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Enterprise digital transformation, accounting information comparability and corporate innovation

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Abstract: In the evolving digital landscape, the digital shift within corporations is pivotal for fostering innovation and elevating competitiveness. This study investigates the impact of digital transformation on enterprise innovation, utilizing a dataset of A-share listed firms from 2010 to 2020. To address sample self-selection, the Propensity Score Matching (PSM) method is employed, dividing enterprises into experimental and control groups based on their level of digital transformation. Additionally, to mitigate endogeneity concerns, all explanatory variables are lagged by one period. The study employs benchmark regression analysis, considering control variables and fixed effects for year and industry, to examine the relationship between digital transformation and innovation. The study constructs models to evaluate the mediating role of accounting information comparability in the relationship between digital transformation and innovation. Notably, a strong positive link is observed between a company's digital evolution and its innovation capacities, suggesting that this evolution substantially augments innovation. Moreover, the consistency of accounting data further amplifies this effect. Such insights offer strategic guidance for companies aiming to bolster innovation amid their digital journey and underscore the necessity for consistent accounting data.

Keywords: digital transformation; accounting information comparability; innovation

1. Introduction

With the development of the global economy, innovation has become the key to high-quality development of enterprises. Innovation, defined as the process of translating ideas into value-creating goods and services, enables firms to stay ahead in the market and adapt to technological changes. However, innovation activities require large investments and long research and development cycles, which make the risk of innovation investment increase. Against this background, the era of digital economy brings us a new opportunity: digital transformation [1]. The Chinese government attaches great importance to this, setting clear goals for digital transformation and introducing a series of policies to promote its realization. In addition, the state has been increasing its investment in major projects such as “East Counts, West Counts” [2] and encouraging all industries to deeply integrate digital technologies to achieve high-quality economic development. **Figure 1** shows that with the development of the digital economy in recent years, the number of patents representing enterprise innovation has steadily increased.

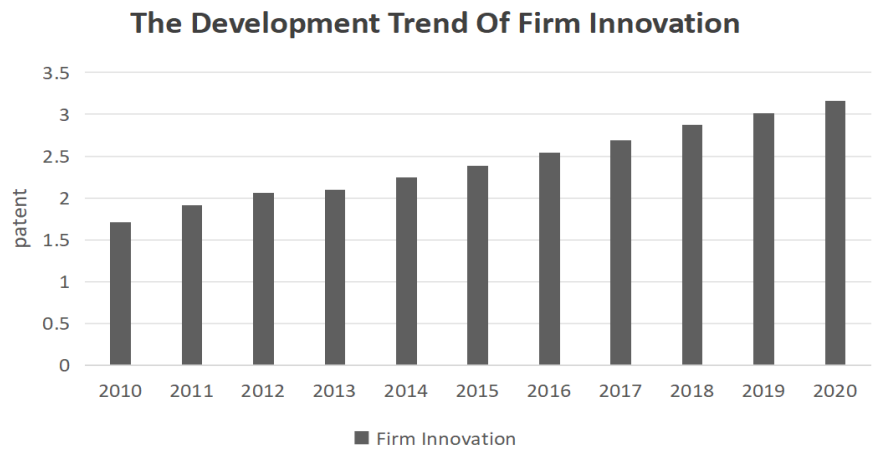


Figure 1. Chart of the development trend of firm innovation.

Digital transformation has become a critical factor in driving enterprise innovation in the contemporary business landscape. Defined as the comprehensive integration of digital technologies into all facets of an organization, digital transformation reshapes how companies operate and deliver value. It involves the adoption of cutting-edge technologies such as artificial intelligence and big data analytics, fostering an environment that promotes continuous innovation and improved business processes. By embracing digital transformation, firms can enhance their innovation capabilities and leverage more comparable and transparent financial information, thereby driving sustainable growth and competitiveness in the digital age. Numerous studies have explored the multifaceted impacts of digitalization on various aspects of business operations, providing valuable insights into how digital transformation can foster innovation and improve overall firm performance. For instance, digital transformation can significantly enhance the efficiency and effectiveness of business processes, leading to increased innovation capabilities [3]. Moreover, the integration of digital technologies can facilitate better decision-making and more agile responses to market changes, further driving innovation [4]. Besides, digital transformation enables more efficient processes, better decision-making, and the creation of new products and services [5], and studies have identified the importance of cultivating a digital culture within organizations to fully leverage the benefits of digital transformation. A digital culture encourages experimentation, agility, and continuous learning, which are critical for innovation [6]. However, the role of regulatory environments in shaping the effectiveness of digital transformation efforts and subsequent innovation is not well explored. Regulatory support and constraints can significantly influence how digital transformation initiatives are implemented and their outcomes [7], but subsequent innovation has not been proven.

