Sustainable Management Review

doi: 10.70693/smr.v1i4.27
Vol 1, No 4 (2026)
Open Access Article

OPEN ACCESS ARTICLE

Highly Educated Employees and Firm Productivity: Agency Cost and Innovation Efficiency Channels in Chinese Listed Firms

Lin Li[1,*]

[1]School of Management, Guangxi Minzu University, 530006 Guangxi China

[*]Corresponding author. Lin Li,17255065@qq.com

Received on September 6 Month 2026; accepted on November 3 Month 2026

Abstract

This study examines the association between education-based human capital and firm productivity and investigates the organizational channels through which that association operates. Using an unbalanced panel of Chinese listed firms from 2007 to 2023, we measure human capital as the share of employees holding a master's degree or above and estimate total factor productivity with the Olley-Pakes method. Regressions with industry and year fixed effects show that a larger share of postgraduate-educated employees is positively associated with firm productivity. Mediation tests indicate that internal governance and operating measures, together with patent-based innovation efficiency, partly transmit this association. The invention-patent channel is stronger than the utility-model and design-patent channel, whereas the proxy for conflicts between controlling and minority shareholders has a negative indirect effect. Industry-level analyses suggest that the governance and operating channel is more pronounced in secondary industries, while the innovation channel is stronger in tertiary industries. The results show that the productivity value of highly educated employees depends on a firm's ability to incorporate their knowledge and skills into governance arrangements and substantive innovation. Because the research design primarily identifies conditional associations, the analysis does not make causal claims beyond the evidence.

Key words: Education-based human capital; Total factor productivity; Agency costs; Innovation efficiency; Chinese listed firms

Introduction

As the Chinese economy has shifted from rapid expansion toward productivity-led growth [Jin, 2018, Shi, 2018, Zhang et al., 2019], firm performance ha s become increasingly dependent on technological capability, resource al location, and organizational efficiency [Bititci, 2007, Hu et al., 2020, Lin e t al., 2003]. Human capital can support each of these functions. Employees with advanced education may absorb complex knowledge more quickly, adapt to new technologies, and improve communication across technical and managerial units. The educational composition of a firm's workforce may therefore help explain persistent differences in productivity.

Research on human capital generally finds that education and skills matter for economic growth and organizational performance. The firm-level evidence, however, leaves several issues unresolved. First, studies often use human capital as a broad label without distinguishing education from experience, occupation-specific skills, or managerial expertise. Second, much of the literature estimates a direct relationship between human capital and innovation or performance but gives less attention to the organizational processes that convert employee knowledge into productive outcomes. Third, the concept of high-quality firm development is often treated as multidimensional [Wei and Li, 2018, Zhao et al., 2019] even when the empirical measure is total factor productivity. When TFP is the dependent variable, firm productivity is the more accurate description of the outcome.

This study focuses on the educational composition of the workforce. We define education-based human capital as the proportion of employees with a master's degree or above and examine its association with total factor productivity estimated by the Olley-Pakes method. We then test two sets of observable channels. The first captures internal governance and operations through administrative and operating expense ratios, total asset turnover, and a proxy for principal-principal agency costs. The second captures innovation efficiency through patent applications per R&D employee, with separate measures for invention patents and for utility-model and design patents. This formulation keeps the theoretical claims close to the variables observed in the data.

The study offers three contributions. First, it replaces an expansive human capital construct with a specific measure of employee education. The resulting interpretation is narrower but more defensible. Second, it examines governance-related and innovation-related channels in the same empirical setting and distinguishes invention patents from other patent types. This distinction reveals whether the association with productivity is concentrated in more substantive forms of innovation. Third, the analysis compares mediation patterns across secondary and tertiary industries, where the organizational uses of highly educated labor are likely to differ.

The remainder of the paper proceeds as follows. Section 2 reviews the relevant literature and develops the hypotheses. Section 3 describes the sample, variables, and empirical models. Section 4 presents the baseline estimates,

© The Author 2026. Sustainable Management Review journal homepage: https://smrjournal.com

industry differences, and mediation results. Section 5 discusses the findings, implications, and limitations.

Literature Review and Hypotheses

Education-Based Human Capital and Firm Productivity

Human capital theory treats education, training, and work experience as investments that improve knowledge, problem-solving capacity, and the ability to use technology [Wang, 1985, Xu and Luo, 2006]. A firm with a larger pool of highly educated employees may be better able to absorb external knowledge, operate complex production systems, and coordinate decisions across organizational units. Regional evidence from China also links the stock of highly skilled labor to labor productivity, with stronger effects as industries move toward more technology-intensive activities [Chen, 2022, Peng and Cao, 2020, Zhang and Ma, 2022].

