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## New Research



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# Role of ESG Ratings in Shaping Investment Attractiveness: Insights from BRICS Countries

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## Abstract

The research objective is to analyze the impact of ESG ratings on the investment attractiveness of companies in BRICS countries in comparison with other countries, as well as to study the sectoral specifics of such influence in BRICS countries. The methodology is based on the regression analysis of the impact of ESG ratings and the duration of their disclosure on investment attractiveness indicators, including Tobin's Q, EV/EBITDA, P/BV, and WACC. The study utilizes a dataset comprising 16 691 observations for 1859 companies from 57 countries between 2014 and 2022, including 2116 observations for 236 companies from BRICS countries. The analysis revealed that an increase in ESG ratings positively affects market value (Tobin's Q) and risk reduction (WACC) in BRICS countries, while in other countries, their influence is associated with increase in EV/EBITDA and decrease in P/BV. Sector analysis revealed that ESG rating increase positively influence market value in information technology and communication sectors. This study is the first to conduct a comparative analysis of ESG impact in BRICS countries and other regions, including a sectoral analysis, which makes the findings valuable for shaping ESG strategies in this market and assessing business sustainability.

**Keywords:** ESG, ESG ratings, green economy, investment attractiveness, corporate social responsibility (CSR), sustainable development, environmental factors, social factors, corporate governance, financial performance, BRICS countries

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# Introduction

Environmental, Social, and Governance (ESG) practices have emerged as a critical component of corporate strategy, shaping financial performance, investment attractiveness, and market valuation across diverse economic contexts. The integration of ESG factors into business operations is no longer discretionary but increasingly essential, driven by evolving investor preferences, regulatory requirements, and stakeholder expectations. While the benefits of ESG adoption are well-documented in developed markets [1; 2], its influence in emerging economies, particularly in BRICS countries, remains underexplored [3; 4]. These economies present unique dynamics due to varying institutional frameworks, governance standards, and socio-economic challenges.

The subject of this study is the impact of ESG ratings on the investment attractiveness of companies in BRICS countries, with a comparative analysis of non-BRICS markets. The object is the relationship between ESG ratings, ESG rating reporting duration, and key investment attractiveness metrics such as Tobin's Q, EV/EBITDA, P/BV ratios, and Weighted Average Cost of Capital (WACC). By additional examination of industrial effects for BRICS countries, this study aims to uncover the specifics by which ESG practices influence financial outcomes and investor behavior.

The scientific novelty of this study lies in its focus on the nuanced ESG dynamics in BRICS countries compared to non-BRICS markets. By analyzing how ESG ratings and reporting influence financial performance and investment attractiveness across sectors, this research also contributes to a deeper understanding of regional and industry-specific variations. The findings offer practical insights for policymakers, corporate leaders, and investors aiming to optimize ESG strategies in diverse market contexts, aligning sustainability goals with financial success.

This study addresses critical gaps in ESG literature by exploring how market conditions, and sectoral factors shape the outcomes of ESG practices. By focusing on BRICS countries, it adds valuable perspectives to the global discourse on sustainable business practices, highlighting the growing importance of ESG as a tool for driving long-term corporate growth and competitiveness.

# Literature review

## Theoretical frameworks of ESG influence on companies' financials and investment attractiveness

ESG factors significantly influence corporate strategy, shaping financial performance, investment attractiveness, and market valuation. Theoretical frameworks such as Stakeholder Theory and Institutional Theory offer insights into these effects. Stakeholder Theory emphasizes that addressing ESG concerns strengthens relationships with various stakeholders, improving reputation and financial outcomes [5]. Institutional Theory highlights how regulatory and societal norms drive ESG adoption to align corporate behavior with expectations and secure legitimacy [5]. Market Theories demonstrate the financial materiality of ESG, with investors using ESG metrics to assess risks and integrate them into decision-making, as aligned with the Efficient Market Hypothesis [5].

Studies consistently show that ESG integration enhances financial performance. For example, companies with robust ESG practices report improved Return on Assets (ROA) and Return on Equity (ROE) due to operational efficiencies and risk management [6; 7]. ESG-compliant firms also attract investor confidence during volatile periods, leading to better stock performance and reduced fluctuations [8; 9]. Furthermore, ESG practices lower financing costs by reducing perceived risk, enabling companies to secure capital at favorable rates [5; 10].

Market valuation sees a positive correlation with ESG, as firms with strong ESG ratings command higher price-to-earnings ratios and market capitalizations, driven by investor demand for sustainability and regulatory alignment [11; 12]. ESG also drives institutional investment, with studies showing that ESG-compliant firms attract long-term, stability-focused investors [13; 14].

However, ESG adoption faces challenges, particularly in resource-intensive sectors where high implementation costs can strain operational efficiency and profit margins [15; 16]. ESG controversies, such as greenwashing accusations, can erode trust and result in negative market reactions [17; 18]. Weak governance exacerbates these risks, leading to inefficiencies and poor financial outcomes in scrutinized industries like oil and gas [19; 20]. Misaligned ESG strategies further complicate impact, with firms struggling to balance ESG goals with profitability often experiencing reduced innovation and lower valuation [21].

## Differences in ESG influence mechanisms in emerging and developed markets

In developed markets, ESG integration is strongly linked to improved financial outcomes such as higher returns on assets and equity, supported by rigorous disclosure standards and investor preferences for sustainability [1; 2]. Strong institutional frameworks ensure consistent reporting, boosting investor confidence and attracting capital, while governance structures like board diversity enhance ESG performance and long-term investment flows [22]. However, as sustainability becomes a baseline expectation, ESG may no longer offer competitive differentiation, with companies adopting these practices primarily to maintain parity [23].

In emerging markets, the relationship between ESG and financial performance is more varied, often sector-specific and influenced by external factors. Environmental investments in industries like energy yield positive outcomes, but governance and social aspects face challenges due to weaker institutional frameworks [3; 20]. Political instability further complicates governance gains, limiting financial benefits like lower equity costs [24]. Foreign investment and global supply chains play a pivotal role in driving ESG adoption, as firms align with international standards to re-

main competitive [4]. However, varied consumer perceptions of corporate social responsibility reduce ESG's universal applicability [25].

Key differences between developed and emerging markets include ESG drivers and outcomes. Developed markets benefit from institutional investor demand for measurable ESG impacts, reduced financing costs, and long-term value creation. In contrast, emerging markets rely on foreign investment to drive adoption and face higher implementation costs, though technological advancements are helping close the gap. Cultural and economic contexts further shape effectiveness, with developed markets focusing on long-term sustainability, while emerging markets prioritize short-term stability [3].

## BRICS perspective on ESG influence of companies' financials and investment attractiveness

The relationship between ESG practices and corporate performance in BRICS countries reveals patterns shaped by socio-economic and regulatory environments. ESG integration is increasingly recognized as a driver of investment attractiveness, particularly in sectors like oil and gas, electric utilities, and banking, where it signals long-term stability and compliance with global trends. Integrated ESG reporting has become critical for evaluating investment attractiveness, especially in sectors like agribusiness and manufacturing, where stakeholders demand transparency.

The development of ESG in BRICS countries is shaped by unique economic, social, and political factors that distinguish this bloc from Western economies. A key characteristic of BRICS is the diversity in market maturity levels and regulatory approaches to sustainable development, leading to significant variations in ESG integration. While China is actively implementing state-led sustainable finance strategies, Brazil focuses on biodiversity conservation, Russia prioritizes the energy transition and emissions regulation, India expands social impact programs, and South Africa is oriented toward economic decarbonization. Despite these differences, the overarching trend of ESG integration is gaining momentum, driven by international pressure, investment needs, and growing domestic demand for sustainable projects.

The influence of different ESG aspects on financial indicators in BRICS countries is heterogeneous, shaped by variations in economic development, regulatory environments, and institutional frameworks. Environmental and social factors generally exhibit a positive correlation with valuation metrics such as Tobin's Q and return on equity (ROE), particularly in countries with emerging financial markets, where sustainable initiatives can enhance investment attractiveness by improving corporate reputation and access to international capital. However, the impact of corporate governance factors is more complex. In China and Russia, strong state involvement in the corporate sector may reduce governance transparency, whereas in India and Brazil, weak protection of minority shareholder rights can limit the effectiveness of ESG practices. These dynamics highlight the institutional vulnerabilities specific to individual BRICS countries [26–28].

The differences in ESG integration are particularly evident in carbon-intensive industries such as energy, metallurgy, and mining, which constitute a significant portion of BRICS economies. In these sectors, the adoption of ESG initiatives can enhance enterprise value by improving efficiency and long-term sustainability. However, it can also exert pressure on credit ratings due to increased capital expenditures associated with decarbonization and the transition to cleaner technologies. For instance, in Russia and South Africa, high dependence on natural resource exports makes balancing environmental commitments with economic stability especially delicate. In contrast, Brazil's environmental initiatives in the agricultural sector may open up new export opportunities but require substantial investments in sustainable practices. Meanwhile, in China, the ESG agenda is largely state-driven, enabling rapid implementation but also posing risks of centralized regulation that may not always align with market mechanisms.

BRICS stock markets also demonstrate unique ESG trends. Companies prioritizing ESG practices show greater stock stability and investor interest during volatile periods [29], while board diversity and governance reforms enhance ESG-driven mergers and acquisitions [30]. Despite these benefits, challenges persist, including high implementation costs in resource-intensive sectors and the need for stronger institutional frameworks to standardize ESG adoption.

These findings highlight the growing importance of ESG in BRICS countries but underscore the need for tailored approaches to address sector-specific barriers and institutional constraints. Improved regulatory support and strategic ESG integration will be essential for scaling sustainable practices across these emerging economies.

## Summary of literature review

The aggregated findings reveal the multifaceted influence of ESG practices across different market contexts, highlighting trends, presented in Table 1.

ESG practices are generally linked to improved financial performance, greater investment attractiveness, and reduced cost of capital, and are driven by operational efficiencies, stakeholder trust, and regulatory alignment. However, these benefits vary across developed, emerging, and BRICS markets due to differences in institutional frameworks and market maturity. In developed markets, ESG practices consistently deliver positive outcomes, including lower financing costs, higher valuations, and strengthened governance. Institutional investors in these regions prioritize sustainability, with social and environmental pillars being particularly impactful due to strong regulatory and consumer pressures.

**Table 1.** Summary of literature review on topic of ESG influence on companies

| Aspect of ESG Impact | General ESG Findings | Developed Markets | Emerging Markets | BRICS Markets |
|---|---|---|---|---|
| Financial Performance | Predominantly positive; ESG enhances operational efficiency and profitability | Stronger correlation; mature ESG practices consistently enhance ROA and ROE | Sector-specific benefits; uneven correlation due to weak institutional support | Positive but uneven; strong outcomes in energy, agribusiness, and manufacturing |
| Investment Attractiveness | Increased institutional investment; ESG ratings improve attractiveness | Dominated by institutional investor demand for ESG-compliant firms | Foreign investment drives ESG adoption and attractiveness | Global supply chains and international capital are key drivers |
| | Higher valuation observed in firms with strong ESG scores | Higher P/E ratios observed for ESG-compliant companies | Improved valuation contingent on external investor confidence | Stock performance stabilized; governance improvements bolster valuation |
| Cost of Capital | Lower cost of capital due to perceived lower risk | Significantly reduced financing costs for ESG leaders | Moderate cost reduction; less developed risk perception frameworks | ESG implementation raises costs but reduces credit risk over time |

*Source*: author.

Emerging markets show more variable ESG outcomes, often influenced by foreign investment and global supply chain dynamics. While weak governance and regulatory enforcement pose challenges, industries like manufacturing and energy benefit from environmental initiatives aligned with global trends. BRICS countries stand out among emerging markets, showing uneven progress but notable success in sectors with global exposure, such as energy and agribusiness. While ESG implementation raises initial costs, it reduces credit risk, stabilizes stock performance, and improves valuation over time. However, the underperformance of social and governance pillars reflects institutional and cultural constraints.

Critical gaps remain in the understanding of ESG's comparative impact on investment attractiveness in BRICS versus other markets. Further research is needed to optimize ESG strategies, addressing the unique challenges of BRICS economies while aligning with global sustainability goals. Such studies could provide actionable insights to bridge theory and practice, ensuring ESG drives sustainable growth and investment across all markets.

# Research methodology

## Research hypotheses

The goal of this paper is to analyze the influence of ESG performance of companies from BRICS markets on their investment attractiveness and compare the outcomes with the situation in other regions. The analysis investigates the following research hypotheses:

- The ESG rating significantly influences the investor attractiveness of companies in BRICS countriess compared to companies from non-BRICS countries.
- The impact of ESG ratings on investor attractiveness in BRICS countries varies significantly across sectors.

## Data

The data used in this analysis includes ESG company data, financial company data and macroeconomic country data. The source of information for ESG and financial data is the Refinitiv database by Thomson Reuters Eikon.

The dataset includes companies that obtained an ESG rating for the entire period of observations. The dataset includes a total of 16691 observations for 1859 companies from 57 countries worldwide. The period covered is 2014–2022. The dataset of BRICS market includes 2116 observations from 236 companies from 7 countries (Brazil, China, Egypt, India, Russia, South Africa, United Arab Emirates). The data for Iraq and Ethiopia is not added due to the absence of companies with ESG ratings. Non-BRICS countries include various countries from Europe, Asia, Oceania, Americas and Africa. More details are provided in Table 2.

**Table 2.** Data overview

| Market | Observations | Unique Companies |
|---|---|---|
| **Non-BRICS countries** | **14 575** | **1623** |
| **BRICS countries** | **2116** | **236** |
| Brazil | 315 | 35 |
| China | 747 | 83 |
| Egypt | 9 | 1 |
| India | 468 | 52 |
| Russia | 34 | 4 |
| South Africa | 534 | 60 |
| United Arab Emirates | 9 | 1 |

*Source*: author.

The companies are categorized by sector based on the Global Industry Classification Standard (GICS), allowing for sector-specific analyses of ESG impacts. This classification provides insights into how industry-specific ESG factors influence financial performance, accounting for the varying levels of ESG risks and regulatory pressures across sectors. GICS sectors and the number of companies in each sector is provided in Table 3.

**Table 3.** GICS sector overview: BRICS countries

| GICS Sector Name | Unique Companies in BRICS countries |
|---|---|
| Communication Services | 13 |
| Consumer Discretionary | 35 |
| Consumer Staples | 26 |
| Energy | 14 |
| Health Care | 19 |
| Industrials | 52 |
| Information Technology | 11 |
| Materials | 49 |
| Utilities | 17 |

*Source*: author.

The full list of explanatory variables is presented in Table 4.

**Table 4.** List of explanatory variables

| Category | Details |
|---|---|
| **ESG Metrics (Independent variables)** | |
| **ESG Rating** | Comprehensive score reflecting a company's overall ESG commitment, providing a holistic view of sustainability practices on a global scale |
| **ESG Years** | Number of years each company has been assigned an ESG rating, capturing sustained ESG efforts over time |
| **Financial Indicators (Dependent variables)** | |
| **Tobin's Q** | Represents market valuation, indicating investor perceptions of the firm's investment potential |
| **EV/EBITDA** | Reflects valuation relative to earnings, used to assess profitability in relation to corporate value |
| **P/B Ratio** | Shows market value vs. book value, used to gauge asset value perception |
| **WACC** | Weighted Average Cost of Capital; indicates cost of capital and reflects risk perception |
| **Control Variables** | |
| **Log Total Assets** | Company size (log-transformed), controlling for scale in models |
| **Log Turnover and Log Revenue** | Represent operational size, ensuring major firm-specific factors are accounted for in models |
| **Log Revenue** | Represents companies' market reach |
| **Instrumental Variables** | |
| **Renewable Energy Consumption (% of Total Final Energy Consumption)** | Proxy for corporate commitment to sustainable energy practices and environmental responsibility |
| **Research and Development Expenditure (% of GDP)** | Proxy for corporate investment in innovation and long-term growth potential |

*Source*: author.

## Methodological approach

This study employs a Two-Stage Least Squares (2SLS) regression to analyze firms in BRICS and non-BRICS countries, enabling comparison across regions. In the first stage, an instrumental variable regression predicts ESG scores using renewable energy consumption and R&D expenditure as instruments, with firm size controls (log-transformed assets, turnover, and revenue) to reduce bias. These predicted ESG values are then used as independent variables in the second stage to isolate the impact of ESG factors on financial outcomes, addressing endogeneity concerns.

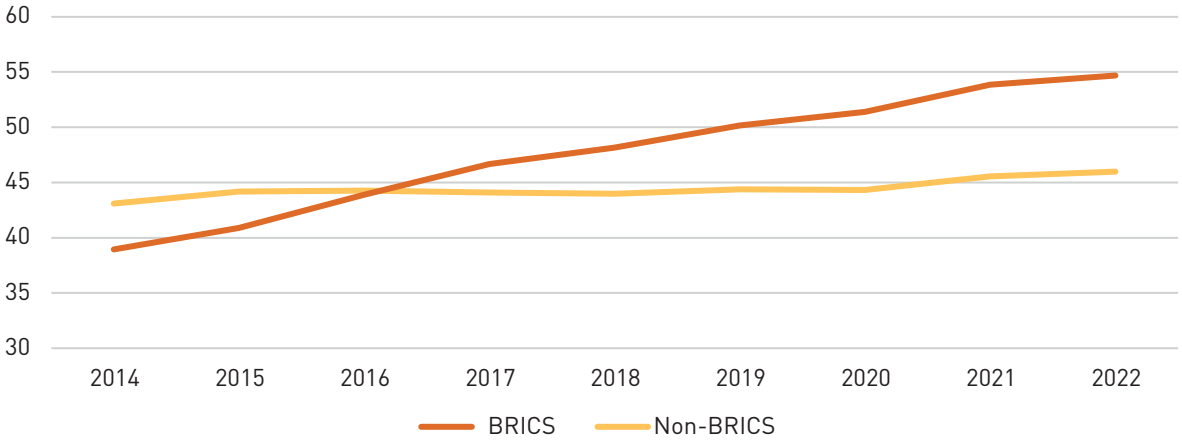
White's robust standard errors correct for heteroskedasticity, and model validity is confirmed with Durbin-Wu-Hausman, Breusch-Pagan, and Durbin-Watson tests. Additionally, a comparative 2SLS regression examines regional differences in ESG's impact on financial performance, with sector-specific analyses for BRICS industries using GICS classification to account for varied ESG-related factors and regulatory environments across sectors.

# Main results

## Trend analysis of BRICS companies' ESG ratings

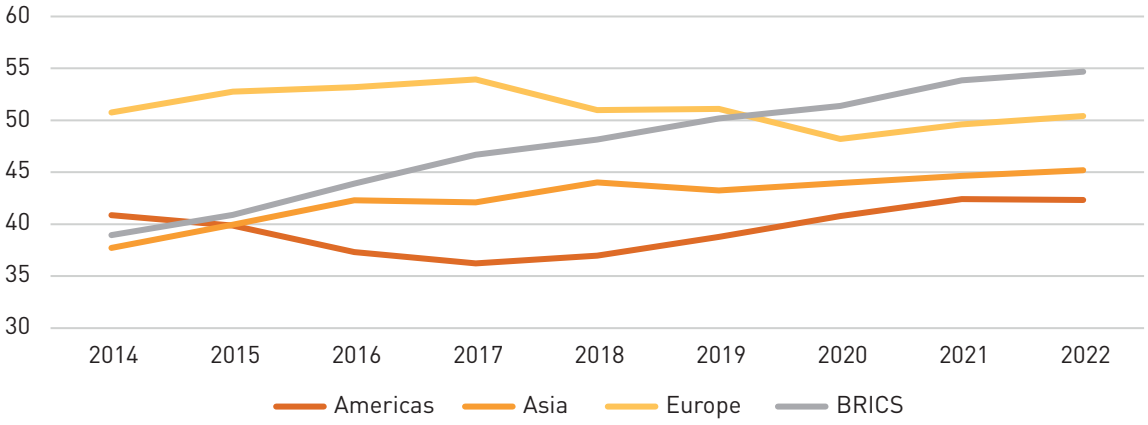
The analysis of average ESG ratings from 2014 to 2022 (Figure 1) reveals distinct trends for BRICS and non-BRICS countries. BRICS countries show a steady and notable increase in ESG scores, rising from an average of 38.9 in 2014 to 54.7 in 2022. This upward trend reflects a significant push in emerging markets to enhance ESG practices, likely in response to global pressures. In contrast, non-BRICS countries, which started with a higher average of 41.1 in 2014, exhibited a more gradual increase, reaching 44.6 in 2022. This slower growth among non-BRICS economies suggests they had already established ESG practices and may include companies with a broad range of ESG scores, from extremely high to low.

**Figure 1.** ESG rating trend: BRICS vs Non-BRICS countries




*Source*: author.

**Figure 2.** ESG rating trend: BRICS, Americas, Asia and Europe




*Source*: author.

Comparing the average ESG rating growth between BRICS and other regions reveals that BRICS countries are rapidly closing the gap with Europe in ESG performance, indicating considerable progress in sustainability practices. Europe's consistently high ratings reflect its well-established ESG infrastructure, while Asia's steady growth demonstrates a rising commitment to ESG principles. Minimal change in the Americas suggests a plateau effect, potentially due to regional differences in regulatory pressure or market demand for ESG transparency. Overall, these trends highlight both the global progress in ESG adoption and the regional variations in the pace and focus of sustainability initiatives (Figure 2).

## ESG rating significantly influences investor attractiveness of companies in BRICS countries compared to companies from non-BRICS countries

In BRICS countries, ESG ratings show a significant positive influence on Tobin's Q compared to non-BRICS countries, suggesting that investors increasingly regard ESG as a signal of sustainable value in BRICS markets (Tables 5–6).

Another market value indicator (P/BV) demonstrated a negative trend with the increase of ESG reporting duration for non-BRICS countries (Table 7), and no effect in BRICS countries (Table 8). This may indicate that with consistent and prolonged ESG rating disclosure, a company is heavily investing in sustainable development. As a result, investors might expect lower profitability in the short term, as the company undergoes a transition to a more sustainable operating model. Another interpretation is that the company's assets may increase in value through enhancements, leading to the company being undervalued. In this case, prolonged ESG rating disclosure may pose a risk for companies to be classified as undervalued. However, if we simultaneously consider the impact of ESG ratings on EV/EBITDA for non-BRICS companies, the relationship appears positive. Prolonged ESG reporting, along with an increase in ESG ratings, may indicate that the company is investing in long-term projects. While these initiatives might not yet yield significant returns, they may increase the company's debt burden (impacting EV) and create uncertainty among investors regarding the current value of the company's assets. Investors may perceive such long-term projects as too risky or anticipate slower profit growth due to increased debt servicing costs.

Higher ESG ratings significantly lower WACC in BRICS, indicating reduced financial risk perception and improved financing conditions due to strong ESG performance (Table 5). However, extended ESG reporting periods tend to increase WACC, as long-term reporting may shift investor perceptions towards stability over growth potential, impacting investor risk-return expectations (Table 8). In non-BRICS countries, ESG does not affect WACC.

To sum up, attention to ESG ratings focuses on risk reduction and increased investor confidence, which lowers the cost of capital.

Long-term attention to ESG reporting may signal a company's transition to a more mature and stable business model, leading to changes in risk perception and higher return expectations from investors.

**Table 5.** ESG rating influence in BRICS countries

| Variable | Tobin's Q | EV/EBITDA | P/BV per share | WACC |
|---|---|---|---|---|
| Const | 18.76788*** | 1129.144* | 8.382447 | 0.282836*** |
| **ESG_rating** | **0.21806*** | **-19.068** | **0.177159** | **-0.00237***** |
| Log_Total_Assets | -2.3184*** | -9.40963*** | -1.26154*** | -0.00786*** |
| Log_Turnover | 0.908304*** | 10.99278*** | 0.433264*** | 0.006608*** |
| Log_Revenue | 0.48086*** | -6.82741 | 0.345681*** | -0.00104 |

*** p<0.01, ** p<0.05, * p<0.1.

*Source*: author.

**Table 6.** ESG rating influence in non-BRICS countries

| Variable | Tobin's Q | EV/EBITDA | P/BV per share | WACC |
|---|---|---|---|---|
| Const | 19.69370*** | 121.31276*** | 18.21905*** | 0.16681*** |
| **ESG_Predicted** | **0.02434** | **0.71932**** | **-0.01098** | **-0.00004** |
| Log_Total_Assets | -1.49160*** | -8.67598*** | -1.49169*** | -0.00552*** |
| Log_Turnover | 0.79379*** | 5.85749*** | 0.84959*** | 0.00329*** |
| Log_Revenue | 0.09702* | -1.62913*** | 0.26497*** | -0.00094*** |

*** p<0.01, ** p<0.05, * p<0.1.

*Source*: author.

**Table 7.** ESG reporting years influence in non-BRICS countries

| Variable | Tobin's Q | EV/EBITDA | P/BV per share | WACC |
|---|---|---|---|---|
| Const | 20.5655*** | 134.8397*** | 18.6360*** | 0.1684*** |
| **ESG Years** | **0.1012** | **7.8860*** ** | **-0.3699**** | **-0.0015** |
| Log_Total_Assets | -1.4973*** | -9.7053*** | -1.4321*** | -0.0053*** |
| Log_Turnover | 0.7974*** | 5.9983*** | 0.8457*** | 0.0033*** |
| Log_Revenue | 0.0942* | -1.4437** | 0.2485*** | -0.0010*** |

*** p<0.01, ** p<0.05, * p<0.1.

*Source*: author.

**Table 8.** ESG reporting years influence in BRICS countries

| Variable | Tobin's Q | EV/EBITDA | P/BV per share | WACC |
|---|---|---|---|---|
| Const | 29.5115*** | 192.3330*** | 17.0708*** | 0.1638*** |
| **ESG Years** | **-0.0476** | **2.9185** | **-0.0198** | **0.0016**** |
| Log_Total_Assets | -2.3224*** | -8.7423** | -1.2696*** | -0.0081*** |
| Log_Turnover | 1.0303*** | 0.3689 | 0.5317*** | 0.0052*** |
| Log_Revenue | 0.3927*** | 0.6967 | 0.2768*** | 0.0001 |

*** p<0.01, ** p<0.05, * p<0.1.

*Source*: author.

## Impact of ESG ratings on investor attractiveness in BRICS countries varies significantly across sectors

The Information Technology and Communication Services sectors demonstrated the most significant impact of ESG ratings on investment attractiveness, showing a positive effect on market valuation and profitability indicators. However, the number of years a company has held an ESG rating in these sectors notably correlates with a more negative influence on investment attractiveness. This may suggest that while a high ESG rating boosts appeal, prolonged ESG reporting could reveal operational challenges or maturity effects that might temper investor perception over time.

An interesting finding emerged in the Energy sector, where the ESG rating negatively impacts market valuation but positively affects company profitability (EV/EBITDA). In other sectors (Materials, Utilities, Industrials, Consumer Discretionary, and Healthcare), there is generally a negative influence on investment attractiveness, particularly associated with the duration of ESG reporting. Industrials stand out as the only sector where prolonged ESG reporting positively impacts profitability, though the ESG rating itself has a negative effect on profitability. Notably, WACC in these industries tends to decrease as the duration of ESG reporting grows, suggesting that longer-term reporting might contribute to lower perceived financial risk. An intriguing result has been identified in the energy sector: ESG ratings have a negative impact on Tobin's Q and P/BV but positively influence EV/EBITDA. This suggests that ESG's effect on investment attractiveness in BRICS countries is highly heterogeneous, shaped by sector-specific dynamics and the duration of ESG reporting.

**Table 9.** ESG factor analysis in BRICS countries: sectoral analysis

| Variable | Tobin's Q | EV/EBITDA | P/BV per share | WACC |
|---|---|---|---|---|
| **Information technology** | | | | |
| ESG rating | 0.5426*** | 30.8575** | 0.1837*** | -0.0027*** |
| ESG Years | -1.2312** | 8.0312 | 0.2905* | 0.0003 |
| **Communication Services** | | | | |
| ESG rating | 0.3489* | 2.0888* | 0.3977** | 0.0032 |
| ESG Years | -2.2702*** | -9.3681*** | -1.6218*** | -0.0045 |

| Variable | Tobin's Q | EV/EBITDA | P/BV per share | WACC |
|---|---|---|---|---|
| **Energy** | | | | |
| ESG rating | -0.1528** | 0.9704* | -0.4118*** | -0.0064 |
| ESG Years | -0.6780*** | -0.412 | -0.4371 | 0.0053 |
| **Materials** | | | | |
| ESG rating | -0.0958* | -0.0958* | 0.0201 | 0.0201 |
| ESG Years | 0.2269* | 24.7695 | -0.0636 | -0.0006 |
| **Utilities** | | | | |
| ESG rating | 0.8162** | -2.6015 | 0.0605 | -0.0012 |
| ESG Years | 0.2877 | 5.5142 | -2.2552*** | 0.0058*** |
| **Consumer Discretionary** | | | | |
| ESG rating | 0.0627 | -2.0612 | 0.1321 | 0.0031* |
| ESG Years | 0.2666 | 4.4743 | -1.3966*** | -0.0056** |
| **Industrials** | | | | |
| ESG rating | -0.2617 | -6.8122** | 0.0761 | 0.0003 |
| ESG Years | -2.6051*** | 11.3204*** | -0.7607*** | -0.0032** |
| **Health Care** | | | | |
| ESG rating | 0.6169*** | 1.1055 | 0.1085 | 0.0025 |
| ESG Years | -3.3619*** | -22.6407** | -2.5658*** | 0.0011 |
| **Consumer Staples** | | | | |
| ESG rating | -0.5902 | 3.1876** | 0.0679 | 0.0042** |
| ESG Years | -5.9400*** | -12.3982*** | -3.4093*** | -0.0157*** |

*** p<0.01, ** p<0.05, * p<0.1.

*Source*: author.

## Summary

The findings reveal significant differences in the impact of ESG ratings and reporting on investment attractiveness and financial performance in BRICS and non-BRICS countries. ESG ratings show a stronger correlation with Tobin's Q in BRICS countries, reflecting investor confidence in these markets, where ESG signals are seen as indicators of sustainability and long-term value. This contrasts with non-BRICS countries, where ESG integration is more directly tied to profitability and operational efficiency, highlighting various stages of ESG adoption across regions.

Longer ESG reporting periods correlate with declining P/BV ratios in both regions, indicating a shift from speculative growth to stability. However, in BRICS countries, extended reporting tends to increase WACC, suggesting a focus on stability over growth potential, while in non-BRICS countries, ESG practices more effectively reduce financial risks. Sectoral analysis shows that ESG ratings positively affect valuation in Information Technology and Communication Services but have mixed impacts in sectors like Energy, where they improve profitability but reduce market valuation due to regulatory and reputational challenges.

These findings emphasize the growing importance of ESG ratings in BRICS countries as signals of sustainable growth, while in non-BRICS countries, established ESG practices yield direct operational benefits. Future research should explore how BRICS companies can refine ESG strategies to align investor expectations with operational realities and compare these dynamics with non-BRICS markets to identify best practices for enhancing investment attractiveness globally.

This study offers valuable practical implications for companies, policymakers, and investors in BRICS countries. Companies can leverage ESG ratings to attract investment and enhance market valuation, particularly in sectors like Information Technology and Communication Services. However, they must balance transparency and operational performance, as prolonged ESG reporting may shift investor focus from growth potential to stability. Policymakers can strengthen institutional frameworks and standard-

ize ESG reporting to enhance risk reduction and global competitiveness. For investors, the findings highlight ESG ratings as critical indicators of long-term sustainability in BRICS markets, with sector-specific strategies needed to optimize returns. By addressing these insights, stakeholders can better align ESG practices with sustainable growth and investment objectives.

## Aknoledgment

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# Modeling the Impact of New Technologies on the Financial Performance of Russian Vertically Integrated Oil Companies

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## Abstract

The article explores the impact of the oil recovery factor on the financial performance of Russian vertically integrated oil companies. Special attention is given to hydraulic fracturing technologies (HFT) and rotary steerable systems (RSS), which are critical for enhancing oil extraction rates and oil recovery factor, particularly for hard-to-recover reserves (HTR). Sanctions have complicated access to these technologies, leading to a deterioration in the financial results of Russian oil companies in 2022-23. The study identified a decrease in revenue due to the restricted activities of foreign oilfield service companies and an increase in the discount on Urals crude oil. Using the financial model of Russia's largest vertically integrated company, Rosneft, it was demonstrated that improving extraction efficiency through the adoption of technologies can increase the company's value by 8%. The analysis highlights that delayed technology replacement directly threatens production sustainability, especially for HTR reserves, which require advanced extraction methods. The study's findings align with the resource-based view: effective management of technological resources is one of the key factors in the competitiveness of oil companies. Under the conditions of sanctions pressure, it remains necessary for Russian oil companies to reduce technological dependence.

**Keywords:** oil industry, development, companies, new technologies, modeling, company value

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## Introduction

The present paper aligns with the resource-based view (RBV) of business [1]. According to the RBV, a company gains an advantage over its competitors by making optimal use of its technical, human and other resources [2]. At the same time, technologies are one of the key resources that enhance oil companies' profitability [3]. The present research models the technologies' impact on the financial performance of vertically integrated oil companies in order to assess the effects of their adoption.

With each passing year, easily accessible oil reserves in Russia are decreasing. As conventional deposits are depleted, companies start developing less accessible resources. The majority of analysts assert that by 2050 hard-to-recover (HTR) oil reserves in the Russian Federation will amount to approximately 70% of the cumulative oil production. The energy strategy of the Russian Federation up to 2035 is based on the target of increasing the oil recovery factor (ORF) from the current level of 0.3 to 0.45 by 2035. Special-purpose technologies are used to enhance recovery efficiency of HTR oil reserves and maintain the ORF at a certain level: rotary steerable systems, hydraulic fracturing and other methods that maximize the volume of hydrocarbon extraction from complex geological structures. One of the projects that facilitates the implementation of this strategy is the road map signed by PJSC Gazprom Neft, the Ministry of Energy of the Russian Federation and the Ministry of Industry of the Russian Federation.

Formerly, advanced oil extraction technologies have been provided to Russian vertically integrated oil companies by the global leaders in oilfield services known as the "Big Four": Halliburton, Schlumberger, Baker Hughes and Weatherford. However, in 2022, operations of these companies were restricted in the Russian market, thus generating a need for import phase-out in order to mitigate operational risks and maintain oil production efficiency. So, currently Russia develops its own technologies, purchases services from domestic service companies and buys components abroad, for example, in China.

The following vertically integrated oil companies have been considered in the present research: PJSC Rosneft, PJSC Lukoil, PJSC Gazprom Neft, PJSC Tatneft, and PJSC Bashneft. Besides, in the paper we compare Russian vertically integrated oil companies to foreign ones: ExxonMobil, Chevron, Shell, BP, and TotalEnergies. It is done to weigh the dynamics of the key financial indicators against each other. The primary objective of the research is to study the effects related to technological development, such as improvement of operating efficiency, cost saving, margin expansion and market capitalization growth. This type of the influence of technology development is confirmed in the papers that reveal the significance of innovation processes for the strengthening of company's competitive position in the global market [4; 5].

## Effects of Development of Hydraulic Fracturing and Rotary Steerable Systems

As of today, the major part of oil is recovered in the oil fields that have already reached the peak of oil production. To operate these fields further, it is necessary to implement new enhanced oil recovery methods. At the moment, the most common technologies are physical ones, such as hydraulic fracturing, lateral drilling, electromagnetic methods, etc. They are also known as workover methods applied in the low profitability wells [6].

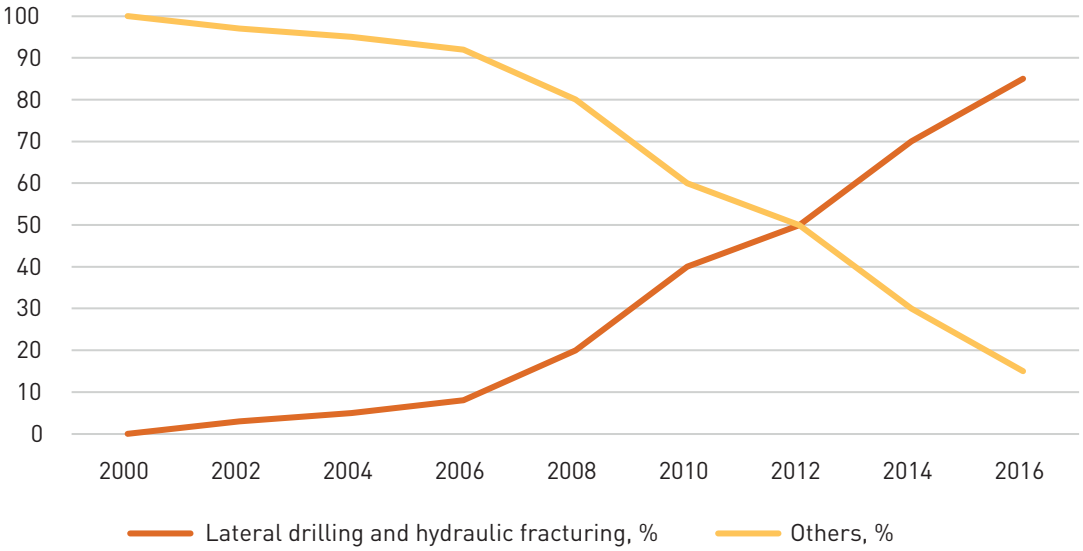
Hydraulic fracturing is one of the methods for the development of productive strata, especially low-permeability ones. It impacts the hole-bottom region, as well as contributes to enhanced oil recovery. Hydraulic fracturing creates a system of deeply extending fractures, thus greatly expanding the drainage area and improving the productive capacity of a well. Several stages of hydraulic fracturing are possible in a horizontal well. This approach is called multistage hydraulic fracturing. In lateral drilling, the rotary steerable systems (RSS) technology is applied.

The foundation of modern improved hydrocarbon extraction methods was laid at the time of technological development of the US oil industry throughout the XX century. The first steps in hydraulic fracturing were taken in 1930s, when non-explosive fluids – well stimulation acids – were brought into use [7]. The effectiveness of the applied technology was proven in 1940-1950s. That is when it became one of the key recovery stimulation techniques, and was used extensively up to the beginning of the XXI century [8]. In the 2000s, a significant breakthrough in this sphere was achieved, so the efficiency of oil recovery was enhanced as compared to conventional methods due to the development of multistage hydraulic fracturing [9]. By 2014–2015, the pilot testing of multistage hydraulic fracturing technology was completed and it was beginning to be widely implemented in the US market, accompanied by a considerable progress in increasing hydrocarbon recovery [10].

It should be noted that hydraulic fracturing technology is the key area of technological progress in oil production that undeniably influences the efficiency of oil field development. Statistical data confirms a wide use of hydraulic fracturing. Thus, in 1949–2010, the number of wells developed in the USA using hydraulic fracturing exceeded 60%. Already by 2016, horizontal wells, where hydraulic fracturing was applied, accounted for 69% of the total number of drilled oil wells and for 83% of the total number of drilled line meters in the USA [11].

According to the US Department of Energy, approximately 95% of wells are currently drilled by hydraulic fracturing. As a result, this technology accounts for two thirds of the total natural gas extraction and approximately half of crude oil production [12].

**Figure 1**. Dynamics of the share of lateral drilling (and hydraulic fracturing) in the total number of wells, 2000–2016




*Source*: [13].

The indicators stated in Figure 1 show the annual growth of integration of lateral drilling technologies (RSS and hydraulic fracturing) into hydrocarbon extraction processes and emphasize a significant impact of these technologies on enhancement of efficiency and economic benefit from the development of deposits. The growing share of the wells drilled using directional and lateral drilling is also indicative of an increase in the share of hard-to-recover reserves in total reserves. Application of hydraulic fracturing was the fundamental factor that determined the opportunities for an increase in the extraction volume and development of new, previously inaccessible hydrocarbon deposits.

In 1952, in the USSR there was a time lag in adaptation and development of hydraulic fracturing [13]. In spite of the fact that the USSR started using hydraulic fracturing approximately at the same time as the USA, its further development slowed down dramatically when large high-output deposits in West Siberia were discovered. Hydraulic fracturing was almost abandoned because "easy" oil did not require additional stimulation methods. At the same time, globally this technology was developed rapidly. Since there was no demand for this technology, Russian equipment and experience in application of hydraulic fracturing fell significantly behind other markets.

An important instrument that ensures improvement of the efficiency of lateral drilling, RSS, was proposed in 1940–1950s [14]. However, its extensive implementation and commercial operation started as late as mid-2000s with Schlumberger's developments [15]. RSS makes an enormous contribution to the improvement of drilling operating procedures, and the analysis of dynamics of their development and adaptation to the oil industry confirms this fact. They comprise innovative equipment, which ensures accurate directional drilling that makes field development more productive and cost-effective.

A significant growth of RSS use is observed North America (from 20% in 2016 to 28% in 2019) due to an increase in the share of wells drilled using this technology. This factor emphasizes the growing interest of operators in the integration of technology solutions to improve the drilling performance. RSS will even more heavily dominate the directional drilling market. Thus, in 2021, their market share already exceeded 50%, and according to forecasts, by 2029 it should be over 70%. Such statistical changes are indicative of the key role of this technology in the drilling process optimization and minimization of its costs [16].

From the point of view of the Russian fuel and energy sector, the scope of drilling where RSS are applied has grown significantly since 2014. At that point, there were less than 210 horizontal wells. In 2024, the scope of horizontal wells drilling in Russia is expected to reach approximately 30,000 km, which equals 7,000–12,000 wells. The reason is that it is necessary to develop new deposits, especially HTR reserves, which account for a significant part of oil extraction [17].

