CHARLES UNIVERSITY

FACULTY OF SOCIAL SCIENCES

Institute of Economic Studies

Bachelor's Thesis

2024 **Yixiang Huang**

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Analysis of the Chinese green bond market and factors influencing issuance interest rates

Bachelor's Thesis

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Study programme: Economics and Finance

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Year of the defence: 2024

Declaration

1. I hereby declare that I have compiled this thesis using the listed literature and resources only.
2. I hereby declare that my thesis has not been used to gain any other academic title.
3. I fully agree to my work being used for study and scientific purposes.

In Prague on 3.1.2024

Yixiang Huang

References

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Abstract

This undergraduate thesis discusses the Chinese green bond market and the factors influencing its issuance rates, with a particular focus on the impact of the Covid-19 pandemic on the issuance rates of green bonds in China. The thesis employs graphical analysis to examine the Chinese green bond market and utilizes the multiple linear regression modeling approach to analyze the factors influencing issuance rates. Ultimately, it finds that the Covid-19 pandemic indeed has a significant impact and alters the model structure of influencing factors. This thesis reached the main result that the Covid-19 pandemic has indeed changed the structure of factors affecting the issuance rate of green bonds.

Abstrakt

Tato bakalářská práce se zabývá čínským trhem se zelenýmidluhopisy a faktory ovlivňujícími jejich emisní sazby, s důrazem na dopad pandemie Covid-19 na emisní sazby zelených dluhopisů v Číně. Práce využívá grafickou analýzu ke zkoumání čínského trhu se zelenýmidluhopisy a metodou vicenásobní lineární regrese analyzuje faktory ovlivňující emisní sazby. Nakonec zjišťuje, že pandemie Covid-19 skutečně má významný vliv a mění strukturu modelu ovlivňujících faktorů. Tato práce dospěla k hlavnímu závěru, že pandemie Covid-19 skutečně změnila strukturu faktorů ovlivňujících míru emise zelených dluhopisů

Keywords

Chinese market, Green bonds, Covid-19 / Coronavirus, Issuance rates, Multiple linear regression, Influencing factors

Klíčová slova

Čínský trh, Zelené dluhopisy, Covid-19 / Koronavirus, Emisní sazby, Vícenásobná lineární regrese, Ovlivňující faktory

Title

Analysis of the Chinese green bond market and factors influencing issuance interest rates

Název práce

Analýza čínského trhu se zelený midluhopisy a faktorů ovlivňujících úrokové sazby při emisi

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I would like to express my gratitude to my supervisor Mgr. Soňa Sivá for her patience and dedication. I would also like to thank my family and friends for their encouragement and support.

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1. Introduction

Climate change is one of the biggest challenges facing the world today. It is responsible for the increase in extreme weather events, as well as an unbroken series of hottest years on record. Indeed, environmental concerns and the threat posed by climate change have been a consistent feature of the World Economic Forum's Global Risks Report (Broom & Gray, 2020). World leaders spent two weeks in Paris during December 2015 hammering out the final wording of an agreement. This agreement, in enhancing the implementation of the convention, including its objective, aims to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty mainly by keeping global temperature increases well below 2°C – and if possible 1.5°C – compared with pre-industrial levels (UNFCCC, 2015).The Chinese Government has issued a "dual-carbon" policy in line with the Paris agreement. The policy mainly stipulates that by 2030, the overall green transformation of economic and social development will have achieved remarkable results, and the energy utilization efficiency of key energy-consuming industries will reach the international advanced level. By 2060, a green, low-carbon and recycling economic system and a clean, low-carbon, safe and efficient energy system will be fully established, energy efficiency will reach international advanced level, the proportion of non-fossil energy consumption will reach more than 80%, the goal of carbon neutrality will be successfully achieved, and the construction of an ecological civilization will have achieved fruitful results, thus opening up a new realm of harmony between human beings and the nature. Among other things, the policy proposes to actively develop green finance. Promote the development of green and low-carbon financial products and services in an orderly manner, set up monetary policy tools for carbon emission reduction, incorporate green credit into the macro-prudential assessment framework, and guide banks and other financial institutions to provide green and low-carbon projects with long-term, low-cost funds. Encourage developmental and policy-oriented financial institutions to provide long-term and stable financing support for the realization of carbon peaking and carbon neutrality in accordance with the principle of marketization and the rule of law. Support qualified enterprises to go public for financing and refinancing for the construction and operation of green and low-carbon projects, and expand the scale of green bonds. It will study the establishment of a national low-carbon transition fund. Encourage social capital to set up

green and low-carbon industrial investment funds. Establish and improve the green financial standard system ((PRC), 2021).

The Chinese government pointed out in the latest "Green Bonds Support Project Catalog (2021 Edition)" that green bonds refer to securities, including but not limited to green financial bonds, green corporate bonds, green debt financing instruments and green asset-backed securities, which are issued in accordance with legal procedures and agreed upon to repay capital and interest, and are used exclusively to support green industries, green projects and green economic activities in accordance with the stipulated conditions ((PBC), 2021). China is currently the world's largest issuer of green bonds, and the issuance of green bonds realizes the green financing needs of enterprises. In the past, China's green financing channels mainly consisted of green credits, which accounted for 60% of the total amount of social financing, and it is necessary to create new financing channels to fulfill the demand for funds, and one of the most important financing channels is green bonds. Therefore, it is very important to determine the interest rate of bond issuance to reduce the financing cost of enterprises. (Wang, 2018)

The aim of my thesis is firstly to discuss the current situation of China's green bond market. I analyze the annualized issuance volume of China's green bonds from 2016, the number of issuances, the distribution of issuance places, the nature of issuers, the industry of issuance, the maturity portfolio, and the credit ranking by drawing line graphs, pie charts, bar charts and other methods, by which I make an overview of China's green bond market. Then I discuss the influencing factors of China's green bond issuance interest rates through regression analysis of data from 2016 to 2023. The explanatory variable is the interest rate at which green bonds are issued, while the explanatory variables are categorized into macro variables (interest rate benchmark, gdp, cpi), micro variables (nature of issuer, credit ranking, issue size, maturity), green factor (whether there is a third-party authentication), and Covid factor (whether it is issued during the Covid period). Through different regression analyses, I find that the Covid-19 does have a negative impact on the interest rate issuance of green bonds, whereas at the same time, the Covid-19 also affects the structure of the factors influencing the interest rate issuance of green bonds. Third-party authentication, as a unique feature of green bonds, has a non-significant impact on the issuance rate after the Covid-19, along with credit ranking. At the same time, the nature of bond issuance produces a significant change in the impact on the issuance rate of green bonds due to the outbreak of the Covid-19,

making state-owned enterprises, as issuers, particularly significant in their role in reducing the issuance rate of green bonds.

2. Literature review

In recent years, due to the rapid development of the green bond market, many scholars around the world have made achievements in researching the factors driving the development of the green bond market. Tu et al. (2020) used the hierarchical analysis method to study the Vietnamese bond market, put forward a series of factors that may affect the expansion of the green bond market, including financial, economic, political, social, institutional, etc., these factors were sent to 10 experts in the energy economy in Asia, and then processed the feedback data of the experts to calculate the coefficient size of each factor, and the conclusion of the study shows that the institutional infrastructure and legal system are the most important influencing factors. Nachemson-Ekwall (2019) focuses on the role of institutional investors in Sweden's green bond market, and finds that Sweden's export-type agencies and government-sponsored mortgage lenders are leading the way in supporting the development of green bonds, while Sweden's local governments are content with successes such as the Public Social Investment Fund and the Social Benefit Bonds and are less supportive of green bonds. Agliardi et al. (2019) argue that tax exemptions for green bonds increased investment in education on environmental protection, increased transparency in the disclosure of information on green projects and that the lowering the cost of green certifications can be effective in promoting the development of the green bond market.