Educational attainment is not itself a productive outcome. Its value depends on job matching, organizational design, and the technological environment. Digital technologies can lower the cost of codifying, sharing, and reusing knowledge, which may increase the returns to employees who perform research, engineering, and analytical work [Chen and Yang, 2021, Xu and Zhang, 2020]. The share of postgraduate-educated employees is therefore a useful observable measure of education-based human capital, but it should not be treated as a complete measure of the firm's skills and experience.

H1: The share of employees holding a master's degree or above is positively associated with firm total factor productivity.

Internal Governance and Operating Channels

Human capital affects production through organizational arrangements [Bititci, 2007]. Employees with technical and managerial expertise may improve information processing, budgeting, workflow coordination, and performance evaluation. The dynamic capabilities literature similarly argues that managers' ability to identify change, combine resources, and adjust organizational structures is an important source of persistent performance differences [Volberda et al., 2013, Zhang and Zhang, 2012].

The empirical meaning of governance proxies requires care. Administrative and operating expense ratios may capture agency costs, but they can also include necessary investments in organizational capacity. Total asset turnover is a direct measure of asset utilization rather than an agency cost. The ratio of other receivables to total assets is used to proxy for conflicts between controlling and minority shareholders. Because these indicators capture different organizational processes, their indirect effects need not have the same sign. Related governance research also shows that executive equity incentives can influence firm upgrading [Xiao and Yang, 2018].

H2: Internal governance and operating measures mediate the association between education-based human capital and total factor productivity, although the direction of the indirect effect may differ across measures.

Innovation Efficiency Channel

Innovation depends on the ability to identify technical problems, recombine knowledge, and convert ideas into usable outputs. Chinese firm-level research emphasizes both the measurement of innovation and the persistence of innovation under policy uncertainty [An et al., 2020, Huo et al., 2023]. A larger proportion of highly educated employees may strengthen a firm's capacity to conduct these activities and raise patent output relative to R&D labor. Patent applications are closer to current research activity than patent grants, although they still represent only one dimension of innovation.

Patent types also differ in technological requirements and expected economic value. Invention patents generally face a more demanding examination of novelty and inventive content than utility-model and design patents. We therefore estimate separate mediation effects for overall patent efficiency, invention-patent efficiency, and the efficiency of utility-model and design patent applications. This approach avoids treating all patent counts as equivalent measures of innovative capability.

H3: Patent-based innovation efficiency mediates the association between education-based human capital and total factor productivity, with a larger contribution from the invention-patent channel than from the utility-model and design-patent channel.

Industry Differences

Secondary industries typically rely on physical assets, standardized processes, and supply-chain coordination [Gereffi, 1999, Guo et al., 2022]. Governance, cost control, and asset utilization may therefore have a relatively direct connection to productivity. Tertiary industries rely more heavily on knowledge-intensive services, intangible assets, and rapid responses to customers, making innovation efficiency a plausible channel for realizing the value of highly educated labor. We treat the industry analysis as exploratory evidence on these differences rather than as a separate causal test.

Methodology and Procedures

Data and Sample

The sample covers Chinese listed firms from 2007 to 2023. The main variables are obtained from the CSMAR database. We exclude ST, *ST, and PT firms, financial firms, and observations from or before a firm's initial public offering year. Continuous variables are winsorized at the 1st and 99th percentiles. After matching observations with complete data for the baseline specification, the regression sample contains 43,547 firm-year observations. The industry subsamples contain 612 observations in primary industries, 32,354 in secondary industries, and 10,581 in tertiary industries.

Listed firms do not use a uniform format when reporting employee education. We standardize descriptions referring to master's and doctoral education and retain observations that disclose the number of employees in this category. This procedure improves comparability but may introduce selection because firms with incomplete disclosure are excluded.

Variables

The dependent variable is total factor productivity estimated with the Olley-Pakes procedure. The method uses investment as a proxy for unobserved productivity shocks and addresses part of the simultaneity between input choices and productivity. The explanatory variable is the number of employees with a master's degree or above divided by total employment. The control variables cover firm characteristics, financial condition, and governance structure.

