# The mediating effect of diversified capital structure on the relationship between business model innovation and firm performance in China

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## Abstract

This paper studies the impact of business model innovation on firm performance, the mediating role of diversified capital structure between business model innovation and firm performance, and the moderating role of external environmental uncertainty in the relationship between business model innovation and firm performance. Taking 45 Chinese domestic listed companies with the concept of Industry 4.0 as the research objects and a total of six years' data from 2014 to 2019 were used. The results show that business model innovation has a positive effect on firm performance, and this effect is more obvious when the external environment is uncertain. At the same time, the diversified capital structure of a firm plays an mediator role between business model innovation and firm performance, and can affect firm performance by adjusting the proportion between Intellectual Capital and Financial Capital of a firm.

## CHAPTER 1  Background

Innovation-driven development strategy, which is not only an inexhaustible

driving force for the development but also a source of high-level performance, competitive advantage and core competence for firms. An important pillar to promote regional and national economic development. The innovation of firms is not only reflected in the innovation of technology and products but also at the organizational level. However, most of the existing studies on innovation in firms focus on the impact of technological innovation on firm performance, and firms continue to focus on the "hard innovation" of technology and products, however, not enough attention is paid to the strategic advantages brought by business model innovation. Google, Amazon, Apple and other technology giants have completed the closed-loop design of their business models while developing technology and products and are driven by internal and external capital to continuously innovate their business models while innovating technology and products, thus achieving high firm value creation in a short period. Therefore, it is necessary to study the role of business model innovation in firm capital structure, strategic decision making and business performance and improve the business capability of high-tech firms in China.

## CHAPTER 2  Literature Review

### 2.1  Business Model Innovation

Business model innovation, as an important component to realize firm value creation and form competitive advantage, is becoming a topic in the fields of strategic management and corporate governance. This topic focusing on business model, business model innovation concept, business model innovation type research, business model innovation and firm performance.

### 2.1.1    Business Model Concept

Although business model have been mentioned for a long time, starting from Amit and Zott's research on business models for e-commerce firms in 2001 (Amit & Zott, 2001), the research on business model for firm value creation, value delivery, and value realization has aroused much attention from the theory community in the past two decades. Since the concept of business model was proposed, scholars have studied it from different perspectives, so the definition of the concept of business model has been inconclusive. For example, from an operational perspective, scholars consider business model as a study of the content, structure, and governance of transactions between a company, its suppliers, and its customers (Amit & Zott, 2001; Hai Guo et al., 2016; Mao et al., 2020), and from an organizational perspective, the definition of a business model is the discovery of new profit opportunities and the reorganization of organizational resources. Profit opportunities and re-integrate organizational resources into a construct, a coherent framework that takes technical features and potential as

inputs and transforms them into economic outputs through customers and markets (Chesbrough & Rosenbloom, 2002; George & Bock, 2011; Massa et al., 2017), and also scholars, based on a marketing stance, see business model as forms in which firms are able to exploit bilateral markets to accurately match various types of users (Eisenmann et al., 2006), while others understand them in terms of value creation, arguing that at the core of business model is the achievement of two functions: value creation and value capture (Chesbrough, 2007; Clauss, 2017), while other scholars understand it from a strategic perspective and consider business model as distinctive operational activity that is compatible with positioning, as an organic combination of operational model, profitability model or strategic positioning (Chesbrough, 2007; Markides, 2006; D. Mitchell & Coles, 2003; Zott et al., 2011).

### 2.1.2     Business Model Elements

A business model combines of elements such as value proposition, internal structure, collaborators, customers, and key internal and external resources. The definition and different perspectives on business model have led some scholars to understand business model from the perspective of elements, considering it as a combination of diversified elements (Afuah & Tucci, 2003; Applegate & Collura, 2000; Bonaccorsi et al., 2006; Mahadevan, 2000; Osterwalder, 2004; Osterwalder & Pigneur, 2010; Pekuri et al., 2014; Yang et al., 2020; Zhang et al., 2016). Different perceptions about business model have also led to the three-factor model of value proposition, value creation, and value claim (Zott et al., 2011), the nine-factor model (Osterwalder et al., 2005), and the four-factor model of customer interface, core competencies, core strategy, and strategic resources (Hamel, 2001).

### 2.1.3     Business Model Innovation Concept

Entrepreneurs, management scientists and economists have conducted in-depth and systematic research on the concept of business model innovation, and business model innovation has become a concern and research hotspot in practical and theoretical research field. In the current era of rapid changes in the market economy, innovative technologies and ideas are bringing new opportunities to business models, and the innovation of firms is not only reflected in the innovation of technologies and products but also the innovation of business models. Research on the definition of business model innovation can be done from several different perspectives. Some scholars, from the perspective of elements, consider business model innovation as the improvement of a company's business model components (Bucherer et al., 2012; Clauss et al., 2019; D. W. Mitchell & Coles, 2004; Velu & Jacob, 2016; Von Delft et al., 2019). Other scholars have taken a value perspective, arguing that business model innovation is a change in the value creation of a firm

and that business model innovation is the discovery of a fundamentally different value proposition, value creation and value capture model for existing businesses (Amit & Zott, 2001; Casadesus-Masanell & Zhu, 2013; Clauss, 2017; Geissdoerfer et al., 2016; Jang et al., 2020; Magretta, 2002; Markides, 2006; David J Teece, 2010; Wirtz et al., 2016). It is also argued that business model innovation is a complex, multi-perspective, multi-factor change that may alter the transaction patterns between various stakeholders (Chen et al., 2020; Foss & Saebi, 2017, 2018; Geissdoerfer et al., 2018; Mao et al., 2020; Spieth et al., 2021; Zott et al., 2011), and some scholars understand it from the perspective of the value chain and the perspective of the collaborators, arguing that business model innovation by firms is about changing their own or their partners' position and role in the existing value chain (Moore, 2004).

### 2.1.4    Business Model Innovation Classification

As research continues, scholars have further begun to investigate the classification of business model innovation. The most widespread one is based on Zott and Amit's study in 2007, which classified business model innovation into efficiency-centred and novel-centred innovation (Foss & Saebi, 2017; Rodriguez et al., 2019; Yu et al., 2020; Zott & Amit, 2008), and a similar classification that divides business model innovation into incremental business model innovation and radical business model innovation (Lindgren & Taran, 2011; Velu & Stiles, 2013). Another more common classification is based on Clauss's study in 2017, which argues that business model innovation can be classified into three categories: value proposition innovation, value creation innovation and value capture innovation according to process. Giesen et al. classify business model innovation into three types of innovation based on innovation paths: revenue model, firm model and industry model (Giesen et al., 2007). Zeng & Song stand for integrating the driving elements of internal and external innovation of firms and classify business model innovation into business system innovation, organizational routines innovation and conceptual cognitive innovation (Zeng & Song, 2014).

### 2.2  Capital Structure

From the research results on capital structure, scholars have been striving for an optimal capital structure and studying the sources of corporate finance to provide a unified conclusion with a guiding effect for firms, producing fruitful research results (Baker & Wurgler, 2002; Haugen & Senbet, 1978; Li et al., 2019; Margaritis & Psillaki, 2010; Sakti et al., 2017; Wu, 2017).

