Insights into the Impact of R&D Investment on Capital Structure Decisions of Chinese High-Tech Firms

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ABSTRACT

By introducing the country-level tax reduction for R&D firms in China as an exogenous event to establish causality, we examine how R&D investments associate with changes in capital structure. We find that, in contrast to the popular belief that firms with higher R&D investments have lower debt ratio via higher agency costs, firms who are approved for the tax credit increase R&D investments and increase debt ratio following the event. However, among those firms that have been approved, the changes in R&D and debt ratio appear to be a one-time effect and thus the policy turns out to fail to create continue impetus for firms to keep investing in innovations.

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By far a number of theories have been proposed to explain the variation in debt ratios across different firms. The commonly underlying assumption is that certain attributes of a firm determine the various costs and benefits associated with debt and equity financing, which thus results in different capital structures (e.g. Myers and Majluf, 1984; Rajan and Zingales, 1995). Among all, R&D investments are most often empirically proved to be one of the most influential determinants of a firm's financing decision (Titman and Wessels, 1988) as indicated by its five natures——long-term, high risk in terms of the probability of failure, unpredictable in outcome, labor intensive and idiosyncratic——that to a large extent affect the cost of financing (Holmstrom,1989). Naturally, for firms that have high R&D intensity, it's recommended to resort to internal funds first, which is the most cost-efficient way and can avoid adverse selection according to the pecking order theory. Nevertheless, a large number of high-tech firms are started to be small and young with inadequate internal funds, which necessitates external financing through either debt or equity(Müller and Zimmermann, 2008; Czarnitzki and Hottenrott, 2011). Regarding external financing, existing literature mainly suggests a negative relationship between R&D investments and debt ratio because of the nature of R&D investments——information asymmetry——that increases cost of debt financing (Bah and Dumontier, 2001; Parthiban et al., 2008). However, extending research of Boot (2000), David et al. (2008) find that there are actually two types of debt with different implications for R&D investment: relational debt (loan between firm and financial institution such as banks) and transactional debt (public securities such as issuing bonds), with the former one more preferred by high R&D intensity firms. Though theoretic grounding is well recognized, empirical research on this subject is limited especially against Chinese market. Therefore, we employ a total number of 2801 Chinese public firms mainly from technology-based industries and use difference-in-difference (DID) approach to examine the relation.

The key research design of this paper is a panel regression model using DID approach including the treatment and control groups that are defined as being qualified and not qualified for a country-level R&D tax credits. The policy is introduced as an exogenous event to establish the causality, which satisfies the relevance and exclusiveness conditions. First, country-level R&D tax credits can lower the R&D user's costs and increase the incentives for R&D activities. Second, country-level R&D tax credits are unlikely to correlate with factors other than R&D investment that can affect corporate capital structure. Both are corroborated by extensive research on the background and the effect of the policy that will be discussed in the second section of the paper. The regressions control for firm and year fixed effects, and firm characteristics known to affect capital structure decision according to existing literature.

Since we use the DID approach to probe into the causal effect of R&D on capital structure by introducing an exogenous shock, two major assumptions underlying the methodology need to be checked as in Sefling (2016) including whether the shock is anticipated by investors, and without the shock, whether the average change in debt ratios would have been the same for both treatment and control firms. Overall, the model assumption is satisfied. First and foremost, we find that R&D investments do not change until the announcement of the policy and thus it serves as a rough proof of the fact that the policy was not expected by the public. Secondly, due to the fact that the law was supposed to cover all the provinces in China, the process took several (0-7) years so that many firms are both in the treatment group and control group at different times, which alleviate some differences between treatment and control firms and thus help satisfy the second assumption. Furthermore, to test whether there exists an endogeneity problem associated with the reverse causality——a firm's capital structure could possibly determine the level of R&D expenses——we create categorical variables indicating the timing of the policy as in Sefling (2016) and run a regression. The results show there is no reverse causality as debt ratio does not change until being qualified for the tax benefit.

Though our paper is not the first to document the relationship between R&D and capital structure, our study is distinct as we try to solve the lingering problem of endogeneity posed by previous scholars by introducing an exogenous shock. Also, the sample examined here is from a single country that has much less research on so far. Thus, our study, though contains weaknesses, helps complement the others.

The remainder of the paper is organized as follows. Section I addresses the theoretical underpinnings of the causal relation between R&D investments and capital structure. Section II introduces the background, identification and the endogeneity problem of the policy. Section III describes the data and empirical methodology. Section IV discusses the empirical results. Section V concludes.

I. Theoretical Link between R&D Investments and Capital Structure Decisions.

So far, there is no universal agreement on the quantitative relationship between R&D investments and a firm's financial leverage—whether it is positive or negative though most of empirical studies point to the latter one. The theoretical underpinning of the negative relationship mainly works through information asymmetry. Compared to other projects, R&D investment are long-term and unpredictable, so it's harder to oversee and are often masked by managers to outsiders as "highly confidential activities" given the fierce competition in high-tech fields. All of those constitute a heightened risk for the firm's creditors as it "increases the risk of their investments, without giving them any additional advantages" (Ridha and Bajka, 2010). As a firm starts to invest more in such risky R&D projects, bondholders will either be disinclined to continue to finance the firm or request a premium to cover the additional risk(Bah and Dumontier, 2001**bah** Parthiban et al., 2008). Therefore, equity is preferred over debt when firms start to increase their R&D investments and look for external financing.

Other than the traditional explanation, Sheridan Titman proposed a more interesting one in 1984 as a firm is not only involved in one kind of agency costs (bond-holders) associated with R&D investments. Other agents including customers, suppliers, and workers could also affect its financing decision due to an increase in R&D investments. The theory behind is that the higher R&D investments, the more likely a firm will produce unique or specialized products. However, these unique products cause agents to bear relatively high costs when it liquidates since the termination of certain products/services make it hard for customers to find substitutions. This leads to unique products indirectly increasing the firm's bankruptcy costs. This issue along with high maintenance fees also make it hard for suppliers to deal with equipment and resources specifically designed for the product. This ultimately leads to consequences as workers will face difficulty in finding jobs that match their specialized skill set. The high costs that the firm imposes on its agents will finally be transferred to the firm itself because of its agents' expectations. If any of them anticipates that the firm will go bankruptcy, he/she will avoid purchasing its goods or services, providing sources, or working for it. And the expectation will, in turn, lower the price of the product, thus making its liquidation value lower than predicted. At this moment, the firm will choose to reduce the leverage to decrease interests payment and thus lower the risk of default to ensure the agents that it won't go into distress. In line with this analysis, a higher R&D investment ratio could lead to a higher risk of bankruptcy. In particular, in face of economic downturns, those firms are more susceptible to adverse shock and, if encountered technological advancement of competitors, may become obsolete overnight, leading to a higher probability of default, which prompts firms to adjust their financial leverage to a lower level as showed by Hou and Li (2010) and Yu (2017). In conclusion, the more firms invest on R&D, the higher indirect costs it imposes on its agents, and the more likely it goes into bankruptcy. Therefore, holding all else fixed, firms with high R&D ratio tend to lower their financial leverages.

