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Research on the Impact of Employee Stock Ownership Plans on Corporate Digital Technology Innovation

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Abstract

Promoting enterprise digital technology innovation is important for facilitating the deep integration of the digital economy and the real economy. Using data from listed companies in the A-share market and the Global Patent Database from 2014 to 2020, this study found that the implementation of employee stock ownership plans by enterprises significantly promotes digital technological innovation by enhancing the stability of hired employees, strengthening the level of risk-taking, and improving financing constraints. Further analysis reveals that the implementation of an employee stock ownership plan has a more significant effect on the digital technology innovation of private enterprises, enterprises with higher annual turnover rates and enterprises with more negative news coverage. Based on these findings, we propose accelerating institutional innovation, improving the financing support system, and implementing differentiated policies to help enterprises better adapt to the development needs of the digital economy and to provide a reference for the formation of new types of production relations, the development of new quality productive forces, and the promotion of high-quality economic development.

JEL classification numbers: G34.
Keywords: Employee stock ownership plan, Digital technology innovation, Risk taking, Financing constraints.

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1. Introduction

The widespread application of digital technologies such as artificial intelligence, cloud computing and big data has propelled the world into a new phase of industrial transformation and technological change. In this context, digital technological innovation is not only a potent weapon in the fight for the high ground of modern industrial development but also a key factor in gaining a new set of technological advantages. To this end, the report of the 20th Party Congress proposes building a new generation of information technology, artificial intelligence and several other new growth engines; accelerating the development of the digital economy; and promoting the deep integration of the digital economy and the real economy. However, the industry's understanding of the unique attributes and motivations of digital technology is still lacking to a certain extent, so the drivers of digital technology innovation in enterprises and its impacts have not been fully explored. Moreover, some enterprises simply regard digitalization as informatization, resulting in the fragmentation and isolation of enterprise digital deployment and the "digital island" phenomenon. This phenomenon ignores the technical attributes and functions of digital technology in terms of information, computing, communication and connectivity, so enterprises' investment in and application of digital technology fall short of expectation or are even counterproductive. Consequently, enterprises lack the motivation to promote digital technology innovation. Therefore, to effectively encourage enterprises to carry out digital technological innovation, promote a deeper integration of the digital economy and the real economy, and attain high-quality economic development, it is necessary to comprehensively examine the source and driving force of enterprise digital technological innovation. Core employees have become a key factor in driving the sustained growth of an organization (Bergman and Jenter, 2007). In the context of China's mixed ownership reform, a series of measures have been taken, including the introduction of employee stock ownership plans, to fully stimulate the contribution of the workforce to economic growth. In particular, in 2014, the China Securities Regulatory Commission (CSRC) relaunched the management system of employee stock ownership plans, which signifies a close connection between employee stock ownership plans and the sustainable growth of enterprises, especially in the era of the digital economy, where digital technological innovations have become key to the sustainable development of enterprises. However, at present, most studies, both domestic and foreign, focus on the value impact and motivation of employee stock ownership plans, while neglecting how these plans affect enterprise digital technological innovation. There is also a lack of research on the related impact mechanism. Exploring whether an employee stock ownership plan has an impact on enterprise digital technology innovation and the specific impact mechanism is critical not only for improving an enterprise’s capacity for system construction and sustainable development but also for providing theoretical guidance to enterprises on new development paths amid fierce market competition, the formation of new types of production relationships, the development of new quality productive forces,

and the promotion of high-quality economic development to provide references.
The contributions of this paper are as follows: first, this paper enriches the literature. The existing research on digital technological innovation has focused mainly on its impact, namely, the impact of enterprises' digital technological innovation on the economic operations of microenterprises. In contrast, this paper focuses on the driving factors and mechanisms of enterprise digital technological innovation. Second, this study supplements the existing research perspectives. Specifically, it supplements research on enterprise digital technological innovation from the perspective of employee shareholding, which helps refine the theoretical framework for this field. Third, this study has practical significance. In an era of accelerated integration of digital technology and the real economy, digital technology innovation has become the key to the sustainable development of enterprises. Employee stock ownership plans are forms of incentives,. An understanding of their impact on enterprise digital technology innovation not only can help enterprises better adapt to the development needs of the digital economy but also can profoundly contribute to the formation of new types of production relationships, the development of new quality productive forces, and the promotion of high-quality economic development.

2. Literature Review

In the literature, three main areas of research are closely related to the concerns of this paper.

2.1 Employee Stock Ownership Plan Research

The employee stock option plan (ESOP) is a voluntary system that encourages employees to hold the company's stocks and options, enjoying residual rights to the stocks and the right to participate in the enterprise's management decisions. Through this system, the enterprise induces a sense of "ownership" among employees by binding them, aiming at retaining internal talent, attracting external talent, and achieving long-term performance incentives. Current research focuses on the following three aspects.
First, in terms of corporate performance, an employee stock ownership plan has multiple effects by motivating employees to hold shares. On the one hand, it improves employees' job satisfaction and loyalty (Aaron, 1992), enhances their willingness to work hard for the company (Kim and Ouimet, 2014), and promotes efficiency in teamwork, thus enhancing the overall performance of the company. On the other hand, some studies have found that there are certain boundary conditions for the incentive effects of employee stock ownership plans, such that when the percentage of employee stock ownership exceeds a certain level, firm performance may decline or even be negatively affected (Bova et al., 2015). Oyer (2005) further found that even nonexecutive general employees who hold company shares may not be incentivized, which is attributed to the "free rider" problem.
Second, in terms of corporate governance, an employee stock ownership plan

prompts employees to participate more actively in corporate decision-making, optimizes the governance environment, strengthens the internal supervision mechanism, improves the effectiveness of internal control and internal supervision, and makes the company's information clearer and more persuasive (Hales et al., 2015). In addition, increasing the proportion of management participation in employee stock ownership plans helps alleviate the agency problem between shareholders and management, reduces agency costs, improves the investment efficiency of the enterprise, closely integrates the interests of employees and shareholders, and positively affects corporate governance (Hochberg and Lindsey , 2010). However, some scholars believe that shareholding employees are "both employees and shareholders", which may lead to the problem of dual identity intersection and thus create new conflicts of interest and agency cost problems (Habib and Hasan, 2021).

