The Impact of Digital Finance on The Financial Constraints of Small and Medium-sized Enterprises

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Abstract. As an important pillar of the national economy, small and medium-sized enterprises play a key role in economic growth, job creation, and innovation. However, due to factors such as small size, insufficient credit, and high financing costs, their development has long been constrained by difficulties and high costs in obtaining financing. The rapid development of digital finance has provided small and medium-sized enterprises with new ways to ease financial constraints through technologies such as big data, artificial intelligence and blockchain. By analyzing relevant literature in recent years, this paper explores the evolution and applicability of the financial constraint index, analyzes the influencing factors and manifestations of financial constraints of small and medium-sized enterprises, and reveals the mechanism by which digital finance acts on financial constraints. The study found that digital finance has broadened financing channels through channels such as crowdfunding, peer-to-peer lending and supply chain finance, and reduced financing costs by using data-driven credit assessments; however, digital transformation has also brought pressure for technological updates and intensified market competition, which may increase the financial burden of some companies. The marginal contribution of this article lies in integrating multidisciplinary perspectives, comprehensively revealing the dual effects of digital finance, and proposing future research directions, such as the moderating role of digital literacy on financing effects. The research provides theoretical support and practical guidance for small and medium-sized enterprises to optimize their financial strategies in the digital economy era, aiming to help them achieve sustainable development and enhance their resilience.

Keywords: Digital finance; financial constraints; small and medium-sized enterprises.

1. Introduction

Digital finance refers to the use of digital technology by Internet companies and financial institutions to expand capital financing, payment, information intermediation and other related businesses, thereby establishing an emerging technology model that goes beyond traditional financial business [1,2]. As an important pillar of the national economy, small and medium-sized enterprises play a key role in economic growth, job creation and innovation promotion [3,4]. However, due to their small size and lack of credit, small and medium-sized enterprises have long faced financial constraints such as difficulty in financing and high financing costs, which seriously limit their development potential [5]. In this context, whether the rapid development of digital finance can provide new possibilities for small and medium-sized enterprises to alleviate these financial constraints has attracted much attention due to its theoretical value and practical significance.

Existing research has examined the relationship between digital finance and financial constraints. Digital finance can significantly alleviate corporate financing constraints [6]. Digital finance can provide small businesses with appropriate financial services, ignoring the high risk premiums and high operating costs associated with the traditional financial system, which will affect the cash flow of enterprises and thus affect the financial constraints of enterprises [7]. Digital finance reduces customer acquisition and risk control costs through scenario integration and big data analysis, effectively serves inclusive finance entities such as small and micro enterprises, improves their financing environment, and affects corporate financing constraints [8].

This article systematically sorts out and analyzes relevant literature in recent years, focuses on the impact of digital finance on the financial constraints of small and medium-sized enterprises, explores

the changes and applicability of indexes for measuring financial constraints, analyzes the influencing factors and manifestations of financial constraints of small and medium-sized enterprises, and analyzes the mechanism by which digital finance acts on financial constraints, and then predicts the future trends of the digital economy and the challenges faced by small and medium-sized enterprises. Based on preliminary thinking on existing research, this paper argues that the impact of digital finance on the financial constraints of small and medium-sized enterprises (SMEs) is dual. On the one hand, digital finance has broadened financing channels through channels such as crowdfunding, supply chain finance, and digital credit, and has used big data and artificial intelligence to optimize credit assessments, significantly reducing the financing costs and thresholds for small and medium-sized enterprises; on the other hand, the acceleration of digital transformation has also brought about intensified market competition and pressure for technological updates, which may increase the financial burden of some small and medium-sized enterprises. This insight suggests that it need to view the role of digital finance dialectically.

The marginal contribution of this article lies in: comprehensively revealing the complex impact of digital finance on the financial constraints of small and medium-sized enterprises by integrating multidisciplinary research results; emphasizing its positive and negative effects, avoiding the limitations of a single perspective; and pointing out future research directions, such as the moderating role of digital literacy on financing effectiveness. Through this review, this paper aims to provide theoretical support and practical guidance for the financial strategy optimization of small and medium-sized enterprises in the digital economy era.

2. Measuring the Financial Constraints of Small and Medium Enterprises

In order to better develop small and medium-sized enterprises, scholars have done a lot of research on measuring the financial constraints of small and medium-sized enterprises in recent years.Among them, the SME financial constraint index, as a core tool for evaluating corporate financing capabilities and external financing costs, plays a key role in corporate finance research.

