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Government Subsidy, Green Credit, Carbon Information Disclosure and the moderation effect of Ownership Property: Evidence from Chinese Listed Agriculture-Related Firms

Weishi Song[1,2], Albattat Ahmad [1*], Zhongye Sun[2]

[1] Graduate School of Management, Management and Science University, Shah Alam 40100, Selangor, Malaysia

[2] School of Economics and Trade, Henan University of Technology, Zhengzhou 450001, China

weishi_song@163.com; dr.battat@msu.edu.my(Corresponding author); 13838332086@126.com

Abstract. From the Kyoto Protocol to the Paris Agreement Protocol, carbon information disclosure has gone from being a theoretical concept to an essential component of carbon trading and management. As agriculture is the second largest source of carbon emissions, the management and disclosure of carbon information of agricultural enterprises cannot be ignored. This paper collected carbon information disclosure data of Chinese agriculture-related enterprises during the eight years from 2012 to 2019,and measured the quality of carbon information disclosure by using content analysis and index method. The impact of government subsidies and green credits on the quality of carbon information disclosure and the moderating effect of ownership property were empirically explored. The results show that both government subsidies and green credits have favorable effects on the quality of carbon information disclosure. Government subsidies and carbon information disclosure quality are negatively moderated by ownership property, while green credit and carbon information disclosure quality are positively moderated by ownership property. This study fills a research gap in agricultural carbon information disclosure, expanding the study of the theory of carbon information disclosure and inventing the research subject. The results of this study may contribute to the development of more effective rules and policies to support agriculture-related firms to improve the quality of carbon information disclosure, and they may also be of interest to stakeholders such as banks and government policy makers.

Keywords: Carbon information disclosure, climate change, government subsidy, green credit, ownership property.

1. Introduction

One of the most important issues confronting industry and economies globally in this century is the increase in greenhouse gas emissions and overreliance on carbon-based fossil fuels (Hatakeda et al. 2012). An increasing collection of data is being produced by researchers into how greenhouse gases affect climate change. According to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (2021), anthropogenic greenhouse gas emissions have caused a temperature increase of about 1.1 degrees Celsius between 1850 and 1900, and within the next 20 years, it is anticipated that the global temperature average would rise to or above 1.5 degrees Celsius. Global warming will increase the frequency of natural disasters and public health incidents such floods, storms, heat waves, forest fires, and infectious disease epidemics (IPCC, 2022). The World Economic Forum (2020) states that the biggest danger to the coming decade may be the failure of climate change mitigation and adaptation. Global action is urgently needed to address climate change in order to prevent its disastrous impacts (Stern 2006). Global agreement on cutting carbon emissions, achieving green growth, and combating climate change is emerging. Reducing carbon emissions, achieving green development, and working together to address climate change are gradually becoming a world consensus. China has emerged as the world's top carbon emitter with the second-largest economy, accounting for 28 % of total CO2 emissions (He, 2021). Under the enormous pressure of carbon emission reduction, it needs both to develop its own economy and actively engage in international climate cooperation. China ratified the Kyoto Protocol in 1998, and it also ratified the Paris Agreement in 2016, making it one of the parties that completed the ratification of the agreement. China declared in September 2020 that its CO2 emissions would peak in 2030 and become carbon neutral by 2060. To reduce CO2 emissions and achieve carbon neutrality, the China Carbon Emissions Trading Center was founded on July 16, 2021.China also intends to gradually diversify the types of carbon emissions trading and extend the market to include more energy-intensive industries.

In order to encourage companies to monitor and report information about their GHG emissions, a variety of voluntary government programs (such as the European Union Emissions Trading Scheme) and non-governmental efforts (such as the Carbon Disclosure Project) have evolved since the late 1990s.These programs and projects seek to lower GHG emissions and encourage businesses to invest in low-emission technology. Enterprises must be proactive in addressing the potential problems caused by GHG emissions since they have an impact on them. For carbon trading and management, complete carbon information is necessary. It is also crucial for disclosure, reference, and forecast, as well as for macroeconomic growth, investor decision-making, and business internal operations (Luo&Tang, 2016). Carbon information disclosure (CID) can assist relevant businesses in identifying their carbon management strengths and weaknesses, cultivate the conscious economic benefits of coordinating emission reduction and development, and give investors access to data on corporate carbon emissions and carbon assets to aid in the oversight and control of these businesses' operational businesses.