Finally, in terms of enterprise innovation ability, employees, as the key driving force of enterprise innovation, can promote the formulation of long-term development strategies through the employee stock ownership plan to improve corporate governance and encourage high-risk research and development (Andersen and Dalgaard, 2011). By combining employee wealth and corporate performance benefits, realizing risk sharing, and generating synergistic benefits, employees' awareness of work innovation can be improved, and the enterprise's risk-bearing ability can be enhanced accordingly, enabling the innovation input to be transformed into innovation output and ultimately improving the innovation efficiency of the enterprise.

2.2 Research Related to Digital Technology Innovation

Digital technology innovation refers to the process whereby enterprises or organizations achieve innovation in products, processes, the organizational structure, and business models through digital technologies such as artificial intelligence and big data and in-depth digital integration with the traditional real economy (Nambisan et al., 2019). At present, research on enterprise digital technology innovation is extensive and focuses on two aspects, its impact effect and realization path.

Enterprise digital technology innovation has many positive effects. By reducing interdepartmental information asymmetry, it enhances enterprise resource integration, effectively promotes continuous product iteration and industrial upgrading, and facilitates technological advancement as well as sustained and stable enterprise development (Liu et al., 2023), thus significantly improving enterprise operational efficiency and financial performance. In addition, the application of digital technologies in R&D innovation and operations management promotes the innovation of high-quality digital products and the streamlining of operations management processes, which enhances the value of enterprises in the market (Acemoglu and Restrepo, 2018). These digitally innovative products and processes contribute to increased customer satisfaction, which in turn improves customer

loyalty and firm competitiveness.

In addition, the literature has explored the realization path of digital technology innovation in detail. On the one hand, emerging digital technologies have changed the traditional value creation mode by penetrating all kinds of production and business activities of real enterprises, replacing traditional manual labour and optimizing resource allocation (Mendling et al., 2020). This innovative technology helps reduce the enterprise's dependence on traditional resources, promote the transformation of business models, and improve the efficiency of resource utilization. On the other hand, research has shown that knowledge acquisition is a core element that drives digital technology innovation in companies (Tumbas et al., 2018). Within a company, the digital technology background of top management can promote the sharing of digital knowledge and enhance the enterprise's overall level of digital technology innovation. External communication with other market players in the industry chain promotes the flow of knowledge and becomes an effective way to explore opportunities for digital technology innovation.

2.3 Research on Employee Stock Ownership Plans and Digital Technology Innovation

The implementation of employee stock ownership plans by enterprises incentivizes the improvement of digital technology innovation ability. On the one hand, the implementation of an employee stock ownership plan can reduce the probability of employees quitting (Klein et al., 1987) and enhance their determination to continue working diligently and dedicate themselves to the company, thus enhancing employee stability. Employees assume the role of "executors" of innovation decisions, and their stability is inextricably linked to innovation output. First, employees have more contact with the company's products, services and customers. Some new ideas emerge as employees produce products, serve others, and interact with customers (Bradley et al., 2018). Second, the main members of the company who implement innovation decisions are technical employees, who are responsible for facilitating innovation (Chang et al., 2015). However, different employees in other positions in the company are important backup forces in the company, and their efforts, stability and cooperation affect whether the innovation efficiency of the final company can be effectively improved (Bradley et al., 2018). On the other hand, the implementation of an employee stock ownership plan can reduce the risk aversion of company management to a certain extent, enhance the enterprise's ability to bravely take risks, and form a mechanism of shared risk-taking, which can provide strong support for enhancing a company's ability to take risks (Alessandri and Pattit, 2014). If an enterprise's risk-bearing ability is gradually enhanced, then the enterprise will be more willing to invest in research and development, thus promoting technological breakthroughs and further innovation. Therefore, the implementation of core employee equity incentives can enhance employee stability and the enterprise's risk-bearing ability, which in turn can promote the enterprise's digital technology innovation.

However, the implementation of employee stock ownership plans by firms may also have an inhibitory effect on the enhancement of digital innovation capabilities. In some companies, shareholders with large shareholdings have developed programs that include defensive employee stock ownership plans to increase their control over the firm. If the first largest shareholder finances the employees in the company and guarantees that it will be able to pay the employees a certain amount of guaranteed returns, this situation will lead to a significant reduction in the company's ability to resist risk, and as corporate innovation is a high-risk, high-investment activity, it is important to maintain a high risk-taking capacity (Manso, 2011). Therefore, the implementation of an employee stock ownership plan by controlling shareholders to increase their control over the company will weaken the corporate risk-taking capacity and inhibit digital technological innovation.

3. Theoretical Analysis and Research Hypotheses

3.1 Employee Stock Ownership Plans and Corporate Digital Technology Innovation

Employee shareholding in enterprises can effectively motivate employees to participate in innovative activities. Although traditional studies have focused on the driving effect of executive shareholding on corporate innovation, more recent studies have gradually revealed the importance of common employee shareholding in enhancing corporate innovation performance. Its impact can be reflected in the following three aspects. First, given that the R&D process is difficult to strictly regulate and that its activities are highly specialized, the information asymmetry between R&D teams and firms may impede the innovation process. Employee shareholding can effectively promote innovation in firms, especially with digital technologies, by enhancing internal monitoring and facilitating collaboration among teams (Chang et al., 2015). Second, employee shareholding enhances employees' sense of identity and belonging to the enterprise, which not only affects employees' behaviour and work attitudes but also helps attract and retain innovative talent, reduce employee turnover, enhance the professional capacity of the enterprise, and prevent a lack of creativity owing to the loss of innovative talent. Finally, employee shareholding helps to better safeguard the use of specialized assets. The effective use of specialized assets requires additional protection and supervision mechanisms. When employees involved in intellectual property rights participate in shareholding, they can better maintain and utilize these specialized assets, ensure that funds are reasonably invested, and guarantee the smooth progress of innovation and other activities.

Enterprise innovation is a continuous investment process and usually has a long payback period. For members of management, the rise and fall of enterprises are closely related to their responsibilities, so they are more willing to invest considerable time and money to promote innovation to support enterprise development. For ordinary employees, the distribution of benefits often ignores their contributions, making it difficult for them to share in the residual earnings of

the enterprise, which may lead to a disconnect between the development of the enterprise and the personal goals of employees and adversely affect the long-term development goals of the enterprise. By granting employees options or shares, the two factors of production, capital and labour, can be closely integrated, prompting employees in turn to closely integrate their personal interests with enterprise development, thus orienting them to the long-term development of the enterprise and encouraging innovative activities. Accordingly, the first research hypothesis is proposed:

H1: The implementation of an employee stock ownership plan can promote the digital technology innovation of enterprises.

