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# The impacts of the COVID-19 pandemic on China's green bond market

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## ARTICLE INFO

## ABSTRACT

The paper applies the event study method and econometric models to investigate the impacts of COVID-19 on China's green bond market for the first time. We find that (1) the COVID-19 pandemic has significant impacts on China's green bond market and increases the cumulative abnormal return (CAR) of the green bonds greatly. After the pandemic is relieved, the CAR drops significantly; (2) the improving of bond issuers' governance capacity, the weakening of information asymmetry and the reinforcing of debt-paying ability can effectively mitigate the negative impacts and positively promote the recovery of bond issuers after the pandemic; (3) the impacts of bond issuers' governance capacity, information asymmetry and debt-paying ability on the CAR of green bonds are significantly heterogeneous before and after the pandemic due to their property rights and whether they are listed or not.

## 1. Introduction

Since December, 2019, the outbreak of coronavirus disease 2019 (COVID-19) has brought serious challenges to the global stock and bond markets (Wagner, 2020). As an important part of green finance system, green bonds are battered by both the capital market and the ecological environment.

As a new financing means in the financial markets, green bonds are developing rapidly in China. The cumulative bond issue exceeded 1.1 trillion RMB from 2016 to 2019, making China the world's second largest green bond market[1]. A large proportion of the raised funds are spent on environmental protection and pollution control, which reflects the importance of green bonds to the development of China's ecological construction.

Therefore, how the green bond market deal with the pandemic shock is especially important. The bond issuers' dept-paying ability directly affects their anti-risk capacity (Gamba and Triantis, 2008). Their governance capacity also has a direct relationship with their resource acquisition ability and resource allocation efficiency (Mitton, 2002). Moreover, the moral hazard and adverse selection caused by information asymmetry also directly influence their recovery after the crisis (Myers and Majluf, 1984). Hence, issuers' governance capacity, level of information asymmetry and debt-paying ability are focused in the paper.

Based on the above, taking the outbreak of COVID-19 pandemic in China as an exogenous shock, this paper uses the event study method and econometric models to investigate the impacts of COVID-19 on China's green bond market for the first time, and analyze the underlying reasons of these impacts to explore how to mitigate the impacts.

## 2. Methodology and Data

### 2.1. Event study method

The event study method (ESM) is widely used in financial studies to identify the impacts of a certain event (Afik et al., 2019). Firstly, January 23, 2020 is defined as the event day when the whole city of Wuhan was locked down because the pandemic outburst. Meanwhile, the time lifting the lockdown on Wuhan (March 24 and April 8 respectively) is used for further analysis[2]. Therefore, [-100, -20] is taken as the estimation period and [-5, 5] as the event window. Finally, we combine the number of confirmed cases, recovered cases and deaths of COVID-19 in China with the above as shown in Fig.1.

Secondly, the average abnormal return (AAR) and cumulative abnormal return (CAR) of the green bonds are calculated based on existing literature (Keele and Dehart, 2011). The detailed calculations are as follows:

$$R_{it} = \alpha_i + \beta_i R_{mt} \tag{1}$$

$$AR_{it} = R_{it} - E(R_{it}) \tag{2}$$

where, $R_{it}$, $E(R_{it})$ and $AR_{it}$ denote the real return, expected return, abnormal return of green bond i on day t respectively; and $R_{mt}$ denotes the real return of the bond market on day t. Using models (1) and (2), we can calculate the AAR and CAR of the green bonds as follows:

$$AAR_t = \frac{1}{N} \sum_{i=1}^{N} AR_{it} \tag{3}$$

$$CAR_{(t1,t2)} = \sum_{t=t1}^{t2} AAR_t \tag{4}$$

where, N denotes the sample size; and $(t_1, t_2)$ is the time interval.