### 2.2.1    Connotation of Capital Structure

For the concept of capital structure, there is often a distinction between a

narrow and a broad sense. The so-called narrow capital structure, which refers mainly to the proportional relationship between owner's equity and creditor's debt, focus on the financing structure of the firm with the total debt divided by total assets as the core variable (Dias et al., 2020; Mallisa & Kusuma, 2017; Qaiser & Sultan, 2019; Ramadan & Ramadan, 2015; Siddik et al., 2017; Sumani & Roziq, 2020). Later on, some scholars have expanded the capital structure to a broad concept involving the composition of long-term and short-term debt ratios and the internal composition and distribution of shareholders' equity capital of the firm, including financing structure, debt structure, and equity structure, often selecting the debt to asset -ratio, long-term debt to asset ratio and the shareholding ratio of the top five (ten largest) shareholders as variables to measure financing structure, debt structure, and equity structure (Hunjra et al., 2020; Orden & Garmendia, 2005; Wu, 2017). With the development of science and technology in recent years, intellectual capital and other resources have played an important role in the capital structure of firms. Scholars have expanded the concept of capital structure to a broader concept and proposed the concept of diversified capital structure, adding intellectual capital, social capital and labor capital to the capital structure (Bollen et al., 2005; Edvinsson & Malone, 1997; Gjerding & Kringelum, 2018; H. Guo et al., 2013; Mavridis & Kyrmizoglou, 2005; Riahi-Belkaoui, 2003; Sanchez-Famoso et al., 2020)

### 2.2.2    The Capital Structure Factors

Based on some capital structure theories, scholars have conducted numerous empirical studies on the capital structure factors. Some of these factors that are confirmed and accepted by many scholars are industry (Bowen et al., 1982; Errunza, 1979; Schwartz, 1959; Schwartz & Aronson, 1967; Scott Jr, 1972; Talberg et al., 2008; Titman & Wessels, 1988), firm size (Harris & Raviv, 1991; Mallisa & Kusuma, 2017; Marsh, 1982; Moh'd et al., 1998; Rajan & Zingales, 1995; Sakti et al., 2017; Titman & Wessels, 1988), managers' shareholding (P. G. Berger et al., 1997; Brailsford et al., 2002; Friend & Lang, 1988; Mehran, 1992; Moh'd et al., 1998; Short et al., 2002), firm profitability (Friend & Lang, 1988; Mallisa & Kusuma, 2017; Petersen & Rajan, 1995; Sakti et al., 2017; Titman & Wessels, 1988), firm growth (Mallisa & Kusuma, 2017; Mehran, 1992; Moh'd et al., 1998; Sakti et al., 2017; Titman & Wessels, 1988), non-debt tax shield (Bradley et al., 1984; DeAngelo & Masulis, 1980; Harris & Raviv, 1991; Titman & Wessels, 1988), outside shareholder (Brailsford et al., 2002; Moh'd et al., 1998; Short et al., 2002). One of the more influential papers was published by Titman and Wessels in 1998, who applied factor analysis method to study the capital structure factors of U.S. manufacturing firms and concluded that it contains eight main aspects, namely, corporate profitability, firm size, equity liquidity, non-debt tax shield, firm growth, liquidity, tangible assets share, industry and time (Titman & Wessels, 1988).

### 2.2.3    Capital Structure Research Indicators

From the existing studies, scholars generally consider debt to asset ratio as the most important consideration of asset structure, in addition to long-term debt to asset ratio (Agrawal & Knoeber, 1996; Dias et al., 2020; Li et al., 2019; Nguyen & Nguyen, 2020; Pirzada et al., 2015; Ramadan & Ramadan, 2015; Siddik et al., 2017; Su, 2004; Titman & Wessels, 1988), short-term debt to asset ratios (Agrawal & Knoeber, 1996; Dias et al., 2020; Nguyen & Nguyen, 2020; Siddik et al., 2017; Su, 2004; Titman & Wessels, 1988; Wu, 2017), the concentration of control (Orden & Garmendia, 2005; Su, 2004; Wu, 2017), debt equity ratio (Qaiser & Sultan, 2019; Rasyid & Linda, 2019; Sumani & Roziq, 2020; Titman & Wessels, 1988).

### 2.3  Firm Performance

In the study of corporate strategy, one of the core issues is to study how to improve firm performance. First, it is to clarify what firm performance is; second, to clarify how firm performance is to be evaluated and measured in order to clarify whether the decision is effective or not. Corporate strategy is the performance of corporate decision making. For many companies, corporate equity is the criteria for the allocation of decision-making power and the status of resources owned by the company, which directly determines the strategic decision and competitive base of the company. Most scholars consider firm performance as a concept of financial or market indicators, which is an expression of the business results of a firm (Santos & Brito, 2012; Tang et al., 2018). Some scholars have included the external performance of comprehensive strength in the scope of firm performance, expanding firm performance to more than just internal matters (Feng et al., 2020). With the gradual enrichment of the concept of business performance, the indicators for measuring business performance have also changed and are not limited to profitability or return. These indicators are evaluated both by objective data and subjective scales. The types and scope of evaluation indicators have been greatly expanded. For firm performance, they generally include commonly used financial performance indicators and non-financial performance indicators, such as corporate image, customer satisfaction, employee recognition, competitive differentiation, etc. Specifically, this includes growth performance (Combs et al., 2005; Queiroz et al., 2020; Wamba et al., 2017), profitability (Jang et al., 2020; Wamba et al., 2017; Wu, 2017), market value (Feng et al., 2020; Hamelink & Opdenakker, 2019; Jang et al., 2020), customer satisfaction (Feng et al., 2020; Hamelink & Opdenakker, 2019; Queiroz et al., 2020), employee satisfaction (Hamelink & Opdenakker, 2019; Younas & Rehman, 2020), corporate image (Queiroz et al., 2020; Younis et al., 2016), environmental performance (Hamelink & Opdenakker, 2019; Younis et al., 2016), owner satisfaction (Aloulou, 2019), organizational operational effectiveness (Feng et al., 2020; Mithas et al., 2011), stock market performance (Combs et al., 2005; Corritore et al., 2020), innovation performance (Ahuja & Novelli, 2017;

Corritore et al., 2020), competitive differentiation (Aloulou, 2019; Queiroz et al., 2020), etc.

## 2.4  Research of Capital Structure and Firm Performance

The relationship between capital structure and firm performance has been a hot topic of research in the academic field, and there is a plenty of literature about it. However the amount of literature studying the capital structure and firm performance of high-technology firms is quite small. Regarding the relationship between capital structure and firm performance, Masulis analyzed the relationship between leverage and firm value as early as 1983 by using the ordinary least squares method with a sample of 133 firms to derive a positive effect between leverage and firm value (Masulis, 1983). Later scholars used multiple regression, structural equation modelling, and data envelopment analysis to obtain completely different findings by empirical analysis of manufacturing, banking, technology, insurance, aviation, and aquaculture industries in France, Malaysia, Vietnam, Pakistan, and EU-15 using data on long-term and short-term leverage ratios and large shareholder ratios as indicators (A. N. Berger & Di Patti, 2006; X. Guo et al., 2020; Li et al., 2019; Margaritis & Psillaki, 2010; Qaiser & Sultan, 2019; Salim & Yadav, 2012). Some scholars conclude that they are positive relationship (Almansour et al., 2019; A. N. Berger et al., 2005; Masulis, 1983; Pirzada et al., 2015), and some think they are negative relationship (X. Guo et al., 2020; Mallisa & Kusuma, 2017; Rajan & Zingales, 1995; Ramadan & Ramadan, 2015; Shubita & Alsawalhah, 2012). Meanwhile, some other scholars believe that they are a complex relationship (A. N. Berger & Di Patti, 2006; Campello, 2006; Chang et al., 2014; Vijayapala & Nurcahyo, 2017), even for different indicators with different findings (Chang et al., 2014; Salim & Yadav, 2012).

## 2.5  Research of Business Model Innovation and Firm Performance

Research on business model innovation and firm performance has become a research hotspot in the field of business model innovation in recent years. Scholars have conducted analyses through case studies, hierarchical regression, partial least squares, structural equation modelling, and fuzzy sets qualitative comparative analysis for firms in manufacturing, technology, insurance, fashion and apparel industries in China, Sweden, Italy, and Southeast Europe (Chesbrough & Rosenbloom, 2002; Cucculelli & Bettinelli, 2015; Desyllas & Sako, 2013; Ghezzi et al., 2010; Pedersen et al., 2018; Smajlović et al., 2019; Wang & Zhou, 2020), most of them argue that business model innovation has a more significant positive relationship with firm performance. For example, Zott and Amit applied ordinary least squares to 190 entrepreneurial and 170 manufacturing firms from different industries in 2007 and 2008, respectively, to study the relationship between business model innovation and firm performance, and came up with a more robust positive conclusion (Zott & Amit, 2007, 2008). Aspara et al. used the ANOVA

method to study 545 Finnish firms in different industries and found that business model innovation can positively affect firm performance (Aspara et al., 2010). In order to clarify the performance effects of service business model innovation (servitisation) and its interaction with product innovation, Visnjic et al. examined two key service business models: the product-oriented model and the customer-oriented model, using a demand-based value creation and complementarity perspective, and validated the positive relationship between them using regression analysis with data from 133 firms from different industries (Visnjic et al., 2016). Hamelink and Opdenakker used four cases from the energy sector for their study and reached the same positive conclusion (Hamelink & Opdenakker, 2019). Ramdani et al. conducted multiple in-depth case studies for ten investment banks in the Middle East as case subjects, again yielding a positive impact relationship (Ramdani et al., 2020).