3.2 Employee Stock Ownership Plans and Employee Stability

The implementation of an employee stock ownership plan allows employees to not only rely on a fixed salary but also share the surplus value of the enterprise. This situation not only helps retain outstanding employees but also attracts more innovative talent, thus significantly reducing employee turnover and enhancing employee stability in the context of the enterprise's digital technology innovation activities (Core and Guay, 2001). On the one hand, from the perspective of two-factor theory, capital and labour are considered crucial factors in the production process, and their synergistic effect is essential to the creation and accumulation of wealth. Employee stock ownership plans increase the synergy between labour and capital. Specifically, they situate employees in the ownership structure of the enterprise and thus help to align the interests of the enterprise and the interests of employees. If employees become shareholders of the enterprise, they are more likely to adjust their behaviour and attitudes, increase their participation and work motivation in relation to innovative activities, stimulate their creative thinking, and contribute to a more efficient development of innovative activities. On the other hand, employees can not only obtain labour income but also have an opportunity to share equity earnings, thus achieving the goal of attracting and retaining talent. Since employee shareholding is usually subject to a lock-up period, this constraint helps prevent the short-sighted behaviour of employees to a certain extent, makes employees pay more attention to long-term interests, and effectively reduces the mobility of employees. From the perspective of enterprise innovation and upgrading, human capital management is a key factor in enterprise innovation activities. Employee turnover may lead to the interruption of enterprise innovation activities. Therefore, the implementation of an employee stock ownership plan can not only reduce staff turnover and help employees implement the enterprise's innovation decisions consistently and continuously but also help ensure the smooth progress of enterprises' innovation activities. Thus, the second research hypothesis is proposed:

H2: Employee stock ownership plans promote firms' digital technology innovation by increasing the stability of firms' hired employees.

3.3 Employee Stock Ownership Plans and Risk-Taking Level

Employee stock ownership plans improve the enterprise's governance mechanism and can enhance the enterprise's risk-bearing capacity, which is manifested in three main aspects. First, by allocating the enterprise's equity to employees, the employee stock ownership plan not only grants them the identity of the enterprise's owner but also enables them to share the enterprise's residual claim rights. This practice contributes to risk diversification and establishes a risk-sharing mechanism, thus improving the enterprise's risk-bearing capacity. In addition, the employee stock ownership plan strengthens employees' supervision of management, enhances the ability to monitor the daily business operations of the enterprise, helps curb management misbehaviour, and promotes interteam collaboration and horizontal supervision. In addition, the problems and information encountered by employees in their daily production and operation activities can be reported to management in a timely manner, facilitating timely adjustments in decision-making. This situation also enables employees to access information at all levels of the company, reduces the information advantage of the majority shareholder and the operations team, mitigates agency problems, encourages management to execute investment projects that enhance corporate value, and further improves the company's risk tolerance. Finally, the employee stock ownership plan also promotes the sharing of information and experiences, strengthens learning and communication among employees, helps improve the quality of the company's business and investment activities, reduces operational risk, and enhances the firm's ability to cope with uncertainty (Chang et al., 2015), which in turn enhances the company's risk tolerance level. Therefore, the third research hypothesis is proposed:

H3: Employee stock ownership plans promote firms' digital technology innovation by increasing the level of corporate risk-taking.

3.4 Employee Stock Ownership Plans and Corporate Finance Constraints

Monetary and nonmonetary compensation are usually the two forms of employee compensation in an enterprise, in which monetary compensation accounts for the majority of employees' income, which, to a certain extent, consumes the funds of the enterprise and may impact the innovative activities of the enterprise. However, the implementation of an employee stock ownership plan can increase cash reserves for the enterprise through the mobilization of equity funds and the diversification of compensation, thus helping to alleviate the enterprise's financing constraints and promote overall innovation output. Specifically, on the one hand, the employee stock ownership plan allows employees to subscribe to a certain number of company shares without cash payments, which provides long-term incentives for employees to participate in the company's operational decision-making and obtain residual income. In addition, this approach leads to compensation diversification while reducing the excessive occupation of cash by monetary compensation, which effectively alleviates financing constraints and guarantees the smooth progress of innovation activities. On the other hand, unlike the executive equity incentive plan,

in which the company's shares are purchased at a substantial discount, the employee stock ownership plan allows a wider range of employees to hold the company's equity at a price close to the secondary market price, which provides more adequate financial support for the enterprise's innovation activities and thus promotes rapid improvement in the enterprise's overall innovation output. In addition, according to signalling theory, one sign that the share price of a listed company deviates significantly from its intrinsic value is trading based on insider corporate information. Such transactions can convey information about excess returns to external investors, draw the attention of the capital market, and provide important support for the enterprise in obtaining more external resources, thus helping to alleviate enterprise financing constraints and promoting an increase in the enterprise's innovation output. Accordingly, the fourth research hypothesis is proposed:

H4: Employee stock ownership plans promote firms' digital technology innovation by alleviating firms' financing constraints.

4. Empirical Research Design

4.1 Econometric Modelling

To test whether employee stock ownership plans play an incentivizing or inhibitory role in corporate digital technology innovation, this paper constructs the following econometric model:

$$Digtech_{i,t+1} = \alpha + \beta ESOP_{i,t} + \gamma Control_{i,t} + \sum Year + \sum Industry + \varepsilon_{i,t} \quad (1)$$

The explanatory variable Digtech, t+1 represents firm-level digital technology innovation indicators. The core explanatory variable ESOPi,t represents the employee stock ownership plan (ESOP), which is used to reflect the implementation status of the company's employee stock ownership plan. controli,t is a series of control variables, including firm size, the gearing ratio (Lev), return on assets (Roa), firm age, the percentage of independent directors (Dirratio), the percentage of the first largest shareholder (OwnCon1), profitgrowth, TobinQ, the nature of property rights (SBP) and the number of shareholders in the company (TobinQ). OwnCon1), Profit (Profitgrowth), Tobin's Q (TobinQ), and Nature of ownership (SOE). ∑Year and ∑Industry denote year fixed effects and industry fixed effects, respectively. To attenuate potential pitfalls in the cross-section, this paper clusters the standard errors in all regressions in the firm dimension.