### 2.2. Model Specification

To analyze the mitigative effects of various factors on the green bond market in the pandemic, a baseline econometric model is constructed as below:

$$CAR_{(t1,t2)} = \alpha_0 + \alpha_1 \, emp_i + \alpha_2 debt - paying_i + \alpha_3 InfoAsym_i + X'\beta \\ + \sum province + \sum Industry + \varepsilon \tag{5}$$

To investigate whether the impacts of bond issuers' governance capacity (emp), debt-paying ability (debt-paying), information asymmetry (InfoAsym) on the CAR differ due to property rights characteristics (Soe) and whether they are listed or not (listing), the interaction term is introduced based on model (1) as below[3]:

$$CAR_{(t1,t2)} = \alpha_0 + \alpha_1 \, emp_i + \alpha_4 \, emp_i \times Soe_i + \alpha_5 Soe_i + \alpha_2 debt - paying_i + \\ \alpha_3 InfoAsym_i + X'\beta + \sum province + \sum Industry + \varepsilon \tag{6}$$

where, i denotes green bond i; industry and province are dummy variables for industries and provinces respectively; CAR represents the market reactions of a green bond. Additionally, based on the existing literature (Schwartz-Ziv and Weisbach, 2013; Tang et al., 2013), we use whether the bond issuers have independent directors, the ratio of net operating cash flow to the interest-bearing liabilities, and the ratio of intangible assets to the total assets as proxy variables for governance capacity (emp), debt-paying ability (debt-paying) and information asymmetry (InfoAsym) respectively; X denotes a series of control variables; and $\varepsilon$ is the random error term.

All the green bonds are selected from August 27, 2019 to June 1, 2020 in China. The relevant data is derived from the Wind database.

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[2] On March 24, the State Council of the People's Republic of China announced that it would end the mandatory lockdown on the city of Wuhan on April 8. So, March 24 and April 8 are selected as the event days when the pandemic was relieved.

[3] Here we only list the interactions of bond issuers' governance and property rights characteristic due to the limited place, which are consistent with the interactions between *debt-paying/InfoAsym* and *Soe/listing*.
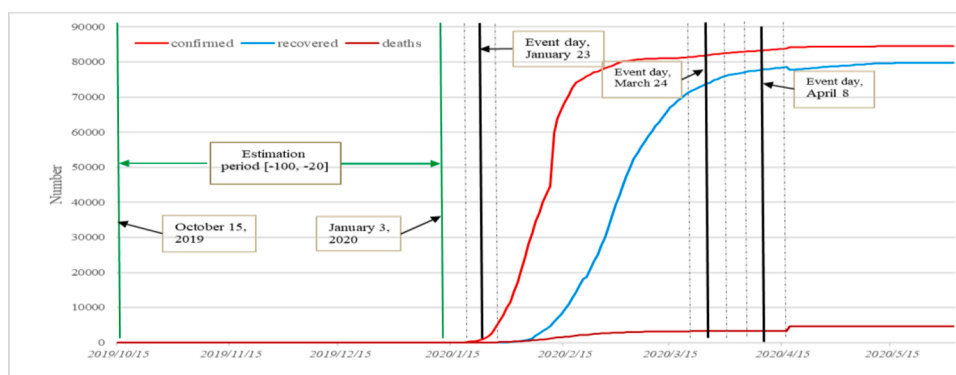
**Fig. 1.** The distribution of event days
Note: the dotted lines are event windows [-5,5] of three event days respectively.

## 3. Empirical results

### 3.1. The reactions of the green bond market

Fig.2-Fig.5 depict that the outbreak of COVID-19 has great impacts on the volatility of the green bond market, with a large-scale of increase in both AAR and CAR. And the two indexes fall sharply after the pandemic is relieved[4]. In addition, considering the sensitivity of estimation periods and event windows to the empirical results, we further check the changes of AAR and CAR in different estimation periods and event windows (Fig.A1 in Appendix A). And such changes are highly consistent with those in Fig.2 and Fig.3.