### 2.6  Limitation of previews research

The existing literature has studied the relationship between business model innovation and firm performance or capital structure and firm performance, but there is a considerable lack of research on business model innovation, capital structure, and the relationship between the three aspects. Business model innovation by firms often requires the introduction of external investment, financing liabilities or adjusting the equity structure, which often implies a certain degree of strategic adjustment or innovation that may have an impact on corporate performance, and how exactly and to what extent is the research innovation of this paper.

### CHAPTER 3  THEORETICAL BASES AND HYPOTHESES

### 3.1  Business Model Innovation Theory

Theories related to business model innovation have received more and more attention from scholars in recent years. However, they are basically in a state of continuous development and improvement with diverse opinions. There is no complete systematic theory of business model innovation, but many relevant theories derived from the basic theory of innovation can explain business model innovation. This part starts from innovation theories and lays the theoretical foundation for later research and analysis by introducing disruptive innovation, open innovation, and dynamic capability theory.

### 3.2  Disruptive Innovation

The theory of disruptive innovation, an important theory in innovation

research in recent years, originated most initially from the concept of disruptive technology proposed by Christensen in The Innovator's Dilemma. Christensen studied in detail the experience of change in industries such as hard disk drives, excavators, and steel manufacturing, and argued that the reason why dominant firms experienced a rapid decline in their strong market position because of the emergence of disruptive technology and were defeated by the new entrants in order to focus on technological change and market changes (Christensen, 1997a, 1997b).

Christensen introduced disruptive innovation in his book "The Innovator's Solution" based on the theory of disruptive innovation techniques in 2003. It is an incremental and efficient innovation, which refers to the incremental improvement of the key performance of a product that is of interest to the mainstream market. Conversely, disruptive innovation does not target the mainstream market. However, a new market or low-end market, providing lower performance than the mainstream product or service, but with price advantages and convenience advantages that are important to non-mainstream consumers, and attracting consumers in the original mainstream market to shift to the new market area and purchase the improved product through subsequent substantial performance improvements, thereby expanding market share. This is the type of innovation that becomes a mainstream product and eventually disrupts the mainstream market (Christensen & Raynor, 2003).

After this, scholars have added and researched a lot on the definition and connotation of disruptive innovation, and have studied the concept of disruptive innovation from different perspectives such as technology, product, business model, process and effect (Carayannopoulos, 2009; Gilbert, 2013; Govindarajan & Kopalle, 2006; Hamel & Prahalad, 2000; Hüsig et al., 2005; Markides, 2006; Thomond et al., 2003), which is the reason why this paper chooses disruptive innovation as a relevant theoretical basis for business model innovation.

### 3.3  Open Innovation

Open innovation theory, in terms of content, fully draws on and incorporates ideas from theories such as collaborative innovation, strategic alliances, and innovation networks. Some scholars argue that the research paradigm of open innovation, in itself, is not innovative because issues such as innovation's emphasis on access to external resources and the need for external linkages have been studied in other literature or related theories (Lieberman & Montgomery, 1998; Trott & Hartmann, 2009). In fact, however, open innovation is innovative in terms of both the stage of implementation of the innovation and the object of openness, giving rise to intermediary services specialized in providing information and opportunities that were previously only available within the firm, allowing firms to trade innovations at different levels (Chesbrough, 2006; Enkel & Gassmann, 2007; Lazzarotti & Manzini, 2009). Therefore, the theory is not a repetition and re-statement of the original research but an inheritance, development and innovation

of the traditional innovation theory.

On this basis, Hastbacka emphasizes the central role of internal and external resources and markets, arguing that open innovation is the process of integrating internal and external technologies and innovative ideas, accompanying the firm's investment behavior, project progress and production operations, and with the help of rational mechanisms, through the distribution of assets and technology transfer to the market, which in turn feeds innovation information back to the firm internally (Hastbacka, 2004). West and Gallagher consider open innovation as a conscious act of integrating the firm's resource capabilities with external resources, systematically encouraging, emerging and finding innovative resources from internal and external sources, and collecting, developing and exploiting market opportunities through multiple channels (West & Gallagher, 2006). Berger and Piller focus on consumers as a source of innovation external to the firm, encouraging feedback, collection, and integration of information from users and consumers so that innovation can be generated more effectively and product and service modifications or specifications can be achieved (C. Berger & Piller, 2003). Other scholars understand open innovation from a cognitive perspective as a cognitive model of creating, transforming, and studying innovative practices, rather than being limited to the practical activity of corporate innovation itself (Chesbrough et al., 2006).

### 3.3.1    Dynamic Capability Theory

Teece defines dynamic capabilities as a firm's ability to integrate, construct and reconfigure internal and external resources to adapt to a rapidly changing environment and explicitly proposes three dimensions of dynamic capabilities: constructive, integrative and reconfigurative capabilities (David J Teece et al., 1997). Eisenhardt and Martin consider dynamic capabilities as a specific and identifiable set of processes (Eisenhardt & Martin, 2000).Teece later added the ability to perceive and identify opportunities and threats to the dynamic capabilities of an firm and explored the relationship between dynamic capabilities and business models, and explored business model innovation and organizational design from the perspective of dynamic capabilities, thus further expanding the connotation and research scope of dynamic capabilities (Heaton et al., 2014; David J Teece, 2007, 2010, 2018). The important learning and innovation attributes of dynamic capabilities enable companies to adapt to new organizational situations and thus improve their performance by continuously updating existing resources or adjusting resource allocation methods under changing situations with the help of knowledge management through the formation of dynamic capabilities.

For dynamic capabilities, scholars have mainly studied the concept, formation and role of dynamic capabilities (Cepeda & Vera, 2007; Luo, 2000; Pavlou & El Sawy, 2011; David J Teece, 2007; David J Teece et al., 1997; Winter, 2003; Zollo & Winter, 2002).

### 3.4   Capital Structure Study

Throughout the research on capital structure, scholars have been striving to find a possible optimal capital structure for firms and the related influencing factors of capital structure in the hope of providing a uniform conclusion with guidance to help firms adjust their capital structure in the period and thus enhance their corporate value, producing fruitful research results (Baker & Wurgler, 2002; Haugen & Senbet, 1978; Li et al., 2019; Margaritis & Psillaki, 2010; Sakti et al., 2017; Wu, 2017). For the effect of capital structure on firm performance, scholars have successively proposed MM theory (Modigliani & Miller, 1958; Sakti et al., 2017), agency theory (Jensen & Meckling, 1976; Li et al., 2019), pecking order theory (Hunjra et al., 2020; Myers & Majluf, 1984), trade-off theory (Kraus & Litzenberger, 1973; Wu, 2017), market timing theory, signalling theory, efficiency risk hypothesis, and franchise value hypothesis (Margaritis & Psillaki, 2010; Nguyen & Nguyen, 2020; Sakti et al., 2017), and others. These theories and hypotheses have provided theoretical support for the subsequent complex capital structure studies. In contrast, scholars have continued to use the corresponding theories to explain their findings, which eventually led to different research conclusions.

### 3.4.1    MM Theory

Academics began to pay attention to the problem of corporate capital structure as early as the 1950s (Durand, 1952), for the source of corporate capital can be divided into two parts, one is shareholders' equity, and the other is debt financing, so what does this capital structure behind the different proportions mean? Modigliani and Miller published "The Cost of Capital, Corporation Finance and the Theory of Investment", which proposed the famous MM theorem. Their research pioneered and is considered a landmark study. They found that under a series of strict assumptions, neither capital structure nor dividend policy should have any effect on firm value, there is no so-called optimal capital structure, and under an ideal capital market, there is no relationship between capital structure and firm value. The cost of equity of a debtor firm is equal to the cost of equity of a debt-free firm in the same risk class plus risk compensation. MM theory poses the problem between capital structure and firm value (Modigliani & Miller, 1958). In response to this idea, many scholars have proved it in different ways: Stiglitz used the multiperiod general equilibrium state preference model, Rubinstein used the mean-variance security valuation have justified the MM theory (Rubinstein, 1973; Stiglitz, 1974).