4.2 Description of Variables

4.2.1 Explained Variable: Firms' Digital Technology Innovation (Digtech)

This study constructs a comprehensive indicator for the digital technology innovation of listed companies in China to measure the level of digital technology innovation of enterprises. Combining the International Patent Classification (IPC) and the Reference Relationship Table of International Patent Classification and

National Economic Industry Classification (2018) and the Statistical Classification of the Digital Economy and Its Core Industries (2021) issued by the National Bureau of Statistics, a unique classification system is constructed: "IPC group - four-digit National Economic Industry Classification (SIC4) - digital economy core industry classification code". Code (SIC4) - Digital Economy Core Industry Classification Code" corresponding to the relationship[2]. In this way, this study harmonizes the SIC 4-digit codes with the corresponding IPC codes at the panel level to more accurately identify digital technology innovation activities at the patent level. Through this classification system, this paper effectively identifies the types of technologies and their corresponding IPC codes that belong to the field of digital technology innovation. This approach can accurately identify digital technology innovation patents applied for by enterprises at the IPC panel level. On this basis, this paper further summarizes the identified digital technology patents from the dimensions of "enterprise - year". This aggregation method is able to construct an enterprise-level digital technology innovation measurement index, which provides a more accurate and comprehensive analytical tool for in-depth research on the impact of digital technology innovation on enterprise development.

4.2.2 Core Explanatory Variables: Employee Stock Ownership Plans (ESOP)

In this paper, $ESOP_{i,t}$ is used as a proxy variable to measure the employee stock ownership plan, which represents whether the company of the ith listed company implements an employee stock ownership plan in year t. If an employee stock ownership plan is implemented, its value is 1; otherwise, it is 0.

4.2.3 Control Variables (Control)

In this paper, the following control variables are selected in order: firm size (Size), the gearing ratio (Lev), return on assets (Roa), firm age (Age), the percentage of independent directors (Dirratio), the percentage of the first largest shareholders (OwnCon1), profit (Profitgrowth), Tobin's Q (TobinQ), and the nature of ownership (SOE). See Table 1 for detailed definitions.

2 In this paper, the IPCs corresponding to the four-digit codes of national economic industries are harmonized at the panel level to more accurately identify digital technology innovation activities at the patent level.

Table 1: Variable definitions and constructs

Variable symbol	Variable name	Description of variable construction
Digtech	Digital technology innovation	Number of patent applications for digital technologies plus 1, then calculate the logarithm
ESOP	Employee stock ownership plan	1 for implementing employee stock ownership plan, otherwise 0
Size	Enterprise size	Natural logarithm of total assets
Lev	Gearing	Total liabilities to total assets
Roa	return on assets	Net profit to total assets
Age	Age of business	Natural logarithm of current year minus establishment year plus 1
Dirratio	Percentage of independent directors	Number of independent directors as a percentage of total number of directors
OwnCon1	Percentage of largest shareholders	Number of shares held by the largest shareholder as a percentage of total shares
Profitgrowth	Net profit growth rate	Year-on-year growth rate of net profit relative to the same period last year
TobinQ	Tobin's Q	(Total Market Capitalization + Total Liabilities)/Total Assets
SOE	Nature of property rights	State participation is 1, otherwise 0

4.3 Data Sources and Processing

The data used in this study are categorized into two main types: patent data and listed company data, covering information about companies listed in China's A-share market from 2014to 2020. The source of patent data is IncoPat, a joint global patent database that includes detailed information such as the disclosure number, type, application number, filing date, main IPC number, applicant, inventor and legal status of each patent. The data of listed companies are sourced from the Cathay Pacific database (CSMAR), with listed companies in Shanghai and Shenzhen A-shares as the initial sample.

In terms of data screening, this paper refers to previous research methods and adopts the following principles for selection: first, data from ST and* ST stocks and financial industries are excluded, as they may be biased due to special market states or industry characteristics. Second, firms with missing information on digital technology patents or with a total number of patent applications less than one were excluded, thus ensuring the completeness and reliability of the data. After screening, a total of 19,130 valid observations were collected in this study. Finally, to avoid the influence of extreme outliers, the variables in the sample were subjected to upper and lower 1% shrinkage to improve the robustness of the data analysis. Through data processing and screening, this study aims to conduct more accurate and in-depth analysis.

4.4 Descriptive Statistics

The descriptive statistics of the variables included in the model are shown in Table 2, in which the maximum and minimum values of Digtech, the digital technological innovation of enterprises in the lagged one-period data, are 4.304 and 0, respectively, and the mean and standard deviation are 0.679 and 0.947, respectively, which indicate differences in the level of digital technological innovation among different companies. The mean and standard deviation of employee stock ownership plan are 0.107 and 0.309, respectively, which indicates a large difference in the equity ownership plans offered by different companies. The mean value of Profitgrowth is -0.387, which indicates that during the period 2014-2020, the net profit of the listed companies in the A-share market experienced negative growth. The data distributions of the other control variables are all within a reasonable range and are not repeated here.

Table 2: Descriptive statistics

Variable	Observed value	Average value	Standard deviation	Minimum value	Maximum values
Digtech	19,130	0.679	0.947	0.000	4.304
ESOP	19,130	0.107	0.309	0.000	1.000
Size	19,130	22.300	1.295	19.400	26.070
Lev	19,130	0.425	0.203	0.050	0.956
Roa	19,130	0.051	0.068	-0.260	0.250
Age	19,130	2.942	0.294	1.609	3.466
Dirratio	19,130	0.377	0.054	0.308	0.571
OwnCon1	19,130	33.920	14.680	8.890	75.260
Profitgrowth	19,130	-0.387	3.912	-25.760	13.200
TobinQ	19,130	2.128	1.431	0.868	9.197
SOE	19,130	0.348	0.476	0.000	1.000

5. Empirical Results and Analysis

5.1 Baseline Regression

Table 3 presents the results of the baseline regression analysis, which is subdivided into four main columns reflecting the regression results under different variable controls. Specifically, Column (1) presents the regression results without control variables and without controlling for industry and year fixed effects. Column (2) presents the results when no control variables are added but industry fixed effects and year fixed effects are taken into account. Column (3) presents the regression results with the inclusion of control variables but without controlling for industry and year fixed effects. Column (4) presents the regression results with both control variables added and controlling for industry fixed effects and year fixed effects.