Table 1 reports the t-tests of AAR and CAR in the three event days above, illustrating that the t-statistics of the two are significantly positive at the level of 5% after the outbreak of COVID-19, while significantly negative at the levels of 5% or 10% after the relief of COVID-19.

After the COVID-19 outbroke, enterprises stopped working, resulting in that the society's demand for renewable energies dropped dramatically. Meanwhile, since renewable energies had no price advantage, the bond market investors quickly responded by selling green bonds at low prices, thereby increasing the AAR of green bonds. The specific reasons are as follows: (i) the clean energy and transportation account for a large proportion in green bonds funding[5] and the overall cost of clean energy is higher than that of the traditional energy (Nie and Lv, 2015). During the pandemic, the production was cut down accompanied with a sharp reduction in local traffic, leading to a decrease in demand for green energies. This prompted bondholders to sell the green bonds thus increasing the AAR of green bonds; (ii) the issuers of the green bonds mainly cover production, transportation and fundamental construction industries[6], which are influenced severely in the pandemic. The shutting down of the production and the travel bans have brought unprecedented shocks to the transportation and construction industries, and a large number of projects involving green bonds were directly suspended or delayed, which directly caused the overall construction duration of the green bond projects to be unpredictable. As a result, bond investors are not optimistic about the performance of green bond issuers, worrying about their credit risks.

However, as the pandemic is relieved, the resumption of work and production, the permission in residents' free migration as well as the recovery of transportation enable the normal operation of the fundamental industries, thus enhancing the confidence of the capital market. Hence, the investors begin to buy green bonds and their CAR drops consequently.

### 3.2. Mitigative effects and mechanisms

#### 3.2.1. Mitigative effects

Table 2 reports the direct impacts of variables listed in baseline model (5) on CAR. On the outbreak of COVID-19, the emp has no significant influence on CAR, and the market reacts mainly on their debt-paying ability under an unprecedented event. The stronger debt-paying indicates that the issuers can more sufficiently prepare for such a sudden event (Gamba and Triantis, 2008). As the pandemic eases, the emp can effectively mitigates the negative impact on CAR. That is, issuers with a strong emp perform an obvious decrease in CAR, while the InfoAsym has no significant influence on it.

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[4] It's important to note that the bond market is different with the stock market. In the bond market, the return rate of the bond is inversely proportional to its price. This is different with our direct intuition, that the return of the financial product should change synchronically with its price. After the COVID-19 outbroke, the green bond market was battered with a huge shock. Hence, the investors worried about the green bonds' credit risks and sold them at low prices, thereby increasing their AAR and CAR. However, as the epidemic eased, AAR and CAR declined rapidly.

[5] The proportion is approximately 63%. See http://iigf.cufe.edu.cn/article/8.html.

[6] The proportion is approximately 78%. See http://iigf.cufe.edu.cn/article/8.html.
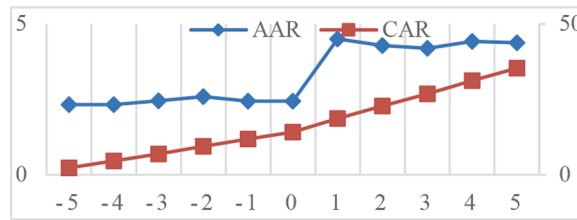
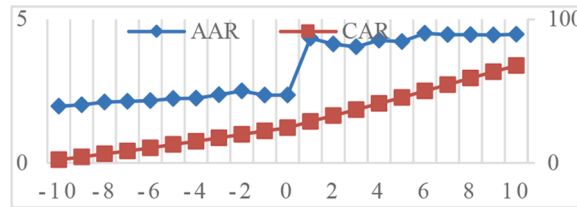**Fig. 2.** Changes of AAR and CAR in [-5, 5] on January 23