### 3.4.2    Trade-off theory

Scholars have proposed a static trade-off theory based on MM theory, which considers the bankruptcy and agency costs of debt. Trade-off theory assumes that firms trade-off between the benefits of debt (tax shield) and the costs of using debt (financial distress and bankruptcy) (Baxter, 1967; Myers, 1984). Graham and

Harvey argue that trade-off theory is one of the two most prominent theories of capital structure, which focuses on finding the optimal capital structure by considering the cost of debt versus the benefits of the debt agent (Graham & Harvey, 2002). The benefits of choosing debt over equity can increase the firm's value (Kraus & Litzenberger, 1973). When the increase in tax avoidance through debt financing is greater than the sum of the increased costs and risks, debt financing should be increased to achieve the optimal capital structure. When the increase in tax avoidance is less than the sum of the costs and risks of debt, debt should be reduced because the size of the firm's debt is too large at that time. However, the offsetting cost of debt is bankruptcy; the cost is big. Bankruptcy would represent the end of the business. However, the higher a firm leverages on the ratio, the greater will be the possibility of bankruptcy (Haugen & Senbet, 1978).

### 3.4.3    Signalling Theory

The trade-off theory, based on MM theory, considers bankruptcy costs and tax avoidance benefits. However, its focus is on the external factors of the firm. It does not take into account the influence of internal factors of the firm, which cannot adequately explain the capital structure problem that belongs to the internal structure embodiment. Ross proposed the signalling theory, in which it is argued that because of the information asymmetry between internal managers and external investors, the choice of financing structure by corporate managers is itself a signal that is transmitted to investors through the choice of capital structure or incentive policies, and that investors analyze and study the transmitted information and judge the value of the firm (Ross, 1977). The signalling theory suggests that debt financing is a signal of good asset quality, and the higher the quality of the firm, the higher the debt ratio, so that firm value is positively correlated with leverage. In Leland and Pyle's study, it is argued that due to the existence of information asymmetry, corporate managers have more information about new investment projects. In contrast, potential participating investors do not have information about the quality of the project, and investors can refer to the shareholding ratio of corporate managers, which is also an indicator and signal for value judgment, so the larger the shareholding ratio of managers will be, the larger the value of the firm will be (Leland & Pyle, 1977).

### 3.4.4    Pecking Order Theory

Myers and Majluf combined their theoretical foundations based on trade-off theory and signalling theory and proposed the pecking order theory (Myers & Majluf, 1984): due to the information asymmetry between business operators and external investors, corporate insiders know more about the situation of corporate operations than external investors and corporate shareholders, and in order to transmit internal financing is preferred in order to convey information about the firm's operations, which can protect the interests of the original shareholders from

being diluted and also avoid the fall of the firm's market value due to the risks arising from external financing. According to the pecking order theory, corporate financing is internal financing, followed by debt financing, and finally external equity financing. Moreover in early studies, it is believed that firm performance and leverage are negatively correlated because the better the performance of a firm, the more investment opportunities it may obtain, but in order to avoid creditors from obtaining the growth benefits of its development, it is not inclined to issue long-term bonds. At the same time, some scholars found through empirical evidence that firm performance and corporate leverage are negatively correlated. Graham and Harvey argue that pecking order theory is one of the important theories of capital structure, unlike the elements of trade-off theory, which argues that the actual corporate leverage ratio does not usually reflect the objectives of capital structure (Graham & Harvey, 2002).

### 3.4.5    Agency Theory

The agency theory introduces the factor of information asymmetry into the study. The perspective examined is the cost and problem formed by the conflict of interest of different stakeholders in the case of their respective asymmetric information, so it is also called agency cost theory. The establishment of the modern firm system and the innovation of the business model have realized the separation of ownership and control of the firm; the firm is owned by the shareholders, who have the ownership, but they do not necessarily have good management ability and experience; the shareholders entrust the firm to the managers, who, in essence, have the control of the firm, especially in dealing with the daily operation; the shareholders and the firm managers form a initial state of the principal-agent relationship. However, this "daily absence" of shareholders causes the lack of information, especially internal information, between shareholders and the managers hired by shareholders, which leads to information asymmetry and creates an important problem in modern governance, namely "principal-agent problem". Also, shareholders and corporate creditors are similarly situated in different positions, resulting in information asymmetry and different interests. This information asymmetry can trigger conflicts of interest between shareholders, corporate managers and creditors, thus creating agency costs.

Berle and Means found that the modern company's equity would be dispersed among many equity investors. The ownership of the company belonged to the equity investors. At the same time the management was actually held by the company's managers, which gave rise to the problem of separation of powers, thus creating conflicts between the shareholders and managers of the company, resulting in agency costs (i.e., the first type of principal-agent conflict conflicts) (Berle & Means, 1932), which is an early discussion of the principal-agent problem.

Jensen and Meckling first introduced the principal-agent problem to capital

structure theory by proposing agency theory (Jensen & Meckling, 1976), which investigates the effect of capital structure on firm value from an alternative perspective. Agency theory analyses risk-sharing, which is particularly evident when there are different views within the firm. Agency theory explains that capital structure results from managers' attempts to minimize costs associated with the separation of management and control and argues that debt financing can effectively mitigate the cost of principal-agent conflicts between a firm's shareholders and managers.

### 3.4.6    Resource Based View

The Resource-Based View (RBV) addresses the relationship between a firm's resources and competitive advantage, building on Schumpeter's view of value creation, which views the firm as a portfolio of resources and capabilities, with resources being the basis for all competitive advantage. The resource-based view theories that a firm needs a set of resources and capabilities that are specific to the firm and that are scarce, heterogeneous, durable, and difficult to imitate relative to competitors and that these resources are combined and utilized in unique ways that may lead to the increase and creation of firm value (Amit & Schoemaker, 1993; Amit & Zott, 2001; J. Barney, 1991; Penrose, 1959; Peteraf, 1993; Wernerfelt, 1984). Chamberlin argues that firms lead to good growth because they have unique resources. Firms are likely to gain economic rents because they have better resources or capabilities than the industry as a whole (Chamberlin, 1933). Penrose, in his book "The Theory of the Growth of the Firm", published in 1959, described resources from an intra-firm perspective, arguing that firms are a collection of resources and that firms differ in the resources they possess (Penrose, 1959). The development of the resource-based view began in 1984 with the publication of Weinerfelt's paper "A resource-based view of the firm". He analyzed the concepts of resource-product matrix and resource location barriers and concluded that firms are different from each other. He concluded that firms should focus on analyzing the resources they possess instead of product analysis and explicitly proposed the resource-based view, emphasizing that new strategic choices originate from a resource-based perspective (Wernerfelt, 1984).

### 3.4.7    Hypotheses

Excellent business model innovation can create benefits for multiple parties. Previous researchers have found that business model innovation is a good way to improve competitive advantage, which can lead to better firm performance (Chen et al., 2020; Huang et al., 2013; Visnjic et al., 2016), and modifying the business model in a more innovative way lead a positive effect on financial performance (Chen et al., 2020; Cucculelli & Bettinelli, 2015; Futterer et al., 2018). Business

model innovation can bring a new marketing concept for firms, allowing customers to perceive that firms bring the unique consumer experience to consumers. This experience contributes to consumer satisfaction, thus improving firm performance (Clauss et al., 2019), and can even open up new markets and gain the unique competitive advantages for firms through disruptive innovation. Business model innovation emphasises the innovation and re-creation of each element of the business model and the value process of the business model to guide and enhance customers' willingness to purchase by providing innovative products, services, or user experiences. Therefore, this paper believe that business model innovation can enable companies to achieve higher firm performance.

H1: Business model innovation positively affects firm performance.

The role of business model innovation in firm performance improvement has been recognized by more and more scholars through the research of various perspectives such as technological innovation, entrepreneurs, customer preference, strategic flexibility, external environment, and competitive pressure. In addition, since business model innovation is generally a strategic innovation, it involves a wide range of company activities and can promote changes and adjustments in many aspects (Clauss, 2017). Business model innovation is generally very disruptive, changing the established assumptions and mindsets of the industry (Markides, 2006; Teece, 2010; Baden-Fuller & Haefliger, 2013). Business model innovation is a higher-level strategic change behavior, much higher than the general business level innovation such as technological innovation, product innovation and channel change (Foss & Saebi, 2017; Foss & Saebi, 2018; Massa & Tucci, 2013). Business model innovation is an organizational innovation process, an unconventional, non-incremental and radical organizational innovation process carried out by an organization in response to exogenous discontinuities (technology, customer preferences, environment, competition, etc.) or the spontaneous drive of executives (Velu, 2015; Zott & Amit, 2010; Chesbrough, 2007; Baldassarre et al., 2017). Disruptive innovation such as business model innovation often implies a change in the capital structure of the company. According to the resource-based theory, it suggests that the resources owned by shareholders are the reason for the heterogeneity of the firm. The firm's resources are the driving force for its development, and that the representatives of the firm's equity owners have different interests and necessarily have different thinking logics, which also affect the firm's innovation decisions (J. Barney, 1991; J. B. Barney, 1986; Conner, 1991; B. Guo et al., 2018; David J. Teece, 2016; Yan et al., 2020). Therefore, the following hypothesis is proposed

H2: Capital structure mediates the relationship between business model innovation and firm performance.