According to the analysis results in Columns (1) to (4), the coefficients of the core explanatory variables are all significantly positive, which supports the view that

employee stock ownership plans can effectively promote the digital technological innovation of enterprises and thus verifies Hypothesis H1. An employee stock ownership plan has a positive effect on stimulating the digital technological innovation of enterprises, and it provides an important theoretical basis for the practice of enterprise management and policy formulation.

Table 3: Baseline regression

Variable	(1)	(2)	(3)	(4)
	Digtech	Digtech	Digtech	Digtech
ESOP	0.326***	0.203***	0.221***	0.128***
	(7.427)	(5.301)	(5.214)	(3.557)
Size			0.129***	0.189***
			(7.460)	(12.319)
Lev			-0.283***	-0.115*
			(-3.997)	(-1.848)
Roa			0.571***	0.943***
			(3.515)	(6.702)
Age			-0.322***	-0.162***
			(-6.986)	(-3.659)
Dirratio			0.604**	0.127
			(2.545)	(0.629)
OwnCon1			-0.003***	-0.000
			(-3.181)	(-0.363)
Profitgrowth			0.001	-0.000
			(0.825)	(-0.204)
TobinQ			0.018**	0.026***
			(2.282)	(3.461)
SOE			-0.180***	-0.009
			(-5.573)	(-0.338)
Constant term (math.)	0.644***	0.129	-1.271***	-3.604***
	(43.975)	(1.574)	(-3.198)	(-9.680)
Observed value	19,130	19,130	19,130	19,130
Adjusted R^2	0.011	0.234	0.051	0.285
industry fixed effect	clogged	be	clogged	be
Year fixed effects	clogged	be	clogged	be

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively, and standard errors clustered at the firm level are in parentheses.

5.2 Robustness Tests

5.2.1 Replacement of Explanatory Variable Measures

Differences in the measurement methods of digital technology innovation may have an impact on the estimation results. For robustness testing, this paper measures a firm's digital technology innovation activities in terms of patents. As digital technology can iterate rapidly, a large number of patents can result from a company's digital technological innovation behaviour; thus, this paper takes digital utility patents (UtilityPatent) and digital invention patents (InventionPatent) as the proxy variables for measuring the enterprise's digital technological innovation indices for regression. The results of the robustness test are shown in Table 4. The regression coefficients of the core explanatory variables are all significantly positive, which is consistent with the results of the benchmark regression.

5.2.2 Replacement of Regression Models

Since the explanatory variable digital technological innovation is characterized by the accumulation of zero values and the continuous distribution of positive values, this paper adopts the Tobit model to retest it. The results show that the implementation of an employee stock ownership plan can have a strong incentive effect that improves the digital innovation ability of enterprises. The regression results are still robust.

5.2.3 Propensity Score Matching

The firm characteristics of the sample implementing an employee stock ownership plan differ from those of the sample not yet implementing an employee stock ownership plan. Additionally, despite the addition of firm-level control variables and industry and year fixed effects, the effects of omitted variables and sample selection bias cannot be fully eliminated, so we use propensity score matching (PSM) to control for systematic differences between the experimental and control groups. Using one year prior to the formal implementation of shareholding as the criterion for matching, one-to-one nearest-neighbour matching is initiated on the data of the experimental group, and the sample of the control group is consequently obtained. In addition, based on the Guiding Opinions on the Pilot Implementation of Employee Stock Ownership Plans in Listed Companies, this paper takes firm size, the gearing ratio, return on assets, firm age, the percentage of independent directors, the percentage of largest shareholders, profit, the Tobin's Q value, and the nature of property rights as the matched covariates. The regression results show that the coefficient of Digtech is significantly positive and that the conclusions of this paper are robust.

Table 4: Robustness test

Variable	Replacement of explanatory variable measures		Replacement of regression models	Propensity score matching
	Utility Patent	Invention Patent	Digtech	Digtech
ESOP	0.066**	0.102***	0.128***	0.098**
	(2.508)	(3.331)	(3.557)	(2.345)
Size	0.119***	0.167***	0.189***	0.201***
	(10.425)	(12.360)	(12.319)	(6.187)
Lev	0.000	-0.132**	-0.115*	0.048
	(0.010)	(-2.532)	(-1.848)	(0.307)
Roa	0.690***	0.652***	0.943***	1.103***
	(6.631)	(5.617)	(6.702)	(3.835)
Age	-0.109***	-0.085**	-0.162***	-0.188**
	(-3.399)	(-2.364)	(-3.659)	(-2.092)
Dirratio	0.056	0.153	0.127	0.068
	(0.392)	(0.884)	(0.629)	(0.174)
OwnCon1	0.000	-0.001	-0.000	0.001
	(0.534)	(-1.106)	(-0.363)	(0.348)
Profitgrowth	-0.000	-0.000	-0.000	-0.001
	(-0.340)	(-0.000)	(-0.204)	(-0.200)
TobinQ	0.013**	0.029***	0.026***	0.038**
	(2.355)	(4.378)	(3.461)	(2.378)
SOE	-0.022	0.010	-0.009	-0.095
	(-1.101)	(0.443)	(-0.338)	(-1.275)
Constant term (math.)	-2.325***	-3.377***	-3.604***	-4.115***
	(-8.454)	(-10.270)	(-9.680)	(-5.293)
Observed value	19,130	19,130	19,130	3,809
Adjusted R^2	0.256	0.263	0.285	0.294
industry fixed effect	be	be	be	be
Year fixed effects	be	be	be	be

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively, and standard errors clustered at the firm level are in parentheses.

5.3 Endogeneity

There may be a potential endogeneity problem in the relationship between employee stock ownership plans and digital technological innovations. To mitigate this problem, the Heckman two-step and instrumental variables methods were chosen for the regression.

5.3.1 Heckman Two-Step Approach

The implementation of an employee stock ownership plan by enterprises may involve self-selection, i.e., companies implementing an employee stock ownership plan have an inherently stronger digital technology innovation ability, which biases the previous estimation results. Therefore, it is re-estimated through the Heckman two-stage model. In accordance with previous methods, the IMR (Nemeth ratio) obtained in the previous step was added in step two. The regression results are shown in Table 5, and the coefficients and significance of the core explanatory variables in Column (2) indicate that an employee stock ownership plan can incentivize the digital technological innovation of enterprises, which supports the findings of the previous study.