The above trends confirm that RSS play a critical role in enhancing efficiency and reducing drilling time, at the same time ensuring a high accuracy in achieving the set goals. Implementation of RSS drives the optimization of hydrocarbon production, increasing economic returns on deposit development and contributing to the sustainable development of the energy industry.

Investing in drilling technologies produced a pronounced influence on the oil industry, improving its efficiency and profitability in the USA and across the globe [15]. Implementation of hydraulic fracturing technology, in particular multistage hydraulic fracturing, curtailed the drilling time by 25% and increased the cumulative oil production (the total amount of oil recovered from a certain deposit or region throughout its producing life) [18]. Additional studies point out an opportunity to increase cumulative oil production up to 36% in the immediate future and a significant improvement of well producing characteristics [19; 20].

Due to the development of RSS, the average drilling rate increased by 26% [21]. This factor was emphasized repeatedly in various studies dedicated to the oil market [22; 23]. Such an approach to the development of RSS provided access to hard-to-reach reserves, increased production, mitigated the impact on the environment and improved the wellbore stability.

Dissemination of new technologies significantly improved the overall effectiveness of the oil industry [24]. This partially solved a number of problems, including cost growth, infrastructure obsolescence, toughening of regulatory requirements, as well as lack of skilled personnel. These new ways helped to improve decision-making, optimization of performed operations and environmental impact mitigation. Thus, RSS and hydraulic fracturing allowed to recover oil and gas from the reserves previously considered inaccessible or economically unsound [25].

Since the 2010s, hydraulic fracturing in Russia has been used on a much more extensive scale. Thus, up to 2014 this technology had ensured additional extraction of 30 million tons of oil. This is indicative of the dynamics of its wide implementation in the oil sector. In 2018, incremental oil production due to the enhanced oil recovery methods, including hydraulic fracturing, amounted to approximately 25 million tons [26]. So, the technology allows to increase the ORF and well flow rate in complex and mature fields. However, there are certain fluctuations in the amount of incremental oil production that depend on economic feasibility and state of the fields [27].

The main prospects of expansion of the technological oil service market are associated with the dynamics of development of the segments in oil-field service which implies sustained growth in the key spheres: horizontal well development (including horizontal sidetracks); hydraulic fracturing and multistage hydraulic fracturing; use of bottom hole drilling systems and geophysical research (including continental shelf projects).

## Comparing EBITDA Margins of Russian and Foreign Vertically Integrated Oil Companies

In modeling we used data from corporate financial statements for 2019–2023. The following indicators were applied in the analysis: revenue, EBITDA, free cash flow (FCF), capital expenditures (CAPEX) etc. Moreover, we used such technical characteristics as extraction volume, production costs, ORF etc. Also, in order to determine the discount, we took into account data on the price of Brent, WTI and Urals.

From the historical point of view, the oil sector was exposed to geopolitical risks, and 2022 was no exception. The sanctions pressure on the Russian oil industry, domestic companies faced not only the denial of access to the cutting-edge technologies which maintain and increase the ORF, but also restrictions such as the price cap on Urals. This aspect exerted a significant influence on the ultimate price of sold products. An increase in the discount for the Russian Urals as compared to Brent and WTI in 2022 amounted to 19%. First of all, this brought pressure on corporate revenues and, consequently, on marginal operating profit (EBITDA margin) of Russian vertically integrated oil companies.

Further we compare the changes in the financial indicators of Russian vertically integrated oil companies and foreign ones in 2022–2023.

**Table 1**. Comparison of revenue of Russian and foreign vertically integrated oil companies, 2019–2023

| | Revenue (billion roubles) | | | | |
|---|---|---|---|---|---|
| | Rosneft | Lukoil | Gazprom Neft | Tatneft | Bashneft |
| 2019 | 8.676 | 7.841 | 2.485 | 932 | 855 |
| 2020 | 5.757 | 5.639 | 2.000 | 796 | 533 |
| 2021 | 8.761 | 9.431 | 3.068 | 1.205 | 852 |
| 2022 | 9.072 | 11.869 | 3.430 | 1.427 | 1.100 |
| 2023 | 9.163 | 7.928 | 3.520 | 1.589 | 1.032 |

| | Revenue ($ billion) | | | | |
|---|---|---|---|---|---|
| | Rosneft | Lukoil | Gazprom Neft | Tatneft | Bashneft |
| 2019 | 134 | 121 | 38 | 14 | 13 |
| 2020 | 80 | 78 | 28 | 11 | 7 |
| 2021 | 119 | 128 | 42 | 16 | 12 |
| 2022 | 134 | 176 | 51 | 21 | 16 |
| 2023 | 108 | 94 | 42 | 19 | 12 |

| | Revenue ($ billion) | | | | |
|---|---|---|---|---|---|
| | ExxonMobil | Chevron | Shell | BP | TotalEnergies |
| 2019 | 265 | 140 | 352 | 184 | 176 |
| 2020 | 182 | 94 | 183 | 109 | 120 |
| 2021 | 286 | 156 | 273 | 164 | 185 |
| 2022 | 414 | 236 | 386 | 249 | 263 |
| 2023 | 345 | 201 | 323 | 213 | 219 |

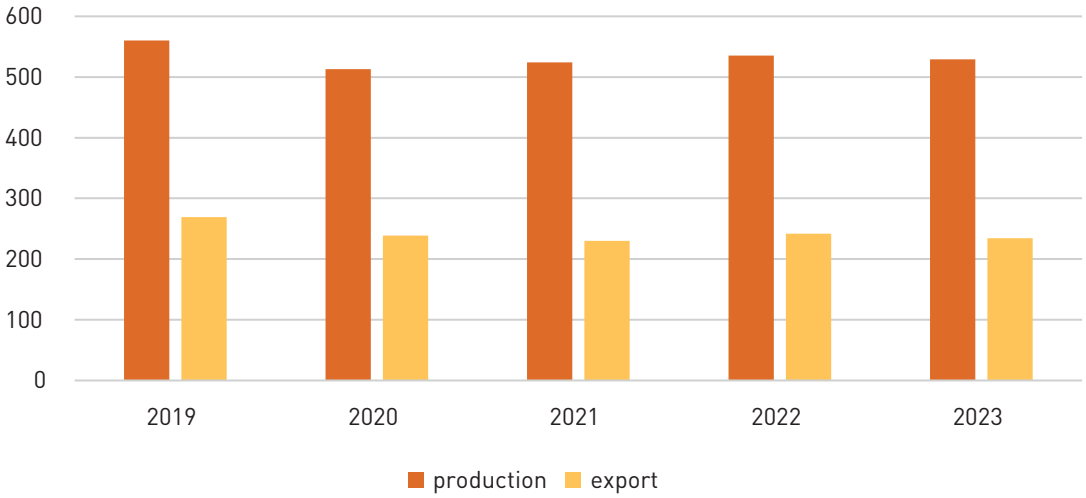
**Table 2.** Comparison of average weighted revenue dynamics in Russian and foreign vertically integrated oil companies, %

| | Russian vertically integrated oil companies | | Foreign vertically integrated oil companies | |
|---|---|---|---|---|
| | Relative change | | | |
| | Average value | Median | Average value | Median |
| 2019–2020 | –7 | –4 | –8 | –6 |
| 2020–2021 | 11 | 7 | 11 | 9 |
| 2021–2022 | 5 | 3 | 9 | 8 |
| 2022–2023 | –6 | –3 | –3 | –3 |

Analysis of Tables 1 and 2 points out a revenue increase in dollar terms in 2022 for Russian vertically integrated oil companies as compared to foreign ones (5 versus 9%). The average weighted growth of Russian oil companies' revenue is lower because, among other things, the Urals discount increased by 19% and the rouble strengthened by 8% against the US dollar within the same period. In 2023, similar revenue dynamics are observed in Russian vertically integrated oil companies, besides, the average weighted values still demonstrate less favorable dynamics as compared to foreign oil companies. This trend may persist in the medium term due to the restrictions on access to technologies.

The most important indicators that show the state of the sector under consideration and the Russian vertically integrated oil companies selected for analysis are export volumes and crude oil production. In 2022–2023, there was a reduction in crude oil exports (Figure 3), and this is to rebound on Russian oil companies' revenue in the nearest reporting periods. For this reason, in the settings of the current rate of reduction in revenue and in order to maintain their financial standing, Russian oil companies have to work on an increase in EBITDA margin.

**Figure 2**. Dynamics of volumes of Urals production and export, million tons




As seen in Table 3, the historic EBITDA margin values of Russian vertically integrated oil companies are higher than those of foreign oil companies. Among other things, this occcurs due to weakening of the rouble. However, in spite of this consistent pattern, EBITDA margin may decrease significantly in the future as a result of the growing oil discount, a reduction in oil exports and restricted access to technologies. This will eventually adversely affect the companies' market value.

**Table 3**. Comparing EBITDA margin of Russian and foreign vertically integrated oil companies, %

| | Rosneft | Lukoil | Gazprom Neft | Tatneft | Bashneft |
|---|---|---|---|---|---|
| 2019 | 24 | 16 | 32 | 31 | 20 |
| 2020 | 21 | 12 | 21 | 23 | 6 |
| 2021 | 27 | 15 | 29 | 24 | 18 |
| 2022 | 28 | 16 | 36 | 34 | 21 |
| 2023 | 33 | 25 | 38 | 25 | 24 |
| | **ExxonMobil** | **Chevron** | **Shell** | **BP** | **TotalEnergies** |
| 2019 | 15 | 25 | 17 | 18 | 20 |
| 2020 | 11 | 13 | 16 | –6 | 15 |
| 2021 | 18 | 26 | 22 | 19 | 23 |
| 2022 | 24 | 28 | 22 | 13 | 22 |
| 2023 | 21 | 24 | 21 | 20 | 23 |

Summing up the results, it should be noted that the actual financial statements of Russian vertically integrated oil companies for 2022-2023 and their comparison to those of foreign oil companies reveal substantial risks for the subsequent stable development of the sector. In the immediate future the effect of the weakened rouble will be limited, thus, resulting in reduced support of revenues of Russian vertically integrated oil companies (and EBITDA margin) ,while the risk of the Urals discount growth may increase. In this scenario, abandonment of development and implementation of the considered technologies by Russian vertically integrated oil companies will jeopardize the possibility of the sector's subsequent growth at the pre-sanction rate.

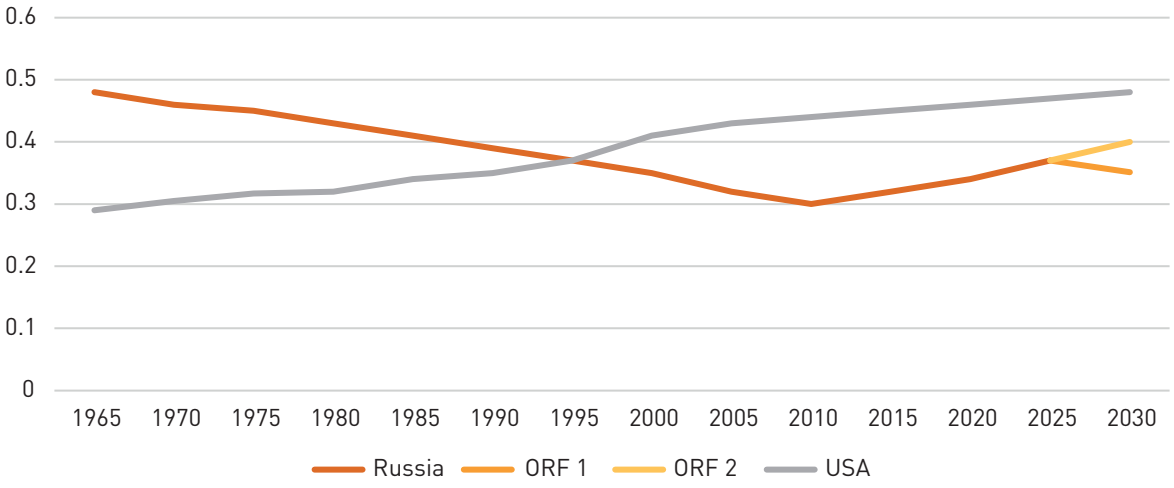
## Cash Flow Modeling

The results of comparison of EBITDA margins of Russian and foreign vertically integrated oil companies provide an opportunity to evaluate how the value of Russian oil companies will change if they abandon replacement or development of the existing technologies over the next five years. Based on the literature review, it should be noted that the oil recovery factor depends directly on such enhanced oil recovery methods as hydraulic fracturing, RSS, and access to their latest modifications, which Russian vertically integrated oil companies lost in 2022. Thereby, we have to evaluate the influence of the ORF on the value of Russian oil companies.

We used the largest Russian oil producer PJSC Rosneft for evaluation. Two main scenarios were considered: according to the first one, Russian oil producers decide against replacement of the technologies withdrawn from Russia (ORF 1), according to the second one, they invest in the development of technologies (ORF 2) (Figure 2). Additionally, the ORF 1 scenario implies a decline in efficiency of oil recovery to a level comparable with the historical one (within the period of 1965 to 2010). At the same time, the ORF 2 scenario implies the attainment of target indicators set by the Energy Strategy of the Russian Federation for the period up to 2035.

According to the model premises, it is assumed that a change in the ORF results in changes in production costs (pretax), recovery volumes and capital investments in development of the oil field.

**Figure 3**. Historical and forecast dynamics of the ORF, %



Notably, an increase in the ORF of foreign vertically integrated oil companies is caused by some specific aspects, for example, management of the project portfolio and predominance of shale oil production, where this indicator is not typically used.

## Modeling of Discounted Cash Flow

For several reasons, the discounted cash flow method (DCF) is a substantiated choice for the study of the influence of new technologies on financial indicators of Russian vertically integrated oil companies [28]. Implementation of new technologies may cause significant changes in corporate cash flows, i.e., both enhanced efficiency and cost saving, and an increase in proceeds from new products and services [29]. Apart from that, the DCF method is widely acknowledged in academic literature as one of the most reliable and flexible tools for evaluation of investment projects and corporate value of companies [30; 31]. Against the background of oil markets' high volatility and specific nature of the Russian economy, DCF offers analysts an opportunity to take into consideration various event scenarios and businesses' susceptibility to the key risks related to the implementation of new technologies [32].

The created model calculates the net effect of the impact produced by the ORF 1 and ORF 2 scenarios on cash flows and the value of PJSC Rosneft. We start calculating the effects of oil recovery with defining the underlying operating profit from the Upstream segment:

$$OP = PV \cdot (SP - PC), \quad (1)$$

where OP – operating profit; PV – production volume; SP – sales price (Urals); PC – production costs.

Then we apply the ORF's effects to determine operating profit after these effects have exerted their impact (OP'):

$$OP' = PV \cdot (1 + ORF) \cdot (SP - PC \cdot (1 - ORF)). \quad (2)$$

$$ORF\ effect = \frac{OP'}{OP} - 1. \quad (3)$$

The obtained values of operating profit for each scenario are compared to the actual value and are carried over to FCF. Moreover, in order to obtain the estimated value of the company, the influence of the ORF's effects on capital expenditures (CAPEX) is taken into account:

$$ORF\ effect(CAPEX) = \frac{CAPEX \cdot (1 - ORF)}{CAPEX} - 1 \quad (4)$$

$$FCF' = FCF + OP \cdot ORF\ effect - $$
$$- CAPEX \cdot ORF\ effect(CAPEX), \quad (5)$$

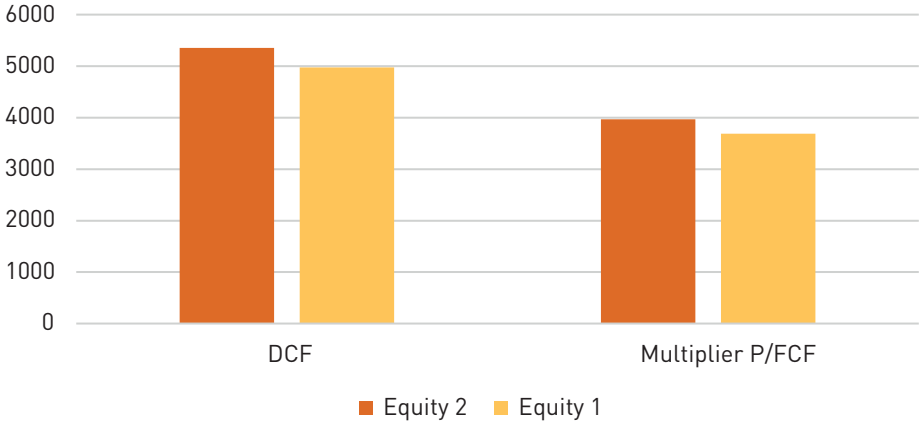
where FCF – factual value of cash flow; ORF effect (CAPEX) – effect of the factor on increase/decrease in capital expenditures; CAPEX – factual value of capital expenditures; *FCF'* – value of cash flow taking into consideration the scenario.

Finally, we calculate the company's value based on the obtained estimated value of cash flow (FCF') taking into consideration the scenarios using the discounted cash flow method (DCF) and the multiples method (P/FCF).

## Results of Calculations

The results of calculation of the two scenarios are indicated in Figure 5, which shows the value of companies Equity 1 and Equity 2 for each scenario of ORF 1 and ORF 2 dynamics, respectively.

**Figure 4**. Estimated value of PJSC Oil Company Rosneft (Equity) depending on the ORF scenario, billion roubles.




In Figure 4, Equity 1 indicates the scenario when the company abandons the development of its own technology (ORF 1); Equity 2 is for the scenario when the company starts to develop its own technology (ORF 2).

The obtained results indicate that a decision on strengthening the technological sovereignty will provide additional 8% of company value for Russian vertically integrated oil companies as compared to the scenario of abandoning the development of technologies (only taking into account the effect on the Upstream).

It should be noted that certain limitations were taken into consideration in the modeling process. There is an important assumption that there is no multiplicative effect of the impact of new technologies from the Upstream segment on the lower business segments – Midstream and Downstream. In case of the multiplicative effect on the

company's margin, the technology replacement scenario (ORF 2) is the most preferable from the standpoint of company capitalization. A deeper study of this limitation in further research is intended.

## Conclusion

Our research provides an opportunity to make several conclusions concerning the technological development of the oil sector. We revealed the significance of hydraulic fracturing and RSS for the development of this sector, in particular, the impact of these technologies on the drilling rate and an increase in the ORF. The examined technologies ensure a significant enhancement in the efficiency of drilling and oil recovery. For this reason, they are widely used across the globe. Lately, the growing share of HTR reserves in the extraction volume has made these technologies even more important.

The 2022 changes in the oil sector exerted a significant negative impact on Russian vertically integrated oil companies. Their revenue dynamics was inferior to that of foreign oil companies due to an increased Urals discount. We also found out that withdrawal of technologies had no immediate effect on the financial indicators of Russian vertically integrated oil companies, and it will most probably manifest itself over a medium-term or long-term horizon.

Furthermore, a limited access to technologies and a decision against their replacement will have an adverse effect on all financial indicators of oil companies in the medium term, reducing their value by over 8%. As a result of the geopolitical crisis of 2022, sanctions were imposed on the Russian oil industry. This caused a series of restrictions, including the price cap for Russian oil and withdrawal from the Russian market of the leading technology solution providers that worked with Russian oil companies. Thus, taking into consideration the growing share of HTR reserves Russian vertically integrated oil companies are forced to invest in replacement of hydraulic fracturing and RSS in order to maintain the current levels of recovery and growth rates of the financial indicators.

The research results are indicative of a high dependence of the Russian oil industry on the technologies provided by the companies that pulled out of Russia in 2022. Besides, it was established by means of comparing revenues of Russian and foreign vertically integrated oil companies that an increase in the oil discount related to the limited access to the technologies produced more significant influence on financial indicators of Russian oil companies in 2022. On the basis of this conclusion, we offered the calculation method that allows to determine how the value of the largest Russian vertically integrated oil companies will change depending on the chosen strategy for implementation of the technologies which lead to ORF growth.

We proposed a financial model using PJSC Rosneft as an example to model a medium-term impact of lack of the technologies under consideration. Based on the model, various scenarios of change in the ORF were considered. The obtained results demonstrate that it is necessary to look for the ways of subsequent technological development of the oil industry in order to improve its financial indicators. The decision against replacement of the technologies may result in the risk of a decrease in the oil production volumes and marginal profit. This will eventually entail a significant reduction in the companies' value.

From a theoretical point of view, this research contributes to RBV. According to this approach, the company may outperform its competitors in terms of efficiency due to the way it uses its technical, human and other resources. Technologies in particular are one of the most important resources of oil companies. Also, according to RBV, development of competitive advantages is possible through efficient management of internal and external resources.

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# Resilience Index Development for Digital Ecosystems and Its Implementation: The Case of Russian Companies

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## Abstract

Study examines the problems of business ecosystems, whose effectiveness and sustainability are determined by the organization of cooperation of all its participants using digital tools. The purpose of the research is to develop an index of digital ecosystem sustainability that would reflect changes in the value of the company. The article defines the main characteristics of digital business ecosystems by adapting the taxonomy of digital ecosystems to the Russian market and measuring the sustainability of Russian companies as Yandex and VK Group by using the digital ecosystem sustainability index (DESIn) that was developed by the authors for determining the strategic position of companies in the market. The authors identified the main classification features of digital ecosystems and measured their stability using financial and non-financial indicators as part of the DESIn index. The results of the research and the developed index of digital ecosystem sustainability can be used by Russian companies for developing their strategies, analysing their competitive positions, and choosing the optimal directions for digital ecosystem development.

**Keywords:** digital ecosystem sustainability index, digital ecosystems, sustainable development, taxonomy, digital transformation, strategy

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# Introduction

A business ecosystem is a business model whose success and sustainability primarily depend on the organization of cooperation among all its participants. This type of business interaction is becoming increasingly popular, especially with the advent of digital tools that simplify processes, enable scaling, and enhance data accessibility and transparency through platform solutions, digital communication, and innovative technologies. Establishing ecosystem relationships and undergoing digital transformation require significant resources to ensure the sustainability of digital ecosystems. Well-established, profit-generating organizations are particularly attractive to investors. Globally, ecosystem-based business relationships are rapidly expanding. In Russia, digital ecosystems emerged recently, and only a few large companies represent this model today.

Despite the abundance of thematic and academic publications on digital ecosystems, this topic remains insufficiently explored, with various definitions of the term "ecosystem" still in use [1].

# Literature Review

## Defining the digital ecosystem and the values it creates

In this research, it is essential to clearly define the nature of a business model based on a digital ecosystem. Various publications [1–5] describe an ecosystem by using concepts such as interaction, collaboration, integration, and value creation.

The following key criteria of an ecosystem have been identified [4; 5]:

- Collaboration-based relationships rather than ownership-based structures.
- Purposeful interaction among key participants to create and share value.
- A broad network of partners.
- Network effects that allow companies to scale efficiently.
- Data integration and sharing.
- Advantages over traditional business models in terms of services, optimized business processes, and specialized communities.

The value generated within ecosystems is primarily linked to interaction processes among participants. According to stakeholder theory, value creation requires a broader understanding of stakeholders beyond just consumers. These processes involve various activities performed by different individuals or groups utilizing diverse resources [6–8].

Societal stakeholders—including government entities, external agencies, the media, and the academic community – contribute to and uphold a stable business environment through regulations and social norms. In return, businesses provide job creation, social and budgetary contributions, tax payments, sponsorships, and other benefits. Collaboration enhances organizational productivity by facilitating market access, strengthening competitive positions, and improving the exploration, acquisition, and utilization of resources and knowledge within business networks [9].

Literature emphasizes the importance of creating structures that enable stakeholders to express expectations regarding sustainable development outcomes. Such structures also encourage participation in addressing sustainability challenges that may emerge in value creation processes [8].

A digital ecosystem is one such structure that allows stakeholders to fulfil their needs effectively. Since it is founded on cooperation, it facilitates the creation and exchange of value when the business model is properly organized.

Digital ecosystems form a distinct category of ecosystems, marking a shift toward digitalization and interconnected business environments. They foster collaboration and value creation through digital tools [10]. The use of digital technologies offers several advantages that impact value creation [11; 12]:

- Enhanced interaction.
- Collaborative data usage.
- Resource sharing.
- Process optimization.
- Expanded market presence and regulatory compliance.

A digital ecosystem is often described as a virtual environment composed of digital objects such as software applications, equipment, and processes. It is supported by a distributed technological infrastructure that enables the creation, distribution, and interconnection of digital services via the Internet [13]. Digital ecosystems represent an advanced evolution of digital business models.

The primary goal of digital services within these ecosystems is to retain users by offering more than just individual products or services. Instead, they provide a comprehensive combination of offerings that generate added value beyond the sum of their individual parts [14]. Thus, based on all these identified characteristics, we define a digital ecosystem as a business model that facilitates stakeholder and organizational interactions in the digital space for the purpose of value creation and exchange.

The term "platform economy" is used in publications on digital ecosystems [1]. Here we will clarify that a platform-based ecosystem and a platform business model have differences: in a platform-based ecosystem, the interaction of participants and the organization's services plays a decisive role, while in a platform business model, the platform is a technological foundation on which players with different interests in interaction develop, and the services of the platform itself are important. Some authors consider the platform as one of the initial stages of the digital ecosystem formation [5].

## Adaptation of the digital ecosystem taxonomy to Russian companies

The authors analyzed the digital ecosystems taxonomy reviews to identify key factors influencing value creation in digital ecosystems, develop value management methods, and ensure transparency and standardization in the field of digital technologies [2].

Digital global ecosystems are complex systems of interconnected digital components that function together to achieve common goals. The main features of such ecosystems are: 1) interdependence: ecosystem components (platforms, applications, services) are tightly integrated and depend on each other for normal functioning; 2) network effect: users, platforms, and services within the ecosystem reinforce each other's value as the ecosystem grows; 3) economic model: ecosystems have their own economic model based on complex business processes and monetization of various components; 4) innovativeness: complex, multi-sided systems based on the use of modern innovative and digital technologies; 5) flexibility and adaptability: ecosystems are able to quickly respond to market changes, introduce innovations, and adapt their components to the needs of users.

The digital ecosystems taxonomy includes the following main types: platform ecosystems formed around a key platform (e.g., Apple, Google, Amazon ecosystem); industry ecosystems uniting companies of the same industry (finance, healthcare, energy); regional ecosystems; small business ecosystems; public sector ecosystems.

Successful digital ecosystems are characterized by the presence of a leader-coordinator, clear user value, openness to innovation, and continuous development.

The academic literature presents various approaches to systematizing the features, elements, and competitive aspects of digital and ecosystem business models. These perspectives include:

- Financial, resource, exchange, and organizational aspects [15].
- Consumer focus, value creation, and opportunity identification [16].
- Interaction, management processes, and data utilization [17].
- Offerings, user experience, platform solutions, data analytics, and pricing models [18].

Based on these studies, a digital ecosystem has the following key characteristics:

1. Industry affiliation.
2. Operational duration.
3. Products and services offered.
4. Innovation and R&D activities.
5. Integration and compatibility of products.
6. Characteristics of the core company managing the ecosystem.
7. Business exchange channels.
8. Origin (online or offline).
9. Type of business integration (horizontal or vertical).
10. Geographic diversification.
11. Ecosystem management model (centralized, decentralized, self-governing).
12. Integration of sustainable development practices.
13. Availability of data storage and management services.
14. Cybersecurity measures.
15. Data accessibility for stakeholders.
16. Supplier-consumer relationship model.
17. Presence of feedback mechanisms.
18. Implementation of digital communication tools.
19. Availability of digital analytics services.

## Financial sustainability indicators

The sustainable financial position of a digital business ecosystem and its participants ensures stability and reliability in interactions. Financial stability refers to a state in which the financial system effectively allocates savings to investment opportunities on a sustainable basis without failures [19]. It also implies the ability to meet financial obligations by:

- Efficiently replenishing funding sources.
- Maintaining an optimal balance between costly and affordable borrowed resources.
- Preventing financial distress that could lead to bankruptcy [20].
- Implementing effective financial risk management strategies.

Internal financial risks encompass business risks associated with financial resources that can be directly managed by the company [21]. The key financial indicators selected by the authors include:

- Current liquidity.
- Financial autonomy ratio.
- Net Debt / EBITDA.
- Return on assets.

## Operating sustainability indicators

The study of ecosystems has identified operating mechanisms that enable firms to simultaneously compete and collaborate within business ecosystems. In particular, it was found that collaboration is linked to a higher level of absorptive capacity – companies within business ecosystems gain critical knowledge, the effective use of which enhances their ability to absorb and apply new insights.

Partnerships within an ecosystem can provide participants with several advantages, such as:

- Stronger market positioning.
- Cost-sharing opportunities.
- Reduced order lead times.
- Improved production efficiency.
- Access to valuable resources.

However, without developing knowledge absorption capabilities, businesses cannot fully leverage collaboration benefits in terms of supply chain flexibility and efficiency [9].

Given the complexity of digital ecosystems and the continuous advancement of technologies required to maintain competitive advantages, this business model must remain dynamic and secure, necessitating the constant monitoring of sustainability parameters.

This paper examines quantitative indicators of supply chain sustainability, including:

- Asset turnover.
- The overrun of the compound annual growth rate (CAGR) over three years compared to the share of R&D costs for the same period.
- Ratio of coverage of operating costs by received cash.
- Duration of the operating cycle.

### Investment and market sustainability indicators

A digital ecosystem is a resource-intensive business unit that requires substantial capital investments. The return on these investments, the maintenance of fixed assets, and strategic acquisitions that introduce new products, services, and technologies are key indicators for sustaining competitive advantages, ensuring operational stability, and supporting long-term growth plans.

The investment sustainability metrics of a digital ecosystem include:

1. The share of investments in strategic partnerships and acquisitions.
2. The asset renewability ratio.
3. The ratio of capital expenditures to revenue.

Additionally, the market sustainability indicators are:

1. Market share and its changes over time.
2. Brand reputation.
3. Customer loyalty levels.
4. The average check indicator.

Furthermore, specific quantitative product metrics can be applied, such as:

- Monthly active users (MAU).
- Daily, weekly, and monthly user engagement levels.

### Digital transformation sustainability indicators

The rapid advancement of technology in recent years compels digital ecosystems to keep pace with innovation, continuously improving, modernizing, and investing in operational processes. Digital approaches such as digital twins, predictive maintenance, and decentralized decision-making can significantly enhance a company's ability to respond to external disruptions, thereby increasing its resilience [22].

The digital transformation of the supply chain is defined as the use of digital technologies to connect, integrate, and optimize business activities, including those involving suppliers and customers [23]. A key aspect of supply chain resilience in digital ecosystems is cybersecurity.

To mitigate risks such as data breaches, account hacking, financial theft, and unauthorized access to critical systems, organizations must not only implement advanced software solutions but also establish comprehensive cyber risk management policies. These policies should address financial, reputational, and organizational risks associated with IT infrastructure incidents.

The security level of a digital ecosystem can be measured using the following key metrics:

- Number of security incidents and their impact on business processes.
- Financial losses incurred due to cyber threats.
- Time required to restore data after a cyberattack.
- Level of protection for digital assets and sensitive data.
- Effectiveness of user training in cybersecurity.
- Implementation of proactive security warnings for service users.

## Development of the Digital Ecosystem Sustainability Index (DESIn)

### Methodology of the Digital Ecosystem Sustainability

***Index (DESIn)***

In our research, the sustainability of digital ecosystems is analysed across nine key areas of organizational development for subsequent application in the balanced scorecard. Within each area, specific sustainability metrics are identified. These metrics are aggregated by area rather than being combined into a single indicator.

Financial, operational, and investment sustainability indicators are assessed using quantitative measures. The evaluation process for these quantitative indicators follows these steps:

1. Indicators are ordered from best to worst.
2. The best-performing indicator receives a score equal to the highest ordinal number among the companies studied, while the worst-performing indicator receives the lowest ordinal number.

In contrast, innovative sustainability, supply chain sustainability, digital transformation, ESG (environmental, social, and governance), and corporate governance indicators are evaluated using qualitative methods. These assessments are based on custom-designed questionnaires containing non-quantitative metrics, developed through a literature review.

The assessment process for non-quantitative indicators follows these steps:

1. Each digital ecosystem is classified into four groups based on the level of development and scale of the assessed indicator. Each group is assigned a score as follows:
   - 0 – indicator absent.
   - 0.5 – underdeveloped indicator.
   - 1 – moderately developed indicator.
   - 1.5 – highly developed indicator.
2. The total points for each digital ecosystem are summed within each sustainability area.

The market sustainability indicator is the only metric that combines both quantitative and qualitative indicators. Its aggregated result is calculated by:

- Grouping quantitative indicators using the same ranking method as above.
- Adding scores for non-quantitative metrics to derive a composite score.

This approach provides a comprehensive sustainability assessment for each research area, enabling comparisons over time and across different digital ecosystems.

## Innovative sustainability indicators

For digital ecosystems, innovation is a fundamental mechanism that enables them to maintain competitive positions and enhance sustainability. Therefore, we propose evaluating innovative sustainability by analysing innovations based on three key criteria: novelty, scale, and significance.

The assessment is structured as follows:

- 0.5 points – innovations related to existing services, products, technologies, or projects that enhance user experience. Examples include new data processing methods, additional services, etc.
- 1.0 point – innovations or collaborative projects introducing a new direction already present in the market or enhancing socially significant products and services. In these cases, the primary focus is on user convenience rather than profit, such as accessible services for specific population segments.
- 1.5 points – breakthrough innovations that transform the digital ecosystem's market presence. These include major contracts, partnerships, or entirely new products and services that were previously unavailable in the market. Examples include expanding into a new country, launching a disruptive product, or adopting groundbreaking technologies.

The total score for each company is calculated by summing its innovation points, with standardization applied if necessary for comparison.

## Market sustainability indicators

Despite the large number of product metrics, our index focuses on market position as a key sustainability indicator, comparing the services and products of different companies.

Market position is evaluated using the following ranking:

- If digital ecosystems operate within the same geographic area, market position is determined by the number of users.
- If digital ecosystems operate in different geographic locations, relative indicators are used instead. For example, market share is measured as the percentage of users relative to the total population in a given area.

Assessing services and products in digital ecosystems is more complex. The comparison is based on the following criteria:

1. Exclusivity – a unique offering available only in one of the studied ecosystems.
2. Novelty – whether a product is new to the market or has already gained widespread adoption with additional features.
3. Popularity – measured by the rating or number of users.
4. Diversity of additional features – for example, payment services may offer instalment plans, loans, cashback, and bonus points in addition to basic transactions.
5. User experience factors, including ease of use, interface quality, instructions, and various service conditions.

The comparison of digital ecosystems follows this sequence:

- Exclusive offerings receive the highest score (1.5 points).
- For non-exclusive services, popularity metrics are used to rank organizations.

If quantitative data is unavailable, the diversity of additional services is analysed:

- 0.5 points – standard set of features.
- 1.0 point – additional services that do not significantly impact usability.
- 1.5 points – enhancements that substantially improve the user experience.

Final aggregation and standardization:

1. If quantitative market data is available, organizations are ranked accordingly, and scores are assigned.
2. If both quantitative and qualitative metrics are used, the quantitative metrics are divided into four groups, each assigned a score of 0.0 / 0.5 / 1.0 / 1.5, following the same scale as qualitative indicators.
3. Finally, the scores for market position and service/product comparison are summed into a single indicator for each company, enabling direct comparison and standardization if necessary.

## Supply chain sustainability indicators

Based on the literature review, we identified non-financial metrics that characterize supply chain sustainability, including:

1. Flexibility.
2. Reliability.
3. Visibility.
4. Collaboration.
5. Trust.
6. Foresight.
7. Omnichannel capabilities.
8. Efforts to reduce supply chain duration.
9. Supplier diversification.
10. Technological flexibility in production.
11. Supply chain coordination.
12. Employee skills.
13. Service quality.

These metrics are assessed within digital ecosystems using the following criteria:

- Existence of policies addressing each indicator.
- Consideration of ecosystem scale in policy implementation.

However, in some cases, explicit supply chain sustainability management policies are not publicly disclosed in corporate statements, development strategies, goals, analytical reports, or other business descriptions. In such instances, the openness of the digital ecosystem plays a critical role, as publicly available information may indirectly indicate how the company manages its supply chain quality.

We use such indirect information to estimate supply chain management as follows:

- 0.5 points – indirect evidence of supply chain sustainability management.
- 1.0 point – direct company statements on managing supply chain sustainability.
- 1.5 points – formal policies that:
  a. Consider ecosystem scale,
  b. Integrate metrics across all business areas,
  c. Include specialized programs, and
  d. Implement unique initiatives for control, management, and recovery procedures.

The final score is calculated by summing the assessed indicators for each company, allowing for comparative analysis and standardization if necessary.

## Digital transformation sustainability indicators

The digitalization level of a digital ecosystem is evaluated across four main categories:

1. Digital Communications.
2. Digital Data.
3. Cybersecurity.
4. Digital Technologies.

Each category includes specific assessment criteria, detailed as follows:

1. Digital Communications.
   - Means of information exchange.
   - User engagement tools.
   - Feedback mechanisms.

Scoring criteria:

- 0.5 points – basic availability of a specific service.
- 1.0 point – improved version of the service, integrated with other services/products
- 1.5 points – multiple similar offerings or an exclusive feature that significantly enhances user experience.

2. Digital Data
   - Data availability and accessibility for participants.
   - Data management policies.
   - Data collection and storage infrastructure.
   - Data analytics tools.
   - Permissions for data usage by external users.

Scoring criteria:

Data management policy:

- 0.5 points – basic policy in place.
- 1.0 point – policy supplemented by transparency, accessibility, and regular updates.
- 1.5 points – comprehensive policy with defined roles, responsibilities, and the ability for users to delete personal data.

Data collection and storage:

- 0.5 points – presence of specialized data centres.
- 1.0 point – advanced security systems and high-tech data centres.
- 1.5 points – high-performance data centres with backup systems, loss prevention, and no major failures in the last three years

Data analytics:

- 0.5 points – basic analytics tools or pre-made reports.
- 1.0 point – advanced data visualization and a wider variety of metrics.
- 1.5 points – AI-driven analytics, machine learning, and sophisticated data processing tools.

Permissions for data usage:

- 0.5 points – permission granted, but with recorded privacy concerns.
- 1.0 point – strict confidentiality control and legal compliance.
- 1.5 points – full compliance with ethical and privacy standards, ensuring strict data security.

3. Cybersecurity:
   - Cybersecurity policies.
   - User data protection.
   - User data management.
   - Vulnerability detection programs.

Scoring criteria:

- Cybersecurity policy & data protection:
- 0.5 points – basic policy in place.
- 1.0 point – dedicated cybersecurity department and standard access verification technologies.
- 1.5 points – certified security measures, response protocols, and strict access controls.

User data management:

- 0.5 points – basic account access control.
- 1.0 point – enhanced security measures for user data.
- 1.5 points – full transparency and complete control over personal data, including the ability to delete all information.

Vulnerability detection programs:

- 0.5 points – basic feedback mechanisms.
- 1.0 point – structured programs for detecting vulnerabilities.
- 1.5 points – comprehensive research, training, and cybersecurity events.

4. Digital Technologies:
   - Blockchain.
   - Robotics and automation.
   - Artificial intelligence (AI) & machine learning.
   - Management platforms.
   - Big data analytics systems.
   - Cloud services & virtual storage.
   - Internet of Things (IoT).
   - Internet of Services (IoS).
   - Distributed ledger technologies.
   - Extended reality (XR): virtual reality (VR), augmented reality (AR), mixed reality (MR).

Scoring criteria:

Adoption & development:

- 0.5 points – use of a single blockchain or similar technology.
- 1.0 point – implementation of multiple digital technologies.
- 1.5 points – participation in technology development, attracting users, or specialization in a competitive area.

### *Sustainable development indicators – ESG*

The sustainable development indicators used for calculating the index can be categorized into four key groups:

1. Quality of Life – accessibility, convenience, service quality, and safety.
2. Ethics and Integrity – information security, personal data protection, anti-corruption and anti-monopoly measures, responsible procurement, and content quality.
3. Human Development – employee well-being, service partnerships, and education for all.
4. Environmental Impact – energy efficiency of infrastructure, waste management, and carbon footprint.

Additionally, we evaluated corporate governance sustainability using the following criteria:

- Board independence.
- Board qualification level.
- Share of related party transactions in revenue.
- Presence of an audit committee.
- Independence of the HR and remuneration committee.
- Number of violations of minority shareholders' rights.

## Application of digital ecosystem taxonomy and the DESIn index

### Application of digital ecosystem taxonomy

The authors applied the adapted digital ecosystem taxonomy to the investigated companies, Yandex and VK Group. The results confirmed the relevance of selecting these companies for the study, as they are industry leaders within the same geographic region, operate in the same sector, utilize similar technologies, and offer comparable services and products. However, they differ in financial and operational indicators, strategies, and overall business activities.

To explore these differences, we applied the Digital Ecosystem Sustainability Index (DESIn), which was specifically developed to this end.

### Using the DESIn index

The application of the DESIn sustainability index to the analysed digital ecosystems shows that VK Group is a weak company in of sustainability metrics. It lags behind Yandex in almost all areas, with the exception of quantitative investment indicators, where it it shows results better than Yandex.

Yandex, on the other hand, demonstrates a high level of sustainability across most areas, achieving scores close to the maximum, despite having the lowest result in the investment category. We attribute the latter to forced transformations within the company driven by geopolitical factors, particularly its redomiciliation in 2024.

## Measurement of quantitative indicators of the DESIn index

The analysis of quantitative indicators of the DESIn index and the normalization of data are presented in Tables 1 and 2.