The theoretical studies on bond issue pricing mainly include the information asymmetry theory proposed by Akerlof (1978), the signaling theory pioneered by Spence (1973) and the principal-agent theory proposed by Jensen & Meckling (1976). The signaling asymmetry theory mainly focuses on the two parties who have different degrees of information mastery in the securities market, the seller is in an advantageous position due to the more adequate information mastery of the subject of the transaction, while the buyer is in an information disadvantageous position; in order to promote the conclusion of the transaction, both buyers and sellers have the motivation to take positive actions to reduce the information asymmetry in the transaction. Specifically applied to bond pricing, bond investors are in an information disadvantageous position due to the difficulty of continuously tracking the use of issue proceeds and changes in the credit qualification of the issuer, but investors need to price the risk of bond issuance based on this information,

so if the bond issuer takes the initiative to take measures to actively reduce the information asymmetry with investors, such as organizing road shows on a regular basis, hiring intermediary institutions with higher recognition in the market, etc., it will be more important for the issuer to take positive actions to reduce information asymmetry in the transaction. Therefore, if bond issuers actively take some measures to reduce the information asymmetry with investors, such as organizing road shows regularly, hiring intermediaries with higher market recognition, and improving the comprehensiveness and accuracy of the disclosure of company's operation information, it will help to reduce the investors' demand for compensation for the uncertainty risk and lower the cost of financing. In signaling theory, better-qualified companies take the initiative to send signals related to corporate value to market investors in order to obtain a higher investment price than the market average. The same applies to the bond market, where the issuer has an incentive to proactively demonstrate to bond investors the business strength and creditworthiness of the company in order to obtain a lower cost of financing. In principal-agent theory, there is an agency conflict between shareholders and creditors, in which the interests of creditors are jeopardized when a company raises its dividend payout ratio or uses the funds raised from the issuance of debentures for high-risk projects. Therefore, bond investors will ask for a higher risk premium for the consideration of agency conflict, while the bond financing entity has the incentive to take some measures on its own initiative to reduce the damage of agency conflict to bond investors, such as adding some more restrictive clauses to the management in the bond issuance terms, strengthening the disclosure of information, and organizing the communication between the management and the investors on a regular basis, and so on.

Bond issue prices are mainly dominated by market interest rates and credit spreads, and existing studies have mainly focused on the factors affecting credit spreads. Ziebart & Reiter (1992) take the newly issued industrial bonds rated by Standard & Poor's and Moody's between 1981 and 1985 as a sample, and use an improved structural model to study the direct and indirect impacts of firms' financial information and ratings on bond issuance prices, and conclude that the financial information affects the bond pricing both directly and indirectly through the impact of bond ratings. John et al. (2003) take fixed-rate public bonds issued between January 1993 and March 1995 as a sample to study the issue spreads of secured and unsecured bonds with the same credit ratings, and find that the issue rates of secured bonds are higher than that of unsecured bonds, and the issue spreads of secured and unsecured issues are larger relative to those with low ratings, long

maturities, and loose issue terms. Focusing on developing country bonds, Cavallo & Valenzuela (2010) study 139 bonds issued by 10 developing countries in Asia and Latin America, and find that individual firm characteristics, bond issuance factors, macroeconomic environment, country sovereign risk, and a number of global factors combine to determine bond issuance credit spreads, with individual firm characteristics being the most important factor, including firm stock price volatility. Among them, individual company characteristics are the most important factors, including company stock price volatility, asset size, capital structure, debt ratio, and so on. Xu (2007) conducted regression analysis on 175 short-term financing bills issued from February to October 2006, and found that the issuance term, bond issuance scale, nature of enterprise, asset scale, industry, and financial indexes of the enterprise have a significant impact on the issuance spreads of the short-term financing bills, specifically, private enterprises with a long issuance term, a large bond issuance scale, and small asset scale have higher issuance spreads. Specifically, the issuance spreads of private enterprises with long issuance period, large bond issuance scale and small asset size are larger. Zhang (2013) focuses on the impact of credit rating on bond issuance pricing, taking 48 unsecured corporate bonds issued from 2009 to 2011 as samples, and finds that after controlling for other characteristics of the company, the credit rating of the bonds has a significant impact on the issuance spreads, and specifically, the higher the credit rating, the lower the issuance spreads. Fang et al. (2013) focus on the relationship between corporate property rights and bond pricing, taking exchange-traded corporate bonds issued from 2007 to 2011 as a sample, and through empirical research, they find that state-owned enterprises have an obvious advantage in bond issuance pricing, and credit spreads are significantly lower than those of private enterprises.

Regarding the factors affecting the issuance price of green bonds, Kapraun & Scheins (2019) find that green bonds with better creditworthiness of the main body and issued in mainstream currencies have a greater price advantage in primary issuance, while Hyun et al. (2020), on the other hand, empirically found that green bond issuance premiums certified by the Climate Bonds Initiative International (CBI) are relatively lower, and even lower for shorter maturities and larger issuance volumes. Yang & Shi, (2020) take 170 green bonds issued from April 2016 to March 2019 as a research sample and find that the financing cost of green bonds issued in the form of public offerings and those whose issuers receive more government subsidies is lower, and the effects of third-party green certifications and the financial status of issuers on the issuance premium of

green bonds are not significant. Zheng & Hu (2021) take 221 green bonds from 2016 to 2018 as a research sample and find that green bonds with larger issuance scale, higher debt rating, and third-party certification have lower issuance interest rates, while the nature of the issuer and issuance period do not have a significant impact on issuance interest rates.

3. Status of China's Green Bond Market

Although China's green bonds started late, they are developing rapidly. From Figure 1, we can see that the issuance volume of China's green bonds within and outside China has increased from 231. 42 billion yuan in 2016 to 983.9 billion yuan in 2022. Among them, the growth rate of issuance was negative in 2020 due to the impact of the new crown epidemic, but it was quickly adjusted in 2021, and the growth rate of issuance in 2021 reached a fierce state of 117.91%. With the recommendations of the world organization and the encouragement and support of the national policy, the issuance of China's green bonds should continue to increase steadily in the future.

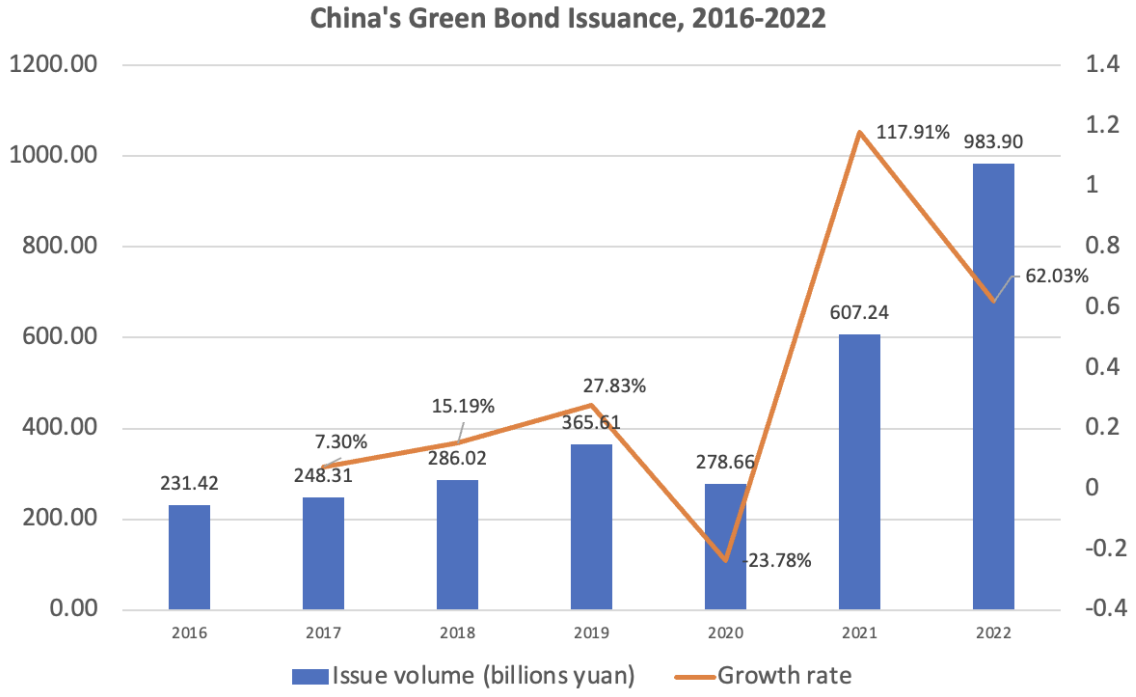

Figure 1 China's Green Bond Issuance, 2016-2022[1]

The number of green bond issues in China has been growing from 2016 to 2022. As can be seen in Figure 2, starting from only 60 issues in 2016, the number of issues has

[1] *Data sources: Green Bond Annual Report, International Institute of Green Finance, Central University of Finance and Economics, http://iigf.cufe.edu.cn/info/1012/6390.htm*

increased to 568 in 2022. 2017 saw the highest growth rate of 105%. It is worth noting that the growth has been positive for several years, even if the issuance volume in 2020 is decreasing, but the number of issuance in 2020 is still increasing steadily. 2020 is affected by the economy, but China is still making efforts in green bonds, and the types of issuance are enriching, so that it can be kept stable.

