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How does the development of digital finance affect small business tax compliance? Empirical evidence from China☆

Jie Ouyang [a], Shiyuan Liu [b,*], Haoran Li [b]

[a] School of Public Finance and Taxation, Zhongnan University of Economics and Law, Wuhan 430073, China
[b] School of Economics and Management, Tsinghua University, Beijing 100084, China

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ABSTRACT

How will the development of digital finance affect corporate tax compliance? In the digital economic age, this is a crucial issue. Using the 2011–2015 national tax survey database (NTSD) and the Peking University digital finance index, this paper examines the causal relationship between digital finance and small business tax compliance. Our baseline results show that each standard deviation increase in the digital finance index reduces the level of tax noncompliance by 7.5% for small businesses. We exclude the interference of contemporaneous policies, utilize a specification design based on neighboring cities across provincial borders, and employ instrumental variable estimation methods to jointly alleviate concerns about endogeneity. Furthermore, mechanism analysis shows that digital finance impacts small business tax noncompliance by easing corporate financing constraints and capturing tax-related "digital information". Finally, we analyze the heterogeneous effects of digital finance development. The effects on tax noncompliance are weaker for large firms (placebo group), small businesses supported by the government's industrial policy, and small businesses located in poor credit environment areas.

1. Introduction

Digital finance, as an actual result of the digital transformation of the economy, is hastening the reconfiguration of the economic landscape in countries throughout the world. Numerous studies have found that the development of digital finance is conducive to encouraging corporate innovation (Li & Li, 2021; Liu, Jiang, Gan, He, & Zhang, 2022), promoting household consumption (Grossman & Tarazi, 2014; Li, Wang, & Wu, 2020; Li, Wu, & Xiao, 2020; Suri, Bharadwaj, & Jack, 2021), stimulating entrepreneurial enthusiasm (Beck, Pamuk, Ramrattan, & Uras, 2018; Luo, Peng, & Zeng, 2021), and even facilitating liberalization in bank interest rates to some extent (Buchak, Hu, & Wei, 2021). However, few researchers have investigated the link between digital finance and corporate tax behavior within the same theoretical framework, ignoring the importance of digital finance in state tax governance. In this paper, we try to bridge this gap by studying the effects of digital finance on small business tax compliance and provide a new understanding of the governance of corporate tax noncompliance in the digital economy era.

Small businesses' tax compliance and enforcement issues have plagued tax authorities worldwide, especially in developing

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* Corresponding author at: 514 Weilun Building, Tsinghua University, No. 30, Shuangqing Road, Haidian District, Beijing, China.
E-mail addresses: 287463814@qq.com (S. Liu), lihr@sem.tsinghua.edu.cn (H. Li).

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countries (Al-Karablieh, Koumanakos, & Stantcheva, 2021; Slemrod, Collins, Hoopes, Reck, & Sebastiani, 2017). Taking China as an example, although small businesses account for over 90% of all market entities, produce over 60% of GDP, and provide approximately 80% of jobs, relevant survey data indicate that over 90% of small businesses engage in tax noncompliance to varying degrees. In the current situation of an ongoing economic downturn and the sluggish growth of fiscal revenue, such widespread tax noncompliance by small businesses will undoubtedly affect budgetary sustainability.[1] According to previous studies, improving a country's financial system is crucial to enhancing corporate tax compliance (Balde, 2021; Beck, Lin, & Ma, 2014; Blackburn, Bose, & Capasso, 2012). This fact induces the following questions: In the age of the digital economy, can the development of digital finance help curb tax noncompliance by small businesses? If so, what is the mechanism behind it? Answering these questions has significant theoretical and practical implications.

Based on a systematic review of the literature, we clarify the theoretical logic of how digital finance affects small business tax compliance. First, digital finance may assist small businesses in relieving their financing constraints, which can help reduce the motivation for small businesses to avoid taxes. Small businesses often face a competitive disadvantage in the market, most notably in regard to the availability of external finance and financing costs (Beck & Demirguc-Kunt, 2006). The International Monetary Fund (IMF) previously pointed out that credit-constrained small businesses may have a strong incentive to engage in tax noncompliance to finance their company operations (Brondolo, 2009; Richardson, Taylor, & Lanis, 2015). In recent years, along with the deep integration of digital technology and finance, digital finance has played an essential role in serving small business financing. Unlike traditional finance, digital finance no longer relies on physical outlets. Using technologies such as big data, cloud computing, blockchain, and artificial intelligence (AI), digital finance establishes a bridge for direct communication between digital finance platforms and businesses. The rise of digital financial services such as P2P online lending and crowdfunding has enhanced access to credit for small businesses (Bollaert, Lopez-de-Silanes, & Schwienbacher, 2021). In addition, digital finance reduces information friction between borrowers and lenders, which helps reduce the transaction costs of credit facilities (Li & Li, 2021). Consequently, the development of digital finance will effectively reduce financing constraints, affecting small business tax compliance.

Second, digital finance can record "digital traces", including third-party payment information, which tax authorities may use for tax audits. As we all know, small business operations are often non-standardized, making it difficult for tax authorities to obtain the accurate and effective tax-related information necessary for tax collection, which objectively provides a space for small businesses to avoid taxes (Slemrod et al., 2017). In the digital finance age, an increasing number of small businesses are being drawn into digital payment systems.[2] According to Klapper. (2017), digital payment systems enable small businesses to receive and pay bills electronically, using a mobile phone, the internet, retail points of sale, and other broadly available access points instead of using cash or checks. The transaction traces left by small businesses in electronic payment systems are important tax-related information (Adhikari, Alm, & Harris, 2021). In China, tax authorities are strengthening their cooperation with digital payment platforms. Using third-party tax-related information from digital payment platforms, tax authorities have identified and punished a variety of typical tax-evading enterprises.[3] Thus, digital finance may reduce small business tax noncompliance by providing more third-party tax information.

To test our research hypotheses, we construct a novel dataset from different official sources. Firm-level data originate from the 2011–2015 national tax survey database (NTSD). NTSD is a nationwide random sample survey conducted by the State Administration of Taxation of China, and more than 400,000 firms are surveyed each year. Importantly, the sample from NTSD covers all regions and sectors in China and contains various forms of financial and tax information of firms, and approximately 87% of the sample are small businesses, which is particularly suited for the study issue of this paper (Liu & Mao, 2019).[4] We use the Peking University digital financial inclusion index to measure a city's development in digital finance. This index is commonly utilized in recent research and is widely acknowledged. Based on the matched data,[5] our paper examines the effects of the development of digital finance on small business tax compliance. We find that the higher the digital financial index (DFI) of a city is, the lower the level of tax noncompliance by small businesses. Our baseline results show that for every standard deviation increase in the city DFI, the level of tax noncompliance decreases by 7.5%.

We then conduct a series of tests to address potential endogeneity issues. First, we try to alleviate the impact of contemporaneous confounding policies on the benchmark results by controlling for additional city-level macro variables. Specifically, the basic conclusion of the paper still holds after considering the contemporaneous impacts of tax collecting technology advancement, tax system reform, and tax and fee reduction policies. Second, we follow the approach of Dube, Lester, and Reich (2010) and Fan, Liu, Qian, and Wen (2018), utilizing policy discontinuities at province borders to further identify the causal effect of digital finance on small business tax compliance. We compare all contiguous city pairs in China that are located on opposite sides of a province border. We still find that the development of digital finance can significantly reduce tax noncompliance by small businesses. Third, we draw on

[1] Beck et al. (2014) and Al-Karablieh et al. (2021) even argue that the lack of government financial resources due to low tax compliance across the society was one of the important factors that triggered the European debt crisis in 2009.

[2] According to the latest data from China's central bank, the penetration rate of digital payments in China is already as high as 86% as of 2021.

[3] As the official newspaper of Chinese tax authorities, *China Tax News* reported several typical cases of tax authorities using third-party payment information to identify and investigate tax-evading enterprises.

[4] In our baseline regressions, we retained only a sample of small firms. In the subsequent heterogeneity analysis, we used large firms as the comparison sample for the placebo test.

[5] In the regressions, we also matched city-level macro variables.

Bollaert et al. (2021) and use the geographical distance from each city to Hangzhou, the origin of digital finance, as an instrumental variable for DFI.[6] The results of the IV estimation still confirm the conclusions of this paper. Additionally, this paper performs extra tests for robustness. For example, the measurement method for corporate tax evasion is replaced; the benchmark regression results are revalidated using a county-level DFI; and a strongly balanced panel dataset is constructed to further control for firm fixed effects and exclude the interference of firm migration factors in the regressions.

After ensuring that the article's benchmark findings are reliable, this study further conducts a detailed test of mechanistic factors. Small business financing constraints and costs are shown to have a significant negative link with DFI. This verifies the article's first hypothesized mechanism, namely, that regional digital finance development reduces small business incentives to avoid taxes by reducing their funding difficulties. We then make full use of the firm tax data in NTSD to provide extensive empirical evidence of the tax-related information supply mechanism. We find that the development of digital finance has significantly increased the probability of small business tax noncompliance being detected. In addition, we see that the penetration of digital finance has led tax authorities to use the traditional simplified approach less to tax small businesses.[7] More importantly, our article further finds that the significant negative relationship between digital finance and small business tax noncompliance is stronger in industries such as wholesale, retail, catering, and lodging,[8] where tax-related information is harder to gather and monitor.

Finally, we study the heterogeneous effects across different types of firms. We first use large firms as the comparison sample for a placebo test. Large firms usually have easier access to external financing and are usually included in key tax source monitoring by tax authorities (Almunia & Lopez-Rodriguez, 2018). Therefore, we do not observe a significant impact of digital finance on tax noncompliance by large firms. Similarly, small businesses that are supported by the government's industrial policy obtain not only policy guarantees in terms of financing but also financial subsidies and tax advantages (Aghion et al., 2015; Zhang, Zhang, & Yang, 2021). Tax authorities will also pay close attention to small businesses that are eligible for government industrial policy support. Thus, digital finance has no significant effect on this sort of firm. We then also try to examine the impact of digital finance on small business tax compliance from the perspective of regional credit environments. We find that digital finance does not significantly inhibit business tax noncompliance in regions with worse credit environments. This finding demonstrates that even in the age of digital finance, credit remains the cornerstone of financial development. To maximize the positive effects of digital finance, a healthy regional credit environment is essential.

Our study extends the literature on the economic consequences of digital finance development. Whereas previous studies that have discussed the economic effects of digital financial development have primarily focused on corporate innovation, household consumption, and individual entrepreneurship (e.g., Beck et al., 2018; Grossman & Tarazi, 2014; Li & Li, 2021; Suri et al., 2021), little attention has been given to the impact on corporate tax compliance. To fill this gap, this paper examines in detail the relationship between digital finance and corporate tax noncompliance. Based on detailed tax administration data in China, this paper verifies the beneficial impact of digital finance in curbing small business tax noncompliance and delves into the underlying reasons why.