Empirical Specification

We estimate the conditional association between education-based human capital and TFP using industry and year fixed effects. The baseline model is:

$$TFP_{it} = \alpha + \beta Talent_{it} + \gamma Controls_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

where TFP denotes total factor productivity for firm i in year t, Talent is the share of employees with a master's degree or above, and Controls is the vector of firm-level covariates. Year and Industry denote year and industry fixed effects. Standard errors are clustered at the firm level. The regressions use standardized variables so that the coefficients can be compared across specifications.

The mediation analysis introduces each internal governance, operating, or innovation-efficiency measure as an intermediate variable and evaluates the product of the relevant coefficients with a bootstrap procedure. The reported analysis uses 100 bootstrap replications. Patent coverage reduces the usable sample, so the governance and innovation models have different total effects. Mediation shares must therefore be interpreted within the corresponding estimation sample rather than compared mechanically across channels.

Table 1. Variable Definitions

Category	Variable	Definition
Dependent variable	Total factor productivity	TFP estimated with the Olley-Pakes method
Explanatory variable	Education-based human capital	Employees with a master's degree or above divided by total employees
Firm characteristic	Firm age	Natural logarithm of current year minus founding year plus one
Firm characteristic	Firm size	Natural logarithm of total assets
Firm characteristic	Labor intensive	One for labor-intensive industries and zero otherwise
Firm characteristic	Fixed asset ratio	Net fixed assets divided by total assets
Firm characteristic	Sales growth	Change in operating revenue divided by lagged operating revenue
Financial condition	Return on assets	Net income divided by average total assets
Financial condition	Leverage	Total liabilities divided by total assets
Financial condition	Cash flow ratio	Net operating cash flow divided by operating revenue
Financial condition	Current ratio	Current assets divided by current liabilities
Governance	Ownership concentration	Shareholding of the largest shareholder
Governance	Independent director ratio	Independent directors divided by total directors and multiplied by 100
Governance	Board size	Natural logarithm of the number of directors
Governance	CEO duality	One when the chair and chief executive are the same person

Table 2. Descriptive Statistics

Variable	Mean	Standard deviation	Minimum	Maximum
Total factor productivity	6.511	0.975	4.139	9.050
Education-based human capital	0.036	0.058	0.000	0.328
Firm age	2.791	0.449	1.386	3.526
Firm size	22.009	1.294	19.678	26.097
Labor intensive	0.358	0.479	0.000	1.000
Fixed asset ratio	0.222	0.165	0.002	0.708
Sales growth	0.164	0.384	-0.579	2.267
Return on assets	0.040	0.065	-0.224	0.216
Leverage	0.425	0.204	0.052	0.896
Cash flow ratio	0.047	0.071	-0.170	0.248
Current ratio	2.411	2.567	0.238	16.591
Ownership concentration	0.348	0.151	0.086	0.743
Independent director ratio	35.885	8.423	0.000	57.140
Board size	2.136	0.209	1.609	2.708
CEO duality	0.266	0.442	0.000	1.000

Empirical Results

Baseline Estimates

Table 3 presents the baseline results. The standardized coefficient on education-based human capital is 0.120 when it is entered alone. The coefficient declines to 0.055 after the models add firm characteristics and year and industry fixed effects, but it remains significant at the 1 percent level. The estimates support H1: the share of postgraduate-educated employees has a stable positive association with TFP after accounting for observed firm characteristics, common industry factors, and year-specific shocks. The specification does not eliminate reverse causality or time-varying unobserved firm characteristics and therefore does not establish a causal effect.

Industry Differences

Table 4 reports estimates by industry group. The coefficient is not statistically significant in primary industries. It is positive and significant in both secondary and tertiary industries, with a larger coefficient in the tertiary sector. The results are consistent with the view that the productivity value of advanced education depends on the knowledge intensity and organizational structure of the industry. The estimate for primary industries should be interpreted cautiously because the subsample is small.

Internal Governance and Operating Channels

We use administrative expenses, operating expenses, total asset turnover, and principal-principal agency costs to describe different aspects of internal governance and operations. Administrative and operating expenses may include both agency costs and productive organizational investment, so their indirect effects should not be read as direct measures of managerial efficiency. Total asset turnover captures asset utilization. The principal-principal agency-cost proxy is other receivables divided by total assets.

Table 7 shows positive indirect effects for the administrative and operating expense ratios and negative indirect effects for total asset turnover and principal-principal agency costs. The net indirect effect is 0.0168, or 30.40 percent of the total effect in this sample. The results support H2 because the organizational measures transmit part of the human capital-productivity association and operate in different directions. The positive expense-ratio paths should not be interpreted as evidence that human capital reduces agency costs. The negative indirect effect of principal-principal agency costs indicates that conflicts between controlling and minority shareholders may weaken the positive association between highly educated employees and productivity.

