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Corporate Income Tax Incentives and R&D Investment in Digital Companies: A New Evidence from China

(Insentif Cukai Pendapatan Korporat dan Pelaburan R&D dalam Syarikat Digital: Satu Bukti Baharu dari China)

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ABSTRACT

The objective of this paper is to investigate the impact of corporate income tax incentives (CITI) on digital companies' R&D investment. We employ a dynamic panel regression technique on data of 685 digital companies retrieved from the Wind database and the CSMAR Database over 2012 - 2021. The main findings demonstrated that CITI significantly affected the R&D investment of China's digital enterprises. The data has been divided into three industries, namely computer and electronic equipment manufacturing (CEM), software and information technology services (SIT), and internet and telecommunications broadcasting (ITB). We discovered that the impact of CITI on R&D investment is different, with industry ITB being affected most, followed by industry SIT, and the CEM industry being least affected. For every percentage rise in the actual tax rate, the R&D investment of the three industries is reduced by 0.0435, 0.0237, and 0.0018 percent respectively. This study extends the existing literature on digital economy tax by focusing on the impact of CITI on R&D expenditure in digital enterprises. This paper has reference value for independent innovation and financial optimization of digital enterprises. It is also crucial for the government to change the aspects of tax policy that are incompatible with the growth of the digital economy. According to this study's policy implications, the government of China should raise tax incentives for businesses engaged in the digital economy to encourage them to invest more in R&D. Besides, they should also make corresponding preferential tax policies according to the industry to which digital enterprises belong, to promote the balanced development of various industries.

Keywords: Corporate income tax incentives (CITI); digital companies; R&D investment; China; dynamic panel regression; digital economy

ABSTRAK

Objektif kertas ini adalah untuk mengkaji kesan insentif cukai pendapatan korporat (CITI) ke atas pelaburan R&D syarikat digital. Kajian ini menggunakan hines regresi panel dinamik yang melibatkan data sebanyak 685 buah syarikat digital bagi tempoh 2012-2021 yang diambil daripada pangkalan data Wind dan Pangkalan Data CSMAR. Penemuan utama kajian menunjukkan bahawa CITI memberi kesan yang ketara terhadap keputusan pelaburan R&D perusahaan digital di China. Data kajian juga telah dibahagikan kepada tiga kumpulan hinese, iaitu pembuatan hinese dan peralatan elektronik (CEM), perkhidmatan perisian dan teknologi maklumat (SIT), dan penyiaran internet dan telekomunikasi (ITB). Analisis mengikut kumpulan hinese mendapati kesan CITI terhadap pelaburan R&D mempunyai impak yang berbeza, dengan hinese ITB yang paling terjejas, diikuti oleh hinese SIT, dan hinese CEM yang paling kurang terjejas. Secara lebih spesifik, bagi setiap satu hinese kenaikan dalam kadar cukai sebenar, pelaburan R&D bagi ketiga-tiga hinese tersebut masing-masing telah berkurang sebanyak 0.0435, 0.0237, dan 0.0018 peratus. Kajian ini melanjutkan literatur sedia ada mengenai cukai ekonomi digital dengan memberi tumpuan kepada kesan CITI terhadap perbelanjaan R&D dalam perusahaan digital. Kertas ini menjadi rujukan kepada perusahaan digital dalam usaha melaksanakan kebebasan berinovasi dan pengoptimuman kewangan. Hasil kajian juga penting kepada pihak kerajaan untuk mengubah dasar cukai sedia ada yang tidak mesra kepada pertumbuhan ekonomi digital. Implikasi penting kajian *ini menyarankan supaya kerajaan China seharusnya menaikkan insentif cukai untuk perniagaan ekonomi digital bagi menggalakkan pelaburan baharu dalam aktiviti R&D. Selain itu, pihak kerajaan juga harus mempertimbangkan dasar cukai keutamaan yang sepadan mengikut jenis hinese perusahaan digital tersebut bagi menggalakkan pembangunan yang seimbang merentasi hinese.*

Kata kunci: Insentif cukai pendapatan korporat (CITI); syarikat digital; pelaburan R&D; China; regresi panel dinamik; ekonomi digital
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INTRODUCTION