Nonetheless, there are theories (Zantout,1997) that demonstrate the possibility of favoring debt over equity when making financing decisions. Moreover, there are empirical studies (Davidson and Brooks,2004) confirm this positive relationship. According to Boot (2000), there are two types of debt with different implications for R&D investment: relational debt (loan between firm and financial institution such as banks) and transactional debt (public securities such as issuing bonds), with the former one more preferred by high R&D intensity firms as people find that R&D intensive firms that are backed more by relational debt outperform those that by transactional debt. Why is that? It can be explained by the flexibility of banks (relational debt) that "enables the firm to restructure debt easily if it experiences difficulties, which decreases the costs of financial distress associated with leverage" (Kang and Stulz, 2000). Apart from the cooperative relationship between creditors and firms, compared to the public involved in the transactional debt, banks are more agile at collecting information on client firms through more administratively complicated monitoring to alleviate the information asymmetry that leads to the additional cost of borrowing. Recall that debt itself is "an effective disciplining device in the hands of shareholders which can be used strategically to curb managerial actions that run counter to the objective of shareholder-value maximization, and control insiders as a mechanism for expropriation of minority shareholders and other outside stakeholders" (Ridha and Bajka, 2010), as long as the information asymmetry is mitigated, relational debt is preferred over equity.

Besides, in response to the claim that bondholders will bear additional risk due to an increase in

R&D investment, Zantout (1997) finds no evidence that announcements of higher R&D investments are associated with bondholders' losses. That is, more R&D activities do not necessarily hurt bondholders' interest and thus will not always increase the cost of borrowing. Especially given the governance role played by debt, debt-financing may be a valuable choice.

II. The Policy of High and New Tech Enterprises

A. Policy Background

At the beginning of 1984, National Technology and Science Committee in China issued a report to the State Council, proposing to establish high-tech industrial zones and build incubators to boost technology development in China. In 1991, 26 High Technology Industry Development Zones were premierely established and several policies were announced to encourage the development of electronic information technology, spatial technology and aeronautical technology. In the following 30 years, as technology and economy developed, the government has changed the definition of high-tech enterprises four times to meet different demands in different phases. The version issued in 2008 is the most well-known one since it was developed in an unusual time to meet urgent needs.

Suffering from the financial depression in 2008 and greatly influenced by globalization, China realized that it must rely on technology innovation to boost economic growth in the new era. In retrospect, although high-tech companies in China had reached impressive accomplishments, which promoted the development of burgeoning industries and flourished economy, the overall technology innovation situation was not so rosy. According to National Bureau of Statistics of China, as of December 2008, only 25% of enterprises above the designated size conducted R&D activities and the average R&D expenses was merely 0.6% of the total expenses. Even for enterprises with medium or large size, their R&D investment was only 0.76% of their total expenditures and only 0.03% of them owned innovation patents. These statistics reveal that companies in China did not invest sufficiently in research and development and they were lack of innovating abilities.

As the international competition becomes more severe, innovation capability has become the core for the development and competence of one country. In international competition, relying on advanced technology, developed countries have occupied the market for a long time. Facing intense competition and limited by their own innovation capability, Chinese high-tech companies were in the predicament of development. Under this circumstance, in the 17th National Congress of Communists, Chinese government proposed a clear mission for Chinese high-tech companies that was to win the initiative in international competitions. To be more specific, these companies were encouraged to increase R&D investment to develop advanced technologies. Instead of focusing on improving productivity, the government requested high-tech companies to stress on innovation and creation.

To motivate companies to shift from labor-oriented firms to technology-driven corporations, the government set forth a program to evaluate companies' technological characteristics and to reward companies who complete this transformation. This program, named "the Administrative Measures for the Determination of High and New Tech Enterprises", designed by Ministry of Finance and State Administration of Taxation, was issued at April 4th, 2008. According to this document, if a company is identified as a "High and New Tech Enterprise", the company can enjoy 40% tax reduction, namely, only paying 15% corporate tax rate. Nevertheless, to obtain this tax benefits, companies were required to satisfy 6 strict conditions. For instance, if the sales revenue of the enterprise during the latest year is less than 50 million yuan, the total R&D expenses shall be at least 6% of the total sales and its revenue from High and New Tech products should be at least 60% of its total revenue in the current accounting year. Moreover, the government only clustered 8 industries to be in the field of High and New Tech field, namely Electronic Information Technology Industry, Biological Medicine Industry, Aviation and Aerospace Industry, Energy Industry, New Material Industry, Environment Industry, High-tech Service Industry and High-tech Rebuilt Traditional Industry.

B. Assessment of the Policy

To assess the efficiency of this policy, researches were conducted from three perspectives, including the nationwide technology improvement, the average R&D ratio in firm level and the influence on firms' performance.

Based on a research conducted by National Technology Committee, after the adoption of this policy, the number of patent application increased three times in five years. In addition, over 2,000 corporations, academies and universities were united to establish 95 Strategy Alliances of Technology Innovation. Nevertheless, according to the research did by Long Tan et. al, taking firms headquartered in Beijing for example, only 30% of companies apt to apply for more patents while the rest of them still never applied after the adoption of the new policy.

In terms of the influence of this policy on corporate R&D ratio, after analysing the R&D ratio of incumbent "High and New Tech Enterprises" and the R&D requirement according to the policy, Guohong Yuan concluded that as long as the corporations were recognized as "High and New Tech Enterprises", they would not increase their R&D ratio anymore. In other words, the effect of this policy might be short-time or even one-time.

Apart from the achievement in technology development, many researches are also interested in the impact of this policy on operating performance. Scholars view are divergent. For instance, taking the sample of public "High and New Tech Enterprises" in China during 2007-2009, Xu Chen proposed that increasing R&D ratio could raise firms' market value significantly. However, Jiangli Yuan took 189 public firms which had R&D expenses in 2008 as a sample to prove that there is no clear relationship between R&D expenses and stock price.

C. Endogeneity and Predictability of the Adoption of the Policy

As the major assumption of the methodology is that without the adoption of the law, the financial leverage of firms listed in China in treatment group and control group would evolve in the same way. To test the validity of the parallel trend assumption, we first check whether the policy was created with no intention of changing the capital structure of firms. That is, the effect of the adoption of the law is an unintended consequence. After analyzing the published announcement about the law and interpretation of the policy by critics, we find that the reasons for launching such a policy do not appear to be related with an attempt to affect firm's capital structure:

1. The policy was designed to boost technology innovation in China so that Chinese companies could compete with international companies from developed countries;
2. In order to be recognized as "High and New Tech Enterprises" as the policy stated, companies do not have to adjust their leverage ratio. Instead, they are required to have certain R&D ratio;
3. According to the policy, the benefits for "High and New Tech Enterprises" is a 40% corporate tax reduction, which does not directly influence debt ratio.

III. Data and Empirical Methodology

A. Sample Selection

The main sample includes 30,800 firm-years for 2801 firms in the High and New Tech Fields under key support of Chinese government that have publicly traded stock over the 2005 to 2015 period, are incorporated in China, and have no missing data for the main variables of interest. The sample starts three years before the issue of "2008 Administrative Measures for Determination of High and New Tech Enterprises" and ends before the announcement of the renewed version. All figures are inflation-adjusted in 2016 RMB. All data is collected from Wind database and Shanghai Stock Exchange.