**Table 1.** Quantitative indicators of DESIn index stability

| Digital ecosystem | Yandex | | | VK Group | | |
|---|---|---|---|---|---|---|
| Time period | 2021 | 2022 | 2023 | 2021 | 2022 | 2023 |
| **Financial indicators** | | | | | | |
| Current liquidity | 1.80 | 1.28 | 0.89 | 0.80 | 1.02 | 0.88 |
| Financial autonomy ratio | 0.53 | 0.55 | 0.38 | 0.57 | 0.47 | 0.34 |
| Net Debt / EBITDA | -0.66 | -0.50 | 0.46 | 1.16 | 5.08 | 233.8 |
| Return on assets (ROA), % | 1.60 | 1.70 | 3.50 | -5.20 | -7.50 | -8.60 |
| **Operational indicators** | | | | | | |
| Asset turnover | 0.69 | 0.85 | 1.02 | 0.42 | 0.36 | 0.33 |
| Exceeding the average revenue growth over three years over the share of costs in R&D, % | | 154 | | | 110 | |
| Ratio of coverage of operating costs by received cash | 0.90 | 0.98 | 0.97 | 1.09 | 0.85 | 0.98 |
| Duration of the operating cycle | 68.27 | 82.02 | 75.27 | 64.51 | 192.35 | 186.98 |
| **Investment indicators** | | | | | | |
| Share of investments in strategic partnerships and acquisitions, % | 0.00 | 1.42 | 0.00 | 7.55 | 0.00 | 12.48 |
| Asset renewability index, % | -0.02 | 19.63 | 27.55 | 2.37 | 21.15 | 11.04 |
| CAPEX / Revenue, % | 13.00 | 10.00 | 11.00 | 10.00 | 16.00 | 24.00 |

*Source:* calculated by the authors.

**Table 2.** Ranking and normalization of quantitative sustainability indicators

| Digital ecosystem | Total | | Normalization | |
|---|---|---|---|---|
| | Yandex | VK Group | Yandex | VK Group |
| **Financial indicators** | **9** | **4** | **8.2** | **3.6** |
| Current liquidity | 2 | 1 | | |
| Financial autonomy ratio | 2 | 1 | | |
| Net Debt / EBITDA | 2 | 1 | | |
| Return on assets (ROA) | 3 | 1 | | |
| **Operational indicators** | **8** | **5** | **7.3** | **4.5** |
| Asset turnover | 1 | 2 | | |
| Exceeding the average revenue growth over three years over the share of costs in R&D | 3 | 1 | | |
| Ratio of coverage of operating costs by received cash | 2 | 1 | | |
| Duration of the operating cycle | 2 | 1 | | |

| Digital ecosystem | Total | | Normalization | |
|---|---|---|---|---|
| | Yandex | VK Group | Yandex | VK Group |
| **Investment indicators** | **3** | **6** | **3.3** | **6.7** |
| Share of investments in strategic partnerships and acquisitions | 1 | 2 | | |
| Asset renewability index | 1 | 2 | | |
| CAPEX / Revenue | 1 | 2 | | |

*Source:* calculated by the authors.

In terms of financial and operational performance, Yandex demonstrates strong results in several key areas, including return on assets and development efficiency. However, its low investment indicators may suggest a focus on shorter-term returns rather than long-term investments.

Conversely, VK Group lags behind, exhibiting the longest operating cycle and a negative return on assets.

## Assessment of innovative sustainability indicators

Due to limited available information, our analysis relied on news articles, reviews, and publicly available information on the company's website.

Methodology for data collection and evaluation:

1. Internet searches were conducted using keyword combinations such as "new project", "new development", and "new product", along with the company's name and the period 2023–2024.
2. The collected information was then evaluated based on the predefined criteria for assessing this indicator.
3. To ensure comparability, we selected the same number of projects for each company from the first pages of search engine results and assessed them accordingly.

Findings:

- Yandex is focused on horizontal ecosystem expansion, introducing new brands and investing in autonomous vehicle development.
- VK Group, in contrast, concentrates on improving and enhancing existing services and products.

## Assessment of market sustainability indicators

The comparison of digital ecosystems based on this criterion revealed differences in services and products.

VK Group's development strategy, which focuses on social networks, video content, and messaging services, does not encompass certain O2O (online-to-offline) assets (Table 3). As a result, this category of services and products received a lower evaluation in the assessment.

**Table 3.** Assessment of market sustainability indicators

| Indicator | Normalization | | Estimation | |
|---|---|---|---|---|
| | Yandex | VK Group | Yandex | VK Group |
| Coverage of the population within the geographical area, million people, % | | | 56.70 | 46.10 |
| Grouping | 0.6 | 0.3 | 1.0 | 0.5 |
| **Quality of different services and products** | | | | |
| Differences | 3.9 | 0.6 | 6.5 | 1 |
| Bank | | | 1 | 0 |
| Browser | | | 1 | 1 |
| Car and kick sharing, taxi | | | 1 | 0 |
| Transport schedule | | | 1.5 | 0 |
| Telemedicine services | | | 0.5 | 0 |
| Delivery services | | | 1.5 | 0 |

| Indicator | Normalization | | Estimation | |
|---|---|---|---|---|
| | Yandex | VK Group | Yandex | VK Group |
| Quality of similar services | | | | |
| Similar services | 3.6 | 1.8 | 6 | 3 |
| Maps, route diagrams, navigators | | | 1.5 | 0.5 |
| Shop | | | 1 | 0.5 |
| Communication | | | 0.5 | 1 |
| Search engine | | | 1.5 | 0.5 |
| Other services | | | 1.5 | 0.5 |
| Total | 8.2 | 2.7 | 13.5 | 4.5 |

*Source:* calculated by the authors.

After selling Zen to VK Group, Yandex lost part of its audience but simultaneously began developing Yandex Q. The company offers a wide variety of services, maintains continuous development, and provides strong alternatives.

## Assessment of supply chain sustainability indicators

The level of openness of the studied digital ecosystems varies, resulting in limited or unavailable information on supply chain sustainability management policies. In such cases, analytical and news reviews, as well as company job postings, served as alternative sources of information. All companies demonstrate a high level of supply chain sustainability, which provides them with a competitive advantage.

## Assessment of digital transformation sustainability indicators

Digitalization indicators are high for both companies, although VK Group's indicators are slightly lower, likely due to the company's level of information openness. Both companies utilize widespread modern digital technologies. Yandex has placed a strong emphasis on AI technologies, launching Neuro in early 2024 – an AI-powered search engine that provides detailed answers using Internet data and is integrated into other ecosystem products. VK Group, on the other hand, focuses on advancements in cloud services, including storage and data management. Both companies are actively developing across key areas of digitalization, which positively contributes to their long-term sustainability.

## Assessment of sustainable development indicators – ESG

The normalized values of these indicators are presented in Table 4.

**Table 4.** Assessment of sustainable development indicators – ESG

| Indicator | Yandex | VK Group |
|---|---|---|
| Quality of life | 1.3 | 1.0 |
| Available environment | 0.6 | 0.6 |
| Convenience, quality and security of services | 0.6 | 0.3 |
| Ethics and integrity | 2.6 | 1.6 |
| Information security and personal data protection | 0.6 | 0.3 |
| Responsible purchases | 0.6 | 0.0 |
| Content quality | 0.6 | 0.6 |
| Anti-corruption and anti-trust measures | 0.6 | 0.6 |
| Human development | 1.9 | 1.9 |
| Staff | 0.6 | 0.6 |
| Service partners | 0.6 | 0.6 |
| Education for all | 0.6 | 0.6 |
| Environmental impact | 1.9 | 0.6 |
| Energy efficiency of own infrastructure | 0.6 | 0.3 |
| Waste management | 0.6 | 0.3 |
| Carbon footprint | 0.6 | 0.0 |
| Risk management | 0.6 | 0.6 |
| Total | 8.4 | 5.8 |

*Source:* calculated by the authors.

## Assessment of corporate governance sustainability indicators

The normalized values of these indicators are presented in Table 5.

**Table 5.** Assessment of corporate governance indicators

| Indicator | Yandex | VK Group |
|---|---|---|
| Board | 5.3 | 3.7 |
| Board independence | 1.1 | 0.5 |
| Qualification and election process: | 1.1 | 0.5 |
| Transactions with related parties | 1.1 | 0.5 |
| Audit Committee | 1.1 | 1.1 |
| Election process | 1.1 | 1.1 |
| HR and Remuneration Committee | 2.1 | 2.1 |
| Independence of the committee | 0.5 | 0.5 |
| Powers and responsibilities of the committee | 0.5 | 0.5 |
| Committee involvement in company processes | 1.1 | 1.1 |
| Shareholder rights | 2.6 | 2.6 |
| Right to participate in company management | 1.1 | 1.1 |
| Right to receive information | 1.1 | 1.1 |
| Right to receive dividends | 0.5 | 0.5 |
| Total | 10.0 | 8.4 |

*Source:* calculated by the authors.

# Analysis of the impact of the DESIn index on EVA

## Investigating the impact of the DESIn index on EVA using financial modelling

To investigate the impact of the DESIn Digital Ecosystem Sustainability Index, developed by the authors, for Yandex and VK Group, we constructed financial models that include the following steps:

1. Data collection and analysis.
2. Revenue forecasting.
3. Estimation of operating expenses.
4. Assessment of capital expenditures and investments.
5. Calculation of the free cash flow (FCF).
6. Evaluation of the weighted average cost of capital (WACC).
7. Calculation of the economic value added (EVA).
8. Estimation of the discounted cash flow (DCF) for comparison with the EVA method.

## Financial model for Yandex

The assumptions and indicators were analysed and selected to ensure the correct calculation of metrics for the Search and Portal division, which includes services such as Search, Geoservices, Weather, and several other offerings in Russia, Belarus, and Kazakhstan, and accounts for nearly all of Yandex's advertising revenue.

Additionally, market indicators were identified and analysed for the E-Commerce division, which includes services such as Yandex Market, the express grocery delivery service Yandex Lavka in Russia, and the grocery delivery service Yandex Food. The company's revenue streams were categorized into the following areas:

- Search advertising.
- Performance CPX.
- Performance video.
- Media advertising.
- E-commerce.
- Ridetech.
- Delivery.
- Yandex Plus.
- Yandex Music.
- Kinopoisk.
- Yandex Afisha.
- Yandex Studio.
- Yandex SDG.
- Yandex Cloud.
- Yandex 360.
- Yandex Education (Practice).
- Devices.
- Alice.

Operating expenses were calculated based on historical unit rates and revenue percentages, with growth rates and revenue percentages validated by market research. Capital expenditures were estimated based on historical revenue percentages, and similar percentages were applied to depreciation and working capital. The WACC calculations, based on the Yandex financial model, are presented in Table 6.

**Table 6.** WACC estimation for Yandex

| WACC calculation | | | |
|---|---|---|---|
| **Cost of equity** | **Calculation** | **%** | **17.02** |
| Risk-free rate | OFZ 15y | % | 13.80 |
| Beta unlevered | Cbonds, YNDX | # | 0.42 |

| WACC calculation | | | |
|---|---|---|---|
| D/E | Analogous | # | 0.05 |
| Tax rate | Tax code RF | # | 20% |
| Beta levered | Calculation | # | 0.42 |
| ERP | Kroll | % | 6.22 |
| Size-premium | Kroll | % | 0.50 |
| **Target capital structure** | | | |
| D/E | Damodaran | # | 0.05 |
| **Cost of debt** | **YTM of Softline's bonds** | **%** | **16.00** |
| Marginal Tax rate | Tax code RF | % | 20.00 |
| After tax cost of debt | Calculation | % | 12.80 |
| **WACC** | **Calculation** | **%** | **16.69** |

*Source:* calculated by the authors.

The calculations were verified by constructing a discounted cash flow (DCF) model. The low debt-to-equity (D/E) ratio was determined based on a retrospective analysis of Yandex's historical financial reports, as well as a comparison with competitors. Yandex maintained negative net debt from 2019 to 2022. The calculations of economic value added (EVA) for Yandex are presented in Table 7.

**Table 7.** Calculation of economic value added (EVA) for Yandex

| Indicator | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 |
|---|---|---|---|---|---|---|
| Equity value | 369.2 | 490.5 | 693.8 | 967.5 | 1 326.0 | 1 784.6 |
| Added value | 33.9 | 57.5 | 139.7 | 193.7 | 254.1 | 319.3 |
| Current invested capital | 888.5 | | | | | |
| PV of value added | 696.7 | | | | | |
| Equity value | 1 585.2 | | | | | |
| Value per share | 4 204.8 | | | | | |

*Source:* calculated by the authors.

## Financial model for VK Group

Similar macroeconomic and market assumptions to those used for Yadex were applied in developing the financial model for VK Group. The assessment of the company was conducted across various segments of its ecosystem, as reflected in the developed model. The only significant difference is the higher WACC, attributed to the company's substantial debt burden (Table 8).

**Table 8.** WACC estimation for VK Group

| WACC calculation | | | |
|---|---|---|---|
| **Cost of equity** | **Calculation** | **%** | **26.39** |
| Risk-free rate | OFZ 10y | % | 13.80 |
| Beta unlevered | Damodaran | # | 1.08 |
| D/E | Analogous | # | 1.00 |
| Tax rate | Tax code RF, % | # | 20 |
| Beta levered | Calculation | # | 1.94 |

| WACC calculation | | | |
|---|---|---|---|
| ERP | Kroll | % | 6.22 |
| Size-premium | Kroll | % | 0.50 |
| **Target capital structure** | | | |
| D/E | Damodaran | # | 1.00 |
| Cost of debt | VK bonds | % | 15.62 |
| Marginal tax rate | Tax code RF | % | 20.00 |
| Cost of debt after tax | Calculation | % | 12.50 |
| **WACC** | **Calculation** | **%** | **18.19** |

*Source:* calculated by the authors.

The calculations of economic value added (EVA) for VK Group are presented in Table 9.

**Table 9.** Calculation of economic value added (EVA) for VK Group

| Indicator | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 |
|---|---|---|---|---|---|---|
| Equity value | 173.3 | 175.5 | 178.5 | 182.5 | 188.2 | 196.1 |
| Added value | (23.2) | (12.4) | 2.2 | 22.2 | 49.9 | 88.7 |
| Required return on invested capital | 31.5 | 31.9 | 32.5 | 33.2 | 34.2 | 35.7 |
| PV of value added | 108.2 | | | | | |
| Equity value | 108.2 | | | | | |
| Value per share | 478.4 | | | | | |

*Source:* calculated by the authors.

## Main conclusions of financial modelling

Our financial models show that the value of Yandex is expected to grow for the following reasons:

1. Yandex remains the most successful Russian Internet company with a highly diversified business portfolio.
2. Despite external challenges, the company's revenue grew by 46% in 2022 and by 53% in 2023. This growth is expected to continue, driven by the rapid development of the e-commerce, ridetech, and delivery markets, where Yandex holds a significant share: in 2023, these markets generated 420 billion roubles (+61% YoY). The advertising market will further drive stock market growth.
3. The departure of many foreign companies has encouraged Yandex to focus on the development of its own ecosystem.
4. Although the e-commerce segment is still operating at a loss, all assets in this area are nearing breakeven. Yandex Market, for example, was close to breaking even as of July and is expected to become profitable in the coming quarters. Ridetech has historically posted positive EBITDA, and O2O services are working toward operational efficiency, with expectations for profitability in the next few years.
5. The number of service subscribers is growing rapidly, with Yandex.Plus subscribers increasing by 66% in 2022 and 58% in 2023. This indicates that Yandex is successfully pursuing its growth strategy and will continue on this path.
6. The company maintains a low debt-to-EBITDA ratio of 0.7, showing a low debt burden.

Key risks for Yandex:

1. Yandex is expanding its business in various segments, but faces high competition in all areas. There is a risk that failure in any major segment could hinder growth expectations.
2. Legislative and regulatory challenges may affect operations.
3. Western sanctions against the Russian Federation negatively impact collaborations with foreign companies and the acquisition of foreign expertise. The ban on high-tech equipment from Western countries may significantly increase modernization costs or lead to technological backwardness.
4. The company has been generating negative free cash flow in recent years due to active investments in growth.
5. Yandex does not currently pay dividends.

6. Shares are traded at a high EV/EBITDA multiple of 15.7 for the Russian market, though this could be justified given the company's growth projections.

In contrast, our analysis for VK Group indicates that the company's shares should be sold at this time for the following reasons:

1. Slowing revenue growth: VK's Social Media & Content Services revenue growth slowed to 31% in H2 2023, down from 41% in H1. This slowdown is partly due to the low base effect.
2. Decreasing profitability: Social Media EBITDA dropped significantly from 19% in H1 2023 to just 1% in H2 2023, reflecting a significant deterioration in profitability.
3. High investment, low profitability: Despite a 10–11% growth in MAU/DAU, the company is still incurring significant losses. For instance, the EdTech segment posted an EBITDA loss of RUB 111 million in H2 2023.
4. Negative free cash flow: The company reported a free cash flow (FCF) loss of RUB 35 billion in 2023 (RUB 44 billion including M&A), compared to a loss of RUB 12 billion in 2022.
5. Growing debt burden: VK's net debt increased from RUB 98 billion in H1 2023 to RUB 139 billion by the end of the year, indicating a deteriorating financial position.
6. Weak share performance: The company's shares show a negative free cash flow yield of –29% in 2023, –14% in 2024, and –3% in 2025, making them less attractive to investors.
7. Profitability issues in other segments: Segments such as VK Play, RuStore, and voice technologies have also shown EBITDA losses, which negatively impact the company's overall profitability.
8. Overvaluation: The current EV/EBITDA of 64.6 indicates that VK shares are significantly overvalued compared to the market average, which may necessitate a revision of their value.

These factors highlight the significant financial and operational risks associated with owning VKontakte (VK) shares, making them less attractive to investors.

Key takeaway: Financial modelling confirms that the DESIn index calculations are correct. Yandex's ecosystem is more developed than VK's, which requires modernization to stay competitive.

## Conclusion

In our research on digital ecosystems, we adapted a taxonomy for Russian companies based on a comprehensive review of the literature and global digital ecosystems. This taxonomy enables us to identify the key classification features of business models and form a clearer understanding of their specifics. The elements of this taxonomy can also be applied to develop business models for digital ecosystems.

Our literature review and financial modelling demonstrated a positive impact of the Digital Ecosystem Sustainability Index (DESIn) on economic value added (EVA). Companies with high DESIn scores, such as Yandex and VK Group, show higher EVA. This confirms that the sustainability of digital ecosystems contributes to an increase in company value by enhancing operational efficiency, reducing risks, and attracting investment. The DESIn index we developed provides a framework for detailed, full-scale studies of digital ecosystems, with flexible implementation. It uses data for external users and examines key areas of an organization's activities through both quantitative and non-quantitative indicators.

Digital ecosystems with high DESIn values demonstrate significant improvements in operational efficiency, including better supply chain resilience management and use of digital infrastructure. These improvements lead to higher asset turnover, reduced operating costs, and optimized business processes, all of which contribute to EVA growth. High DESIn values also positively impact the investment attractiveness of companies. Sustainable digital ecosystems attract more investors due to their stability and long-term growth potential, thereby increasing company value.

Companies with high DESIn scores are also more likely to implement innovations that help them maintain competitive advantages and adapt to rapidly changing market conditions. Innovative sustainability metrics show a strong correlation with EVA growth, leading to greater investor confidence and, ultimately, an increase in company value.

In conclusion, our study has achieved its objectives and solved the set tasks: we identified the main features and criteria of digital ecosystems, explained the relevance of sustainability indicators and their impact on company value, and developed a method for measuring the sustainability of digital ecosystems. The DESIn index has shown its effectiveness in analysing digital ecosystem sustainability.

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# Ownership Structure and Innovation Quality: Evidence from Patenting Activities

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## Abstract

High-quality innovation can provide companies with a competitive advantage in the market, enabling them to become leaders and effectively respond to challenges from competitors. This paper aims to offer recommendations to Chinese policymakers on enhancing innovation quality. It adopts a corporate governance perspective to examine the impact of ownership structure (ownership concentration, state ownership, institutional ownership, and managerial ownership) on innovation quality. Using patent data from Chinese listed companies from 2012 to 2021, the study reveals that innovation quality is influenced by different ownership structures. State ownership, institutional ownership, and managerial ownership positively affect innovation quality. Contrary to expectations, ownership concentration leads to a decline in innovation quality. This approach differs from previous research in two key aspects. First, it identifies ownership factors that enhance innovation quality, addressing the limitations of earlier studies that focused solely on single ownership types. Second, by focusing on invention patent information, it captures innovation quality, providing a more accurate assessment of firms' true innovative capabilities in a transitional economy.

**Keywords:** ownership structure, ownership concentration, state ownership, institutional ownership, managerial ownership, innovation quality

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# Introduction

Corporate innovation is a key factor in achieving competitive advantage for enterprises. Technological advancements have been proven to create jobs and increase income, thereby significantly promoting macroeconomic growth [1–3]. Consequently, innovation is often considered a potent tool for enhancing national competitiveness [4–5]. High-quality innovation typically leads to breakthrough products, services, or processes, providing sustainable competitive advantages that are difficult for competitors to replicate, thus ensuring a more enduring market position [6–9]. However, high-quality innovation also increases the risk of failure, potentially depleting resources and damaging the company's reputation [10–12]. Conversely, firms that emphasize quantity of innovation, even at the expense of quality, often view this approach as a risk mitigation strategy: if some high-quality innovations fail, others may succeed, balancing the overall outcome. Unfortunately, an excessive focus on quantity can dilute resources, reduce overall innovation quality, and lead to long-term strategic disadvantages [13].

While many transitional countries and regions have policies that encourage firms to increase innovation activities, these policies often place relatively less emphasis on the quality of innovation [14–15]. Previous studies have debated the extent to which ownership structure can influence overall innovation [16]. While the importance of overall innovation quantity is undeniable, exploring the relationship between ownership structure and innovation quality can help to better assess the true "innovation value" of ownership. The Anglo-American model, characterized by dispersed ownership, and the German-Japanese model, characterized by bank-based financing, concentrated ownership, and insider ownership, are specific to developed countries [17]. These established models may not accurately describe the unique institutional differences in transitional economies. For instance, Chinese firms have distinct characteristics in their equity structures, including more concentrated ownership, prevalent family ownership, and a growing trend of state ownership [18]. However, existing literature lacks a comprehensive assessment of the relationship between ownership structure and innovation quality in these transitional economies. Addressing this gap is crucial as equity structure influences the incentive mechanisms for both internal and external stakeholders. Understanding these relationships can help firms allocate resources more effectively, directing them toward high-value innovation activities.

This paper aims to fill this gap. Firstly, we provide a thorough analysis and comparison of ownership structures. Specifically, we examine the impact of ownership concentration, state ownership, institutional ownership, and managerial ownership on innovation quality. Secondly, we measure the quality of innovation by utilizing invention patent information from Chinese listed companies. By examining the technological content of patents, we differentiate high-quality invention patents from other categories of lower-quality patents within China's patent applications. This approach allows us to identify high-quality patents within the scope of corporate innovation activities. China, as a significant economic power with a transitional economy, offers an interesting context for examining the relationship between ownership structure and innovation quality, given its distinctive corporate governance models compared to developed countries. Our sample comprises data from 3,837 Chinese listed firms from 2012 to 2021. The results indicate that state, institutional, and managerial ownership positively influences innovation quality, while ownership concentration has a negative impact.

This paper makes several contributions. Firstly, it examines the relationship between ownership structure and innovation quality from multiple perspectives, addressing the limitations of previous research that focused solely on the impact of a single type of ownership on innovation. Secondly, it extends the literature on the relationship between equity structure and innovation quality, a topic that has been underexplored, particularly in transitional economies. By utilizing invention patent information, this study offers new insights, which are valuable for emerging economies seeking to improve their innovation governance mechanisms and achieve economic transformation.

The remainder of this paper is structured as follows. Second section reviews the existing literature and develops the hypotheses. Third section describes the data, main variables, and research methods used in this study. Fourth section presents the empirical results, while Fifth section concludes the paper.

# Theoretical Foundations and Hypothesis Development

## Agency Theory

Agency theory, a fundamental component of institutional economics and contract theory, primarily focuses on the principal-agent relationship [19]. This relationship involves one or more principals hiring agents under a contractual agreement, granting the agents certain decision-making authority to manage the firm. As companies grow and evolve, corporate governance mechanisms also change, with the separation of ownership and control being a prominent indicator of this transformation [20].

Agency theory posits that agents typically possess more information than principals, and this information asymmetry adversely affects the principals' ability to effectively monitor whether the agents are acting in the principals' best interests [21–22]. Conflicts of interest and differing priorities, such as attitudes towards innovation risk, lead to agency conflicts when agents act on behalf of principals [23]. These principal-agent problems arise when the interests of the two parties diverge and when there is information asymmetry, with agents having more information. Principals cannot directly ensure that agents always act in their best interests, especially when activities beneficial to the principals involve high costs and risks for the agents, such as innovation activities [20; 24].

### Institutional Theory

Institutional theory focuses on the interaction between institutions and organizations, emphasizing that corporate behaviour is largely influenced by specific social and institutional contexts or frameworks [25–27]. These institutions include social, economic, and political organizations, as well as informal social norms and rules. When formulating and implementing business strategies, companies need to consider their external environment and institutional norms [28]. This is particularly important in transitional economies, where firms must adapt to different institutional constraints to acquire necessary resources and support [29].

The institutional dimension of firms allows scholars to better understand corporate decisions regarding the adaptation to the institutional logic of developing new or internal resources. Many Chinese scholars have observed that institutional factors alter the application of agency theory assumptions in state-owned enterprises (SOEs) [30–31]. Due to path dependence, Chinese SOEs are subject to extensive government intervention, including ownership control and the recruitment system for senior managers [32]. Specifically, although SOEs enjoy privileges conferred by government agencies, the links between the government and SOEs create institutional pressures that compel SOEs to use resources to attain public goals set by the government, including economic growth and national innovation strategies [30; 32].

## Hypothesis Development

### Ownership Concentration and Innovation Quality

The relationship between ownership concentration and innovation can be predicted by considering the role of information asymmetry in the corporate innovation process. Generally, managers tend to focus more on short-term financial returns than long-term innovation benefits. This myopic behaviour can lead to reduced investment in innovation activities [33].

From an agency theory perspective, ownership concentration serves as a monitoring mechanism to reduce information asymmetry [34]. When ownership is concentrated among large shareholders, these shareholders have a stronger incentive to oversee information relating to innovation investments and influence management [35]. This mitigates the problem of dispersed ownership, where small shareholders are neither willing nor able to bear the costs of monitoring managers. Furthermore, the value of the shares held by large shareholders depends on the commercial value of the company, and successful innovation often leads to an increase in stock prices [36]. Given their focus on the company's stock price, large shareholders are more motivated to oversee investments in high-quality innovation activities and promote R&D processes that have a potential to yield significant innovation benefits, thereby ensuring the enhancement of innovation quality in the firm. Thus, our first hypothesis may be formulated as follows:

*H1:* Ownership concentration positively influences the quality of innovation.

### State Ownership and Innovation Quality

In emerging markets, institutional factors significantly influence firms' R&D activities [37–40]. These factors include social, economic, and political organizations, as well as informal social norms and rules. The innovation process is seen as a dynamic accumulation of learning and innovation, intricately linked with the country's economic structure and institutional environment [41]. Therefore, when formulating and implementing corporate strategies, SOEs in transition economies must prioritize external environment considerations and their own institutional norms.

The managers of Chinese SOEs exhibit distinct institutional characteristics, being more akin to bureaucrats than to typical private entrepreneurs [42]. This unique group frequently rotates positions with government officials. Notably, within this specific institutional context, SOE managers, acting as agents of the government shareholder, are driven by political motives and often adhere to public economic goals set by the government. These political motives overweigh general short-term profit considerations [43]. Indeed, higher political ranks typically lead to rapid increases in income and reputation, far beyond what short-term corporate performance can achieve. The Chinese government tends to adopt long-term strategies to promote high-quality innovation and industrial upgrading. Consequently, the underlying political motivations drive SOEs to increase R&D investment and enhance innovation quality. This leads to our second hypothesis:

*H2*: State ownership positively influences the quality of innovation.

### Institutional Ownership and Innovation Quality

Institutional investors have emerged as major players in the field of corporate governance. Prior research indicates that they positively impact corporate performance and strategic decision-making by monitoring and constraining managers' self-serving motives. Institutional investors also contribute to reducing agency costs by exerting pressure on managers to focus on company performance and competitive potential [44–45].

Unlike dispersed small shareholders, institutional investors typically hold significant stakes, which motivate them to oversee managers' innovation decisions. This oversight can reduce managerial opportunism and ensure that corporate resources are genuinely directed toward improving innovation quality [46]. Furthermore, institutional investors play a crucial coordinating role among internal and external stakeholders, including the government, board of directors, employees, and suppliers [47]. As both major shareholders and key participants in the national economy, these institutional investors exert pressure on firms to pursue long-term innovation outcomes associated with high-quality innovation rather than merely short-term performance. Therefore, we hypothesize:

*H3*: Institutional ownership positively influences the quality of innovation.

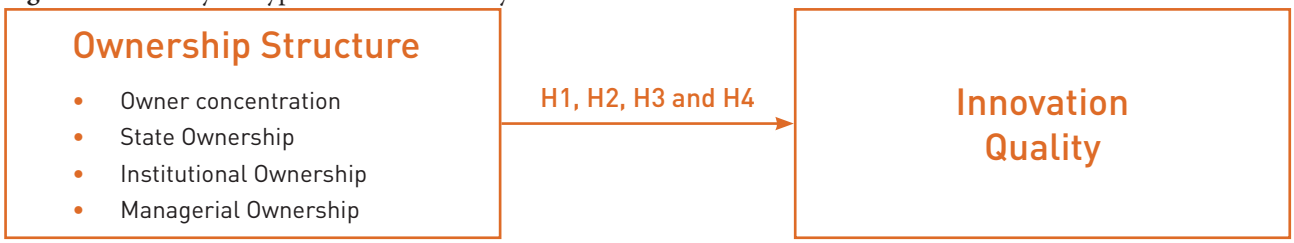
### Managerial Ownership and Innovation Quality

In the realm of corporate governance, innovation is characterized by its long-term and high-risk nature [48]. Due to information asymmetry, managers possess more information than shareholders [49]. When acting on behalf of shareholders, managers may prioritize their personal short-term interests, fearing the potential failure of innovative projects. This can lead them to make decisions that favour their interests rather than the company's long-term success. Unlike shareholders, who typically pursue long-term gains and acknowledge the inherent risks of innovation, managers may be less inclined to invest in innovation due to its potential negative impact on short-term performance.

However, when managers hold significant ownership stakes in the company, their interests align more closely with those of shareholders [50]. This alignment mitigates the agency problem, as managers are more likely to act in the best interests of the company, focusing on long-term value creation through innovation. Equity incentives provide managers with a vested interest in pursuing high-reward innovation strategies. Since their personal wealth is tied to the company's innovation performance, managers are motivated to ensure the success of innovation initiatives, thus improving the quality of innovation activities. Based on this rationale, we propose the following hypothesis:

*H4*: Managerial ownership positively influences the quality of innovation.

**Figure 1.** Summary of Hypotheses in this Study




## Methodology

### Sample and Data

Using the CSMAR database, we constructed a comprehensive dataset covering the ownership and financial information of Chinese listed companies from 2012 to 2021. Patent information related to innovation was sourced from the CNRDS database. The data underwent the following pre-processing steps: 1) financial firms (e.g., banks, insurance companies, and mutual funds) were excluded due to their distinct governance structures; 2) companies that experienced consecutive losses for two years and faced delisting risks were removed, as these firms are marked as "Special Treatment" by the China Securities Regulatory Commission, indicating severely abnormal financial conditions; 3) companies with missing data were excluded to minimize the impact of incomplete data on the results; and 4) all continuous variables were winsorized at the 1st and 99th percentiles.

### Variable Measurement and Model Specification

The dependent variable in this study is innovation quality (IQ), measured as the natural logarithm of the number of invention patents filed by the company. Invention patents typically involve new technical solutions, reflecting high levels of technological innovation and R&D investment. Obtaining an invention patent requires a rigorous examination process, including evaluations of novelty, inventiveness, and utility. Therefore, invention patents often point to a company's breakthroughs in technological innovation and high-quality R&D outcomes. In China, invention patents must meet the requirements of "novelty, inventiveness, and utility" to pass the examination. In contrast, design patents or utility model patents only require the absence of prior similar applications. Thus, invention patents demonstrate a higher degree of technological advancement and quality. Additionally, IQ_A, defined as the natural logarithm of the number of granted invention patents, is used as a robustness check indicator. These are two of the most commonly used measures of innovation quality in previous research [51].

This study focuses on four key test variables. First, ownership concentration (TOP1) is measured by the total percentage of shares held by the largest shareholder. In China, the prevalent phenomena of cross-holdings and pyramid structures have long complicated ownership frameworks, making calculations of state ownership percentages potentially inaccurate, as the degree of control might not be fully reflected in direct shareholdings. To examine the impact of state ownership (SOE), we created a dummy variable, where 1 indicates that a firm is controlled by a government entity, and 0 otherwise. Institutional ownership (INST) refers to the proportion of shares held by institutional investors. Similarly, managerial ownership (Mshare) denotes the percentage of the company's shares held by its managers. These measures align with those used in prior literature [30; 32].

Additionally, we included several control variables that potentially affect IQ, consistent with prior research (e.g., Beyer et al., 2012; Choi et al., 2011; Pu & Zulkafli, 2024 [17; 32; 35]). These variables include firm size (logarithm of total

assets), firm age (natural logarithm of years since establishment plus one), financial leverage (total debt divided by total assets), sales growth (ratio of current to previous year's operating revenue), and board size (natural logarithm of the total number of directors on the board). The measurements of these variables are given in Table 1.

To mitigate the impact of unobserved industry heterogeneity and temporal variations on IQ, we included industry and year fixed effects. This ensures that the observed relationship between ownership structure and innovation quality is not confounded by industry-specific or time-specific factors. The basic empirical model is as follows:

$$IQ_{i,t} = \alpha_0 + \alpha_1 OS_{i,t} + \alpha_2 Size_{i,t} + \alpha_3 FirmAge_{i,t} + \\ + \alpha_4 Lev_{i,t} + \alpha_5 Growth_{i,t} + \alpha_6 Board_{i,t} + Year + \\ + Industry + \varepsilon, \quad (1)$$

where $\alpha_0$ denotes the intercept, and $\alpha_1 - \alpha_6$ are the coefficients to be estimated. OS refers to the four ownership structure variables – TOP1, SOE, INST, and Mshare; $\varepsilon$ is the error term; $i$ denotes the cross-sectional dimension for firms; and $t$ denotes the time series dimension.

**Table 1.** Summary of Variable Descriptions and Measurements

| Measurement | |
|---|---|
| **Panel A: Dependent Variables** | |
| IQ | The natural logarithm of the company's applied invention patents plus one. |
| **Panel B: Independent Variables** | |
| TOP1 | The percentage of firm shares owned by the largest shareholder. |
| SOE | Dummy variable equal to 1 if the company is a state-owned entity and 0 otherwise. |
| INST | The percentage of company shares owned by institutional investors. |
| Mshare | The percentage of company shares owned by top management. |
| **Panel C: Control Variables** | |
| Size | The logarithm of total assets. |
| FirmAge | The natural logarithm of the number of years since the firm's establishment plus one. |
| Lev | The book value of total debts divided by total assets. |
| Growth | The ratio of the change in operating income to the operating income in the previous year. |
| Board | The natural logarithm of the total number of directors on the firm's board. |

*Source*: prepared by the author.

# Findings and Discussion

## Descriptive Statistics and Correlation Matrix

The descriptive statistics for the key variables in our study are presented in Table 2; they include the mean, standard deviation, and minimum and maximum values. From Table 2, we see that the mean innovation quality (IQ) for 3,837 listed firms in China during 2012–2021 is 1.873. The mean number of granted patents (IQ_A) is slightly lower at 1.231, indicating that the actual number of granted patents is generally lower than the total number of patent applications. This aligns with the reality of patent activities, as not all applications are ultimately accepted.

Regarding the test variables, the average ownership concentration (TOP1), measured by the largest shareholder's holding percentage, is 34.015%, with a standard deviation of 14.757%, and ranges from 8.630% to 74.180%. The mean value of state ownership (SOE) is 0.343, with a standard deviation of 0.475, and ranges from 0.000 to 1.000. Institutional ownership (INST) has a mean of 43.909%, with a standard deviation of 25.036%, and ranges from 0.321% to 94.529%. Managerial ownership (Mshare) averages 13.834%, with a standard deviation of 19.572%, and ranges from 0.000% to 68.955%. These statistics provide an overview of the ownership structures within our sample, highlighting the diversity in ownership concentration, state involvement, institutional investments, and managerial stakes in the firms.

For the control variables, the sample firms have an average company size (log of total assets) of 22.256, an average firm age (log of years since establishment plus one) of 2.920, a financial leverage (total debt to total assets) of 0.420, a sales growth rate of 0.169, and an average board size (log of the number of directors) of 2.122.

The industry distribution data in Table 3 shows that the manufacturing industry accounts for the largest share, with 66% of total firm observations, followed by the information transmission, software, and information technology services industry at 6.99%. The wholesale and retail industry and real estate industry contribute 4.98 and 3.89%, respectively. Several industries, including agriculture, forestry, animal husbandry, and fishery as well as mining, represent smaller shares, around 1 to 3% each. A few sectors, such as residential services and education, account for less than 0.5%. The cumulative distribution indicates that over 90% of observations come from the top eight industries, reflecting a concentration in manufacturing and information-related sectors.

**Table 2.** Descriptive Statistics

| Variable | N | Mean | Std. dev. | Min | Max |
|---|---|---|---|---|---|
| IQ | 25940 | 1.873 | 1.526 | 0.000 | 5.974 |
| IQ_A | 25940 | 1.231 | 1.251 | 0.000 | 5.063 |
| TOP1 | 25940 | 34.015 | 14.757 | 8.630 | 74.180 |
| SOE | 25940 | 0.343 | 0.475 | 0.000 | 1.000 |
| INST | 25940 | 43.909 | 25.036 | 0.321 | 94.529 |
| Mshare | 25940 | 13.834 | 19.572 | 0.000 | 68.955 |
| Size | 25940 | 22.256 | 1.282 | 19.814 | 26.153 |
| FirmAge | 25940 | 2.920 | 0.319 | 1.609 | 3.497 |
| Lev | 25940 | 0.420 | 0.202 | 0.050 | 0.893 |
| Growth | 25940 | 0.171 | 0.388 | -0.544 | 2.445 |
| Board | 25940 | 2.122 | 0.197 | 1.609 | 2.708 |

*Source*: calculated by the author.

**Table 3.** Industry Distribution

| No. | Industry Code | Industry Name | Freq. | Percent | Cum. |
|---|---|---|---|---|---|
| 1 | A | Agriculture, forestry, animal husbandry, and fishery | 301 | 1.16 | 1.16 |
| 2 | B | Mining | 570 | 2.2 | 3.36 |
| 3 | C | Manufacturing | 17,120 | 66 | 69.36 |
| 4 | D | Electricity, heat, gas, and water production and supply | 835 | 3.22 | 72.58 |
| 5 | E | Construction | 664 | 2.56 | 75.13 |
| 6 | F | Wholesale and retail | 1,293 | 4.98 | 80.12 |
| 7 | G | Transportation, storage, and postal | 741 | 2.86 | 82.98 |
| 8 | H | Accommodation and catering | 69 | 0.27 | 83.24 |
| 9 | I | Information transmission, software, and information technology services | 1,814 | 6.99 | 90.24 |
| 10 | K | Real estate | 1,009 | 3.89 | 94.12 |
| 11 | L | Leasing and business services | 298 | 1.15 | 95.27 |
| 12 | M | Scientific research and technical services | 294 | 1.13 | 96.41 |
| 13 | N | Water conservancy, environment, and public facilities management | 343 | 1.32 | 97.73 |
| 14 | O | Residential services, repairs, and other services | 4 | 0.02 | 97.74 |
| 15 | P | Education | 35 | 0.13 | 97.88 |
| 16 | Q | Health and social work | 59 | 0.23 | 98.11 |
| 17 | R | Culture, sports, and entertainment | 335 | 1.29 | 99.4 |
| 18 | S | Comprehensive industry | 156 | 0.6 | 100 |
| | Total | | 25,940 | 100 | |

*Note*: The first column represents the industry number, the second column shows the industry code, the third column lists the industry name, the fourth column provides the frequency of firm observations in each industry, while the fifth and sixth columns display the frequency proportion and cumulative proportion for each industry, respectively.

The Pearson correlation analysis in Table 4 indicates that ownership structure influences IQ in distinct ways. INST and Mshare show positive and significant correlations with IQ, suggesting that the oversight and vested interests of these stakeholders support higher innovation quality. In contrast, TOP1 is negatively correlated with IQ, implying that high ownership concentration may not incentivize innovation. Meanwhile, SOE has a weak positive but non-significant correlation with IQ, indicating a potentially complex relationship that requires further exploration. Additionally, Table 5 shows the Variance Inflation Factor (VIF) values for the primary variables in this study, ranging from 1.03 to 2.92, indicating that multicollinearity is not a concern in our model.