This paper also partially responds to the theoretical debate on the issue of tax administration in the digital economy era. A large body of literature highlights that the digital economy presents both challenges and opportunities for government tax administration (e.g., Agrawal & Fox, 2021; Fetzer & Dinger, 2019; Haslehner, Kofler, Pantazatou, & Rust, 2019). Our study provides further supplementary evidence to a certain extent, showing that in the digital economy era, digital finance can effectively improve the tax compliance of small businesses and facilitate the government's tax management.

In addition, our paper also contributes to a growing literature on the impact of technology on tax enforcement. Technological improvement may provide tax authorities with greater capabilities to track transactions, facilitate third-party reporting and hence better collect taxes (Bellon, Dabla-Norris, Khalid, & Lima, 2022; Fan, Liu, et al., 2018; Li, Wang, & Wu, 2020; Li, Wu, & Xiao, 2020). In essence, digital finance is also mainly driven by information technological improvement. Existing studies have emphasized the active application of information technology by tax authorities to obtain and supervise tax-related information. In contrast, our paper focuses on the supply side of tax-related information by digital finance, which differs from the literature by examining a previously overlooked dimension.

Finally, our paper relates to a set of studies that focuses on how to improve tax compliance for small businesses. In this type of literature, financing constraints and third-party tax-related information are identified as key factors affecting small business tax compliance (e.g., Adhikari et al., 2021; Al-Karablieh et al., 2021; Alm, Liu, & Zhang, 2019; Chen, Hong, Kim, & Ryou, 2021). This paper further adds to the above literature. We find that alleviating corporate financing constraints and increasing the supply of tax-related information are the two main mechanisms through which digital finance affects small business tax compliance. This paper incorporates digital finance, financing constraints, tax-related information, and small business tax compliance into a unified analytical framework.

The rest of the paper is organized as follows: Section 2 conducts the literature review and formulates the research hypotheses. Part 3 presents the data sources, variable construction, and identification strategies. The main empirical results are presented in Section 4. In

[6] It should be noted that the geographic distance between cities is time-invariant, and to obtain estimates of the instrumental variables, we cross-multiply the geographic distance with the year dummy variable, like the method of Angrist and Krueger (1991).

[7] In practice, tax authorities usually use the simplified taxation method for small businesses due to the difficulty of obtaining tax-related information about them. The use of the simplified taxation method has dropped, which means that, to some extent, the rise of digital finance does provide tax authorities with more tax-related information.

[8] Tax-related information for direct consumer-oriented industries such as wholesale, retail, catering, and lodging is usually regarded as the most difficult to obtain and monitor in the literature (Fan, Liu, et al., 2018).

Section 5, we examine the mechanism of this article. Section 6 discusses heterogeneous effects. Section 7 concludes.

2. Literature review and hypotheses

In this section, we attempt to elucidate the mechanisms of the impact of digital finance on the governance of small business tax noncompliance based on the literature review.

2.1. Digital finance, financing constraints, and small business tax noncompliance

Small businesses often face outstanding financing difficulties owing to information asymmetry issues and a relative lack of collateralizable assets (Andrikopoulos, 2009; Chan & Kanatas, 1985). According to recent studies, financing challenges not only limit small business investment and innovation but also readily motivate small businesses to engage in tax aggressive behavior (Brondolo, 2009; Campello, Graham, & Harvey, 2010; Kersten, Harms, Liket, & Maas, 2017). Researchers find that when getting external funding for a business becomes tough, managers are more prepared to take on more risk, changing the firm's equilibrium position with respect to tax noncompliance (Edwards, Schwab, & Shevlin, 2016). In equilibrium, as long as the marginal gains exceed the marginal expenses, a firm will engage in tax noncompliance tactics (Chen, Chen, Cheng, & Shevlin, 2010). Small businesses are often unable to obtain external funding, and cash flow from internal sources is directly linked to their survival, default, and bankruptcy. As a result, despite any negative reputational effects, small businesses may have little choice but to adopt a higher risk appetite and become more tax aggressive as the need for cash becomes vital, particularly because the tax burden is a large cash outflow (Richardson et al., 2015).

Prior research provides us with relevant evidence confirming the relationship between financing constraints and corporate tax compliance. For instance, based on a large sample of US data, Chen and Lai (2012) discover that financially constrained businesses are more active in their tax avoidance than financially unconstrained businesses. Edwards et al. (2016) find a similar result, arguing that increased financial restrictions drive firms to enhance internal finances through tax noncompliance. Richardson et al. (2015) report that Australian businesses in financial difficulties during the 2008 financial crisis engaged in higher tax avoidance. Finally, Alm et al. (2019) provide international evidence, and their empirical results indicate that more financially constrained businesses are more likely to engage in tax noncompliance activities. This is mostly because tax noncompliance allows them to partially compensate for inadequate cash flow caused by financial constraints. All the above studies confirm that when businesses face financing constraints, they tend to substantially evade their own tax obligations.[9] We are relatively certain that this conclusion holds true for small businesses as well, given that they are more likely to face barriers to financing.

Digital finance in China has developed rapidly over the last decade as internet and mobile communication technologies have advanced. In theory, digital finance has the following advantages over traditional finance, which can help small businesses finance more efficiently, thereby reducing corporate tax noncompliance incentives. First, digital finance has broadened access to finance for small businesses and improved the availability of credit facilities (Bollaert et al., 2021; Li & Li, 2021). Digital finance extensively uses modern information technology to provide financial services and has developed a wide range of digital financial services platforms and products for all types of firms, such as peer-to-peer (P2P) lending and crowdfunding, that go well beyond the traditional bank branch's service scope (Gomber, Koch, & Siering, 2017). According to Dietrich, Amrein, Heyde, Heuerman, and Rudisuhli (2019), loans to small businesses from digital finance platforms in the U.S. increased 1000-fold between 2006 and 2018. Second, digital finance can reduce the cost of credit for small businesses to some extent. On the one hand, digital finance offers financial services through the internet, PCs, and mobile phones, allowing borrowers and lenders to create direct communication and interaction channels and reducing unnecessary search and transaction costs (Li & Li, 2021). On the other hand, the development of digital finance has intensified the competition with traditional finance, forcing traditional banks to reduce their lending rates appropriately and even accelerating their own digital transformation (Cole, Cumming, & Taylor, 2019). De Roure, Pelizzon, and Thakor (2022) find that P2P digital financial platforms provide lower interest rates to borrowers than banks. Using detailed data on digital financial transactions in China, Buchak et al. (2021) confirm that the penetration of digital finance stimulates traditional banks to accelerate the process of interest rate liberalization, which in turn will benefit more businesses. Third, the development of digital finance can improve the convenience of access to finance for small businesses. Compared with traditional finance, digital finance utilizes big data, cloud computing, and artificial intelligence (AI) to maximize access to corporate information, which helps alleviate information asymmetry between financial institutions and small businesses,[10] thereby simplifying credit review procedures and shortening loan review time. (Fuster, Plosser, Schnabl, & Vickery, 2019).

Based on our analysis above, financing constraints are an important incentive for small businesses to avoid taxes, but the development of digital finance can alleviate the dilemma of small businesses in financing issues. Accordingly, we believe that the following research hypothesis is reasonable:

Hypothesis 1. The development of regional digital finance can reduce small businesses' tax noncompliance behavior by easing their financing constraints.

[9] None of the above studies separately discuss tax evasion by small businesses.

[10] It should be noted that the alleviation of information asymmetry between borrowers and lenders also helps to reduce financing costs.

2.2. Digital finance and tax-related information supply

Information is the basis of taxation by the government. In the absence of tax-related information, tax authorities cannot obtain sufficient tax revenue, and it is difficult to effectively combat tax noncompliance (Carrillo, Pomeranz, & Singhal, 2017; Kleven, 2014; Pomeranz, 2015). Especially for small businesses, the features of their business management make it more challenging for tax authorities to monitor their tax-related actions. First, small business accounting and financial management are seldom standardized sufficiently to give full, accurate, and timely financial information (Slemrod et al., 2017). Second, small businesses also frequently accept payments in difficult-to-monitor cash, exacerbating the tax enforcement problem (Gordon & Li, 2009). Therefore, compared with the cost for large firms, the cost for tax authorities to obtain tax-related information of small businesses is much higher, which objectively provides room for small businesses to avoid taxes (Chen et al., 2021).[11]

In the age of digital finance, the payment and collection traces left on the internet by individuals and businesses provide tax authorities with a rich supply of tax-related information (Brockmeyer & Somarriba, 2022). According to Slemrod et al. (2017) and Adhikari et al. (2021), when the IRS obtains detailed customer payment data from third-party payment entities, small businesses report much more taxable income. In China, with the rapid development of digital finance in recent years, an increasing number of small businesses and consumers are included in the third-party payment system. A study by Chen (2016) noted that the size of third-party payments in China grew 114-fold between 2010 and 2015, reaching RMB 118,675 billion.[12] In this context, Chinese tax authorities have strengthened the supervision of third-party payment information, and many local tax bureaus have started to cooperate with third-party payment platforms, using third-party payment information as the basis to investigate and punish several enterprises for tax noncompliance.[13] Therefore, our second hypothesis is as follows:

Hypothesis 2. The development of digital finance eases small business tax noncompliance by providing more tax-related information.

3. Data, variables, and empirical strategy

3.1. Data and sample selection

In our study, we mixed three distinct datasets. First, we employ firm-level data from the national tax survey database (NTSD), which is a unique, extensive, and mostly untapped resource (Liu & Mao, 2019). The data are acquired using a stratified random sample approach by the State Administration of Taxation. Although the NTSD consists of mixed cross-sectional data, it covers enterprises of different types, industries, and regions and is highly representative. At the same time, the data quality of NTSD is guaranteed. Local tax authorities will conduct additional checks before reporting the final data and compare it with the existing tax-related information they have to minimize false positives in the survey data as much as possible. This dataset contains rich firm-level information, including different forms of taxes paid, tax penalties, business information, and financial information. In addition, this set of data also has a unique advantage; that is, it contains a large number of small business samples, which allows us to discuss in detail the tax governance issues of small businesses. According to the classification standards established by the Ministry of Industry and Information Technology, we identify small businesses through three indicators: the number of employees, assets, and operating income. In our paper, small businesses include both “small businesses” and “microbusinesses”. Finally, we find that more than 2 million of the samples in the 2011–2015 National Tax Survey Data (NTSD) are small or micro businesses, accounting for 87% of the total sample. For the purposes of this study, only the small and micro firm samples (collectively referred to as small businesses) are retained in our full-text regressions, while the large firm samples are used only for the placebo tests in Section 6.1.