In February 2020, the first market-wide green epidemic prevention and control bond and green epidemic prevention and control asset securitization product, Huadian International Power Company Limited's 1.551 billion yuan green directed asset-backed note (epidemic prevention and control bond) was approved for issuance, with the underlying asset being the renewable energy tariff surcharge subsidy payment and a maturity of 2.5 years, the raised funds are prioritized for protecting Hubei, Ningxia, Shandong Green infrastructure construction, power supply, and emergency repair of epidemic prevention and control power supply systems in Inner Mongolia and other regions. In November, Qingdao Water Group issued the country's first blue bond - the first green medium-term note of 2020, with an issue size of 300 million yuan and a maturity of three years, raising funds for the construction of seawater desalination projects. The bond not only meets the green bond standard, but also meets the attributes of blue bond, which is the first blue bond issued by a non-financial enterprise in the world. As a kind of green bond, blue bond raises funds specifically for sustainable marine economy, which can play an important role in promoting marine protection and sustainable utilization of marine resources. (Research Bureau, 2021)

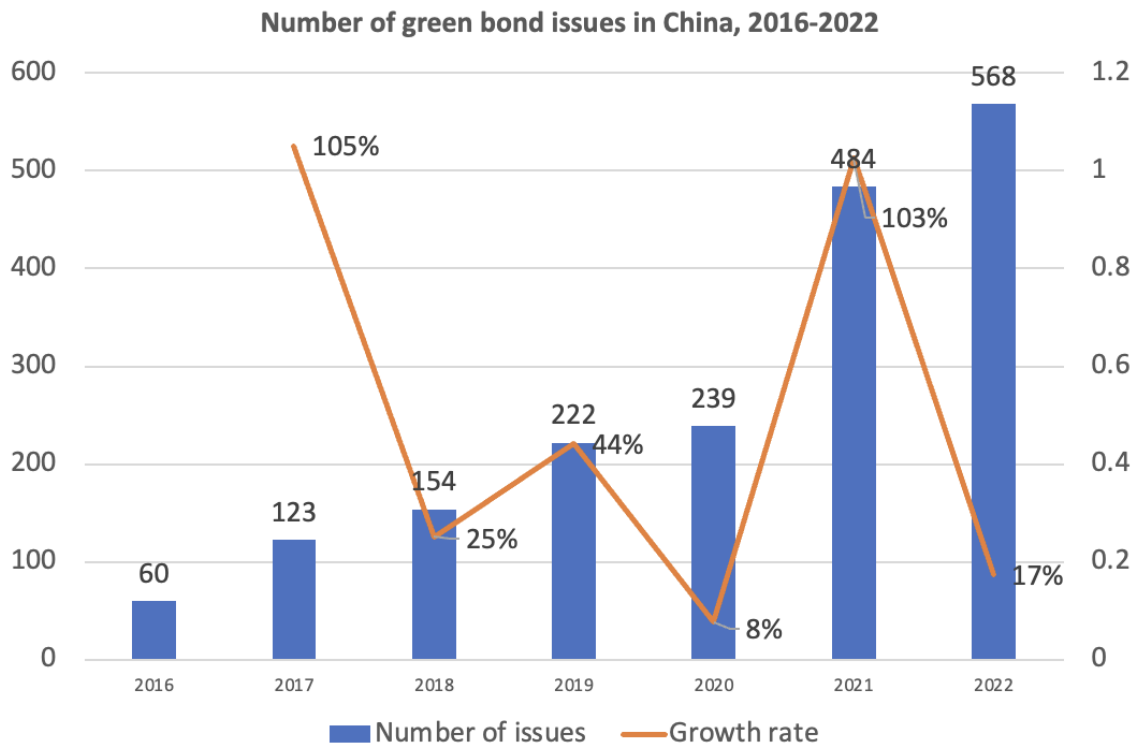

Figure 2 Number of green bond issues in China, 2016-2022[2]

In 2022, China's green bonds were issued mainly on the interbank market. As can be seen in Figure 3, it accounts for 55.96 percent of the total, followed by the Shanghai Stock Exchange with 36.61 percent, and finally the Shenzhen Stock Exchange with 7.43 percent. In addition, for green bonds issued abroad, the Hong Kong Stock Exchange is still the most important market for green bond issuance and trading in China.

[2] *Data sources: Green Bond Annual Report, International Institute of Green Finance, Central University of Finance and Economics, http://iigf.cufe.edu.cn/info/1012/6390.htm*

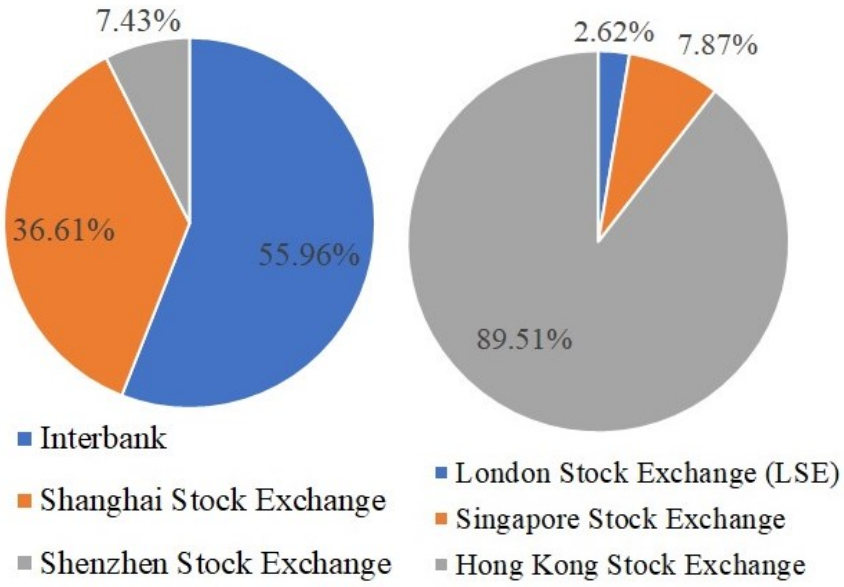

Figure 3 Distribution of Green Bond Listing Locations in China, 2022- domestic vs overseas [3]

In 2022, judging from the nature of green bond issuers in China depicted in Figure 4, the main body of domestic green bond issuers is still dominated by central state-owned enterprises and local state-owned enterprises, with state-owned enterprises issuing a total of 564 green bonds, with a scale of 723.05 billion yuan. The total number of green bonds issued by state-owned enterprises accounted for 84.43% and the scale accounted for 83.95% of the total number of green bonds issued by state-owned enterprises. Among the issuers of SOEs, the most important one is still the central state-owned enterprises, with an issuance scale of 519.18 billion yuan. In particular, the Hungarian government issued 2 billion yuan of green sovereign panda bonds, which is the first time since the release of the 2022 China Green Bond Principles that a foreign sovereign issuer has issued green bonds in the Chinese bond market.

[3] *Data sources: China Green Bond Market Annual Report, Anrong Credit Rating Co. http://arrating.com.cn/*