"Digital economy" refers to a set of economic activities where data resources serve as the primary source of production, modern information networks serve as the primary conduit, and effective information and communication technology use serves as the primary impetus for increasing economic structure efficiency (China National Bureau of Statistics 2021). Three essential components that are directly linked to the digital economy are data resources, contemporary information networks, and information and communication technology. Technological innovation is a key strategic tool for transforming the economic development process and achieving high-quality development in the digital economy. Additionally, spending on research and development is a crucial component of technical innovation for businesses operating in the digital economy (Sen et al. 2020). China's digital economy has grown quickly in recent years, exhibiting vast coverage and unmatched influence. This development has become a significant catalyst for reorganizing the economic system, reallocating factor resources, and boosting core competitiveness. The digital economy in China grew to 45.5 trillion yuan in 2021, according to the "China Digital Economy Development Report (2022)," representing a year-over-year increase of 16.2%, which is 3.4 percentage points greater than the GDP growth rate during the same period. Additionally, it represents 39.8% of the GDP, demonstrating the crucial role the Internet economy plays in China.

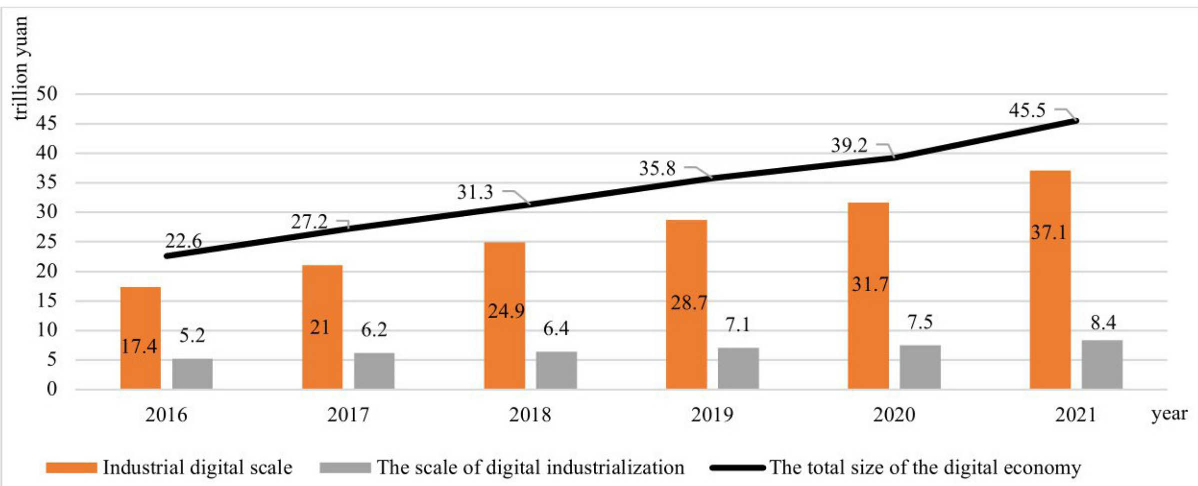

FIGURE 1. China's digital economy's development from 2016 to 2021
Source: Compiled according to the "White Paper on China's Digital Economy (2021)".

A difficult issue that occurs in China's digital economy enterprises is a lack of innovation capabilities and R&D investment, despite the country's outstanding progress in this area (Jianbin & Ruijuan 2022). The top 50 firms in each country's R&D statistics were sorted, and it was discovered that there was still a discrepancy between Chinese companies' R&D spending and that of industrialized nations. The top 50 Chinese firms spent an average of 1207.99 million euros on R&D in 2018, which was barely 30% of American spending (4079.17 million euros) and less than Germany and Japan (1537.41 and 1558.02 million euros, respectively).

One of the governmental strategies for promoting technological innovation and raising investment in R&D is tax incentives. According to the theory of endogenous economic growth, R&D spending is the key component of business innovation and development and has influenced innovation significantly. However, R&D activities have obvious positive externalities, leading to market failure and insufficient R&D investment (Bloom et al. 2019). Additionally, the sharing and public welfare aspects of the digital economy are more apparent when compared to the general economic form, which will significantly dampen the excitement of digital economy firms for research and development (Sen et al. 2020). The government must provide considerable support for the R&D investments made by enterprises in the digital economy because there are market failures. The preferential corporate income tax policy has been widely implemented in numerous nations as one of the key tools for the government to support company innovation since it can effectively lower R&D costs and encourage businesses to expand R&D investment. To encourage business technological innovation and boost capital investment in R&D, China has currently implemented several preferential corporate income tax policies, including tax reductions, pre-tax deductions, and accelerated depreciation. But how successful is the business income tax preference program in promoting R&D? How much of an effect would varying corporate income tax rates have on business R&D spending? How do digital businesses in various sectors react to favorable tax regulations differently? This article will examine these concerns.