Our second dataset includes information on digital finance at the city level. These data come from the DFI compiled by Peking University (Guo et al., 2020). The Peking University Institute of Digital Finance created the DFI using big data provided by Ali Financial Services. It captures both cross-sectional and temporal variation in access to and use of digital financial services in China (Lai, Yan, Yi, & Zhang, 2020). Our third dataset contains socioeconomic data at the city level from the China City Statistical Yearbook. Finally, we use information on business location to combine the resultant firm-level dataset with city-level DFI and socioeconomic data.

Before conducting the regression analysis, we processed the data as follows: First, we removed the sample with zero firm employment and negative asset size; second, the top and bottom 1 percentiles of the distribution of firm-level variables are winsorized during regressions to guarantee correct findings. Finally, since the DFI has been compiled since 2011 and the NTSD dataset is currently available only up to 2015, our sample period is limited to the period 2011–2015. Over 2 million firm-level observations were gathered for the baseline regression over the study’s full sample period, which ran from 2011 to 2015.

[11] In practice, tax authorities in various countries usually include large enterprises in the scope of key tax source monitoring, while the supervision of small enterprises is relatively more lenient (CTPA, 2011; Almunia & Lopez-Rodriguez, 2018).

[12] According to the latest statistics, the percentage of China’s population using third-party payments has exceeded 87% in 2021, with the payment scale reaching RMB 210 trillion.

[13] For example, the Chongqing tax bureau used WeChat payment records to discover that an educational training institution had concealed RMB 140 million of corporate taxable income (China Tax News, 2021).

3.2. Variables

3.2.1. Measuring corporate tax noncompliance

In our study, we use a mainstream approach to construct business tax noncompliance indicators. The discrepancy between a business's book accounting earnings and its taxable earnings, according to Manzon and Plesko (2002), is an effective indication of business tax noncompliance. In general, the wider the discrepancy between book accounting earnings and taxable income, the higher the degree of tax noncompliance, showing that the firm's accounting profit is not in compliance with tax legislation (Wilson, 2009). In our benchmark regression, business tax noncompliance is equal to book accounting earnings minus taxable earnings.[14] Both the business's book accounting profits and its taxable earnings are included in the NTSD dataset. Thus, the business's book-tax differences (*BT*) are simply:

$$BT_{it} = Y_{it}^{S} - Y_{it}^{T} \tag{1}$$

In Eq. (1), BT_{it} represents the book-tax gap for business i in year t, Y_{it}^{S} represents the business's book accounting earnings, and Y_{it}^{T} represents the business's taxable profits. To exclude the influence of business size in the regression, we are consistent with Mills (1998), Desai and Dharmapala (2006), and Wilson (2009) and divide BT_{it} by the total assets of the firm.[15] Panel A of Table 1 shows the definitions and descriptive statistics for business tax evasion. It is important to note that the average value of book-tax differences in Table 1 is negative, which requires us to give a reasonable explanation. In fact, an important reason for this result is that approximately 30% of our sample of small businesses are loss-making enterprises (see Fig. 2). These loss-making enterprises have negative book earnings and zero taxable earnings, which objectively causes the distribution of book-tax differences to shift to the left (see Fig. 1), thus making the mean value negative.

3.2.2. Measuring digital finance

As mentioned earlier, we use the DFI compiled by Peking University to measure the development of digital finance in a city. This index considers three aspects of digital financial services: the breadth of coverage, the depth of usage, and the availability of digital services. Payment, insurance, monetary funds, investment, credit investigation, and credit monitoring are the six types of subindexes that fall under the overall index (Li, Wang, & Wu, 2020; Li, Wu, & Xiao, 2020). Peking University compiled DFIs at the provincial, city, and county levels at the same time. In this research, we use the city-level DFI for regression analysis and the county-level index for robustness testing. In addition, in the regression analyses, the DFI was divided by 100. Panel B of Table 1 shows the descriptive statistics for the city DFI (*DFI*).

3.2.3. Control variables

We account for a variety of macroeconomic variables that might influence both the growth of digital finance in cities and corporate tax compliance. First, we control for the city's GDP and GDP growth rate (*Growth*); second, we add the total number of bank branches in the city to the regression equation (*Finance*), which accounts for the influence of conventional finance; and finally, we control for the number of internet users (*Internet*) and cell phone subscribers in the region (*Mobile*), which has been highlighted in the literature as an important factor influencing the development of digital finance. In addition, we control for firm-level factors that may affect business tax compliance by referring to previous studies. Specifically, we include firm size, firm employment, firm cash flow, and firm leverage. All these aforementioned micro factors are thought to directly affect businesses' tax noncompliance decisions. Panel C and Panel D of Table 1 show the definitions and descriptive statistics for the control variables.

3.3. Empirical strategy

To validate our study hypothesis, we built the benchmark regression model that is presented below:

$$BT_{ijct} = \beta_0 + \beta_1 DFI_{ct} + \beta_2 X_{ijct} + \beta_3 Z_{ct} + \varphi_j + \varphi_c + \varphi_t + \varepsilon_{ijct} \tag{2}$$

The main outcome variable we are interested in is business tax noncompliance, denoted by BT_{ijct}. The term DFI_{ct} refers to the progress of digital finance in city c in year t. We use Peking University's city DFI to quantify it. In Eq. (2), $X_{ijct}$is a business-level characteristic vector, $Z_{ct}$is a city-level characteristic vector, and φ_j, φ_c and φ_t are industry, city, and time fixed effects, respectively. In Eq. (2), the vector X_{ijct}includes the log of firm total assets, the log of employees, the firm cash flow (net cash flow from operational activities divided by total assets), and firm leverage (total assets divided by total liabilities). The vector Z_{ct} includes the log of GDP per capita, GDP growth rate, the log of the number of internet subscribers, the log of the number of mobile phone users and the log of the number of bank branches.

A potential worry is that the endogeneity of digital finance may distort the OLS estimates in our baseline specification (2). In our particular context, the issue may arise because of omitted variable bias and measurement errors.[16] First, due to data limitations, not all

[14] In the robustness test, we also used other methods to measure corporate tax noncompliance.

[15] Following the reviewer's suggestion, we also tried to standardize Book-Tax differences with book earnings. We retested the main regression results of the article with this new dependent variable and found that the conclusions still hold (See Table A2 in page).

[16] The core explanatory variable (DFI) of this paper is at the city level, and the explained variable is at the firm level. Therefore, endogeneity is unlikely to arise from reverse causality.

Table 1
Variable summary statistics.

	Obs	Mean	Std	Min	Max
Panel A: Outcome Variables					
Corporate tax noncompliance (BT: Book-Tax Differences)	2,822,399	−0.0100	0.100	−0.590	0.400
Panel B: Key Explanatory and Instrumental Variables					
Digital Finance Index (DFI)	2,655,613	1.350	0.490	0.180	2.310
Distance (Distance to Hangzhou)	2,580,877	724.906	515.604	0	3793.6
Panel C: Enterprise-Level Control Variables					
Size (Natural log of total assets)	2,822,363	9.810	2.540	0.690	26.89
Leverage (Total liabilities/Total assets)	2,822,399	0.530	0.330	0	1
Cash (Cash Flow/Total Assets)	2,822,258	0.0200	0.170	−0.510	1.100
Employee (Natural log of employees)	2,821,861	3.390	1.730	0	8.040
Panel D: City Level Control Variables					
GDP (Natural log of GDP per capita)	2,591,103	11.01	0.590	9.010	13.99
Growth (GDP growth rate)	2,586,977	0.100	0.0300	−0.190	0.550
Finance (Natural log of the number of bank branches)	2,649,507	4.330	1.070	1.390	6.340
Mobile (Natural log of the number of mobile phones)	2,594,412	6.590	0.950	3.640	9.720
Internet (Natural log of the number of internet users)	2,575,691	4.830	1.060	1.610	8.020

Note: This table shows the summary statistics of enterprise-level and city-level variables.

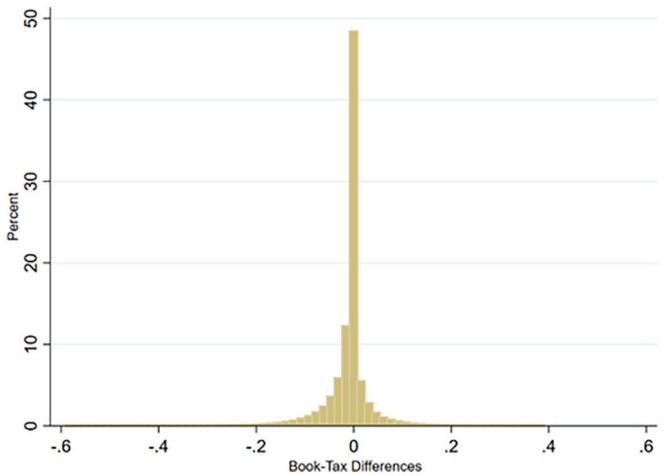

Fig. 1. Distribution of tax noncompliance indicator.

characteristics that influence small business tax compliance are included in the benchmark regression model, and these missing variables may be strongly connected to the growth of digital finance. Second, although Peking University's DFI has been frequently employed as a proxy variable for the growth of digital finance in an area in previous studies (Chen & Zhang, 2021; Guo et al., 2020; Lai et al., 2020), measurement mistakes are unavoidable.

To address endogeneity concerns and to identify the causal effect of digital finance on small business tax noncompliance, we will perform further work in the following three areas. First, the contemporaneous interference policies most likely to bias the baseline estimates will be discussed one by one. Specifically, we will focus on the contemporaneous impact of technological advances in taxation, tax system reform and tax reduction policies on tax noncompliance by small businesses. Second, we follow the approach of Dube et al. (2010) and Fan, Liu, et al. (2018), exploiting policy discontinuities at province borders to further identify the effect of digital finance on small business tax noncompliance. With this approach, we can largely alleviate concerns about the problem of omitted variables. Third, we use instrumental variable estimation. We follow Buchak et al. (2021) by employing the distance from each city to Hangzhou as an instrumental variable for digital finance. In terms of relevance, Hangzhou is the origin of digital finance in China, and distance to Hangzhou is an important factor influencing the diffusion of digital finance. More crucially, after controlling for city fixed effects and a variety of economic and social characteristics, the distance between the city and Hangzhou is largely exogenous. It should be noted that the geographic distance between cities is time-invariant, and to obtain estimates of the instrumental variables, we cross-multiply the geographic distance with the year dummy variable, similar to the method of Angrist and Keueger (1991).