Innovation, as the core driving force of enterprise development, has been studied in depth by many scholars. Schumpeter made an in-depth discussion on enterprise innovation at the beginning of the last century and pointed out that enterprise innovation covers many aspects such as systems, technology, markets, and management. In recent years, many scholars have explored the influencing factors of corporate innovation from different perspectives, including the internal shareholding structure and scale of the enterprise, as well as the external financing environment and macro policies. However, relatively few studies have focused on how digital

transformation affects corporate innovation. Although some scholars have explored this issue from the perspectives of talent effects, dynamic capabilities, and knowledge management, it is clear that this is not enough. So, this paper aims to explore the following key research questions: What is the impact of digital transformation on enterprise innovation? How does accounting information comparability mediate the relationship between digital transformation and enterprise innovation? What are the differences in the impact of digital transformation on innovation across various industries and firm sizes? What are the potential endogeneity issues in studying the relationship between digital transformation and enterprise innovation, and how can they be addressed?

Accounting information comparability also plays a crucial role in this context, as it enables stakeholders to make more informed decisions, thereby enhancing the overall impact of digital transformation on innovation [8]. Studies have shown that greater comparability of financial statements can lead to more efficient capital allocation and reduced information asymmetry [9]. With the support of digital technology, companies can collect, integrate, and analyze data more effectively, thus improving the comparability of their accounting information. And highly comparable accounting information can not only help firms better assess the effectiveness of their innovation strategies but also provide external investors with more accurate and reliable information, thus reducing the risk of innovation investment. Therefore, the purpose of this paper is to explore how firms' digital transformation can promote firm innovation by affecting the comparability of accounting information.

The marginal contributions of this paper are mainly in the following aspects: first, we explore how firms' digital transformation affects firms' innovation from the perspective of accounting information comparability, which provides new perspectives and theoretical support to the existing literature. Second, we provide insights into the mechanisms of how digital transformation and comparability of accounting information work together on firm innovation. Finally, we also explore how to further improve the comparability of firms' accounting information in the digital economy to better support firm innovation.

2. Theoretical analysis and research hypotheses

2.1. Enterprise digital transformation and enterprise innovation

With the rapid development of the digital economy, enterprises are in urgent need of transformation, especially digital transformation, in order to maintain their competitive position. Digital transformation not only means the upgrading of technology but also the overall change of enterprise culture, management mode, and business model. The relationship between digital transformation and innovation has been a focal point of contemporary research, with numerous studies examining how digital technologies impact enterprise innovation capabilities. The existing literature provides robust evidence of the positive impact of digital transformation on innovation, emphasizing the importance of digital culture, financial transparency, and industry-specific strategies. However, there are still several areas that require further exploration, such as the long-term effects of digital transformation, its impact on SMEs, the influence of regulatory environments, and the mediating and moderating

factors involved. Addressing these gaps will provide a more comprehensive understanding of how digital transformation can drive sustainable innovation across various contexts.

First, the institutional innovation aspect. Digital transformation requires enterprises to form a new set of institutional logic internally to adapt to the external digital economic environment [10]. This institutional innovation can help enterprises better adapt to the external environment, improve their responsiveness and flexibility, and thus promote innovation. Second, technological innovation aspect: digital technologies, such as big data, cloud computing, artificial intelligence, etc., provide powerful tools and means for enterprises to develop and innovate their products and services more quickly and accurately [11]. Third, market innovation aspect: digital transformation enables enterprises to better understand market demand and respond more quickly to market changes, thus promoting market innovation. Fourth, management innovation: digital transformation promotes the flattening of enterprise management, enabling enterprises to better stimulate the innovation potential of employees and improve their innovation efficiency [12]. In summary, we believe that digital transformation can promote enterprise innovation in many ways.