Given this background, this paper's primary goal is to examine how CITI affects the R&D investments made by digital companies. This study examines the CITI effect on R&D investment in digital economy enterprises by outlining the core industries that make up the digital economy according to the latest classification of the National Bureau of Statistics and using the sample of China's A-share listed digital companies from 2012 to 2021. Additionally, to examine the heterogeneity of the influence of CITI on the R&D investment of digital economy enterprises in various industries, the digital economy will also be divided into three industries: computer and electronic equipment manufacturing (CEM), software and information technology services (SIT), and Internet and telecommunications broadcasting (ITB). By employing a dynamic panel regression technique on data from 685 digital companies, this study finds that CITI affected the R&D investment of China's digital enterprises significantly and the impact is different in the three industries.

Two significant reasons can be used to explain why this study chose to evaluate how CITI affected the R&D investments made by Chinese digital enterprises. First, this study is beneficial to policymakers and firms in the digital economy industry. Exploring the impact of CITI on the R&D expenditures of digital firms, it has reference value for independent innovation, strategic adjustment, and financial optimization of digital enterprises. Furthermore, it is of great significance for the government to modify the portions of its tax laws that are incompatible with the growth of the digital economy to increase the core competitiveness of Chinese digital companies.

Secondly, by concentrating on the effect of CITI on R&D expenditure in digital economy businesses, this research broadens the corpus of information on taxation in the digital economy that already exists. Most of the previous study on digital economy taxation focuses on tax collection and management issues such as whether to collect digital tax (Xianchun & Meihui 2020), the rules for identifying permanent establishments (Tao et al. 2020), and the challenges to the tax system (Weijun & Changsheng 2020). However, there are few studies on the effect of the digital economy CITI on R&D investment. A recent study on the impact of tax incentives on business innovation by Tian et al. (2020) has mainly focused on the tax super deduction policy without concentrating on all the CITI policies. Additionally, this study also enhances the previous research by choosing digital economy companies for research according to the most recent definition of the digital economy industry. Recent research about the incentives of tax preferential policies on R&D expenditure of digital economy enterprises by Jianbin and Ruijuan (2022) only chooses high-tech enterprises as the research object without considering all the digital economy enterprises. The study discovered that favorable corporate income tax policies considerably increased the R&D expenditure based on data from 436 high-tech companies from 2012 to 2020 by a two-way fixed effects model.

There are five sections in this article. The second section reviews the literature on CITI and R&D investment, while the third section explains the baseline empirical model using dynamic panel data estimate. The full sample empirical findings and sub-industry findings are compiled in section four. The final section concludes and offers some policy implications of the research.

LITERATURE REVIEW

The effect of tax incentives on R&D investment has been examined in several earlier studies. Within the broad area of research, there have been several streams of studies. One stream of research indicated that CITI could motivate the R&D investment of enterprises. As stated by an analysis of the pertinent literature conducted by Bloom et al. (2019), tax incentives lower the actual cost of R&D projects. They also discovered that over the long term, R&D investment increases by at least 10% for every 10% reduction in tax expenditures. Zhengbin et al. (2020) used the breakpoint regression model to investigate the impact of the income tax sharing reform on corporate innovation using the data of Chinese industrial companies. Research shows that the decrease in the tax rate will allow enterprises to have more disposable surplus to increase R&D expenditure. Ivus et al. (2021) conducted an analysis of the enterprise-level data of Indian private firms from 2001 to 2016 using the double difference model DID, and the results showed that the R&D tax credit policy led to a sharp increase in R&D expenditure, indicating that the implementation of preferential tax policies can significantly motivate enterprises to invest more in R&D activities.

However, the association between CITI and company R&D investment has also been shown in other streams to be neutral or even negative. Some research contends that companies might forgo investing in R&D and innovation in favor of opportunistic actions such as geographic migration (Akcigit et al. 2019) and whitewashing R&D expenses (Chen et al. 2021). Yanyan and Kun (2016) found the promotion effect of tax incentives is effective, but the impact on R&D activities is not significant. In the study by Zhouyu et al. (2013), the degree of tax incentives and the intensity of business technological innovation are correlated in an inverted U pattern. Tax incentives can greatly encourage innovation when their intensity is lower than the crucial value, and when it is higher than the critical value, taxes will stifle it.