Innovation Efficiency Channel

Table 8 reports the mediation estimates for patent-based innovation efficiency. Overall innovation efficiency, invention-patent efficiency, and other-patent efficiency all have positive indirect effects. Together, the three measures account for 31.48 percent of the total effect in the corresponding sample.

Table 3. Education Based Human Capital and Total Factor Productivity

Variable	Model 1	Model 2	Model 3	Model 4
Education-based human capital	0.120*** (9.60)	0.041*** (5.27)	0.037*** (4.70)	0.055*** (7.19)
Firm age		0.051*** (5.87)	0.031** (2.57)	0.020* (1.76)
Firm size		0.567*** (63.22)	0.562*** (60.24)	0.566*** (62.26)
Labor intensive		0.068*** (3.58)	0.076*** (4.00)	0.010 (0.38)
Fixed asset ratio		-0.202*** (-22.41)	-0.198*** (-21.51)	-0.185*** (-18.79)
Sales growth		0.055*** (14.83)	0.056*** (14.82)	0.064*** (17.32)
Return on assets		0.120*** (18.91)	0.124*** (19.58)	0.111*** (18.37)
Leverage		0.153*** (13.71)	0.157*** (13.69)	0.136*** (12.32)
Cash flow ratio		0.044*** (8.93)	0.041*** (8.36)	0.044*** (9.37)
Current ratio		-0.029*** (-3.47)	-0.030*** (-3.53)	-0.035*** (-4.39)
Ownership concentration		0.030*** (3.55)	0.031*** (3.67)	0.036*** (4.65)
Independent director ratio		-0.032*** (-2.62)	-0.031** (-2.55)	-0.020* (-1.88)
Board size		-0.042*** (-4.67)	-0.037*** (-4.05)	-0.030*** (-3.61)
CEO duality		-0.012** (-2.03)	-0.016*** (-2.82)	-0.019*** (-3.49)
Year fixed effects	No	No	Yes	Yes
Industry fixed effects	No	No	No	Yes
Observations	43,576	43,547	43,547	43,547
Adjusted R-squared	0.016	0.598	0.602	0.637

Note: The table reports standardized coefficients followed by t statistics. Standard errors are clustered by firm. ***, **, and * denote significance at the 1, 5, and 10 percent levels.

Table 4. Industry Differences in the Human Capital Productivity Association

Item	Primary industries	Secondary industries	Tertiary industries
Education-based human capital	0.151 (1.39)	0.036*** (4.02)	0.099*** (7.05)
Controls	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes
Observations	612	32,354	10,581
Adjusted R-squared	0.500	0.649	0.626

Note: The table reports standardized coefficients followed by t statistics. *** denotes significance at the 1 percent level.

Table 5. Mediating Variables

Channel	Measure	Definition
Governance and operations	Administrative expense ratio	Administrative expenses divided by operating revenue
Governance and operations	Operating expense ratio	Administrative and selling expenses divided by operating revenue
Governance and operations	Total asset turnover	Operating revenue divided by average total assets
Governance and operations	Principal-principal agency costs	Net other receivables divided by total assets
Innovation efficiency	Overall innovation efficiency	Patent applications divided by ln R&D employees plus one
Innovation efficiency	Invention-patent efficiency	Invention patent applications divided by ln R&D employees plus one
Innovation efficiency	Other-patent efficiency	Utility-model and design patent applications divided by ln R&D employees plus one

Invention-patent efficiency contributes 14.79 percent, compared with 5.04 percent for utility-model and design patents. The result supports H3 and suggests that the association between highly educated employees and productivity is more closely related to technologically substantive patent output than to patent counts alone.

The governance and innovation models use different effective samples, which explains the different total effects in Tables 7 and 8. The mediation shares of 30.40 and 31.48 percent are meaningful only within their respective samples and do not show that one broad channel is stronger than the other.

Industry Differences in the Mediating Channels

Table 9 shows that the net governance and operating channel accounts for 67.46 percent of the total association in secondary industries, compared with a slightly negative share in tertiary industries. The contributions of overall innovation efficiency and invention-patent efficiency are 22.26 and 22.99 percent in tertiary industries, both larger than the corresponding estimates for secondary industries. These patterns are consistent with the greater importance of asset use, process control, and cost management in secondary industries and the stronger reliance on knowledge conversion and intangible outputs in tertiary industries.