Agriculture, forestry, and other land-use activities emitted around 13% of carbon and 44% of methane (CH4) between 2007 and 2016, according to the IPCC's Special Report on Climate Change and Land (2019), accounting for 23% of all net anthropogenic greenhouse gas emissions. Agriculture has become the second largest source of carbon emissions and is receiving increasing attention. As the world's largest agricultural country, developing low-carbon agriculture is crucial for China to achieve low-carbon economic development. The primary force behind the development of low-carbon agriculture is agricultural firms. With the increasing improvement of carbon trading market, the participation of agricultural enterprises in carbon trading is not only one of the ways to realize low-carbon agriculture, but also a way to solve the problem of environmental externalities with market mechanism. In this context, carbon information disclosure and carbon emission reduction of agricultural enterprises are crucial to a low-carbon economy. However, being the second-largest source of carbon emissions, agriculture, has not received sufficient attention in terms of its significance in carbon emission reduction. The existing carbon information disclosure mechanism in China is immature, with

the disclosure subjects being heavy polluting industries and mostly policy-based mandatory disclosure, and there are no mandatory carbon information disclosure requirements for other industries. Therefore, it's critical to comprehend what drives agriculture-related companies to better disclose carbon information.

The driving forces behind this study are the increasing economic significance of knowledge about carbon information disclosure, as well as the rising demand for information about carbon, especially the increasing attention to agricultural enterprises as the main actors in developing low-carbon agriculture. Therefore, this study examines the GHG disclosure levels of all agriculture-related firms listed on the Shanghai and Shenzhen stock exchanges from 2012 to 2019, and explores whether government subsidies and green credit affect the differences in carbon information disclosure levels, as well as the moderating effect of ownership property. This study makes a variety of literary contributions. First, this study fills a vacuum in the study of agricultural carbon information disclosure by filling it with listed firms that are relevant to agriculture, broadening the area of theoretical research on carbon information disclosure. In addition to the moderating influence of property ownership, this study also examines the crucial roles that government subsidies and green credits play in guaranteeing more openness in climate change actions. The study viewpoint is original, and the author is aware of no literature that has looked at how government subsidies and green credits affect the disclosure of carbon information. Third, the findings of this study might be utilized to build more effective laws, rules, and policies to support better quality carbon information disclosure in agriculture-related businesses. These findings may be of interest to government policy makers as well as stakeholders like banks.

The remainder of this study was structured as follows: Section 2 offered the literature review; Section 3 examined the theoretical framework and research hypotheses; Section 4 described the study strategy and methodology; Section 5 presented and discussed the empirical results; and Section 6 explored the conclusions and limitations.

2. Literature Review

2.1 Carbon information Disclosure

Many studies on corporate carbon information disclosure have been conducted by both the practical and academic worlds since the establishment of the Carbon Disclosure Project (CDP) in the UK in 2000.So far, we have not obtained a consistent understanding of carbon disclosure methods. According to some academics, carbon assets ought to be disclosed in the financial statements. In an effort to improve accounting standards, the EU, the US, Australia, and other nations have tried to incorporate carbon information. Another viewpoint holds that the carbon information can be revealed in financial statements using the carbon footprint accounting approach since the final product in the manufacturing chain is the breakthrough point for carbon footprint measurement (Caballo&Domenech,2010). Carbon information should include changes in financial returns, corporate strategy, business risks, potential violation hazards, and public liabilities faced by the corporation as a result of carbon emissions. In general, carbon information is an extension of environmental information on carbon issues. A separate environmental financial reporting form or descriptive disclosure in a business strategy report related to the financial statements are two different ways that disclosure can be made (Zhang,2010).

Prior research has used three main methods to assess the quality of carbon disclosure (Hahn et al., 2015): the first is a binary variable that assesses a company's participation in a particular voluntary carbon disclosure program (Stanny,2013); the second is the CDP's carbon disclosure score, which assesses the degree of thoroughness of a company's responses to CDP questions (Luo&Tang, 2014; Alsaifi, 2021); and the third is the Carbon Disclosure Index, where components are based on disclosure frameworks and standards, such as the CDP questionnaire (Choi et al., 2013), the ISO 14061 standard (Rankinet al., 2011), or a number of readily available frameworks and guidelines (Haque&Deegan, 2010). The disclosure index values are based on content analysis of corporate websites or environmental and sustainability reports (Freedman & Jaggi, 2005;Comyns,2016).