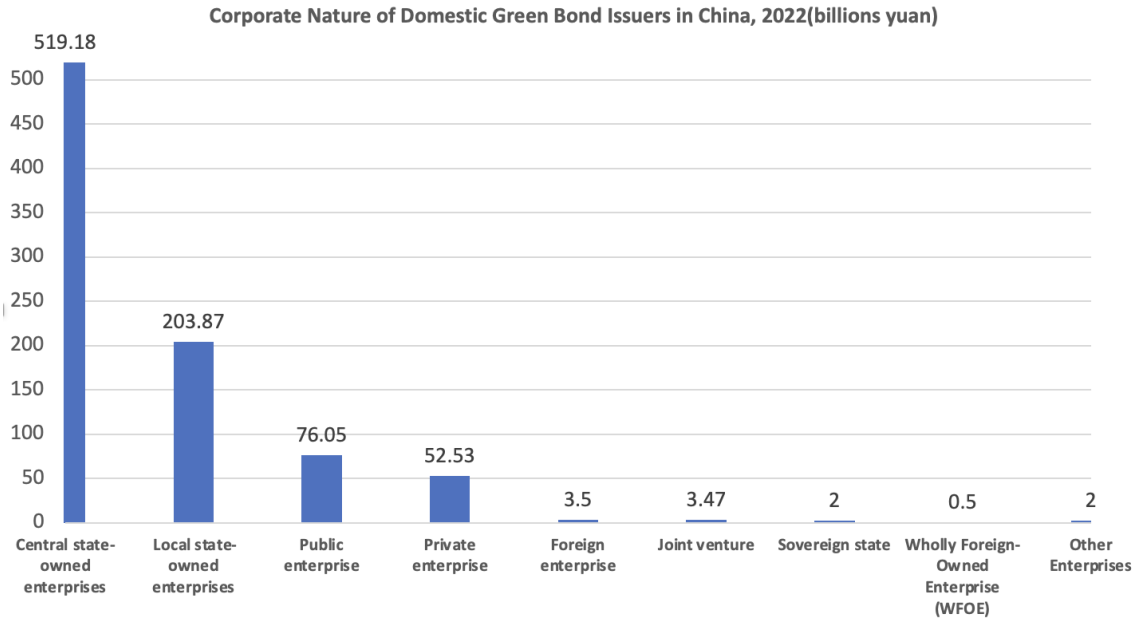

Figure 4 Corporate Nature of Domestic Green Bond Issuers in China, 2022(billion yuan)[4]

In 2022, the issuance type of green bonds in China mainly takes financial bonds as the main bond type, as can be seen in Fig. 5, the issuance scale of financial bonds reaches 432.38 billion yuan, and the number of issuances is 232. This is mainly due to policies such as the Green Finance Guidelines for the Banking and Insurance Industry, which promotes the release of green financial bond issuance, and the large scale of single issuance by financial institutions. The next largest issuance was public utility bonds, with an issuance size of 204.31 billion yuan and a total of 147 bonds. The third is the industrial bonds, although the issuance scale is only 142.02 billion yuan, but the number of issues reached 211, more than the number of issues of public utilities. In addition, the types of issues include energy, real estate, materials, consumer discretionary, information technology and sovereigns.

[4] *Data sources: China Green Bond Market Annual Report, Anrong Credit Rating Co. http://arrating.com.cn/*

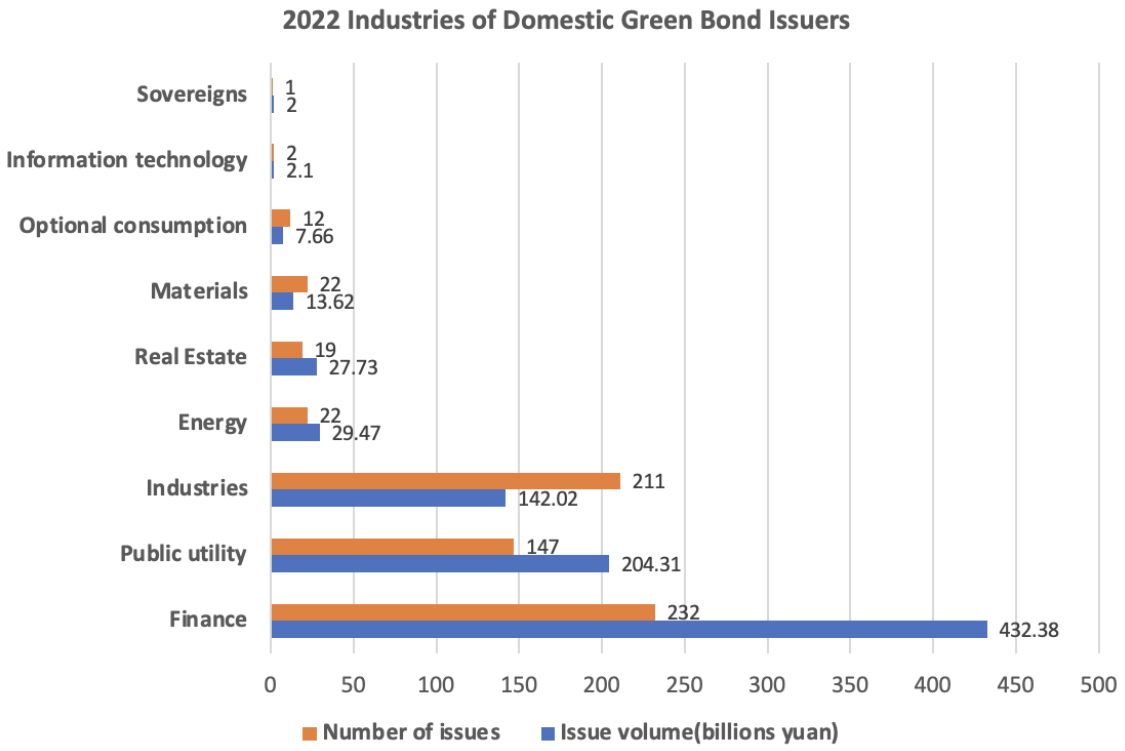

Figure 5 2022 Industries of Domestic Green Bond Issuers[5]

In Figure 6, it can be seen that in 2022, the proportion of 3-year green bond issuance scale in the total green bond issuance scale is 70.7%, an increase of 12.4 percentage points compared with 2021; the proportion of 5-year green bond issuance scale in the total green bond issuance scale is 12.73%, an increase of about 23.51 percentage points compared with the previous year; the proportion of 7-year green bond issuance scale in the total green bond issuance scale is 0.88%, with little change compared with the previous year; overall, the issuance term is concentrated in the short and medium term. The proportion of 7-year green bond issuance in the total green bond issuance scale is 0.88%, with little change compared with the previous year, and in general, the issuance period is concentrated in the short and medium term.

[5] *Data sources: China Bond Information Network. https://www.chinabond.com.cn*

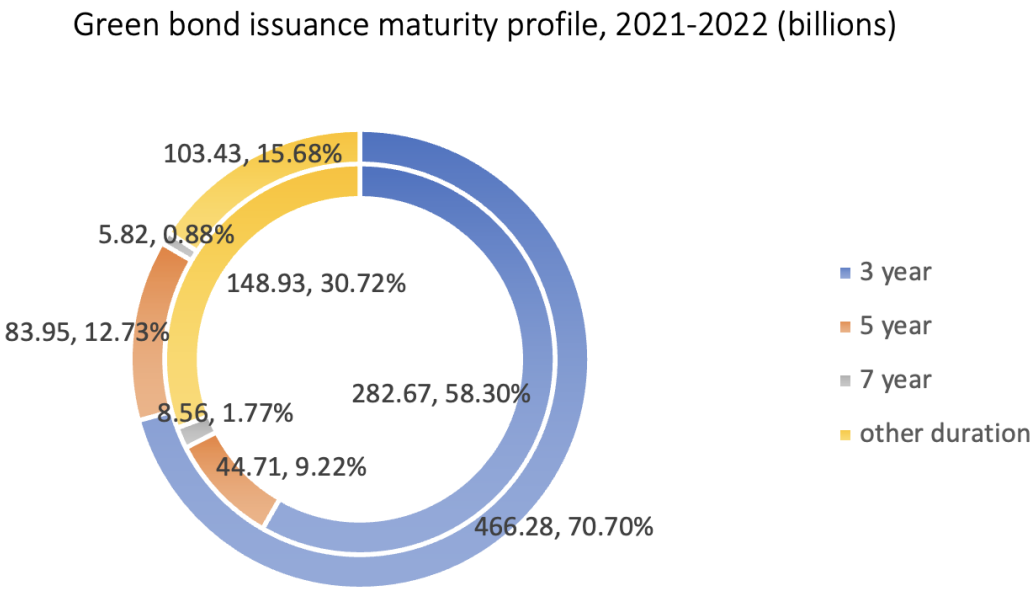

Figure 6 Green bond issuance maturity profile, 2021-2022 (billion yuan)[6]

In 2022, the main rating of green bonds will be mainly AAA, and the number of AAA green bonds issued will be 264, with a scale of 513.541 billion yuan. The number of issuances accounted for 39.52% and the scale accounted for 59.62%. Since 2016, the credit rating of green bond issuers has been dominated by AAA, and the proportion of unrated subjects has increased in recent years.