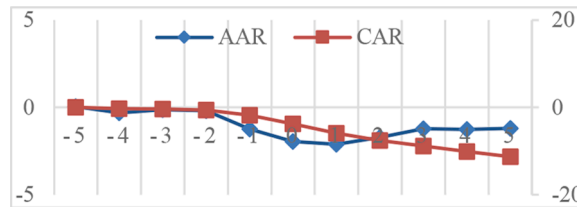**Fig. 3.** Changes of AAR and CAR in [-10,10] on January 23



**Fig. 4.** Changes of AAR and CAR in [-5, 5] on March 24
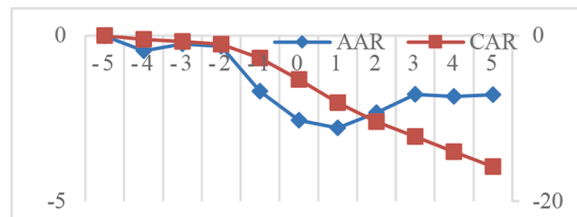


**Fig. 5.** Changes of AAR and CAR in [-5, 5] on April 8

According to model (6), the regression results of different event days and event windows are obtained as shown in Table 3 and Appendix A. Fig.6[7] depicts the marginal effects of the interaction terms.

### 3.2.2. Mechanism analysis based on the difference in property rights

Table 3 reports that on the event day when the pandemic outburst, the emp and InfoAsym of issuers have significant indirect influences on CAR by the difference of property rights. Specifically, the emp of state-owned enterprises has a negative influence on CAR while the other types of enterprises have a positive one, and the influence of InfoAsym on CAR is opposite to emp (Fig.6). The debt-paying has no significant difference regarding the property rights type. On the two event days when the pandemic is relieved, the emp has a significantly direct impact on CAR, but not caused by the difference of property rights. Such difference notably influences the CAR via debt-paying rather than InfoAsym.

### 3.2.3. Mechanism analysis based on whether the issuers are listed or not

Table 3 reports that in the first event day (Outburst of Pandemic), emp, InfoAsym and debt-paying cannot significantly affect green

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[7] Due to the limited space, we only report the marginal effects of the interaction terms with property rights characteristics in the event window of [-1,1].

**Table 1**
Tests of AAR and CAR in the event days

|  | Jan. 23 | | Mar. 24 | | Apr. 8 | |
| --- | --- | --- | --- | --- | --- | --- |
| Event window | t-test | p-value | t-test | p-value | t-test | p-value |
| AAR-5 | 1.6277 | 0.1042 | 0.5011 | 0.6165 | -0.0672 | 0.9464 |
| AAR-4 | 1.6245 | 0.1049 | -1.8754 | 0.0612* | -2.3303 | 0.0201** |
| AAR-3 | 1.6269 | 0.1044 | -1.0548 | 0.2919 | -1.5244 | 0.128 |
| AAR-2 | 1.6326 | 0.1032 | -1.2864 | 0.1988 | -1.8005 | 0.0723* |
| AAR-1 | 1.6205 | 0.1058 | -1.9772 | 0.0485** | -2.4023 | 0.0166** |
| AAR0 | 1.6204 | 0.1058 | -1.9637 | 0.05* | -2.3178 | 0.0208** |
| AAR1 | 2.0116 | 0.0448** | -1.9705 | 0.0492** | -2.3222 | 0.0206** |
| AAR2 | 2.0319 | 0.0427** | -1.9672 | 0.0496** | -2.3683 | 0.0182** |
| AAR3 | 2.0363 | 0.0423** | -1.9071 | 0.057* | -2.447 | 0.0147** |
| AAR4 | 2.0272 | 0.0432** | -1.9006 | 0.0578* | -2.453 | 0.0145** |
| AAR5 | 2.028 | 0.0431** | -1.8541 | 0.0642* | -2.4468 | 0.0147** |
| CAR [-5, 5] | 1.863 | 0.0631* | -1.966 | 0.0497** | -2.451 | 0.0145** |
| CAR [-4, 4] | 1.857 | 0.0639* | -1.973 | 0.0489** | -2.433 | 0.0153** |
| CAR [-3, 3] | 1.849 | 0.0651* | -1.976 | 0.0486** | -2.415 | 0.016** |
| CAR [-2, 2] | 1.835 | 0.0671* | -1.977 | 0.0485** | -2.379 | 0.0177** |
| CAR [-1, 1] | 1.803 | 0.072* | -1.972 | 0.0491** | -2.342 | 0.0195** |

Note: * p < 0.10, ** p < 0.05, ***p < 0.01.