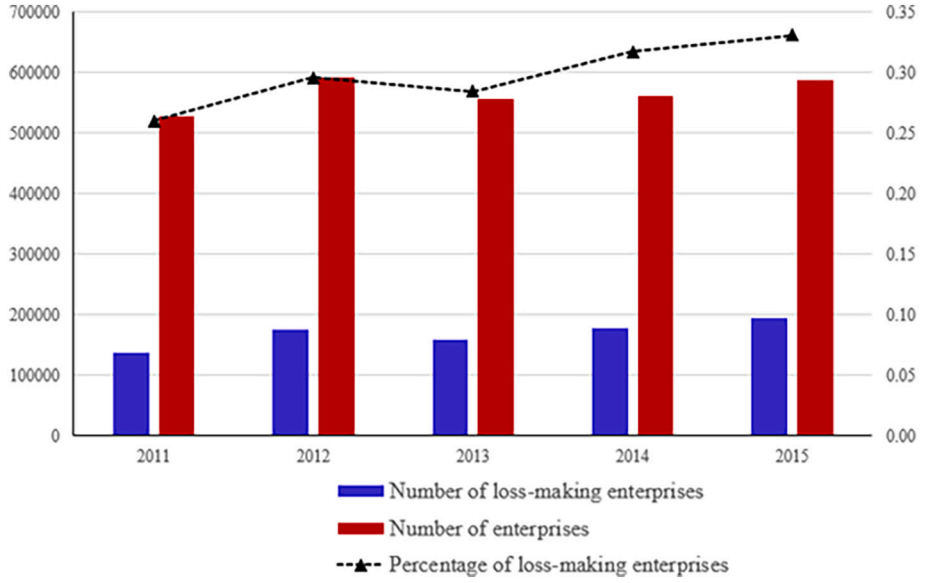

Fig. 2. Percentage of loss-making firms.

4. Empirical results

4.1. Benchmark results analysis

Table 2 reports the estimation results of Eq. (2). In column (1), in addition to the variable Digital Finance Index (*DFI*), we include only city fixed effects, industry fixed effects, and year fixed effects. Column (2) expands on column (1) by including firm-level micro variables, while column (3) expands on column (1) by including city-level macro variables. Finally, column (4) controls both the firm- and city-level variables. In Table 2, the standard errors of all regression results are clustered at the city level. According to the regression findings in Table 2, the growth of city digital finance has significantly decreased small business tax noncompliance. We can see from column (4) that the coefficient of DFI is −0.0151, which is significant at the 5% level. This also means that for every standard deviation increase in the City DFI, the tax noncompliance level of small businesses decreases by 7.5%. In summary, we discover that an increase in the digital finance of a city is associated with lower small business tax noncompliance. The findings are robust when a variety of firm- and city-level variables are controlled for.

4.2. Excluding the influence of confounding factors

In this subsection, to obtain a causal relationship between digital finance and small business tax noncompliance, we explore in detail some confounding factors that may lead to the overestimation of the benchmark results in this paper.

First, we examine the role of tax collection techniques. Applying modern information technology to tax collection and administration is critical for governments to strengthen their tax collection capacity and combat tax noncompliance effectively (Ali, Shifa, Shimeles, & Woldeyes, 2015; Bellon et al., 2022). While digital finance is booming in China, the country's tax authorities are also investing heavily in technology upgrades, the most visible of which is the launch of the Golden Tax Phase III Project. The Golden Tax Phase III system leverages big data and cloud computing technologies and establishes national networking, enabling tax authorities to effectively track enterprises' economic activities across multiple sources and ascertain their true tax liabilities (Li, Wang, & Wu, 2020; Li, Wu, & Xiao, 2020). As such, some studies have found that the level of tax noncompliance by businesses drops significantly after the Golden Tax III project is put into place. This may have led to an overestimation of the baseline results in this paper.

In column (1) of Table 3, we introduce a control variable, GTP, to isolate the effect of the Golden Tax III project from the baseline results. Due to the gradual implementation of the Golden Tax III project by year and region from 2013 to 2016, we define GTP as 1 when cities pilot the Golden Tax III project and 0 otherwise. According to the regression results in column (1), the point estimate of the coefficient on DFI becomes −0.0154 after controlling for GTP, but it remains statistically significant at the 5% level.

Second, another challenge to this paper's benchmark regression results is the impact of contemporaneous tax system reform. The Chinese government has implemented a series of tax system reforms in recent years, the most noteworthy of which is the reform of replacing the business tax with a value-added tax (*VAT*) starting in 2012. This will also affect businesses' tax evasion behavior. Before

Table 2
Benchmark results: impact of digital finance on small business tax noncompliance.

	Explained variable: Corporate tax noncompliance (BT)			
	(1)	(2)	(3)	(4)
DFI	−0.0121* (0.00620)	−0.0141** (0.00589)	−0.0140** (0.00685)	−0.0151** (0.00661)
Size		0.00816*** (0.000472)		0.00816*** (0.000487)
Leverage		−0.0117*** (0.000979)		−0.0114*** (0.000998)
Cash		0.0211*** (0.00328)		0.0206*** (0.00331)
Employee		−0.00302*** (0.000251)		−0.00305*** (0.000258)
GDP			0.00242 (0.00201)	3.67e-05 (0.00216)
Growth			0.0198 (0.0138)	0.0161 (0.0137)
Finance			−0.000391 (0.000519)	−0.000458 (0.000531)
Mobile			−0.00166 (0.00381)	−0.00234 (0.00353)
Internet			0.00116 (0.00101)	0.000999 (0.000972)
City FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Observations	2,123,583	2,123,110	2,043,362	2,042,898
R-squared	0.022	0.039	0.022	0.039

Note: This table presents the benchmark results of digital finance and small business tax noncompliance. Column 1 is the result of univariate regression; Column 2 expands on column 1 by including firm-level micro variables, while column 3 expands on column 1 by including city-level macro variables. Finally, column (4) controls both the firm- and city-level variables. Columns 1–4 all control for city fixed effects, industry fixed effects, and time fixed effects. Standard errors in parentheses are clustered at the city level. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table 3
Excluding the influence of confounding factors.

	Explained variable: Corporate tax noncompliance (BT)			
	The Golden Tax III Project	The Business Tax to Value-Added Tax Reform		Tax and Fee Reductions
	(1)	(2)	(3)	(4)
DFI	−0.0154** (0.00653)	−0.0157** (0.00679)	−0.0152** (0.00739)	−0.0174** (0.00675)
GTP	−0.000537 (0.00138)			
BTA			−0.0486*** (0.0124)	
Tax Break				0.0150*** (0.00128)
Fee Burden				0.00316*** (0.000204)
Control variables	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Observations	2,042,898	1,442,588	1,306,135	2,042,898
R-squared	0.039	0.034	0.041	0.042

Note: Column 1 examines the role of tax collection techniques. We include the dummy variable (*GTP*) of whether the Golden Tax III project is implemented in each city in our baseline regression. Columns 2 and 3 attempt to minimize the confounding effect of the reform of business tax to value-added tax on the benchmark results. In column 2, we exclude firms in the service sector from the full sample. In column (3), we go a step further by controlling the overall tax burden of corporate business tax and value-added tax (*BTA*). Column 4 further considers the disruption of tax and fee reduction policies during the same period. Standard errors in parentheses are clustered at the city level. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

this reform, China levied a business tax on the service sector and a value-added tax on the manufacturing sector. The reform replaced business tax with value-added tax in the service sector. As a result, the revenue and costs of service businesses will be more closely monitored after the reform because the sales revenue and purchase cost information will be recorded on the value-added tax invoice (Shen & Krever, 2017), which means that the room for tax noncompliance of service businesses is greatly reduced.[17] Simultaneously, manufacturing businesses can deduct all services purchased from their VAT tax bases following the reform, allowing the procurement costs of those services to be included in the VAT deduction chain. Therefore, the overall turnover tax burden on manufacturing businesses will decrease, reducing the incentive for businesses to avoid taxes to a certain extent. Based on the above analysis, the effect of the transition from business tax to value-added tax may be confounded in the baseline regression results of this paper.

To alleviate our concerns about this issue as much as possible, we have done the following. Given that the business tax to value-added tax reform will result in a significant increase in tax compliance by service sector firms, our benchmark results may be driven

[17] The sales revenue and purchase cost information on a company's VAT invoice not only helps with VAT supervision, but it also serves as an important third-party source of information for corporate income tax collection (Li et al., 2021).

primarily by service sector firms. For this reason, we exclude firms in the service sector from the full sample. The corresponding regression results are reported in column (2) of Table 3. We find that this does not change the basic conclusion of the article. In column (3), we go a step further by controlling the overall tax burden of firm business tax and value-added tax (*BTA*) to eliminate the impact of the change in turnover tax burden caused by switching business taxes to value-added taxes in the reform. It is noted that the core explanatory variables' significance and coefficient magnitudes in column (2) and column (3) are similar to the baseline results in column (4) of Table 2.

Third, the massive tax and fee reductions enacted between 2012 and 2015 may also have reduced business tax noncompliance. To address this potential issue, we created a dummy variable (*Tax Break*) based on the NSTD data that indicates whether the firm has received a small business tax break. We also calculated the fee burden that companies pay to the government. We control for the above variables in our regression in column (4) of Table 3. The results demonstrate that our findings remain valid.

4.3. Identification of City pairs across province Borders

To further reduce the potential endogeneity issue, we follow the approach of Dube et al. (2010) and Fan, Liu, et al. (2018), exploiting policy discontinuities at province borders to further identify the effect of digital finance on small business tax noncompliance. Specifically, we compile a database of all city pairings in China that span a provincial boundary. Two cities are considered a pair if they share a boundary and belong to separate provinces. We give a pair ID (p) to every pair of cities. Because a city may belong to many city pairs, each city in this city-pair dataset may have multiple replicates. We then match our NTSD dataset with the city-pair dataset.[18] Theoretically, the new city-pair-firm dataset can alleviate our concerns about endogeneity. We can use the new dataset to further control for time-varying unobserved factors by including city-pair-year fixed effects. As argued by Dube et al. (2010) and Fan, Liu, et al. (2018), contiguous regions are relatively similar in terms of underlying economic conditions. By including city-pair-year fixed effects, we can effectively compare the tax noncompliance of small businesses to that in the bordering city within the same city pair, exploiting only the relative changes in digital finance between these two cities because bordering cities within a city pair are more similar than nonbordering cities. Our new dataset ultimately contains 1,719,895 observations from 174 city pairs. We use the following regression model for our empirical investigation:

$$BT_{ijct} = \beta_0 + \beta_1 DFI_{ct} + \beta_2 X_{ijct} + \beta_3 Z_{ct} + \varphi_j + \varphi_c + \varphi_{pt} + \varphi_t + \varepsilon_{ijct} \tag{3}$$

where φ_{pt} are city-pair-year fixed effects. In Eq. (3), the city-pair-year fixed effects φ_{pt} account for city-pair-specific time-varying shocks. The remaining symbols in Eq. (3) have exactly the same meaning as in the baseline regression model.