The evolution of these indices reflects a move from the early complex combination of qualitative and quantitative methods to a more universal and simplified approach. There is a clear logical progression between the Kaplan - Zingales (KZ) Index, Whited - Wu (WW) Index, Size - Age(SA) Index, Financial Constraints (FC) Index, the KZ index laid the foundation, emphasizing investment-cash flow sensitivity as a measure of financial constraints, but sample limitations led to subsequent improvements; the WW index expanded the sample and improved universality based on the KZ, capturing time-varying characteristics through a dynamic model; the SA index criticized the complexity and endogeneity of the KZ, further simplifying it to size and age variables, enhancing its applicability to small and medium-sized enterprises. This time series evolution reflects the shift in research paradigms: from small-scale, in-depth samples to large-sample universality, and from multivariate endogenous models to simple exogenous indicators that avoid endogeneity. Furthermore, the FC index is combined with the KZ, WW, and SA indices, and a complex model is used to combine external and internal factors of the enterprise, making the measurement index of financial constraints more comprehensive and in-depth.

The KZ index was proposed by Kaplan and Zingales in 1997 to test whether investment-cash flow sensitivity is a reliable measure of financial constraints, based on the earlier work of Fazzari et al [9,10]. Kaplan and Zingales analyzed the annual reports, SEC filings, and management statements of 49 low-dividend-paying companies from 1970 to 1984, combining qualitative (such as financial disclosure), quantitative data (It contains five variables: Cash Flow/Capital (CF_i), Tobin's Q (Q_i), Debt/Capital (Lev_i), Dividend/Capital (Div_i) and Cash/Capital ($Cash_i$)), and constructed an index using an ordered logit model. The formula of KZ index is

$$KZ_i=-1.002\times CF_i+0.283\times Q_i+3.139\times Lev_i-39.368\times Div_i-1.315\times Cash_i \quad (1)$$

This method innovatively quantifies the level of financial constraints, providing in-depth insights. However, its strengths lie in its ability to capture subtle information disclosed by management, its intuitiveness, and its innovative methodology. Its weaknesses, however, lie in its small sample size, inconsistent subjective classifications, and its reliance on endogenous variables, which limit its generalizability. This laid the theoretical foundation for subsequent indices, but also exposed challenges in their generalization.

On this basis, Whited and Wu proposed the WW index in 2006, which improved the sample limitations of KZ and used the generalized method of moments (GMM) and the investment Euler equation [11]. Based on the Compustat large sample data from 1975 to 2001, it covered six variables: cash flow/assets(CF_i), dividend payment indicators($DivDummy_i$), logarithm of total assets($LnTA_i$), industry sales growth(ISG_i), company sales growth(SG_i) and long-term debt/asset ratio($TLTD_i$). The formula is the corresponding linear combination, which is

$$WW_i=-0.091\times CF_i-0.062\times DivDummy_i+0.021\times TLTD_i-0.044\times LnTA_i$$
$$+0.102\times ISG_i-0.035\times SG_i \tag{2}$$

This method emphasizes dynamically capturing time-varying constraints in investment decisions, and variable selection is based on theoretical derivation to ensure cross-industry and cross-time applicability. Compared with KZ, WW has the advantages of large sample coverage, strong explanatory power, and the ability to dynamically analyze financial health and growth characteristics; however, its disadvantages include reliance on endogenous variables (such as dividends and leverage) that may lead to bias, complex models with high computational costs, and less-than-expected applicability to small and medium-sized enterprises, This marks a logical leap from the small sample depth of KZ to the large sample universality, strengthening the empirical evidence of the index.

In a further evolution, Hadlock and Pierce criticized the multivariate endogeneity and complexity of KZ in 2010 and proposed the SA (Size-Age) index, which only uses the logarithm of assets and firm age as exogenous indicators and analyzes the SEC filings of randomly sampled firms from 1995 to 2004 through an ordered logit model [12]. The formula is a nonlinear combination, which is

$$SA_i=-0.737\times Size_i+0.043\times Size_i^2-0.040\times Age_i \tag{3}$$

The method regresses simplicity, confirms the high correlation between size and age and financial constraints, and removes endogenous variables to improve robustness. Compared with KZ and WW indices, the advantages of SA index are that the model is simple and easy to calculate, avoids endogenous problems, and is especially suitable for small and medium-sized enterprises. But its disadvantages are that ignoring factors such as cash flow may cause information loss, and the nonlinear assumption of the scale-age relationship is invalid in some scenarios. This reflects the shift from the complex optimization of KZ via WW to the simplified logistic regression of SA, prioritizing universality and repeatability, and marks the maturity of financial constraint measurement towards a more refined direction.