**Table 2**
The regression results of the factors influencing the CAR

|  | Jan. 23 | | | Mar. 24 | | | Apr. 8 | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | (-1,1) | (-3,3) | (-5,5) | (-1,1) | (-3,3) | (-5,5) | (-1,1) | (-3,3) | (-5,5) |
| emp | -0.053 | -0.031 | -1.054 | -15.812** | -37.007** | -58.001** | -30.274** | -66.134** | -101.79** |
|  | (0.503) | (1.353) | (1.940) | (6.577) | (15.103) | (23.563) | (12.696) | (27.704) | (42.593) |
| debt-paying | -0.241** | -0.759** | -1.596** | -3.401* | -8.169** | -12.754** | -8.165** | -17.174** | -26.036** |
|  | (0.106) | (0.315) | (0.634) | (1.665) | (3.847) | (5.971) | (3.302) | (7.105) | (10.866) |
| InfoAsym | -0.0004 | -0.017 | -0.096 | -0.363 | -0.823 | -1.286 | -0.615 | -1.377 | -2.136 |
|  | (0.011) | (0.046) | (0.093) | (0.251) | (0.597) | (0.929) | (0.494) | (1.049) | (1.597) |
| Con & FE | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| Obs | 367 | 367 | 367 | 367 | 367 | 367 | 366 | 366 | 366 |
| $R^2$ | 0.169 | 0.161 | 0.151 | 0.204 | 0.206 | 0.206 | 0.228 | 0.228 | 0.228 |

Notes: * p < 0.10, ** p < 0.05, ***p < 0.01; the values in parentheses are robust standard errors; FE includes province and industry fixed effects; Con means control variables.

**Table 3**
The regression results on property rights types and whether listed or not (event window [-1,1])

|  | Jan. 23 | | | Mar. 24 | | | Apr. 8 | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| The regression results on the difference of property rights [CAR (-1,1)] | | | | | | | | | |
| emp × Soe | 0.861* | | | 0.817 | | | 7.395 | | |
|  | (0.495) | | | (7.377) | | | (15.296) | | |
| InfoAsym × Soe | | -0.059*** | | | -0.064 | | | -0.391 | |
|  | | (0.016) | | | (0.408) | | | (0.773) | |
| debt-paying × Soe | | | 0.077 | | | -4.476* | | | -8.630* |
|  | | | (0.108) | | | (2.214) | | | (4.727) |
| $R^2$ | 0.175 | 0.171 | 0.170 | 0.205 | 0.205 | 0.205 | 0.228 | 0.228 | 0.228 |
| The regression results on whether listed or not [CAR (-1,1)] | | | | | | | | | |
| emp × listing | 0.215 | | | -25.69** | | | -46.998** | | |
|  | (0.344) | | | (9.872) | | | (21.318) | | |
| InfoAsym × listing | | 0.018 | | | -0.844** | | | -1.674** | |
|  | | (0.030) | | | (0.344) | | | (0.657) | |
| debt-paying × listing | | | 0.474 | | | 1.704 | | | 0.538 |
|  | | | (0.604) | | | (6.716) | | | (11.830) |
| $R^2$ | 0.170 | 0.170 | 0.170 | 0.205 | 0.205 | 0.205 | 0.228 | 0.229 | 0.228 |
| Con & FE | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| Obs | 367 | 367 | 367 | 367 | 367 | 367 | 366 | 366 | 366 |

Notes: * p < 0.10, ** p < 0.05, ***p < 0.01; the values in parentheses are robust standard errors; FE includes province and industry fixed effects; Con means control variables.

bonds' CAR by whether the issuers are listed or not. On the latter two event days (Relief of Pandemic), the significant influence of emp on CAR is the result of whether issuers are listed or not rather than property rights characteristics. The marginal effect of emp on CAR of listed issuers is smaller than that of non-listed issuers, and InfoAsym influences CAR in a similar way. Debt-paying doesn't exert any influence on CAR by whether the issuers are listed or not.