B. Empirical Methodology

We adopt a DID research design to examine the relationship between the recognition of "High and New Tech Enterprises" and the leverage ratio at the firm-year level. In particular, we estimated the following panel regression model:

$$\ln(Debt_{it}) = \alpha_1 \ln(R\&D_{it}) + \alpha_2 Size_{it} + \alpha_3 ROC_{it} + \alpha_4 \ln(Market\,to\,Book\,Ratio_{it}) + \alpha_5 \ln(Fixed\,Asset\,Ratio_{it}) + \alpha_6 Recognition_t + \omega_t + \nu_i + \xi_{it} \quad (1)$$

where $Debt_{it}$ is a specific measure of financial leverage at firm i in year t, and $R\&D_{it}$, $Size_{it}$, ROC_{it}, $Market\,to\,Book\,Ratio_{it}$, $Fixed\,Asset\,Ratio_{it}$ are indicator variables for the research and development expenditure over sales, total assets growth rate, return on capital, firm market to book ratio, and fixed assets over total assets for firm i in year t respectively. Moreover, the regression model also includes fixed year effects ω_t and firm fixed effects ν_i.

IV. Empirical Results

A. *Recognition of "High and New Enterprises" and Financial Leverage*

In this research, both commonly-used measures of financial leverage ratios (book debt ratio and market debt ratio) are applied. Since market debt value is hard to estimate, it is prevalent to use book debt as a proxy in calculating the market debt ratio. In order to prevent encompassing impacts of short term liabilities, we calculate the book debt value by subtracting total current liabilities from total liabilities. To be consistent, we also omit the influence from current liabilities when calculating total assets. In terms of the equity value, we consider both book shareholders' equity and market cap. We use book value as the primary measure because book leverage ratio is apt to be the focus for managers to make capital structure decisions (Graham and Harvey, 2002) Moreover, market values are not very stable in emerging markets such as China. Nonetheless, considering the rigorousity of our research, the results relating to market debt ratio are also presented. All the following results are used either measure of leverage ratio as the dependent variable.

Figure 2(a) and figure 2(b) present a graphical analysis of the relation between the recognition of the “High and New Enterprises” on leverage ratio. To create these figures, we followed Serfling’s model (2016) and regressed book leverage ratio (or market leverage ratio) against dummy variables indicating the year relative to the recognition, dummy variables representing the accounting year of data to control for year fixed effects, and continuous variables including R&D expense over sales (R&D ratio), and variables to control firm characteristics that may affect capital structure including log assets(a control of firm size), the firm market-to-book ratio(a proxy for growth opportunities) , ROC (a proxy for the availability for internal funds), the proportion of assets that are fixed(a proxy for potential collateral), an indicator variable for whether the firm paid a common dividend(a proxy for financial constraints). In terms of the dummy variables indicating the year relative to the recognition, we choose 3 years before and after its recognition. The y-axis of the following graphs plot the estimated coefficients on each indicator variable (See Figure 2(a) and 2(b)). The x-axis shows the time relative to the recognition of the “High and New Technology Enterprises”. The following graphs show that there is a difference before and after the recognition. However, according to the result from t value, the difference is not significant at 95% confidence level.

B. Empirical Results and Discussion

As in the sample both the response variable (book/market debt ratio) and numerical predicting variables are long right-tailed and they are money data, we take natural logs of them in the following analysis. Now let’s look at the side-by-side boxplot of logged book debt ratio versus the categorical variable (adopted or not) and scatter plots of the logged book debt ratio versus logged R&D over sales to see whether there is something going on as expected: Figure 3(a) and 3(b) are here.

As depicted in Figure 3(a), there is little difference of the book debt ratio between the adopted year data and not adopted. In addition, the scatter plot demonstrates that there is almost no relationship between R&D ratio and book debt ratio. To further confirm the relationship, an ANCOVA model (See TableIII) is deployed in this analysis as we have categorical variables like year fixed effect here.

As shown in Table II, R^2 being 30% suggests one-thirds of the variability in the logged book debt ratio is explained by the model. Indicated by those close-to-zero p-values, both R&D ratio and control variables turn out to be significant predictors for a firm's leverage ratio in this sample. Also, an increase in book debt ratio is documented after the recognition of the policy, though not statistically significant. The relationship between R&D ratio and debt ratio appears to be positive instead of negative as we expected. Specifically, the coefficient of logged R&D ratio suggests that given all else equal, a 1% increase in R&D ratio is associated with a 0.039% increase in book debt ratio. Furthermore, collinearity is not a problem since VIF(See Table IV) for each predicting variable is smaller than $\max\{10, 1.1[1/(1-0.152)]\}$.

As up until now, the model assumes the same slope for firm i in year j regardless of its recognition status, namely whether it is an High and New Tech Enterprise. To probe into this problem, an interaction variable of R&D ratio and adopted or not is added. Results are displayed in Table V.

As shown by both the t-statistics and the partial F-test, the p-value of the interaction term is 0.072, which is significant on 0.1 confidence level. Therefore, we will stick to the simple model for now without the interaction effect.

Besides, while using DID approach, one thing we need to check is the potential endogeneity concerns related to reverse causality. Inspired by Serfling, we create four categorical variables to document the timing of financial leverage changes relative to the timing of the passage of the policy: will be passed in one year; passes the policy this year; passed the policy one year ago; passed the policy two years or more ago. If there exists reverse causality, we would expect there will be statistically important relationship between the first categorical variable and the leverage ratio. Result details could be found in Table VI, VII and VIII.

Fortunately, there is no evidence that suggests a trend of declining/increasing leverage before the passage of the policy as showed by the p-value of "adopted in one year" of being 0.22. Furthermore, it seems that only after two years did firm start to adjust its book debt ratio suggested by the p-value of "adopted two years or more ago" being 0.01. The coefficient of this variable suggests that holding all else fixed, firms that started to enjoy the policy two years ago have debt ratio increased by 31% ($e^{0.27}$). Before we delve into the implication of the results, let's check the least squares model's assumption as we have noticed nonconstant variance and potential leverage points from Figure 3(a) and Figure 3(b) at the beginning. New residual plots are Figure 4(a), 4(b), 4(c) and

4(d).

Although there exist only few outliers and no influential points as suggests by Cook's distance (all of the observations have Cook's distance less than 0.5), there is apparent non-normality and nonconstant variance here (as the fitted book debt ratio goes down, the variability of the residuals increases), which is common to ANCOVA model. Levene's test(See Table IX) further confirms the existence of nonconstant variance as showed by the p-value close to zero.

Given that we've already put the data in the logged scale, let's try using weighted least squares approach to address the nonconstant variance. The results of a weighted ANCOVA with weights being 1/estimated variance of the errors of the observations under each year could be found in Table X, XI,XII and XIII.

Now that the residual plot looks better now, and the implication of the model remains largely unchanged. (See Figure **??**) To better observe the timing effect here (i.e. when firm starts to adjust its debt ratio after the passage of the policy), let's apply Tukey comparison(See Table **??**) to see whether there is significant difference between subsequent years of the debt ratio of the firms that had been qualified for the policy: Figure 5 is here.

We can see that there are no statistically significant differences among timings that all of the pairs have zero in the confidence interval with p-value close to 1. It suggests that though there exist differences between firms that had been approved for the policy and not approved and firms typically wait for two years or more to adjust their debt ratio (as the t-statistics for adopted or not is not significant), among those firms that had been approved, the change in financial leverage after the recognition is not evident, which is consistent with the research done by Guohong Yuan on the effect of the policy. Yuan documents that after being approved for the tax credit, companies largely did not continue to invest in R&D and apply for more patents. Hence, the debt ratio would not change much accordingly, holding all else equaled.