2.2. Enterprise digital transformation, accounting information comparability, and enterprise innovation

In today's digital era, businesses are undergoing swift transformations. The digital shift has revolutionized corporate operations and significantly altered their information management and dissemination methods. Through the lens of digital tech and accounting data management, the integration of advancements like big data, cloud solutions, and AI enables firms to handle diverse accounting data with increased precision and speed. This elevates the reliability and comprehensiveness of accounting details, expediting their release to satisfy the immediate informational requirements of investors and other concerned parties. In terms of transparency and trust, tools like blockchain amplify the clarity of accounting data, offering stakeholders a clearer glimpse into the company's genuine operational status, which in turn fosters increased confidence. Thus, a firm's digital transition can enhance the comparability of its accounting details.

And regarding the impact of accounting information comparability on enterprise innovation, it can be analyzed from four aspects: the basis of innovation decision-making, the convenience of financing, risk management and innovation, and stakeholder participation. First, highly comparable accounting information provides firms with important feedback about their innovation strategies. Firms are able to use this information to clearly understand which innovation projects or strategies are successful and which need to be adjusted or abandoned so that they can allocate resources more precisely [13]. Second, financing is key in innovation activities. Highly comparable accounting information can better demonstrate a firm's operating conditions and potential growth, attracting the attention of investors and financial institutions. This will help firms obtain financing more easily to support their innovation projects. Third, when firms' accounting information is highly comparable, they can perform risk assessment more effectively. This risk assessment can help firms

better manage the risks associated with innovation, thus encouraging bolder attempts at innovation [14]. Fourth, highly comparable accounting information can also facilitate the engagement of stakeholders, such as suppliers, customers, and partners. When these stakeholders are able to better understand a firm's operations, they may be more willing to participate in and support the firm's innovation programs. In summary, we argue that digital transformation can further promote firm innovation by improving the comparability of accounting information. This paper proposes the following hypotheses:

H1: Digital transformation can significantly enhance corporate innovation.

H2: Accounting information comparability plays a pivotal intermediary role in the influence of enterprise digital transition on business innovation.

3. Research design

3.1. Sample source

This study examines A-share listed firms between 2010 and 2020. Companies in the financial and insurance sectors were omitted, as were ST and *ST-designated firms. Additionally, entities without the necessary data were disregarded. After this screening process, we were left with a total of 20,093 sample data points. To ensure the robustness of the study, all continuous variables were adjusted at both the top and bottom 1% to minimize the effects of outliers. All requisite data for this research was derived from the Wind database.

3.2. Model construction

3.2.1. Model construction

To evaluate the influence of digital transformation on business innovation and the intermediary role of accounting information comparability, this study formulates a specific model. Detailed definitions of the variables can be found in **Table 1**:

$$\text{Patent}_{i,t} = \alpha_0 + \alpha_1 \text{DCG}_{i,t} + \alpha_2 \text{Controls}_{i,t} + \text{Industry} + \text{Year} + \xi_{i,t} \quad (1)$$

$$\text{Comp}_{i,t} = \alpha_0 + \alpha_1 \text{DCG}_{i,t} + \alpha_2 \text{Controls}_{i,t} + \text{Industry} + \text{Year} + \xi_{i,t} \quad (2)$$

In this framework, the term 'Controls' encompasses all control variables. The 'Year' and 'Industry' variables indicate the respective fixed effects for time and sector. Meanwhile, and ξ is the random error term.

3.2.2. Definition of variables

Explained variable: firm innovation (innovation). Enterprise innovation can be measured from two dimensions: one is based on innovation output, usually using indicators such as the number of patent applications and authorizations [15]; the other is based on innovation input to assess the innovation activity of enterprises. In this study, we choose the method of innovation output and use the number of patent applications as a metric, based on the study of Kong et al. [16]. This method is adopted because, on the one hand, invention patents better reflect the scientific and technological innovation capability of enterprises compared with R&D inputs [16]; on the other hand, the number of patent applications is more stable than the number of

patents granted, which may be affected by a variety of factors [17]. In order to eliminate data skewness, we take the logarithm of all patent values after adding 1 to get three variables: Patent, Patent1, and Patent2, which represent the total innovation quantity, innovation quality, and innovation quantity of enterprises, respectively.