### 3.2.4. Influencing factors and mechanisms

First, almost all the green bond issuers suffered from a sudden shock, hence the emp cannot effectively mitigate the impacts on CAR overall. However, emp can affect CAR differently through the difference of property rights. The impacts on state-owned enterprises are negative while the impacts on other types of enterprises are positive, because the insufficient incentives and government intervention result in state-owned enterprises' poor governance capability (Borisova et al., 2012). Meanwhile, the capital market is in an abnormal state and the property of state-owned is especially important under the unprecedented pandemic. In this situation, state-owned enterprises have stronger governance capabilities, effectively reducing exogenous shocks by relaxing financing constraints, gaining subsidies and more convenient bank loans and perform a stronger risk tolerance (Faccio, 2006). This view is also verified by the regression results, which suggest that the emp of the state-owned enterprises can help themselves to obtain government subsidies (Table A2 in Appendix A). However, due to the unclear property rights of state-owned enterprises, there is an apparent principal-agent problem, lower transparency and information asymmetry (Liu and Cao, 2015). Consequently, InfoAsym with a negative effect on CAR in non-state-owned enterprises turn to a less negative or even positive impact on state-owned enterprises. Debt-paying is an important guarantee for enterprises to deal with sudden crises (Beltratti and Stulz, 2012), which suggests that overall debt-paying capacity has a significantly direct impact on CAR, and the impact isn't mitigated by issuers' property rights or whether the issuers are listed or not.

Second, at the beginning of the pandemic, the large scale of shutting down in production led to an imbalance in the product supply market and henceforth a huge volatility in the capital market in the short term. During this pandemic, the enterprises are faced with a severe shock no matter whether they are listed or not and no matter what kind of enterprises they are. The larger the crisis is, the larger impact the enterprises encounter and the wider industry scale is involved (Acharya et al., 2012). Hence all the green bond issuers are hit in the pandemic. As a result, there is no difference between enterprises being listed and those not.

On the event days when Wuhan's lockdown ended, the market recovered to a rational status, the importance of property rights was weakened (Sun and Tong, 2003) and the role of whether the issuers are listed or not was revealing. This is because the listed issuers have better emp and lower InfoAsym than others. As for the issuers not listed, the independent directors have no real rights, resulting in a weaker governance (Demise, 2006). And these issuers suffer from more severe information asymmetry and consequently a higher agent cost (Bitler et al., 2005) due to the lower requirements on overall information disclosure. Meanwhile, the securities market has higher requirements for listed enterprises about governance and information disclosure, hence whether the issuer is listed or not has a significant impact on CAR by emp and InfoAsym after the capital market recovers.

## 4. Conclusions and implications

The paper investigates the impacts of COVID-19 on China's green bond market using the event study method and econometric models. We find that (1) the pandemic has significant impacts on China's green bond market and increases the CAR of the green bonds greatly. After the pandemic is relieved, the CAR drops significantly; (2) the improving of issuers' governance capacity, the weakening of information asymmetry and the reinforcing of debt-paying ability can effectively mitigate the negative impacts and positively promote the recovery of bond issuers after the pandemic; (3) the impacts of bond issuers' governance capacity, information asymmetry and debt-paying ability on the CAR of green bonds are significantly heterogeneous before and after the pandemic due to their property rights and whether they are listed or not.