5.3.2 Instrumental Variables Approach

Whether a firm implements an employee stock ownership plan is usually influenced by the level of the mean value of the employee stock ownership plan in the same province, but the mean value of the provincial employee stock ownership plan does not directly affect the firm's digital technology innovation capability. Thus, the instrumental variables are selected to exclude the provincial mean data of the firm's own employee stock ownership plan. On this basis, industry and year fixed effects are further controlled. The results of the regression are shown in Column (4) of Table 5. The coefficient of the employee stock ownership plan is still significantly positive, which is basically consistent with the benchmark results, further verifying the reliability of the above empirical results.

Table 5: Endogeneity analysis

Variable	The Heckman Two-Step		Instrumental variable	
	(1)	(2)	(3)	(4)
	ESOP	Digtech	ESOP	Digtech
ESOP		0.117***		1.063***
		(3.243)		(3.239)
IMR		0.963***		
		(2.668)		
IV			0.750***	
			(8.507)	
Size	0.286***	0.421***	0.045***	0.147***
	(19.006)	(4.603)	(10.837)	(7.122)
Lev	-0.369***	-0.421***	-0.041*	-0.074
	(-3.999)	(-3.219)	(-1.935)	(-1.141)
Roa	-0.697***	0.378	-0.135***	1.054***
	(-3.004)	(1.492)	(-2.601)	(7.115)
Age	-0.123**	-0.263***	-0.013	-0.147***
	(-2.459)	(-4.456)	(-0.847)	(-3.275)
Dirratio	-0.480*	-0.248	-0.090	0.212
	(-1.897)	(-0.989)	(-1.282)	(1.048)
OwnCon1	-0.004***	-0.003**	-0.001**	0.000
	(-3.737)	(-2.276)	(-2.445)	(0.404)
Profitgrowth	0.008**	0.007**	0.001*	-0.001
	(2.018)	(2.213)	(1.862)	(-0.758)
TobinQ	0.041***	0.058***	0.008***	0.019**
	(3.472)	(4.053)	(3.258)	(2.347)
SOE	-0.913***	-0.762***	-0.111***	0.103**
	(-21.982)	(-2.587)	(-13.003)	(2.138)
Constant term (math.)	-7.986***	-10.793***	-0.836***	-2.824***
	(-18.485)	(-3.891)	(-7.714)	(-6.343)
Observed value	19,130	19,130	19,130	19,130
Pseudo R^2 /Adjusted R^2	0.151	0.286	0.091	0.285
Industry fixed effect	be	be	be	be
Year fixed effects	be	be	be	be

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Standard errors clustered to the firm level are in parentheses in Columns (1) and (2), t values are in parentheses in Column (3), and z values are in parentheses in Column (4).

5.4 Impact Mechanism Testing

Based on the theoretical analysis above, this section tests the role of the employee stock ownership plan through hired employee stability, the risk-taking level and corporate financing constraints by conceiving the following model:

$$mechanism_{i,t} = \alpha + \beta ESOP_{i,t} + \gamma Control_{i,t} + \sum Year + \sum Industry + \varepsilon_{i,t} \qquad (2)$$

where $mechanism_{i,t}$ is the mechanism variable, and the other variables are set as in (1).

5.4.1 Employee Stability Enhancement Effect

To measure the stability of hired employees, this paper draws on the methodology of Bentley et al. (2013) and measures the degree of hired employee stability in a company by the standard deviation and the size difference of the number of employees during the last five years. If the standard deviation or the size difference is small, employee turnover occurs less frequently and the employee stability is good.

Columns (1) and (2) in Table 6 report the estimation results of Model (2). The regression results in the table reveal that the implementation of employee stock ownership plans by firms significantly reduces the degree of turnover of hired employees and increases the stability of hired employees in firms. This finding suggests an inextricable link between the stability of hired employees and the output of final innovation outcomes. The employee stock ownership plan binds the interests of the company with those of the employees and encourages the latter to contribute to enterprise innovation in a more permanent and stable way, which improves the quality and efficiency of the final innovation output. Thus, Hypothesis H2 is verified.

5.4.2 Risk-Taking Enhancement Effect

The risk-taking level is measured similarly to the construct of hired employee stability. This paper uses the standard deviation and the size difference of the firm's earnings level over the past five years to measure the firm's attitude in the face of risk. The larger the standard deviation or the size difference is, the higher the firm's earnings volatility, indicating a higher willingness to take risks, the a greater preference to take risks, and a stronger risk-taking ability.

Table 6, Columns (3) and (4) report the estimation results of Model (2) with firms' risk-taking level as the mechanism variable. The results show that the coefficient of the employee stock ownership plan is significantly positive, i.e., the implementation of an employee stock ownership plan by enterprises can enhance the risk-taking level of enterprises. The implementation of the employee stock ownership plan not only enhances the motivation of employees to work hard, promotes mutual supervision, and forms effective risk sharing but also allows the enterprise to have more sufficient human resources and financial support in the face of risk. This plan also lays a more solid material foundation for the company to bear risk, thus enhancing the company's risk-taking level and further generating incentives for enhancing its innovation ability. Hypothesis H3 is therefore verified.

5.4.3 Financial Constraint Mitigation Effects

There are many ways to measure the financing constraints of enterprises. The SA index is commonly used to express the level of financing constraints of enterprises. The higher the SA index is, the greater the financing constraints faced by enterprises. Column (5) of Table 6 reports the estimation results of Model (2) with the degree of firms' financing constraints as the mechanism variable. The coefficient of the

employee stock ownership plan is significantly negative at the 1% level, which indicates that the implementation of the employee stock ownership plan can alleviate the financing constraints of enterprises. An employee stock ownership plan increases the cash reserves of enterprises, alleviates the financing constraints faced by enterprises, provides financial support for enterprise digital technology innovation, and promotes enterprise digital technology innovation. The Hypothesis H4 proposed in this paper is thus verified.