In 2020, Gu Leilei, Guo Jianluan and Wang Hongyu expanded the simplified logic of SA, criticized its limitations of ignoring dynamic factors such as cash flow and leverage, and proposed the Financing Constraint(FC) Index, which comprehensively used asset size($size_{i,t}$), financial leverage($lev_{i,t}$), cash dividends(CashDiv),market value ratio($MB_{i,t}$), net working capital(NWC) and profit before interest($EBIT$) and total assets(ta) as multidimensional indicators.The financial statement data of listed companies from 1995 to 2018 were analyzed through a two-step ordered logit model [13].The formula is a probabilistic nonlinear combination, which is

$$Z_{i,t}=\alpha_0+\alpha_1 size_{i,t}+\alpha_2 lev_{i,t}+\alpha_3\left(\frac{CashDiv}{ta}\right)_{i,t}+\alpha_4 MB_{i,t}+\alpha_5\left(\frac{NWC}{ta}\right)_{i,t}+\alpha_6\left(\frac{EBIT}{ta}\right)_{i,t} \tag{4}$$

$$P(QUFC=1or0|Z_{i,t})=\frac{e^{Z_{i,t}}}{1+e^{Z_{i,t}}} \tag{5}$$

This method emphasizes the robustness of stratification. It first conducts a preliminary orderly classification based on size, age and dividend payout ratio to confirm the constraint threshold, and then uses Logit regression to fit the probability value as a continuous index to improve the dynamic capture of financing constraints. Compared with KZ, WW, and SA indices, the advantages of FC are that it integrates endogenous and exogenous variables and provides continuous probability measures to avoid binary classification bias, which is especially suitable for emerging market companies. The disadvantages are the complexity of model parameter estimation and data dependence, which may introduce noise in small samples or non-listed companies. This reflects the evolution of the method from the simple exogenous SA to the multidimensional probabilistic FC, giving priority to accuracy and applicability, and marks the deepening of financial constraint measurement towards a more comprehensive direction.

In general, the logical relationship among KZ, WW, and SA is reflected in a problem-solving chain through temporal evolution: KZ is pioneering but limited by samples and endogeneity, WW expands universality but retains complexity, SA simplifies to enhance applicability, and FC integrates and becomes more in-depth and systematic. This progression not only improves the index's accuracy in measuring the financial constraints of small and medium-sized enterprises but also promotes the transformation of research from subjective depth to objective universality.

3. The Impact of Digital Finance on the Financial Constraints of Small and Medium-sized Enterprises

3.1. Factors Affecting the Financial Constraints of Small and Medium-sized Enterprises

The financial constraints of small and medium-sized enterprises (SMEs) are affected by multiple factors, which together determine their financing capacity and external financing costs. The following is an analysis of the main influencing factors: According to Hadlock and Pierce‘s paper, firm size is the core determinant of financial constraints [12]. Smaller companies usually have limited assets and lack collateral, which means they face higher barriers to obtaining bank loans or capital market financing [1]. Small businesses are often considered riskier, and banks and investors are more stringent in their credit assessments [14]. Firm age is negatively correlated with financial constraints [12]. Startups, lacking a long-term credit history and stable cash flow, typically face higher financing costs and stricter loan terms [12].In contrast, mature companies find it easier to establish credit and obtain lower-cost external funds. Small and medium-sized enterprises are often regarded as high-risk targets by financial institutions due to insufficient information disclosure and low financial transparency [10]. Lack of credit ratings or low credit ratings make it difficult for SMEs to obtain low-cost financing, which in turn exacerbates financial constraints.Industry growth rate and degree of competition have a significant impact on financial constraints.Whited and Wu pointed out that small and medium-sized enterprises in high-growth industries may face a larger funding gap due to the need for rapid expansion, while enterprises in low-growth industries may find it difficult to obtain investment due to fierce market competition [3,11]. Macroeconomic fluctuations, such as rising interest rates or economic recession, can make it more difficult for small and medium-sized enterprises to obtain financing. Kaplan and Zingales emphasized the impact of internal cash flow on investment decisions [10]. Small and medium-sized enterprises usually rely on internal funds for investment. When cash flow is insufficient, the high cost of external financing will further restrict their development [9].