The results of our city-pair firm sample are shown in Table 4. The results in column (1) show that the coefficient of DFI is −0.0219, which is significant at the 1% level. In columns (2)–(4), we further consider potential policy shocks at the provincial level and industry level while controlling for city-pair-year fixed effects. Columns (2) and (3) add province-year fixed effects and industry-year fixed effects, respectively, based on column (1). Column (4) is based on column (1), adding province-year fixed effects and industry-year fixed effects at the same time. As we can see from the results in Table 4, the findings of this paper still hold. Therefore, the above results can further alleviate our concern about the problem of omitted variables.

4.4. Instrumental variable approach

The preceding series of sensitivity tests instils us with greater confidence in the article's findings. However, the possible estimation bias due to measurement error still needs to be treated with caution. Therefore, we try to find a suitable instrumental variable to alleviate this concern. In this section, we draw on Buchak et al. (2021) to use the distance to the birthplace of digital finance in China (Hangzhou) as an instrumental variable for the DFI. Additionally, considering that the distance variable is time-invariant, we estimate the regression results of the instrumental variable by cross-multiplying the distance variable with the year dummy variable, as in Angrist and Keueger (1991).

The instrumental variable estimations are reported in Table 5. Columns (1) and (3) report the corresponding first-stage estimation results. Where column (1) is the result of controlling for firm micro variables, and column (3) controls for both firm- and city-level variables. We find that the further away from the city of origin of digital finance, the lower the DFI, and this effect has been somewhat persistent over time. These results are consistent with our intuition and are similar to the findings of previous studies (Buchak et al., 2021).

Columns (2) and (4) report the results of the second stage of the regression. We first note that the Hansen statistic (*p*-value) reported at the bottom of columns (2) and (4) is greater than 0.15, implying that the null hypothesis of no correlation between the instruments and the error term in the regressions cannot be rejected. Additionally, the F-statistics obtained from the regressions are all higher than 10, indicating that our IV estimates are not susceptible to concerns about weak instrumentation. In columns (2) and (4), the estimated coefficients of DFI are −0.0255 and − 0.0323, respectively, both significant at the 5% level.[19] The above results suggest that the basic conclusions of the article do not change substantially after we correct for potential endogeneity bias.

[18] A firm-year observation will occur multiple times in the new dataset if this firm's city is a member of multiple city pairings.

[19] Note that the estimates for DFI in the IV estimations of Table 5 are about two times larger than the OLS estimations of Table 2, implying that endogeneity may bias the OLS estimates toward zero.

Table 4
Identification of city pairs across province borders.

	Corporate tax noncompliance (BT)			
	(1)	(2)	(3)	(4)
DFI	−0.0219*** (0.00742)	−0.0223*** (0.00816)	−0.0232*** (0.00589)	−0.0219*** (0.00808)
Size	0.00808*** (0.000656)	0.00806*** (0.000654)	0.00806*** (0.000647)	0.00806*** (0.000650)
Leverage	−0.0130*** (0.00136)	−0.0132*** (0.00142)	−0.0130*** (0.00136)	−0.0132*** (0.00141)
Cash	0.0177*** (0.00385)	0.0182*** (0.00381)	0.0177*** (0.00380)	0.0181*** (0.00380)
Employee	−0.00282*** (0.000321)	−0.00283*** (0.000306)	−0.00284*** (0.000322)	−0.00285*** (0.000307)
GDP	−0.000364 (0.00288)	0.00276 (0.00192)	−0.00144 (0.00250)	0.00198 (0.00200)
Growth	0.0257 (0.0206)	0.0115 (0.0151)	0.0220 (0.0177)	0.0107 (0.0142)
Finance	−0.000845 (0.000703)	0.000197 (0.000484)	−0.000823 (0.000634)	0.000108 (0.000439)
Mobile	−0.000373 (0.00484)	−0.00353 (0.00341)	3.20e-05 (0.00430)	−0.00412 (0.00317)
Internet	0.00161 (0.00113)	0.00238 (0.00153)	0.00160 (0.00111)	0.00263* (0.00141)
City-pair-year FE	Yes	Yes	Yes	Yes
Province-Year FE	No	Yes	No	Yes
Industry-Year FE	No	No	Yes	Yes
City FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Observations	1,333,875	1,333,874	1,333,845	1,333,844
R-squared	0.039	0.040	0.042	0.043

Note: This table presents the results of the city-pair firm-level sample. Column 1 includes city-pair-year fixed effects in our baseline regression. Columns 2 and 3 add province-year fixed effects and industry-year fixed effects on the basis of column (1), respectively. Column 4 is based on column 1, adding province-year fixed effects and industry-year fixed effects at the same time. Standard errors in parentheses are clustered at the city level. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Furthermore, for cautionary reasons, the IV estimations must account for the possibility that firms would self-select to register in places close to Hangzhou. If this is the case, the results of the IV estimation may also be biased. To alleviate concerns about this issue, we further restrict the sample to firms registered before Alibaba was established in Hangzhou. This is because these firms were registered before Alibaba was established and are unlikely to self-select register near Hangzhou for better access to digital financial services. We use the tax identification number from NTSD data to match with the Chinese business registration data (CBRD) to obtain the business registration time information. After we obtained information on the time of firm registration, we restricted the regression sample. The corresponding results are reported in columns (5)–(6) of Table 5, and from the results of the second stage, the coefficient of the DFI is −0.036, which is significant at the 5% level, strengthening our confidence in the IV estimations.

4.5. Other robustness checks

4.5.1. Alternative measures of firm tax noncompliance

To further establish the robustness of our conclusion, we conduct a robustness check using various metrics of tax noncompliance. First, although book-tax differences (*BT*) have been widely used as a proxy for corporate tax noncompliance (Wilson, 2009), Desai and Dharmapala (2006) argue that they may be partially explained by earnings management. To overcome this problem, we follow Chen et al. (2021) and utilize residual book-tax differences (*RBT*) as a proxy for tax noncompliance. *RBT* denotes the residual component of a regression relating total book-tax differences (*BT*) to total accruals (*TA*). *TA* is defined as net income minus operating cash flows divided by total assets. *RBT* is a measure of unexplained total book-tax differentials that takes earnings management into account. A lower *RBT* indicates less tax noncompliance. Second, Dyreng, Hanlon, and Maydew (2010) assert that the lower a firm's effective tax burden (ETB) is within its industry, the greater the likelihood of tax noncompliance. Consequently, we depend on their results while also capturing corporate tax noncompliance via the effective tax burden (*ETB*).[20] If digital finance successfully reduces small businesses' tax noncompliance, this reduction should be reflected in their effective tax burden.

Columns (1)–(2) of Table 6 report the results of alternative tax noncompliance measures. We use *RBT* as the dependent variable in column (1) and *ETB* as the dependent variable in column (2). Column (1) shows that the DFI coefficient is significantly negative at the 5% level, which is consistent with our prediction, implying that digital finance plays an important role in the governance of small business tax noncompliance. In column (2), the coefficient on DFI is positive at the 5% level, indicating that the development of digital finance significantly increases small businesses' effective tax rate. In essence, this is indirect evidence of a decrease in tax noncompliance by small businesses, bolstering the article's baseline findings. As demonstrated above, our findings are consistent with alternative tax noncompliance measures.

4.5.2. Regression using county-level DFI

Considering the imbalance of digital finance development within prefecture-level cities, we use the county-level DFI as the

[20] Since this paper focuses on the tax noncompliance of corporate income tax. Therefore, the effective corporate tax burden (ETB) in this paper is equal to the corporate income tax expense divided by the total profit.

Table 5
Estimation results for instrumental variables.

	First-stage	Second-stage	First-stage	Second-stage	First-stage	Second-stage
	DFI	BT	DFI	BT	DFI	BT
	(1)	(2)	(3)	(4)	(5)	(6)
HZ Distance*D2012	−0.00006*** (0.00001)		−0.00006*** (0.00002)		−0.00007*** (0.00002)	
HZ Distance*D2013	−0.00008*** (0.00002)		−0.00008*** (0.00002)		−0.00009*** (0.00002)	
HZ Distance*D2014	−0.00006*** (0.00002)		−0.00007*** (0.00002)		−0.00008*** (0.00002)	
HZ Distance*D2015	−0.00006*** (0.00002)		−0.00006*** (0.00002)		−0.00007*** (0.00002)	
DFI	–	−0.0255* (0.0144)	–	−0.0323** (0.0148)	–	−0.0360** (0.0150)
Size	−1.89e-06 (0.00010)	0.00812*** (0.000486)	−0.00013* (0.00008)	0.00815*** (0.000487)	0.00021** (0.00009)	0.0044*** (0.0003)
Leverage	0.0004 (0.0007)	−0.0114*** (0.00101)	0.0003 (0.0007)	−0.0114*** (0.00101)	−0.00071 (0.00056)	−0.0162*** (0.0014)
Cash	0.0025*** (0.0008)	0.0207*** (0.00329)	0.0022*** (0.0007)	0.0207*** (0.00331)	0.0027*** (0.00067)	0.022*** (0.004)
Employee	0.0001 (0.0002)	−0.00302*** (0.000257)	0.0002 (0.0002)	−0.00304*** (0.000259)	0.00002 (0.00009)	−0.0018*** (0.00032)
GDP	–	–	0.0594*** (0.0109)	0.00101 (0.00206)	0.0692*** (0.0123)	0.0023 (0.0017)
Growth	–	–	0.1423 (0.1301)	0.0205 (0.0148)	0.314** (0.150)	0.0329* (0.0181)
Finance	–	–	−0.0088* (0.0050)	−0.000618 (0.000597)	−0.009 (0.007)	0.0001 (0.0007)
Mobile	–	–	0.0573** (0.0275)	−0.00175 (0.00365)	0.103*** (0.035)	−0.0006 (0.0038)
Internet	–	–	−0.0188*** (0.0068)	0.000795 (0.000964)	−0.019*** (0.007)	−0.0004 (0.0011)
F-statistic	–	55,757	–	63,809	–	13,648
Hansen J Test p value	–	0.2880	–	0.1975	–	0.4047
City FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,064,831	2,064,831	2,042,435	2,042,435	283,051	283,051
R-squared	–	0.018	–	0.018	–	0.081

Note: This table reports the results of the estimation of instrumental variables. Columns 1, 3 and 5 show the first-stage regression results of using distance-to-Hangzhou as IV for DFI, and columns 2, 4 and 6 report the second-stage regression results. Standard errors in parentheses are clustered at the city level. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table 6
Other robustness checks.