Academics have gradually started looking into the factors affecting the quality of carbon information disclosure as stakeholders' knowledge of low-carbon issues has increased. Overall, internal micro-level and external macro-level elements of organizations are the key influences and drivers of carbon information disclosure quality (Li, 2017). The results of Roman et al. (2021) with regard to the internal micro-level of enterprises demonstrate that the sustainability status of firms, gender diversity policies, and other firm characteristics (particularly firm size) considerably enhance carbon disclosure. According to Prado-Lorenzo et al. (2009), firm size and overall market capitalization were favorably connected, whereas profitability was adversely correlated with the disclosure of GHG information in 101 businesses across different countries. Zhao et al. (2019) found that firm characteristics such firm size, financial risk, industry characteristics, and sales growth rate had a significant impact on the disclosure of carbon information. In their empirical study of the impact of financial factors on CID, Chen&Wang (2017) discovered that business size, profitability, equity characteristics, and the percentage of outstanding shares all have a direct impact on CID. Additionally, Chithambo& Tauringana (2014) discovered that business size is favorably linked with transparency among 210 firms in the FTSE 350, but debt and financial slack are inversely connected with disclosure. According to Luo et al. (2012), economic and societal forces are strongly connected with the GHG information disclosure by Global 500 enterprises. These pressures are examples of external macro-level variables that drive firms to disclose GHG information. Focusing on the factors that affect carbon emissions disclosure (CED) in the annual reports of UK higher education institutions, Saha et al. (2021). The results indicate that actual carbon emissions, environmental audits, and government-mandated carbon reduction objectives are strongly and favorably related to disclosure of carbon emissions. Anwar et al. (2021) observed that the adoption of country-level carbon pricing regulations significantly boosted the number of voluntary environmental disclosures using a sample of 103 enterprises from 44 countries between 2015 and 2017.After reviewing the annual reports of 126 real estate businesses listed on Bursa et al. (2016) came to the conclusion that the main factors influencing disclosure are social, financial, and market forces. Additionally, Mia et al. (2021) used content analysis to study corporations' carbon disclosure in 219 annual reports from 73 Australian listed companies. The study's findings demonstrated that when environmental restrictions were made legal, the number of disclosures relating to carbon considerably rose.

2.2 Government Subsidy

Government subsidy refers to the act of the government giving public resources to a recipient in a one-way manner. An enterprise, such as one connected to a state-supported industry, a loss-making enterprise, etc., or an individual, such as a needy citizen whose income is below a specific criterion, can be the receiver. In this essay, we concentrate on government subsidies that businesses receive, i.e., financial and non-financial resources that are given to businesses by the government without payment. Gratuitous appropriation, financial subsidies, tax breaks, and gratuitous allocation of non-monetary assets are the major types of government support for businesses. Ex ante subsidies and ex post subsidies are two ways that government subsidies can be categorized from the perspective of enterprise government subsidies. Ex ante subsidies mainly refer to the government setting subsidy standards in advance, and eligible enterprises can obtain subsidies only after the government approves them through active application; ex post subsidies mainly refer to the government issuing subsidies for specific enterprises' specific behaviors after their economic behaviors occur, such as "tax contribution incentives" and "loss subsidies "etc. (Shi et al., 2020). Government subsidies have a resource endowment effect, and as a redundant resource, they can both directly fund business operations and intervene when necessary to share investment risks with businesses and address innovative market failures (Wu et al., 2014). According to the notion of resource dependence, organizations must collect essential resources from their environment in order to live, and the value of those resources defines how dependent those organizations are on their surroundings (Lin et al., 2015). Government grants have a big influence on how listed firms operate since they are a valuable limited resource. Typically,

businesses actively engage in social responsibility and work with the government to advance their policy objectives, which can help them access more resources and further their own development (Su &He, 2010; Du&Chen, 2016). Second, government subsidies have signaling effects that can help reduce the information asymmetry issue between borrowers and lenders as well as enable businesses to directly obtain liquid cash at no interest cost and increase their ability to service debt, sending out favorable financial signals to outside investors and boosting their confidence in making investments (Li et al., 2014).Additionally, government subsidies can be seen as a form of institutional legitimacy. In China, a strong government-enterprise relationship is more likely to send signals of a safe and sound operation to outside investors (Liu&Sun, 2006). Consequently, obtaining government subsidies is equivalent to giving outside investors an implicit credibility guarantee, which makes it simpler to attract outside investors to provide ongoing financial support. Finally, government subsidies involve policy orientation and judgment on the expected value of businesses, i.e., approval of government subsidies is more significant to the projected value of businesses' innovative R&D activities than other self-financing channels.Government subsidies express the national strategic policy direction, which is more likely to promote and sustain businesses' creative R&D operations, in contrast to the starting point of external investors focused on investment returns. Currently, businesses who disclose their social responsibility reports spend an increasing amount of attention to revealing the pertinent details of government subsidies. It is clear that the government's actual actions play a significant part in encouraging enterprise carbon information sharing.For businesses with higher profitability, the better the voluntary carbon information disclosure is done, the more they can benefit from additional rewards from the business, whether material or immaterial rewards, which can help build a positive reputation and image for the business and encourage long-term development of the enterprise, the establishment of subsidies can make businesses with lower profitability gain additional benefits and be more willing to make carbon disclosure.