**Table 4.** Pearson Correlation

| | (1) IQ | (2) TOP1 | (3) SOE | (4) INST | (5) Mshare | (6) Size | (7) FirmAge | (8) Lev | (9) Growth | (10) Board |
|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 1.000 | | | | | | | | | |
| (2) | -0.026*** | 1.000 | | | | | | | | |
| (3) | 0.007 | 0.223*** | 1.000 | | | | | | | |
| (4) | 0.057*** | 0.493*** | 0.412*** | 1.000 | | | | | | |
| (5) | 0.017*** | -0.090*** | -0.481*** | -0.650*** | 1.000 | | | | | |
| (6) | 0.307*** | 0.186*** | 0.354*** | 0.444*** | -0.360*** | 1.000 | | | | |
| (7) | -0.027*** | -0.089*** | 0.197*** | 0.062*** | -0.246*** | 0.178*** | 1.000 | | | |
| (8) | 0.069*** | 0.057*** | 0.286*** | 0.211*** | -0.312*** | 0.525*** | 0.168*** | 1.000 | | |
| (9) | 0.036*** | -0.010 | -0.085*** | 0.028*** | 0.071*** | 0.038*** | -0.044*** | 0.026*** | 1.000 | |
| (10) | 0.054*** | 0.020*** | 0.273*** | 0.232*** | -0.203*** | 0.273*** | 0.058*** | 0.156*** | -0.023*** | 1.000 |

*Note*: this table shows the correlation coefficients for the key variables defined in Table 1. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$, respectively.

**Table 5.** Variance Inflation Factor Analysis

| Variable | VIF | 1/VIF |
|---|---|---|
| INST | 2.92 | 0.34 |
| Mshare | 2.40 | 0.42 |
| Size | 1.73 | 0.58 |
| TOP1 | 1.57 | 0.64 |
| SOE | 1.49 | 0.67 |
| Lev | 1.46 | 0.68 |
| Board | 1.15 | 0.87 |
| FirmAge | 1.12 | 0.89 |
| Growth | 1.03 | 0.97 |
| Mean VIF | 1.65 | |

## Multivariate Results

The main regression results in Table 6 reveal the effects of the independent variables – ownership concentration (TOP1), state ownership (SOE), institutional ownership (INST), and managerial ownership (Mshare) – on innovation quality (IQ) (columns 1–4). Additionally, a combined model including all four independent variables is conducted as a sensitivity test (column 5). Each model incorporates industry and year fixed effects, ensuring that variations due to these factors are controlled.

First, ownership concentration negatively impacts innovation quality. The results in columns 1 and 5 of Table 6 contrast with previous studies on overall innovation, which suggest that dispersed ownership in developed economies enables shareholders to diversify investment risks, benefitting overall innovation (e.g., Chatterjee & Bhattacharjee; Choi et al. [16; 17]). Our study, rooted in the context of China's transition economy, does not guarantee the applicability of these conclusions in other settings. Research by Shleifer and Vishny (1986) [52] suggests that large shareholders often prioritize immediate returns over long-term investments, potentially limiting firms' innovation incentives. This effect may be more pronounced when concentrated ownership fosters risk aversion, as large shareholders may avoid investing in uncertain, innovation-driven projects. In fact, Minetti et al. [36] indicate that, in transitional economies, concentrated ownership can result in entrenched large shareholders, causing conflicts of interest with minority shareholders and possibly hindering complex, long-term investments into aspects like innovation.

Second, state ownership has a positive impact on innovation quality. The results in columns 2 and 5 of Table 6 support findings by Aoki et al. [53], who note that SOEs often receive government support for innovation to achieve national development goals. Studies of SOEs in emerging economies have similarly highlighted increased R&D investment, resources, and political backing for innovation projects. Due to institutional differences, managers of Chinese SOEs, unlike their private-sector counterparts, face

less pressure to meet performance targets; instead, improving innovation quality serves as a political performance indicator. This institutional setting encourages effective oversight of innovation quality by managers and signals active engagement in innovation.

Third, institutional ownership positively influences innovation quality. The results in columns 3 and 5 of Table 6 are consistent with the findings of Aghion et al. [54], who argue that institutional investors are generally oriented toward long-term performance and may therefore support innovation investments. Institutional investors typically possess extensive resources and expertise to monitor and evaluate their investments. Our findings support the view that active involvement by institutional investors improves corporate governance, including decisions related to enhancing innovation quality. This enhanced monitoring mitigates managerial opportunism and promotes investment in high-quality innovation projects.

Fourth, managerial ownership is positively correlated with innovation quality. The results in columns 4 and 5 of Table 6 indicate that managerial ownership as a governance mechanism can mitigate adverse factors in innovation activities. Managers holding company shares directly benefit from the success of the firm's innovation, aligning their interests with those of shareholders, consistent with the perspective of Jensen and Meckling (1976) [20]. With equity stakes, managers may be more inclined to pursue long-term innovation strategies that enhance firm value. Additionally, some publications, such as Karácsony et al. (2023) [55], suggest that managers with ownership stakes may take appropriate risks in innovation to enhance the firm's reputation and competitiveness. Thus, equity incentives provide managers with greater motivation to pursue high-return innovation projects.

Among the control variables, firm size shows a positive effect on innovation quality, consistent with the view of Herrera and Sánchez-González (2012) [56] that larger firms typically have more R&D resources, enabling a higher share of innovation projects. Conversely, firm age is negatively associated with innovation quality, possibly due to the inertia and resistance to change often observed in older firms, as noted by Coad et al. (2015) [57]. Additionally, leverage negatively impacts innovation quality, supporting the view that high debt levels constrain firms' financial flexibility, potentially limiting R&D investment [58]. Finally, board size positively impacts innovation quality, as board members provide oversight and strategic direction for innovation, consistent with the findings of Zona et al. (2012) [59].

In summary, our results reinforce existing theories regarding the impact of ownership structure on innovation quality, with distinct effects observed for different ownership types. These findings underscore the complexity of ownership governance mechanisms in shaping corporate innovation strategies, suggesting that policies tailored to ownership structure could further optimize the quality of corporate innovation outcomes.

**Table 6.** Main Regression Results

| | (1) IQ | (2) IQ | (3) IQ | (4) IQ | (5) IQ |
|---|---|---|---|---|---|
| TOP1 | -0.001* | | | | -0.004*** |
| | (-1.84) | | | | (-6.52) |
| SOE | | 0.117*** | | | 0.164*** |
| | | (6.43) | | | (8.45) |
| INST | | | 0.001** | | 0.004*** |
| | | | (2.03) | | (7.40) |
| Mshare | | | | 0.002*** | 0.005*** |
| | | | | (3.58) | (9.44) |
| Size | 0.609*** | 0.599*** | 0.601*** | 0.612*** | 0.592*** |
| | (79.01) | (77.41) | (74.65) | (78.67) | (73.45) |
| FirmAge | -0.116*** | -0.141*** | -0.111*** | -0.093*** | -0.112*** |
| | (-4.53) | (-5.46) | (-4.39) | (-3.59) | (-4.24) |
| Lev | -0.355*** | -0.379*** | -0.346*** | -0.328*** | -0.317*** |
| | (-7.99) | (-8.55) | (-7.80) | (-7.34) | (-7.04) |
| Growth | 0.010 | 0.020 | 0.009 | 0.006 | -0.000 |
| | (0.52) | (1.05) | (0.46) | (0.29) | (-0.02) |
| Board | 0.174*** | 0.146*** | 0.173*** | 0.190*** | 0.112*** |
| | (4.37) | (3.61) | (4.30) | (4.74) | (2.76) |

| | (1) IQ | (2) IQ | (3) IQ | (4) IQ | (5) IQ |
|---|---|---|---|---|---|
| _cons | -11.529*** | -11.241*** | -11.441*** | -11.753*** | -11.238*** |
| | (-63.97) | (-60.78) | (-61.66) | (-62.46) | (-58.18) |
| P value of F test | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| P value of Hausmann test | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Year FE | Y | Y | Y | Y | Y |
| Industry FE | Y | Y | Y | Y | Y |
| N | 25 940 | 25 940 | 25 940 | 25 940 | 25 940 |
| Adj. $R^2$ | 0.439 | 0.440 | 0.439 | 0.440 | 0.442 |

*Note*: values in parentheses are robust t-statistic. * p < 0.1, ** p < 0.05, *** p < 0.01, respectively.

*Source*: calculated by the author.

***Robustness Check***

The regression results in the previous section reveal a nuanced relationship between ownership structure and innovation quality. In this section, we employ three methods to ensure the robustness of these results.

First, we use an alternative dependent variable. To address potential measurement errors related to IQ, we introduce an alternative dependent variable: the natural logarithm of the total number of patents granted to a firm plus one (IQ_A), following the methodology of Chen and Zhang [60]. Unlike previous studies that rely on patent applications as an innovation indicator, the number of granted patents represents the actual number recognized and certified by government intellectual property agencies. The first column of Table 6 shows the robustness test results based on the alternative dependent variable. The estimated coefficients of the four test variables (TOP1, SOE, INST, and Mshare) are similar in magnitude and direction, confirming the robustness of the baseline regression.

Second, we conduct a subsample test. Removing post-2019 COVID-19 samples tests the robustness of the baseline regression by controlling for the abnormal disturbances and external shocks caused by the pandemic, ensuring the validity and reliability of the analysed results. The COVID-19 pandemic had a profound impact on the global economy and business operations, potentially causing significant variations in firms' innovation activities, financial performance, and innovation decisions. The results in the second column of Table 7 indicate that the relationship between TOP1 and IQ is negative and significant, while SOE, INST, and Mshare continue to positively influence firms' innovation quality. These findings are consistent with previous results, confirming the consistency of our conclusions.

Third, we employed two alternative estimation methods to enhance the robustness of our results. On the one hand, given the count nature of patents, fixed-effects model estimates may be misleading. Therefore, we re-estimated model (1) using a Poisson model and a maximum likelihood estimation to address this concern. On the other hand, while IQ is largely continuously distributed across positive values, it includes a subset of observations with zero values, making the Tobit model particularly appropriate under these conditions. Thus, we reran model (1) using the Tobit specification. The results from both alternative models (see Table 6, columns 3 and 4) align with the conclusions of our main regression model, further confirming the robustness of our findings.

**Table 7**. Robustness Checks

| | (1) IQ_A | (2) IQ | (3) IQ | (4) IQ |
|---|---|---|---|---|
| TOP1 | -0.003*** | -0.004*** | -0.002*** | -0.004*** |
| | (-4.74) | (-5.78) | (-5.07) | (-6.48) |
| SOE | 0.145*** | 0.160*** | 0.066*** | 0.150*** |
| | (8.67) | (7.06) | (6.38) | (7.73) |
| INST | 0.002*** | 0.003*** | 0.002*** | 0.003*** |
| | (4.38) | (5.12) | (8.20) | (7.00) |
| Mshare | 0.002*** | 0.005*** | 0.004*** | 0.005*** |
| | (3.89) | (6.67) | (12.66) | (9.38) |

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | IQ_A | IQ | IQ | IQ |
| Size | 0.483*** | 0.576*** | 0.293*** | 0.602*** |
| | (67.34) | (59.57) | (74.90) | (75.46) |
| FirmAge | -0.070*** | -0.113*** | -0.075*** | -0.062*** |
| | (-3.10) | (-3.73) | (-5.48) | (-2.48) |
| Lev | -0.356*** | -0.331*** | -0.158*** | -0.336*** |
| | (-9.18) | (-6.21) | (-6.23) | (-7.45) |
| Growth | -0.048*** | 0.016 | -0.008 | -0.033 |
| | (-2.97) | (0.70) | (-0.81) | (-1.72) |
| Board | 0.127*** | 0.131*** | 0.104*** | 0.096*** |
| | (3.61) | (2.75) | (4.95) | (2.36) |
| _cons | -9.502*** | -10.893*** | -5.880*** | -12.404*** |
| | (-56.24) | (-47.45) | (-60.26) | (-58.73) |
| Year FE | Y | Y | Y | Y |
| Industry FE | Y | Y | Y | Y |
| N | 25 940 | 18 891 | 25 940 | 25 940 |
| Pseudo $R^2$ | | | 0.166 | 0.156 |
| Adj. $R^2$ | 0.388 | 0.444 | | |

*Note*: values in parentheses are robust t-statistic. * p < 0.1, ** p < 0.05, *** p < 0.01, respectively.

*Source*: calculated by the author.

## Conclusion

Using patent data from Chinese listed companies between 2012 and 2021, this study addresses the current confusion surrounding the impact of four types of ownership structures on innovation quality. Unlike previous research that treats patents as a holistic phenomenon, we examine technologically significant invention patents from the perspective of patent quality, empirically testing the impact of ownership structure on innovation quality in China's transitional economy. Drawing on agency theory, we find that ownership concentration is detrimental to innovation quality, while institutional ownership and managerial ownership are two corporate governance mechanisms that drive improvements in innovation quality. We incorporate institutional theory into the framework of state ownership and innovation quality, confirming that state-owned enterprises with institutional support have an inherent advantage in enhancing innovation quality. Through a series of checks, including alternative dependent variables, subsample tests, and Poisson models, the results are found to be robust.

These findings suggest that in transitional economies like China, innovation quality is closely linked to ownership structure. Excessive ownership concentration is not beneficial; instead, state ownership, institutional ownership, and managerial ownership enable firms to access resources and innovation advantages that are difficult to obtain in traditional centralized institutional forms.

This study adds to the literature on ownership structure and innovation quality in transitional economies. Previous research has emphasized the critical role of ownership in enhancing holistic innovation. Our results demonstrate that ownership structure is a vital means for firms to acquire scarce resources and address institutional gaps from corporate governance mechanisms. We provide empirical evidence from a transitional economy, highlighting that high ownership concentration negatively impacts innovation quality due to risk aversion and short-term profit motives, thereby challenging the traditional belief in its governance benefits. Conversely, our findings indicate that state ownership positively influences innovation quality, countering the inefficiency narrative often associated with SOEs, while institutional ownership enhances corporate governance and innovation by leveraging investor resources and expertise. Additionally, managerial ownership aligns managers' interests with those of shareholders, promoting high-quality innovation and mitigating agency problems, which offers a comprehensive understanding of internal stakeholder equity participation in innovation outcomes.

This study offers several policy implications for promoting high-quality innovation through balanced ownership

structures. Policymakers should encourage broader share ownership and protect minority shareholder rights to mitigate the risks of ownership concentration. Supporting SOEs by providing resources and fostering autonomy can leverage their potential for high-quality innovation. Attracting institutional investors through favourable regulatory frameworks can enhance governance and strategic decision-making, while incentivizing managerial ownership through stock options and performance-based rewards can align managerial interests with long-term innovation goals. Tailoring policies to the unique characteristics of transitional economies, particularly by recognizing the roles of state ownership and institutional investors, is essential for promoting sustainable and high-quality innovation.

However, this study also has limitations. First, the sample selection is limited to Chinese listed companies. While this sample provides sufficient and reliable data given China's status as the largest transitional economy, it excludes non-listed companies and other transitional economies, potentially causing sample selection bias. Future research could consider cross-national comparisons and include non-listed firms. Second, the identification of innovation quality is based solely on invention patents, which, although reflective of technological innovation, may not capture the full spectrum of innovation quality. Future studies could collect more detailed high-tech patent information to deepen research on innovation quality. Lastly, while this study examines the impact of four ownership structures on innovation quality, it does not test moderating effects. Future research could explore other corporate governance mechanisms as moderating variables to further investigate the mitigating and promoting roles of corporate governance.

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# Financial Inclusion and Bank Performance: Evidence from the Banking Sector in Ethiopia

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## Abstract

Evidence shows that financial inclusion plays a key role in driving economic growth and social development by strengthening the financial system and reducing poverty and income inequality. However, its impact on the financial performance of banks remains inconclusive. This paper explores the relationship between financial inclusion and the financial performance of commercial banks in Ethiopia, using a sample of 16 banks. We analyse 10 years of data (2013–2022) collected manually from the National Bank of Ethiopia (NBE) and the annual reports of commercial banks. A two-step system Generalized Method of Moments (GMM) is employed, alongside other linear panel data model estimators. The findings reveal that increased financial inclusion has a significant positive impact on the financial performance (ROA and ROE) of commercial banks in Ethiopia. The GMM estimation result also shows that bank performance indicators (ROA and ROE) are positively associated with their past realizations. Regarding bank-specific control variables, the cost-efficiency ratio has a significant negative impact on bank profitability. The study recommends that banks improve accessibility by expanding branch networks and ATMs and by offering innovative financial products to enhance profitability.

**Keywords:** financial inclusion, GMM, bank performance, Ethiopia

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## Introduction

Financial inclusion is gaining momentum globally [1] and has attracted increasing attention from scholars, policymakers, and other stakeholders in the financial industry [2]. It is a relatively recent and emerging topic in the financial literature, particularly from the supply-side perspective, and has become an important policy agenda in developing countries [3].

While financial inclusion is straightforward to define and recognize [4], it remains a multidimensional concept [5]. It can be described as the process of integrating the financially excluded population into the formal financial system, enabling them to access essential financial services such as savings, payments, credit, and insurance [6]. Financial inclusion is also defined as providing affordable, convenient, and timely financial services to all members of society, especially the poor and vulnerable [7]. One common indicator of financial inclusion is the ownership of formal accounts [2]. However, having access to financial services is not the same as using financial services. Even though individuals and businesses may have access to these services, they might choose not to use them due to various socioeconomic, cultural, or opportunity cost factors.

The performance of firms is defined as an economic outcome that reflects the effectiveness of organizations. Banks can mobilize deposits by increasing the number of individuals and businesses that open and use formal bank accounts. They can also expand access to loans, allowing more people and businesses to borrow, while simultaneously boosting investments in sectors such as business, education, and healthcare. This can be accomplished by offering innovative financial products at affordable prices. As a result, banks' financial performance and efficiency improve as more people and businesses utilize their loans and other financial services. Ultimately, this contributes to the development of an inclusive financial system, enabling banks to provide affordable services to all segments of the economy, particularly to the underprivileged [8].

A vast body of literature exists worldwide on the correlation between commercial bank performance and financial inclusion. However, research specifically examining the relationship between financial inclusion and the profitability of banking firms in Ethiopia remains limited, apart from a few empirical studies on financial inclusion, its status, drivers, and barriers.

In the existing global literature, there are two competing perspectives on the relationship between financial inclusion and bank performance. Some scholars argue that financial inclusion positively impacts bank performance, while others contend that it poses risks that may erode profitability. Most studies on this topic focus on cross-country or regional analyses, with limited research at the micro (bank) level. Therefore, the primary objective of this study is to examine the impact of financial inclusion on the financial performance of Ethiopian commercial banks using 10 years of bank-level data.

## Literature Review and Hypotheses

In most cases, financial inclusion is primarily associated with access to credit from formal financial institutions. However, it is a multidimensional concept that extends beyond credit availability for individuals and firms [4]. To develop evidence-based policies, it is crucial to obtain reliable and comprehensive data that capture the various dimensions of financial inclusion [9]. This may involve establishing standardized definitions for financial inclusion indicators that can guide policymaking, track progress, and assess the impact of policy reforms.

Broadly, financial inclusion can be categorized into four key dimensions: access, quality, usage, and impact [9]. Therefore, multiple indicators must be considered to accurately measure financial inclusion. Commonly used indicators include the proportion of account holders per 1,000 adults (bank penetration), the number of bank branches and ATMs per 100,000 adults (availability/access), and the volume of outstanding bank loans and deposits (usage). Relying on any single indicator may provide only a partial and potentially misleading picture of financial inclusiveness.

A comprehensive measure of financial inclusion that integrates these indicators is necessary to gain a full understanding of a financial system's inclusiveness. An effective financial inclusion measure should reflect its multidimensional nature, be simple to compute, and allow for cross-country comparisons [10; 11].

Financial performance indicators of a firm can be categorized into accounting-based and market-based measures. Accounting-based measures assess a firm's (in this case, a bank's) profitability using traditional financial metrics such as Return on Assets (ROA), Return on Equity (ROE), Net Interest Margin (NIM), Gross Income, and Net Income [12].

Market-based performance metrics, on the other hand, reflect profitability from a shareholder perspective. Common indicators include the Market-to-Book Value Ratio (MTB), Price-to-Earnings Ratio (P/E), Earnings Per Share (EPS), Tobin's Q, and Market Return [13; 14].

There is an ongoing debate in management research regarding the relationship between accounting-based and market-based metrics. While both are widely recognized as valid measures of financial health, their correlation remains contested. Theoretically, market-based indicators are considered forward-looking, representing projections of a firm's future or long-term financial performance, whereas accounting-based measures are retrospective, reflecting past or short-term financial outcomes. However, the extent to which past financial success translates into future performance remains unsettled [13].

Accounting-based metrics are influenced by management's accounting choices and reporting standards, making them backward-looking. In contrast, market-based metrics, often preferred by shareholders, anticipate the future. They assume market efficiency, where stock prices are believed to reflect the firm's intrinsic value. Unlike accounting

measures, market-based indicators incorporate all pertinent information and provide a broader perspective on performance. In theory, market-based metrics offer a more realistic assessment of a company's financial success compared to accounting-based measures [14].

Overall, financial success is not a one-dimensional concept, as accounting profitability and market performance represent distinct dimensions with limited empirical overlap [13]. Due to this separation, developing a unified theory of financial performance that effectively explains variations in both accounting-based and market-based measures remains a challenge.

Instead, researchers should prioritize formulating separate hypotheses for each metric and explore why their variations are largely uncorrelated. While accounting earnings reflect a company's past financial performance, stock market value represents its future potential. Although the two may be related, their underlying logic and theoretical foundations are fundamentally different and should not be assumed to be interchangeable [13].

The existing literature presents two competing perspectives on the relationship between financial inclusion and the financial performance of commercial banks. On the one hand, some argue that financial inclusion enhances bank performance. On the other, financial inclusion is viewed as a risky endeavour that may reduce profitability. Despite these contrasting views, a substantial body of research supports the notion that financial inclusion positively influences bank performance worldwide.

The positive relationship between financial inclusion and bank performance is supported by several key findings. Greater financial sector access and outreach help reduce asymmetric information and agency problems between borrowers and lenders [15]. Additionally, financial inclusion enables banks to mobilize deposits from a diverse customer base, thereby lowering return volatility [16]. As a result, banks become less dependent on risky and costly money market funds, further stabilizing their returns [17]. By expanding access to financial services, financial inclusion also enhances banking efficiency. Numerous empirical studies, particularly in developing and emerging economies, reinforce the positive impact of financial inclusion on bank performance (see, for example, [2; 8; 18–25]).

The other strand of literature argues that financial inclusion can have a negative impact on the performance of commercial banks (see, for example, [26–29]) or that there is no significant relationship between financial inclusion and bank performance [30]. Critics highlight potential risks such as higher operational costs, increased exposure to non-creditworthy borrowers, and lower profit margins from small-scale financial services, which could undermine banks' overall profitability.

Therefore, empirical findings on the relationship between financial inclusion and bank performance remain inconclusive, even though a vast majority of studies support a positive correlation between the two. In light of the reviewed literature, the following study hypotheses and sub-hypotheses are developed to further investigate this linkage:

**H1:** Financial inclusion has a significant positive effect on the financial performance of commercial banks in Ethiopia.

**H1a:** Financial inclusion has a significant positive effect on the Return on Assets (ROA) of commercial banks in Ethiopia.

**H1b:** Financial inclusion has a significant positive effect on the Return on Equity (ROE) of commercial banks in Ethiopia.

# Data and Research Methodology

## Sample and Data

As of the first quarter of 2023, the total number of banks in Ethiopia reached 31, comprising 2 public and 29 privately owned banks. However, many of these banks are still in their infancy; for instance, 13 of them were established in 2021/22.

Given data availability and sufficiency, this study includes 16 commercial banks and analyses 10 years of data from 2013 to 2022. Data was manually collected from the National Bank of Ethiopia (NBE) – the country's central bank – as well as from the annual reports of each commercial bank.

## Variables and Measurements

### *Dependent Variables*

Consistent with previous research studies [8; 21–25; 29; 30], this study employs Return on Assets (ROA) and Return on Equity (ROE) as metrics for assessing the financial performance of banks.

ROA is the ratio of profit before tax to total assets, measuring management's ability to generate income from the bank's assets. In other words, it reflects the efficiency with which a firm utilizes its resources to generate revenue [31].

ROE is an accounting ratio that represents the profit a company earns relative to the equity capital invested by shareholders. It also indicates how effectively management utilizes shareholders' capital to generate returns.

### *Independent Variables*

Given that the main objective of this paper is to examine how financial inclusion affects the financial performance of commercial banks in Ethiopia, financial inclusion serves as the independent variable.

Financial inclusion can be measured using various indicators categorized into three key dimensions: access/availability of banking services, bank penetration, and usage of banking services [10; 11]. Consistent with prior studies [8; 22–25; 29; 30; 32–34], this study employs six financial inclusion indicators:

- Access/availability dimension: number of commercial bank branches and ATMs.
- Penetration dimension: number of deposit and loan accounts.

- Usage dimension: amount of outstanding deposits and loans.

Consistent with previous studies [8; 23; 30; 34], this study constructs a financial inclusion index using the Principal Component Analysis (PCA) technique to capture the common components of the six individual financial inclusion indicators.

To apply the PCA technique and develop a composite financial inclusion index, the first step involves computing a dimension index for each financial inclusion indicator at the bank level using the following formula [10; 11]:

$$d_i = \frac{A_i - m_i}{M_i - m_i},$$

where $d_i$ refers to the dimension index for the $i^{th}$ indicator;

$A_i$ – to the actual value of indicator $i$;

$M_i$ – the maximum value of indicator $i$;

$m_i$ – the minimum value of indicator $i$.

The formula ensures that the index for the $i^{th}$ dimension ($d_i$) falls within the range of 0 to 1 ($0 \le d_i \le 1$). A higher value of $d_i$ (closer to 1) indicates greater efforts by banks towards financial inclusion, while a lower value of $d_i$ (closer to zero) suggests weaker financial inclusion.

Given that there are $n$ financial inclusion dimensions, bank $i$ is represented as point $D_i = (d_1, d_2, d_3, \ldots d_n)$ in an $n$-dimensional Cartesian space. Point $O = (0, 0, 0, \ldots, 0)$ represents the worst-case scenario of financial inclusiveness, whereas point $I = (1, 1, 1, \ldots)$ represents the best-case scenario across all financial inclusion dimensions.

In the second step, a composite financial inclusion index is constructed using the Principal Component Analysis (PCA) technique. Since all six financial inclusion indicators in this study tend to move together, it is reasonable to assign equal weights to each individual indicator.

Applying PCA is particularly useful in this context as it helps address correlations among variables, ensuring that the composite index effectively captures the common components of the six financial inclusion indicators [34].

In the PCA technique, the first principal component is the one that captures the highest variation in the dataset, explaining most of the fluctuations in the financial inclusion indicators.

Subsequent components capture the remaining unexplained variation in the dataset, following an orthonormal trend [34].

### *Control Variables*

To account for the effects of omitted variables, this study incorporates a set of bank-specific factors that are expected to have a significant influence on bank performance. These factors include leverage, bank size, bank age, liquidity, and cost efficiency ratios. The selection of these variables aligns with previous empirical research (see, for example [25; 30]).

## Data Analysis Techniques

The study analysed the data using STATA 15 software, applying the xtabond2 command for dynamic panel data estimation. STATA's xtabond2 command implements the Arellano-Bond and Arellano-Bover/Blundell-Bond Generalized Method of Moments (GMM) estimators, which are widely used in econometrics to address heteroskedasticity, autocorrelation, and endogeneity issues in panel datasets [35; 36].

**Table 1.** Description of the Variables Used in the Study

| Variable Name | Symbol | Measurement | Dimension | References |
|---|---|---|---|---|
| **Dependent Variables** | | | | |
| Return on Assets | ROA | Profit Before Tax / Total Assets (%) | | [2; 8; 15; 19–25; 29; 30; 34; 35] |
| Return on Equity | ROE | Profit Before Tax / Total Equities (%) | | |
| **Independent Variables** | | | | |
| Number of bank branches | NBRANCHES | Log of the number of bank branches | Availability/ Access | [8; 9; 10; 11; 20–25; 29; 30; 32–37] |

| Variable Name | Symbol | Measurement | Dimension | References |
|---|---|---|---|---|
| Number of ATMs | NATMs | Log of the number of ATMs | Availability/ Access | [8; 9; 10; 11; 20–25; 29; 30; 32–37] |
| Number of deposit accounts | NDEPOSITAC | Log of the number of deposit accounts | Bank Penetration | |
| Number of loan accounts | NLOANAC | Log of the number of loan accounts | | |
| Total amount of deposits | AMTDEPOSITS | Log of total amount of deposits | Usage of banking services | |
| Amount of outstanding loans and advances | AMTLOANS | Log of the number of loans and advances by banks | | |
| Financial Inclusion | FI | The composite index of financial inclusion constructed from the above six indicators with the help of the PCA technique | | |
| **Control Variables** | | | | |
| Leverage | LEV | Total Liabilities / Total Assets at the end of financial year t (%) | | [20; 23–25; 30] |
| Bank size | SIZE | Natural logarithm of total assets at the end of year t | | |
| Liquidity ratio | LIQR | Liquid Assets / Total assets | | |
| Cost efficiency ratio | CER | Cost-to-Income ratio | | |
| Age of bank | AGE | The number of years the bank is in operation | | |

***Model Specification***

To empirically test the relation between financial inclusion and the profitability of the banking industry in Ethiopia, the following regression models were used:

$$ROA_{it} = \beta_0 + \beta_1 FI_{it} + \beta_2 LEV_{it} + \beta_3 LIQR_{it} + \beta_4 CER_{it} + \\ + \beta_5 LNSIZE_{it} + \beta_6 AGE_{it} + \varepsilon_{it}, \quad (1)$$

$$ROE_{it} = \beta_0 + \beta_1 FI_{it} + \beta_2 LEV_{it} + \beta_3 LIQR_{it} + \beta_4 CIR_{it} + \\ + \beta_5 LNSIZE_{it} + \beta_6 AGE_{it} + \varepsilon_{it}, \quad (2)$$

where *ROA* and *ROE* are alternative proxies for the performance of commercial banks; $\beta_0$ is the constant term; *FI* is the composite financial inclusion index constructed from the six financial inclusion dimensions by using the PCA technique; *LEV*, *LIQR*, *CER*, *LNSIZE*, and *AGE* are bank specific control variables representing leverage, liquidity ratio, efficiency ratio (cost-to-income ratio), size of banks (taken as the log of assets of banks), and age of banks in Ethiopia, respectively; $\beta_0$ represents the constant term; $\beta_1$–$\beta_6$ represent beta coefficients of the predictors; and $\varepsilon_{it}$ denotes the error term.

To estimate the regression models, Ordinary Least Squares (OLS) and Fixed Effects (FE) model estimators were used as baseline regression analyses.

Both the Lagrange Multiplier (LM) test – to determine the presence of significant random effects in the panel data model – and the Hausman (DWH) test – to choose between Random Effects (RE) and Fixed Effects (FE) panel estimators – were conducted.

The Breusch-Pagan LM test results indicated that significant random effects exist in the panel when *ROA* is used as the financial performance measure. However, panel-wise random effects were not significant when *ROE* was used as the performance metric.

Subsequently, the Hausman test confirmed that the Fixed Effects (FE) model is preferred over the Random Effects (RE) model, with a significant p-value of 0.019.

Before interpreting the OLS and FE estimation results, several diagnostic tests were conducted to detect the presence of multicollinearity, heteroskedasticity, and autocorrelation (serial correlation) issues.

The Breusch-Pagan / Cook-Weisberg test for heteroskedasticity in OLS and the modified Wald test for groupwise heteroskedasticity both indicated the existence of heteroskedasticity in the dataset. Additionally, the Wooldridge test for autocorrelation in panel data revealed the presence of first-order serial correlation (autocorrelation) in the dataset.

Serial and cross-sectional correlations, along with heteroskedasticity in the error terms of a panel dataset, are serious issues [38]. Various studies suggest that the standard OLS or fixed/random effects approaches are inefficient estimators when heteroskedasticity and serial correlation are present, and alternative model estimators should be considered [34; 38–40].

In such cases, it is suggested that Feasible Generalized Least Squares (FGLS) and OLS with robust standard errors are more efficient estimators than standard OLS [38]. The Generalized Least Squares (GLS) technique can also be used to overcome serial correlation issues, particularly in a balanced panel dataset with large N and relatively small T [40]. Similarly, OLS with robust standard errors is effective in addressing both heteroskedasticity and autocorrelation issues [34].

Miller and Startz also recommend the FGLS regression as more efficient than standard OLS when heteroskedasticity is present in the error terms [39]. Therefore, in line with the above empirical evidence, FGLS, OLS, and FE estimation methods with robust standard errors are employed.

Finally, the results from these estimators are compared with those from the two-step system GMM, one of the most widely used dynamic panel data model estimators, to address the issue of endogeneity.

In panel data analysis, the issue of endogeneity – which primarily arises from factors such as unobserved heterogeneity, simultaneity, measurement errors, and dynamic endogeneity – has gained increasing attention in recent empirical studies. This issue is particularly concerning as it may lead to inconsistent estimates or coefficients with incorrect signs, potentially resulting in misleading inferences, false conclusions, and wrong interpretations of theoretical frameworks [25; 34; 41].

In theoretical terms, the fixed effects technique is used to control for unobserved heterogeneity in situations where firm-specific variables are time-invariant and correlated with the explanatory variables under the assumption of strict exogeneity. Strict exogeneity implies that explanatory variables (such as financial inclusion indicators in this case) are not influenced by the past or current performance of the firm (*ROA* or *ROE*) [41; 42].

However, in practice, the strict exogeneity assumption may not hold, as past and present performance of the firm can potentially affect the current and future values of the independent variable. Furthermore, according to Wooldridge [40], the fixed effects approach is a static model estimator for panel data analysis, which does not allow for the inclusion of past realizations of the dependent variable as a predictor in the model.

Unlike FE or RE estimation techniques, the OLS estimator cannot address the issue of unobserved heterogeneity, even though the fixed effects method is effective in dealing with endogeneity when firm-specific factors are time-invariant and correlated with the regressors [40].

Generally, the OLS, FE, and RE model estimators may yield inconsistent and biased estimates when endogeneity problems, arising from any source of endogeneity, are present in the data. To address the issue of endogeneity, various dynamic panel data model estimators can be applied, including the Instrumental Variable (IV) method, Two-Stage Least Squares (2SLS), Three-Stage Least Squares (3SLS), as well as Difference and System GMM methods.

Consistent with previous studies [25; 30; 34; 40–42], this paper employs the two-step system GMM, which is the most widely used dynamic panel data model estimator and a robust technique to address the problem of endogeneity. This is particularly useful in situations where the variables of the study are susceptible to sources of endogeneity, such as unobserved heterogeneity, simultaneity, dynamic endogeneity, and omitted variable bias.

GMM mitigates endogeneity problems by transforming the data internally and using lagged values of the outcome variable as an explanatory variable [41]. As a result, the inferences and conclusions drawn in this research are based on the outputs from the two-step system GMM.

To empirically examine the relationship between the financial performance of commercial banks – measured by *ROA* and *ROE* – and financial inclusion, using the financial inclusion index (FI) constructed from six indicators as a composite measure of financial inclusion, the following dynamic panel data regression models are employed:

$$ROA_{it} = \beta_0 + \beta_1 ROA_{i,t-1} \ \beta_2 FI_{it} + \beta_3 LEV_{it} + \beta_4 LIQR_{it} + + \beta_5 CER_{it} + \beta_6 LNSIZE_{it} + \beta_7 AGE_{it} + \varepsilon_{it}, \quad (3)$$

$$ROE_{it} = \beta_0 + \beta_1 ROE_{i,t-1} \ \beta_2 FI_{it} + \beta_3 LEV_{it} + + \beta_4 LIQR_{it} + + \beta_5 CER_{it} + \beta_6 LNSIZE_{it} + \beta_7 AGE_{it} + \varepsilon_{it}, \quad (4)$$

# Empirical Results and Discussion

## Descriptive Analysis

Table 2 summarizes the descriptive statistics of the study variables in three sections: performance variables, financial inclusion variables, and control variables during the study period. The descriptive statistics of the study variables are computed using their actual values. However, for the purpose of the regression analysis, the logarithmic values of all the financial inclusion indicators and the assets of banks were used.

Regarding the financial performance variables, the profitability indicators of commercial banks (*ROA* and *ROE*) over the last 10 years were, on average, 2.8 and 22%, respec-

tively, with standard deviations of 1.16 and 13.4%. Given its higher standard deviation, ROE is a relatively volatile measure of the financial performance of commercial banks in Ethiopia, compared to *ROA*.

Concerning the indicators of financial inclusion, it is observed that the mean number of branch networks of commercial banks and ATMs over the past 10 years were only 282 and 216, respectively. This suggests that, for a nation with a population of over 100 million, there were remarkably few bank branches and ATMs. The mean number of deposit account holders and borrowers (loan accounts) was found to be 2,222,814 and 14,627, with standard deviations of 5,109,629 and 29,501, respectively.

Commercial banks, on average, have mobilized a total of 47,261.686 million Ethiopian Birr from three main types of deposits: savings, demand, and time deposits. On average, they have also disbursed total loans of 26,641.862 million Ethiopian Birr to different sectors of the economy. The standard deviations of the number of bank branch networks, ATMs, depositors and loan borrowers, and the amount of deposits and loans are extremely high, mainly due to the presence of outliers in the dataset.

The relatively low number of depositors and the small amount of deposits mobilized by commercial banks in Ethiopia, along with other factors, is largely attributed to the low level of outreach of commercial banks, especially through their branch networks.

In relation to the control variables, the financial leverage of the banks, calculated as the percentage of total liabilities to total assets, is found to be around 78 percent. This indicates that commercial banks are much more dependent on equity financing than debt financing.

The value of assets owned by commercial banks in Ethiopia was found to be, on average, around Birr 61,281.018 million during the study period. The liquidity ratio, calculated as the ratio of total liquid assets to total assets, was shown to be around 21 percent, with an 8 percent standard deviation.

The average cost-to-income ratio (also known as the cost-efficiency ratio or CER) was found to be around 56 percent. A lower cost-to-income ratio is typically preferable, as it has an inverse relationship with bank performance. This means that as the cost-efficiency ratio (CER) increases, banks become more inefficient and less profitable.

Lastly, the mean age of banks in Ethiopia is 17 years, suggesting that the banking sector is still in its infancy stage.

**Table 2.** Descriptive Statistics of the Variables Used in the Study

| Variable | Observations | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| **Performance Variables** | | | | | |
| ROA | 160 | 2.76 | 1.158 | -7.507 | 5.127 |
| ROE | 160 | 21.999 | 13.384 | -25.243 | 95.364 |
| **Financial Inclusion Variables** | | | | | |
| NBRANCHES | 160 | 281.669 | 339.993 | 7 | 1975 |
| NATMs | 160 | 216.056 | 553.191 | 0 | 3952 |
| NDEPOSITAC | 160 | 2,222,814.4 | 5,109,629.8 | 5346 | 35900000 |
| NLOANAC | 160 | 14,627.034 | 29,501.531 | 92 | 154637 |
| AMTDEPOSIT | 160 | 47261.686 | 120564.62 | 158.366 | 889708.14 |
| AMTLOANS | 160 | 26641.862 | 56715.016 | 100.328 | 481234.93 |
| **Control Variables** | | | | | |
| LEV | 160 | 78.215 | 21.241 | 17.389 | 96.283 |
| SIZE | 160 | 61281.018 | 161320.15 | 380.562 | 1200000 |
| LIQR | 160 | 21.031 | 7.993 | 8.232 | 52.413 |
| CIR | 160 | 55.694 | 16.436 | 24.554 | 204.232 |
| AGE | 160 | 17.094 | 12.091 | 2 | 60 |

**Table 3a.** Correlation Matrix of the Study Variables

| Variables | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) ROA | 1.000 | | | | | | | | | | | | |
| (2) ROE | 0.503* | 1.000 | | | | | | | | | | | |
| (3) NBRANCHES | -0.114 | 0.460* | 1.000 | | | | | | | | | | |
| (4) NATMs | -0.107 | 0.281* | 0.909* | 1.000 | | | | | | | | | |
| (5) NDEPOSITAC | -0.099 | 0.407* | 0.951* | 0.933* | 1.000 | | | | | | | | |
| (6) NLOANAC | -0.039 | 0.571* | 0.928* | 0.858* | 0.923* | 1.000 | | | | | | | |
| (7) AMTDEPOSIT | -0.076 | 0.408* | 0.937* | 0.945* | 0.986* | 0.932* | 1.000 | | | | | | |
| (8) AMTLOAN | -0.080 | 0.412* | 0.929* | 0.899* | 0.968* | 0.895* | 0.976* | 1.000 | | | | | |
| (9) LEV | 0.011 | 0.054 | 0.125 | 0.132 | 0.172* | 0.168* | 0.143 | 0.115 | 1.000 | | | | |
| (10) NLSIZE | -0.023 | 0.508* | 0.851* | 0.664* | 0.717* | 0.726* | 0.687* | 0.720* | 0.018 | 1.000 | | | |
| (11) LIQR | 0.092 | -0.221* | -0.538* | -0.350* | -0.379* | -0.400* | -0.355* | -0.389* | 0.031 | -0.702* | 1.000 | | |
| (12) CIR | -0.853* | -0.555* | -0.020 | 0.007 | -0.007 | -0.097 | -0.034 | -0.032 | 0.114 | -0.197* | 0.008 | 1.000 | |
| (13) AGE | -0.004 | 0.619* | 0.714* | 0.649* | 0.679* | 0.807* | 0.699* | 0.654* | -0.062 | 0.615* | -0.261* | -0.195* | 1.000 |

*Note*: The table presents Pearson's pairwise correlation coefficients.