	Corporate tax noncompliance (RBT)	Effective Tax Burden (ETB)	County-Level DFI	Strongly Balanced Panel Data
	(1)	(2)	(3)	(4)
DFI	−0.00236** (0.00116)	0.0373** (0.0151)	−0.0174*** (0.00608)	−0.0102** (0.00471)
Size	0.00120*** (4.45e-05)	−0.00338*** (0.000570)	0.00644*** (0.000578)	0.00943*** (0.000808)
Leverage	0.00184*** (0.000158)	0.0301*** (0.00243)	−0.0152*** (0.00121)	−0.0191*** (0.00172)
Cash	−0.0225*** (0.00269)	−0.0135*** (0.00136)	0.0239*** (0.00420)	0.0148*** (0.00176)
Employee	−0.00104*** (9.57e-05)	0.00419*** (0.000603)	−0.00320*** (0.000430)	0.000925 (0.000587)
GDP	−8.99e-05 (0.000358)	−0.0114** (0.00535)	0.0198 (0.0186)	0.00106 (0.00177)
Growth	−0.00169 (0.00224)	0.0939* (0.0491)	0.0158 (0.0563)	0.0261* (0.0134)
Finance	−0.000127* (7.00e-05)	−0.00138 (0.00125)	5.73e-05 (0.000934)	0.000496 (0.000470)
Mobile	−0.000155 (0.000544)	−0.0136 (0.00844)	−0.00742 (0.00685)	0.00410 (0.00271)
Internet	−7.46e-05 (0.000120)	0.000384 (0.00345)	−0.00917*** (0.00243)	−0.000979 (0.000933)
Firm FE	No	No	No	Yes
City FE	Yes	Yes	Yes	No
Time FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	No
Observations	2,042,898	639,246	195,685	74,597
R-squared	0.184	0.070	0.050	0.015

Note: The control variables in the baseline regressions are all controlled for in Table 6. Column 1 utilizes residual book-tax differences (*RBT*) as a proxy for tax evasion. Column 2 uses the effective tax burden (*ETB*) as an indirect measure of corporate tax evasion. However, columns 3 and 4 still use book-tax differences (*BT*) as a measure of corporate tax evasion. In column 3, we use the county-level DFI as the explanatory variable. In column 4, we use the strongly balanced panel data for regression. Standard errors in parentheses are clustered at the city level. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

explanatory variable in this subsection of the regression. The results are reported in column (3) of Table 6. Because the county-level DFI has only been compiled since 2014, the regression sample in column (3) is heavily reduced. The findings, however, indicate that the development of digital finance still reduces small business tax noncompliance, with the coefficient being significantly negative at the 1% level.

4.5.3. Regression using strongly balanced panel sample data

The firm data used in this paper are cross-sectional data from a year-by-year sample survey, which does not allow us to control for time-invariant firm factors. In addition, this also makes it impossible to rule out the interference of enterprise migration on the benchmark regression results. For example, companies may relocate to areas where digital finance is better developed to have easier access to credit resources. To this end, this paper attempts to retain only the firm samples that have been in the NTSD dataset from 2011 to 2015 to construct a strongly balanced panel dataset.[21] In column (4) of Table 6, we use the retained balanced panel data for regression. However, unlike the benchmark regression, we control for firm fixed effects and year fixed effects. The regression results show that digital finance still significantly reduces tax noncompliance by small businesses. This result effectively alleviates our concerns about the aforementioned two issues.

4.5.4. The influence of different dimensions of DFI

Considering the rich composition of DFI, we further examine the impacts of DFI on tax noncompliance from three aspects: breadth, depth, and digitalization. They reflect the coverage breadth, use depth and digital service provision of digital finance, respectively.[22] Table 7 reports the corresponding regression results. Interestingly, in columns (2)–(3), the depth of use of digital finance (DFI _depth) and the digital service provision of digital finance (DFI _digitization) have a significant impact on corporate tax noncompliance, and the coefficients are all significant at the 5% level. However, in column (1), the coefficient of breadth of digital financial usage (DFI _breadth) is not significant, although it remains negative. The above results show that to fully exploit the important role of digital finance in small business tax governance, it is necessary to deeply integrate with and provide convenient digital financial services for business operations, as opposed to depending merely on growing digital finance coverage.

5. Mechanisms

This paper confirms that regional digital finance development can improve small business tax compliance. How does digital finance affect small business tax compliance? In this section, we will examine the mechanisms in detail.

[21] In the strongly balanced panel dataset, we also exclude those businesses that have changed their place of incorporation.
[22] Appendix Table A3 in the revised manuscript shows the components of the Digital Financial Index (DFI) in detail.

Table 7
Impact of different dimensions of DFI on corporate tax noncompliance.

	Explained variable: Corporate tax noncompliance (BT)		
	(1)	(2)	(3)
DFI _breadth	−0.00138 (0.00616)		
DFI _depth		−0.00887** (0.00360)	
DFI _digitization			−0.00312** (0.00146)
Control variables	Yes	Yes	Yes
City FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Observations	2,042,898	2,042,898	2,042,898
R-squared	0.039	0.039	0.039

Note: This table presents the regression results of the digital finance indices for different dimensions. Column (1) is the result of the coverage breadth index; column (2) is the result of the usage depth index; and column (3) is the result of the service facilitation index. Standard errors in parentheses are clustered at the city level. *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.

5.1. Improving business financing

According to the theoretical analysis framework presented in Part II, digital finance can effectively alleviate financing constraints and reduce financing costs for small businesses (Bollaert et al., 2021; Fetzer & Dinger, 2019), which can help reduce the tax noncompliance incentives of small firms. To test this mechanism, we first construct a synthetic index to measure firm financing constraints, drawing on Musso and Schiavo (2008). Specifically, we chose five distinct variables that convey critical information about the presence of corporate financing constraints. The selection of these variables was based on existing studies, and they usually reflect the financial constraint status of the firm in different dimensions. They are cash flow (cash flow from operating activities divided by total assets), current ratio (current assets divided by current liabilities), accounts receivable turnover ratio (sales revenue divided by accounts receivable), solvency ratio (owner's equity divided by total liabilities), and profitability (total profit divided by total assets).

For each of these five dimensions, we assign values based on their quartiles in the same industry, with values ranging from 1 to 4, corresponding to quartiles of (75%–100%], (50%–75%], (25%–50%], and (0–25%], respectively. Finally, we combine the scores for each of the five dimensions of the firm to obtain a composite indicator of financing constraints (FC). The higher a firm's FC score is, the more severe the financing constraint it faces. The OLS result in column (1) of Table 8 indicates a significant negative relationship between digital finance and firm financing constraints, corroborating our theoretical expectation that digital finance is effective at relieving small firms' financing constraints. The IV result in column (2), with Hangzhou distance as an instrumental variable,[23] shows similar patterns.

Additionally, we examine the impact of digital finance on corporate financing costs. In the regressions, we quantify the cost of corporate financing by the ratio of corporate interest expenses to total liabilities. Columns (3)–(4) of Table 8 report the relevant regression results, with column (3) for OLS and column (4) for IV, which both show that digital finance significantly lowers firms' financing costs. The above empirical results in Table 8 demonstrate that digital finance can significantly reduce small business financing constraints and costs, revealing a critical path for digital finance to influence small business tax noncompliance.

5.2. Adding tax-related information supply

An important reason for small businesses' serious tax noncompliance is the difficulty of obtaining and supervising their tax-related information (Adhikari et al., 2021). By integrating digital technologies such as big data, cloud computing, artificial intelligence, blockchain, and the Internet of Things with financial services, digital finance may maximize access to business information (Chen et al., 2021). Among them, digital finance's third-party collection and payment function maintains an exhaustive and accurate record of small businesses' transactions, and their customer collection records serve as a direct tax data trail. In recent years, tax authorities in many places in China, such as Chongqing, Hangzhou, Shenzhen, Tianjin, and Nanjing, have investigated and punished a number of small businesses for tax noncompliance by auditing their receipts and records of transfers on third-party payment platforms.[24]

Due to the prevalence of digital finance's third-party payment function, a significant number of small businesses leave digital traces during transactions, offering critical information for tax authorities' audits, potentially increasing the likelihood that small businesses' tax noncompliance would be uncovered. Columns (1) and (2) of Table 9 verify this logic. In columns (1) and (2), our explained variable is a dummy variable (*Detected*) to measure whether the tax noncompliance of the company is detected by the tax authorities. According

[23] We estimate the regression results of the instrumental variable by cross-multiplying the distance variable with the year dummy variable.
[24] Information source: https://mp.weixin.qq.com/s/YAs6dCCK3kaNDJ3EFTRVmg.

Table 8
Impact of digital finance on corporate finance constraints and costs.

	FC	FC	Interest Expenses	Interest Expenses
	(1) OLS	(2) IV	(3) OLS	(4) IV
DFI	−0.283** (0.132)	−0.802*** (0.251)	−0.0141*** (0.00321)	−0.0702*** (0.0202)
Size	0.0942*** (0.00651)	0.0942*** (0.00651)	0.00190*** (6.66e-05)	0.00189*** (6.75e-05)
Leverage	6.627*** (0.0232)	6.628*** (0.0233)	−0.00830*** (0.000642)	−0.00826*** (0.000642)
Cash	−5.007*** (0.0708)	−5.007*** (0.0705)	−0.00192*** (0.000717)	−0.00172** (0.000733)
Employee	−0.247*** (0.00830)	−0.246*** (0.00831)	0.00139*** (0.000154)	0.00140*** (0.000162)
GDP	0.00914 (0.0292)	0.0387 (0.0325)	0.00130 (0.000901)	0.00439*** (0.00120)
Growth	−0.169 (0.220)	−0.0288 (0.247)	−0.0140* (0.00778)	0.0134 (0.0121)
Finance	0.00139 (0.00770)	−0.00328 (0.00925)	−4.01e-05 (0.000281)	−0.000674 (0.000443)
Mobile	0.0397 (0.0490)	0.0601 (0.0566)	0.00687*** (0.00202)	0.01000*** (0.00278)
Internet	−0.0240** (0.0109)	−0.0298** (0.0123)	−0.00111** (0.000512)	−0.00181*** (0.000606)
F-statistic	–	46,143	–	41,928
Hansen J Test p value	–	0.110	–	0.153
City FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Observations	1,458,740	1,458,463	1,140,919	1,140,820
R-squared	0.657	0.636	0.095	0.022

Note: This table presents the regression results of digital finance on firms' financing constraints and financing costs. Columns 1 and 3 are the OLS regression results, and columns 2 and 4 are the IV estimates. Standard errors in parentheses are clustered at the city level. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table 9
The impact of digital finance on tax authorities' access to tax-related information.