Conclusion and Implications

Main Findings

This study examines the association between the educational composition of a firm's workforce and total factor productivity in Chinese listed firms from 2007 to 2023. The baseline estimates show that the share of employees with a master's degree or above is positively associated with TFP. The association is statistically significant in secondary and tertiary industries but not in the smaller primary-industry sample.

Table 6. Descriptive Statistics for Mediating Variables

Variable	Observations	Mean	Standard deviation	Minimum Maximum
Administrative expense ratio	54,804	0.088	0.074	0.008 0.475
Operating expense ratio	54,051	0.160	0.132	0.014 0.722
Total asset turnover	51,136	0.649	0.455	0.071 2.675
Principal-principal agency costs	54,793	0.020	0.035	0.000 0.219
Overall innovation efficiency	32,166	2.102	6.381	0.000 36.117
Invention-patent efficiency	32,166	0.932	3.377	0.000 23.416
Other-patent efficiency	32,166	0.465	1.950	0.000 13.982

Table 7. Mediation through Internal Governance and Operations

Mediating measure	Indirect effect	Share of total effect
Administrative expense ratio	0.0152	27.61%
Operating expense ratio	0.0107	19.38%
Total asset turnover	-0.0068	-12.41%
Subtotal for first group	0.0191	34.57%
Principal-principal agency costs	-0.0023	-4.17%
Net indirect effect	0.0168	30.40%
Total effect	0.0551	100.00%

Table 8. Mediation through Innovation Efficiency

Mediating measure	Indirect effect	Share of total effect
Overall innovation efficiency	0.0037	11.65%
Invention-patent efficiency	0.0047	14.79%
Other-patent efficiency	0.0016	5.04%
Net indirect effect	0.0100	31.48%
Total effect	0.0318	100.00%

Table 9. Industry Differences in Mediation Shares

Channel and measure	Full sample	Secondary industries	Tertiary industries
Administrative expense ratio	27.61%	55.73%	7.63%
Operating expense ratio	19.38%	31.55%	3.26%
Total asset turnover	-12.41%	-16.53%	-6.48%
Subtotal for first group	34.57%	70.75%	4.41%
Principal-principal agency costs	-4.17%	-3.28%	-5.15%
Net governance and operating effect	30.40%	67.46%	-0.75%
Overall innovation efficiency	11.65%	10.92%	22.26%
Invention-patent efficiency	14.79%	14.13%	22.99%
Other-patent efficiency	5.04%	5.31%	Not reported

The mediation analysis identifies distinct organizational channels. Governance and operating measures account for a net 30.40 percent of the total association in their estimation sample, with negative indirect effects for total asset turnover and principal-principal agency costs. Patent-based innovation measures account for 31.48 percent of the total association in the innovation sample. The contribution of invention-patent efficiency exceeds that of utility-model and design patents. Industry results indicate that governance and operating measures matter more in secondary industries, whereas innovation efficiency is more prominent in tertiary industries.

Theoretical Implications

The findings support a specific interpretation of human capital. Employee education has a stable relationship with productivity, but the relationship depends on organizational processes that convert knowledge into production outcomes. By defining human capital as the share of postgraduate-educated employees, the analysis also sets a clear boundary on its claims. The estimates concern education-based human capital, not the combined effects of experience, professional certification, tacit knowledge, or health.

The mediation results further show why broad labels such as managerial efficiency and innovative capability can be misleading. Expense ratios, asset turnover, and controlling-shareholder agency costs represent different economic processes. Patent types also vary in technological content. Empirical work on human capital should therefore match each theoretical mechanism to a measure with a defensible economic interpretation.

Managerial and Policy Implications

For managers, hiring more highly educated employees does not by itself ensure productivity gains. Firms also need decision rights, evaluation systems, and collaborative routines that allow advanced skills to be used in operations and research. Secondary-industry firms may obtain more value from process governance, asset use, and the control of agency conflicts. Tertiary-industry firms may benefit more from knowledge sharing and the conversion of research effort into substantive innovation.

For policymakers, the evidence favors attention to the match between educational supply and industry demand rather than an exclusive focus on the number of advanced-degree holders. Intellectual property protection, researcher mobility, and minority-shareholder protection may influence the conditions under which firms convert human capital into productivity. These implications follow from observed associations; the study does not directly estimate the effect of any specific policy.