In general, when the external environment in which a firm operates is more stable, there is no great pressure on the firm to change and innovate, and the existing products and models are able to satisfy the needs of customers and achieve more stable profitability. However, "*turbulent environments put more pressure on firms to bring new products to market faster*" (Calantone et al., 2003; Olavarrieta

& Friedmann, 2008), and innovation becomes a necessary way to counteract the environmental pressure and improve firm performance (Miller & Friesen, 1983). Other scholar believes that "*high market turbulence may increase the uncertainty and the risk of innovation investment and, as a consequence, reduce the innovation activity of firms*"(March, 1991). However, this paper argues that in highly dynamic environments, firms often need to engage in greater exploration to resolve the crisis brought by such uncertainty (Freel, 2005; Wiersema & Bantel, 1993), and business model innovation is undoubtedly the most important way. When firms are in low dynamics environment, the benefit enhancement brought by business model innovation is likely to be absorbed by the stability of the market. While in high dynamics environment, firms need to continuously innovate in order to gain competitive advantage, the easier it is to seize the business opportunities brought by market changes and achieve excess profits (Lumpkin & Dess, 2001). Therefore, the following hypothesis is proposed.

H3: Environmental dynamics play a moderating role between business model innovation and firm performance.

### CHAPTER 4  Method

### 4.1  Sample

The data are obtained from Wind database and public annual reports of listed companies, some data are obtained from the official websites of listed companies and China National Bureau of Statistics released data. The data from Wind database is used because of its availability and consistency of statistical caliber, which comes from public annual reports and is updated in a timely manner, so that a sufficient amount of data can be formed as needed to prevent statistical bias. In this paper, 74 companies listed in the Chinese public market are selected for the study, all of which exist as Industry 4.0 concept stocks. However, in order to be more scientific and accurate in the subsequent analysis stage and to maintain the balance of the panel data set, the above samples were processed. Firstly, by removing the samples with serious missing data in the sample observation period (2014-2019). Secondly, by excluding the firms with ST. Thirdly few companies with missing values were supplemented manually by referring to the data in the annual reports. The number of firms involved in the model estimation is 45, applying their data for a total of 6 years from 2014 to 2019, and the total number of observations is 7065. To mitigate the effect of different units on data relationships, all data were normalized.

### 4.2  Variables

### 4.2.1    Dependent Variables

Firm performance is the dependent variable in this study. There are various

indicators representing firm performance, which generally include commonly used financial performance indicators as well as non-financial performance indicators, such as corporate image, customer satisfaction, employee identification, and competitive differentiation. The most important of these are ROA (return on assets), ROE (return on equity), ROI (return on investment), and Tobin's Q (market value of the firm/replacement cost of capital) and EPS (earnings per share), which are based on the capital market value of the firm, to calculate the profitability of the firm.

In this paper, we use ROE (Joecks et al., 2013; Lee et al., 2016; Rowe & Morrow Jr, 1999; Sur et al., 2019; Wu et al., 2020), ROIC (Sheng et al., 2011; Tang et al., 2018; Tihanyi et al., 2019) and EPS (Wu, 2017; Tihanyi et al., 2019) to measure firm performance. ROE represent short-term performance, it is the ratio of net income after tax to owner's equity. ROE measures the return on assets invested by shareholders and reflects the effectiveness of using its own capital. ROIC represent long-term performance, it is the ratio of net operating income to total capital. ROIC is used to measure the effectiveness of using invested capital, which determines the future value of the firm. EPS represent the stock market performance of a firm, it is the ratio of net income attributable to common shareholders and the number of common shares issued. EPS reflects the level of profitability of the common shareholders' investment and is the final measure of the company's profitability.

### 4.2.2    Independent Variables

The independent variables of this paper is business model innovation (BMI), which have 3 dimensions including value creation, value transfer and value realization. We measure BMI using financial indicators.

The value creation dimension refers to the business activities and cost structure for producing or supplying products and services to create new value and meet the target customers' demand. Such as the core competencies and capital situation. Capital utilization capacity and debt paying ability are key elements in the value creation process. Therefore, this paper uses 2 financial indicators: current ratio and equity to debt ratio to represent the value creation dimension (Zhengyang et al., 2019). The current ratio is the ratio of current assets to current liabilities. If the indicator is high, it means that creditors face less risk. The equity to debt ratio is the ratio of owner's equity to total liabilities. The larger of the equity to debt ratio, the lower the financial leverage of the firm and the risks.

The value delivery dimension refers to the way consumers receive the product or service. Firms need to engage with various stakeholders in the process of delivering value, involving transfer goods, capital and assets. This paper chooses 2 indicators to represent value delivery, including inventory turnover ratio and total

assets turnover ratio. Inventory turnover ratio is the ratio of cost of goods sold to average inventory. Total assets turnover ratio is the ratio of sales revenue to average total assets. The indicators measure the efficiency of one firm, which higher numbers mean the higher turnover speed.

The value realization dimension means that firms control and reduce costs to create more profit source. This paper use income growth rate, net profit growth rate, and main operating profit ratio to measure value realization dimension. The income growth rate measures the extent to which a firm's revenue has changed compared with last year. Net profit growth rate measure the growth of a firm's net profit for the current year compared to the previous year. Main operating profit ratio is operating profit divided by income, this indicator measures the profitability of a firm.

### 4.2.3    Mediator Variables

In this paper, we use diversified capital structure as the mediator variables. Diversified capital structure includes both Intellectual Capital and Financial Capital, and in studying the impact of their structure on performance, this paper uses the proportional relationship between intellectual capital and financial capital as the variable of diversified capital structure. Intellectual Capital (IC) includes human capital (HC), organizational capital (OC), relational capital (RC). Cash paid to and on behalf of employees, administrative expenses and selling expenses were selected to represent HC, OC and RC. We also use the sum of current assets and fixed assets to represent the financial capital of the firm (FC). Diversified capital structure is FC divided by IC which is the sum of HC, OC and RC (Jian Zhenqiang&Li Jilong, 2013).

### 4.2.4    Moderate Variables

External Environment (Extenvir) as the moderate variables usually used in some researches. Drawing on the research of other scholars, we measure the external environment in terms of four variables, including Economic Policy Uncertainty Index（EPUI）and Trade Policy Uncertainty Index(TPUI), both could be found in Economic Policy Uncertainty Index website. The third indicator is Industrial Firm Sentiment Index(IESI), measured by annual change in production of industrial firms. The fourth indicator is KE Qiang Index (KQI), named after Chinese Premier Li Keqiang to reflect China's economic growth.