Only a few studies have been conducted to specifically focus on Chinese digital firms' R&D investment encouraged by cooperative income tax advantages, even though each of these streams provides significant and distinctive additions to the literature on how CITI impacts the R&D investment of enterprises. According to a study by Jianbin and Ruijuan (2022) using data from high-tech firms from 2012 to 2020 and a two-way fixed effect model, China's corporate income tax favorable policies have greatly boosted the R&D expenditure of enterprises. Using the digital economy companies in Shenzhen from 2017 to 2020 as a research sample, Si and Wenlong (2021) discovered that the tax and fee reduction strategy considerably boosted the digital companies' R&D expenditure. However, the study samples used in this literature are not typical and solely consider digital economy businesses in Shenzhen.

Based on the previous discussion, this study fills in several gaps in the literature about the impact of tax incentives on R&D investment. First, it uses dynamic panel data models to do data analysis and uses a straightforward yet sophisticated dynamic modeling estimator. Second, rather than choosing randomly all high-tech businesses for inquiry, this study picks the digital economy industry for focused research based on the most recent defining document of the sector. Thirdly, this study categorizes and compares the effects of CITI on R&D spending in three significant but unstudied industries.

METHODOLOGY

VARIABLES AND DATA DESCRIPTION

As previously stated, the research objective of this paper is to investigate the response of R&D expenditure of digital economy enterprises to CITI. The research sample is China's A-share-listed digital firms from 2012 to 2021. The data come from the Wind database and the CSMAR Database. Due to the insufficient publication of R&D spending data of listed businesses before 2012, the sample in this study is intercepted as data after 2012. The key sectors of the digital economy mainly include computer communications, electronic equipment manufacturing, telecommunications, Internet, software, information technology services, and other industries. Given the significance of the core sector of the digital economy and the accessibility of data, this study eliminates outlier samples like ST businesses and instead chooses 685 Chinese A-share listed companies in the core sector of the digital economy as the specific research objects.

The dependent variable of this study is enterprise R&D investment. Given the availability and completeness of data and drawing on the practice of existing literature (Shiyuan et al. 2020), this study measures enterprise R&D investment by enterprise R&D intensity.

In terms of independent variables: Although there are various forms of preferential corporate income tax policies for R&D expenditure in digital economy enterprises, they are comprehensively reflected in the reduction of the actual tax rate (Guochao et al. 2017). Therefore, this study uses the actual corporate income tax rate to measure CITI. A company's actual corporate income tax rate decreases as more tax benefits are received by the company itself. To reduce the estimation bias caused by omitted variables, this study controls several characteristic variables that influence firms' R&D investment, including enterprise size, asset-liability ratio, ratio of current assets to total assets, return on assets, and enterprise growth.

TABLE 1. The variables of the regression

Variable Category	Variable Name	Variable Interpretation
Dependent Variable	R&D investment	The amount of enterprise R&D investment is calculated as the ratio of R&D expenditures to operating income.
Independent Variable	Actual corporate income tax rate	The tax incentives that companies receive are measured using their actual income tax rates. A company's actual tax rate decreases as more tax incentives are granted to it. Actual corporate income tax rate = income tax expense payable ÷ (total pre-tax profit – deferred tax expense ÷ legal tax rate).
Control Variables	Size of Enterprise (Size)	Logarithm of Assets=IN Total Assets
	Asset-liability ratio (ALR)	Asset-liability ratio = Total Liabilities/Total Assets
	Current Assets Ratio (CAR)	Current Assets Ratio=Current Assets/Total Assets
	Return on assets (Return)	Return on assets = Net profit / Total Assets
	Business growth (Growth)	Business growth is measured by the growth rate of operating revenue.

ESTIMATION STRATEGIES

The estimation was performed using a panel data analysis, and the data format consists of non-balanced data for 685 enterprises (N) across 10 years from 2012 to 2021 (T). This study will assess the effect of corporate income tax on R&D investment using dynamic panel data regression models. The lagged R&D among the regressors is a feature of the dynamic panel models, so it is more equipped to capture the dynamics of the data compared to static panel models.

DYNAMIC PANEL GMM ESTIMATION

After the lagged R&D is incorporated into the model, the static panel estimate is no longer effective. As a result, the GMM approach has been used to provide more reliable parameters due to different endogeneity problems. The following factors were accepted as the dynamic model's R&D investment determinants:

$$RD_{it} = \beta_0 + \alpha RD_{i,t-1} + \beta_1 TAX_{it} + \beta_2 SIZE_{it} + \beta_3 ALR_{it} + \beta_4 CAR_{it} + \beta_5 RETURN_{it} + \beta_6 GROWTH_{it} + \lambda_i + \varepsilon_{it} \quad (1)$$

Among them: I and t are the individual and year of the enterprise respectively; RD represents the enterprise R&D investment; TAX represents the actual corporate income tax rate; λ_i is the firm-specific effect (that captures the individual heterogeneity) and ε_{it} is the disturbance.