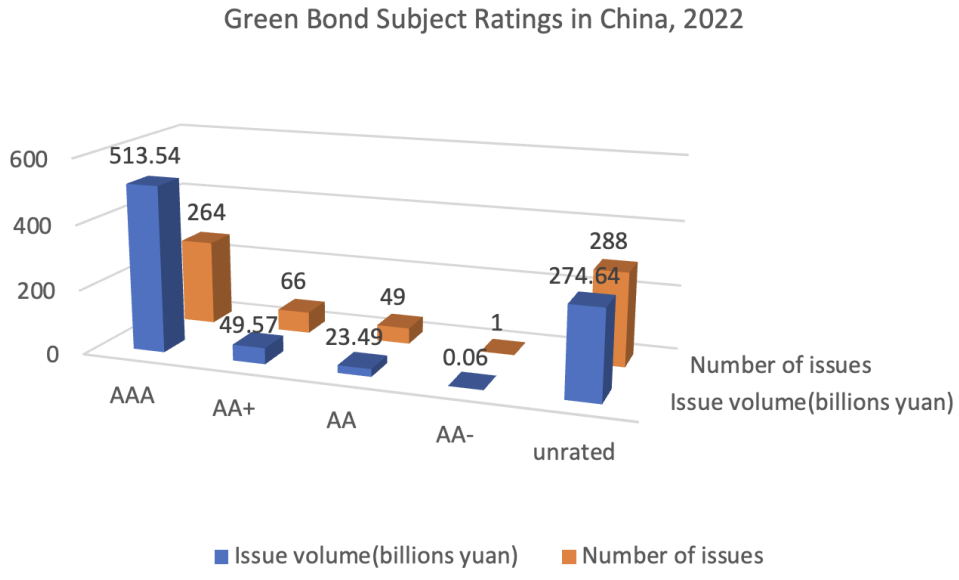

Figure 7 Green Bond Subject Ratings in China, 2022[7]

[6] *The outer ring shows green bond issuance in 2022 and the inner ring shows green bond issuance in 2021. Data sources: China Bond Information Network. https://www.chinabond.com.cn*

[7] *Data sources: China Green Bond Market Annual Report, Anrong Credit Rating Co. http://arrating.com.cn/*

From the perspective of bond rating, the number of AAA green bonds issued was 288, with a scale of RMB 542.180 billion. The number of issues accounted for 43.11% and the scale accounted for 62.95%. Since 2016, AAA rating has also dominated green bond debt ratings, but the proportion of unrated bonds has risen sharply due to the impact of the abolition of mandatory ratings in the issuance process by regulatory departments since 2021.

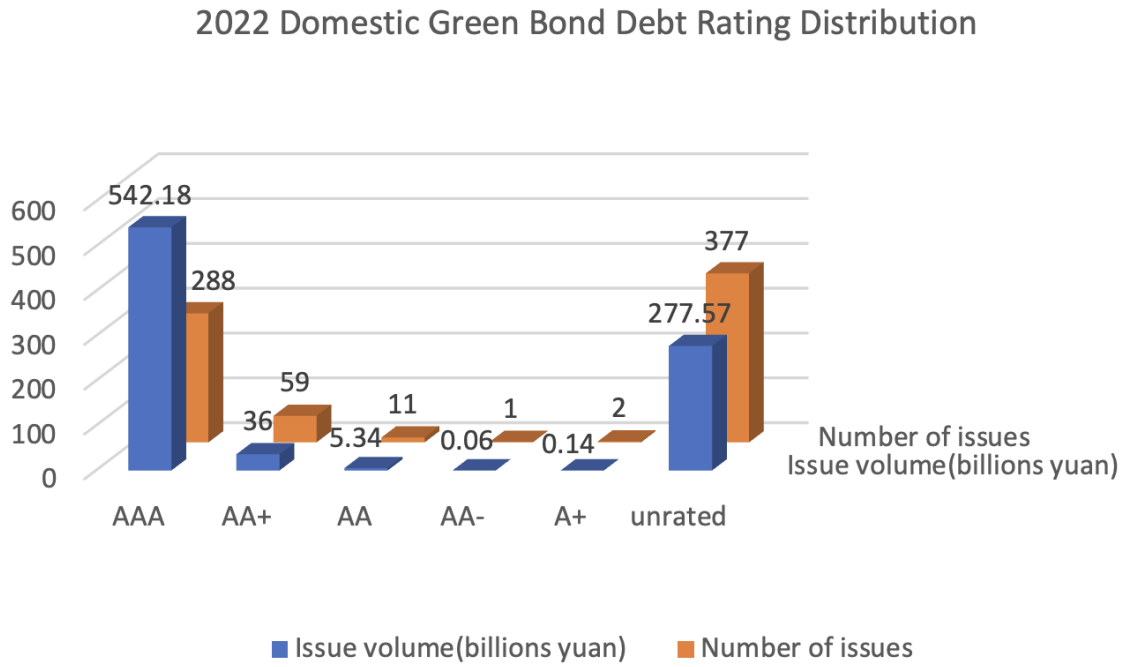

Figure 8 2022 Domestic Green Bond Debt Rating Distribution[8]

4. Empirical analysis

In the process of issuing green bonds, one of the most important indicators is the issuance rate. The issuance interest rate affects the price of green bonds, which is of great significance to the healthy and steady development of the market. The development of the green bond market will have a significant effect on the green finance sector. Therefore, it is necessary to study the green bond issuance rate. Chapter 3 introduces the development of China's green bond market, showing the rapid development of China's green bond market, but this market data can only show the "quantity" of green bond development. Has there been any change in the influencing factors of green bond issuance interest rates as of the latest data as of 2023? In particular, whether the Covid-19 has a

[8] *Data sources: China Green Bond Market Annual Report, Anrong Credit Rating Co. http://arrating.com.cn/*

significant impact on the entire green bond market. Therefore, we establish a model and conduct a regression analysis to analyze the factors that cause the fluctuation of issuance interest rates.

4.1. Selection of Research Variables

According to the above, the purpose of this thesis is to investigate the influencing factors of green bond issuance interest rate and the magnitude of the effect of each influencing factor, so the explained variable is set as the green bond issuance interest rate.

Explanatory Variables: Based on the literature review, we define the four categories of explanatory variables influencing the issuance rate of green bonds: macro factors, micro factors, green factors and Covid factors.

Macro factors

Gross Domestic Product (GDP): the gross domestic product is the core indicator of national economic accounting and an important indicator of a country's or region's economic status and development level. Therefore, GDP is closely related to the bond market, and a steady growth in GDP will certainly lead to an upward trend in the bond market. So I hypothesize that the coupon rate of green bonds will be positively correlated with GDP, i.e., when GDP grows, the coupon rate of green bonds will also grow.

Consumer price index (CPI): the consumer price index is one of the main macroeconomic indicators of inflation, and is used to reflect changes in the price level of consumer goods and services purchased by households. Rising CPI indicates inflation, and the central bank may adopt tightening monetary policy and raise benchmark interest rates to curb inflation. This could lead to higher interest rates in the overall bond market, including green bonds.

Benchmark interest rate: the benchmark interest rate in this thesis is selected from the interest rate of the national debt, the national debt as a kind of national credit-based bonds, its security is very high, basically zero risk. Therefore, I assume that the coupon rate of green bonds should be positively correlated with the treasury rate, i.e., when the treasury rate rises, the coupon rate of green bonds will also rise.

Micro factors

The nature of the issuer: the issues body, i.e., the issuer of green bonds, is mainly divided into state-owned enterprises and non-state-owned enterprises, and the authority and credibility of different issuing bodies are different, and the attraction strength for investors is also different. State-owned enterprises are relatively safe for investors, so the

interest rates demanded by investors should be low. So I assume that the interest rate on green bonds issued by state-owned enterprises should be lower.

Issue size: the scale of issuance indicates how many green bonds are issued. Under normal conditions, the size of a bond issue is directly proportional to the cost of financing, so it is generally believed that the larger the issue size, the more difficult it is to finance and the greater the cost. Therefore, I hypothesize that the issuance size is positively related to the coupon rate of green bonds, i.e., the larger the issuance size is, the higher the coupon rate of green bonds is.

Maturity: maturity refers to the number of years for repayment of bond principal determined at the time of bond issuance, the issuer of the bond must repay the principal at maturity, and the right of bondholders to recover the principal at maturity is protected by law. In general, the longer the term of the bond, the greater the impact of changes in market interest rates on its price, the greater the interest rate risk of the bond, the higher the interest rate demanded by the bond investors, the higher the yield of the bond. Therefore, I hypothesize that the maturity is positively related to the coupon rate of green bonds.