Now that we find that the relationship between R&D investments and debt ratio is positive in contrast to many existing literature, it's necessary to go back to check the theoretical underpinnings and assumptions under each of the theories discussed in the section I to find out the possible explanations.

Firstly, the major assumption under the information asymmetry theory that buttresses the negative relationship is that creditors normally do not have adequate information to monitor the operations of the firm, which increases their risks of the loan and thus raises the cost of lending. However, according to a report done in 2013 by the Innovation Department, most of the high-tech companies rely on bank loans, which is relational debt instead of public debt. Recall the theory that backs up the positive relation, this type of debt is favorable to firms because in most situation banks are able to keep track of the latest information of the firm and thus alleviate the addition cost of borrowing introduced by information asymmetry.

Furthermore, the government has continuously played an important role in facilitating the lending activities between banks and high-tech firms. For instance, a number of science and technology credit unions have been set up, and all major commercial banks have been asked to strengthen credit investment in scientific research. In the report by the Innovation Department, it is documented that of the total new loan amount of 1 trillion yuan per year, loans supporting science and technology development account for 22% to 23%. That is to say, every 4 yuan that a bank lends, nearly 1 yuan goes to the technology industry. In 2005, under the support of four state-owned commercial banks, industrial and commercial bank, agricultural bank, Bank of China and Construction Bank, the Ministry of science and technology recommended 1246 high-tech projects to the bank, with a total application of 22 billion 900 million yuan. In the industrialization plan, bank loan has become the second largest source of funds after internal financing. In addition, in February 14, 2006, the State Council issued the notice on the implementation of a number of supporting policies on implementing the plan for the development of the medium and long term science and technology development (2006-2020 years), and listed the financial support as one of the ten major contents of the development of high-tech enterprises. One of the biggest breakthrough of this policy is that banks can become other than creditors in high-tech projects. All of the above suggests that the lending environmental faced by high-tech companies has been harmonious thanks to abundant policy supports and thus the major drawback of debt-financing is minimized in the sampled firms.

Apart from the salubrious relationship between banks and high-tech firms facilitated by the government, the CBRC (China Banking Regulatory Commission) has also set up few rules to help high-tech companies survive from the standpoint of debt-financing. Specifically, in the "Guidance of China Banking Regulatory Commission on improving and strengthening financial services for hi-tech enterprises by commercial banks", Article 9 says that commercial banks should set reasonable term of credit and repayment methods according to the financing requirements and cash flow characteristics of high and new technology enterprises. Instalment credits and flexible additional period of grace (only payments of interest during the period) are allowed. In response to the risky nature of the R&D investments of high-tech companies, CBRC encourages that high-tech enterprises with independent intellectual property rights and assessed by the state competent authorities to try use intellectual property as collaterals to apply for loans and commercial banks should cordially give financial support to such firms. Therefore, relational debt from banks do not add additional cost, but also is beneficial to high-tech firms.

Secondly, the most important assumption behind the agency costs theory that suggests a negative relation by Titman is that important agencies of the firm can rationally assess the probability of the liquidation of the firm. However, in reality, Chinese firms are famous for delaying "bad news" so that there is little chance for customers, suppliers, or even employees to know in advance the operational performance of a firm, let alone whether it will be in financial distress in the coming future. According to a report done in 2015 by China Federation of Industrial Economics and China Enterprise Management Research Society, the awareness of Chinese enterprises to disclose information is relatively weak, and the content of disclosure is mainly qualitative description, quantitative data is relatively limited. Thus, the lack of information symmetry to the public makes it harder for those important agencies to impose additional costs on the firm and "force" it to reduce leverage ratio.

In sum, our results are justifiable given that our sample satisfies the assumptions under the positive relation and violates the assumptions behind the theory that supports negative relation. With regard to the results that among those firms that had been approved for the tax benefits, their debt ratio does not change much in the subsequent years, we find out it is largely due to the nature of R&D investments: most R&D investments end up in negative Net Present Value, meaning a loss to firms, so it's legitimate to choose not to invest more as the policy does not prescribe that firms are obliged to increase R&D investments after being qualified. Thus, it seems that the problem China is struggling with in terms of technology breakthrough is not in a quantitative sense but a qualitative. According to a report called "The Global Effect of China's Innovation" done by Mckinsey Global Institute in 2015, though the total amount invested in R&D in China ranked the first among the world, the output of those projects is gloomy with the number of patents being 0.96 compared to America's 12.65 after scaling, the number of citation being 6.21 compared to 16.02, and the number of papers published in high-tech fields journals being 8.99 compared to 21.24. Therefore, the policy implication of our model is that though the tax credits could boost firms' R&D investments by reducing their operating costs, the effect largely remains one-time and the government should strive to come up with more detailed qualification guides to encourage firms conduct a few high-quality R&D projects rather than a jumble of ideas and follow-ups are needed to build a healthy environment for firms to keep innovating.

C. Econometric Concerns and Pre-treatment Trends

To test the possibility of reverse causality, we examine whether the adoption of the law is related to pre-existing financial leverage by regressing the book leverage on year fixed effects and four indicator variables drawn from Sefling's paper: Law will pass the law next year, passed the law one year ago, passed the law in the current year, passed the law two or more years ago (See Appendix **??**). The results imply that there is no documented trend of declining book or market leverage before the adoption of the law and that they decline only after the adoption of the law.

V. Conclusion

In this paper, we study the relation between R&D investments and capital structure decisions using firms in China. To establish the causality of the relationship, we introduce an exogenous shock——an R&D related policy——that aims to boost firms' R&D investments by providing tax benefits and decreasing their operating costs. Using a difference-in-difference research inspired by Serfling (2016), we group firms from affected high-tech industries into two groups: a)Treatment group, firms being qualified for the tax benefits and b) Control group, firms not being qualified. To understand those data, we conduct several regressions to show the change in debt ratios of those firms.

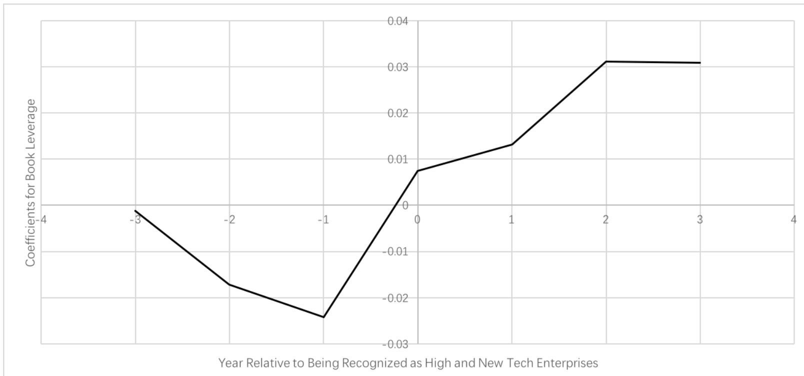
In contrast to existing literature and empirical studies that suggest a negative relation between R&D intensity and debt ratio, we document a positive relationship and the results are robust when we use alternative leverage measures. We also find that most firms do not adjust their debt ratio within the first two years of being recognized. Among firms that had been qualified for the tax benefits, the R&D ratios do not change much in the subsequent years, so do the debt ratios.