Two sources of persistence across time define the dynamic panel data regression in equation (1). First is autocorrelation due to the presence of a lagged $RD_{i,t-1}$ which relies on the firm's specific effect (λ_i). Due to this association, the estimation of this dynamic panel in equation (1) exhibits Nickell bias. When T grows too big or gets close to infinity, it will eventually vanish. The second is individual effects characterizing the heterogeneity among the firms (unobserved firm-specific effects). As a result, the OLS, fixed effect, and random effect estimators used in static panel model estimation are all biased and inconsistent, which is the so-called dynamic panel estimation bias problem. The dynamic panel technique has been used extensively in the previous study using firm-level data analysis, in particular modeling the determinants of a firm's investment spending (for example, Karim & Azman-Saini 2013 and Karim 2012) and the determinants of firm-level equity return (for example, Karim et al. 2011, 2013, 2022, and Karim & Zaidi 2015).

One solution to this problem involves taking the first differences of the original model. However, first differencing can produce a correlation between the transformed lagged term and the transformed error term even though it removes time-invariant unobserved heterogeneity. Blundell and Bond (1998) suggest the system GMM estimator in response. It utilizes lagged first differences as the instruments and combines the first differencing method with a levels regression. Because it uses a more effective set of instruments to address the weak instruments issue, the system estimator is more effective than its various competitors. Overall, the system GMM reduces the estimation error by introducing level equations based on the differential GMM. Also, the system GMM is divided into one-step GMM and two-step GMM. There is a disagreement between scholars relating to the effectiveness of one-step and two-step system GMM (Shokr 2023). The two-step GMM further adds the residuals of the one-step GMM results to the new estimation based on the one-step GMM to build a consistent variance-covariance matrix, which further relaxes the assumption that the residuals need to be independent and hineseastic in the one-step GMM.

Following the system GMM estimation of the data, Blundell and Bond (1998) have suggested two specification tests to validate the system GMM's estimation results. First is the Sargan or Hansen test, which is used to examine over-identifying limitations in the statistical model. It looks at the validity of the instruments as a whole and determines if the instrument variable and error term are connected. The model is impartial and the instrument variables are exogenous if the instruments are valid. The second test is the serial correlation test in the disturbances (Arellano & Bond 1991). For the first-order difference of the perturbation term, where the p-value of AR(1) is less than 0.1, autocorrelation is typically permitted. However, for the second-order difference of the perturbation term, where the p-value of AR(2) should be more than 0.1, autocorrelation is not permitted.

RESULTS AND DISCUSSION

This section begins with a full-sample data analysis of 685 digital firms, on the basis of which a sub-sample of digital firms in three different industries is analyzed, and a comparison is also made between the full sample and the sub-sample. Finally, a robustness test is conducted to ensure the stability and reliability of the conclusions.

FULL SAMPLE ANALYSIS

The estimation findings for the impact of CITI on R&D investment are summarized in Table 2 utilizing dynamic panel system GMM estimation. The lagged R&D is significant as displayed in the column. The p-values produced by executing a first-order and second-order serial correlation test on the residual are represented by the AR(1) p-value and AR(2) p-value respectively. There is no serial correlation in the residuals, as shown by AR(1) is less than 0.1 and AR(2) is greater than 0.1. The Hansen test is used to determine whether the instrumental variable has an issue with over-identification. A P value larger than 0.1 denotes acceptance of the null hypothesis, that is, the instrumental variable is valid and there is no over-identification problem. At the 1% level of significance, the Wald test disproves the hypothesis that all of the model coefficients are zero, indicating that the system GMM is generally significant. Therefore, system GMM is adequate for interpreting the findings.