Bond rating: the bond rating is the credit rating of a bond as a target when the issuing entity issues the bond. A bond usually has both a bond rating and a subject rating. The higher the bond rating, the higher the credibility of the company. The higher the credit rating, the safer and less risky the bond. So, I'm assuming that the higher the credit rating, the lower the coupon rate on the green bond.

Green Factor

Third-party authentication: the third-party authentication is a kind of organization that consists of enterprises, business units, social groups and other organizations of various natures, and it does not belong to the category of state organs. It is approved by the Certification and Accreditation Administration of the State Council, and obtains legal personality according to law, and has a certain qualification to engage in certification activities within the scope of the approval of the agency. Third-party authentication has a certain degree of authority, can make the enterprise's reputation and word of mouth to enhance the third-party authentication is also conducive to investors to make investment choices. So, I assume that green bonds with the third-party authentication have lower coupon rates.

Covid Factors

Covid: the impact of the Covid-19 is a special consideration in this thesis. In general,, the COVID-19 pandemic has caused economic instability, and government may lower benchmark interest rates, leading to a decrease in the issuance yield of green bonds. So I assume that the Covid–19 affects the coupon rate of green bonds to be lower.

Variable		Name	Symbol	Definition
Explained variables		Coupon Interest Rate	Rate	Green Bond Issue Rate (%)
Explanatory variables	**Macro factors**	Benchmark interest rate	benchmark	Interest rates on government bonds of the same maturity in the corresponding month)
		GDP	GDP	GDP in the quarter of issue (billions of yuan)
		CPI	CPI	CPI in the quarter of issue
	Micro factors	Nature of the issuer	state	State-owned enterprises = 1, non-State-owned enterprises = 0
		Credit rating	rating	AAA=3, AA+ =2, AA=1, Other= 0
		Issue size	size	Size of bond issue (billions of yuan)
		Maturity	maturity	Maturity of bonds (in years)
	Green factor	Third-party authentication	authentication	Whether the bond is certified as "green" by a third party (Yes=1, No=0)

	Covid factor	Covid	Covid	Covid = 0 for green bonds issued before January 23, 2020; and Covid = 1 otherwise

Table 1 Explanation of relevant variables

4.2. Sample selection

From chapter 3 we can see that from 2016 to 2022, a total of 1,850 green bonds have been issued in China. I obtained the data from 2016 to May 2023 by accessing the Wind database, which is one of the most comprehensive databases in China, it has financial terminals covering global financial market data and information, as well as global macro and industry economic databases. I got 3,870 observations due to the fact that the same bond was broken down into different tranches, resulting in different interest rates, maturity dates and issuance times, but due to the incomplete latest data, most of them are concentrated in April and May 2023, for example, the CPI and GDP of that quarter have not been updated yet. At the same time, there were duplicates of data because it was traded in the interbank and the exchange at the same time, resulting in a different stock code, but all other information was the same, and I deleted the duplicates. After data cleaning, a total of 3,537 valid bond samples were obtained.

4.3. Descriptive statistics

The descriptive statistics of the variables are shown in the following table. The maximum value of the interest rate of green bond issuance is 8.5%, the minimum value is 0.1%, the mean value is 3.96%, and the standard deviation is 1.22, which indicates that the fluctuation of the interest rate of green bond issuance is small. The maximum value of green bond issuance size is 30 billion yuan, the minimum value is 4.8 million yuan, the average value is 1.41 billion yuan, and the standard deviation is 2.51, which indicates that the issuance size of green bonds fluctuates a little bit more than the issuance rate of green bonds. The maximum value of the issuance period of green bonds is 30 years, the minimum value is less than one month, the average value is 6.77 years, and the standard deviation is 6.56, which reveals that the distribution of the issuance period of green bonds is uneven, and most of the green bonds are medium- and long-term bonds. The mean value of the credit rating of green bonds is 1.87, and the median is 3, which indicates that green bonds with AAA rating still occupy the majority. At the same time, we can also

observe that: in terms of the nature of issuers, there are more non-state-owned enterprises; in terms of third-party authentication, there are more green bonds without green authentication; and in terms of the Covid, there are more green bonds issued after the beginning of the Covid-19.

vars	n	mean	sd	median	mad	min	max	se
Rate	3536	3.96	1.22	3.64	0.83	0.10	8.50	0.02
size	3536	1.41	2.51	0.70	0.65	0.00	30.00	0.04
bench-mark	3536	2.87	0.44	2.87	0.47	1.98	3.95	0.01
state	3536	0.39	0.49	0.00	0.00	0.00	1.00	0.01
rating	3536	1.87	1.35	3.00	0.00	0.00	3.00	0.02
Authenti-cation	3536	0.26	0.44	0.00	0.00	0.00	1.00	0.01
GDP	3536	26373.74	3820.54	26435.57	3993.00	16241.00	33550.79	64.25
CPI	3536	102.16	1.30	102.10	0.89	99.50	105.40	0.02
Covid	3536	0.64	0.48	1.00	0.00	0.00	1.00	0.01
maturity	3536	6.77	6.56	5.00	2.97	0.03	30.00	0.11

Table 2 Table of descriptive statistics for variables[9]

4.4 Correlation Matrix

The following table shows the results of correlation matrix. According to the correlation matrix of the variables, it can be concluded that: the green bond issuance rate is positively correlated with the benchmark interest rate and the correlation is strong; the issuance scale is negatively correlated with the issuance rate and the correlation is strong; the issuance period is negatively correlated with the issuance rate but the correlation is weak; the issuance rating is positively correlated with the issuance rate but the correlation is weak; the nature of issuance entity is negatively correlated with the issuance rate and the correlation is strong; the third-party authentication is negatively correlated with the issuance interest rate and the correlation is weak, indicating that the issuance interest rate of bonds with third-party authentication is lower than that of bonds without third-party certification. Meanwhile, the correlation between the explanatory variables is low, and it can be assumed that the model does not have the problem of multicollinearity.

[9] *Data source: https://www.wind.com.cn/,*"sd" refers to "standard deviation.", "mad" stands for "mean absolute deviation."

Rate	size	bench mark	state	rating	authentic-cation	GDP	CPI	Covid	maturity
1									
-0.21	1								
0.39	0.01	1							
-0.1	0.06	-0.33	1						
0.01	0.07	0.17	-0.04	1					
-0.06	-0.02	-0.3	0.27	-0.06	1				
-0.24	-0.01	-0.47	0.2	-0.13	0.24	1			
-0.02	-0.02	0.15	-0.18	0.06	-0.16	-0.42	1		
-0.36	0.02	-0.47	0.1	-0.13	0.18	0.66	-0.42	1	
-0.03	0.08	0.68	-0.38	0.11	-0.3	-0.18	0.19	0.02	1

Table 3 Table of correlation matrix

4.5. Modeling

Based on the variable selection and analysis described above, I developed a multiple linear regression model as follows.

$$Rate = \alpha + \beta_{1i} Macro + \beta_{2i} Micro + \beta_3 Covid + \beta 4\ Authentication + \epsilon$$

where α denotes the constant term, ϵ denotes the random error, β denotes the coefficient of the explanatory variable.

4.6. Result

This section provides results of multiple linear regression analyses performed in R.

term	estimate	std.error	t-value	p.value
(Intercept)	4.842	1.761	2.749	0.006
size	-0.082	0.007	-12.303	4.30E-34
benchmark	1.965	0.074	26.407	2.24E-140
state	-0.145	0.038	-3.833	0.0001
rating	-0.048	0.013	-3.870	0.0001
authentication	0.035	0.041	0.851	0.395
GDP	5.86E-06	6.12E-06	0.957	0.339
CPI	-0.056	0.016	-3.520	0.0004
Covid	-0.153	0.059	-2.567	0.0103
maturity	-0.092	0.005	-20.070	6.36E-85
Residual standard error: 0.9844 on 3526 degrees of freedom				
Multiple R-squared: 0.348, Adjusted R-squared: 0.3463				
F-statistic: 209.1 on 9 and 3526 DF, p-value: < 2.2e-16				

Table 4 Multi - regression analysis 1

The results of my first model are shown in table 4. Although the R-squared is not very high, only 0.35, which only shows that the model is a fair fit, the p-value is much less than 0.001, which indicates that the results are significant at the 0.1% level. We can clearly observe that the effects of third-party authentication and GDP are not significant, but the overall model is statistically significant. We try to remove the insignificant variables to see if we can improve the model.

term	estimate	std.error	statistic	p.value
(Intercept)	5.364	1.689	3.176	0.002
size	-0.083	0.007	-12.356	2.296E-34
benchmark	1.954	0.074	26.531	1.41E-141
state	-0.138	0.037	-3.688	0.0002
rating	-0.049	0.013	-3.911	9.37E-05
CPI	-0.059	0.016	-3.806	0.0001
Covid	-0.126	0.055	-2.303	0.021
maturity	-0.092	0.005	-20.336	5.00E-87
Residual standard error: 0.9844 on 3528 degrees of freedom				
Multiple R-squared: 0.3477, Adjusted R-squared: 0.3464				
F-statistic: 268.6 on 7 and 3528 DF, p-value: < 2.2e-16				

Table 5 Multi- regression analysis 2

After removing the variables, all the explanatory variables are still significant, and the model is still significant. However, we find that the R-squared of the model is not different from the previous one, which means that the new model has a similar fit, and overall, the model is not significantly improved.