*, **, *** represent statistical significance at 10%, 5%, and 1%, respectively

**Table 3b.** Correlation Matrix and *VIF* of the Study Variables after Applying *PCA* to the Financial Inclusion Indicators

| Variables | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| (1) *ROA* | 1.000 | | | | | | | |
| (2) *ROE* | 0.503* | 1.000 | | | | | | |
| (3) *FI* | -0.088 | 0.435* | 1.000 | | | | | |
| (4) *LEV* | 0.011 | 0.054 | 0.147 | 1.000 | | | | |
| (5) *NLSIZE* | -0.023 | 0.508* | 0.749* | 0.018 | 1.000 | | | |
| (6) *LIQR* | 0.092 | -0.221* | -0.414* | 0.031 | -0.702* | 1.000 | | |
| (7) *CIR* | -0.853* | -0.555* | -0.031 | 0.114 | -0.197* | 0.008 | 1.000 | |
| (8) *AGE* | -0.004 | 0.619* | 0.721* | -0.062 | 0.615* | -0.261* | -0.195* | 1.000 |
| **Multicollinearity Diagnostics** | | | | | | | | |
| VIF | | | 3.56 | 1.11 | 4.67 | 2.30 | 1.18 | 2.44 |
| 1/*VIF* | | | 0.28 | 0.90 | 0.21 | 0.43 | 0.85 | 0.41 |
| Mean *VIF* | | | 2.54 | | | | | |

*Note*: *, **, *** represent statistical significance at 10%, 5%, and 1%, respectively

## Correlation Analysis

The pairwise correlations among all the study variables and the variance inflation factor (VIF) of the explanatory and bank-specific control variables are presented in Tables 3a and 3b. As shown in Table 3a, the profitability measures of commercial banks (*ROA* and *ROE*) are not highly correlated, with a correlation coefficient of 0.503, making it justifiable to use both *ROA* and *ROE* as alternative measures of bank performance.

As expected, all the financial inclusion indicators exhibit substantial correlations, with the coefficient of association exceeding 85%. The strong correlation among the financial inclusion variables raises concerns about multicollinearity. To address this issue, the *PCA* technique was applied, and the results of the pairwise correlation and the *VIF* after applying the *PCA* are presented in Table 3b below. A single financial inclusion index (*FI*) was constructed from six financial inclusion indicators using the *PCA* technique, thereby alleviating the concern of multicollinearity.

## Regression Results

Tables 4 and 5 present the results of applying OLS, FE, FGLS, and GMM model estimators to the relationship between financial inclusion and the performance of banking companies in Ethiopia. Table 4 presents the regression results using the FE, FGLS, and GMM estimation techniques, with ROA as the measure of banks' financial performance and the financial inclusion index (FI) as the independent variable. Similarly, Table 5 reports the regression results from the OLS, FGLS, and GMM estimation methods with ROE as an alternative proxy for the financial performance of commercial banks. Both regressions also include key bank-specific variables that have a significant impact on profitability, such as leverage, bank size, cost efficiency, liquidity ratio, and bank age, to control for omitted variable bias.

**Table 4.** Effects of Financial Inclusion on Bank Performance (*ROA*)

| | ROA | | |
|---|---|---|---|
| Variable | FE | FGLS | GMM |
| L.ROA | | | 0.469** |
| | | | (0.012) |
| FI | 0.0836** | 0.0514** | 0.108** |
| | (0.026) | (0.018) | (0.016) |
| LEV | 0.0120*** | 0.00519** | 0.00368 |
| | (0.001) | (0.026) | (0.267) |
| NLSIZE | 0.256 | 0.172*** | 0.222 |
| | (0.508) | (0.000) | (0.169) |
| LIQR | -0.0172** | -0.0119** | -0.0113 |
| | (0.048) | (0.014) | (0.421) |
| CIR | -0.0666*** | -0.0633*** | -0.0561*** |
| | (0.000) | (0.000) | (0.000) |
| AGE | 0.140 | -0.0126*** | -0.0165** |
| | (0.181) | (0.001) | (0.019) |
| Constant | 0.991 | 8.005*** | 7.009*** |
| | (0.862) | (0.000) | (0.005) |
| Observation | 160 | 160 | 144 |
| Number of groups | | | 16 |
| Number of instruments | | | 10 |
| R-Squared | 0.818 | | |
| AR(1) (p-value) | | | 0.111 |
| AR(2) (p-value) | | | 0.619 |
| Sargan test (p-value) | | | 0.471 |
| Hansen test (p-value) | | | 0.616 |

*Note*: *, **, and *** represent statistical significance at 10%, 5%, and 1%, respectively; the values in parentheses indicate p-values.

To apply dynamic panel data model estimators, it is generally required to meet the Sargan test for instrument validity, the Hansen test for model over-identification, and the Arellano-Bond test for first- and second-order autocorrelation of error terms (AR(1) and AR(2)). However, in a two-step system GMM estimation using the xtabond2 command, the Hansen test and the Arellano-Bond test for second-order autocorrelation (AR(2)) are considered more critical. Both tests should not be significant at the conventional 5% significance level. For the Hansen test, p-values between 0.05 and 0.80 are recommended, with the optimal range lying between 0.1 and 0.25 [43; 44].

In our model, the Hansen test for over-identification and the Arellano-Bond test for second-order autocorrelation (AR(2)) are not significant, with p-values of 0.590 and 0.451 when *ROA* is the dependent variable and 0.220 and 0.441 when *ROE* is the dependent variable, respectively. In addition, the number of instruments in both regressions is fewer than the number of groups, confirming that our models do not suffer from instrument proliferation.

The regression results from the FE, FGLS, and GMM estimation methods indicate that the financial inclusion index (FI) – constructed from six financial inclusion indicators – has a positive and significant impact on the performance of Ethiopian commercial banks, as measured by ROA, at the 10%, 1%, and conventional 5% significance levels, respectively. However, financial inclusion does not have a significant effect on the performance of commercial banks when measured by *ROE* in both OLS and GLS estimators. Nonetheless, in the GMM estimation, financial inclusion has a positive and significant effect on ROE at the 1% significance level, with a p-value of 0.004.

Thus, the findings of this study confirm hypothesis H1 and its sub-hypotheses (H1a and H1b), indicating that financial inclusion (FI) has a positive and significant association with the performance (*ROA* and *ROE*) of Ethiopian commercial banks. These results align with numerous prior empirical studies [8; 20–23; 25; 34], but contradict the findings of [29; 30].

In the GMM model, the lagged values of the dependent variables were also included as explanatory variables to assess the relationship between the outcome variables and their past values. According to prior research [41; 42], a maximum of two lags is generally sufficient to capture the effects of past values on the dependent variable. Accordingly, one lag of the dependent variables (ROA and ROE) was included in this study, and both were found to have a statistically significant positive relationship with their past values at the 5 and 1% significance levels, with p-values of 0.012 and 0.000, respectively.

**Table 5.** Effects of Financial Inclusion on Bank Performance (ROE)

| | ROE | | |
|---|---|---|---|
| **Variable** | **OLS** | **FGLS** | **GMM** |
| L.ROE | | | 0.604*** |
| | | | (0.000) |
| FI | 0.546 | 0.600 | 1.114*** |
| | (0.435) | (0.545) | (0.004) |
| LEV | 0.0924** | 0.0999*** | 0.0233 |
| | (0.023) | (0.002) | (0.381) |
| NLSIZE | 1.700** | 2.260*** | 1.465 |
| | (0.035) | (0.000) | (0.156) |
| LIQR | -0.00883 | -0.0344 | -0.142* |
| | (0.947) | (0.465) | (0.091) |
| CER | -0.360*** | -0.300*** | -0.370*** |
| | (0.000) | (0.000) | (0.000) |
| AGE | 0.554*** | 0.442*** | 0.0178 |
| | (0.005) | (0.000) | (0.841) |
| Constant | 8.850 | 2.435 | 44.60*** |
| | (0.432) | (0.758) | (0.005) |
| Observations | 160 | 160 | 144 |
| R-squared | 0.613 | | |

| | ROE | | |
|---|---|---|---|
| Variable | OLS | FGLS | GMM |
| Number of groups | 16 | 16 | 16 |
| Number of instruments | | | 10 |
| AR(1) P-value | | | 0.101 |
| AR(2) P-value | | | 0.220 |
| Sargan test (P-value) | | | 0.074 |
| Hansen test (P-value) | | | 0.441 |

*Note*: *, **, and *** represent statistical significance at 10%, 5%, and 1%, respectively; the values in parenthesis indicate p-values.

Regarding the impact of bank-specific control variables on the performance of commercial banks, the cost efficiency ratio (CER) significantly and negatively affects *ROA* and *ROE* across all models (OLS, FE, GLS, and GMM). This suggests that, as banks improve cost efficiency, their profitability increases.

The estimation results from the FE, OLS, and GLS models indicate that leverage (*LEV*) has a positive and significant effect on bank performance (*ROA* and *ROE*). However, in the GMM model, leverage remains positively associated with performance but is not statistically significant.

In the FE and GLS models, the liquidity ratio (LIQR) has a significant negative effect on *ROA*, while in the GMM model, although the coefficient remains negative, the impact is not statistically significant. Similarly, the liquidity ratio (*LIQR*) negatively correlates with *ROE* across all three models, with statistical significance at the 10% level only in the GMM estimation.

Unexpectedly, a negative and statistically significant relationship was found between bank age (*AGE*) and *ROA* in the GLS and GMM models, while the effect was positive but not significant in the FE model. However, regarding the link between AGE and ROE, it was positive and significant in the OLS and GLS models but not significant in the GMM model.

The inverse relationship between *AGE* and *ROA* aligns with the findings of [45–47]. This negative association may stem from increased organizational rigidities and the expansion of rent-seeking behaviour over time [47]. Additionally, the age-profitability relationship may follow a convex pattern, where profitability initially declines as firms age but improves again in later stages [45].

As evidenced by the GMM model, bank size (*LNSIZE*), proxied by the log of banks' assets, does not have a statistically significant relationship with performance (*ROA* and *ROE*), though the coefficients remain positive. However, results vary across different estimation models regarding the size-performance relationship.

## Effects of Individual Financial Inclusion Variables on Bank Performance

In the preceding sub-sections, the relationship between financial inclusion and bank performance was discussed using a single financial inclusion index (FI), constructed from the first components of six financial inclusion indicators. In contrast, this sub-section presents the effects of individual financial inclusion indicators on bank performance. Tables 6 and 7 present the GMM estimation results for the association between each individual financial inclusion variable and bank performance, as measured by *ROA* and *ROE*, respectively.

As reported in the correlation analysis section, there are very high correlations (greater than 85%) among the individual financial inclusion indicators. This indicates the presence of multicollinearity, making it unjustifiable to use a single regression model to simultaneously estimate the effects of each individual financial inclusion variable on bank performance indicators. Therefore, in line with Bhatter & Chhatoi [24], a separate regression model was employed to assess the impact of each individual financial inclusion indicator on the performance of commercial banking institutions in Ethiopia.

As shown in Table 6 (Models 1–6), all individual financial inclusion indicators, except for the number of loan accounts (number of borrowers), have a positive and significant impact on the performance of Ethiopian banking companies when measured by *ROA*. Specifically, the number of bank branches (NBRANCHES), ATMs (NATMs), deposit accounts (*NDEPOSITAC*), total deposit amount (*AMTDEPOSIT*), and total loans and advances (*AMTLOANS*) are positively associated with *ROA*.

Similarly, as reported in Table 7, all financial inclusion indicators – except for the number of ATMs and the number of borrowers (loan accounts) – have a positive and significant effect on the profitability of Ethiopian banks when performance is measured by ROE. Additionally, the lagged values of the performance indicators (*L.ROA* and *L.ROE*) exhibit a positive and significant impact on commercial banks' performance across all models.

Thus, the effects of individual financial inclusion indicators on the performance of Ethiopian banking firms, as measured by *ROA* and *ROE*, align with the impact of the composite financial inclusion index (FI). This is evident from Model 7 in Tables 6 and 7.

**Table 6.** Effects of Individual Financial Inclusion Indicators on ROA

| Variables | (Model 1) ROA | (Model 2) ROA | (Model 3) ROA | (Model 4) ROA | (Model 5) ROA | (Model 6) ROA | (Model 7) ROA |
|---|---|---|---|---|---|---|---|
| L.ROA | 0.542*** | 0.457** | 0.460** | 0.421** | 0.453** | 0.455** | 0.469** |
| | (0.007) | (0.013) | (0.013) | (0.018) | (0.013) | (0.012) | (0.012) |
| NLNBRANCHES | 2.966** | | | | | | |
| | (0.014) | | | | | | |
| NLNATMs | | 1.237** | | | | | |
| | | (0.041) | | | | | |
| NLNDEPOSITAC | | | 1.740** | | | | |
| | | | (0.027) | | | | |
| NLNLOANAC | | | | 0.417 | | | |
| | | | | (0.439) | | | |
| NLAMTDEPOSIT | | | | | 1.393** | | |
| | | | | | (0.010) | | |
| LNAMTLOAN | | | | | | 1.455* | |
| | | | | | | (0.054) | |
| FI | | | | | | | 0.108** |
| | | | | | | | (0.016) |
| LEV | 0.003 | 0.004 | 0.003 | 0.005 | 0.004 | 0.005 | 0.004 |
| | (0.406) | (0.173) | (0.305) | (0.168) | (0.226) | (0.186) | (0.267) |
| NLSIZE | -0.359* | -0.187 | -0.227 | -0.144 | -0.189 | -0.198 | -0.222 |
| | (0.077) | (0.160) | (0.186) | (0.325) | (0.195) | (0.211) | (0.169) |
| LIQR | -0.010 | -0.012 | -0.012 | -0.010 | -0.011 | -0.011 | -0.011 |
| | (0.510) | (0.366) | (0.399) | (0.459) | (0.402) | (0.402) | (0.421) |
| CER | -0.057*** | -0.056*** | -0.056*** | -0.056*** | -0.056*** | -0.056*** | -0.056*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| AGE | -0.022*** | -0.0134* | -0.0153** | -0.0107* | -0.0142* | -0.0118* | -0.0165** |
| | (0.001) | (0.084) | (0.027) | (0.093) | (0.058) | (0.087) | (0.019) |
| Constant | 7.935*** | 6.537*** | 7.007*** | 6.064*** | 6.568*** | 6.569*** | 7.009*** |
| | (0.005) | (0.002) | (0.007) | (0.005) | (0.004) | (0.006) | (0.005) |
| AR(1) p-value | 0.101 | 0.123 | 0.108 | 0.123 | 0.118 | 0.111 | 0.111 |
| AR (2) p-value | 0.625 | 0.628 | 0.614 | 0.609 | 0.618 | 0.612 | 0.619 |
| Hansen p-value | 0.592 | 0.662 | 0.644 | 0.628 | 0.618 | 0.594 | 0.616 |

Note: *, **, and *** represent statistical significance at 10%, 5%, and 1%, respectively; the values in parenthesis indicate p-values.

**Table 7.** Effects of Individual Financial Inclusion Indicators on ROE

| Variables | (Model 1) ROE | (Model 2) ROE | (Model 3) ROE | (Model 4) ROE | (Model 5) ROE | (Model 6) ROE | (Model 7) ROE |
|---|---|---|---|---|---|---|---|
| L.ROE | 0.657*** | 0.553*** | 0.608*** | 0.537*** | 0.589*** | 0.602*** | 0.604*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| NLNBRANCHES | 28.59*** | | | | | | |
| | (0.001) | | | | | | |
| NLNATMs | | 3.916 | | | | | |
| | | (0.565) | | | | | |
| NLNDEPOSITAC | | | 19.43*** | | | | |
| | | | (0.001) | | | | |
| NLNLOANAC | | | | 6.219 | | | |
| | | | | (0.434) | | | |
| NLAMTDEPOSIT | | | | | 15.61*** | | |
| | | | | | (0.005) | | |
| NLAMTLOAN | | | | | | 21.42*** | |
| | | | | | | (0.002) | |
| FI | | | | | | | 1.114*** |
| | | | | | | | (0.004) |
| LEV | 0.012 | 0.043 | 0.019 | 0.033 | 0.030 | 0.028 | 0.023 |
| | (0.639) | (0.153) | (0.453) | (0.249) | (0.316) | (0.335) | (0.381) |
| NLSIZE | -2.920** | -0.682 | -1.417 | -0.757 | -1.076 | -1.438 | -1.465 |
| | (0.017) | (0.515) | (0.135) | (0.431) | (0.289) | (0.184) | (0.156) |
| LIQR | -0.139* | -0.135 | -0.143* | -0.124 | -0.138* | -0.143* | -0.142* |
| | (0.099) | (0.110) | (0.086) | (0.123) | (0.100) | (0.091) | (0.091) |
| CER | -0.379*** | -0.374*** | -0.371*** | -0.372*** | -0.368*** | -0.368*** | -0.370*** |
| | (0.000 | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| AGE | -0.045 | 0.120 | 0.017 | 0.080 | 0.040 | 0.042 | 0.018 |
| | (0.528) | (0.320) | (0.830) | (0.548) | (0.674) | (0.651) | (0.841) |
| Constant | 56.10*** | 34.67*** | 43.28*** | 36.44*** | 39.34*** | 42.37*** | 44.60*** |
| | (0.000) | (0.008) | (0.001) | (0.005) | (0.003) | (0.003) | (0.002) |
| AR (1) p-value | 0.0801 | 0.117 | 0.0970 | 0.0909 | 0.111 | 0.120 | 0.101 |
| AR (2) p-value | 0.211 | 0.229 | 0.222 | 0.222 | 0.224 | 0.226 | 0.220 |
| Hansen p-value | 0.311 | 0.575 | 0.435 | 0.560 | 0.495 | 0.432 | 0.441 |

*Note*: *, **, and *** represent statistical significance at 10%, 5%, and 1%, respectively; the values in parenthesis indicate p-value.

## Conclusion and Recommendations

This study used a two-step system GMM technique on a sample of sixteen commercial banks to examine the impact of financial inclusion on the financial performance of Ethiopia's banking industry. The GMM estimation results were compared with other linear panel data analysis techniques, including OLS, FE, and Feasible Generalized Least Squares (FGLS).

The study utilized ten years of data (2013–2022), manually collected from the country's central bank, officially known as the National Bank of Ethiopia (NBE), and the annual reports of each commercial bank included in the sample. Since bank performance was measured using two alternative indicators – *ROA* and *ROE* – two separate econometric models were specified to estimate the relationship between financial inclusion and these performance metrics.

Initially, six financial inclusion indicators were considered: the number of branch networks and ATMs (measuring banking service availability/access), the number of depositors and borrowers (reflecting banking penetration), and the amounts of outstanding deposits and loans (capturing financial service usage). In the next step, a composite financial inclusion index (FI) was constructed by applying the PCA technique to extract the first principal component from these six indicators.

To account for omitted variable bias, the study also included several bank-specific control variables known to significantly influence financial performance, such as leverage, liquidity ratio, cost efficiency ratio, bank size, and bank age.

The study found that the composite financial inclusion index (FI) has a significant positive impact on the performance of Ethiopia's banking sector, as measured by both *ROA* and *ROE*. The GMM model estimation also revealed that the lagged values of performance measures (*L.ROA* and *L.ROE*) have a positive and significant effect on the current and future financial performance of commercial banks.

Regarding the control variables, the cost efficiency ratio is the only variable that significantly affects both *ROA* and *ROE*, with negative coefficients. No statistically significant relationship was found between the liquidity ratio and *ROA*, whereas its association with *ROE* is negative and significant at the 10% significance level. Leverage does not have a significant effect on either *ROA* or *ROE*. Bank age negatively and significantly affects ROA, while its effect on ROE is positive but not statistically significant. Additionally, bank size shows no significant relationship with either performance measure.

The findings of this research will contribute to a broader global understanding of the relationship between financial inclusion and the performance of commercial banks.

Firstly, this study provides empirical evidence that increased financial inclusion activities positively influence the profitability of commercial banks. It also highlights key bank-specific variables that determine their financial performance.

Secondly, the findings will be valuable to financial institutions in shaping their strategic initiatives to enhance financial inclusion efforts.

Thirdly, the study offers insights for government agencies and financial sector regulators responsible for promoting financial inclusion in the country. Given that Ethiopia is the second most populous country in Africa, with a large unbanked population, banks have a significant opportunity to expand their outreach. This can be achieved by increasing branch networks and ATMs, offering accessible and tailored financial services, and promoting financial literacy among the population.

## Statement of availability of data

This study used data collected manually from the National Bank of Ethiopia (NBE) and annual reports of each commercial bank in the sample.

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# Can ESG Buffer the Pains of Digital Transformation? Evidence from Chinese Listed Companies

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## Abstract

Despite the strategic imperative of digitalization, its impact on firm performance remains debated, often showing initial negative effects. Using a panel of 1,543 Shanghai Stock Exchange (SSE) listed firms (2013-2023), we investigate the dynamic relationship between digital transformation (DT) and financial performance. Employing two-way fixed-effects models and path analysis, we uncover dynamic effect: DT negatively impacts financial performance contemporaneously, mediated by increased financing constraints, but yields positive returns in the long run. Crucially, we find that strong Environmental, Social, and Governance (ESG) performance mitigates the negative short-term effects of DT. Robustness checks, including replacement variables, PSM-DID and addressing endogeneity, confirm our findings. This study contributes by reconciling mixed evidence on DT's value, identifying financing constraints as a key mechanism, and demonstrating strong ESG enhances early-stage financial resilience.

**Keywords:** digital transformation, digitalization paradox, financial performance,ESG, financing constraints, moderating effects, China

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# Introduction

In the digital era, traditional industrial enterprises are implementing digital transformation strategies to respond to rapid market changes and competitive pressures. The 2022 Global Digital Economy Competitiveness Development Annual Report ranks China ranks second in digital economy competitiveness, just behind the United States [1].

Previous research has shown the economic role of digital technologies in optimizing supply chains, enhancing operational efficiency [2] and improving firms' ability to cope with complex environments [3]. However, a 2021 survey by the Tencent Research Institute revealed a set of obstacles, including a "lack of funds", a "lack of leadership support", and, more critically, difficulties in internal organizational coordination [4] and challenges related to complex digital tools and solutions [5; 6]. Scholars indicate that as many as 70% of digital transformation have led to economic losses for enterprises [7], with actual returns frequently falling short of expectations [8]. A key contributing factor is management's lack of expertise and leadership in navigating digital transformation, which exacerbates challenges associated with the digital divide [9]. Additionally, digital disruption can destabilize industries, and only a minority of organizations are adequately prepared to address such disruptions [10]. A variety of factors leads to the "digitalization paradox" where expected financial gains do not proportionally reflect the scale of digital investments [8]. Despite the growing body of research on the effects of digital transformation, a critical gap remains in understanding the underlying mechanisms by which digital transformation can negatively impact the financial performance of large-scale corporations in the short term. In addition, there is a shortage of evidence on whether ESG at the corporate level can mitigate this adverse effect of digital transformation. What expectations should the management and board of directors of large companies have when engaging in such a twin transformation?

We focus on China for several reasons. Under pressure from global competition, Chinese companies need to strategize between transformation and rising costs. Especially as China's demographic dividend gradually fades, with increasing technology and labour costs, it remains an open question whether the investment in transformation by Chinese enterprises can proportionally match the benefits brought by the latter in the short term [11]. Second, to compete in global markets, Chinese companies have to align with new sustainable development objectives, making ESG corporate innovation more urgent. For this reason, our study focuses on companies listed on the main board of the Shanghai Stock Exchange (SSE), exploring their performance and challenges during twin innovations. These companies are typically large and have a long operating history, mature business models, and stable performance, representing high-quality enterprises with significant industry and public effects. However, they have bigger systems and infrastructure and stronger organizational inertia, creating substantial difficulties in structural transformation [12] and making the challenges more complex. When involved in the digital transformation process, companies that emphasize the principles of sustainability in their strategies are more likely to gain loyalty and recognition from shareholders and other stakeholders [13]. Nevertheless, studies exploring the synergistic effects of ESG and digital transformation are still scarce. We conceptualize ESG as a managerial innovation that encompasses both internal governance and external evaluation dimensions and explore its moderating influence on the link between digital transformation and corporate performance, particularly through the lens of financing constraints.

This study offers two key contributions to the literature. First, it elucidates the specific mechanisms underpinning the dynamic effect of digital transformation (DT) on financial performance – initial decline followed by long-term gains. Focusing on mature Chinese firms, we pinpoint financing constraints as a critical, yet underexplored, channel driving the short-term dip. We argue that the substantial investments, high failure rates, slow returns, and disruptive uncertainty associated with DT heighten information asymmetries and perceived risks, thereby restricting firms' financing capabilities in the initial phase. This finding extends the concept of the 'digitalization paradox' [8] by providing a concrete explanatory mechanism. Second, this research demonstrates the synergistic interplay between ESG performance and DT. We reveal that strong ESG credentials act as a significant moderator, effectively buffering the negative short-term financial consequences of digital initiatives. This suggests a practical solution to the digitalization paradox: integrating robust sustainability practices can mitigate the initial downsides of DT. Our findings highlight the necessity of examining these corporate strategies jointly and underscore the strategic value of embedding sustainability within digital transformation efforts to maximize benefits and minimize risks.

# Literature review

## Impact of digital transformation on financial performance

Simply introducing and applying technologies does not equate to digital transformation: true digital transformation occurs when technologies are used to fundamentally alter how a company generates profit. At the same time, the impact of digital transformation on financial performance is a subject of considerable debate in the research community.

Existing studies suggest that investments in digital transformation have a positive impact on financial performance by reducing information asymmetry levels [14], lowering costs [14; 15], obtaining additional cash flow [16], improving inventory turnover and total asset turnover [17], enhancing capital utilization efficiency [18], and increasing economies of scale by leveraging the resources and experience of partners [19]. However, some research suggests that the correlation between the two depends on the stage of digital transformation, the speed of transformation, the level of investment in transformation, the financial condi-

tion, and the strategic orientation of the firm. According to Fabian et al. [20], although the implementation of lower levels of digital transformation can enhance efficiency, such endeavours often encounter diminishing returns, limiting profits. In contrast, Yonghong et al. [17] state that although corporate profitability decreases in the initial stages of digital transformation, the firm's net profit margin gradually increases as the digital process deepens. Meanwhile, Sun et al. [21] explore the impact of the speed of digital transformation on corporate financial distress, finding a U-shaped relationship between the two, with the CEO's IT background modifying this relationship into an inverted U-shape. Research by Vu et al. [22] using the fixed effects quantile method shows that only high-performance companies benefit from digital transformation, while other companies do not. Guo's [23] study reveals that digital transformation has a U-shaped relation with profit-oriented financial performance and is positively correlated with process-oriented operational performance. Fabian [24] indicates that firms inclined towards radical changes and those with more rigid organizations obtain lower returns from digital transformation.

Some scholars view the relationship negatively [25]. Among them, Solow [26] proposes the "productivity paradox", arguing that information technology investment does not affect or even negatively impacts corporate financial performance. Matt et al. [27] corroborate this view, demonstrating that over half of the businesses using digital transformation strategies have seen a decline in performance compared to their pre-transformation levels, with some even running the risk of bankruptcy. Xie et al. [28] argue that corporate digital transformation needs to go through two periods – "overcoming organizational inertia" and "forming new management routines" – during which learning costs inevitably rise, limiting the positive impact on financial performance. Hanelt et al. [29] further highlight that digital transformation does not inherently guarantee profitability, as it often brings additional operational and integration costs that can erode financial returns. In this perspective, Jardak and Ben Hamad [30] note that the benefits of IT investments and digital marketing may take years to materialize, with the high value of IT assets not being immediately amortized, which can negatively impact return on assets (ROA) in the short term. Other scholars study individual industries. For example, Forcadell [13] indicates that for banks, the challenges brought by digital transformation may hinder potential gains and threaten their survival, whereas the reputation established by corporate sustainability compensates for these weaknesses in digital capabilities. Isma Coryanata et al. [31] examine banking firms listed on the Indonesia Stock Exchange and show that the implementation of digital transformation by banks leads to a decrease in their return on investment.

This paper aims to reconcile conflicting perspectives on the impact of digital transformation on financial performance by examining the complex interplay of mediators and moderators.

## Impact of ESG on firm performance

Existing research on ESG mostly analyses its influence on corporate financial performance and risk management capabilities. Most studies indicate that excellent ESG performance can enhance financial performance [32], an effect that is more pronounced for larger companies [33]. However, this impact is not always linear and depends on different factors, including the market in which the company is operating and its size. Research by Garcia et al. [34] illustrates the market heterogeneity characteristic of ESG's financial impact, demonstrating a significant positive relationship between the two in companies from developed countries yet a negative correlation in companies from emerging markets. Bruna [35], using data from 350 European listed companies, finds that the marginal impact of ESG performance on financial performance is nonlinear and varies with the level of ESG performance scores and company size. Conversely, some studies make the opposite conclusion. For instance, research by Landi et al. [36] on Italian listed companies suggests that investors do not seem to value corporate social responsibility (CSR). Saygili et al.'s [37] study on companies listed on the Istanbul Stock Exchange indicates that environmental disclosure significantly harms corporate financial performance.

Moreover, research suggests that CSR serves as a risk management instrument with the capacity to mitigate risks during crises and safeguard firms against negative effects on their cash flow [38; 39]. Benlemlih et al. [40] indicate that companies that engage in extensive and objective environmental and social disclosure build good reputation and trust among stakeholders, thereby helping to mitigate their idiosyncratic and operational risks. Sassen et al. [41], using a sample of European panel data from 2002 to 2014, demonstrate that corporate social performance significantly reduces idiosyncratic, total, and systematic risks. Albuquerque et al. [42] study how CSR investments can improve product differentiation, thereby reducing exposure to systemic risk. Hoepner et al. [43] also find that engagement in ESG transformation can reduce downside risk. However, Korinth et al. [44] provide evidence from the German stock market showing that ESG investments initially reduce systemic risk, yet excessive investment ultimately increases systemic risk, leading to a U-shaped dependence.

Recent academic research has done a lot to examine the direct impact of ESG practices on corporate financial performance and risk management. However, studies on the synergistic effects of ESG and digital transformation are still sparse. The few available ones indicate that a firm's sustainability reputation affects the relationship between digital disclosure and stock market valuation [45], while the breadth and concentration of sustainability play a moderating role between digital reputation and financial performance [46]. Forcadell's [13] study of the banking industry suggests that the challenges posed by digital transformation may hinder potential gains and harm resilience, while the reputation generated by corporate sustainability could mitigate these digital transformation shortcomings.

Therefore, examining how ESG functions as a moderating variable in the relationship between digital transformation and financial performance will address existing research gaps, extend sustainability research to ESG indicators, and reveal how ESG practices can optimize financial performance during digital transformation.

# Hypotheses

## Impact of digital transformation on financial performance

From the perspective of resource-based theory, digital transformation leverages data as an independent production factor to create value by improving efficiency [47; 48], increasing revenue [49], saving costs [50], and controlling risks [51], thereby indirectly enhancing the productivity and financial performance of enterprises. However, few studies mention the resource consumption issues within digital transformation. As a form of innovation, digital transformation is a resource-consuming activity that initially necessitates significant ongoing investment: the fixed investment in high-cost digital infrastructure and the subsequent maintenance and upgrade costs [49; 52], the expenses for recruiting digital technology professionals and daily digital training for employees [53], and the coordination costs associated with integrating digital technologies with existing resources and abilities [54].

Over half of Chinese enterprises are still at the initial stages of digital technology application (National Information Center, 2020), making funding a significant challenge for digital transformation [55]. Furthermore, in the early phase, the complete benefits of digital transformation have yet to manifest, while the expenses associated with integration may offset the promotion of digital transformation for business growth [23], resulting in a disproportionate increase in operational costs relative to revenue. This may lead to an initial decline in return on assets. This process is particularly evident in large enterprises with more extensive systems and infrastructure, organizational inertia, and long-existing mindsets and processes [56], leading to higher communication, coordination, and integration costs. Excessively rapid digital transformation can easily create an insurmountable gap between the company's existing resources and capabilities, directly impacting internal management decisions and resource allocation efficiency. Consequently, the organization may lack the capacity to continue supporting the deep implementation of digital transformation and fail to adjust internal activities and structures dynamically to adapt to external environmental changes [57], potentially impacting its financial performance.

Although studies show that digital transformation can help mitigate principal-agent conflicts and strengthen internal corporate governance structures [58], it can also create greater uncertainty and operational risk, exacerbate external and internal information asymmetry, and increase financing constraints, which can negatively affect financial performance. Previous research has mostly assumed the success of digital transformation, almost unequivocally affirming the positive signals it sends. The effectiveness of digital transformation heavily relies on how prepared an organization is to embrace and implement digital innovation. The high probability of digital failure and slow return on investment exacerbate operational uncertainty for enterprises [8]. In addition, digital transformation redefines markets, disrupts traditional business models and industry divisions, and shatters competitive landscapes [59]. It poses an existential threat to mature, large-cap companies that thrived during the pre-digital era [60]. The boundaries between product categories and industries are becoming indistinct, while competitiveness increasingly depends on multisided platforms [61]. In the face of greater uncertainty risks, information on firms' investments becomes more complex and variable, increasing specific risks and information asymmetries [62] and directly impacting the expenses associated with corporate debt and equity financing [63].

Moreover, cross-industry operations that follow digital transformation require significant investments unrelated to the core business. To maintain digital agility, companies must continually modify and reallocate current digital assets [64]. However, this "reallocation of resources" can have competitive effects and negatively impact core business performance [27; 59]. Based on signalling theory, external investors may adopt a cautious attitude towards the enterprise's future profitability and operational stability due to concerns over the potential negative impact on the core business or the failure of digital investments, leading to financing constraints and adversely affecting subsequent financial performance.

**H1**: Digital transformation can negatively impact the financial performance of mature, large-cap corporations in the short term.

**H2**: Digital transformation increases financing constraints, thereby negatively affecting the financial performance of mature, large-cap corporations in the short term.

## Moderating role of ESG innovative practices

Enhanced ESG performance signifies a firm's strong sustainability and promotes reputation and stakeholder trust [65]. Stakeholder trust can not only offset the potential downsides of digital transformation [66] and enhance its market expectations [67], but it can also bring competitive advantages and brand premiums [68], thereby increasing stakeholder tolerance for temporary declines in operational and financial performance during digital transformation.

Firms with good ESG innovative practices enhance the quality of their human capital, facilitating integration of digital technologies with existing resources and organizational structures. The digital transformation process encounters risks like the shortage of skilled labour and the loss of experienced managers [69]. However, companies with strong ESG performance attract high-quality talent by adopting green human resource management strategies

[70], which enhance employees' sense of belonging and self-respect and their work motivation [71] and ultimately promote improvements in financial performance.

Good ESG practices lead to superior risk management capabilities [72], transparency, and compliance, while reducing risks associated with information asymmetry, including firm-specific and operational risks [40]. Digital transformation in mature, large-cap enterprises entails significant operational risks and uncertainties. However, firms with strong ESG innovative practices and results are more adept at handling technology compliance, market resistance, and regulatory shifts, which helps them to safeguard internal stability and protect core operations and financial performance.

**H3**: ESG innovative practices can mitigate the adverse effect of digital transformation on the financial performance of mature, large-cap corporations.

## Moderating role of ESG innovative practices in the mediating mechanism of financing constraints

According to signalling theory, strong ESG performance serves as a positive signal that companies send in situations of information asymmetry within capital markets [73]. This signal indicates that the company is not merely pursuing short-term profits but incorporating sustainable development strategies as part of its long-term plan for digital transformation. It demonstrates a comprehensive and long-term commitment to the goals of digital transformation, thereby mitigating the impact of negative signals such as potential failure and slow return on investment during the digital transformation process. This releases positive signals about the company's internal risk resilience and legitimacy, increases the support of different stakeholders such as investors, consumers, and government departments, and secures more stable long-term capital to alleviate potential financing constraints during digital transformation.

Good ESG innovative practices and performance enhance the firm's overall market image [74] and shows investors that it possesses strong operational signals and risk resilience, thereby boosting external investor confidence [75]. Such practices can increase stakeholders' tolerance for temporary operational or financial performance declines during digital transformation, thereby reducing external financial constraints and debt costs [76]. Additionally, good ESG practices lower regulatory risks and operational uncertainties by ensuring compliance and mitigating risks related to products and technologies [77]. This can increase information transparency, which enables the company to establish a broad network and broaden financing access [78]. For instance, good ESG practices encourage companies to issue green bonds [79] and funds in equity crowdfunding [80], thus easing the capital constraints faced during digital transformation.

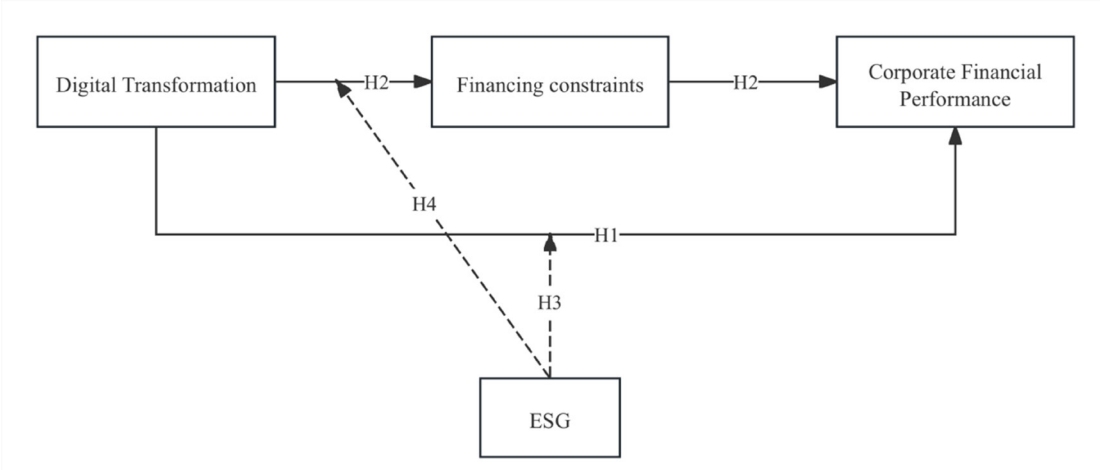
Strong ESG performance presents a responsible and trustworthy image to stakeholders. This can help to establish long-term stable supply chain partnerships, strengthening the company's cohesion with its suppliers and customers [81], and reduce the incidence of commercial fraud [82], which in turn facilitates greater access to commercial credit financing [83] and supports long-term sustainable development strategic goals.

Furthermore, good ESG is often related to high levels of environmental awareness and commitment, signalling organizational legitimacy that helps to attract long-term investors, secure stable long-term funds that can be used for digital transformation, and gain the support of government regulatory bodies. This enhances access to financing privileges and government resources, such as fiscal subsidies [84; 85].

**H4**: ESG innovative practices alleviate the financing constraints caused by digital transformation, thereby promoting corporate financial performance.

Figure 1 provides a visual representation of the research model for this study.

**Figure 1.** Research model



# Research design

## Data sources

This study uses a sample of companies listed on the main board of the Shanghai Stock Exchange (SSE) from 2013 to 2023. The choice of observation period is explained by several factors. In 2013, the Chinese government introduced a policy initiative to promote information consumption and expand domestic demand, launching the national informationization strategy and providing support for digital transformation. Additionally, 2013 marked the beginning of construction work on China's 4G network, rapidly advancing mobile internet technology and supporting digital transformation [86]. Our data on digital transformation was manually collected, as well as being sourced from the Wind Financial Terminal and CSMAR databases. The sample selection was based on the following principles: 1) excluding samples with insufficient data; 2) omitting financial and insurance companies due to their particularities [87]; and 3) excluding ST, PT, and *ST companies [88]. The final dataset consists of 1,543 sample companies and 12,833 sample observations. We used Stata 17.0 software for empirical analysis.

## Description of variables

*Dependent variable*: corporate financial performance (CFP). This paper measures CFP using return on assets. To confirm the robustness of the model, our research also uses return on equity (ROE) in place of ROA for regression.

*Independent variable*: digital transformation (DT). Most of the current literature employs textual analysis to represent DT using keyword word frequencies associated with DT in companies' annual reports [86; 89]. While word frequency reflects executives' awareness of DT, awareness does not necessarily translate into action [90]. Digital intangibles make more economic sense than word-frequency analysis, because they measure a company's investment in DT. Thus, this study aligns with previous research [90; 91] to measure DT as the proportion of intangible assets associated with digital transformation keywords like *software, artificial intelligence,* and *big data* disclosed in annual financial statements. This proportion of relevant intangible assets to total assets at year-end serves as a proxy for DT.

*Mediating variable*: financing constraints (FC). Scholars have proposed various metrics to measure financing constraints, including single factors such as asset size and dividend payout ratio and composite indices like the SA index [92], KZ index [93], and WW index [94]. Among these, the KZ index indicates the extent to which a firm's investment depends on internal cash flow, thereby reflecting the size of financing constraints [95]. The KZ index integrates multiple dimensions of a company's financial position and market conditions, providing a comprehensive understanding of how financing constraints influence financial decisions, capital structure and, ultimately, financial performance. Therefore, aligning with previous studies [96–98], we adopt the KZ index, as originally proposed by Kaplan and Zingales [93]. The KZ index is constructed as follows:

$$KZ = \sum_{1}^{5} KZ_{j.} \qquad (1)$$

In Equation (1), the value of $KZ_1$ is 1 if the ratio of operating cash flow to total assets for the prior period ($CF_{i,t}/Asset_{i,t-1}$) is below the median, and 0 otherwise. The value of $KZ_2$ is 1 if the ratio of cash dividends to total assets for the prior period ($DIV_{i,t}/Asset_{i,t-1}$) is below the median, and 0 otherwise. The value of $KZ_3$ is 1 if the ratio of cash holdings to total assets for the prior period ($C_{i,t}/Asset_{i,t-1}$) is below the median, and 0 otherwise. The value of $KZ_4$ is 1 if the debt-to-asset ratio is above the median, and 0 otherwise. The value of $KZ_5$ is 1 if Tobin's Q is above the median, and 0 otherwise. We sum these indicators using Equation (1) to calculate the *KZ* index. Then, the regression coefficients are estimated using *ordered logistic regression*, utilizing the *KZ* index as the dependent variable. A higher *KZ* index suggests that firms are experiencing more severe financing constraints.