Nonetheless, as in Sefling (2016) it's possible that policy-makers may be motivated by factors that they do not explicitly address. Therefore, further research on whether some political and economic features are correlated with the adoption of the law should be done, such as whether GDP per capita had increased after the adoption the law,which may affect the capital structure choice of firms. Secondly, to test whether the adoption the law was anticipated, we document that R&D ratio did not decline after the adoption of the law. To further solidify the assumption, evidence from the stock market can be deployed as in Serfling (2016) to whether there is abnormal change in stock price of a firm before the government announces that it is being qualified.

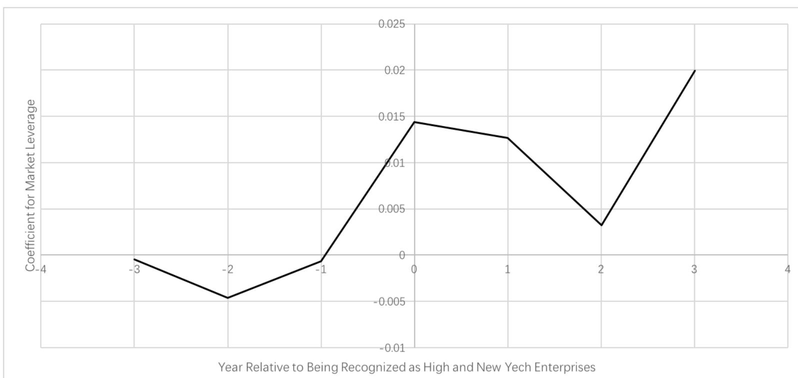
The findings are consistent with theories that suggest a positive relationship between R&D investments and debt ratio from the viewpoint of the benefits of relational debt from banks facilitated by the government. Thanks to a range of policies and guidelines launched by the government, the financing relation between banks and high-tech firms are healthy and promising, which to some extent alleviates the additional cost of borrowing introduced by information asymmetry and prompts firms to choose debt over equity as their first choice of financing following internal funds. However, though the amount of R&D investments had increased after the policy, the effect did not last long and thus our results serve to suggest that the government should figure out a way to deal with the post-policy R&D stagnation situation.

Appendix A. Analysis Details

Figure 1. The Effect of the Recognition of the "High and New Enterprises" on Leverage Ratio

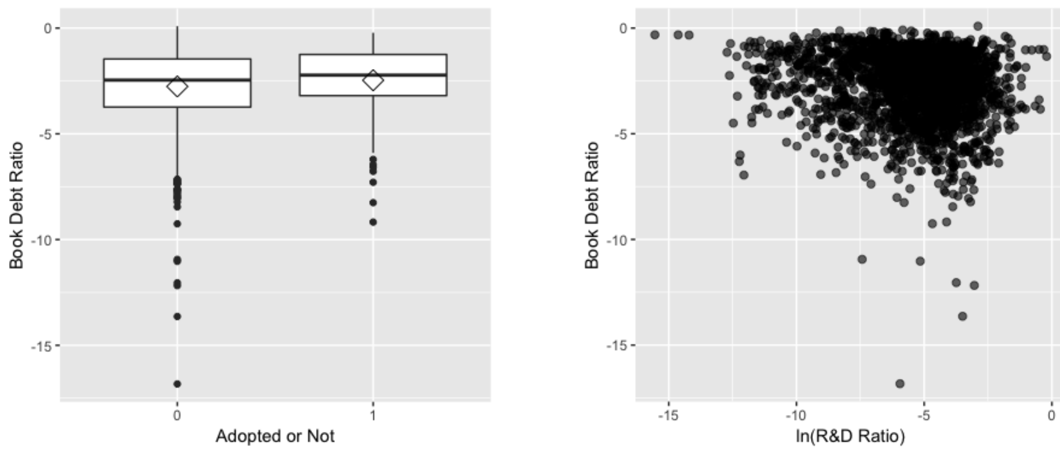


(a) Book Leverage Ratio



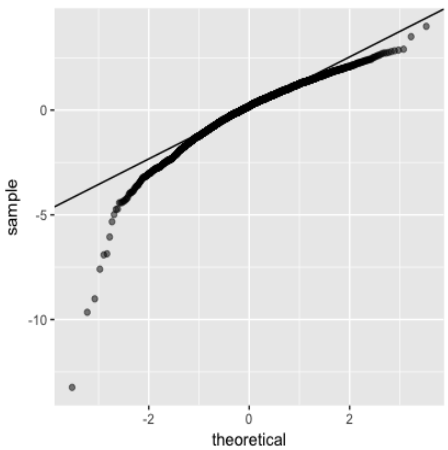
(b) Market Leverage Ratio

Figure 2. The Relationships between R&D Ratio and Adopted Status, and between R&D Ratio and Book Debt Ratio

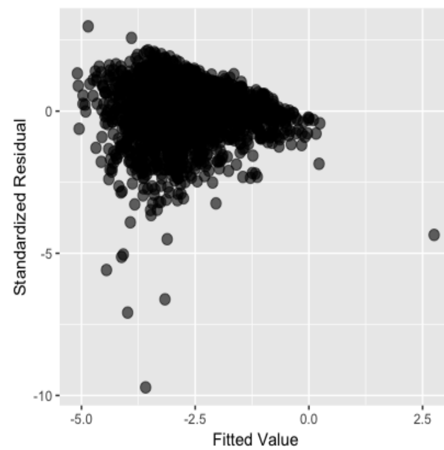


(a) Side-by-side Boxplot (b) Scatter Plot

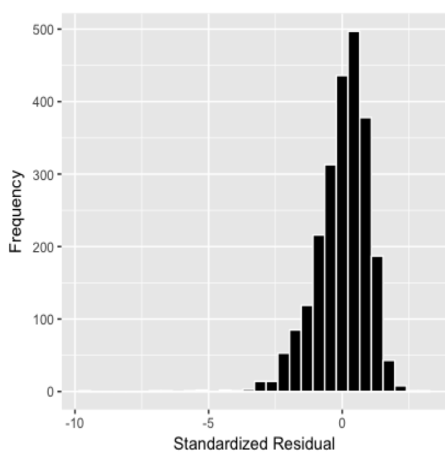
Figure 3. The Relationships between R&D Ratio and Adopted Status, and between R&D Ratio and Book Debt Ratio



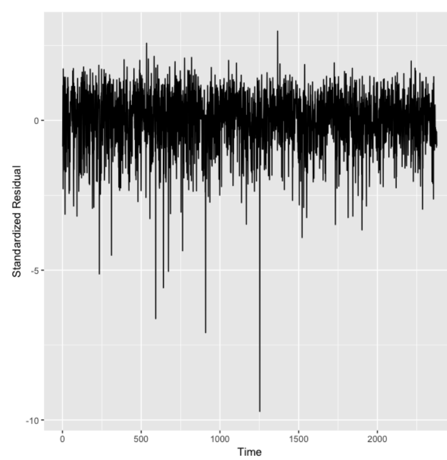
(a) Q–Q (quantile-quantile) Plot



(b) Scatter Plot



(c) Histogram of Standardized Residuals



(d) Time Series of Residuals

Table I Data Description

heightVariables	Treatment		Control		T-test		
	Mean	St.D	Mean	St.D	t-value	p-value	
Dependent Variable							
Book Debt Ratio	0.168	0.167	0.140	0.160	2.643	0.008	*
Market Debt Ratio	0.080	0.106	0.070	0.110	1.612	0.107	
Main Explanatory Variable							
R&D Ratio	0.021	0.030	0.020	0.050	0.774	0.439	
Control Variables							
Market Book Ratio	3.916	3.404	4.140	8.000	(0.470)	0.638	
ROC	0.052	0.115	0.070	0.240	(1.456)	0.145	
Pay Dividend or Not	0.702	0.458	0.628	0.484	2.499	0.013	*
Size	22.205	1.246	21.990	1.390	2.563	0.010	*
Fixed Asset Ratio	0.229	0.125	0.210	0.130	2.665	0.008	*