TABLE 2. The impact of CITI on digital companies' R&D investment based on full sample by system GMM

Variables	System GMM estimation	
	(one-step)	(two-step)
Lag of R&D	0.6998***	0.7502***
	(0.0359)	(0.0923)
TAX	-0.0045*	-0.0063*
	(0.0025)	(0.0149)
SIZE	0.0086*	0.0136*
	(0.0052)	(0.0129)
ALR	-0.0224	-0.0721
	(0.0402)	(0.0921)
CAR	-0.0268	0.0341
	(0.0462)	(0.1238)
Return	-0.0422**	-0.0611
	(0.1922)	(0.078)
Growth	-0.0040***	-0.0045*
	(0.0004)	(0.0017)
AR(1)	0,000	0.000
AR(2)	0.9030	0.9330
Number of observations	4938	4938
Number of groups	871	871
Number of instruments	39	39
Wald Test	53952.45***	9249.23***
Hansen test	-	0.578

*** p<0.01, ** p<0.05, * p<0.1

Notes: The variables are denoted as follows: SIZE – Size of Enterprise, ALR – Asset-liability ratio, CAR – Current Assets Ratio, RETURN –Return on assets, GROWTH – Business growth.

The lag of R&D is significant in both one-step and two-step system GMM at the 1% level of significance although the coefficients are slightly different. This demonstrates the validity of including the lagged terms of R&D in the model. An increase of one percentage point (1%) in firm-level R&D investment from the prior year resulted in a rise of 0.75% in current firm R&D expenditures in two-step system GMM estimation. Besides, a regression coefficient of higher than 0.69 in the two estimations demonstrates that enterprise R&D spending is significantly more inactive than other factors' influences, which is consistent with reality. Generally speaking, businesses that invest more in R&D are more likely to reap the rewards of their investments in research and innovation, which in turn encourages businesses to continue investing in R&D.

The actual corporate income tax rate coefficient is significant and hurts R&D investment. In two-step system GMM estimation, a unit increase in the actual tax rate in digital companies decreased R&D investment by 0.0063%, this negative affecting result is consistent with the one-step system GMM. Past studies have also found similar results, which indicated that tax incentive has s significant impact on R&D expenditure (Si & Wenlongti 2021). This indicates that R&D investment in enterprises involved in the digital economy has been significantly boosted by China's present corporate income tax-preferred policies, which primarily comprise low tax rates and a super deduction for R&D costs. As can be observed, the CITI reduces the expenses associated with R&D, which in turn effectively corrects the market failure of R&D investment in businesses engaged in the digital economy to some extent.

The size of the digital company, which is calculated by the company's total assets, also significantly influences R&D investment in system GMM. In two-step estimation, a 1% increase in the size of the company leads to a rise in R&D investment spending by 0.0136%, while it increased by 0.0086% at the 10% significance level using the one-step system GMM. This is mainly because the larger the firm, the more funds are available for R&D

spending. The result is consistent with Zuoyi and Wenbin (2020), who found that for every 1 percentage point rise in firm size, corporate R&D expenditures increased by 0.42 percentage points through principal component analysis.

Regarding the return on assets and business growth, these two variables showed a negative association with R&D spending, which is not as we expected. This is mostly because while formulating plans and deciding where to invest in R&D, businesses must take into account the impact of several factors, including the market, the macro-economy, and even national legislation. Businesses have recently become more cautious about increasing R&D investment because of the epidemic's effects. Even if their revenues increase, companies might cut back on this expenditure and continue to be innovative by adopting new technology, contracting out R&D, or employing other less expensive techniques. Guangchun (2022) discovered that the COVID-19 pandemic had a detrimental impact on research and development (R&D) investment. Additionally, Xiaowu (2020) found corporate profitability and firms' R&D investment intensity exhibit an inverse connection.

SAMPLE SPLITTING ACCORDING TO INDUSTRIES

The aforementioned regression primarily examines the overall impact of the CITI on the R&D expenditures of businesses engaged in the digital economy. Additionally, as mentioned above, the core industries of the digital economy include three major categories of industries in the classification of national economic industries: computer and electronic equipment manufacturing (CEM), software and information technology services (SIT), and Internet and telecommunications broadcasting (ITB). Enterprises in different industries enjoy different preferential tax policies, which may lead to different suppression of actual corporate income tax rates on R&D investment. To verify the heterogeneity effect, this paper further carried out regression analysis by industry. Table 3 provides an overview of the key empirical findings. The dynamic panel data were utilized for the study since the lagged RD in the system GMM is significant in each of the three industries.