Overall, my model is statistically significant, although the new model does not provide a better fit. I will not discuss the GDP results since it is not significant.

The regression coefficient of issue size is -0.08, which indicates that the larger the green bond issue size, the lower the green bond issue interest rate, which is inconsistent with the hypothesis. The reason may be the instability of the green bond issue size and other factors such as the issue period, or the selection of the bond size unit is not appropriate.

The regression coefficient of benchmark interest rate is 1.95, indicating that the green bond issuance interest rate will increase with the growth of benchmark interest rate,

which supports the hypothesis and indicates that the national bond interest rate has a strong guiding effect on the issuance interest rate of green bonds.

The regression coefficient of the nature of the issuing body is -0.14, there is a negative correlation between the issuing entity being a state-owned enterprise and the lower interest rates of green bonds. In other words, green bonds issued by state-owned enterprises may have lower issuance compared to those issued by non-state-owned enterprises. This is possibly due to the perception in the market that state-owned enterprises are generally considered more creditworthy, and investors may be willing to accept lower returns for a relatively safer investment. Importantly, this aligns with my earlier assumptions.

The regression coefficient of bond rating is -0.05, indicating that the higher the green bond rating is, the lower the issuance interest rate of green bonds, which verifies the hypothesis and shows that the green bond rating can reflect the risk status of green bonds, which in turn affects the issuance interest rate.

The regression coefficient of residents' consumption price index is -0.06, indicating that the higher the residents' consumption price index is, the lower the issuance rate of green bonds, this is contrary to the assumption. I think it is related to the strong support from the Chinese government for the development of green finance, especially through measures such as fiscal subsidies and tax incentives. As mentioned earlier, the Chinese government has put forward the Dual Carbon Policy for 2030. Additionally, according to the China's Green Bond Issuance and Investment Opportunity Report (Climate Bonds Initiative and SynTao Green Finance, 2020), China is projected to require annual support ranging from $424 billion to $566 billion for green investments until 2030.

The regression coefficient of maturity is -0.09, indicating that the longer the term of green bond issuance, the lower the interest rate of green bond issuance, and the hypothesis is rejected. This may be due to the fact that the green bond market has been developed for a short period of time and the issuance period fluctuates greatly.

The regression coefficient of the Covid is -0.13, p-value is 0.02, which is significant at the level of 5%, indicating that the green bond issuance rate decreases under the influence of the Covid. Dong Guo and Peng Han (2021) demonstrate that although green bonds can be used as a hedge against financial shocks, the epidemic did reduce the effectiveness of green bonds as a hedge against bonds, stocks and oil which indicates that the Covid has an important influence on the green bond. Nana Liu (2022) also pointed out that the interdependence between green bonds and associated assets is time-varying,

and one of the structural mutations in the dynamic conditional correlation between green bonds and associated assets is Covid-19. My results are in line with their research results. The Covid-19 did have a negative impact on the issuance of green bonds.

Finally, I mention that third-party green authentication does not have statistical significance, indicating that third-party green certification does not have a significant impact on the issuance rate of green bonds. This differs from the results of the previous literature from Yang & Shi (2020) and Zheng & Hu (2021). However, the data used in the previous literature are before Covid-19. Moreover, when analyzing the data of China's green bonds from 2016 to 2020, Zhen Sun et al (2022) concluded that third-party certification cannot significantly reduce the financing cost of financial green bonds, which also indirectly confirms my results. This results suggest that the Covid-19 may be the reason for the change in the interest rate structure of green bond issuance (especially the impact of third-party green authentication).

4.7. Result of extension analysis I

In order to verify the hypothesis that the Covid-19 has had an effect to authentication as a driver of the issuance rate, I perform the regression analysis on the two subsamples – before the Covid-19 and after the Covid-19. I divided all the data into two parts. Covid= 0 means that the observation is not in the Covid-19 period and Covid = 1 stands for observations in the Covid-19 period. Based on this split, I performed regression analyses on the two groups of data.

term	estimate	std.error	statistic	p.value
(Intercept)	-5.887	3.065	-1.920	0.055
size	-0.093	0.011	-8.254	0.000
benchmark	1.990	0.122	16.339	0.000
state	-0.047	0.066	-0.715	0.475
rating	-0.133	0.023	-5.748	0.000
authentication	0.153	0.082	1.860	0.063
GDP	0.000	0.000	4.523	0.000
CPI	0.041	0.028	1.431	0.153
maturity	-0.126	0.008	-16.330	0.000
Residual standard error: 0.9957 on 1247 degrees of freedom				
Multiple R-squared: 0.3741, Adjusted R-squared: 0.3701				

F-statistic: 93.17 on 8 and 1247 DF, p-value: < 2.2e-16

Table 6 Multi- regression analysis before "Covid"

term	estimate	std.error	statistic	p.value
(Intercept)	14.893	2.238	6.653	0.000
size	-0.082	0.008	-10.074	0.000
benchmark	1.619	0.103	15.790	0.000
state	-0.180	0.045	-3.996	0.000
rating	-0.015	0.015	-1.061	0.289
authentication	0.007	0.046	0.144	0.885
GDP	0.000	0.000	-3.661	0.000
CPI	-0.140	0.020	-6.856	0.000
maturity	-0.069	0.006	-11.185	0.000
Residual standard error: 0.9483 on 2271 degrees of freedom Multiple R-squared: 0.2067, Adjusted R-squared: 0.2039 F-statistic: 73.95 on 8 and 2271 DF, p-value: < 2.2e-16				

Table 7 Multi- regression analysis after "Covid"

Through this analysis, I have obtained different results. First of all, I must say that the Covid-19 epidemic has led to a change in the structure that affects the issuance rate. Although third-party authentication is not significant in my results, we can see that the nature of the enterprise before the epidemic has no significant impact on the issuance rate, but it is very significant after the beginning of the epidemic. After the beginning of Covid-19 epidemic, the changes in credit ranking and third-party authentication on issuance rates were completely insignificant. I think the significant impact of state-owned enterprise issuers is related to the non-significant credit ranking and third-party authentication, which is related to the sudden increase in risk of Covid-19 and the impact on investor sentiment and choice. Ziye Liu (2022) proposed that due to the sudden impact of the epidemic, the bond market has undergone significant changes, and systemic risk increases with the increase of Covid-19. Investors have started to change their investment choices, choosing bonds with stable characteristics. The Chinese government (2021), in proposing carbon peaking and carbon neutrality, has also stated that it will vigorously develop and support green and low-carbon investments by state-owned enterprises.

This all corroborates the results of my analysis that the nature of the green bond issuer becomes particularly important and has a significant impact on the nature of green bond issuance after the start of the Covid-19 epidemic.

4.8. Result of extension analysis II

term	estimate	std.error	statistic	p.value
(Intercept)	-0.740	0.231	-3.201	0.001
size	-0.082	0.007	-12.309	0.000
benchmark	1.894	0.077	24.448	0.000
state	-0.147	0.038	-3.887	0.000
rating	-0.051	0.013	-4.039	0.000
authentication	0.037	0.041	0.907	0.365
Covid	-0.089	0.054	-1.647	0.100
maturity	-0.089	0.005	-18.921	0.000
`GDP_G(%)`	0.021	0.006	3.584	0.000
inflation	0.010	0.021	0.486	0.627
Residual standard error: 0.9837 on 3526 degrees of freedom				
Multiple R-squared: 0.349,Adjusted R-squared: 0.3473				
F-statistic: 210 on 9 and 3526 DF, p-value: < 2.2e-16				

Table 8 Multi- regression of extension analysis II

I tried again to change GDP to GDP quarter-on-quarter growth and CPI to inflation. Considering that the gpd growth rate may be more reflective of the real growth of the economy rather than just the aggregate. The inflation rate highlights the overall trend of price changes. The result shows that the growth rate of GDP has a positive and significant effect on the interest rate of green bond issuance. I believe that in times of economic prosperity, investors may be more concerned about future sustainability and environmental development. Therefore, they are more likely to tend to invest in projects related to green bonds, which may also lead to an increase in the interest rates of these bonds. At the same time, high GDP growth rates may be accompanied by greater investment and capital flows, and the green bond market may be boosted by increasing investment in sustainability. Changes in supply and demand may lead to higher interest rates on green bonds. However, the inflation rate did not have a significant impact on the interest rates of green bond issues. This may be due to the special nature of the green bond market, which differs between green and traditional financial markets.