Table II Regression Result(Default) and Heteroskedasticity-robust Errors

	Dependent variable:	
	Book Debt Ratio	
	Default	Robust
	(1)	(2)
adopted or not	0.162*	0.162**
	(0.087)	(0.081)
year1	-0.284	-0.284
	(0.344)	(0.377)
year2	0.129	0.129
	(0.125)	(0.135)
year3	-0.117	-0.117
	(0.113)	(0.127)
year4	0.284***	0.284***
	(0.102)	(0.103)
year5	-0.005	-0.005
	(0.097)	(0.116)
year6	-0.140	-0.140
	(0.088)	(0.095)
year7	-0.060	-0.060
	(0.085)	(0.092)
year8	0.042	0.042
	(0.082)	(0.080)
year9	0.027	0.027
	(0.081)	(0.078)
ln(r&d ratio)	0.039***	0.039***
	(0.014)	(0.013)
roc	-0.791***	-0.791***
	(0.129)	(0.244)
size	0.582***	0.582***
	(0.029)	(0.028)
ln(market book ratio)	-0.217***	-0.217***
	(0.058)	(0.069)
dividend	-0.485***	-0.485***
	(0.064)	(0.065)
ln(fixed assets to total assets)	0.404***	0.404***
	(0.037)	(0.042)

Constant	-14.109***	-14.109***
	(0.652)	(0.654)
Observations	2,377	2,377
R^2	0.296	0.296
Adjusted R^2	0.292	0.292
Residual Std. Error (df = 2360)	1.366	1.366
F Statistic (df = 16; 2360)	62.158***	62.158***
Note:	*p<0.1; **p<0.05; ***p<0.01	

Table III ANCOVA Test

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Sum Sq	10	650.062	1,356.460	6.392	26.530	615.811	4,404.285
Df	10	237.700	745.704	1	1	1	2,360
F value	9	123.354	180.744	1.640	7.359	119.892	467.789
Pr(>F)	9	0.019	0.037	0.000	0.000	0.007	0.098

Table IV Results of Variance Inflation Factor

	GVIF	Df	GVIF^(1/(2*Df))
adopted or not	1.029	1	1.014
year	1.529	9	1.024
ln(r&d ratio)	1.186	1	1.089
roc	1.059	1	1.029
size	1.782	1	1.335
ln(market book ratio)	1.899	1	1.378
dividend	1.094	1	1.046
ln(fixed assets to total assets)	1.070	1	1.034

Table V Results after Adding the Interaction Term

	Dependent variable:	
	Book Debt Ratio	
	Default	Robust
	(1)	(2)
adopted or not	0.552**	0.552***
	(0.234)	(0.204)
year1	-0.277	-0.277
	(0.344)	(0.377)
year2	0.127	0.127
	(0.125)	(0.135)
year3	-0.115	-0.115
	(0.113)	(0.127)
year4	0.282***	0.282***
	(0.102)	(0.103)
year5	-0.009	-0.009
	(0.097)	(0.117)
year6	-0.142	-0.142
	(0.088)	(0.095)
year7	-0.059	-0.059
	(0.085)	(0.092)
year8	0.043	0.043
	(0.082)	(0.079)
year9	0.028	0.028
	(0.081)	(0.078)
ln(r&d ratio)	0.031**	0.031**
	(0.015)	(0.014)
roc	-0.790***	-0.790***
	(0.129)	(0.244)
size	0.583***	0.583***
	(0.029)	(0.028)
log(marketbookratio)	-0.216***	-0.216***
	(0.058)	(0.069)
dividend	-0.482***	-0.482***
	(0.064)	(0.065)
ln(fixed assets to total assets)	0.401***	0.401***
	(0.037)	(0.042)

adopted or not:log(rdratio)	0.078*	0.078**
	(0.043)	(0.037)
Constant	-14.184***	-14.184***
	(0.653)	(0.654)
Observations	2,377	2,377
R^2	0.297	0.297
Adjusted R^2	0.292	0.292
Residual Std. Error (df = 2359)	1.365	1.365
F Statistic (df = 17; 2359)	58.748***	58.748***

Note: *p<0.1; **p<0.05; ***p<0.01

Table VI Summary of the Regression with Categorical Timing

	Dependent variable:
	book debt ratio
adopted in one year	0.241
	(0.200)
adopted last year	-0.039
	(0.205)
adopted this year	-0.069
	(0.194)
adopted two years or more ago	0.271**
	(0.107)
year1	-0.290
	(0.344)
year2	0.128
	(0.125)
year3	-0.093
	(0.114)
year4	0.306***
	(0.103)
year5	0.007
	(0.098)
year6	-0.144
	(0.088)
year7	-0.068
	(0.085)
year8	0.032
	(0.082)
year9	0.013
	(0.082)
log(rdratio)	0.039***
	(0.014)
roc	-0.794***
	(0.129)
size	0.584***
	(0.029)
log(marketbookratio)	-0.214***
	(0.058)
dividend	-0.482***

	(0.064)
log(fixedtoassets)	0.405***
	(0.037)
Constant	-14.141***
	(0.652)
Observations	2,377
R^2	0.298
Adjusted R^2	0.292
Residual Std. Error	1.366 (df = 2357)
F Statistic	52.649*** (df = 19; 2357)
Note:	*p<0.1; **p<0.05; ***p<0.01

Table VII ANCOVA Test with Categorical Timing

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Sum Sq	13	500.639	1,206.182	0.066	12.091	224.929	4,395.024
Df	13	182.846	653.256	1	1	1	2,357
F value	12	93.322	164.614	0.036	1.625	73.355	470.038
Pr(>F)	12	0.159	0.302	0.000	0.000	0.123	0.850

Table VIII VIF Results with Categorical Timing

	GVIF	Df	GVIF^(1/(2∗Df))
adopted in one year	1.034	1	1.017
adopted last year	1.038	1	1.019
adopted this year	1.027	1	1.014
adopted two years or more ago	1.044	1	1.022
year	1.680	9	1.029
ln(r&d ratio)	1.188	1	1.090
roc	1.060	1	1.029
size	1.783	1	1.335
ln(market book ratio)	1.900	1	1.378
dividend	1.096	1	1.047
ln(fixed to assets)	1.071	1	1.035

Table IX Levene's Test

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Df	2	1,188.000	1,667.358	9	598.5	1,777.5	2,367
Sum Sq	2	519.422	708.325	18.560	268.991	769.853	1,020.283
Mean Sq	2	1.247	1.153	0.431	0.839	1.654	2.062
F value	1	4.784		4.784	4.784	4.784	4.784
Pr(>F)	1	0.00000		0.00000	0.00000	0.00000	0.00000