Explanatory variable: Enterprise Digital Transformation Intensity (DCG). Domestic research often gauges a firm's digital transformation progression by counting digital-related terms in annual reports, a method detailed by Wu et al. [18]. Using this approach, we tallied the occurrences of such terms in the annual reports of listed firms. These reports contain detailed disclosures about the companies' strategic initiatives, investments, and implementations related to digital technologies. A systematic keyword search is conducted within the annual reports to identify relevant mentions of digital transformation activities. Keywords include terms such as "digital strategy," "IT investment," "digitalization," "innovation through technology," "big data," "cloud computing," "artificial intelligence," and "Internet of Things (IoT)." To address data skewness, we incremented the frequency count by one and then applied a logarithmic transformation, resulting in the DCG variable that represents the company's digital transformation level.

Mediating variable: accounting information comparability (Comp). Accounting information comparability is concerned with the consistency of the accounting system, ensuring that different economic operations are consistent when translated into accounting information. In short, financial statements are more comparable when firms apply similar accounting treatments to similar economic operations. To measure this comparability, we refer to the approach of De Franco et al. [19]. First, we conduct a regression analysis based on Equation (3) using firms' data for the 16 quarters prior to period t , where $Earning_{i,t}$ represents the ratio of a firm's quarterly profit to its opening market capitalization, and $Return_{i,t}$ denotes the quarterly stock return. If firms i and j are assumed to have the same economic operations, then based on the estimation of Equation (3), we can use Equations (4) and (5) to predict their expected surpluses. Further, we calculate the difference between the expected surpluses of the two firms and take the opposite of the average of their absolute values so that we obtain the comparability of accounting information between firms i and j as shown in Equation (5). In order to obtain the comparability of accounting information for a particular company, we match it with other companies in the same industry. Finally, we rank the comparability of each pair of firms and take the average value of the comparability of the firm with all other firms in its industry (Comp) as the measure of the comparability of accounting information of that firm. Theoretically, the larger this value is, the more comparable the firm's accounting information is.

$$Earning_{i,t} = \alpha_i + \beta_i Return_{i,t} + \varepsilon \quad (3)$$

$$E(Earning)_{i,i,t} = \alpha_i + \beta_i Return_{i,t} \quad (4)$$

$$E(Earning)_{i,j,t} = \alpha_i + \beta_i Return_{i,t} \quad (5)$$

$$Comp_{i,j,t} = -1/16 \times \sum_t^{t=15} |E(Earning)_{i,i,t} - E(Earning)_{i,j,t}| \quad (6)$$

Control Variables: This study incorporates several control variables: the company's scale (Size), leverage ratio (Lev), total asset returns (ROA), operational income growth rate (Growth), board member count (Board), proportion of independent directors (Indep), the largest shareholder's ownership percentage (Top1), equity balance level (Balance), and ownership configuration (SOE). The paper concludes by also controlling for year effects and fixed effects. This is shown in **Table 1**:

Table 1. Table of control variable definitions.

Variable Name	Variable Symbol	Variable Definition
Enterprise Size	Size	Taking the natural logarithm of total business assets
Gearing Ratio	Lev	Total liabilities/total assets
Return on Total Assets	ROA	Net profit/total assets
Operating Revenue Growth Rate	Growth	(Current Operating Income – Previous Operating Income)/Previous Operating Income
Number of Directors	Board	Number of Board of Directors
Proportion of Independent Directors	Indep	Number of independent directors/total number of board members
Shareholding ratio of the largest shareholder	Top1	Number of shares held by the first largest shareholder/total number of shares
Shareholding checks and balances	Balance	Total percentage of shares held by the second to fifth largest shareholder/percentage of shares held by the first largest shareholder
Ownership Structure	SOE	If the enterprise is a state-owned enterprise, take 1, otherwise take 0

3.2.3. Variable descriptive statistics

Table 2 presents the descriptive statistics of the studied variables. As evident in **Table 2**, the average values for corporate innovation are 2.589, 1.785, and 2.076 with

Table 2. Descriptive statistics of variables.

Variable	N	Mean	Std Dev	Min	Max
Patent	20,093	2.589	1.712	0	7.18
Patent1	20,093	1.785	1.503	0	6.531
Patent2	20,093	2.076	1.640	0	6.332
DCG	20,093	1.412	1.416	0	4.934
Comp	20,093	-0.009	0.007	-0.039	0.003
Size	20,093	22.38	1.302	19.52	26.21
Lev	20,093	0.467	0.209	0.0668	0.961
ROA	20,093	0.0323	0.0683	-0.289	0.217
Growth	20,093	0.179	0.564	-0.632	4.124
Board	20,093	8.687	1.720	5	15
Indep	20,093	0.3749	0.0538	0.3333	0.5714
Top1	20,093	0.3400	0.1464	0.0923	0.7365
Balance	20,093	0.0066	0.0057	0.0002	0.0255
SOE	20,093	0.465	0.499	0	1

respective standard deviations of 1.712, 1.503, and 1.640. This suggests significant

variations in innovation levels across firms. The mean and standard deviation for digital transformation (DCG) are 1.412 and 1.416, highlighting considerable dispersion. This diversity in the sample data confirms its suitability for statistical analysis.