Based on the conclusions above, we recommend that policy makers should reinforce the prevention and control of the pandemic and promote the research and development of vaccines, which are fundamental to the development of the green bond market. Meanwhile, policy makers should also issue credit support polices to mitigate the enterprises' shortage of funds. Additionally, the bond issuers should improve their governance capacity and information disclosure to boost the investors' confidence.

## CRediT authorship contribution statement

**Xing Yi:** Methodology, Data curation, Software, Writing - original draft, Writing - review & editing. **Caiquan Bai:** Conceptualization, Investigation, Writing - original draft, Writing - review & editing. **Siyuan Lyu:** Writing - original draft, Writing - review & editing. **Lu Dai:** Data curation, Writing - review & editing.
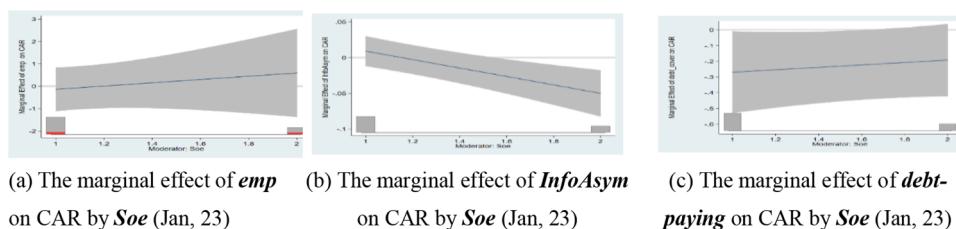
(a) The marginal effect of *emp* on CAR by *Soe* (Jan, 23)  (b) The marginal effect of *InfoAsym* on CAR by *Soe* (Jan, 23)  (c) The marginal effect of *debt-paying* on CAR by *Soe* (Jan, 23)

**Fig. 6.** The marginal effects of interaction terms
(a) The marginal effect of emp on CAR by Soe (Jan, 23)(b) The marginal effect of InfoAsym on CAR by Soe (Jan, 23)(c) The marginal effect of debt-paying on CAR by Soe (Jan, 23)

## Declarations of Competing Interest

## Funding

## Appendix A

Table A1 and A2 Figure A1

**Table A1**
The results on property rights types and whether listed or not (event windows [-3,3] and [-5,5])

| | Jan. 23 | | | Mar. 24 | | | Apr. 8 | | |
|---|---|---|---|---|---|---|---|---|---|
| *The regression results on property differences [CAR (-3,3)]* | | | | | | | | | |
| emp × Soe | 2.523** | | | 2.173 | | | 14.265 | | |
| | (1.195) | | | (17.034) | | | (32.642) | | |
| InfoAsym × Soe | | -0.121*** | | | -0.220 | | | -0.709 | |
| | | (0.040) | | | (0.947) | | | (1.641) | |
| debt-paying × Soe | | | 0.173 | | | -9.722* | | | -19.120* |
| | | | (0.333) | | | (5.125) | | | (9.982) |
| *The regression results on property differences [CAR (-5,5)]* | | | | | | | | | |
| emp × Soe | 4.504** | | | 3.205 | | | 20.803 | | |
| | (1.843) | | | (26.391) | | | (49.764) | | |
| InfoAsym × Soe | | -0.170 | | | -0.329 | | | -1.006 | |
| | | (0.102) | | | (1.459) | | | (2.497) | |
| debt-paying × Soe | | | -0.062 | | | -15.032* | | | -29.538* |
| | | | (0.682) | | | (7.899) | | | (15.145) |
| *The regression results on whether listed or not [CAR (-3,3)]* | | | | | | | | | |
| emp × listing | -0.366 | | | -58.608** | | | -103.187** | | |
| | (1.590) | | | (23.084) | | | (45.623) | | |
| InfoAsym × listing | | 0.084 | | | -1.953** | | | -3.628** | |
| | | (0.084) | | | (0.789) | | | (1.429) | |
| debt-paying × listing | | | 2.045 | | | 3.967 | | | 1.061 |
| | | | (2.044) | | | (15.696) | | | (25.644) |
| *The regression results on whether listed or not [CAR (-5,5)]* | | | | | | | | | |
| emp × listing | -3.377 | | | -91.312** | | | -158.784** | | |
| | (3.875) | | | (36.013) | | | (69.551) | | |
| InfoAsym × listing | | 0.122 | | | -3.035** | | | -5.562** | |
| | | (0.142) | | | (1.226) | | | (2.197) | |
| debt-paying × listing | | | 3.831 | | | 6.168 | | | 1.769 |
| | | | (3.629) | | | (24.469) | | | (39.378) |
| Con and FE | YES | YES | YES | YES | YES | YES | YES | YES | YES |