Table X Weighted Least Squares Approach-Regression Results

	Dependent variable:
	bookdebtratio
adopted in one year	0.194
	(0.207)
adopted last year	-0.013
	(0.212)
adopted this year	-0.095
	(0.190)
adopted two years or more ago	0.229**
	(0.099)
year1	-0.288
	(0.406)
year2	0.124
	(0.137)
year3	-0.096
	(0.126)
year4	0.307***
	(0.105)
year5	0.005
	(0.116)
year6	-0.148
	(0.099)
year7	-0.066
	(0.093)
year8	0.035
	(0.081)
year9	0.017
	(0.080)
log(r&d ratio)	0.037***
	(0.014)
roc	-0.876***
	(0.138)
size	0.579***
	(0.028)
log(marketbookratio)	-0.215***
	(0.056)
dividend	-0.474***

	(0.062)
log(fixedtoassets)	0.376***
	(0.035)
Constant	-14.086***
	(0.640)
Observations	2,377
R^2	0.309
Adjusted R^2	0.304
Residual Std. Error	1.359 (df = 2357)
F Statistic	55.508*** (df = 19; 2357)
Note:	*p<0.1; **p<0.05; ***p<0.01

Table XI Weighted Least Squares Approach-ANCOVA

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Sum Sq	13	498.662	1,195.640	0.007	9.944	211.315	4,352.337
Df	13	182.846	653.256	1	1	1	2,357
F value	12	95.045	169.224	0.004	1.449	72.346	484.139
Pr(>F)	12	0.170	0.312	0.000	0.000	0.161	0.950

Table XII Weighted Least Squares Approach-VIF

	GVIF	Df	GVIF^(1/(2*Df))
adoptedinoneyear	1.032	1	1.016
adoptedlastyear	1.032	1	1.016
adoptedthisyear	1.027	1	1.013
adoptedtwoyearsoremoreago	1.040	1	1.020
year	1.646	9	1.028
log(rdratio)	1.185	1	1.089
roc	1.064	1	1.032
size	1.830	1	1.353
log(marketbookratio)	1.929	1	1.389
dividend	1.100	1	1.049
log(fixedtoassets)	1.072	1	1.035

Table XIII Levene's Test

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Df	2	1,187.500	1,666.651	9	598.2	1,776.8	2,366
Sum Sq	2	502.333	707.496	2.058	252.195	752.470	1,002.608
Mean Sq	2	0.326	0.138	0.229	0.277	0.375	0.424
F value	1	0.540		0.540	0.540	0.540	0.540
Pr(>F)	1	0.847		0.847	0.847	0.847	0.847

Figure 4. Standardized Residuals under Weighted ANCOVA Approach

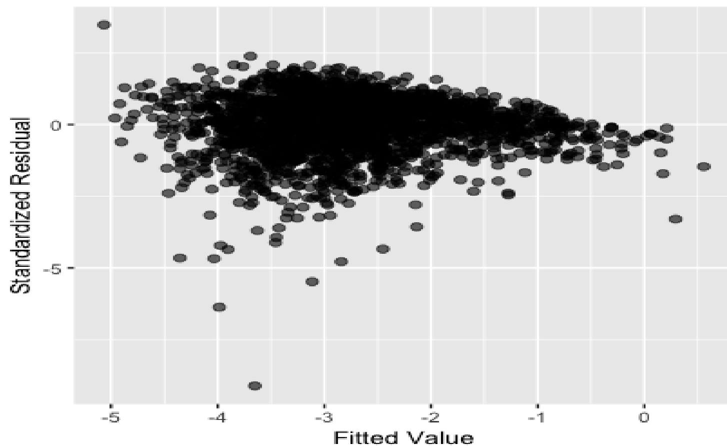


Figure 5. Tukey Comparison

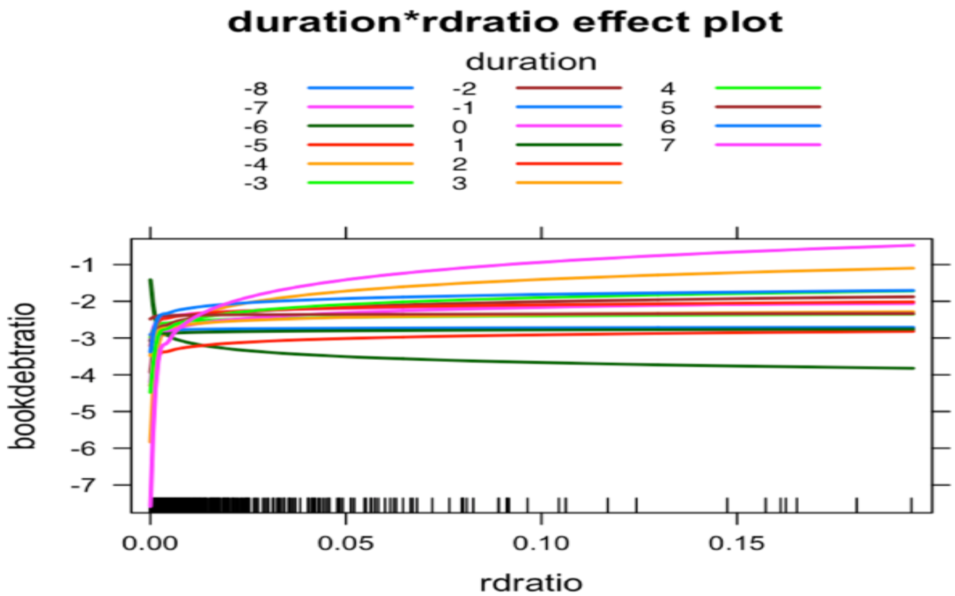


Table XIV Tukey Comparison

lhs	rhs	estimate	std.error	statistic	p.value
-7 - -8	0.000	-1.122	1.571	-0.715	1.000
-6 - -8	0.000	-1.435	1.550	-0.927	1.000
-5 - -8	0.000	-2.128	1.421	-1.498	0.976
-4 - -8	0.000	-1.380	1.439	-0.960	1.000
-3 - -8	0.000	-1.348	1.418	-0.951	1.000
-2 - -8	0.000	-1.333	1.380	-0.966	1.000
-1 - -8	0.000	-1.531	1.390	-1.102	0.999
0 - -8	0.000	-1.518	1.394	-1.089	1.000
1 - -8	0.000	-1.601	1.396	-1.147	0.999
2 - -8	0.000	-1.150	1.401	-0.821	1.000
3 - -8	0.000	-1.455	1.405	-1.036	1.000
4 - -8	0.000	-1.329	1.410	-0.943	1.000
5 - -8	0.000	-1.166	1.411	-0.827	1.000
6 - -8	0.000	-1.023	1.420	-0.721	1.000
7 - -8	0.000	-1.121	1.493	-0.751	1.000
-6 - -7	0.000	-0.314	1.050	-0.299	1.000
-5 - -7	0.000	-1.006	0.908	-1.109	0.999
-4 - -7	0.000	-0.259	0.884	-0.293	1.000
-3 - -7	0.000	-0.227	0.871	-0.260	1.000
-2 - -7	0.000	-0.211	0.827	-0.255	1.000
-1 - -7	0.000	-0.409	0.811	-0.505	1.000
0 - -7	0.000	-0.397	0.826	-0.480	1.000
1 - -7	0.000	-0.479	0.835	-0.574	1.000
2 - -7	0.000	-0.028	0.838	-0.033	1.000
3 - -7	0.000	-0.333	0.846	-0.394	1.000
4 - -7	0.000	-0.207	0.857	-0.242	1.000
5 - -7	0.000	-0.045	0.854	-0.052	1.000
6 - -7	0.000	0.100	0.870	0.115	1.000
7 - -7	0.000	0.002	0.987	0.002	1.000
-5 - -6	0.000	-0.693	0.831	-0.834	1.000
-4 - -6	0.000	0.055	0.810	0.068	1.000
-3 - -6	0.000	0.088	0.760	0.115	1.000
-2 - -6	0.000	0.103	0.745	0.138	1.000
-1 - -6	0.000	-0.096	0.722	-0.133	1.000
0 - -6	0.000	-0.083	0.715	-0.117	1.000
1 - -6	0.000	-0.166	0.735	-0.225	1.000
2 - -6	0.000	0.286	0.744	0.385	1.000