Table 6: Analysis of impact mechanisms

Variable	(1)	(2)	(3)	(4)	(5)
	employeesd	employeesize	roesd	roesize	SA
ESOP	-0.105*	-0.236*	0.003**	0.008**	-0.024***
	(-1.845)	(-1.832)	(2.241)	(2.210)	(-6.609)
Size	0.632***	1.457***	-0.006***	-0.014***	1.227***
	(14.286)	(13.999)	(-9.089)	(-9.201)	(423.010)
Lev	0.021	0.018	0.026***	0.059***	-0.018**
	(0.187)	(0.070)	(5.604)	(5.432)	(-2.037)
Roa	-0.973***	-2.215***	-0.177***	-0.406***	-0.180***
	(-3.389)	(-3.368)	(-13.742)	(-13.407)	(-10.340)
Age	-0.205*	-0.507**	0.006**	0.014***	-0.049***
	(-1.833)	(-1.999)	(2.510)	(2.608)	(-8.251)
Dirratio	1.463***	3.431***	0.013	0.031	0.160***
	(2.740)	(2.788)	(1.237)	(1.262)	(5.924)
OwnCon1	0.001	0.001	-0.000**	-0.000**	0.000***
	(0.357)	(0.299)	(-2.039)	(-2.073)	(3.779)
Profitgrowth	-0.004	-0.011	-0.000***	-0.001***	0.001***
	(-1.250)	(-1.350)	(-4.006)	(-3.974)	(2.978)
TobinQ	0.064***	0.151***	0.006***	0.014***	0.025***
	(4.478)	(4.600)	(8.605)	(8.568)	(16.484)
SOE	0.031	0.047	-0.008***	-0.019***	-0.006*
	(0.550)	(0.362)	(-5.647)	(-5.616)	(-1.783)
Constant term (math.)	-11.423***	-26.325***	0.135***	0.323***	-22.455***
	(-8.669)	(-8.536)	(7.756)	(7.833)	(-342.453)
Observed value	15,151	15,151	14,050	14,050	19,130
Adjusted R^2	0.256	0.261	0.252	0.248	0.997
Industry fixed effect	be	be	be	be	be
Year fixed effects	be	be	be	be	be

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively, and standard errors clustered at the firm level are in parentheses.

6. Further Analysis

6.1 Impact of the Nature of the Enterprise

According to the current research insights, the diverse nature of enterprises results in obvious heterogeneity in the impact of the same measures on different enterprises. To explore in detail the heterogeneous impact of employee stock ownership plans on digital technology innovation in enterprises, this paper divides the research sample into three main categories—state-owned enterprises, private enterprises and other enterprises—for detailed analysis.

The regression results in Table 7 indicate that the implementation of an employee stock ownership plan significantly promotes digital technology innovation in private enterprises, but the effect is not significant in state-owned enterprises or other enterprises. This phenomenon may be closely related to factors such as the governance structure and decision-making mechanism of different enterprise types. Private firms usually have a more flexible governance structure and a more agile and rapid decision-making process. This flexibility makes it easier for employee stock ownership plans to play a positive role in such an environment. In contrast, SOEs may be subject to more complex bureaucratic systems and government interventions, and the implementation of employee stock ownership plans creates more resistance and challenges to the achievement of firms' digital technology innovations. Furthermore, SOEs are generally regarded as organizations that serve the public interest, and in addition to their business activities, they must assume certain social responsibilities, such as providing employment opportunities, improving social welfare, and promoting local economic development. These social responsibilities limit SOEs' freedom in innovation, and the innovation effect of employee stock ownership plans is affected by these external factors.

6.2 Impact of the Annual Turnover Rate

In the stock market, the annual turnover rate is considered an important indicator of stock trading activity, with higher values usually representing shorter shareholder holding cycles and stronger market trading pressure. In a high turnover rate environment, market participants tend to favour short-term returns and pay relatively little attention to long-term corporate value growth. This dynamic often leads to the dominance of short-term investors with low tolerance for failure and limited risk tolerance, thus negatively impacting firms' innovation activities. Many innovation projects are naturally high risk, requiring large capital investments and posing a high risk of failure. In addition, due to information asymmetry, it is difficult for the market to assess the true value of innovation projects accurately. In this case, the implementation of an employee stock ownership plan significantly increases a firm's tolerance for failure. Employees, as firm insiders, have a deeper understanding of and trust in the firm's operations and innovation projects, which in turn facilitate corporate innovation. Therefore, this paper hypothesizes that the positive effect of implementing an employee stock ownership plan on corporate digital technology innovation is more pronounced in firms with high annual

turnover rates.

To verify the correctness of this speculation, this paper takes the annual turnover rate as a measure of stock market trading pressure, divides the sample into two groups, high annual turnover rate and low annual turnover rate, according to the median annual turnover rate, and performs the corresponding regression analysis. The results show that in the high annual turnover rate group, the positive effect of employee stock ownership plans on digital technological innovation is more significant, which is fully reflected in the magnitude of the regression coefficients. This finding strongly supports the prediction of this study that firms in the high annual turnover rate group can incentivize digital technology innovation more effectively by implementing an employee stock ownership plan. Through employee stock ownership plans, firms can cultivate employees' focus on long-term corporate development and reduce their sensitivity to short-term market fluctuations, thus mitigating, to a certain extent, the negative impact of market myopia on firms' innovation activities. This finding validates the significant value of employee stock ownership plans in promoting corporate innovation, especially in an environment facing higher market volatility and short-term investor behaviour.

6.3 Impact of Negative Publicity

Firms that face considerable negative press often face the risk of long-term failure or even bankruptcy, a stressful environment that hones a firm's risk tolerance. Hence, companies that face frequent negative press are more inclined to innovate to avoid risk than those with less negative press. The "market pressure hypothesis" suggests that when a company receives a large amount of media coverage, especially negative news coverage, investment managers will be under psychological pressure, which will have a negative impact on business operations. On the other hand, negative information reported by the media can, to a certain extent, help firms correct their mistakes, improve their business performance, and enhance their risk prevention ability, which is beneficial for corporate innovation.

To analyse the heterogeneity of firms' responses in the face of different amounts of negative news, this study uses the number of negative news items plus one and then takes the logarithm to measure the degree of negative media coverage of firms. By comparing the number of negative news stories for each firm with the median of all negative news stories, the sample is divided into two groups, a high number of negative news stories and a low number of negative news stories, and regression analysis is performed. The results show that in the group with a high number of negative news stories, the implementation of an employee stock ownership plan by enterprises has a more significant effect on the enhancement of digital technology innovation ability, which implies that enterprises suffering from a higher number of negative news stories can realize digital technology innovation through the implementation of an employee stock ownership plan.