TABLE 3. CITI's effects on digital enterprises' R&D investment based on sample splitting by industry using two-step system GMM

Industry	CEM	SIT	ITB
Lag of R&D	0.6201***	0.5494***	0.8306***
	(0.0876)	(0.0840)	(0.0996)
TAX	-0.0018*	-0.0237*	-0.0435*
	(0.0067)	(0.0138)	(0.0256)
SIZE	0.0035	0.0256***	0.0064
	(0.0049)	(0.0092)	(0.0075)
ALR	-0.0445**	-0.4153	-0.0356
	(0.0205)	(0.0622)	(0.0126)
CAR	-0.1522**	0.0073	0.0081
	(0.0693)	(0.0714)	(0.0183)
Return	-0.0118	-0.1040*	-0.0381**
	(0.0429)	(0.0558)	(0.0148)
Growth	-0.0205	-0.0998***	-0.0094***
	(0.0027)	(0.0238)	(0.0022)
AR(1)	0.0480	0.0050	0.0000
AR(2)	0.5660	0.5560	0.4580
Observations	2520	1563	445
Number of groups	456	278	85
Number of instruments	39	56	41
Wald Test	2249.08***	1324.05***	903.93***
Hansen test	0.5780	0.2580	0.8110

*** p<0.01, ** p<0.05, * p<0.1

The results of the regression by industry are consistent with the results of the overall regression, and they demonstrate that the company's R&D expenditure in the prior period has a considerable impact on the high R&D expenditure in the current period. The R&D expenditure of businesses will climb by 0.7502 percentage points for every percentage point increase in R&D spending during the prior period. The Internet sector will see an increase of 0.8306 percentage points, while the software sector will see an increase of 0.5494 percentage points.

The results also revealed that the actual tax rate caused by preferential corporate income tax policies in different industries has a great influence on corporate R&D expenditures at the 10% level of significance. Among them, CITI has the greatest impact on corporate R&D intensity on the Internet and telecommunications broadcasting industry, followed by software and information technology services, the computer and other electronic equipment manufacturing industries are least affected by the increase in the actual tax rate. For every percentage rise in the actual tax rate, the R&D expenditures of the three industries are reduced by 0.0435, 0.0237, and 0.0018 respectively. As for the reasons, compared with the computer and electronic equipment manufacturing industry, the Internet and telecommunications broadcasting industry is a "high-tech" industry, and products and technologies are updated quickly. By assuming certain R&D risks, enterprises may obtain huge profits brought by new technologies and products. Therefore, affected by external competitive pressures and internal profit-seeking motives, enterprises in this industry may be more willing to spend more of the savings brought about by CITI on R&D activities, resulting in higher R&D investment intensity. The impact of CITI on the R&D expenditures of high-tech businesses was also examined by Jianbin and Ruijuan (2022) using a two-way fixed effects model. He discovered that the impact on R&D intensity is greatest for businesses in the software and information technology services industry, followed by businesses in the computer communications and other electronic equipment manufacturing industry, while the impact on R&D intensity is least for businesses in the manufacturing of medical devices.

The size is significant in the SIT industry while it is not significant in the computer and Internet industries. Shiyuan et al. (2020) also found firm size is significant for R&D investment for firms in the software industry. The ALR (Asset-liability ratio) showed a negative effect on R&D investment in CEM at the 1% level of significance. The effects of the asset-liability ratio have been demonstrated in earlier studies with comparable outcomes. According to Hong and Yuanyue (2020), an enterprise's high debt ratio will prevent it from investing in R&D, and the higher the gearing ratio, the riskier the enterprise is and the less money it has available, which prevents it from acting independently in terms of innovation. The return and growth showed a negative impact on R&D investment in the software and Internet industry, which doesn't show the expected results. This is primarily because rising enterprise revenue and profit do not necessarily translate into rising R&D expenditure. Enterprises will evaluate the long-term development of the firm, the external policy environment, and other issues when contemplating R&D investment because R&D investment has the characteristics of big investment amount, lag in return period, and negative externality. According to Xiaowu's (2020) research, corporate profitability and firms' R&D investment intensity exhibit an inverse connection, and profits are not the primary driver of businesses' R&D spending.

FULL SAMPLE AND SPLITTING SAMPLE COMPARISON

This study's findings indicate that tax incentive has proven to be significant for all three industries. Additionally, Technology-intensive businesses, such as those on the Internet and software, are more receptive to tax incentives, according to the regression results. To encourage these businesses to raise their R&D spending, the Chinese government should increase tax benefits for such industries. There is industrial heterogeneity in the enterprise size effect on R&D investment, as seen by the fact that while the size of the enterprise is significant for the entire sample, it is only significant for the software industry in the sub-industry. Compared to the other two industries, the software industry's asset size has a bigger effect on R&D spending. There are differences in the impact of the asset-liability ratio and the current asset ratio on R&D expenditures across industries, as evidenced by the fact that the asset-liability ratio and current asset ratio are not significant for the entire sample but are only significant for the computer industry. The one-step system GMM shows return on assets and company growth to be significant variables, however, the computer industry does not consider these two factors to be significant.