3 - -6	0.000	-0.020	0.749	-0.026	1.000
4 - -6	0.000	0.107	0.762	0.140	1.000
5 - -6	0.000	0.270	0.759	0.355	1.000
6 - -6	0.000	0.413	0.775	0.533	1.000
7 - -6	0.000	0.315	0.906	0.348	1.000
-4 - -5	0.000	0.748	0.622	1.204	0.998
-3 - -5	0.000	0.780	0.574	1.361	0.991
-2 - -5	0.000	0.795	0.497	1.601	0.956
-1 - -5	0.000	0.598	0.508	1.177	0.998
0 - -5	0.000	0.610	0.510	1.196	0.998
1 - -5	0.000	0.528	0.504	1.048	1.000
2 - -5	0.000	0.979	0.527	1.860	0.863
3 - -5	0.000	0.674	0.544	1.239	0.997
4 - -5	0.000	0.799	0.556	1.440	0.983
5 - -5	0.000	0.962	0.555	1.736	0.917
6 - -5	0.000	1.105	0.581	1.904	0.842
7 - -5	0.000	1.008	0.746	1.351	0.991
-3 - -4	0.000	0.033	0.553	0.059	1.000
-2 - -4	0.000	0.048	0.495	0.097	1.000
-1 - -4	0.000	-0.151	0.455	-0.332	1.000
0 - -4	0.000	-0.138	0.477	-0.290	1.000
1 - -4	0.000	-0.221	0.485	-0.454	1.000
2 - -4	0.000	0.231	0.479	0.482	1.000
3 - -4	0.000	-0.075	0.505	-0.148	1.000
4 - -4	0.000	0.052	0.525	0.099	1.000
5 - -4	0.000	0.215	0.519	0.413	1.000
6 - -4	0.000	0.358	0.547	0.654	1.000
7 - -4	0.000	0.260	0.720	0.361	1.000
-2 - -3	0.000	0.016	0.436	0.036	1.000
-1 - -3	0.000	-0.183	0.408	-0.448	1.000
0 - -3	0.000	-0.171	0.393	-0.433	1.000
1 - -3	0.000	-0.253	0.421	-0.600	1.000
2 - -3	0.000	0.199	0.429	0.463	1.000
3 - -3	0.000	-0.107	0.427	-0.250	1.000
4 - -3	0.000	0.020	0.457	0.043	1.000
5 - -3	0.000	0.182	0.461	0.395	1.000
6 - -3	0.000	0.326	0.486	0.670	1.000
7 - -3	0.000	0.228	0.672	0.339	1.000
-1 - -2	0.000	-0.198	0.331	-0.598	1.000

0 - -2	0.000	-0.186	0.333	-0.558	1.000
1 - -2	0.000	-0.268	0.332	-0.809	1.000
2 - -2	0.000	0.184	0.359	0.512	1.000
3 - -2	0.000	-0.122	0.375	-0.326	1.000
4 - -2	0.000	0.004	0.382	0.011	1.000
5 - -2	0.000	0.167	0.391	0.427	1.000
6 - -2	0.000	0.310	0.431	0.721	1.000
7 - -2	0.000	0.213	0.634	0.336	1.000
0 - -1	0.000	0.013	0.290	0.044	1.000
1 - -1	0.000	-0.070	0.310	-0.226	1.000
2 - -1	0.000	0.382	0.302	1.265	0.996
3 - -1	0.000	0.076	0.330	0.231	1.000
4 - -1	0.000	0.202	0.357	0.567	1.000
5 - -1	0.000	0.365	0.340	1.073	1.000
6 - -1	0.000	0.508	0.385	1.320	0.993
7 - -1	0.000	0.411	0.607	0.677	1.000
1 - 0	0.000	-0.083	0.292	-0.283	1.000
2 - 0	0.000	0.369	0.308	1.200	0.998
3 - 0	0.000	0.064	0.305	0.209	1.000
4 - 0	0.000	0.190	0.344	0.551	1.000
5 - 0	0.000	0.352	0.342	1.031	1.000
6 - 0	0.000	0.496	0.362	1.369	0.990
7 - 0	0.000	0.398	0.585	0.681	1.000
2 - 1	0.000	0.451	0.307	1.471	0.979
3 - 1	0.000	0.146	0.331	0.442	1.000
4 - 1	0.000	0.272	0.346	0.786	1.000
5 - 1	0.000	0.435	0.349	1.246	0.996
6 - 1	0.000	0.578	0.386	1.498	0.976
7 - 1	0.000	0.480	0.603	0.797	1.000
3 - 2	0.000	-0.306	0.325	-0.939	1.000
4 - 2	0.000	-0.180	0.359	-0.500	1.000
5 - 2	0.000	-0.017	0.339	-0.049	1.000
6 - 2	0.000	0.127	0.380	0.334	1.000
7 - 2	0.000	0.030	0.602	0.049	1.000
4 - 3	0.000	0.126	0.354	0.357	1.000
5 - 3	0.000	0.289	0.360	0.802	1.000
6 - 3	0.000	0.432	0.370	1.170	0.998
7 - 3	0.000	0.335	0.586	0.571	1.000
5 - 4	0.000	0.163	0.365	0.447	1.000

6 - 4	0.000	0.306	0.414	0.740	1.000
7 - 4	0.000	0.209	0.622	0.335	1.000
6 - 5	0.000	0.144	0.379	0.379	1.000
7 - 5	0.000	0.046	0.607	0.076	1.000
7 - 6	0.000	-0.098	0.569	-0.172	1.000

Table XV Pre-treatment Trend

	Dependent variable:
	bookdebtratio
adoptedinoneyear	0.294
	(0.234)
adoptedlastyear	0.064
	(0.239)
adoptedthisyear	0.013
	(0.227)
adoptedtwoyearsoremoreago	0.419***
	(0.124)
Constant	-2.754***
	(0.036)
Observations	2,376
R^2	0.006
Adjusted R^2	0.004
Residual Std. Error	1.619 (df = 2371)
F Statistic	3.352*** (df = 4; 2371)
Note:	*p<0.1; **p<0.05; ***p<0.01

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