Table 7: Heterogeneity analysis

Variable	Nationalized business	Private business	Other enterprises	High annual turnover rate	Low annual turnover rate	High number of negative news stories	Low number of negative news stories
	Digtech	Digtech	Digtech	Digtech	Digtech	Digtech	Digtech
ESOP	0.050	0.134***	0.178	0.161***	0.118***	0.161***	0.108***
	(0.468)	(3.391)	(1.452)	(3.331)	(2.838)	(3.132)	(2.800)
Size	0.212***	0.165***	0.338***	0.152***	0.220***	0.206***	0.114***
	(8.492)	(7.877)	(7.334)	(7.575)	(11.878)	(10.156)	(7.054)
Lev	-0.284***	-0.013	-0.347*	-0.017	-0.237***	-0.210**	-0.023
	(-2.621)	(-0.160)	(-1.812)	(-0.230)	(-2.883)	(-2.372)	(-0.317)
Roa	0.561**	1.096***	0.465	0.909***	0.995***	1.164***	0.764***
	(1.978)	(6.064)	(1.190)	(5.647)	(4.905)	(5.432)	(4.802)
Age	-0.061	-0.176***	-0.404***	-0.205***	-0.076	-0.106*	-0.203***
	(-0.796)	(-3.150)	(-2.649)	(-4.009)	(-1.331)	(-1.801)	(-3.991)
Dirratio	0.090	0.285	-0.283	-0.035	0.216	0.280	-0.078
	(0.275)	(1.077)	(-0.420)	(-0.158)	(0.800)	(0.986)	(-0.348)
OwnCon1	-0.001	0.002*	-0.003*	0.000	-0.001	-0.000	-0.001
	(-1.030)	(1.667)	(-1.651)	(0.283)	(-1.042)	(-0.069)	(-0.818)
Profitgrowth	0.001	-0.001	-0.002	0.000	-0.001	-0.001	0.002
	(0.238)	(-0.303)	(-0.342)	(0.226)	(-0.521)	(-0.651)	(0.797)
TobinQ	0.031*	0.021**	0.043**	0.022**	0.028***	0.022**	0.009
	(1.813)	(2.187)	(2.249)	(2.176)	(2.809)	(2.059)	(0.939)
SOE	-0.100	-0.187*	0.497	-0.045	0.027	0.003	-0.020
	(-0.996)	(-1.730)	(1.425)	(-1.352)	(0.804)	(0.064)	(-0.638)
Constant term (math.)	-4.222***	-3.174***	-5.196***	-2.656***	-4.520***	-4.118***	-1.873***
	(-6.936)	(-6.284)	(-4.635)	(-5.736)	(-9.319)	(-8.226)	(-4.900)
Observed value	6,670	10,784	1,676	9,565	9,565	8,831	10,299
Adjusted R^2	0.345	0.249	0.428	0.258	0.329	0.347	0.247
Industry fixed effect	be	be	be	be	be	be	be
Year fixed effects	be	be	be	be	be	be	be

Note: *, **, and *** indicate significant at the 10%, 5%, and 1% levels, respectively, and standard errors clustered to the firm level are in parentheses.

7. Conclusions and Insights

In the current era of the rapid development of digital technology and its integration with the real economy, digital technology has become a key technological pillar for high-quality economic development. Using the data of listed companies in the A-share market and patent data from the global patent database from 2014 to 2020, this paper examines the impact of the implementation of employee stock ownership plans by enterprises on digital technology innovation and its mechanism. The results of the study show that, first, the implementation of an employee stock ownership plan significantly promotes the digital technology innovation of enterprises. Second, in terms of the mechanism of action, the implementation of employee stock ownership plans by enterprises promotes digital technological innovation by enhancing the stability of hired employees, increasing the level of risk taking, and improving financing constraints. These findings reveal that the implementation of employee stock ownership plans provides three advantages in terms of enterprise digital technology innovation, namely, managerial empowerment, risk sharing, and financial readiness. In addition, the results of the heterogeneity analysis show that the implementation of the employee stock ownership plan has a more significant effect on the digital technology innovation of private enterprises, enterprises with higher annual turnover rates and enterprises with a higher number of negative news stories.

Given the above findings, the policy implications of this paper are as follows:

First, enterprises should accelerate institutional innovation and effectively promote the implementation of employee stock ownership plans. First, it is necessary to improve relevant laws and regulations to clarify the tax policy and equity transfer of employee stock ownership plans to provide enterprises with good legal protection and facilitation. Second, the government needs to strengthen publicity and education for enterprises and employees and improve their knowledge and understanding of the ESO plan. Moreover, the government can promote exchanges and learning among enterprises by organizing seminars, forums and other activities. Third, the government needs to continue to improve the regulatory mechanism to supervise and manage the implementation of employee stock ownership plans by enterprises to promote stable operation and effective implementation of employee stock ownership plans.

Second, the financing support system should be improved, and the level of enterprise risk-taking should be increased. First, a financing support system should be established that is more flexible and adaptable to the needs of innovation, more convenient financing channels should be provided, and the cost of enterprise financing should be reduced. Second, financial institutions and enterprises should be encouraged to establish long-term cooperative relationships, share project risk, and incentivize financial institutions to invest more in digital technology through a risk-sharing mechanism to promote in-depth research and development of digital technology. Third, the government should provide enterprises with financial support and policy support through financial subsidies, tax incentives, etc., and

encourage more enterprises to implement employee stock ownership plans.
Third, differentiated employee stock ownership plan policies should be formulated to address the characteristics of enterprises. First, private enterprises should design flexible equity incentive programs, such as stock options, stock awards, stock purchase plans, etc., to adapt to the different needs of employees and the development stage of the company and to promote the implementation of the employee stock ownership plan. Second, enterprises with high annual turnover rates should link the employee stock ownership plan with long-term performance and encourage employees to hold the company's stock for a longer period of time by setting up a longer period of stock ownership or releasing equity in stages to increase the stability of employees and their concern for the long-term development of the enterprise. Third, enterprises with more negative news coverage should not only improve their information disclosure mechanism but also enhance the disclosure of high-quality information to reduce the negative impact of information asymmetry.

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