3.2. Digital Finance can Ease Financial Constraints

The rapid development of the digital economy has provided new possibilities for SMEs to alleviate financial constraints, mainly through the following mechanisms: Digital finance provides SMEs with diversified financing channels through emerging models such as crowdfunding, P2P lending and supply chain finance [1]. For example, crowdfunding platforms allow small and medium-sized

enterprises to raise funds directly from the public, bypassing the high barriers to entry of traditional banks. Digital finance uses big data and artificial intelligence technologies to optimize credit assessments and reduce customer acquisition and risk management costs [2]. By analyzing businesses' transaction data, supply chain information, and online behavior, digital financial platforms can more accurately assess the creditworthiness of small and medium-sized enterprises, thereby reducing the difficulty of loan approval. Digital financial platforms also offer higher operational efficiency than traditional financial institutions, reducing intermediary costs [6]. For example, supply chain finance provides low-cost, short-term financing to small and medium-sized enterprises by integrating transaction data from upstream and downstream companies. Digital finance serves groups that are underserved by the traditional financial system, such as small and micro enterprises [7]. Through tools like mobile payments and digital credit, SMEs can access financial support more conveniently. Digital finance provides SMEs with more funds for R&D and technological upgrades, thereby alleviating innovation bottlenecks caused by financial constraints [8,14].

4. Conclusion

This study systematically reviews the comprehensive impact of digital finance on the field of financial constraints of small and medium-sized enterprises, revealing its strategic significance as an emerging paradigm in reshaping the financing landscape. As the micro-engine of economic growth, small and medium-sized enterprises often fall into financial difficulties due to insufficient resource endowments and external uncertainties, which inhibit their expansion and transformation potential. With the help of cutting-edge technologies, digital finance has innovatively bridged the structural gaps in the traditional financial system and achieved more inclusive resource allocation and risk governance through diversified platforms and algorithm optimization. This mechanism not only broadens financing channels but also improves decision-making efficiency and promotes the optimization and reorganization of internal elements of the enterprise.The evolution of financial constraint measurement tools reflects the gradual optimization of methodology, transforming from the early variable-intensive framework to the contemporary model that focuses on exogenous variables and dynamic monitoring, significantly improving the validity and pertinence of the assessment. The analysis of the causes of constraints clarifies the complexity of the interaction between micro-enterprise attributes and macro-market dynamics, and emphasizes the need for an integrated analysis using a multi-dimensional framework. Through interdisciplinary integration, this article deepens the understanding of the dual effects of this topic and looks forward to subsequent research paths, such as technological inclusion under policy intervention. Ultimately, this research provides theoretical insights for SMEs to build a financial optimization framework in the digital economy transformation, driving their evolution towards a more adaptable and competitive form.

The government should improve the digital financial regulatory framework, encourage the compliant development of P2P lending and crowdfunding platforms, provide tax incentives or subsidies to support the digital transformation of small and medium-sized enterprises, establish a data sharing platform to reduce the cost of credit assessment for SMEs. SME managers should improve their digital literacy and proactively adopt digital financial tools to optimize their financing structures. Meanwhile, it is necessary to balance financialization and real investment to avoid financial risks caused by over-reliance on financial assets. When evaluating SMEs, investors should pay attention to their digital transformation capabilities and use of digital financial instruments. Prioritize companies with stable cash flow and high digital literacy to reduce investment risks. Existing research has insufficiently explored the long-term effects and potential risks of digital finance, especially the lack of empirical analysis of the moderating effect of digital literacy on financing outcomes among SMEs.In addition, the samples are mostly concentrated in specific regions or industries, and cross-national comparative studies are rare. The risk management mechanisms of digital financial platforms are not yet fully mature, and P2P lending and crowdfunding platforms may be subject to credit default

risks. Furthermore, the high cost of technological upgrades for small and medium-sized enterprises in the digital economy can lead to uncertainty in investment returns.

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