*Moderator variable*. The Huazheng ESG rating is taken as the moderator variable due to its comprehensive coverage, frequent updates, and advanced calculation techniques [99]. Widely recognized and employed in various studies to evaluate ESG [67; 100], this index offers an extensive evaluation with over 300 indicators spanning environmental, social, and governance dimensions. Its quarterly updates provide more timely data compared to other indices that are updated only semi-annually or annually. Furthermore, the integration of semantic analysis and natural language processing algorithms enhances the index's precision and reliability. The Huazheng ESG rating index also includes detailed scores for the three individual dimensions, allowing for a more in-depth analysis. These strengths make it an excellent tool for measuring ESG performance.

*Control variables*. Based on prior research [23; 101], we chose the following control variables for the model: firm size (Size), age (Age), revenue growth rate (Growthrate), debt-to-asset ratio (Lev), firm research and development expenditures (R&D), fixed asset ratio (FA), Tobin's Q (TobinQ), property rights contexts (SOE), board of directors' independence (Ind), and shareholding concentration (Top1). Finally, we incorporate the COVID-19 pandemic as a dummy variable to capture the influence of this significant global health event on CFP, ensuring that our analysis accurately reflects the effects of DT and other factors, independent of the disruptions caused by the pandemic. These variables collectively provide a comprehensive framework for analysing the factors affecting CFP.

**Table 1.** Description of variables

| Variable type | Variable name | Symbols | Variable description |
|---|---|---|---|
| Dependent variable | Corporate Financial Performance | CFP | Return on assets |
| | | ROE | Return on equity |
| Explanatory variable | Digital Transformation | DT | Proportion of intangible assets related to digital transformation keywords to total assets at year-end |
| Mediator variable | Finance constraints | FC | KZ index |
| Moderator variable | Corporate ESG | ESG | Huazheng ESG Rating |
| Control variable | Enterprise size | Size | Logarithm of total assets |
| | Enterprise age | Age | Logarithm of (years of observation minus years of establishment) |
| | Growth rate of revenue | Growthrate | (Current operating income minus prior operating income) divided by prior operating income |
| | Gearing | Lev | Total liabilities divided by total assets |
| | R&D expenditure | R&D | Logarithm of total firm R&D expenditures |
| | Fixed Asset Ratio | FA | Fixed assets at the end of the period as a percentage of total assets |
| | Property rights contexts | SOE | 1 for state-owned enterprises, and 0 otherwise |
| | Board independence | Indep | Ratio of independent directors to the total number of directors |
| | Shareholding concentration | Top1 | Proportion of shares owned by the largest shareholder of the enterprise |
| | Future growth opportunities | TobinQ | Market value of the company / replacement cost of assets |
| | Dummy variables | COVID-19 | 0 if the year precedes the outbreak of COVID-19 and 1 if it follows the outbreak |

*Note*: The table comprehensively explains and quantifies all variables.

## Model design

A firm's financial performance is greatly affected by specific and unobservable firm individual characteristics [102], such as corporate culture [103; 104] and management style [105; 106]. This model can effectively mitigate the influence of unobservable variables related to year and firm decrease estimation biases, and improve the statistical reliability of the results [107]. However, it necessitates the utilization of panel data and substantial sample observations [108]. This paper employs panel data for regression analysis on 12,833 observations, qualifying for the use of this model.

To test the correlation of DT and CFP, the following regression model is constructed:

$$\mathrm{CFP}_{i,t} = \alpha_0 + \alpha_1 \mathrm{DT}_{i,t} + \alpha_2 \mathrm{Controls}_{i,t} + \\ + \sum \mathrm{Year} + \sum \mathrm{Firm} + \nu_{i,t}, \quad (1)$$

where $i$ indicates the company, $t$ represents time, $\mathrm{CFP}_{i,t}$ indicates the corporate financial performance of company $i$ in year $t$, $\mathrm{DT}_{i,t}$ represents the level of digital transformation of company $i$ in year $t$, $\mathrm{Controls}_{i,t}$ indicate all control variables, $\sum \mathrm{Year}$ and $\sum \mathrm{Firm}$ represent the time and firm fixed effects, and $\nu_{i,t}$ is the exogenous disturbance term, which has a normal distribution with mean 0 and variance $\sigma^2$.

To examine the mediating effect of financing constraints, this study employs the causal steps approach to mediation [109; 110]. Expanding on regression Model (1), we construct Models (2) and (3):

$$FC_{i,t} = \beta_0 + \beta_1 DT_{i,t} + \beta_2 Controls_{i,t} + \\ + \sum Year + \sum Firm + \nu_{i,t}, \quad (2)$$

$$CFP_{i,t} = \gamma_0 + \gamma_1 DT_{i,t} + \gamma_2 FC_{i,t} + \gamma_3 Controls_{i,t} + \\ + \sum Year + \sum Firm + \nu_{i,t}, \quad (3)$$

where $FC_{i,t}$ represents the corporate financing constraints, while the other variables are the same as in the above model. If $\beta_1$ and $\gamma_2$ are significant at the same time, there is a mediating effect of financing constraints between the two. According to the previous theoretical analysis, this paper predicts $\beta_1$ to be significantly positive and $\gamma_2$ to be significantly negative.

To verify the moderating effect of ESG, we build Model (4), drawing on the moderating effect model [109]:

$$CFP_{i,t} = \alpha_0 + \alpha_1 DT_{i,t} + \alpha_2 ESG_{i,t} + \alpha_3 ESG_{i,t} \times DT_{i,t} + \\ + \alpha_4 Controls_{i,t} + \sum Year + \sum Firm + \nu_{i,t}, \quad (4)$$

where $ESG_{i,t} \times DT_{i,t}$ is the interaction term. According to the theoretical analysis in Section 2, $\alpha_3$ is expected to be significantly positive.

Based on the interpretation of Edwards and Lambert [109] of the moderated mediation effect model, Models (5) and (6) are constructed for confirming the moderating effect of ESG on the first half of the mediation effect path, while Model (7) is built for confirming the direct moderating effect of ESG on the mediation effect path:

$$FC_{i,t} = \beta_0 + \beta_1 DT_{i,t} + \beta_2 ESG_{i,t} + \beta_3 Controls_{i,t} + \\ + \sum Year + \sum Firm + \nu_{i,t}, \quad (5)$$

$$FC_{i,t} = \beta_0 + \beta_1 DT_{i,t} + \beta_2 ESG_{i,t} + \beta_3 ESG_{i,t} \times DT_{i,t} + \\ + \beta_4 Controls_{i,t} + \sum Year + \sum Firm + \nu_{i,t}, \quad (6)$$

$$CFP_{i,t} = \gamma_0 + \gamma_1 DT_{i,t} + \gamma_2 ESG_{i,t} + \gamma_3 FC_{i,t} + \gamma_4 ESG_{i,t} \times \\ \times DT_{i,t} + \gamma_5 Controls_{i,t} + \sum Year + \sum Firm + \nu_{i,t}. \quad (7)$$

If $\beta_3$ of $ESG_{i,t} \times DT_{i,t}$ is significant, then ESG moderates financing constraints caused by digital transformation. If $\gamma_4$ is significant, then the moderating effect of ESG does not work entirely through the mediating variable $FC_{i,t}$. According to the theoretical analysis, the predictive coefficient $\beta_3$ is significantly negative and $\gamma_4$ is significantly positive.

# Results and discussion

## Main effect regression analysis

Table 2 shows the relationship between DT and CFP. Column 1 shows the results without control variables and without firm and time fixed effects. Column 2 presents the results of the two-way fixed effects model without control variables. Column 3 shows the findings after including all control variables and accounting for year, industry, and city effects. Column 4 presents the findings of regressions that incorporate control variables and utilize a two-way fixed effects model (Model (1)). The results consistently demonstrate that DT has a negative impact on CFP at the 1% significance level. This finding supports the previous theory and confirms Hypothesis 1.

**Table 2.** Benchmark regression results

| | Model (1) | | | |
|---|---|---|---|---|
| | CFP | CFP | CFP | CFP |
| DT | -0.0316*** | -0.0135*** | -0.0123*** | -0.0175*** |
| | (-10.39) | (-2.78) | (-4.21) | (-4.17) |
| Size | | | 0.0106*** | 0.0071*** |
| | | | (21.92) | (5.72) |
| Age | | | -0.0011*** | -0.0037** |
| | | | (-14.18) | (-2.09) |
| Growthrate | | | 0.0383*** | 0.0356*** |
| | | | (27.65) | (27.65) |
| Lev | | | -0.1022*** | -0.0953*** |
| | | | (-59.81) | (-51.92) |
| R&D | | | 0.0001 | 0.0003** |
| | | | (0.59) | (2.51) |
| FA | | | -0.0569*** | -0.0845*** |
| | | | (-13.72) | (-12.59) |

| | Model (1) CFP | CFP | CFP | CFP |
|---|---|---|---|---|
| SOE | | | -0.0054*** | -0.0040 |
| | | | (-3.84) | (-1.29) |
| Indep | | | -0.0004 | -0.0003 |
| | | | (-0.39) | (-0.19) |
| Top1 | | | 0.0003*** | 0.0003*** |
| | | | (8.87) | (3.23) |
| TobinQ | | | 0.0045*** | 0.0022*** |
| | | | (16.61) | (6.61) |
| COVID-19 | | | -0.0150*** | 0.0060 |
| | | | (-4.81) | (0.36) |
| Constant | 0.0443*** | 0.0513*** | -0.1800*** | -0.0300 |
| | (67.54) | (25.31) | (-8.63) | (-1.00) |
| Year FE | No | Yes | Yes | Yes |
| Industry FE | No | No | Yes | No |
| City FE | No | No | Yes | No |
| Firm FE | No | Yes | No | Yes |
| Observations | 12,833 | 12,833 | 12,833 | 12,833 |
| R-squared | 0.008 | 0.018 | 0.402 | 0.273 |

*Note*: The T statistic is in parentheses; *, **, and *** represent significance levels of 10%, 5%, and 1%, respectively.

## Mediating effect analysis

The regression results for the mediating effect are shown in Table 3. In Model (2), the estimated coefficient of DT on FC is significantly positive at the 5% level (0.3405). It means that as DT increases, the FC faced by firms also rises. In column 3, the coefficient of FC is significantly negative at the 1% level (0.0103). These findings suggest that DT, by increasing the FC of firms, leads to a decrease in CFP. This finding further supports Hypothesis 3.

Moreover, Model (3) demonstrates that the estimated coefficient of DT on CFP is significantly negative at the 1% level (0.014), while the absolute value of this coefficient is lower than the absolute value of the coefficient in Model (1), implying that FC partially mediates this relationship. Specifically, DT influences CFP partly through the mediating role of FC and partly through *direct effects*.

**Table 3.** Mediating effect

| | Model (1) CFP | Model (2) FC | Model (3) CFP |
|---|---|---|---|
| DT | -0.0175*** | 0.3405*** | -0.0140*** |
| | (-4.17) | (2.99) | (-3.47) |
| FC | | | -0.0103*** |
| | | | (-30.89) |
| Size | 0.0071*** | 0.1536*** | 0.0087*** |
| | (5.72) | (4.57) | (7.28) |
| Age | -0.0037** | 0.3207*** | -0.0004 |
| | (-2.09) | (6.73) | (-0.22) |

| | Model (1) CFP | Model (2) FC | Model (3) CFP |
|---|---|---|---|
| Growthrate | 0.0356*** | -0.7747*** | 0.0276*** |
| | (27.65) | (-22.19) | (21.87) |
| Lev | -0.0953*** | 0.3952*** | -0.0912*** |
| | (-51.92) | (7.93) | (-51.62) |
| R&D | 0.0003** | 0.0073** | 0.0004*** |
| | (2.51) | (2.13) | (3.23) |
| FA | -0.0845*** | 2.4960*** | -0.0588*** |
| | (-12.59) | (13.70) | (-9.05) |
| SOE | -0.0040 | 0.1339 | -0.0026 |
| | (-1.29) | (1.60) | (-0.87) |
| Indep | -0.0003 | -0.0344 | -0.0006 |
| | (-0.19) | (-0.88) | (-0.45) |
| Top1 | 0.0003*** | -0.0130*** | 0.0001* |
| | (3.23) | (-5.83) | (1.67) |
| TobinQ | 0.0022*** | 0.1483*** | 0.0037*** |
| | (6.61) | (16.63) | (11.58) |
| COVID-19 | 0.0060 | -3.4629*** | -0.0297* |
| | (0.36) | (-7.58) | (-1.83) |
| Constant | -0.0300 | -4.8431*** | -0.0799*** |
| | (-1.00) | (-5.96) | (-2.78) |
| Year FE | Yes | Yes | Yes |
| Firm FE | Yes | Yes | Yes |
| Observations | 12,833 | 12,833 | 12,833 |
| R-squared | 0.273 | 0.127 | 0.329 |

*Note*: The T statistic is in parentheses; *, **, and *** represent significance levels of 10%, 5%, and 1%, respectively.

## Moderating effect and moderated mediation effects analysis

Model (4) in Table 4 shows the *total moderating effect* of ESG. The coefficient of the interaction term DT×ESG is significantly positive at the 1% level (0.0028). This means that good ESG performance can significantly alleviate the negative impact of DT on CFP. Consequently, in firms with superior ESG performance, the detrimental effects of DT on CFP are less severe.

Figure 2 and Table 5 depict the two-way interactions. They demonstrate that when ESG performance is poor, the linear slope is negative (-0.123). Conversely, when ESG performance is high, the slope becomes positive (0.035), indicating that in the case of higher ESG scores, the negative impact of DT turns into a positive effect.

In Model (6) of Table 4, the interaction term DT×ESG has an estimated coefficient that is significantly negative at the 5% level (-0.0376), indicating that ESG significantly moderates the relationship between DT and FC. In brief, as ESG performance improves, the positive impact of DT on FC weakens, thus verifying Hypothesis 4.

The results of Model (7) in Table 4 show that the estimated coefficient of DT×ESG is significantly positive at the 1% level (0.0024), suggesting that the moderating effect of ESG is not entirely mediated by FC. Moreover, the coefficient of DT×ESG in *the direct effect* is smaller than that in *the total effect* of ESG (0.0024 in Model (7) compared to 0.0028 in Model (4)), suggesting that the moderation effect of ESG is *partially* mediated by FC. This further confirms that good ESG performance can both directly mitigate the negative impact of DT on CFP and enhance CFP by reducing the increase in FC caused by DT.

**Table 4.** Moderating effects and moderated mediation effects

| | Model (4) CFP | Model (5) FC | Model (6) FC | Model (7) CFP |
|---|---|---|---|---|
| DT | -0.2253*** | 0.3504*** | 3.1138*** | -0.1935*** |
| | (-5.84) | (3.08) | (2.97) | (-5.22) |
| ESG | 0.0003** | -0.0103*** | -0.0069** | 0.0002* |
| | (2.19) | (-3.16) | (-1.96) | (1.71) |
| DT×ESG | 0.0028*** | | -0.0376*** | 0.0024*** |
| | (5.40) | | (-2.65) | (4.86) |
| FC | | | | -0.0102*** |
| | | | | (-30.69) |
| Size | 0.0065*** | 0.1634*** | 0.1649*** | 0.0081*** |
| | (5.21) | (4.84) | (4.89) | (6.83) |
| Age | -0.0042** | 0.3311*** | 0.3305*** | -0.0008 |
| | (-2.38) | (6.93) | (6.92) | (-0.47) |
| Growthrate | 0.0359*** | -0.7783*** | -0.7804*** | 0.0279*** |
| | (27.96) | (-22.29) | (-22.35) | (22.15) |
| Lev | -0.0950*** | 0.3857*** | 0.3893*** | -0.0911*** |
| | (-51.79) | (7.73) | (7.80) | (-51.51) |
| R&D | 0.0003*** | 0.0074** | 0.0072** | 0.0004*** |
| | (2.60) | (2.16) | (2.09) | (3.31) |
| FA | -0.0842*** | 2.4681*** | 2.4835*** | -0.0588*** |
| | (-12.55) | (13.54) | (13.62) | (-9.06) |
| SOE | -0.0038 | 0.1328 | 0.1316 | -0.0025 |
| | (-1.24) | (1.59) | (1.57) | (-0.84) |
| Indep | -0.0005 | -0.0300 | -0.0297 | -0.0008 |
| | (-0.37) | (-0.76) | (-0.76) | (-0.60) |
| Top1 | 0.0003*** | -0.0128*** | -0.0128*** | 0.0001 |
| | (3.12) | (-5.76) | (-5.75) | (1.58) |
| TobinQ | 0.0022*** | 0.1483*** | 0.1481*** | 0.0037*** |
| | (6.68) | (16.64) | (16.61) | (11.61) |
| COVID-19 | -0.0326 | -4.3839*** | -4.6700*** | -0.0803*** |
| | (-1.07) | (-5.32) | (-5.62) | (-2.73) |
| Constant | -0.0895*** | -3.3463*** | -3.5837*** | -0.1316*** |
| | (-2.84) | (-4.02) | (-4.27) | (-4.39) |
| Year FE | Yes | Yes | Yes | Yes |
| Firm FE | Yes | Yes | Yes | Yes |
| Observations | 12,833 | 12,833 | 12,833 | 12,833 |
| R-squared | 0.276 | 0.128 | 0.129 | 0.332 |

*Note*: The T statistic is in parentheses; *, **, and *** represent significance levels of 10%, 5%, and 1%, respectively.

**Figure 2.** Two-way linear interactions

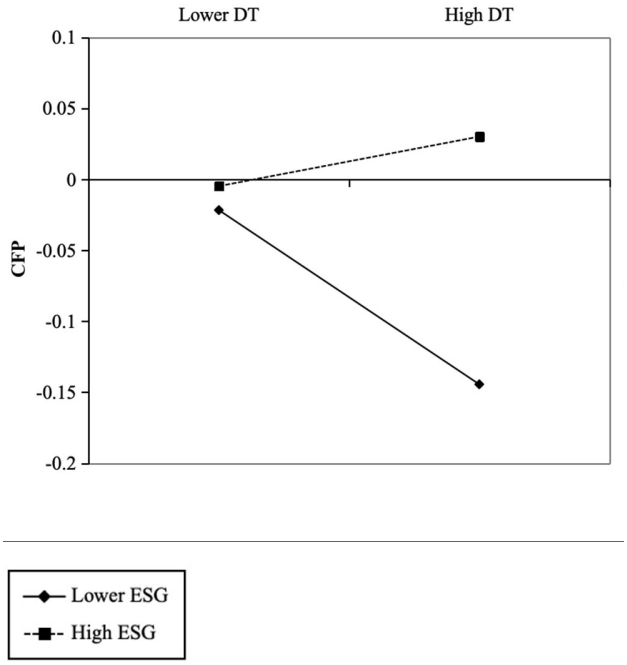



**Table 5.** Simple slope tests

| | Lower ESG | High ESG |
|---|---|---|
| Gradient of slope | -0.123 | 0.035 |
| t-value of slope | -6.484 | 3.295 |
| p-value of slope | 0.000 | 0.001 |

## Robustness tests

### *Alternative variables*

In alignment with previous studies [15; 30], this paper substitutes ROE for CFP to verify the findings' robustness. Column 1 of Table 6 displays that the effect of DT on ROE is significantly negative at the 5% level (0.0849). This corroborates the reliability of our findings. To address concerns regarding the external validity of the KZ index, particularly its sensitivity to the sample and specific time period used for its construction, we employ the WW index [111] as an alternative measure. A robustness check using the WW index confirms the consistency of our results.

### *PSM-DID*

To effectively mitigate the policy shocks associated with the "Action Plan for Industrial Internet Development" policy introduced by the Chinese government and to prevent systematic differences in the financial performance of firms in pilot and non-pilot cities, we employ propensity score matching-difference-in-differences (PSM-DID) analysis to incorporate the policy shocks into the regression model. This method allows us to redefine the control group sample to ensure a direct comparison and analysis between the control and treatment groups [112]. Initially, we categorize the overall sample based on the digitization pilot city documents issued by China, distinguishing between the experimental group (enterprises located in the digitization pilot cities) and the control group (enterprises located outside the digitization pilot cities). Then, the Logit model is used to compute the propensity scores for DT. Third, matching is performed using the 1:1 nearest neighbour matching method. We chose all control variables for logistic regression and propensity matching scores. The outcomes of the balance hypothesis test are presented in Figure 3. There is a significant common support region for the propensity scores of the experimental and control groups, and most of the samples' propensity scores fall within this region, indicating that the propensity score distributions of the two groups are generally balanced. Figure 4 illustrates a notable decrease in the standard deviation of most variables, indicating that the PSM method employed in this research effectively mitigates the sample selection bias. Figure 5 shows that the propensity score density curves differ significantly between the two groups before matching but become similar after matching, indicating that PSM effectively reduces selection bias.

In the PSM-matched sample, test for consistent trends in the CFP between the treatment and control groups before the policy was implemented. Figure 6 provides strong evidence supporting the *parallel trend assumption*. The coefficients for the pre-treatment period (time -4 to 0) are close to zero, with their confidence intervals including zero, suggesting no systematic differences in the outcome variable trends between the treatment and control groups prior to the policy implementation. This indicates that, in the absence of treatment, the trajectories of the outcome variable for the two groups would have evolved similarly over time.

The model after considering policy shocks is specified as follows:

$$\mathrm{CFP}_{i,t} = \alpha_0 + \alpha_1 \mathrm{DT}_{i,t} + \alpha_1 \mathrm{DID} + \alpha_2 \mathrm{Controls}_{i,t} + \\ + \sum \mathrm{Year} + \sum \mathrm{Firm} + \nu_{i,t}, \quad (8)$$

Here, DID represents the policy shocks, other variables are the same as the above model.

Column 4 of Table 6 shows that in the matched sample, after accounting for policy shocks, the effect of DT on CFP remains consistent with the results of previous studies, showing a negative effect at the 1% level (-0.0156).. This provides additional evidence of the reliability of the research findings.

**Figure 3.** Common value range of the propensity score

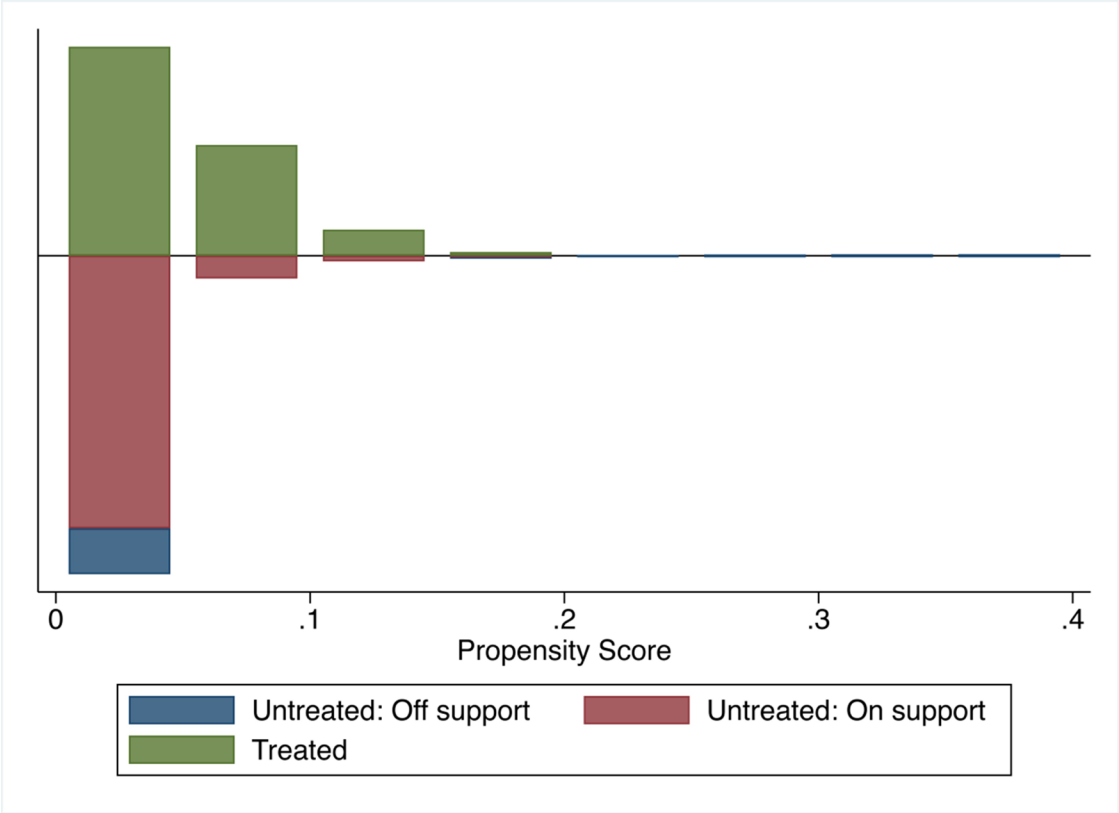



**Figure 4.** Standardized bias for each variable

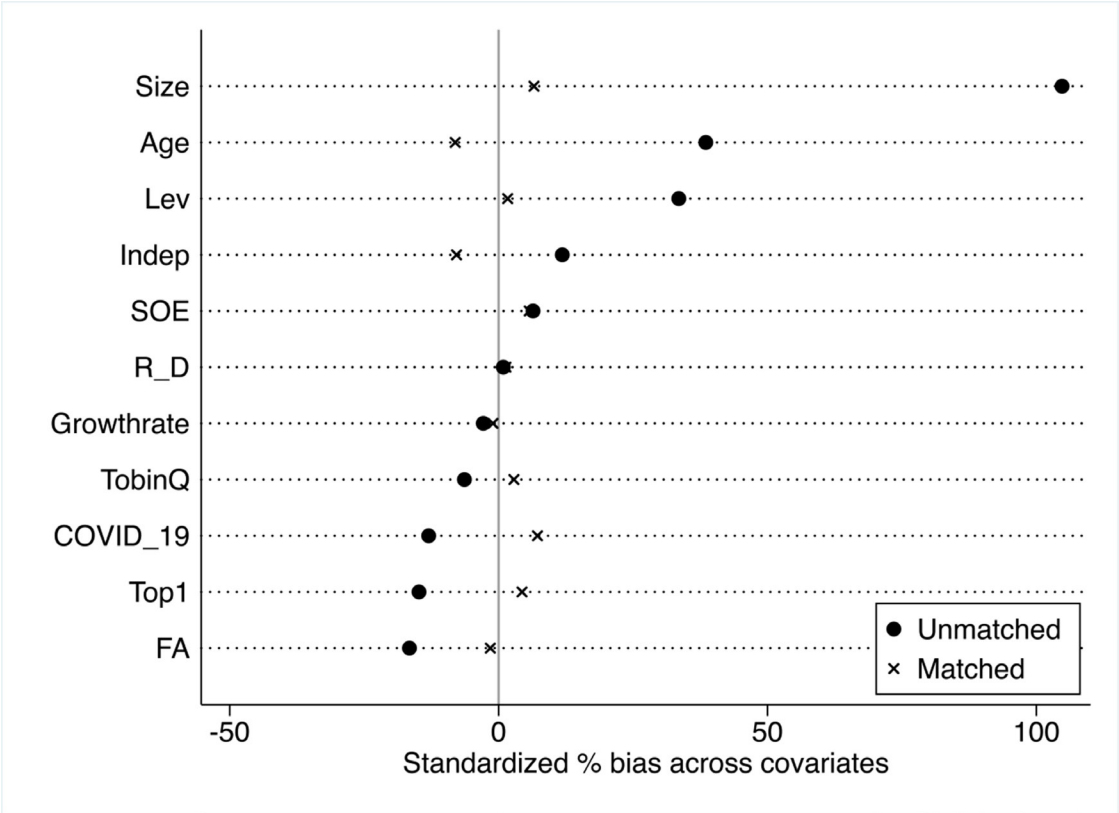


**Figure 5.** Kernel density before and after PSM

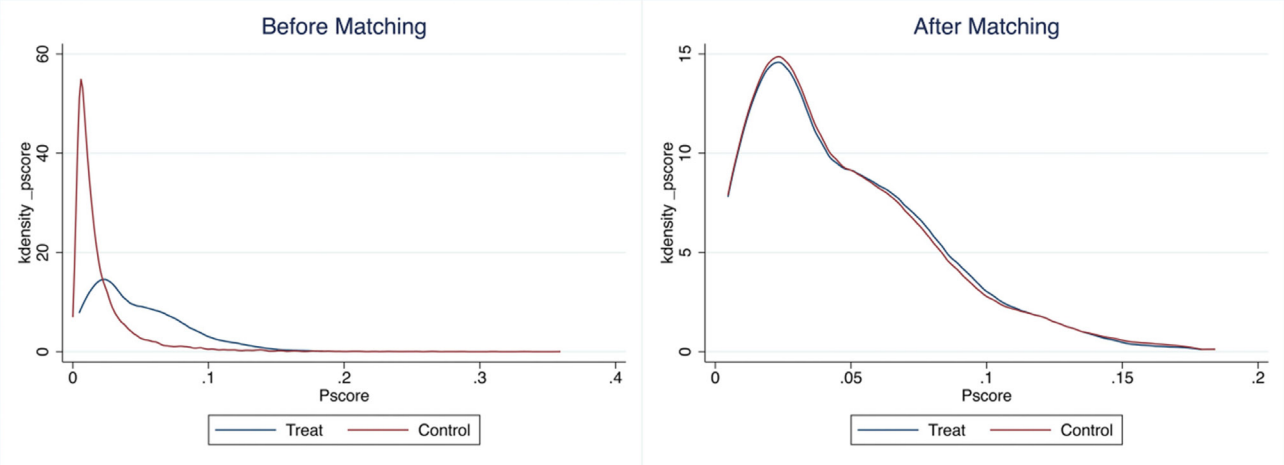
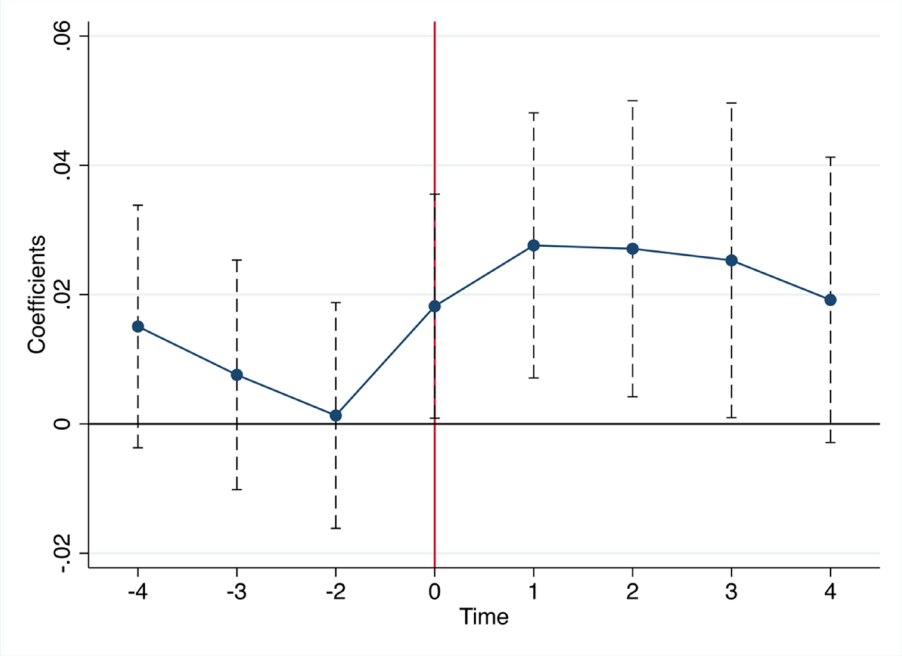



**Figure 6.** Parallel-trend test




***Endogeneity test***

Although individual and time effects were incorporated into the baseline regressions to manage heterogeneity in firms' financial performance, endogeneity problems may still persist due to reverse causality. High ROA not only reflects strong profitability but also a higher competitiveness and risk tolerance, making companies more willing to invest in DT even if the latter causes short-term financial pressure. To address this issue, we selected the lagged one-period year-end ratio of mobile phone subscribers in the city where the company operates *(MphoneUsers*$_{t-1}$*)* [113] and the lagged one-period degree of Digital Economy Index *(DEI*$_{t-1}$*)* of cities as instrumental variables (IV).

The digital transformation of a firm is closely linked to the external digital environment of its region. The mobile phone penetration rate in the city where the firm's headquarters is located serves as an indicator of the local digital infrastructure. This infrastructure influences the parent company's digital adoption and its efforts to implement digital technologies in subsidiaries across various cities. Due to the differences in urban development across China, firms based in cities with higher mobile phone penetration are generally more advanced in digital transformation [114], thereby satisfying the relevance condition for this instrument. Additionally, the exogeneity condition is met, as the local mobile penetration rate is unlikely to have a direct impact on the company's financial performance. Similarly, following Tao et al. [115], a city-level DEI index was constructed using data from the *China Urban Statistical Yearbook* and *Local Statistical Yearbook*, applying the entropy weight method. The DEI$_{t-1}$ reflects the overall digital infrastructure and digital economy level in a city, but it does not directly influence a company's financial performance.

The first stage in Table 6 reveals that the coefficients for *MphoneUsers*$_{t-1}$ and *DEI*$_{t-1}$ are significantly positive, indicating that the IV and endogenous explanatory variables are highly correlated. In Column (5), the p-value of the Klei-

bergen-Paap rk LM statistic is below 0.01, signifying that the null hypothesis of "under-identification of IV" is rejected at the 1% level of significance. The Cragg-Donald Wald F statistic and the Kleibergen-Paap Wald rk F statistic both surpass the 10% critical threshold (19.93), rejecting the null hypothesis of "weak IV". P-value for the Hansen J-test test is higher than 0.1, suggesting the absence of an over-identification problem. The results of the second stage indicate that the impact of DT on CFP is significantly negative at the 1% level (-0.0799). Moreover, the absolute value of the coefficients of DT increase compared to the two-fixed effects regression (-0.0175). Thus, the estimated impact of DT on CFP is greater after accounting for endogeneity, indicating that the findings derived in this paper are robust.

**Table 6.** Robustness test and endogeneity test results

| | Alternative variable | | | PSM-DID | TSLS-First stage | | TSLS-Second stage |
|---|---|---|---|---|---|---|---|
| | ROE | WW | CFP | CFP | DT | DT | CFP |
| DT | -0.0849** | 0.0947*** | -0.0170*** | -0.0156*** | | | -0.0799*** |
| | (-2.27) | (4.09) | (-4.06) | (-3.85) | | | (-3.48) |
| WW | | | -0.0049*** | | | | |
| | | | (-2.89) | | | | |
| DID | | | | 0.0110** | | | |
| | | | | (2.02) | | | |
| Mphone Users$_{t-1}$ | | | | | 0.1637*** | | |
| | | | | | (4.07) | | |
| DEI$_{t-1}$ | | | | | | 0.0965*** | |
| | | | | | | (4.21) | |
| Size | 0.0376*** | -0.1295*** | 0.0065*** | 0.0122*** | -0.0063** | -0.0186*** | 0.0140*** |
| | (3.42) | (-18.95) | (5.13) | (9.20) | (-2.27) | (-6.92) | (13.44) |
| Age | -0.0055 | -0.0052 | -0.0037** | -0.0034** | 0.0023 | 0.0035 | -0.0009*** |
| | (-0.35) | (-0.53) | (-2.11) | (-2.07) | (0.58) | (0.91) | (-6.72) |
| Growthrate | 0.0911*** | -0.0716*** | 0.0352*** | 0.0330*** | -0.0006*** | -0.0005*** | 0.0003 |
| | (7.96) | (-10.09) | (27.26) | (27.01) | (-2.94) | (-3.09) | (1.16) |
| Lev | -0.0979*** | -0.0550*** | -0.0955*** | -0.1665*** | 0.0001 | 0.0436*** | -0.1356*** |
| | (-6.00) | (-5.43) | (-52.02) | (-33.94) | (0.02) | (4.44) | (-19.28) |
| R&D | -0.0004 | -0.0011 | 0.0003** | 0.0000 | -0.0015*** | -0.0007*** | -0.0001 |
| | (-0.40) | (-1.52) | (2.47) | (0.04) | (-5.46) | (-2.95) | (-0.25) |
| FA | -0.1909*** | -0.1646*** | -0.0853*** | -0.0489*** | -0.1048*** | -0.0674*** | -0.0381*** |
| | (-3.20) | (-4.45) | (-12.71) | (-7.04) | (-6.98) | (-5.04) | (-4.92) |
| SOE | -0.0286 | -0.0228 | -0.0041 | 0.0006 | 0.0194*** | 0.0044 | -0.0082*** |
| | (-1.04) | (-1.34) | (-1.32) | (0.21) | (2.80) | (0.74) | (-3.42) |

| | Alternative variable | | | PSM-DID | TSLS-First stage | | TSLS-Second stage |
|---|---|---|---|---|---|---|---|
| | ROE | WW | CFP | CFP | DT | DT | CFP |
| Indep | -0.0077 | -0.0000 | -0.0003 | -0.0001 | 0.0001 | -0.0020 | -0.0006 |
| | (-0.60) | (-0.01) | (-0.19) | (-0.05) | (0.02) | (-0.71) | (-0.35) |
| Top1 | 0.0006 | 0.0003 | 0.0003*** | 0.0003*** | 0.0005*** | 0.0003* | 0.0003*** |
| | (0.80) | (0.67) | (3.25) | (4.16) | (2.76) | (1.69) | (4.04) |
| TobinQ | 0.0092*** | -0.0003 | 0.0022*** | 0.0029*** | -0.0015** | -0.0008 | 0.0048*** |
| | (3.16) | (-0.18) | (6.60) | (7.69) | (-2.10) | (-1.26) | (3.24) |
| COVID-19 | 0.0054 | 0.1213 | 0.0066 | 0.0021 | 0.0421 | 0.0212 | -0.0041* |
| | (0.04) | (1.31) | (0.39) | (0.13) | (1.12) | (0.66) | (-2.00) |
| Constant | -0.6354** | 2.0176*** | -0.0201 | -0.1250*** | 0.2574*** | 0.2139*** | -0.2022*** |
| | (-2.39) | (12.22) | (-0.67) | (-3.91) | (2.81) | (3.24) | (-9.17) |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 12.833 | 12.833 | 12.833 | 9.898 | 10.439 | 10.439 | 10.439 |
| R-squared | 0.013 | 0.196 | 0.273 | 0.215 | 0.027 | 0.054 | 0.2305 |
| Kleibergen-Paap rk LM statistic | | | | | | | 105.696 [0.0000] |
| Kleibergen-Paap rk Wald F statistic | | | | | | | 68.994 |
| Cragg-Donald Wald F statistic | | | | | | | 408.492 |
| Hansen J test | | | | | | | 0.049 [0.8254] |

*Note*: The T statistic is in parentheses; *, **, and *** represent significance levels of 10%, 5%, and 1%, respectively; the P value is in brackets.

## Dynamic Analysis

Building upon our baseline findings which consistently indicated a negative contemporaneous association between digital transformation and firm performance, we further investigate the temporal dynamics of this relationship. Recognizing that the impacts of strategic investments like DT often unfold over time and may involve initial costs followed by eventual benefits, we employ a distributed lag model (DLM). This allows us to disentangle the immediate versus lagged effects of DT on ROA, while controlling for performance persistence ($ROA_{t-1}$). The model takes the form:

$$CFP_{i,t} = \alpha_0 + \alpha_1 DT_{i,t} + \alpha_2 DT_{i,t-1} + \alpha_3 ROA_{i,t-1} + \\ + \alpha_4 Controls_{i,t} + \sum Year + \sum Firm + \nu_{i,t}, \quad (9)$$

In Table 7, the DLM estimation yields nuanced insights that refine our initial baseline interpretation. First, the coefficient on lagged ROA is significantly positive at the 1% level, confirming the expected performance persistence. Second, consistent with our baseline static models, the coefficient on contemporaneous DT remains significantly negative. This reinforces the finding that, in the short term, engaging in DT is associated with lower ROA, likely reflecting the significant upfront investments, implemen-

tation challenges, and potential operational disruptions inherent in these initiatives. Crucially, however, the dynamic analysis reveals a contrasting picture over a slightly longer horizon. The coefficient on the first lag of DT is significantly positive. This suggests that the performance benefits derived from digital transformation—such as enhanced efficiency, improved innovation, or better market positioning—begin to materialize and outweigh the initial costs in the period following the primary investment and implementation phase.

Taken together, the DLM results reconcile the negative finding from the static baseline model with the strategic imperative often ascribed to digitalization. The negative contemporaneous effect primarily captures the initial investment phase and adjustment costs, while the positive lagged effect signals the eventual realization of benefits. This pattern strongly suggests a J-curve dynamic, where performance initially dips due to DT implementation before subsequently improving as the transformation matures and yields returns.

