NQP is associated with a distinct operating profile characterized by lower internal expense intensity, stronger asset conversion, and better receivables efficiency. By incorporating human capital, innovation capability, green production, and data-factor utilization, the NQP measure extends beyond digital transformation alone and links multidimensional productive upgrading to firm-level operating outcomes. In this respect, the present findings are broadly aligned with recent evidence that digital transformation can strengthen technical efficiency, operational routines, and value creation when sup-

ported by complementary organizational capital and process-level upgrading (Tian et al., 2023; Zhang & Deng, 2024; Zareie et al., 2024).^[1,2,3]

5.3 Boundary Conditions

The heterogeneity results suggest that the value of NQP is context-dependent. Differences across firm-size groups are limited, implying that the relationship is not confined to a particular size class. By contrast, the stronger association in high-NQP regions indicates that external digital and innovation ecosystems facilitate the conversion of internal capability upgrading into operating gains. This finding is consistent with the view that firm-level capabilities and regional ecosystem complementarities jointly shape the economic returns to upgrading.

5.4 Identification Boundaries

The findings should not be overstated. Observational panel data cannot fully eliminate residual confounding, and part of the baseline association may reflect persistent firm trajectories rather than short-run shifts induced by NQP alone. The significance of future-NQP placebo terms in simpler specifications and the attenuation of contemporaneous effects after adding firm-specific trends both point to this possibility. The results should therefore be interpreted as robust panel associations with mechanism-consistent support rather than as definitive causal estimates. Future research could strengthen identification by combining the firm-level NQP measure with plausibly exogenous shocks, such as staggered digital-infrastructure expansion, industrial digitalization pilots, or data-factor reform programs.

5.5 Practical Implications

For managers, the results suggest that NQP-related cost reduction depends less on technology spending itself than on whether digital, innovation-related, green, talent, and data inputs are translated into process-level discipline. Improving receivables workflows, strengthening asset-utilization governance, and building robust data-governance routines appear especially important. For policymakers, the regional results indicate that digital infrastructure and innovation ecosystems materially shape how effectively firm-level NQP can be converted into operating gains.

6 Conclusion

6.1 Main Conclusions

Using panel data for Chinese A-share listed firms from 2012 to 2024, this study examines whether firm-level NQP is associated with cost reduction and efficiency enhancement. The findings show that higher NQP is consistently associated with lower period-expense intensity, measured by `threefee_rate`. This relationship is concentrated

in management-expense intensity rather than sales-expense intensity, indicating that NQP is more closely linked to internal administration, coordination, and operating discipline than to outward-facing selling activities.

6.2 Limitations and Future Research

Several limitations should be noted. First, although the baseline and robustness results support a stable negative association between NQP and expense intensity, the significance of future-placebo terms and the attenuation of the contemporaneous coefficient under firm-specific linear trends suggest that time-varying firm trajectories may still matter. Future research should therefore pursue stronger causal identification through exogenous shocks, quasi-natural experiments, or more plausibly exogenous policy variation.

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