### 4.2.5    Control Variables

We use firm age(age) and firm size(size) as the control variables, which is commonly used in other researches. The firm age is 2020 minus the year when the firm established plus 1 and the firm size is log of the number of employees.
A summary of the above variables is shown in Table 1

Table 1: Variable Definition Table

| Definition | Sub-indicators | Indicators | Explanation |
|---|---|---|---|
| Firm Performance(performance) | Short-term performance | ROE | Return on Equity |
| | Long-term Performance | ROIC | Return on Invested Capital |
| | Market performance | EPS | Earnings Per Share |
| Business Model Innovation(BMI) | Value Creation | Quick Ratio（QR） | Current assets/current liabilities |
| | | Debt ratio (DR) | Equity/total debt |
| | Value Transfer | Inventory turnover ratio(INTR) | Cost of sales/average inventory |
| | | Total Asset Turnover Ratio(TATR) | Sales revenue/average total assets |
| | Value Realization | Income Growth Ratio(IGR) | Current year's operating income/prior year's operating income -1 |
| | | Net Profit Growth Ratio(NPGR) | Net profit for the year/prior year - 1 |
| | | Main Operating Profit Ratio(MOPR) | Operating profit/operating income |
| Capital Structure(Capstr) | Intellectual Capital(IC) | Human Capital(HC) | Cash payments to and on behalf of employees |
| | | Organizational Capital(OC) | Management costs |
| | | Relational Capital(RC) | Sales cost |
| | Financial capital(FC) | Financial Capital(FC) | Sum of current assets and fixed assets |
| | Diversified Capital Structure | TLVE | FC/（HC+OC+RC） |
| External Environment(Extenvir) | | Economic Policy Uncertainty Index（EPUI） | http://www.policyuncertainty.com/ |
| | | Trade Policy Uncertainty Index(TPUI) | |
| | | Industrial firm sentiment index(IESI) | Annual change in production of industrial firms |
| | | KE Qiang Index(KQI) | Named after Chinese Premier Li Keqiang to reflect China's economic growth |
| Control Variables | | Firm Age(age) | 2020-start year+1 |
| | | Firm Size(size) | Log of the number of employees |

**4.2.6  Results and analysis of the empirical study**

**4.2.7  Descriptive Statistics**

Table 2 shows descriptive statistics for each variable that is not standardized. Net Profit Growth Ratio is over 500, it means there is a wide variation in profit

generating capacity in different firms. And the debt equity ratio also has a huge difference. Most of the indicators of corporate performance and business model innovation have large standard deviations, implying large differences between firms, while the standard deviations of the indicators of diversified capital structure are small, and the diversified capital structures of the firms are relatively similar. To reduce the effect of outliers, the Shrink tail process is first performed at 1%. In order to eliminate the effect of different data units on the model relationships, we normalized all data.

Table 2: Descriptive Statistics of Data

| variable | N | max | min | mean | p50 | sd |
|---|---|---|---|---|---|---|
| ROE | 270 | 43.95 | -154.3 | 3.992 | 5.617 | 15.44 |
| ROIC | 270 | 60.30 | -70.93 | 4.524 | 5.205 | 11.12 |
| EPS | 270 | 2.388 | -3.670 | 0.225 | 0.230 | 0.555 |
| QR | 270 | 11.95 | 0.385 | 1.999 | 1.521 | 1.489 |
| DR | 270 | 1686 | 10.70 | 229.6 | 171.4 | 192.7 |
| INTR | 270 | 26.68 | 0.442 | 3.080 | 2.269 | 3.604 |
| TATR | 270 | 1.962 | 0.114 | 0.508 | 0.439 | 0.290 |
| IGR | 270 | 643.1 | -68.94 | 19.87 | 10.79 | 55.61 |
| NPGR | 270 | 885.4 | -6443 | -57.87 | 6.770 | 500.9 |
| MOPR | 270 | 37.41 | -239.1 | 4.323 | 8.042 | 26.52 |
| TLEV | 270 | 1.239 | 0.0480 | 0.206 | 0.168 | 0.155 |

### 4.3 Business Model Innovation Score

This paper uses factor analysis to conduct a comprehensive evaluation of business model innovation. First, Bartlett's test at 1% significance level shows that the index system could be used for factor analysis (Table 3). Then, principal component analysis was used to extract the common factors, the selected factor extraction criterion was eigenvalue≥1, and the orthogonal varimax method was chosen to rotate the factors to obtain the rotated factor loadings matrix (Table 4). Finally, the composite evaluation value of business model innovation was obtained based on the factor score coefficient matrix (Table 5) and factor analysis table (Table 6).

Table 3: KMO and Bartlett Test

| Year | | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|
| KMO | | 0.513 | 0.548 | 0.535 | 0.563 | 0.543 | 0.645 |
| Bartlett test of sphericity | Chi² | 134.010 | 124.596 | 125.400 | 114.972 | 148.458 | 134.153 |
| | df | 21 | 21 | 21 | 21 | 21 | 21 |
| | Sig. | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Table 4: 2014-2019 Total Variance Contribution of Factor Analysis of Cross-Sectional Data

| Factors | Initial Eigenvalue | | | Sum of squared rotating loads | | | Year |
|---|---|---|---|---|---|---|---|
| | Eigenvalue | Proportion | Cumulative | Variance | Proportion | Cumulative | |
| 1 | 2.307 | 32.953 | 32.953 | 1.99308 | 0.2847 | 0.2847 | |
| 2 | 1.588 | 22.684 | 55.638 | 1.71281 | 0.2447 | 0.5294 | 2014 |
| 3 | 1.382 | 19.748 | 75.386 | 1.5711 | 0.2244 | 0.7539 | |
| 1 | 2.28579 | 0.3265 | 0.3265 | 2.06656 | 0.2952 | 0.2952 | |
| 2 | 1.82649 | 0.2609 | 0.5875 | 1.79652 | 0.2566 | 0.5519 | 2015 |
| 3 | 1.24877 | 0.1784 | 0.7659 | 1.49797 | 0.214 | 0.7659 | |
| 1 | 2.18611 | 0.3123 | 0.3123 | 2.03066 | 0.2901 | 0.2901 | |
| 2 | 2.12955 | 0.3042 | 0.6165 | 1.96612 | 0.2809 | 0.571 | 2016 |
| 3 | 1.19295 | 0.1704 | 0.7869 | 1.51182 | 0.216 | 0.7869 | |
| 1 | 2.40672 | 0.3438 | 0.3438 | 2.27234 | 0.3246 | 0.3246 | |
| 2 | 1.48854 | 0.2126 | 0.5565 | 1.54803 | 0.2211 | 0.5458 | 2017 |
| 3 | 1.41525 | 0.2022 | 0.7586 | 1.49015 | 0.2129 | 0.7586 | |
| 1 | 2.26344 | 0.3233 | 0.3233 | 2.11324 | 0.3019 | 0.3019 | |
| 2 | 2.0021 | 0.286 | 0.6094 | 2.01443 | 0.2878 | 0.5897 | 2018 |
| 3 | 1.40563 | 0.2008 | 0.8102 | 1.54349 | 0.2205 | 0.8102 | |
| 1 | 2.8171 | 0.4024 | 0.4024 | 2.32217 | 0.3317 | 0.3317 | |
| 2 | 1.74855 | 0.2498 | 0.6522 | 1.81621 | 0.2595 | 0.5912 | 2019 |
| 3 | 1.24793 | 0.1783 | 0.8305 | 1.6752 | 0.2393 | 0.8305 | |

The principal component method was used to extract the common factors, and the eigenvalues and variance contribution rates of each factor were obtained as shown in Table 4 from 2014 to 2019. The eigenvalues of the first three factors were all greater than 1, and the cumulative variance contributions were basically above 70%. The eigenvalues of the first three factors are all greater than 1, and the cumulative variance contribution rate are all above 70%. This indicates that the first three common factors basically cover the information of all the secondary indicators and have a high degree of explanation.

Firstly, we calculate the 3 common factor score (F1, F2, F3) of every firm from 2014 to 2019(Table 5), and then, we use the variance contribution of each public factor as the weight to calculate the comprehensive factor score of business model innovation (BMI) of listed firm (Table 4). Such as in 2019, Calculating the composite factor score of a company's business model innovation as following.

BMI=(0.3317×F1+0.2595×F2+0.2393×F3)/0.8305

In this way, the business model innovation composite factor scores of all sample companies during the sample period are calculated as a measure of their

business model innovation.