Notes: * $p < 0.10$, ** $p < 0.05$, ***$p < 0.01$; the values in parentheses are robust standard errors; FE includes province and industry fixed effects; Con means control variables.

**Table A2**
Issuers' governance capacity and government subsidies by different property characteristics

| | State-owned enterprises subsidies | Non-state-owned enterprises subsidies |
|---|---|---|
| Emp | 0.922*** | -0.293 |
| | (0.080) | (0.526) |
| Other variables and FE | YES | YES |
| Obs | 305 | 62 |
| $R^2$ | 0.888 | 0.993 |

Notes: * $p < 0.10$, ** $p < 0.05$, ***$p < 0.01$; the values in parentheses are robust standard errors; FE includes province and industry fixed effects; Con means control variables.
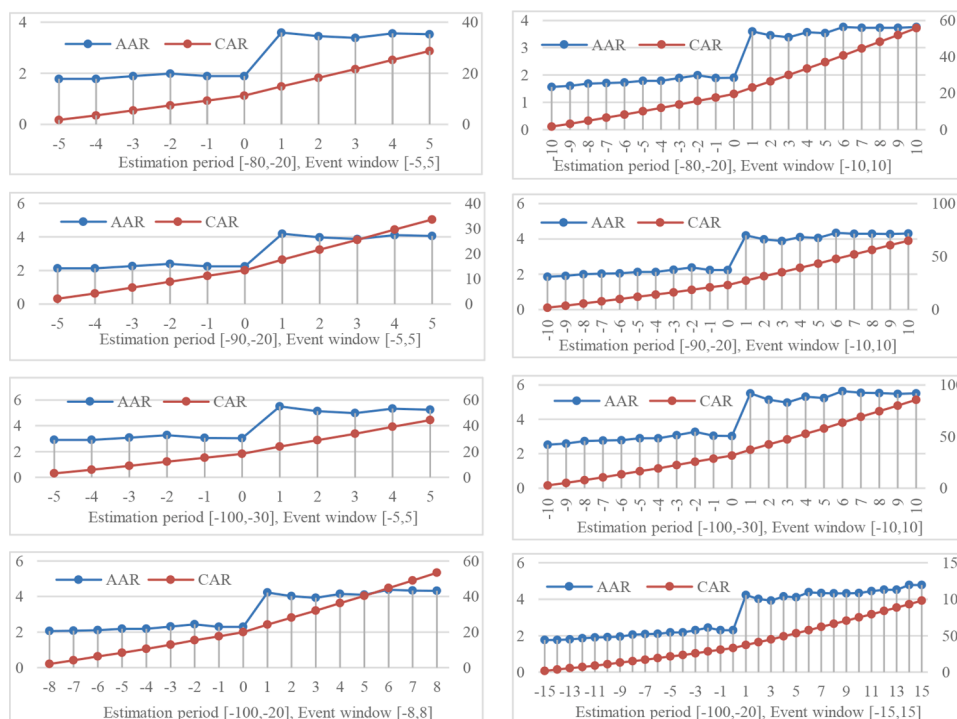
**Fig. A1.** Changes of AAR and CAR on 23, January

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