4. Empirical results and analysis

4.1. Benchmark regression analysis

The regression analysis of Equation (1) in **Table 3** reveals that the correlation coefficients of enterprise innovation indicators Patent, Patent1, and Patent23 with the DCG of the enterprise's degree of digital transformation are 0.269, 0.285, and 0.215, respectively, which implies that when the degree of digital transformation of the enterprise is increased by 10%, the innovation level of the enterprise is correspondingly increased by 2.69%, 2.85%, and 2.15%, and the level of digital transformation of the enterprise is increased by 2.69%, 2.85%, and 2.15%, 2.85%, and 2.15%, respectively. This result clearly indicates that there is a significant positive correlation between firms' digital transformation and their level of innovation, and this correlation is validated at the 1% level of statistical significance. It can be seen that the higher the degree of digital transformation, the more significant is its positive contribution to corporate innovation, thus confirming the H1 hypothesis.

Table 3. Benchmark regression results.

Variable	Equation (1)			Equation (2)
	Patent	Patent1	Patent2	Comp
DCG	0.269*** (29.987)	0.285*** (32.350)	0.215*** (22.175)	0.023*** (8.295)
Constant	-75.093*** (-10.220)	-59.717** (-8.228)	-61.193*** (-7.672)	16.383*** (7.185)
Controls	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
Observations	20,093	20,093	20,093	20,093
R-squared	0.103	0.105	0.116	0.280

Note: ***, **, and * denote significant at the 1%, 5%, and 10% levels, respectively, and *t*-values in parentheses are the same as below.

Meanwhile, the correlation coefficient between the degree of digital transformation (DCG) and the comparability of accounting information (Comp) is 0.023, which means that when the degree of digital transformation of enterprises increases by 10%, the comparability of accounting information can be increased by 0.23%. This further confirms that digital transformation has a significant positive impact on the comparability of accounting information, and this finding is solidly supported at the 1% level of statistical significance.

4.2. Robustness tests

4.2.1. Propensity score matching method (PSM)

To circumvent the problem of sample self-selection, this study applies the propensity score matching method (PSM). Based on the digital transformation level of enterprises, we regard the top 25% of enterprises as the experimental group with a high level of digital transformation and the rest as the control group. By introducing the dummy variable DCG_dum, we assign a value of 1 to the experimental group (high level of digitalization) and a value of 0 to the control group (low level of digitalization). Meanwhile, considering the characteristics of the enterprises such as whether they are loss-making (Loss), two jobs in one (Dual), the nature of the property rights (Soe), and whether they are a Big 4 auditing firm (Big 4), we adopt the radius matching method for pairing, where the threshold value was set at 0.01, resulting in 10,824 valid samples. The results of parallel hypothesis testing for PSM revealed that before matching, the experimental group differed significantly from the control group on several characteristics. This implies that these characteristics may act as confounding variables. However, after matching, these differences were significantly reduced, indicating that the matching was successful and ensured the consistency between the experimental and control groups on the key features. This further demonstrates the effectiveness of PSM. Based on the screened sample, we further conducted a regression analysis of the relationship between the degree of digital transformation and firm innovation. As shown in columns (1), (2), and (3) of **Table 4**, the results of the analysis again support our initial hypothesis.

Table 4. Robustness test results.

Variable	(1)	(2)	(3)	(4)	(5)	(6)
	Patent	Patent1	Patent2	Patent	Patent1	Patent2
DCG	0.312*** (24.292)	0.328*** (26.377)	0.237*** (16.519)	0.225*** (25.754)	0.226*** (28.768)	0.148*** (17.910)
Constant	−59.117*** (−5.073)	−39.842*** (−3.418)	−51.937*** (−4.135)	−63.317*** (−8.793)	−37.071*** (−5.762)	−55.646*** (−7.880)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10,824	10,824	10,824	20,093	20,093	20,093
R-squared	0.085	0.083	0.080	0.251	0.231	0.210

4.2.2. Lagged explanatory variables

In response to the above conclusions about how the degree of digital transformation of firms affects firm innovation, there may be questions. In particular, there may be certain omitted variables that affect both firm digital transformation and firm innovation, thus biasing the findings. Furthermore, given that innovation is a time-intensive process, the issue of endogeneity here cannot be ignored.