	Detected (0–1)		VCM (0–1)		Corporate tax evasion (BT)	
	(1) OLS	(2) IV	(3) OLS	(4) IV	(5) OLS	(6) IV
DFI	0.0790*** (0.0225)	0.175* (0.0917)	−0.0497** (0.0235)	−0.212** (0.0830)	−0.0132** (0.00643)	−0.0327** (0.0148)
DFI* direct-to-consumer	–	–	–	–	−0.00222*** (0.000822)	−0.00182** (0.000871)
Size	0.00149*** (0.000212)	0.00149*** (0.000212)	−0.00947*** (0.000831)	−0.00948*** (0.000830)	0.00814*** (0.000487)	0.00814*** (0.000486)
Leverage	0.00502*** (0.000746)	0.00498*** (0.000735)	−0.0506*** (0.00372)	−0.0505*** (0.00378)	−0.0114*** (0.00100)	−0.0114*** (0.00101)
Cash	−0.00144 (0.000905)	−0.00167* (0.000933)	−0.0114 (0.00829)	−0.0111 (0.00831)	0.0206*** (0.00329)	0.0207*** (0.00330)
Employee	0.00392*** (0.000526)	0.00389*** (0.000514)	−0.0140*** (0.00158)	−0.0139*** (0.00156)	−0.00305*** (0.000258)	−0.00304*** (0.000259)
GDP	−0.000776 (0.00527)	−0.00624 (0.00812)	−0.00358 (0.00759)	0.00561 (0.00818)	5.44e-05 (0.00212)	0.00114 (0.00205)
Growth	0.0262 (0.0501)	0.00117 (0.0474)	−0.109* (0.0599)	−0.0666 (0.0587)	0.0158 (0.0136)	0.0208 (0.0146)
Finance	−0.00250 (0.00255)	−0.00161 (0.00283)	0.00218 (0.00215)	0.000670 (0.00257)	−0.000422 (0.000527)	−0.000606 (0.000597)
Mobile	−0.00424 (0.0128)	−0.00753 (0.0136)	−0.00416 (0.0144)	0.00138 (0.0137)	−0.00206 (0.00351)	−0.00146 (0.00365)
Internet	0.000102 (0.00265)	0.00125 (0.00313)	−0.00476 (0.00613)	−0.00669 (0.00661)	0.000920 (0.000975)	0.000707 (0.000963)
F-statistic	–	63,809	–	63,810	–	67,882
Hansen J Test p value	–	0.169	–	0.081	–	0.201
City FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,042,898	2,042,435	2,042,896	2,042,433	2,042,898	2,042,435
R-squared	0.036	0.002	0.113	0.020	0.039	0.018

Note: This table reports regression results for the impact of digital finance on tax authorities' access to tax-related information. The dependent variable in columns 1 and 2 is a dummy variable that indicates whether corporate tax noncompliance was discovered by tax authorities (*Detected*); Columns 3 and 4 have as the dependent variable a dummy variable that indicates whether tax authorities use verification collection methods to assess small enterprises' taxable income (*VCM*). The dependent variable in columns 5–6 remains consistent with the measure of corporate tax evasion in the benchmark regression. Columns 1, 3, and 5 in the table show the OLS estimates, and columns 2, 4, and 6 show the IV estimates. Standard errors in parentheses are clustered at the city level. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

to the information in the NTSD, if an enterprise pays back taxes and fines after being audited by the tax authorities, we believe that its tax noncompliance has been discovered, and the explained variable is assigned a value of 1; otherwise, it is assigned a value of 0. The OLS and IV estimation results in columns (1) and (2) are consistent with our theoretical expectation that the development of digital finance significantly enhances the probability of small business tax noncompliance being detected.[25]

Next, we provide further evidence to demonstrate the tax-related information supply mechanism. In practice, when tax authorities have difficulty collecting tax-related information from small businesses, such as their expenses and earnings, they often rely on verification collection methods to assess small businesses' taxable income.[26] Although the verification collection method is recognized by tax law, the businesses that adopt this method typically face only a very low combined tax rate, which not only results in a massive tax loss but also encourages a large number of enterprises to continuously register new small businesses to minimize their true tax obligations. Therefore, it is reasonable to expect that if the third-party payment function of digital finance does indeed provide tax authorities with a trail of small business transactions, tax authorities will reduce their reliance on the verification collection method to a certain extent.

The regression results in columns (3) and (4) of Table 9 provide supporting evidence for our conjecture. According to the data contained in the NTSD, we generate a dummy variable (*VCM*), which equals 1 if the taxable income of an enterprise is determined by the tax authority using verification collection methods and 0 otherwise. We use this dummy variable as the explained variable in columns (3)–(4) of Table 9. The regression results of OLS in column (3) and IV in column (4) both indicate that the development of regional digital finance reduces the probability of small businesses' taxable income being verified for taxation by tax authorities.

Finally, tax authorities' ease of access to tax-related information for small businesses differs by industry. We can utilize this fact to further test the mechanism in this subsection. Typically, tax-related information is more difficult to obtain and monitor for those industries that directly face the final consumer, such as wholesale, retail, and restaurant industries (Pomeranz, 2015). However, in recent years, direct-to-consumer businesses have made the most extensive use of digital finance's third-party payment function. As a result, we expect digital finance to have a greater effect on small business tax noncompliance in these industries.

We divide the companies into two categories according to whether they are in the industry directly facing the final consumers.[27] In columns (5) and (6), we cross-multiply the DFI with the "direct-to-consumer" dummy variable and add the interaction terms to the baseline regression equation. In line with our prediction, the interaction terms in columns (5)–(6) of Table 9 are significantly negative at the 5% level, implying that small businesses that directly serve the final consumer experience a greater decline in their level of tax noncompliance as digital finance develops, which provides further additional evidence for the tax-related information supply mechanism.

6. Heterogeneous effects

In this section, we explore the diverse influence of digital finance on tax noncompliance by businesses in three dimensions, firm, industry, and region, with the aim of providing further evidence for the mechanism posited by this article and offering relevant references for policy optimization.

6.1. *Effects by firm type*

Studies have shown that large enterprises have greater access to financing than small businesses (Liu & Mao, 2019). Moreover, tax authorities around the world, including China, usually include large enterprises in the scope of key tax source monitoring (Almunia & Lopez-Rodriguez, 2018). As a result, large enterprises face weaker financing constraints than small businesses, and tax authorities have easier access to their tax-related information. According to the logic of the mechanism in this paper, digital finance should have no substantial impact on the tax noncompliance behavior of large enterprises. We can use large enterprises as the comparison sample for a placebo test.

Table 10 investigates the impact of digital finance on tax noncompliance by various types of enterprises. We distinguish the large enterprise sample and the small business sample in NTSD using the Chinese Ministry of Industry and Information Technology's identification criteria. For each subsample, we repeat the previous baseline and instrumental variable regressions. Columns (1) and (4) of Table 10 present the results of OLS and IV estimation for the large enterprise sample, while columns (2) and (5) present the results of

[25] These results can reflect that a higher DFI makes tax evasion more likely to be detected, but they also might imply that a higher DFI induces more detected tax evasion. Therefore, we remind readers to be cautious about the results in columns (1)–(2). However, we also emphasize that the results in columns 1–2 of Table 9 cannot be viewed in isolation. Combined with the results in the remaining columns of Table 9, it may be more reasonable to interpret the regression results in columns (1)–(2) as indicating that a higher DFI makes tax noncompliance more likely to be detected.

[26] Compared to general manner of audit collection, verification collection method is applied to firms which are lack of tax-related information such as expenses and earnings. According to Chinese corporate income tax law, verification collection method is used to verify tax liability through the following approaches: ①To make verification by referring to the tax burden on local taxpayers in the same or similar industry and with approximate business scale and income level; ②To make verification by referring to the amount of taxable income or the amount of costs and expenses; ③To make verification on the basis of calculation and inference or measurement of the consumed raw materials, fuel, energy, etc.; or; ④To make verification through other reasonable approaches.

[27] In Table A1, we detail the industries for end-consumers.

Table 10
Results by firm type.

	Large Firm	Small Firm	Full	Large Firm	Small Firm	Full
	(1) OLS	(2) OLS	(3) OLS	(4) IV	(5) IV	(6) IV
DFI	−0.0106	−0.0151**	−0.0100* (0.00539)	−0.00932	−0.0323**	−0.0128 (0.0140)
	(0.0176)	(0.00661)		(0.0334)	(0.0148)	
DFI*Small			−0.00418***			−0.00409***
			(0.0010)			(0.00101)
Small			0.0116*** (0.00193)			0.0115*** (0.00202)
F-statistic	–	–	–	694	63,809	72,340
Hansen J Test p value	–	–	–	0.090	0.1975	0.1614
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	24,882	2,042,898	2,342,479	24,880	2,042,435	2,341,969
R-squared	0.080	0.039	0.039	0.007	0.018	0.017

Note: This table presents the regression results of different firm types. Columns 1–3 in the table show the OLS estimates, and columns 4–6 show the IV estimates. Standard errors in parentheses are clustered at the city level. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

small business estimation.[28] As Table 10 shows, although the coefficient on DFI is negative for both groups of firms, it is statistically nonsignificant for large enterprises but significant at 5% for small businesses, which is in line with our previous theoretical expectations. In columns (3) and (6), we include an interaction between DFI and the firm type dummy (*Small*) in the regression with the full sample. The coefficients on the interaction term in columns (3) and (6) are −0.00418 and − 0.00409, respectively, both significant at the 1% level, confirming that there is a substantial difference in tax noncompliance behavior between large and small enterprises. The above regression results provide additional support for the mechanism described in this paper.

6.2. *Effects by industry*

In China, to better promote economic growth, the central government and local governments formulate industrial policies in their own "five-year plans" to select priority sectors for development and provide special policy attention to these industries (Wu, Zhu, & Groenewold, 2019). Specifically, industrial policy encourages commercial banks to be more inclined to allocate credit funds to key industries with government support, which helps improve the ease of access to credit funds for these industries and thus alleviates financing constraints (Zhang et al., 2021). Furthermore, the government's industrial policy will give commensurate financial subsidies and tax breaks to the key industries, which will also assist in reducing some of the financing strains on the relevant industries (Aghion et al., 2015). Additionally, in China's government performance appraisal system, the development of key industries is regarded as an important achievement of local governments in promoting economic transformation. Thus, various local government departments, including taxation authorities, will closely monitor and count the operating indicators of enterprises in key industries. Accordingly, if the logic of this study is followed, the influence of digital finance on the tax noncompliance behavior of businesses within the scope of key industries should be limited, while the inhibitory effect of digital finance on tax noncompliance behavior should be more evident in nonkey industry businesses.

Based on the 12th Five-Year Plan (2011–2015) formulated by the central and provincial governments, we divide the sample into two subsamples: key industries supported by the government's industrial policy and nonkey industries. The findings are shown in Table 11. Consistent with our expectations, the impact of digital finance on small business tax noncompliance is only significant in nonkey industries, as shown by the OLS and IV estimates. In column (3) and column (6), we interact DFI with the industry type dummy (*nonkey industry*) in a regression for the full sample.[29] The coefficients on the interaction term for the OLS and IV estimates are −0.0039 and − 0.0032, respectively, and are significant at the 1% and 5% levels. These results again confirm that the effect of digital finance on small business tax noncompliance is significantly larger for firms in nonkey sectors. The above regression results again strengthen our confidence in the mechanism of this paper.