**Table 7.** Dynamic Analysis

| | Model (9) | | | |
|---|---|---|---|---|
| | CFP | CFP | CFP | CFP |
| DT | -0.0288*** | -0.0179*** | -0.0188*** | -0.0128** |
| | (-4.93) | (-2.91) | (-3.38) | (-2.22) |
| $ROA_{t-1}$ | 0.5505*** | 0.1967*** | 0.3638*** | 0.0968*** |
| | (73.39) | (20.78) | (43.10) | (10.34) |
| $DT_{t-1}$ | 0.0123** | 0.0166*** | 0.0143** | 0.0142** |
| | (2.10) | (2.72) | (2.57) | (2.47) |
| Size | | | 0.0094*** | 0.0206*** |
| | | | (19.30) | (14.42) |
| Age | | | -0.0005*** | -0.0037** |
| | | | (-6.17) | (-2.24) |
| Growthrate | | | 0.0011*** | 0.0010*** |
| | | | (6.58) | (6.58) |
| Lev | | | -0.0931*** | -0.1756*** |
| | | | (-29.19) | (-32.86) |
| R&D | | | -0.0000 | 0.0002 |
| | | | (-0.15) | (1.56) |
| FA | | | -0.0285*** | -0.0598*** |
| | | | (-7.15) | (-8.45) |
| SOE | | | -0.0023* | -0.0015 |
| | | | (-1.77) | (-0.47) |
| Indep | | | 0.0002 | -0.0009 |
| | | | (0.20) | (-0.60) |
| Top1 | | | 0.0002*** | 0.0004*** |
| | | | (5.56) | (4.26) |
| TobinQ | | | 0.0026*** | 0.0025*** |
| | | | (9.90) | (7.64) |

| | Model (9) | | | |
|---|---|---|---|---|
| | CFP | CFP | CFP | CFP |
| COVID-19 | | | -0.0067** | 0.0025 |
| | | | (-2.37) | (0.18) |
| Constant | 0.0168*** | 0.0307*** | -0.1696*** | -0.3089*** |
| | (26.83) | (17.07) | (-8.65) | (-9.26) |
| Year FE | No | Yes | Yes | Yes |
| Industry FE | No | No | Yes | No |
| City FE | No | No | Yes | No |
| Firm FE | No | Yes | No | Yes |
| Observations | 11,131 | 11,131 | 11,131 | 11,131 |
| R-squared | 0.332 | 0.058 | 0.436 | 0.171 |

*Note:* The T statistic is in parentheses; *, **, and *** represent significance levels of 10%, 5%, and 1%, respectively.

# Heterogeneity analysis

## Heterogeneity in shareholdings

According to the resource-based view (RBV), state-owned enterprises (SOEs) benefit from unique resource endowments that enable them to secure government funding and policy advantages [117; 118]. This support allows SOEs to more effectively manage the high costs and inherent risks of digital transformation. These enterprises can not only leverage government-provided resources and policies to alleviate financial pressures during the initial stages of digital transformation but also fulfil public policy objectives [119] and social responsibilities, thereby enhancing the drive for long-term sustainable development through digital transformation [120]. This approach strengthens relationships with stakeholders, allowing SOEs to gain more social capital and market trust and mitigating the short-term negative impacts of transformation on financial performance. In contrast, private enterprises often face greater challenges in the process of digital transformation, especially in the context of "ownership discrimination" in China, where they struggle to obtain credit support comparable to that of SOEs [113]. Financing constraints impose greater financial pressure on private enterprises, making it difficult for them to advance digital agendas smoothly, which may lead to a deterioration in financial performance. We conduct heterogeneity analysis to verify the differences between firms with different equity natures. We set SOE = 1 if the enterprise is an SOE, and SOE=0 otherwise. The results in Table 8 show that the effect of digital transformation on financial performance is significantly negative (-0.0317) at the 1% level in private enterprises and that the effect is not significant in SOEs. This confirms our view above.

## Heterogeneity of the competitive market environment

The intensity of market competition may directly influence firms' resource allocation and strategic choices regarding digital transformation, leading to potential variations in the latter's impact on financial performance across different competitive environments. In this study, the Herfindahl-Hirschman Index (HHI) is used as a proxy variable for the degree of market competition, and heterogeneity is analysed based on the median split of HHI. HHI = 0 if HHI is greater than the median, and HHI = 1 otherwise. Typically, industries with lower HHI values experience more intense competition. The results in Table 8 indicate that in highly competitive environments (HHI = 1), the coefficient for digital transformation is negative at the 1% significance level (-0.0293), whereas in less competitive environments (HHI = 0), the relationship is not statistically significant.

Overall, intense market competition challenges firms' profitability [121]. It also necessitates substantial resource allocation across multiple domains, including product development, marketing, and digital infrastructure. On account of limited resources, firms may struggle to balance these investments, constraining the depth and efficiency of their transformation efforts [122]. This directly impacts internal management decisions and resource allocation efficiency, hindering the ability to rapidly achieve

profitability through digital transformation and negatively affecting financial performance. Conversely, in less competitive markets, firms face reduced external pressures and are less disrupted by competitors with regard to resources and financing channels [123]. This allows for more deliberate planning and implementation of digital transformation. Such firms have sufficient time and resources to integrate digital technologies with existing business models, enhancing operational efficiency without significantly increasing costs. Therefore, in less competitive markets, digital transformation is unlikely to negatively impact financial performance and may even contribute to long-term financial gain, though this result is not statistically significant.

## Heterogeneity of firm age

We further categorized enterprises by the number of years since IPO, using the sample median. Enterprises with an IPO age greater than 13 years were assigned Age = 1, while those with an IPO age of 13 years or less were assigned Age = 0. The results in Table 8 indicate that digital transformation has a significantly negative impact on financial performance for long-listed enterprises, while the impact is not significant for younger enterprises.

Long-listed enterprises typically possess substantial industry experience and resource accumulation, but they also face significant challenges related to organizational inertia and structural change [12]. During the digital transformation process, these well-established firms often need to invest heavily in system upgrades and process reengineering, which not only incurs financial costs but may also disrupt existing business models and competitive advantages [59]. According to the resource-based view (RBV), this process of reconfiguring resource allocation can lead to a short-term decline in financial performance, posing a threat to the survival of large, well-established firms that were successful during the pre-digital economy era [60], especially if they fail to effectively manage organizational changes during the transformation. In contrast, younger enterprises are typically more flexible and adaptable, allowing them to swiftly adjust their business models and integrate new technologies with existing resources during digital transformation. Although younger firms also face the challenge of resource consumption during the transformation, their lower organizational inertia and higher innovation capacity result in a smaller negative impact on financial performance, and they may even benefit from the transformation. The results of this heterogeneity test further validate the findings in our benchmark regression.

**Table 8.** Heterogeneity test of shareholdings, competitive market environment, and firm age

| | SOE = 0 | SOE = 1 | HHI = 0 | HHI = 1 | Age = 0 | Age = 1 |
|---|---|---|---|---|---|---|
| | CFP | CFP | CFP | CFP | CFP | CFP |
| DT | -0.0317*** | -0.0044 | 0.0026 | -0.0293*** | 0.0096 | -0.0258*** |
| | (-4.70) | (-0.85) | (0.40) | (-4.88) | (1.39) | (-4.31) |
| Size | 0.0060*** | 0.0157*** | 0.0059*** | 0.0104*** | 0.0247*** | 0.0096*** |
| | (2.90) | (9.46) | (3.03) | (5.22) | (9.95) | (5.32) |
| Age | -0.0050* | -0.0024 | -0.0010 | -0.0057** | -0.0064*** | -0.0031 |
| | (-1.94) | (-1.02) | (-0.38) | (-2.33) | (-3.10) | (-1.10) |
| Growthrate | 0.0477*** | 0.0245*** | 0.0389*** | 0.0348*** | 0.0482*** | 0.0287*** |
| | (23.33) | (15.50) | (21.20) | (18.17) | (24.32) | (15.92) |
| Lev | -0.0916*** | -0.1784*** | -0.0911*** | -0.1550*** | -0.1812*** | -0.0893*** |
| | (-42.05) | (-27.85) | (-43.04) | (-20.46) | (-23.08) | (-39.77) |
| R&D | 0.0003 | 0.0005*** | 0.0003 | 0.0003* | 0.0002 | 0.0003* |
| | (1.44) | (3.29) | (1.37) | (1.83) | (0.71) | (1.69) |
| FA | -0.1080*** | -0.0509*** | -0.0654*** | -0.0892*** | -0.0990*** | -0.0777*** |
| | (-9.54) | (-6.21) | (-7.09) | (-8.47) | (-9.76) | (-7.65) |
| SOE | | | 0.0026 | -0.0058 | -0.0003 | -0.0004 |
| | | | (0.53) | (-1.34) | (-0.06) | (-0.09) |
| Indep | 0.0039 | -0.0024 | -0.0020 | 0.0014 | -0.0011 | 0.0003 |
| | (1.34) | (-1.50) | (-1.02) | (0.61) | (-0.47) | (0.12) |

| | SOE = 0 CFP | SOE = 1 CFP | HHI = 0 CFP | HHI = 1 CFP | Age = 0 CFP | Age = 1 CFP |
|---|---|---|---|---|---|---|
| Top1 | 0.0000 | 0.0003*** | 0.0005*** | -0.0000 | 0.0001 | 0.0003* |
| | (0.30) | (3.26) | (3.89) | (-0.08) | (1.09) | (1.94) |
| TobinQ | 0.0026*** | 0.0006 | 0.0025*** | -0.0011** | 0.0030*** | 0.0014*** |
| | (5.87) | (1.22) | (5.85) | (-1.98) | (5.57) | (2.73) |
| COVID-19 | 0.0046 | -0.0085 | -0.0144 | 0.0182 | 0.0087 | 0.0015 |
| | (0.19) | (-0.37) | (-0.59) | (0.78) | (0.43) | (0.06) |
| Constant | -0.0050 | -0.1955*** | -0.0423 | -0.0397 | -0.3997*** | -0.0766 |
| | (-0.11) | (-4.40) | (-0.90) | (-0.86) | (-7.24) | (-1.32) |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 6,247 | 6,586 | 6,500 | 6,333 | 5,757 | 6,383 |
| R-squared | 0.367 | 0.172 | 0.345 | 0.163 | 0.282 | 0.307 |

*Note*: The T statistic is in parentheses; *, **, and *** represent significance levels of 10%, 5%, and 1%, respectively.

## Heterogeneity in environmental, social, and governance performance

Given the distinct characteristics of the three ESG dimensions, this study groups firms by their average environmental, social, and governance scores to investigate the effect of these differences on the relationship between digital transformation and financial performance. The findings in Table 9 show that variations in environmental performance have little effect on this relationship: digital transformation negatively impacts financial performance regardless of environmental performance. However, differences in social responsibility and governance performance significantly influence this relationship. When social responsibility and governance are weak, digital transformation notably harms financial performance, but when they are strong, this negative impact becomes insignificant.

Further analysis reveals that strong social responsibility and governance performance send positive signals to the market, boosting investor confidence and support [65], attracting government policy support and financial subsidies [84], and increasing opportunities for credit financing within the supply chain [83]. These factors alleviate the financial pressures associated with the significant investments required for digital transformation [78], thereby improving financial performance. Additionally, high levels of social responsibility and internal governance can attract top-tier human resources [70], providing sustained momentum for digital transformation, increasing its efficiency, and mitigating the negative impacts of initial cost increases and profitability declines. This helps buffer the risk of deteriorating financial performance. These findings offer a deeper analysis of the moderating role of ESG performance and further clarify how each dimension individually influences this relationship.

**Table 9.** Heterogeneity test of environmental, social, and governance performance

| | E_high CFP | E_low CFP | S_high CFP | S_low CFP | G_high CFP | G_low CFP |
|---|---|---|---|---|---|---|
| DT | -0.0226*** | -0.0157*** | 0.0014 | -0.0332*** | -0.0057 | -0.0221*** |
| | (-3.28) | (-2.59) | (0.26) | (-4.53) | (-1.16) | (-2.91) |
| Size | 0.0144*** | 0.0088*** | 0.0209*** | 0.0027 | 0.0106*** | 0.0051** |
| | (7.08) | (4.63) | (11.45) | (1.27) | (6.60) | (2.17) |
| Age | -0.0043** | -0.0030 | -0.0041** | -0.0029 | -0.0046** | -0.0033 |
| | (-2.08) | (-1.02) | (-2.16) | (-0.79) | (-2.47) | (-0.98) |
| Growthrate | 0.0399*** | 0.0325*** | 0.0357*** | 0.0352*** | 0.0388*** | 0.0315*** |
| | (21.30) | (17.45) | (20.75) | (17.04) | (25.34) | (13.82) |
| Lev | -0.1987*** | -0.0861*** | -0.1881*** | -0.0841*** | -0.1493*** | -0.0874*** |
| | (-26.55) | (-40.92) | (-26.50) | (-37.95) | (-25.07) | (-34.20) |

| | E_high CFP | E_low CFP | S_high CFP | S_low CFP | G_high CFP | G_low CFP |
|---|---|---|---|---|---|---|
| R&D | -0.0001 | 0.0004* | -0.0000 | 0.0007*** | -0.0000 | 0.0008*** |
| | (-0.54) | (1.91) | (-0.17) | (2.93) | (-0.25) | (3.07) |
| FA | -0.0851*** | -0.0710*** | -0.0728*** | -0.0789*** | -0.0697*** | -0.0925*** |
| | (-8.68) | (-6.76) | (-7.07) | (-7.61) | (-9.53) | (-6.92) |
| SOE | -0.0043 | -0.0075 | -0.0004 | -0.0066 | -0.0037 | -0.0064 |
| | (-0.95) | (-1.59) | (-0.10) | (-1.26) | (-1.01) | (-1.16) |
| Indep | 0.0002 | -0.0016 | -0.0005 | -0.0014 | 0.0002 | -0.0021 |
| | (0.10) | (-0.70) | (-0.28) | (-0.52) | (0.11) | (-0.65) |
| Top1 | 0.0003** | 0.0003** | 0.0004*** | 0.0003** | 0.0004*** | 0.0002 |
| | (2.52) | (2.41) | (3.29) | (2.01) | (4.59) | (1.42) |
| TobinQ | 0.0046*** | 0.0009** | 0.0069*** | -0.0001 | 0.0050*** | 0.0006 |
| | (6.10) | (2.22) | (11.17) | (-0.17) | (10.96) | (1.12) |
| COVID-19 | 0.0142 | -0.0079 | 0.0045 | -0.0031 | 0.0195 | -0.0012 |
| | (0.70) | (-0.28) | (0.25) | (-0.09) | (1.10) | (-0.04) |
| Constant | -0.1467*** | -0.0703 | -0.3099*** | 0.0660 | -0.0963*** | 0.0190 |
| | (-3.10) | (-1.53) | (-7.52) | (1.17) | (-2.64) | (0.33) |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes |
| FirmFE | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 6,059 | 6,774 | 7,014 | 5,819 | 7,602 | 5,231 |
| R-squared | 0.234 | 0.322 | 0.212 | 0.340 | 0.224 | 0.317 |

*Note*: The T statistic is in parentheses; *, **, and *** represent significance levels of 10%, 5%, and 1%, respectively.

## Conclusion and discussion

Our results show that digital transformation as a means of innovation policy has a complex dynamic effect on the financial performance of mature, large-cap Chinese firms. Specifically, we observe an initial detrimental impact, contrasting with some prior studies [2; 47; 48].This research focuses on Chinese enterprises characterized by organizational inertia, extensive infrastructure, and heavy reliance on traditional business models. Moreover, unlike previous scholars who measure digital transformation using words frequency [86] or a dummy variable [48], we adopt digital assets as an indicator of the digital transformation level. Digital assets serve as a better explanatory variable for studying the effect of digital transformation on return on assets, providing a more accurate reflection of a firm's involvement in digital innovation. Our findings offer a new perspective by highlighting that, for mature enterprises, digital transformation is still largely at the digital equipment and technology application stage, which requires substantial initial investments. This upfront investment explains the initial negative impact on ROA. However, consistent with a J-curve dynamic often seen in large-scale investments, the benefits of digital transformation are not immediate but manifest later,, leading to disproportionate increases in operational costs relative to revenue and, consequently, a short-term decline in return on assets. Additionally, this study examines the considerable failure rate of digital transformation and the resulting operational uncertainties, particularly with regard to traditional business model changes and the impact on the core business. These circumstances support the digitalization paradox theory [8], which links digital investments to challenges in revenue growth. Our study goes further by providing a more comprehensive analysis of how these digital investments lead to imbalanced costs and returns over time, negatively impacting overall financial performanceinitially, and identifying the mediating role of financing constraints in this process.

In light of these findings highlighting the dynamic, J-curve-like nature of returns, it is essential for firms to recognize the potential for temporary financial setbacks during the initial phases of digital technology adoption. These challenges largely stem from increased capital expenditures, heightened operational costs, and the complexities of integrating digital technologies into existing business processes before the longer-term benefits materialize. To mitigate these risks, companies must adopt a strategic approach that carefully aligns digital transformation initiatives with their core business objectives. A targeted, phased implementation strategy, where key business functions are prioritized for digital integration, can help minimize operational disruptions and optimize resource allocation. Furthermore, firms must enhance their risk assessment and management frameworks to better navigate the uncertainties inherent in digital transformation. By refining their digital strategies

and improving risk management practices, firms can better balance the initial costs inherent in this dynamic effect with the long-term benefits of digital transformation.

Furthermore, this research highlights the crucial synergy between digital innovation and ESG management innovation in improving the financial performance of large, mature firms from a sustainable development perspective. It underscores the importance for companies to integrate sustainability principles into their digital transformation initiatives. The findings show that ESG effectively alleviates the adverse effects of digital transformation (particularly the initial downturn) by reducing financing constraints. Strong ESG performance enhances stakeholder tolerance for financial performance declines during digital transformation and raises expectations for its eventual success. Strong ESG practices also help to address challenges in human capital, facilitate the smoother integration of digital technologies, improve risk management, and reduce uncertainties associated with the transformation's dynamic payoff structure. From a signalling theory perspective, ESG sends positive signals to capital markets about a firm's long-term sustainable development goals, countering potential negative signals of digital transformation failures and slow returns and easing financing constraints. Moreover, ESG strengthens trust with suppliers, customers, and regulators, expanding financing channels. It further supports Yin's [124] argument that integrating digital technologies with green activities is a crucial factor in boosting digital competitiveness.

Our research findings provide new strategic ideas for firms on advancing digital transformation agendas and offsetting the dynamic short-term financial pressures brought by digital transformation through an improvement of ESG performance, ultimately promoting long-term sustainable development. At the same time, enhanced ESG performance is a focus for companies aiming to bolster their market reputation and financing capacity.

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# Dividend Policy of Russian Companies: Impact of Board of Directors

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## Abstract

The purpose of this study is to examine the relationship between corporate governance and dividend policy of Russian companies based on two theoretical models: the outcome model and the substitution model, which imply the opposite nature of the relationship between corporate governance and dividend payments. The main characteristics of the board of directors as a key mechanism of corporate governance are considered: women representation on the board, independence of the board, the share of directors with foreign experience, frequency of meetings, permanence of the board composition, the average tenure of board members, concurrent independent directors and CEO duality. The novelty of the study lies in analyzing a wide range of characteristics of the boards of directors of Russian public companies whose shares are traded on the Moscow Exchange. Using a sample of 31 Russian companies for the period from 2010 to 2022, fixed-effects regression models showed that the women representation on the board of directors, concurrent independent directors and permanence of the board composition are positively related to dividend payments of Russian companies. No significant relationship was found between dividend payments and such corporate governance characteristics as board independence, the share of directors with foreign experience, frequency of board meetings, and the CEO's membership in the board of directors. This may indicate the specifics of governance in Russian companies, where a high concentration of majority shareholders and government involvement may limit the influence of independent management bodies. The results of the study may be useful for company managers, investors and regulators to optimize corporate governance and make decisions regarding dividend policy.

**Keywords:** corporate governance; board of directors; dividend payments; company; outcome model; substitution model

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## Introduction

There are several reasons for which corporate governance attracts increasing attention of the global community, and they range from international economic integration to social and ethical problems. Due to capital markets' globalization companies are forced to adjust to corporate governance regulatory standards and expectations of the global investor community related to the ESG agenda, and this has a direct impact on stock returns [1].

Agency theory holds that there is a conflict of interests between shareholders and managers of the company [2]. Managers are not interested in paying dividends because they have an opportunity to apply funds towards personal privileges or prefer to reinvest profits in the projects which strengthen their control and influence on the company, even if shareholders will not gain high profits from such projects. Sound corporate governance is important in defusing the agency conflict and protecting shareholder interests. Dividend payments function as a mechanism of agency costs reduction by means of limiting the cash flow which managers may use at their sole discretion [2; 3].

There are two theoretical models which explain the relationship between corporate governance and dividend payments: the outcome model and the substitution model. They implicate existence of a positive and negative relationship, respectively [4]. Companies with well-developed corporate governance are disposed to higher dividends [4]. This is in line with the outcome model which states that well-developed corporate governance allows shareholders to exercise their rights in order to force management to pay dividends, thus, precluding managers from taking advantage of corporate funds. On the contrary, in companies with weaker corporate governance dividends may function as a substitute mechanism compensating for shortcomings in the corporate governance system. This is consistent with the provisions of the substitution model.

The authors of empirical studies obtain mixed results: some studies discover substantiation for the provisions of the outcome model [4–8], others – of the substitution model [9–11]. Consequently, there becomes relevant the research aimed to determine which model describing the relationship between corporate governance characteristics and dividend payments prevails in the Russian market.

Previous studies of the Russian market which address the relationship between corporate governance and dividend payments were mainly focused on analyzing joint-stock companies for earlier periods. So, the papers by Ambardnishvili et al. [12], Nazarova and Emelyanova [13] covered the period of 2009–2012 and 2015–2017, respectively, while Larin et al. [14] studied dividend payments of public companies for 2016. The paper by Belous [15] studies dividend policy of Russian companies under the sanctions imposed by the US and EU against the companies' board of directors and CEO. In the research by Ershova et al. the ownership structure expressed in terms of the share which belongs to the government and private business is considered a factor of corporate governance [16]. The authors reveal that influence of the ownership structure on Russian companies' dividend policy manifests itself only during external economic shocks [16].

There are two aspects of the novelty of the present research. First, we study public companies listed on the Moscow Exchange whereas the majority of previous studies were focused on joint-stock companies which did not go on to IPO [12; 13]. The difference of listed public companies from other joint-stock companies consists in more stringent requirements to information disclosure, composition of the board of directors and corporate governance structure. Public companies have to comply with regulatory standards of corporate governance, ensure transparency of financial statements and take into consideration interests of a wide range of minority shareholders. Unlike public companies non-listed joint-stock companies may have a limited number of owners and lower transparency. Second, we analyze a wider set of the board of directors' characteristics than previous studies of Russian companies. Due to adding supplementary characteristics of the board of directors we may gain a more comprehensive view of its composition and functioning.

Corporate governance is a system of mechanisms used by stakeholders to control the corporation management ensuring protection of their interests [17]. Amidst ownership separation and control there arises a need for the tools to supervise the management. The board of directors plays the key role in this process acting as the main mechanism for monitoring and control of managers' actions in the shareholders' interests [17]. As long as shareholders do not dispose of sufficient resources and incentives to control independently the management this function is delegated to the board of directors. The board of directors (BD) is the key mechanism of corporate governance which balances interests of managers and shareholders as well as transparency and accountability of the company to the investors and regulatory authorities [17–19]. Acting as a supervisory body the board of directors plays an essential role in shaping dividend policy including defining the share of net profit to be distributed among the shareholders and has the right to recommend the amount of dividend payout to the general meeting of shareholders. Dividend policy is the key instrument of corporate governance, it influences the company's investment attractiveness and ensures a balance between shareholders' and managers' interests [20]. The present research considers the relationship between the principal characteristics of the board of directors (women representation on the BD, number of the BD meetings, independence of the BD, share of directors with foreign experience on the BD, permanence of the BD composition, share of concurrent independent directors, CEO duality) and dividend payments in 31 Russian companies for 2010–2022. As a result of constructing regression models with fixed effects it was revealed that most of the studied corporate governance characteristics were positively associated

with an increase in dividend payments in Russian companies. This result may support partially the outcome model. We are also the first to study the relationship between permanence of the BD composition and dividend payments of Russian companies and we find out that a more stable BD composition is related positively to the amount of company's dividend payments.

The paper consists of three sections. In the first one we conduct a survey of the studies which interconnect corporate governance characteristics with dividend payments. On the basis of the review the research hypotheses are generated. The second section describes the data and methodology of the research. The third section presents the modeling results and discussion.

## Literature Review

Literature identifies two models of the relationship between corporate governance and dividend payments – the outcome model and substitution model [4] which imply existence of a positive and negative relationship, respectively.

According to the outcome model dividend payments are a result of strong protection of shareholders' interests [4]. Corporate governance is a set of mechanisms aimed at ensuring for the investors a certain return on capital employed [21; 22]. Corporate governance is aimed at securing the shareholder rights as well as control over decision-making processes and actions of managerial staff [7]. In case of highly protected rights minority shareholders exercise their powers to force companies to pay dividends, thus, precluding managers and controlling shareholders from use of corporate cash flows to their own advantage [4; 23; 24]. Shareholders may vote for directors who support certain dividend policy; provide a stricter control over the corporation making it less attractive for managers to retain excess cash flows; file lawsuits against the companies spending excessive amounts on the operations beneficial only for the managers [4]. Dividend payments protect investors from expropriation by management and principal shareholders: the stronger corporate governance the better the rights of minority shareholders are secured and the greater the amount of dividends paid by the company.

As per the substitution model dividend payments act as a substitute mechanism of legal protection and a compensation for shortcomings in the corporate governance system. Companies with weak corporate governance pay dividends to develop a positive reputation with shareholders in order to raise capital on beneficial terms in the future [4]. In the countries with poor legal protection of minority shareholders it is of particular importance because dividends are the key mechanism for mitigation of the risk of shareholders' resource expropriation by managers [4]. Dividend payments defuse the conflict of interests between managers and shareholders compensating for drawbacks of corporate governance [11; 25]. Unlike the outcome model the substitution model implies a negative relationship between the corporate governance quality and dividend payments.

Thus, there are two concepts: the outcome model implicating a positive relationship between the corporate governance quality and dividend payments and the substitution model implying a negative relationship with dividend payments. The research issue of the present paper is: which model prevails in the Russian market – is there a relationship between high dividend payments and highly developed corporate governance or do they serve as a mechanism for compensation of its drawbacks?

Previous studies performed in the Russian market mainly supported implications of the outcome model [12–14; 26]. Therefore, hypotheses of the present research are put forward premised on the results of the outcome model.

The board of directors is an important part of corporate governance and plays a critical role in shaping the corporate strategy and decision-making in a company. The upper echelons theory postulates that personal characteristics and experience of top managers and directors produce a significant impact on strategic decisions and, consequently, on the company performance [27]. Proceeding from this, the assumption is made that the efficiency of control over management depends on the composition of the board and characteristics of its members [28].

The principal BD characteristics which determine the corporate governance quality are: the frequency of BD meetings [5; 29], independence of BD members [30], women representation on the BD [31; 32], share of directors with foreign experience on the BD [33], permanence of the BD composition [8], concurrent independent directors [8] and CEO duality [34].

### Regularity of the Board of Directors' Meetings

Regular meetings help the BD to control the company operations and take informed decisions [35–37]. More frequent BD meetings tighten monitoring of managers' activity and boost shareholders' confidence in protection of their interests. This results in lower agency costs [38]. Regular meetings may enhance the board of directors' efficiency, besides, the frequency of meetings is an indicator that directors fulfill their duties [39].

Most previous studies are focused on examining the relationship between regularity of meetings and corporate financial performance [38; 40-45]. In spite of empirical confirmation of significance of the board meetings' regularity for corporate governance, compliance with regulatory requirements and improvement of corporate financial performance [46; 47] empirical data concerning the relationship between the frequency of meetings and dividend payments are still contradictory. Some studies, for example, the ones examining emerging markets of Eastern Asia [5] and Saudi Arabia [29] detect a positive relationship between the number of the board meetings and dividend payments (the outcome model). In the markets of the UK [37], Sri Lanka [48] and Malaysia [9] a negative relationship was found (the substitution model).

Thus, we presume that more frequent meetings of the board of directors drive improvement of the corporate governance quality because they provide an opportunity to respond timely to changes in the company improving control over management activities and reducing information asymmetry. This makes decision-making more transparent and efficient.

**Hypothesis 1.** The frequency of meetings of the board of directors has a positive relationship with dividend payments of Russian companies.

## Independence of the Board of Directors

Independence of the BD is measured as the share of independent directors in the total number of BD members [49]. In Russia a director is considered to be independent if he has no relations with company's contractors, competitors or the government. The Bank of Russia recommends companies to have the boards of directors represented by independent directors at least by one third and also encourages to assess independence of the board of directors' members on a regular basis.

Inability to serve the shareholders' and company interests may undermine the directors' reputation. Therefore, independent directors have a stake in controlling the actions of managers in order to keep up their public reputation [50]. This also helps them to avoid potential lawsuits and retain their position on the board of directors [51; 52]. Greater board independence improves internal control and makes management more disciplined. As a result, protection of shareholder interests improves and agency costs decrease [8].

A lot of studies confirm the outcome model: independence of the board is positively associated with dividend payments both in the emerging market of Australia [53] and Sri Lanka [48] as well as in the US market [8; 54]. Nevertheless, some studies detect a negative relationship, and this is in line with the conclusions of the substitution model: if independent directors have proper authority to control managers' activity it is not so necessary to pay dividends as a means of protecting shareholders from misconduct of the management [5; 29; 37; 55–58].

On the basis of a sample of Russian companies for 2015–2017 provisions of the outcome model were confirmed: the share of independent directors on the board has a positive relationship with the payout ratio in partially government-owned companies [13]. When independent directors are disinterested they have an opportunity to protect the shareholders' interests more often while making their decisions.

Thus, we presume that a larger share of independent directors on the board improves the corporate governance quality in the company because independent directors ensure objective control of the management, thus, reducing agency costs and protecting the shareholders' interests.

**Hypothesis 2.** The share of independent directors on the board has a positive relationship with dividend payments of Russian companies.

## Women Representation on the Board of Directors

Literature provides no consensus of opinion concerning the influence of women representation on the corporate governance quality [59]. On the one hand, a larger share of women on the board drives implementation of various ideas, prospects and experience in the decision-making process [37], as a result, this process may be improved and agency costs – reduced [60; 61]. Female directors are more likely to abide by law, they are more susceptible to ethical issues and are less risk-prone [62], and this provides better control over managers' activities [63]. Female directors pay more attention to corporate reputation and shareholder interests [62]. Studies suggest that companies with a large share of women on the board of directors pay larger dividends and this is in line with the conclusions of the outcome model [31; 48; 64-68]. On the basis of a sample of Russian companies for 2015–2017 we also confirmed the outcome model: the probability of dividend payments in Russian companies is higher if there are women on the board of directors [13]. However, conclusions of the substitution model are also empirically confirmed: the share of women on the board of directors turns out to be negatively associated with dividend payments of companies in India, China, Russia [32] and Indonesia [69].

On the other hand, some studies suggest that women's membership in the board of directors does not preclude accounting abuses or reduce agency costs [70; 71]. Probably, this is due to the fact that a large share of women on the board may complicate decision-making because they have different approaches and management style, and this potentially impedes coordination among the board members [72]. Besides, when women are appointed directors of the board as a mere formality for the sake of regulatory compliance rather than based on their competence level women's influence on corporate governance may be limited [72].

In spite of differing perspectives in literature we proceed from the assumption that an increase in the number of women on the board of directors results in improvement of the corporate governance quality driving implementation of various ideas and experience in the decision-making process, enhancing compliance with ethical standards and respect of the shareholders' interests as well as tightening control over managers' activity.

**Hypothesis 3.** Women representation on the board of directors has a positive relationship with dividend payments of Russian companies.

## Directors with Foreign Experience

Directors with foreign experience on the board of directors facilitate implementation of corporate governance best practices, especially in the countries with weak protection of investors' rights [33; 73]. An increase in the share of directors with foreign experience speeds up renewal of the BD management practices [73]. An increment in the share of directors with foreign experience on the BD strengthens

corporate governance by improving the monitoring of management's activity by the BD [74] and supports protection of shareholders' rights and interests [33]. The majority of studies reveal a positive relationship between the share of directors with foreign experience in the total number of the board members and dividend payments [33; 75-79]. Besides, based on the sample of Russian companies for 2015-2017 no significant relationship between the payout ratio and the share of directors with foreign experience was detected [13].

Thus, we assume that a large share of directors with foreign experience drives improvement of the corporate governance quality, implementation of best practices and strengthening of protection of shareholder interests.

**Hypothesis 4.** The share of directors with foreign experience on the board has a positive relationship with dividend payments of Russian companies.

## Permanence of the Board Composition

It is pointed out that in case of resignation of directors with long tenures on the board a company loses their accumulated experience and knowledge which are important for monitoring of the managerial activity [80]. Director's tenure is an important factor which determines the quality of his work performance because it allows him to accumulate more experience and knowledge [81]. When the composition of the board of directors changes the monitoring of managerial activity may weaken for some time. Directors with short tenures and limited experience perform monitoring and consulting less effectively because they lack knowledge about the company business and history [68]. Companies with serious board members' turnover are more likely to face misconduct and incur higher agency costs [82]. A more stable board of directors controls the CEO's and the entire management's activity better [82]. Thus, stability of the board composition characterized by its relative unchangeability over time ensures better control over managerial activity and reduces agency costs [8]. In this paper permanence of the board of directors is understood as the share of directors who remained on the board in comparison to the previous year.

Thus, we presume that permanence of the board of directors facilitates better control over managerial activity and reduces agency costs ensuring experience and knowledge accumulation necessary for efficient monitoring.

**Hypothesis 5.** Permanence of the board of directors has a positive relationship with dividend payments of Russian companies.

## Concurrent Independent Directors

There is no consensus of opinion in literature concerning the influence of independent directors' busyness on the corporate governance quality. On the one hand, the more boards a director participates in the stronger his reputation is because this testifies to recognition of his expertise and competence in the external market [83]. Directors who hold several positions have a better idea of various managerial strategies and business models and, consequently, have an opportunity to control the management and take decisions better [84]. The results of empirical studies show that concurrent independent directors may improve the quality of corporate governance and financial performance of the company [85; 86].

On the other hand, it may be difficult for a concurrent independent director to distribute his time and attention between different responsibilities [87]. Highly occupied directors reduce their efforts for monitoring of managerial activity in each company [88; 89], consequently, managers' misconduct becomes likelier and agency costs grow [90]. Weak corporate governance is characteristic of the companies with the majority of external directors who are simultaneously BD members in two or more companies [91]. Empirical studies detect a negative relationship between concurrent directors and dividend payments [8; 90]. In this paper concurrent directors are understood as the share of directors who occupy the position of an independent director in several companies [8].

We proceed from the assumption that a large share of concurrent directors on the board lessens control over managerial activity and results in a decline in the corporate governance quality.

**Hypothesis 6.** The share of concurrent independent directors has a negative relationship with dividend payments of Russian companies.

## Concurrent Service as the CEO and Chairman of the Board of Directors

In case of concurrent service as the CEO and chairman of the board of directors the director obtains significant control and the ability to turn down proposals of other directors [47]. Such duality of positions changes the functioning of the board of directors for the worse and softens control significantly, thus, accumulating power in the hands of the CEO [92]. As a result, the CEO gets more opportunities to pursue his own interests at the shareholders' expense, and this increases agency costs [34; 67].

The results of empirical studies are controversial: some of them confirm provisions of the outcome model and reveal a negative relationship between CEO duality and dividend payments [29; 56; 93-95] while others detect confirmations of the substitution model and find out a positive relationship with dividend payments [5; 31; 32; 65; 96].

In the Russian Federation combining positions is prohibited legislatively: according to Federal Law No. 208-FZ of 26.12.1995 as amended on 25.12.2023, a person who performs functions of the sole executive body cannot be at the

same time the chairman of the company board of directors. (supervisory board)[1]. In this paper we consider concurrent service as the CEO and a board director. CEO's membership on the board of directors casts doubt on independence of the board and may result in significant concentration of power and loosening of control of the management.

Thus, we presume that concurrent service as the CEO and chairman of the board of directors in the same company weakens control over the management because it concentrates power in the hands of the same person impairing effectiveness of the board of directors. This raises the risks of decisions which favour the CEO at the shareholders' expense, thus, increasing the agency costs and degrading the quality of corporate governance.

**Hypothesis 7.** CEO's membership on the board of directors of the same company has a negative relationship with dividend payments of Russian companies.

## Data

In the research we use data on 31 public companies from the Russian stock market for 2010–2022. The lower limit of this time interval is related to recovery from the global financial crisis of 2008-2009 while the upper limit (2022) – to the latest available reports of the company. The following restrictions of the sample have been applied:

- Companies were included in the Moscow Exchange Index on a regular basis (over 4 times within the considered time horizon);
- Within the considered period companies paid dividends at least once (3 companies were eliminated from the sample based on this criterion);
- For each company ordinary dividends are considered;
- Financial companies are eliminated.
- The sources of data are corporate annual reports, appendices to them and financial statements (IFRS).

## Methodology

In this paper the logarithm of dividends per share is the dependent variable [97-100]. We use two model specifications: the one with the variables characterizing the BD in the current period (formula (1)) and the one with the lagged variables characterizing the BD (formula (2)). Year and company fixed effects are used in all models.

$$\ln(\mathrm{DPS}_{it}) = \beta_1 + \beta_2 \mathrm{ROA}_{it} + \beta_3 \mathrm{Stage}_{it} + \beta_4 \mathrm{CAPEX}_{it} + \\ + \beta_5 \ln(\mathrm{Assets}_{it}) + \beta_6 \mathrm{Debt}_{it} + \beta_7 \mathrm{G}_{it} + \beta_8 \mathrm{Women}_{it} + \\ + \beta_9 \ln(\mathrm{Meet}_{it}) + \beta_{10} \mathrm{Age}_{it} + \beta_{11} \mathrm{Exp}_{it} + \beta_{12} \mathrm{Foreign}_{it} + \\ + \beta_{13} Ind_{it} + \beta_{14} Perm_{it} + \beta_{15} Comb_{it} + \beta_{16} CEO_{it} + \\ \beta_{17} Size_{it} + \sum_{k=1}^{K-1} \alpha_k d_{ki} + \sum_{t=1}^{T-1} \gamma_t Time_t + \varepsilon_{it}, \quad (1)$$

$$\ln(DPS_{it}) = \beta_1 + \beta_2 ROA_{it} + \beta_3 Stage_{it} + \beta_4 CAPEX_{it} + \\ + \beta_5 \ln(Assets_{it}) + \beta_6 Debt_{it} + \beta_7 G_{it} + \beta_8 Women_{it-1} + \\ + \beta_9 \ln(Meet_{it-1}) + \beta_{10} Age_{it-1} + \beta_{11} \mathrm{Exp}_{it-1} + \\ + \beta_{12} Foreign_{it-1} + \beta_{13} Ind_{it-1} + \beta_{14} Perm_{it-1} + \\ + \beta_{15} Comb_{it-1} + \beta_{16} CEO_{it-1} + \beta_{17} Size_{it-1} + \\ + \sum_{k=1}^{K-1} \alpha_k d_{ki} + \sum_{t=1}^{T-1} \gamma_t Time_t + \varepsilon_{it}, \quad (2)$$

where $DPS_{it}$ – dividends per share; $ROA_{it}$ – return on assets; $Stage_{it}$ – variable of the life cycle stage; $CAPEX_{it}$ – capital expenditures to revenue ratio; $Assets_{it}$ – total assets; $Debt_{it}$ – debt to assets ratio; $G_{it}$ – government participation share; $Women_{it}$ – women representation on the BD; $Meet_{it}$ – number of BD meetings; $Age_{it}$ – average age of the BD members; $Exp_{it}$ – average tenure of the BD members; $Foreign_{it}$ – share of directors with foreign experience; $Ind_{it}$ – share of independent BD members; $Perm_{it}$ – permanence of the BD; $Comb_{it}$ – share of concurrent independent directors; $CEO_{it}$ – binary variable taking on the value of 1 if the CEO is on the BD and 0 – otherwise; $Size_{it}$ – BD size; $d_{ki}$ – binary variables of companies; $Time_t$ – binary variables of years; $\varepsilon_{it}$ – random error. Index $i$ indicates the company number, index $t$ indicates the year; $K$ – total number of companies; $T$ – total number of years; $\beta_s, \alpha_k, \gamma_t$ – ratios.

### Control variables

The company financial performance and corporate governance characteristics are used as control variables. Debt load is related negatively to the amount of dividend payments due to interest-bearing liabilities which reduce net income and the ability to pay dividends [5; 12; 55; 101-105]. High profitability of the company generates the profit sufficient to maintain stable or growing dividend payments [97; 106]. As capital investment increases the plowback ratio grows [107]. Companies applying more funds towards capital expenditures have on average more opportunities for growth. Profit is reinvested in business expansion and development, so the share of profit allocated to dividends decreases [107]. Companies with a high book value of assets have at their disposal more internal resources to finance investment and may allocate the free cash flow to pay dividends [108]. The stage of company's life cycle determined by the earned capital ratio (the ratio of retained earnings to equity) [109] has a positive relationship with dividend payments: companies with a high ratio (with the profit accumulated for distribution) on average pay dividends more often while firms with a low ratio as a rule do not pay dividends [109; 110].

[1] Article 66. Election of the company board of directors (supervisory board).
URL: https://www.consultant.ru/document/cons_doc_LAW_8743/33caef9cd49459da61c3eed258e7beda703c467d/ (accessed date: 03.04.2024).

Analyzing dividend payments of Russian companies it is necessary to take into consideration the share of government ownership in the corporation's capital [111; 112]. According to the regulatory requirements of the Ministry of Finance of the Russian Federation partially government-owned companies have to pay dividends of at least 50% of profit calculated as per the International Financial Reporting Standards (IFRS).