ROBUSTNESS CHECKS

Equation (1) was re-estimated by the difference GMM model and the model without forward orthogonal deviation to perform robustness testing. In general, the main conclusion of the study remains constant with the system GMM. For example, if the actual tax rate increases by 1%, the enterprise R&D expenditure will decrease by 0.0115 in the difference one-step GMM, and in the difference two-step GMM, the enterprise R&D expenditure will decrease by 0.0109.

TABLE 4. The impact of CITI on digital companies' R&D investment using difference GMM and GMM model without forward orthogonal deviation

Variables	Difference GMM estimation (one-step)	Difference GMM estimation (two-step)	Model without forward orthogonal deviation
Lag of R&D	0.5863***	0.4908***	0.7280***
	(0.0652)	(0.1277)	(0.0665)
TAX	-0.0115**	-0.0109*	-0.0061*
	(0.0058)	(0.0062)	(0.0035)
SIZE	-0.0057	-0.0051	0.0125
	(0.0039)	(0.0108)	(0.0077)
ALR	0.0240	0.0416	-0.0696
	(0.0335)	(0.0608)	(0.0740)
CAR	-0.0175**	-0.0271	0.0158
	(0.0079)	(0.0789)	(0.0731)
Return	-0.0418***	-0.0325	-0.0622*
	(0.012)	(0.019)	(0.0357)
Growth	-0.0002	-0.0044**	-0.0047**
	(0.0018)	(0.002)	(0.0021)
AR(1)	0.0000	0.0010	0.0000
AR(2)	0.9660	0.7040	0.9430
Number of observations	4045	3280	4938
Number of groups	753	671	871
Number of instruments	40	54	39
Wald Test	-	-	9233.53***
Hansen test	-	0.7050	0.6500

CONCLUSION

The digital economy is a set of brand-new economic activities that significantly demonstrate the nation's overall strength in the digital era. The favorable corporate income tax laws that encourage the R&D investment of digital economy businesses must be significantly improved if China's digital industry is to constantly increase its competitiveness and impact.

The government should enforce a greater degree of regulation regarding research and development spending deductions. The results of the study show how the advantageous corporate income tax policy has a significant incentive effect on the R&D spending of firms involved in the digital economy. Enterprises in the digital economy invest more in R&D the more tax incentives there are. R&D investment is the core link in the innovation and development of digital economy enterprises. For enterprises operating in the digital economy, a more aggressive R&D expense deduction policy can be enacted to further reduce their R&D expenses and maximize the innovation-inducing effects of favorable corporate income tax regulations. This will encourage these businesses to increase their R&D investment. For example, the super deduction ratio of R&D expenditure for digital economy companies can be increased from the current 100% to 150% or 200%, to further encourage digital firms to increase R&D investment.

The research's findings show that the industry a company belongs to has an impact on the degree to which the current preferential tax laws have an impact on their R&D operations. Therefore, the development of the industry to which the business belongs should adopt particular tax preference regulations to encourage the balanced growth of varied sectors.

The scope of favorable corporate income tax rates must likewise be increased. The findings of this study's empirical research demonstrate that preferential corporate income tax policies with low tax rates as its primary component have greatly boosted the R&D investment of businesses engaged in the digital economy. This demonstrates how the present preferential corporate income tax rate has successfully encouraged digital economy businesses to invest in R&D. By extending the low corporate income tax rate (15%) for high technology enterprise-qualified digital economy businesses to all companies that are included in the important sectors of the digital economy, the government can increase incentives for businesses operating in the digital economy to invest in R&D and strengthen their capacity for technological innovation.

Additionally, businesses in the digital economy need to fully understand the value of R&D to their long-term expansion. Digital enterprises should continue to increase the size of their assets and maintain an appropriate level of debt in addition to taking advantage of pertinent national tax policies that encourage R&D expenditures. These actions can, to some extent, effectively enhance the technological innovation activities of digital enterprises.

Further research is suggested to investigate the effects of various tax incentives, including greater deductions for R&D expenses, preferential tax rates, and faster depreciation of fixed assets, on digital firms' R&D investment.

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