6.3. *Effects by regional credit environment*

Is the disincentive effect of digital finance on small business tax noncompliance different depending on the regional credit environment? Exploration of this question will aid in the future improvement of public policy. Essentially, credit is the building block of

[28] The results of column (2) and column (5) in Table 10 are identical to the results of column (4) in Table 2 and column (4) in Table 5 in the previous section.

[29] We assign a value of 1 to small businesses in nonkey industry and a value of 0 to small businesses in key industries. Columns (3) and (6) include the full samples in the regression.

Table 11
Results by industry.

	Key Industries	Nonkey Industry	Full	Key Industries	Nonkey Industry	Full
	(1) OLS	(2) OLS	(3) OLS	(4) IV	(5) IV	(6) IV
DFI	0.00330 (0.00816)	−0.0162** (0.00695)	−0.0122* (0.00622)	−0.0218 (0.0292)	−0.0315** (0.0150)	−0.0225 (0.0167)
DFI*Nonkey industry			−0.00390*** (0.000672)			−0.00320** (0.00143)
Nonkey industry			0.00492*** (0.00123)			0.00403* (0.00215)
F-statistic	–	–	–	4959	59,084	59,547
Hansen J Test p value	–	–	–	0.2407	0.2261	0.2867
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	169,476	1,873,421	2,042,898	169,456	1,872,978	2,042,435
R-squared	0.033	0.041	0.029	0.012	0.018	0.020

Note: This table presents the regression results of different industry types. Columns 1–3 in the table show the OLS estimates, and columns 4–6 show the IV estimates. Standard errors in parentheses are clustered at the city level. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

financial development. Digital finance is more inclusive and convenient than traditional finance and has the potential to assist a greater number of small businesses (Bollaert et al., 2021; Maskara, 2020). However, the development of digital finance is also inextricably linked to a healthy credit environment. Digital finance, in particular, makes use of information technologies such as big data, cloud computing, and blockchain to more precisely identify credit risks (Chen & Zhang, 2021), making it more responsive to the credit environment. As a result, it is reasonable to believe that digital finance will play a relatively limited positive role in regions with poor credit environments. This is not conducive to alleviating the financing woes of most small businesses and may force them to still possess a strong incentive to avoid taxes. Therefore, the analysis above demonstrates the need to establish a good regional credit environment to maximize the benefits of digital finance.

We empirically test how the consequences of digital finance on small business tax noncompliance vary according to the credit environment in each region. First, we construct indicators of each city's credit environment. Specifically, we aggregate the number of businesses having credit defaults at the city level using publicly accessible information on court judgments involving businesses. Next, we calculate the city's credit environment by dividing the total number of businesses experiencing credit defaults by the city's entire population.[30] In general, the larger the proportion of businesses in credit default in a city, the worse the regional credit environment is. As a second step, we divide the whole sample in half using the credit environment indicator's median. A city credit environment indicator greater than the median is regarded as an area with a bad credit environment, while a city with a credit environment indicator less than the median is considered as an area with a good credit environment.

Columns (1)–(2) and (4)–(5) in Table 12 report the results of the subsample regressions for OLS and IV, respectively. Only in the sample with a favorable credit environment does the regression coefficient of DFI become significantly negative, but in the sample with a poor credit environment, the coefficient is nonsignificant. In addition, in columns (3) and (6), we include interactions between DFI and the credit environment indicator in the regressions with the full sample. The interaction term coefficients for the OLS and IV estimates are 0.000139 and 0.000210, respectively, and are statistically significant at the 5% and 1% levels. This is consistent with the subsample regression findings, confirming that the disincentive impact of digital finance on tax noncompliance by small businesses is weaker in locations with poor credit environments than in places with favorable credit environments. The above results suggest that building a healthy regional credit environment is just as vital as fostering the development of digital finance. Without a good credit environment, it is difficult for digital finance to play a positive role.

7. Conclusions

Using tax administrative data and city-level DFI for China from 2011 to 2015, this paper examines the impact of digital finance development on small business tax compliance. Both OLS and IV estimates suggest that digital finance significantly reduces tax noncompliance by small businesses. Our analysis of the underlying mechanisms finds that digital finance affects small business tax noncompliance through two channels: alleviating corporate financing constraints and increasing the supply of tax-related information. Finally, we analyze the heterogeneous effects of digital finance development. The effects on tax noncompliance are weaker for large enterprises (placebo group), small businesses supported by the government's industrial policy, and small businesses located in poor credit environment areas. These results are shown to be robust across a number of sensitivity analyses.

With the rise of digital finance in countries around the world, our research has broader practical relevance. First, based on the

[30] Due to the absence of an accurate count of all companies at the city level, we can only divide the number of defaulting enterprises by the entire population.

Table 12
Results by city credit environment.

	Number of credit defaulting firms/total population (CDR)			Number of credit defaulting firms/total population (CDR)		
	< Median	> Median	Full	< Median	> Median	Full
	(1) OLS	(2) OLS	(3) OLS	(4) IV	(5) IV	(6) IV
DFI	−0.0117* (0.00654)	0.0209 (0.0177)	−0.0185*** (0.00702)	−0.0300* (0.0165)	−0.0294 (0.0505)	−0.0490** (0.0200)
DFI* CDR			0.000139** (0.00005)			0.000210*** (0.00008)
CDR			−0.000296*** (0.000107)			−0.000425*** (0.000147)
F-statistic	–	–	–	45,337	17,055	56,691
Hansen J Test p value	–	–	–	0.6928	0.6760	0.3079
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,463,177	578,958	2,042,141	1,462,714	578,958	2,041,678
R-squared	0.036	0.052	0.039	0.015	0.026	0.018

Note: This table presents the regression results of different city credit environments. Columns 1–3 in the table show the OLS estimates, and columns 4–6 show the IV estimates. Standard errors in parentheses are clustered at the city level. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

findings of this paper, countries can further improve the inclusiveness and accessibility of digital finance. This helps alleviate the financial constraints of small businesses, which in turn reduces their incentive to be tax noncompliant. Second, in the era of digital finance, tax authorities should make full use of the "digital traces" generated by digital finance as an important third-party information source to combat tax noncompliance by small businesses. Third, credit remains the cornerstone of digital finance development. To realize the positive role of digital finance in curbing tax noncompliance by small businesses, it is necessary to build a good regional credit environment.

Data availability

The authors do not have permission to share data.

Appendix A

Table A1
Industries that directly face the final consumers.

	Industry Name	Industry Code		Industry Name	Industry Code
1	Wholesale industry	F51	5	Business Service Industry	L72
2	Retail Industry	F52	6	Residential service industry	O80
3	Accommodation industry	H61	7	Motor vehicles, electronic products, and daily use products repair industry	O81
4	Restaurant operation	H62	8	Other service industries	O82

Table A2
Regression results normalized by book earnings on book-tax differences.

	Corporate Tax Noncompliance (Normalize Book-Tax differences with book earing)		
	Benchmark regression results	City pairs across province borders	IV estimation results
	(1)	(2)	(3)
DFI	−0.0660*** (0.0150)	−0.0415** (0.0161)	−0.0796* (0.0449)
Size	−0.00284*** (0.000365)	−1.15e-05 (0.000414)	−0.00285*** (0.000365)
Leverage	−0.0516*** (0.00181)	−0.0391*** (0.00207)	−0.0517*** (0.00181)
Cash	−0.0914*** (0.00313)	−0.0886*** (0.00354)	−0.0913*** (0.00313)
Employee	−0.0787*** (0.000577)	−0.0717*** (0.000661)	−0.0787*** (0.000577)
GDP	0.00456 (0.00470)	−0.00113 (0.00494)	0.00532 (0.00527)
Growth	−0.0713** (0.0324)	−0.103*** (0.0395)	−0.0678** (0.0343)
Finance	0.00740*** (0.00130)	0.00870*** (0.00147)	0.00728*** (0.00136)
Mobile	0.00440 (0.00695)	−0.0145* (0.00767)	0.00487 (0.00710)
Internet	−0.00540** (0.00243)	−0.0166*** (0.00278)	−0.00556** (0.00248)
City FE	Yes	Yes	Yes

(*continued on next page*)

Table A2 (*continued*)

	Corporate Tax Noncompliance (Normalize Book-Tax differences with book earing)		
	Benchmark regression results	City pairs across province borders	IV estimation results
	(1)	(2)	(3)
Time FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
City-pair-year FE	No	Yes	No
F-statistic	–	–	63,084
Hansen J Test *P* value	–	–	0.245
Observations	2,005,089	1,504,138	2,004,626
R-squared	0.065	0.065	0.016

Note: In this table, we normalize book-tax differences with book earnings. Column 1 is a retest of the baseline results. Column 2 is the result of controlling for city-pair-year fixed effects. Column 3 shows the estimation results of the instrumental variables. Standard errors in parentheses are clustered at the city level. *, **, *** indicate significance at the 10%,5%, and 1% levels, respectively.

Table A3
Digital financial inclusion index and subindices.

General index	Coverage breadth	Alipay account coverage	Number of Alipay accounts per 10,000 persons
			Ratio of accounts with credit card linkage
			Average number of linked debit and credit cards per Alipay account
		Payment	Frequency of payments per capita
			Amount of payments per capita
			Ratio of high frequency users
		Monetary Fund	Number of Yu 'E Bao per capita
			Amount of Yu 'E Bao per capita
			The number of Yu 'E Bao buyers per 10,000 Alipay users
		Lending	Number of accounts with consumer credits per 10,000 accounts
			Number of loans per capita
			Amount of loans per capita
	Usage depth		Number of accounts with micro enterprise credit per 10,000 accounts
			Number of loans per micro entrepreneurs
			Amount of loans per micro entrepreneurs
		Insurance	Number of accounts with insurance per 10,000 accounts
			Number of insurance schemes participated per capita
			Amount of insurance per capita
		Investment	Number of accounts with investments per 10,000 accounts
			Number of investments per capita
			Amount of investment per capita
		Credit	Number of calls of natural person's credit per capita
			The number of users using credit-based services per 10,000 Alipay users (including finance, accommodation, travel, social, etc.)
	Digital service provision	Mobilization	Ratio of mobile payments in total payments
			Ratio of the amount of mobile payments in total
		Cost	Average interest rate of loans to enterprises
			Average interest rate of consumer credits
		Credit	Ratio of "Ant Check Later" payments in total payments
			Ratio of the amount of "Ant Check Later" payments in total
			Ratio of the number of Ant credit without margin in them with margin
			Ratio of the amount of Ant credit without margin in them with margin
		Convenience	Ratio of QR code payments in total payments
			Ratio of the amount of QR code payments in total

Source: Guo et al. (2020).

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