Table 5: Factor Score Coefficient Matrix from 2014 to 2019

|  | 2014 | | | 2015 | | | 2016 | | |
|---|---|---|---|---|---|---|---|---|---|
|  | factor1 | factor 2 | factor 3 | factor1 | factor 2 | factor 3 | factor1 | factor 2 | factor 3 |
| QR | 0.50899 | 0.04965 | 0.08665 | 0.48349 | -0.02886 | 0.08455 | -0.02748 | 0.49335 | 0.05155 |
| DR | 0.50418 | 0.08827 | -0.01936 | 0.47209 | 0.0018 | 0.05374 | -0.00619 | 0.48765 | 0.06317 |
| INTR | 0.09905 | -0.01538 | 0.58286 | 0.11689 | 0.02453 | 0.61966 | -0.05899 | 0.09709 | 0.61628 |
| TATR | -0.05454 | 0.01967 | 0.54076 | -0.00158 | 0.06678 | 0.55963 | -0.04212 | 0.0071 | 0.55942 |
| IGR | 0.06022 | 0.49111 | 0.04724 | -0.08225 | 0.47666 | 0.06121 | 0.35932 | -0.20428 | -0.08431 |
| NPGR | 0.02139 | 0.48068 | -0.04666 | 0.0152 | 0.5001 | 0.02138 | 0.43741 | -0.00523 | 0.02332 |
| MOPR | 0.03514 | 0.35739 | 0.00398 | 0.17334 | 0.28854 | -0.02385 | 0.43434 | 0.07025 | -0.07568 |
|  | 2017 | | | 2018 | | | 2019 | | |
|  | factor1 | factor 2 | factor 3 | factor1 | factor 2 | factor 3 | factor1 | factor 2 | factor 3 |
| QR | 0.42544 | 0.06291 | -0.03589 | -0.04765 | 0.48652 | 0.04821 | -0.03835 | 0.52192 | 0.03797 |
| DR | 0.41828 | 0.04312 | -0.01928 | 0.03725 | 0.46386 | -0.01385 | -0.04756 | 0.52941 | -0.02748 |
| INTR | 0.10755 | 0.58635 | -0.01667 | -0.08094 | 0.0734 | 0.59635 | -0.12854 | 0.06711 | 0.57621 |
| TATR | -0.01783 | 0.54298 | 0.04962 | 0.01503 | -0.04116 | 0.54838 | -0.06329 | -0.05613 | 0.54629 |
| IGR | -0.21797 | -0.05411 | 0.41277 | 0.33479 | -0.18643 | -0.06062 | 0.32538 | -0.06134 | 0.07606 |
| NPGR | -0.01086 | 0.07992 | 0.58592 | 0.43862 | -0.01925 | -0.00213 | 0.43131 | -0.04342 | -0.13838 |
| MOPR | 0.19858 | -0.09934 | 0.39656 | 0.41348 | 0.0935 | -0.03823 | 0.42222 | 0.00762 | -0.10075 |

According to the rotated factor loading matrix table (Table 6), the index system can be divided into 3 main factors. The first main factor has large loadings on Quick Ratio(QR) and Debt Ratio(DR). Based on the economic meaning of each indicator, this factor reflect the capacity of capital working. So it is the capital working capacity factor and related with business model innovation value creation. The second main factor has large loadings on Inventory Turnover Ratio(INTR) and Total Asset Turnover Ratio(TATR). Based on the economic meaning of each indicator, this factor reflect the capacity of assets working. So it is the assets working capacity factor and related with business model innovation value transfer. The third main factor has large loadings on Income Growth Ratio(IGR), Net Profit Growth Ratio(NPGR) and Main Operating Profit Ratio(MOPR). Based on the economic meaning of each indicator, this factor reflect the profitability. So it is the

profitability factor and related with business model innovation value realization.

Table 6: Rotated Factor Loadings Matrix from 2014 to 2019

|  | 2014 | | | 2015 | | | 2016 | | |
|---|---|---|---|---|---|---|---|---|---|
|  | factor1 | factor 2 | factor 3 | factor1 | factor 2 | factor 3 | factor1 | factor 2 | factor 3 |
| QR | 0.9782 | -0.1106 | 0.0375 | 0.9665 | -0.0574 | -0.0496 | 0.0502 | 0.9477 | -0.0949 |
| DR | 0.9744 | -0.0449 | -0.1272 | 0.9554 | 0.004 | -0.098 | 0.0958 | 0.9365 | -0.0692 |
| INTR | 0.0893 | -0.0521 | 0.896 | 0.0084 | -0.0859 | 0.8789 | 0.0785 | -0.0258 | 0.882 |
| TATR | -0.2222 | 0.0666 | 0.8607 | -0.2127 | -0.0002 | 0.8246 | 0.0795 | -0.1806 | 0.831 |
| IGR | -0.0798 | 0.8188 | 0.0731 | -0.1807 | 0.8411 | 0.0204 | 0.6673 | -0.3072 | 0.0459 |
| NPGR | -0.1348 | 0.814 | -0.0671 | 0.0363 | 0.8942 | -0.0811 | 0.8941 | 0.0626 | 0.165 |
| MOPR | -0.0694 | 0.5986 | 0.0071 | 0.3747 | 0.528 | -0.1631 | 0.8728 | 0.2435 | -0.0108 |
|  | 2017 | | | 2018 | | | 2019 | | |
|  | factor1 | factor 2 | factor 3 | factor1 | factor 2 | factor 3 | factor1 | factor 2 | factor 3 |
| QR | 0.9423 | -0.0321 | 0.0076 | -0.0085 | 0.9664 | 0.0046 | 0.1107 | 0.9372 | 0.0683 |
| DR | 0.9345 | -0.0608 | 0.0317 | 0.1521 | 0.9422 | -0.0678 | 0.0499 | 0.944 | -0.0468 |
| INTR | 0.0626 | 0.8751 | -0.0196 | -0.0141 | 0.0631 | 0.892 | 0.0933 | 0.111 | 0.8867 |
| TATR | -0.1993 | 0.8451 | 0.0616 | 0.1581 | -0.146 | 0.855 | 0.1842 | -0.0926 | 0.8714 |
| IGR | -0.4184 | -0.0245 | 0.5842 | 0.6619 | -0.3129 | 0.01 | 0.7837 | 0.0022 | 0.3325 |
| NPGR | 0.0366 | 0.1166 | 0.8701 | 0.9232 | 0.0341 | 0.1055 | 0.8983 | 0.0583 | 0.0421 |
| MOPR | 0.5397 | -0.2216 | 0.6218 | 0.88 | 0.2614 | 0.0302 | 0.9185 | 0.1501 | 0.1022 |

## 4.4 Firm Performance Score and External Environment Score

The correlation coefficient method is used to calculate the firm performance score and the external environmental uncertainty score. The weight of ROE, ROIC and EPS of every listed firms in industry 4.0 from 2014 to 2019 showed in Table 7. So we can calculate the firm performance score for each year. Because the external environment is same for every firms, so we just use 6 years data together, and use corelation coefficient method to calculate the weight of EPUI, TPUI, IESI and KQI. Then calculate the score of external environmental. This results in two indicators, external environment and firm performance, expressed using "Extenvir" and "Performance".

Table 7: Firm Performance and External Environmental Uncertainty Weight

| firm performance weight | | | external environmental uncertainty weight | | | | Year |
|---|---|---|---|---|---|---|---|
| ROE | ROIC | EPS | EPUI | TPUI | IESI | KQI | |
| 0.33820841 | 0.341499086 | 0.320292505 | 0.265992474 | 0.266580433 | 0.259760113 | 0.20766698 | 2014 |
| 0.337229897 | 0.337052781 | 0.325717322 | 0.265992474 | 0.266580433 | 0.259760113 | 0.20766698 | 2015 |
| 0.341685226 | 0.338715664 | 0.319599109 | 0.265992474 | 0.266580433 | 0.259760113 | 0.20766698 | 2016 |
| 0.346823149 | 0.341157426 | 0.312019425 | 0.265992474 | 0.266580433 | 0.259760113 | 0.20766698 | 2017 |
| 0.33649635 | 0.339051095 | 0.324452555 | 0.265992474 | 0.266580433 | 0.259760113 | 0.20766698 | 2018 |
| 0.338095238 | 0.330335097 | 0.331569665 | 0.265992474 | 0.266580433 | 0.259760113 | 0.20766698 | 2019 |

### 4.5 Regression analysis

Firstly, the explained variables (ROE, ROIC, EPS and performance) were

tested one by one using the fixed effect model, and it was found that the P-values were all less than 0.01. Then, we carry out the fixed effect and random effect were tested respectively and use Hausman test. All the P-values of the T test were all less than 0.01. The fixed effect model should be used. The model test results of the four dependent variables (ROE, ROIC, EPS and Performance) are shown in Table 8.