We also use the board of directors' characteristics as control variables: the average age of the board members, average tenure on the BD and BD size [76; 78; 113; 114]. With advancing age directors become more conservative, are less prone to risky strategies and more inclined to pay dividends [18]. Director's tenure is defined as the number of years when the director occupies the position of a director on the board [113; 115]. Recently appointed directors may be more interested in risky projects and investing in innovation to show instant results of their activity than in dividend payments [116; 117]. Directors with longer tenure may improve monitoring and decision-making in the company [78; 81]. Long tenure enhances the quality of control, mitigates the risk of expropriation of minority shareholders' resources and has a positive relationship with dividend payments [14]. The board size has a controversial relationship with the quality of corporate governance. On the one hand, a larger board of directors may encounter communication and coordination difficulties, and this curtails its ability to control effectively the managerial actions entailing problems with corporate governance [46]. On the other hand, in researchers' opinion, an increase in the number of board members is related to higher expertise and experience and this may reduce agency costs and improve monitoring of managerial activity [118]. Taking into consideration conflicting results of the studies concerning the relationship between the board size and the corporate governance quality we use this BD characteristic feature as a control variable and do not put forward separate hypotheses to verify the results of the substitution model and outcome model [14].

All applied variables are described in Table 2 of the appendix, descriptive statistics are indicated in Table 3 of the appendix. The multiple regression model with company and year fixed effects was used to verify the suggested hypotheses [119].

Several problems may arise when constructing models. Time-invariant or slightly time-variant variables should be eliminated from the fixed effects models. For this reason, we check the number of companies where the considered variables changed over time. Thus, the number of companies with changes in the BD size within the research period is 21, the number of companies with changes in the variable of "CEO's membership on the BD" within the research period is 12. As a result, we may use these variables for modelling. As long as correlation between random errors is possible for the same companies we use standard errors clustered by companies. Another potential problem is endogeneity brought about by the two-way cause-and-effect relationship between the dependent variable and the variables of interest. In order to solve this problem we build a model using lagged values of the variables which characterize the BD. Another potential source of endogeneity is omission of an essential variable. It is eliminated by adding control variables related to corporate dividend policy. Endogeneity may be a result of self-selection: we consider the companies which have at least once made dividend payments within the studied period. However, only 3 companies were eliminated on the basis of this criterion, so we may assume that it produces no significant influence on the modelling results.

## Modelling Results

The results of modelling are presented in Table 1. Regression models revealed no significant relationship between the frequency of the board of directors' meetings and dividend payments (Table 1, Model 1). At the same time, in the model with lagged variables the coefficient preceding such variable turns out to be significant, therefore, **hypothesis 1 is partially confirmed** (Table 1, Model 2). The board of directors' meetings may be formal in nature offering to discuss routine issues and never solving major problems [120]. Frequency of such meetings may not be indicative of the actual managerial activity and quality of control over the corporate operations [46].

**Table 1.** Results of regression models

| | ln(DPS) | |
|---|---|---|
| | Model 1 | Model 2 |
| Return on assets | 5.649*** | 5.576*** |
| | (0.927) | (1.417) |
| Life cycle stage | 0.150 | -0.469 |
| | (0.269) | (0.379) |
| Capital expenditures/Revenue | -2.135 | -4.869** |
| | (1.853) | (2.049) |

| | ln(DPS) | |
|---|---|---|
| | Model 1 | Model 2 |
| Logarithm of total assets | 0.749 | 1.128** |
| | (0.527) | (0.509) |
| Debt/Total assets | 1.347* | 1.491 |
| | (0.729) | (0.960) |
| Share of government participation | 0.549 | 0.004 |
| | (0.460) | (0.646) |
| Women representation on the BD | 3.294* | 2.235* |
| | (1.846) | (1.237) |
| Logarithm of the number of BD meetings | 0.162 | 0.449*** |
| | (0.223) | (0.155) |
| Average BD age | 0.013 | 0.039 |
| | (0.034) | (0.048) |
| Average BD tenure | 0.103 | -0.083 |
| | (0.063) | (0.091) |
| Share of directors with foreign experience | 1.359 | -0.578 |
| | (0.954) | (0.793) |
| Share of independent directors | -0.566 | 0.329 |
| | (0.799) | (0.602) |
| Permanence of the BD composition | 1.206** | 1.169* |
| | (0.479) | (0.689) |
| Concurrent service | 1.973** | -0.291 |
| | (0.863) | (1.178) |
| CEO's membership on the BD | 0.113 | 0.445 |
| | (0.182) | (0.361) |
| BD size | -0.001 | 0.011 |
| | (0.048) | (0.090) |
| Number of observations | 304 | 255 |
| Within $R^2$ | 0.291 | 0.220 |
| Adjusted Within $R^2$ | 0.245 | 0.157 |

*Note*: the table presents estimates of ratios of the models with company and year fixed effects. Model 2 uses lagged variables of the BD characteristics. Standard errors clustered by companies are used. *, ** and *** stand for 10%, 5% and 1% significance levels, respectively.

We have not detected a significant relationship between independence of the board of directors and dividend payments. So, **hypothesis 2 is not confirmed** (Table 1). A serious share of majority shareholders including government entities is often characteristic of Russian companies. In such cases independence of the board of directors may be formal and not necessarily cause changes in decision-making. Independent directors may lack power sufficient to introduce significant changes in corporate policy including the dividend payment issues [65; 121]. Our result disagrees with the previous research based on a sample of Russian companies for 2015–2017 which revealed a positive relationship between independence of the board of directors and the payout ratio in partially government-owned companies [13]. Most studies support the outcome model in terms of the relationship between the share of independent directors on the board and company dividend payments [8; 30; 48; 54].

Women representation on the board of directors turns out to have a positive relationship with dividend payments in both models (Table 1). This result is in line with some previous studies [13; 31; 48; 65; 66; 103]. Thus, **hypothesis 3 is confirmed**.

Growth of the share of directors with foreign experience on the board is not statistically related to an increase in dividends per share. Thus, **hypothesis 4 is not confirmed**. This result is consistent with the previous research performed in the Russian market [13]. Foreign experience may be non-applicable in the Russian market due to significant differences in the economic conditions, corporate culture and legislative characteristic features, and this limits the influence of such directors on dividend policy.

Greater permanence of the board composition turns out to be positively related to dividend payments of the company in both models and this is consistent with the outcome model [8]. Significance of the coefficient preceding the lag of the variable of permanence of the board composition confirms its influence on dividend payments. So, **hypothesis 5 is confirmed**.

The share of concurrent independent directors turns out to have a positive relationship with dividends per share [122]. At the same time, in the model with lagged variables the coefficient preceding this variable is insignificant. **Hypothesis 6 is confirmed partially**.

We have not detected a significant relationship between CEO's membership on the board of directors and dividend payments, so **hypothesis 7 is not supported**. This result may stem from the fact that CEO's membership on the board of directors in itself is not a sufficient prerequisite for lobbying someone's own interests and influencing dividend policy [8; 37; 76; 121].

The majority of revealed significant relationships between control variables and dividend payments are in line with the results of previous studies [97; 98; 109]. The sign of the coefficient preceding the variable of the debt-to-assets ratio differs from the findings of previous studies [123]. The positive relationship of the debt-to-assets ratio may be due to the company strategy aimed at an increase of debt load in order to invest in operational components of business, and potentially this drives growth of revenue and, under otherwise equal conditions, net income of the company. Consequently, the company may rise dividend payments. The coefficients preceding the variables of the average age of BD members, BD size, average tenure of BD members and share of government participation turned out to be insignificant (Table 1, Model 2) [12].

Thus, 2 out of 7 hypotheses are confirmed fully, while two hypotheses are confirmed partially. As long as we cannot assert with complete certainty that there is a relationship between women representation on the BD and concurrent independent directors and the corporate governance quality we also cannot state univocally that the outcome model is confirmed. Dividend payments of Russian companies have a positive relationship with the number of the board meetings, women representation on the board, permanence of the board of directors and the share of concurrent independent directors. Insignificance of many board of directors' characteristics as related to their influence on dividend payments may be due to high ownership concentration in Russian companies. Under such conditions the board decisions are often taken in the interests of majority shareholders who control the key aspects of corporate governance including dividend policy [20]. This may limit the influence of the board characteristics on dividend payments.

## Conclusion

In the present research we consider the relationship between the principal characteristics of the board of directors as the key mechanism of corporate governance (women representation on the BD, share of directors with foreign experience on the BD, frequency of BD meetings, permanence of the BD composition, concurrent independent directors, CEO duality) and dividend payments in 31 Russian companies from 2010 to 2022. The relationship is considered from the perspective of provisions of the two following models: the outcome model and substitution model. We applied regression models with company and year fixed effects to verify the hypotheses. The logarithm of dividends per share was used as the dependent variable in the models.

The results of the models show that women representation on the BD, number of meetings, the share of concurrent independent directors and greater permanence of the board composition have a positive relationship with dividend payments of Russian companies.

This conclusion is partially in line with the outcome model which states that improvement of corporate governance characteristics is related to an increase in dividend payments. However, there is no consensus of opinion in the literature concerning the influence of women representation and concurrent independent directors on the corporate governance quality, so an unambiguous conclusion is impossible.

We have not revealed a significant relationship between dividend payments and such corporate governance characteristics as independence of the board of directors, CEO's membership on the board and the share of directors with foreign experience. This may be caused by a special nature of governance in Russian companies where high concentration of majority shareholders and government participation may curtail the influence of independent bodies on governance.

On the basis of the research results it is recommended to the companies to pay attention to providing a well-balanced composition of the board of directors including an increase in women representation and ensuring permanence of the board. The board of directors' composition and its members' characteristics may be indicative of the corporate governance level, company's commitment to shareholders' interests and may influence corporate dividend policy.

The research is limited by analysis of only one aspect of corporate governance – the board of directors' composition. Certain characteristics of the board may be indicative of the corporate governance quality just partially. Future studies may be dedicated to the corporate governance index which comprises several factors of corporate governance. So, the corporate governance quality and impact on dividend policy may be assessed more comprehensively.

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# Appendix

**Table 2.** Variable descriptions

| Designation | Description |
|---|---|
| Dividends per share | Dividends per one share |
| Payout ratio | Ratio of paid dividends to net income |
| Return on assets | Return on assets |
| Life cycle stage | Ratio of retained earnings to equity |
| Capital expenditures / Revenue | Share of capital expenditures in the revenue |
| Logarithm of total assets | Logarithm of the book value of assets |
| Debt / Total assets | Ratio of debt to total assets |
| Women representation on the BD | Share of women on the board of directors to the size of the board of directors |
| Number of BD meetings | Number of the board of directors' meetings held within a certain year |
| Average age of the BD | Average age of the board of directors' members |
| Average tenure of the BD | Average tenure of directors on the board |
| Share of independent BD members | Share of independent directors to the size of the board of directors |
| Share of directors with foreign experience | Share of directors with foreign experience to the size of the board of directors |
| Share of government participation | Share of government participation in the company |
| Permanence of the BD | Share of the directors who stayed on the board in year t as compared to year t-1 |
| Concurrent service | Share of concurrent independent directors employed by two or more companies |
| CEO's membership on the BD | A dummy variable which equals one if CEO is a member of the board of directors and zero – otherwise |
| Size of the BD | Size of the board of directors |

**Table 3.** Descriptive statistics of variables

| | Mean | St. deviation | Min. | Quarter 0.25 | Quarter 0.75 | Max. |
|---|---|---|---|---|---|---|
| Dividends per share (RUB/ share) | 100 | 285 | 0 | 0.2 | 74 | 2,689 |
| Payout ratio | 0.055 | 0.049 | 0 | 0.018 | 0.082 | 0.235 |
| Return on assets | 0.09 | 0.08 | -0.17 | 0.04 | 0.13 | 0.43 |
| Life cycle stage | 0.63 | 0.51 | -1.96 | 0.42 | 0.92 | 2.89 |
| Capital expenditures / Revenue | 0.13 | 0.08 | 0.01 | 0.06 | 0.18 | 0.34 |
| Logarithm of total assets (measured in million RUB) | 13.27 | 1.23 | 10.74 | 12.54 | 13.74 | 17.11 |
| Debt / Total assets | 0.53 | 0.22 | 0.08 | 0.35 | 0.69 | 1.11 |
| Stakeholder of government participation | 0.15 | 0.24 | 0 | 0 | 0.33 | 0.80 |
| Women representation on the BD | 0.07 | 0.08 | 0 | 0 | 0.11 | 0.33 |
| Number of BD meetings (units) | 21.80 | 15.96 | 4 | 12 | 25 | 104 |
| Average age of the BD (years) | 52.79 | 6.32 | 37 | 48.4 | 57.2 | 70 |
| Average tenure of the BD (years) | 4.49 | 2.52 | 0.22 | 2.47 | 5.91 | 12.40 |
| Share of directors with foreign experience | 0.25 | 0.22 | 0 | 0 | 0.4 | 0.8 |
| Share of independent directors on the BD | 0.40 | 0.15 | 0 | 0.31 | 0.46 | 0.78 |
| Permanence of the BD | 0.82 | 0.18 | 0.11 | 0.71 | 1 | 1 |
| Concurrent service | 0.11 | 0.12 | 0 | 0 | 0.18 | 0.56 |
| CEO's membership on the BD | 0.83 | 0.37 | 0 | 1 | 1 | 1 |
| Size of the BD (persons) | 10.57 | 2.46 | 4 | 9 | 11 | 21 |

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# Impact of Sanctions on the Internal and External Environment of Companies: Review

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## Abstract

The purpose of our study is to identify the main scientific results and promising areas related to sanctions against companies, assessment of their effectiveness, and creation of an anti-sanctions policy. To achieve this goal, we used the text analysis methodology and expert assessment. The empirical base of the study included 724 publications about sanctions for 2014–2024, indexed in Scopus. Based on the text analysis methodology (calculating the frequency of words and phrases, correlations, conducting a thematic analysis using BERTopic), the main scientific areas were identified: a company's internal environment, external environment – the financial and banking sector, and external environment – trade policy and foreign investment. To test model quality, we analyzed their Coherence Score and Divergence, the topics do not overlap and have sufficient internal coherence. Based on expert analysis, the main scientific ideas and authors were identified for each direction. The articles highlight Russia's potential key partners, in particular China, and researchers attempt to predict long-term effects of sanctions or to assess the actual impact that they have already exerted. This work will be useful for researchers in the development of the proposed scientific directions, and for practitioners in formulating anti-sanction policies to mitigate the negative consequences of sanctions.

**Keywords:** sanctions, impact of sanctions, sanctions and economy, text analysis, review article

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## Introduction

There is a number of theoretical and empiric studies dedicated to evaluating both primary and secondary impact of sanctions on the internal and external corporate environment. Primary sanctions are levied on companies from various industries in a sanctioned country. However, due to deep global economic integration, sanctions have an impact on companies both in the sanctioning and the sanctioned countries, as well as on enterprises in third countries [1]. If the latter violate the sanctions regime, penalties are also likely to be imposed on them. This type of sanctions are called secondary sanctions [2], i.e., penalties levied by the USA on Chinese companies for engaging in financial operations with North Korea. According to [3; 4] sanctions may also be imposed on various areas of a company's activities. A sanctions campaign may be divided into several stages that are indicative of their potential power: diplomatic actions (such as suspension of joint projects, expulsion from international organizations, etc.), measures applied to certain individuals and companies (ban on entering certain countries, assets freeze, credit restraints), sectoral sanctions (trade and financial restrictions, ban on exports of technologies). At the same time, sanctions' efficiency is also questionable. Some authors think that large and self-sufficient countries deal with the negative consequences of sanctions much more effectively than small nations [5], while others assume that tough sanctions [6] and narrowly focused sanctions [7] may be effective. As for the sanctions against Russia, there are contradictory assessments in scientific research. For example, Korhonen et al. assert that sanctions have produced an obvious and negative impact [8]. Besides, no adjustment strategies are capable of restoring the economy quickly to the pre-sanction size [9].

At the same time, Kholodilin and Netšunajev stated that sanctions had merely an insignificant effect [10], while Klinova and Sidorova found no significant influence of sanctions on the Russian economy [11]. Paper [12] demonstrates the possible unsuccessful results of imposing sweeping sanctions on a country using the example of unilateral sanctions levied against North Korea. Sometimes sanctions initiators fail when a correct strategy allows a country to develop its industry and science with a high degree of autonomy.

The purpose of our research is to reveal the main scientific results and promising areas related to sanctions against companies and an assessment of their effectiveness, as well as devising an anti-sanctions policy. To achieve this goal, we applied text analysis methodology and expert assessment.

The empirical base of the research comprised 724 articles about sanctions published in 2014–2024 and indexed in Scopus. It should also be noted that in spite of a number of review articles dedicated to the evaluation of the sanctions' impact on corporate operations, these papers focused on the study of certain problems. For instance, one of the papers studies 345 articles on sanctions imposed by the UN Security Council (1990–2023) and defines the main sanctioned areas [13]. Thus, it is virtually the first time when the studies dedicated to sanctions and their impact on the internal and external environment of companies in Russian and foreign literature are systematized.

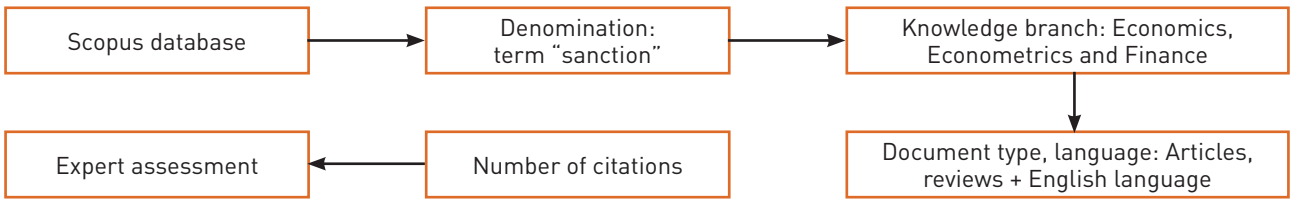
## Research Methodology

In considering the methodology of structuring a review article, we may subdivide it, with certain reservations, into several approaches. The first approach comprises an expert assessment, which implies that researchers read a large body of literature on a certain subject, analyze it and determine the principal scientific areas, current scientific trends, and define the core issues of the studies. However, there are some drawbacks in this approach: subjective estimates and a limited corpus of literature. To eliminate these drawbacks, certain researchers used another approach: bibliometric analysis which entails the selection of the most frequently cited publications. In our research we apply algorithmic computer analysis, which provides an opportunity to automatically analyze the texts and special features of papers by summing or visualizing text data.

## Data Description

In order to review the studies dedicated to the impact of sanctions on the external and internal environment of corporate operations, we compiled a sample of articles in English using the Scopus international database. Search requests on the research topic were used to select papers, the term "sanction" and "company" was applied to compile the sample, while the branch of knowledge was limited to Economics, Econometrics and Finance. At the next stage, the database was refined by using additional filters: document types (only articles and literature reviews) and language (only English). We also manually eliminated the articles that did not completely match the studied topic. As a result, the final database comprised 730 English-language papers. The structure chart the demonstrates the sample compilation method is presented in Figure 1. Thus, the subsequent analysis of thematic fields was performed on the basis of the most-cited articles in international databases.

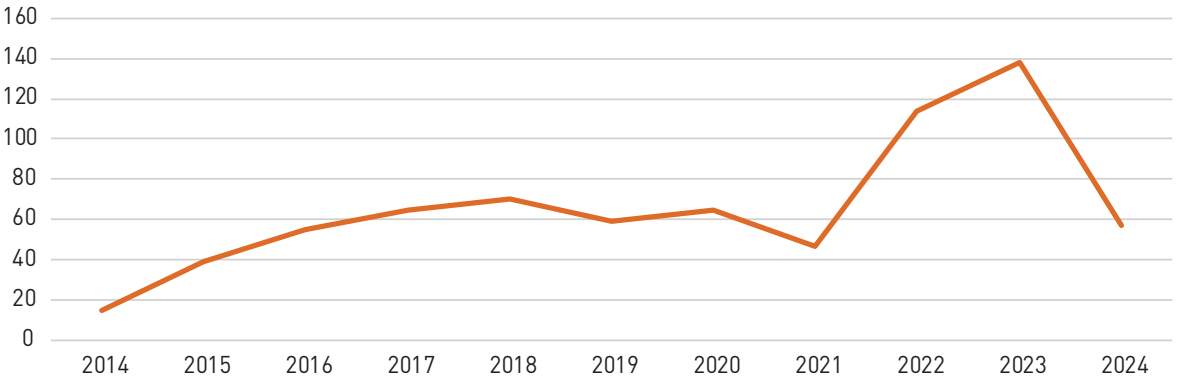
**Figure 1.** Formation of the analytical base




*Source*: Authors' calculations.

Figure 2 shows the number of articles dedicated to sanctions by year. The number of publications on the topic of sanctions was growing gradually in 2014-2018, peaking at the time of sanctions being imposed on Russia. After the special operation began in 2022, the number of papers doubled as compared to the previous year and grew even more in 2023.

**Figure 2.** Number of Scopus articles by year




*Source*: Authors' calculations.

Using the text analysis methods, we determine the principal topics of these articles and compile general reviews of this research field.

## Research Results

We are going to analyze the abstracts, or the short, succinct summaries of the articles that describe the relevance, purpose, methods and results of the research. In general, our analysis follows the algorithm below:

1) preliminary preparation of the text, which is obligatory for text analysis and comprises elimination of figures, special characters and stop words (prepositions, pronouns etc.). Consequently, text lemmatization (reduction to the base word form) is performed;
2) statistical text analysis: analysis of the number of word and word combination entries ;
3) correlation analysis, which essentially demonstrates how often the words occur together with the words we target. We will study correlations with the words "sanction", "company", "stock";
4) topic modeling of abstracts by applying the BERTopic machine learning algorithm. At this stage we use implementation of the BERT neural transformer network for topic modeling by applying the BERTopic algorithm. It is the latest topic modeling method that takes into account word semantics and analyzes sentences as a whole.

As for text analysis methods, in our research we apply several techniques. At the first stage, we resort to the frequency analysis technique. Table 1 presents 40 most frequent terms.

**Table 1.** Word frequency in article abstracts

| Word | Frequency | Word | Frequency |
|---|---|---|---|
| economic | 929 | import | 264 |
| country | 729 | financial | 254 |
| trade | 603 | crisis | 239 |
| policy | 487 | energy | 222 |
| state | 473 | global | 220 |
| market | 441 | cooperation | 217 |
| economy | 427 | factor | 215 |
| development | 391 | European | 213 |
| international | 374 | change | 212 |
| foreign | 339 | China | 212 |
| impact | 336 | world | 211 |
| result | 335 | growth | 205 |
| political | 328 | industry | 203 |
| increase | 304 | price | 197 |
| effect | 303 | period | 193 |
| region | 289 | level | 192 |
| relation | 288 | national | 189 |
| company | 267 | sector | 189 |
| export | 267 | Ukraine | 187 |
| investment | 266 | risk | 169 |

*Source*: Authors' calculations.

It should be noted that we have eliminated the words "Russia / Russian" and "sanction" because their high frequency is obvious and provides no value for the analysis of articles' contents. We manually eliminated the words insignificant for the studied topic that frequently appear in abstracts (for example, "article"). It is evident from Table 1 that the papers on sanctions are mainly focused on the issues of economy and trade relevant for companies, along with import and export issues. We may also note that the words assessing the impact of sanctions (impact, effect) were mentioned 336 times. As for countries, China was the subject of discussion as often as Russia. Some of the articles

are dedicated to anti-sanction policy and cooperation of countries; sanctions affect investment policy and targeted specific industries.

At the next stage of text analysis, we determine the frequency of word combinations in the text array. Table 2 presents 40 most frequent word combinations.

**Table 2.** Frequency of word combinations in article abstracts

| Word combination | Frequency | Word combination | Frequency |
|---|---|---|---|
| economic sanction | 103 | stock market | 41 |
| Russian economy | 96 | direct investment | 41 |
| long term | 95 | member state | 40 |
| European Union | 94 | economic policy | 40 |
| sanction Russia | 87 | Western country | 38 |
| United States | 76 | negative impact | 38 |
| sanction impose | 75 | short term | 37 |
| import substitution | 75 | Russia Ukraine | 37 |
| foreign policy | 74 | Russia China | 37 |
| academy science | 74 | national economy | 37 |
| foreign trade | 73 | international relation | 37 |
| exchange rate | 73 | impact sanction | 37 |
| economic development | 67 | Ukrainian crisis | 36 |
| economic growth | 61 | economic relation | 36 |
| North Korea | 57 | relation Russia | 33 |
| limit trade | 52 | growth rate | 33 |
| Russian company | 48 | financial sanction | 33 |
| effect sanction | 48 | sanction regime | 32 |
| political economic | 43 | cooperation Russia | 32 |
| sanction policy | 42 | export import | 30 |

*Source*: Authors' calculations.

We also eliminated from Table 2 the word combinations insignificant for the topic (for example, "result", "show"). We may note that the combinations "economic sanctions" and "Russian economy" occur most frequently. Long-term effects (long term) occupy the third position among frequently occurring word combinations, i.e., article abstracts evaluate the effect of sanctions over a long-term horizon. As for analyzed countries, there are the sanctioned ones, for example, North Korea and the ones imposing sanctions – the European Union, the United States. The main research topics comprise the exchange rate, trade restrictions, financial sanctions, sanctions policy and economic policy. We also consider the issues of influence on certain Russian companies (Russian company) and cooperation issues.

At the next stage we are going to analyze word correlation. Table 3 presents 20 words which correlate most closely with the words "sanctions", "companies" and "stock".

**Table 3.** Word correlations in article abstracts for the words "sanction", "company", "stock"

| Sanction | Company | Stock |
|---|---|---|
| Impose | Russia / Russian | return |
| Russia / Russian | foreign | volatility |
| pressure | investment | market |
| impact | sector | index |
| effect | activity | traditional |
| economic | large | exchange |
| measure | market | price |
| policy | German | reaction |
| regime | government | Federation |
| consequence | private | ruble |
| Iran | business | common |
| negative | economy | rate |
| condition | firm | joint |
| Western | policy | position |
| target | enterprise | government |
| crisis | state | global |
| result | direct | Russia / Russian |
| financial | domestic | labor |
| influence | capital | audit |
| significant | investor | billion |
| imposition | banking | demand |
| introduce | manufacturing | Ukraine |

*Source*: Authors' calculations.

Let us examine the word "sanctions" and its correlations. As we see in Table 3, the word "impose" (which contextually represents the topic of introducing sanctions) most closely correlates with "sanctions". Pressure and influence are also among the main topics, and these terms (impact, effect, measure, consequence, result) constitute a large share. As for the correlation with the word "company", we see that studies consider the issues of foreign investment, the impact of sanctions on companies from different sectors, aspects of sanctions' impact on government-owned companies, and investment. As for the stock market and stock, their volatility and response are mainly considered in relation to ongoing events. The topic of the impact of sanctions on the exchange rate and stock market indices is studied most frequently.

Now we proceed from statistical methods to topic analysis using BERTopic. In the automatic mode, the algorithm determined three prevailing topics in narrowly focused articles that only examine sanctions and their influence on Russia. In order to test model quality, we applied the Coherence Score. This metric measures the extent to which the words from each topic are interrelated. The higher the Coherence Score, the more coherent and interpretable the topic. We also used the Divergence metric to test them. This metric measures the extent of difference between the topics in the model. It is important because topic modeling should reveal the topics that are sufficiently distinct to provide a useful and accurate view on the content of data. We obtained the following values: Coherence Score 0.41 and Divergence 0.55. These are the optimal values; the topics do not overlap and are sufficiently internally interrelated.

Table 4 contains lists of defined words and a certain topic.

**Table 4.** Topic modeling results

| Topic | Words |
|---|---|
| Corporate internal environment | sanction, enforcement, target, punishment, individual, effect, behavior, paper, policy, reward, right, audit, state, find, result, provide, sender, crime, country, institution |
| External environment – financial and banking sectors | Russia, market, price, economic, sanction, economy, financial, rate, shock, global, stock, bank, exchange, country, growth, currency, stress, study, reserve |
| External environment – trade payout and financing investment | Russia, sanction, economic, country, relation, trade, policy, study, region, development, foreign, industry, political, article, economy, European, state, author, cooperation |

*Source*: Authors' calculations.

The BERT algorithm determined the prevailing topics of the sanctions' impact on the internal and external environment of a company. The internal environment comprises the issues of individual effects for companies, audit, parties' behavior, etc. The external environment was divided by the algorithm into two subtopics. The first one is related to the impact of sanctions on the stock market, banking sector, and exchange rate. The second subtopic comprises the issues of trade policy and export-import relations.

In the next section, we are going to determine the principal scientific ideas within three major topics.

# Principal Scientific Fields

## Internal Environment of a Company

The first portion of studies is related to the impact of primary sanctions on corporate finance. Sanctions may influence various aspects of company's operations. Resource limitations, weakening of bonds with international markets and increased risk and uncertainty caused by sanctions change the company's business operations [14]. Economic sanctions may adversely affect social policy and exacerbate instability [15]. Some researchers believe that the imposed sanctions raise the risk for global investors by decreasing direct foreign investment [16; 17]. Also, sanctions influence indirectly trading partners and supply chains, causing market failures [18], high transaction costs, weak protection of intellectual property rights or significant uncertainty [17; 19].

Sanctions influence the procurement of human capital and may also impede international mobility and external hire of essential professionals, as well as drive up national demand for highly qualified specialists. Social instability may potentially hinder educational progress and force skilled personnel to migrate. Ultimately, sanctions can slow down the process of human capital development and cause damage to the national educational system as a result of loss of professionals able to impart knowledge to others [20]. Some studies address the impact of sanctions on the companies' HR management. Sanctions may change living conditions for the worse, thus affecting corporate personnel [21]. The authors of a study based on panel regression and analysis of 137 countries from 1961 to 2018 found out that as a result of UN and US-European sanctions, emigration from the targeted countries increases by approximately 20%. Besides, they revealed no gender differences in the migration effect of sanctions [22].

Russian and foreign studies consider the issues related to the specific features of the external and internal corporate strategy [23]. Insofar as economic motivation is concerned, it is apparent that the companies' cost price increases to overcome the consequences of sanctions. At the same time,

the cost of conducting business grows, thus providing certain opportunities for institutional arbitrage [24]. In a formerly targeted country, risks of conducting business and extra costs related to entering a new location arise. All of the above may influence companies' investment attractiveness. Some industries (for example, oil and gas, coal mining, shipbuilding, agricultural-industrial or microelectronics) have to adjust continuously to changes and respond to new external challenges and develop specialized narrowly focused counter-sanctions measures [25–28].

Theoretical and empirical studies determined various corporate counter-sanctions strategies. The behavior of Vietnamese timber exporters in the framework of the US and Chinese economic sanctions is studied on the basis of interviews with key government officials and companies' top management [1]. Applying the key concepts of the realism school and stakeholder theory, the authors found out that companies experienced both positive and negative consequences of sanctions. Besides, they utilized four strategies: alignment, evaluation of prospects, mitigation, and isolation. The authors proved that companies applied several strategies to address the negative consequences of sanctions.

A series of studies address the development of transnational corporations' strategy under sanctions, for example, they study the impact of US transnational corporations and the subsequent financial market response to Russia's special military operation in Ukraine in February 2022 [29]. The decisions of transnational corporations at the company level range from withdrawing from Russia to remaining on the Russian market under any sanctions. However, such extreme strategies are lossmaking for the companies committed to them. It may be noted that in the short term, transnational companies prefer "intermediate" solutions, which maintain a balance between shareholder interests and regulatory and ethical requirements. Also, country differences in corporate strategies were revealed, for example, Chinese investors "do not punish" the companies that stay in Russia. The authors defined 8 business development strategies: 1) business termination; 2) suspension of all operations; 3) suspension of insignificant operations; 4) cessation of new types of activity; 5) termination of further investment; 6) cessation of new supplies to branches; 7) reducing operations; 8) continuance of ordinary business. The studies also describe another strategy of withdrawal from the sanctioned country for international companies, which consists in selling assets to the local elite in order to preserve a part of the company value [30].

Sanctions influence companies in both sanctioning and sanctioned countries, as well as enterprises in third countries. Secondary sanctions are the sanctions imposed on the countries that do not observe the sanctions regime [2], for example, the USA levied penalties on Chinese companies for financial transactions with North Korea. As for the Russian-Ukrainian conflict, economic sanctions were imposed on the countries and companies conducting business with Russia [31]. From the economic point of view, companies should reconsider their business relations because relationships with sanctioned entities may result in punitive measures applied by sanctioning bodies, first and foremost, the United States and European Union [32]. Companies are forced to balance between their economic interests and geopolitical pressure, especially when they face possible financial and reputational damage [33]. Apart from that, multinational enterprises that operate under sanctions regimes and intend to withdraw should also take into consideration the ethical implications and face the risk of reputational damage that arises due to the support of the targeted regime [18; 34].

Yet another study analyzes the relations between business risk and audit price formation by means of studying economic sanctions of 2014 imposed on Russia by the Western community [35]. Sanctions mostly targeted Russian government-owned companies, thus, possibly raised business risks for such companies, and increased audit fees due to pass-through expenses arising from an increased audit risk caused by sanctions, which are transferred to customers. After the sanctions were imposed, the Big Four companies charged government-owned companies higher fees for their audit.

Thus, on the basis of the literature review, we revealed the main scientific fields related to human capital, internal and external strategies, and mitigation of additional risks caused by sanctions against companies.

## External Environment – Financial and Banking Sectors

The second area is related to evaluating the impact of sanctions and international conflicts on financial markets. Geopolitical risk affects stock markets [36], correlation of financial markets, and thereby, occurrence of crises [37] and the overall stability of the financial system [38].

We are going to consider the area related to the impact of sanctions on the stock market. A series of studies have proven that the short-term impact of international conflicts on financial markets is usually negative. If we consider sanctions and the companies' behavior in the course of the last conflict, stock return estimates will be different for the companies that stayed in Russia and the ones that left. Some authors think that the strategy of withdrawal from Russia is optimal based on studying the short-term effects of unadjusted stock returns weighted by the market value [29]. It turned out that the portfolios of companies that have remained in Russia are inferior to those of the companies that pulled out. Some other authors (see, for example, Glambosky and Peterburgsky [39]) prove that the companies that have withdrawn from Russia completely have the highest negative abnormal returns.

The next category of authors evaluates the spillover of financial crises caused by international conflicts and sanctions. Preceding studies pointed out a change in the financial integration of stock markets during a crisis. The majority of studies address an increase in volatility during a financial crisis [40; 41]. As for sanctions, the reason behind the concerted market movement may be the links be-

tween economies or the impact of sanctions, which is estimated by a set of dummy variables depending on the dates when sanctions were imposed, inter-market correlation coefficients, the GARCH structure, cointegration model and probit model. For example, in order to assess the influence of sanctions on stock markets, estimates of moving cross-market correlations and models from the GARCH family are used to model stock returns and volatility [42].

Apart from the above, statistical evaluation of the stock indices' distribution before and after introduction of sanctions revealed a statistically significant increase in volatility. At the same time, structural breaks in "heavy tails" were not proven, i.e., the impact of sanctions on the Russian stock market is ambiguous [43]. The researchers used the event window methodology and found out that investors value the companies located in the countries that have imposed sanctions on Russia higher than the stock markets in the countries that have not introduced sanctions against Russia. Besides, investors assess the companies differently when they are politically connected to or located in countries with lower geopolitical risks [44].

As for the financial system in general, based on the data from TARGET2 (the real-time gross settlement system for the euro zone), it was revealed that the sanctions introduced by the European Union against Russian banks significantly reduced financial transactions with authorized Russian bank accounts, both in terms of the extensive and intensive margins. Exclusion from SWIFT, a global provider of secure financial messaging services, turned out to be the most effective sanction measure [45]. The role of restrictions on the use of international reserves as economic sanctions is studied, leading to determine the optimal manner for a sanctioning country to impose restrictions, taking into account geopolitical benefits [46]. Sanctions may also influence the interbank market, for example, some studies demonstrate that sanctions imposed on Russia probably impact the banks of Belorussia and Kazakhstan [47].

A series of studies evaluate whether bitcoin is used to circumvent financial sanctions. Blockchain-based cryptocurrencies, which are considered as an alternative to the conventional financial system, may process payments internationally and entirely independently of any banks. Nevertheless, there are studies that prove that bitcoin is not used to evade sanctions on a large scale [48]. Researchers determined the impact of sanctions on the volatility of exchange rates and oil prices. Thus, using a panel vector autoregressive model (VAR) that comprises data on 23 countries other than Russia and Ukraine for the period of 01.02.2022 to 24.02.2023, the studies demonstrated that the overall impact of the economic support provided to Ukraine is generally limited. Sanctions against Russia affect Ukraine as well. If they are imposed by the G7 countries or developed countries, the consequences for Russia are typically more pronounced [49].

So, we may note that sanctions influence the behavior of the financial market, however, their impact is ambiguous.

## External Environment – Trading Policy and Foreign Investment

Sanctions influence companies' trading activities. Trading sanctions are intended to damage the sanctioned country's economy. However, this impact is double-natured: if sanctions restrain trade, they also cause damage to the sanctioning countries. Studies attempt to estimate the spillover of sanctions within a certain economy, or within a group of countries, or within transition economies in general. Some studies prove that insignificant sanctions increase welfare in the sanctioning country because sanctions ignore the elasticity of supply and demand in the sanctioning country [50]. It was also revealed that EU sanction measures exert a greater impact on Russia than US measures, while Russian countersanction measures will produce a more serious impact on the EU than on the US.

From the economic point of view, it would be optimal for the US and EU to drop sanctions against Russia, while counter measures should take into consideration the effects of trade redirection. Some authors determine the impact of sanctions on corporate export and import policy [51]. They note that Russian sanctions imposed on European and American food imports reduced the trade flows to a greater extent (almost eightfold) than those levied by the EU and US on exports of oil-field equipment. The sanctions may be ineffective because a multilateral agreement aimed at introducing the measures that create costs for countries of origin was made and enforced [52; 53]. Kaempfer and Lowenberg assumed that manufactures were a more cohesive and politically efficient group of interests than consumers. So, sanctions are more likely to restrict imports from the targeted country than exports to the targeted country [54]. In a broader sense, one might say that a ban on exports deprives exporters of the sanctioning country of foreign markets, while a ban on imports creates new markets for domestic producers in the targeted country. Therefore, it is more likely that import restrictions will evoke more political support than export restrictions [55].

In the next study, the authors evaluated the quantitative estimate of the impact of economic sanctions imposed on Russia by Western and other countries based on the model of global trade general equilibrium [56]. They revealed that if the countries of origin decide to impose 100% import duties and export taxes on trade with Russia, the Russian GDP would decrease by 3-7% due to a significant shrinkage of exports. Such a decision would affect to a certain extent all countries of origin; for example, electric power and town gas prices in Japan would grow by 3-4%.

The impact of economic sanctions imposed by Western countries on exports from the Russian Federation and the impact of counter sanctions on its imports were studied based on the data on 49 trading partners of the Russian Federation in 2011-2018. Gravity modeling revealed that economic sanctions against the Russian Federation and its counter sanctions result in a decrease in the aggregate value of both Russian exports and imports [57]. Sanctions

reduce the value of Russian exports to sanctioning countries by 25.25%, while counter sanctions decrease the value of Russian imports from sanctioned countries by 25.92%. The effect of sanctions and counter sanctions on exported and imported products is nonuniform.

The authors of an empirical study estimated the impact of exporting companies on sanctions using French companies as an example by applying dynamic binary choice models with fixed effects. It was discovered that new sanctions imposed on Iran and Russia significantly reduced the likelihood that companies would provide services to such sanctioned markets, while the (temporary) removal of the US sanctions from Cuba and lifting of sanctions from Myanmar produced no effect or had an insignificant effect on trade, respectively. Apart from that, the impact of sanctions is highly heterogeneous from the viewpoint of firm size. The companies more dependent on trade financing tools suffer more damages, while previous experience of conducting business in a sanctioned country significantly reduces the effect of sanctions. Companies may evade sanctions by means of indirect export through neighboring countries [57]. Considering the efficacy of sanctions from the standpoint of Russian companies, Golikova and Kuznetsov think that Russian companies most involved in trade and technological chains with the European Union and Ukraine will be most damaged by sanctions [58]. Sectoral sanctions may also result in economic severance from traditional trading partners, while sanctions against the defense industry may increase a country's defense expenditures [59]. Another article asserts that sanctions may further enhance the role of the Russian Federation not just in the sectors directly affected by sanctions, but also in the Russian economy in general [60].

The studies address rather narrow topics. Thus, evaluation of the impact of sanctions on the environment showed that by restricting the purchase of high-performance technologies, sanctions may lead to a depletion of natural resources and influence environmental indicators [43]. According to the results, the majority of sanctions cause environmental degradation, while trading sanctions improve the environment of the targeted country. Apart from that, secondary sanctions inadvertently exacerbate economic instability, especially in such sectors as the power industry, where Russia plays a prominent part in global supplies [61].

The impact of sanctions on corporate trade flows, export and import is evaluated in this section. It has been revealed that sanctions have a mixed effect due to the expansion of the domestic market and redirection of companies' trade flows.

## Conclusion

We have analyzed academic papers dedicated to sanctions. The largest number of sanctions was imposed in 2022-2023. The topic aroused less interest only during the COVID-19 pandemic, when no new large sanctions packages were introduced. The main topics are the examination of the impact on the financial market and banking, as well as on industry and external trading relations between countries. Articles often describe prospective principal partners for Russia, in particular, China. As a rule, researchers try to forecast long-term effects of sanctions or evaluate the impact that has already been produced.

Based on the text analysis methodology, the principal areas have been determined: the internal environment of a company, the external environment – financial and banking sector, the external environment – trade policy and foreign investment. Relying on expert analysis. the main scientific ideas and authors were defined for each area. The present paper will be useful for researchers in developing the proposed scientific fields, and for practitioners in formulating anti-sanction policies to mitigate the negative consequences of sanctions.

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