To address these issues, this paper refers to an approach of lagging all explanatory variables by one period, which can alleviate the potential endogeneity problem. As

shown in columns (7), (8), and (9) of **Table 4**, even after accounting for these lags, every 1% increase in the degree of digital transformation (DCG) increases Patent, Patent1, and Patent2, 3 by 0.225%, 0.226%, and 0.148%, respectively. These results still hold at the 1% level of significance, thus reconfirming the validity of hypothesis H1.

4.2.3. Conclusions and insights

This research distinctly underscores a notable positive linkage between the extent of digital transformation and business innovation. As companies amplify their digital endeavors, they simultaneously bolster their innovative pursuits and proficiencies. This reiterates the indispensable nature of digital transformation in today's economic milieu for a company's enduring expansion and competitive edge. The research also highlights that digital transformation positively impacts the uniformity of accounting data. Crucially, this improved accounting data uniformity serves as a conduit linking digital transformation to enterprise innovation. Put differently, by refining the consistency of accounting details, digital transformation further amplifies a firm's innovative endeavors. However, there are some potential limitations related to the subjectivity of self-reported metrics about digital transformation. Self-reported measures, especially those derived from annual reports, are subject to the biases of the reporting firms. Companies may portray their digital transformation efforts more favorably to appeal to investors and stakeholders, potentially leading to an overestimation of their actual digital transformation intensity. This subjectivity can introduce systematic bias, making it challenging to accurately assess the true extent of digital transformation and its impact on innovation. Second, firms may vary in how they report and describe their digital transformation initiatives, leading to inconsistencies in the data collected. These differences can arise from varying levels of detail, terminology, and emphasis in the annual reports. Inconsistent reporting standards can compromise the comparability of digital transformation measures across different firms, potentially affecting the robustness of the study's conclusions. Self-reported measures also lack independent verification, meaning that the reported data on digital transformation may not always reflect actual practices and investments. Firms may exaggerate or underreport their digital activities due to strategic considerations or errors in reporting. Without external validation, the reliability of self-reported measures is questionable, which can affect the study's overall validity. While self-reported measures provide valuable insights into firms' digital transformation efforts, these potential limitations highlight the need for caution in interpreting the results. Future research could benefit from incorporating more objective measures of digital transformation, such as direct investment data, technology usage statistics, and third-party assessments, to complement self-reported information and provide a more comprehensive understanding of the phenomena under study.

This research emphasizes several practical implications for both business managers and policymakers, providing actionable insights that can guide strategic decisions and policy formulations to enhance enterprise innovation through digital transformation and improved accounting information comparability. Firstly, enterprises must delve deeper into digital transformation, recognizing it as more than just a technological shift—it's instrumental in spurring innovation and enhancing

overall competitiveness. Managers should develop and implement comprehensive digital strategies that integrate these technologies into their core business processes to drive innovation and maintain competitive advantage. For optimal impact, this transformation should be in harmony with the firm's long-term objectives and strategies. Secondly, during this digital transition, the emphasis should be placed on refining the accuracy and consistency of accounting data. This approach serves the dual purpose of catering to external stakeholders' informational requirements while solidifying the foundation for informed internal decisions. This can be achieved by adopting international accounting standards and leveraging advanced financial reporting tools. Lastly, in light of the importance attached to digital transformation and accounting data consistency, policymakers should design and implement incentives such as tax breaks, grants, and subsidies for businesses that invest in digital technologies and innovation. Additionally, creating innovation hubs and providing support for research and development can further spur digital adoption. Parallely, policymakers should enforce and promote regulations that ensure high standards of financial reporting and transparency. This includes adopting international financial reporting standards and providing guidelines for consistent financial disclosures. In conclusion, for policymakers, the findings highlight the need to create a supportive regulatory and infrastructural environment that encourages digital adoption and fosters innovation across different industries. By implementing these practical recommendations, both managers and policymakers can drive sustainable economic growth and maintain competitive advantage in the digital era.

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