Table 8: Regression Result

|  | ROE | EPS | ROIC | Performance |
|---|---|---|---|---|
| BMI | 1.470*** | 1.263*** | 1.508*** | 1.415*** |
|  | (11.83) | (10.77) | (12.49) | (12.23) |
| _cons | -3.06e-10 | 1.03e-09 | 2.25e-09 | 0.0000435 |
|  | (-0.00) | (0.00) | (0.00) | (0.00) |
| *N* | 270 | 270 | 270 | 270 |

*t* statistics in parentheses
$^*$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$

Through the above regression analysis, we find that the coefficient of BMI is 1.47 for the model of short-term performance measurement indicator ROE, and business model innovation has a significant impact on ROE at the significance level of 0.001. For the model of long-term performance measurement index ROIC, the coefficient of BMI is 1.263, and business model innovation has a significant impact on ROIC at the significance level of 0.001. According to EPS model, the coefficient of BMI is 1.508, and business model innovation has a significant impact on EPS at the significance level of 0.001. According to the model of the comprehensive evaluation index of firm performance constructed by us, the coefficient of BMI is 1.415, and the business model innovation has a significant impact on the Performance at the significance level of 0.001.

Through the above regression equation verification, we found that there was a significant positive promoting effect between BMI and corporate performance, and Hypothesis 1 was verified. Business model innovation positively affects firm performance.

Then, the Sobel Test method was used to verify the mediating effect of BMI as the independent variable, ROE, ROIC, EPS and Performance as the dependent variables, LTEV as the mediating variable, and the dummy variables of firm size, firm age and annual as the control variables. 1000 samples were taken, and the 95% confidence interval of the samples was finally found as shown in the table below. No matter the choice of long-term performance, short-term performance, market performance or the comprehensive index of firm performance constructed by us, the confidence interval of bs_2 does not contain zero (Table 9). Therefore, diversified capital structure plays an intermediary role in the relationship between business model innovation and firm performance. Hypothesis 2 was verified. Capital structure mediates the relationship between business model innovation and firm performance.

Table 9: Sobel Test Result

|  | Observed Coef. | Bias | Bootstrap Std. Err. | [95% Conf. Interval] | |
|---|---|---|---|---|---|
| ROE_bs_2 | 0.87513087 | 0.001793 | 0.14407421 | 0.588987 | 1.151398 |
| ROIC_bs_2 | 0.86257394 | -0.00958 | 0.1621319 | 0.5274587 | 1.14766 |
| EPS_bs_2 | 0.82583363 | 0.003985 | 0.14444936 | 0.563636 | 1.131228 |
| Performance_bs_2 | 0.85558907 | -0.00171 | 0.16485525 | 0.5389096 | 1.166382 |

After that, we tested the moderating effect of environmental uncertainty on ROE, ROIC, EPS and our constructed indicator Performance. As shown in the table 10, environmental uncertainty enhances the significant impact of BMI on firm performance. It shows that under the dynamic environment, the business model innovation of firms is more conducive to improving their own business performance. Therefore, it reminds us that we should pay attention to the uncertainty of the environment. In this case, we should carry out our own business model innovation. Hypothesis 3 was verified. Environmental dynamics play a moderating role between business model innovation and firm performance.

Table 10: Moderate Effect

|  | ROE | ROIC | EPS | Performance |
|---|---|---|---|---|
| BMI | 1.431*** | 1.474*** | 1.230*** | 1.380*** |
|  | (0.106) | (0.106) | (0.104) | (0.100) |
| Extenvir | -0.268*** | -0.235*** | -0.226*** | -0.243*** |
|  | (0.043) | (0.043) | (0.042) | (0.041) |
| c.BMI#c.Extenvir | 0.559*** | 0.499*** | 0.482*** | 0.514*** |
|  | (0.081) | (0.081) | (0.079) | (0.076) |
| N | 270.000 | 270.000 | 270.000 | 270.000 |
| r2 | 0.670 | 0.668 | 0.686 | 0.692 |

Standard errors in parentheses

$^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$

In order to better demonstrate the effect of moderating effect, it is found that environmental uncertainty has a significant positive moderating effect on ROE, ROIC, EPS and Performance by drawing a moderating effect diagram.
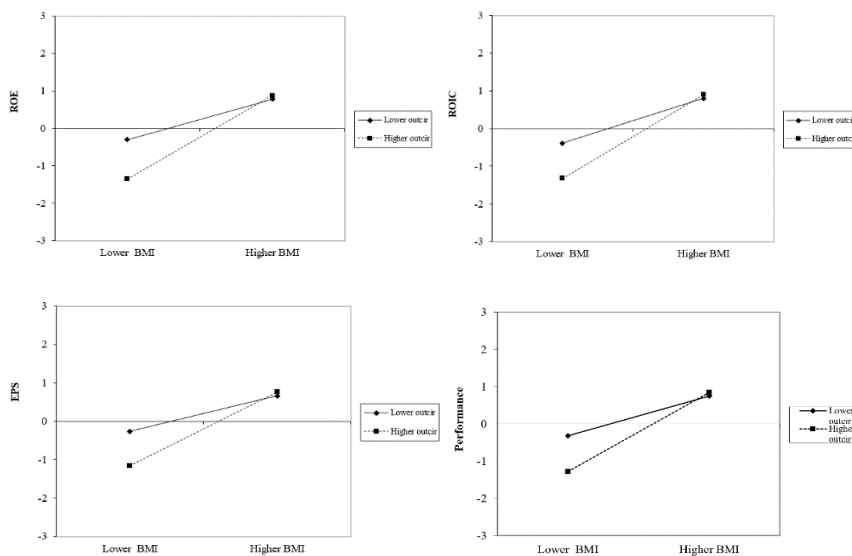
### CHAPTER 5  Conclusion

### 5.1  Conclusion

Taking 45 Chinese domestic listed companies with the concept of Industry 4.0 as the research objects, this paper divides business model innovation into three dimensions of value creation innovation, value transfer innovation and value realization innovation. Principal component analysis is used for dimensionality reduction on a yearly basis to obtain the comprehensive evaluation index of business model innovation. Then the author uses the correlation coefficient method to set up and measure the comprehensive index of firm's external environment uncertainty and firm's performance. This paper studies the impact of business model innovation on firm performance, the mediating role of diversified capital structure between business model innovation and firm performance, and the moderating role of external environmental uncertainty in the relationship between business model innovation and firm performance. Among them, different dimensions of business models are measured by using corporate financial indicators, which is more objective and reliable. Economic Policy Uncertainty Index (EPUI), Trade Policy Uncertainty Index (TPUI), Industrial Firm Sentiment Index (IESI) and KE Qiang Index (KQI) are measured by a total of four indicators. The diversified capital structure is measured by the ratio of Intellectual Capital and Financial Capital. A total of six years' data from 2014 to 2019 were used.

The results show that business model innovation has a positive effect on firm performance, and this effect is more obvious when the external environment is uncertain. At the same time, the diversified capital structure of a firm plays an intermediary role between business model innovation and firm performance, and can affect firm performance by adjusting the proportion between Financial Intellectual Capital and Financial Capital of a firm.

### 5.2  Research significance

This study has the following three aspects of significance:

(1)     From the perspective of diversified capital structure, it expands the research on the mechanism of business model innovation on firm performance. This study found that business model innovation to the firm performance in addition to direct role through the capital structure can also have indirect effects on firm performance. Previous research on business model innovation and firm performance are mainly concentrated in the study of its direct relation, and capital structure as an intervening variable, this study introduces research business model innovation indirect impact on firm performance. It is found that diversified capital structure plays a mediating role between business model innovation and firm performance.

(2)     Guide firms to attach importance to the promoting effect of business model innovation on firm performance. This study found that business model

innovation has a positive effect on firm performance, so as to expanding the category of firm innovation, business model innovation as improve firm competitive ability, the way to improve the firm performance, plays an important role, for manufacturing firm to carry on the business model innovation, cultivation and innovation firm competitive advantage, in order to survive and develop in the competition. For example, the transformation and upgrading of manufacturing firms and the servitization of manufacturing firms are the manifestation of the firm's own business model innovation, which is conducive to the improvement of firm performance.

(3)     Through the verification of the regulatory role of external environment, we find that in industries or periods with greater environmental dynamics, firms should pay more attention to their own business model innovation, so as to better enhance their competitiveness.

## 5.3  Limitations

This study also has the following limitations: (1) This study only selected the listed companies with the concept of industry 4.0, and has not yet analyzed firms in other industries. Therefore, the generality of the research conclusions is insufficient, so future studies can include firms in other industries. (2) The measurement of business model innovation can also refer to the methods of many other scholars and use scales for subjective measurement. Therefore, further data collection and improvement of this study should be conducted through questionnaires or interviews in the future.

## CHAPTER 6  References

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