Limitations

The study has four limitations. First, the share of postgraduate-educated employees does not capture occupational skills, work experience, or tacit knowledge. Second, incomplete education disclosure may create sample selection. Third, industry and year fixed effects do not remove reverse causality or time-varying unobserved firm heterogeneity, so the estimates should be read as conditional associations. Fourth, expense ratios and patent applications are imperfect mechanism proxies, and the current mediation tests use a limited number of bootstrap replications. Future research could add firm and year fixed effects, lagged human capital, exogenous variation in graduate labor supply, and outcome measures based on patent citations, technological scope, and commercialization.

References

B. Jin. Economic research on high-quality development. *China Industrial Economics*, (4):5–18, 2018.

D. Shi. Green development and the new stage of global industrialization: China's progress and comparison. *China Industrial Economics*, (10):5–18, 2018.

J. Zhang, Y. Hou, P. Liu, J. He, and X. Zhuo. The objectives and strategic path of high-quality development. *Management World*, 35(7):1–7, 2019.

U. S. Bititci. An executive's guide to business transformation. *Business Strategy Series*, 8(3):203–213, 2007.

H. Hu, B. Dou, and A. Wang. Corporate financialization and productivity. *The Journal of World Economy*, 43(1):70–96, 2020.

H. Lin, M. Xia, J. He, and H. Guan. Problems confronting the development of small and medium-sized enterprises: A questionnaire survey of beijing, liaoning, jiangsu, zhejiang, hubei, guangdong, and yunnan. *Social Sciences in China*, (2):84–94, 2003.

M. Wei and S. Li. Study on the measurement of economic high-quality development level in china in the new era. *The Journal of Quantitative & Technical Economics*, 35(11):3–20, 2018. doi: 10.13653/j.cnki.jqte.2018.11.001.

J. Zhao, D. Shi, and Z. Deng. Research on the connotation of high-quality development. *Research on Economics and Management*, 40(11):15–31, 2019.

T. Wang. *General theory of talent studies*. Tianjin People's Publishing House, 1985.

S. Xu and H. Luo. *A history of Marxist thought on talent*. China Personnel Press, 2006.

L. Chen. Theoretical basis and empirical studies of agglomeration economy influencing urban economic growth: Literature review and prospect. *Progress in Geography*, 41(7):1325–1337, 2022. doi: 10.18306/dlkxjz.2022.07.015.

W. Peng and W. Cao. The impact of human capital agglomeration on regional high-quality development and its heterogeneity. *Seeker*, (5):180–189, 2020.

L. Zhang and L. Ma. Digital economy, industrial structure upgrading, and total factor productivity. *Statistics & Decision*, 38(3):5–10, 2022. doi: 10.13546/j.cnki.tjyjc.2022.03.001.

X. Chen and X. Yang. The impact of digital economy development on industrial structure upgrading: Based on grey relational entropy and dissipative structure theory. *Reform*, (3):26–39, 2021.

X. Xu and M. Zhang. Research on the scale measurement of china's digital economy: Based on an international comparison. *China Industrial Economics*, (5):23–41, 2020.

H. W. Volberda, F. A. J. Van den Bosch, and C. V. Heij. Management innovation: Management as fertile ground for innovation. *European Management Review*, 10(1):1–15, 2013. doi: 10.1111/emre.12007.

J. Zhang and S. Zhang. On organizational mechanism for dynamic capabilities building: Case study from the perspective of knowledge sharing and collective interpretation. *Studies in Science of Science*, 30(9):1405–1415, 2012.

S. Xiao and J. Yang. Does executive equity incentive promote firm upgrading? evidence from chinese listed companies. *Nankai Business Review*, 21(3):66–75, 2018.

T. An, J. Wei, and X. Shu. Measuring innovation in chinese manufacturing enterprises: An intertemporal comparison based on micro-level innovation surveys. *Social Sciences in China*, (3):99–122, 2020.

Y. Huo, X. He, and Y. Tao. The impact of economic policy uncertainty on the persistence of corporate innovation: A nonlinear perspective. *Journal of Technology Economics*, 42(2):64–77, 2023.

G. Gereffi. International trade and industrial upgrading in the apparel commodity chain. *Journal of International Economics*, 48(1):37–70, 1999. doi: 10.1016/S0022-1996(98)00075-0.

Z. Guo, S. Cao, and J. Feng. The impact of supply-chain relational capital on high-quality enterprise development. *Friends of Accounting*, (6):33–39, 2022.