My first regression shows a negative impact of CPI and extension regression shows that if I change CPI to inflation, the coefficient is positive and insignificant. In this case, the relationship between inflation (measured by CPI) is not straightforward. Because I get different results if I use inflation.

5. Discussion of results

After empirical analysis, it can be got the following conclusions: The benchmark interest rate has a positive impact on the issuance rate of green bonds. Conversely, factors such as issuance scale, issuing entity nature, CPI, Covid-19, maturity, and GDP growth rate have a negative impact on the issuance rate of green bonds. The model constructed in this paper includes the new indicator - Covid-19. To analyze its role in green bond issuance rates, empirical data analysis that have been conducted indicates that if you want to reduce the overall green bond issuance rates, you need to put forward a reasonable and legitimate policy for the Covid-19 and make adjustments. Combining the results of the empirical analysis with the development of the green bond market summarized in the previous section, the following suggestions are made to reduce the financing cost of green bonds and promote the development of green bonds.

China, as a unique type of party-state different from any Western political system, sees the Communist Party ruling alone and possessing 'absolute' rights (Ren, 2013). This can also be seen from my empirical results, for example, the nature of the issuing entity has a significant impact on the issuance interest rates of green bonds. The following primarily offers suggestions to the government from different perspectives, in order to better align with the Chinese government's 'dual carbon' policy.

Expanding government support measures

The support policies enacted by the government have played a facilitating role in reducing the financing costs of green bonds. However, government support is not solely achieved through offering preferential subsidies to issuers of green bonds; rather, it aims to promote their healthy and sustainable development. To achieve the desired effect of fostering the development of the green bond market for the growth of the green industry, it is imperative to concurrently support issuers, financial institutions, and investors.

For issuers, the government can continue to support their issuance through various assistance policies, such as subsidies for government investments and bond discounts, attracting issuers to the market with financing advantages. Simultaneously, there is a need to lower the issuance threshold of green bonds and moderately reduce the capital requirements for companies issuing green bonds, facilitating the issuance process for small and medium-sized enterprises, particularly those associated with the green industry.

Encouraging local governments to establish green bond guidance funds, injecting state capital to enhance investor confidence, indirectly securing social financing for green

bond issuers, supports the development of the green bond market. Financial institutions should intensify the promotion of green bonds, providing investors with specific information and investment advantages to attract more participation.

For green bond investors, preferential measures such as interest subsidies should be offered to increase their investment returns and solidify their investment confidence. In the early stages of supporting the development of the green bond market, the government should increase the degree of policy support and adjust it as the market matures.

Enhancing information transparency of green bonds

The goal of green bonds is to promote the sustainable and healthy development of the ecological environment and natural resources, which are, to a certain extent, considered public resources. Therefore, the information related to the issuance and operation of green bonds should ensure a certain level of transparency. This is essential to safeguard the right to information and choice for investors, reduce investment risks, and consequently lower financing costs.

Firstly, it is crucial to improve the information disclosure system for green bonds. Strengthening this system provides bond investors, potential investors, and the public with more opportunities to understand green bonds. Additionally, it enhances the societal oversight of issuers of green bonds.

Developing green bonds fintech

Integrating financial technology with other advanced technologies to establish a comprehensive green bond information platform. Utilizing rapidly evolving technologies such as big data and artificial intelligence, the goal is to create an all-encompassing green bond information platform for the timely disclosure of relevant information. This facilitates easy access to information for investors and researchers, while also enabling regulatory authorities to track and scrutinize the entire process of green bond issuance.

Improving business-specific measures

Formulate and improve incentives and penalties for enterprises issuing green bonds. For enterprises of different sizes and natures, formulate incentives and subsidies that are in line with the enterprises' own needs, and speed up the progress of implementation. For example, in the event of an epidemic, the debt service period for green bonds can be extended appropriately. At the same time, more severe penalties should be imposed for rent-seeking behavior or violation of the principles of bond issuance in green bond issuance.

Harnessing government's exemplary and leading role

As the issuing entity, the government possesses higher resilience and risk tolerance compared to businesses, enabling the exploration of new areas for bond issuance, such as household greening projects and epidemic prevention and greening projects in construction. Simultaneously, building upon the solid foundation of existing green finance pilot zones, it is advisable to construct more comprehensive green development zones based on local conditions.

Strengthening "Green" awareness

To advance the “Paris Agreement” and China's “dual-carbon” policy, it is recommended to encourage people to strengthen their green awareness. Fostering awareness of green investments and refining green investment channels is essential. As information on green financial products becomes increasingly comprehensive, it is crucial to intensify promotional efforts and encourage investors to develop a green investment consciousness. Introducing more investment varieties, such as implementing special green bonds during epidemic periods with open public issuance, will provide investors with more reliable investment channels.

Standardizing quality requirements for Green Third-Party authentication

The insignificant results of third-party authentication may also be caused by the insufficient standardization of the authentication process. Existing green authentication organizations differ in their assessment and authentication contents during their business, and the regulatory authority lacks uniform standards for the quality of third-party assessment and authentication. Therefore, the regulatory authority should guide and supervise the third-party authentication bodies and formulate and improve the quality standards for green authentication, so that the assessment and certification work of third-party authentication bodies can be more standardized.

6. Conclusion

China's green bonds have developed rapidly in recent years, and the development status is good. This thesis aimed to identify influencing factors of green bonds' issuance rate. By means of multiple linear regressions, I found the following. Firstly, the benchmark interest rate has a positive impact on the issuance rate of green bonds. Conversely, factors such as issuance scale, issuing entity nature, Covid-19, maturity, and GDP growth rate have a negative impact on the issuance rate of green bonds. Secondly, the issuance rates of green bonds are influenced by various factors. It is worth noting that

the relationship between inflation (measured by CPI) and the issuance interest rates of green bonds is not straightforward. This thesis specifically models data separately before and after the onset of the Covid19 pandemic, revealing that the pandemic did indeed change the structure of factors influencing the issuance rates of green bonds. Thirdly, although the impact of GDP is not significant, the growth rate of GDP has a highly positive effect on the issuance rates of green bonds. Fourthly, CPI has a negative impact on the issuance rates of green bonds, contrary to expectations, particularly with a significant negative impact observed only after the onset of the Covid-19 pandemic. This is believed to be related to the strong support provided by the Chinese government in terms of funds and policies.

This thesis focuses on the significant impact of the Covid-19 pandemic on the issuance rates of green bonds. The Chinese government should adopt a moderately loose monetary policy while controlling inflation to stimulate financial market vitality. Additionally, during exceptional periods, the government should play a regulatory role in stabilizing market panic and mitigating the economic impact of unforeseen events.

Currently, the bond market in China is smaller compared to the stock market, with limited financing efficiency. The government should promote the overall development of the capital market, gradually rectifying the imbalance in the financing structure. Simultaneously, the government should enhance tracking and supervision of the financial market, establish a sound market management system, and facilitate quick and effective market stabilization during major crises.

In addition to stringent regulation, the government should relax intervention in the bond market and reasonably guide market development. Attention should also be given to the credit rating industry, improving the accuracy, fairness, and authority of third-party credit ratings, refining industry entry and exit mechanisms, regulating the behavior of institutions within the industry, preventing corruption, and avoiding market monopolies by a few institutions.

Undoubtedly, green bonds play an irreplaceable role in financing green projects. The standardized operation of the green bond market will expand corporate financing channels, reduce corporate financing costs, enhance the efficiency of social capital allocation, and promote green development while reducing waste of social resources. However, in the face of the rapid development of the green bond market, it is crucial to seriously address the hidden risks. Alongside active development, safeguarding the

standardized development of the green bond market is essential for assessing and preventing risks in the market.

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