Studies already conducted have revealed that as a direct form of governmental market involvement, government subsidies may encourage businesses to enhance environmental performance in a variety of ways, including front-end prevention and end-of-pipe treatment (Yuan&Kong, 2015; Luet al. 2019; Wang& Zhang, 2020).Wu&Yang (2014) find that government subsidies can be considered as firm-specific redundant resources, and firms can invest the acquired redundant resources in environmental investment activities. Wang&Xie (2014) find that Chinese firms rely mainly on self-financing and external government support for the end-of-pipe management of pollutant emissions. Government subsidies, as an effective ex ante incentive, can directly or indirectly transfer payments to microeconomic agents, bringing more disposable financial resources to enterprises, including direct financial earmarked funds and indirect financial support from other channels (Guo, 2018), alleviating the financial shortage barrier of enterprises' green governance and enhancing their awareness of environmental responsibility and environmental protection investment capacity (Shi et al., 2016; Lu et al. 2019).Baietal(2018) found that energy-intensive and pollution-intensive firms would actively carry out environmental investment activities, including the introduction of energy-saving technologies to improve energy use efficiency, with substantial financial support from the government. According to Lu et al. (2019), financial support from local governments can help businesses become more conscious of their environmental responsibilities and encourage them to invest more in green initiatives. These initiatives then have an impact on the production system and serve as a front-end preventative measure. Regarding its impact mechanism, Yue (2018), Liu & Wang (2019), and Chen et al. (2019) argue that the key reason why government subsidies can enhance the environmental performance of enterprises is that government subsidies have capital supplementation and signaling effects, which to a certain extent widen the financing channels of enterprises, alleviate the financial constraints of their environmental protection activities, and provide diversified financial support for their environmental protection investments. Cheng (2015) proposed that, based on government subsidies, enterprises that conduct proactive carbon emission reduction strategies in which the enterprises' investment in carbon emission

reduction strategies increases with the increase of government over-subsidy coefficient, confirming that government subsidies are a key factor in enterprises' proactive carbon emission reduction. Government subsidies have a resource endowment effect, and as a redundant resource, they can both directly fund business operations and intervene when necessary to share investment risks with businesses and address innovative market failures (Wu et al., 2014).

2.3 Green Credit

In October 2002, the International Finance Corporation (IFC) and ABN AMRO Bank introduced the Equator Principles in London, which attempt to decide whether to grant loans by measuring and judging the social and environmental risks of projects (Karim, 2016). Green credit originates from the Equator Principles, which refers to the lending process in which financial institutions fully consider environmental and social risks in the process of promoting sustainable social development and direct funds to environmentally friendly industries and projects in accordance with national environmental policies and laws and regulations, thus achieving a "green allocation" of credit resources (Zagaria, 2018). The core concept of green credit is that financial institutions should take the environmental factors of enterprises as an important principle when granting loans, support loans for environmentally friendly enterprises and implement preferential low interest rate policies, and restrict loan projects for polluting enterprises, so as to influence the environmental and socially responsible behavior of enterprises through financial means and ultimately achieve long-term, green and sustainable development. According to Lin (2021), the essence of green credit operation lies in guiding the development direction of enterprises from the source of funds, reducing credit support for highly polluting enterprises or adopting high interest rate credit for their credit and stopping new credit support, cutting off bank support for their capital chain from the source and forcing the enterprises to withdraw from the market or transform. To engage in environmental protection construction, resource recycling and other enterprises with high environmental benefits to lower the threshold of entry, so that funds flow to environmental projects and industries at lower interest rates. In this way, more capital as well as social capital can be realized to flow into green industries. In other words, the essential difference between green credit compared to traditional credit is whether banks consider the environmental impact of the project or enterprise when conducting credit operations. According to Wu et al. (2012), green credit can improve corporate information transparency, strengthen the connection between the financial and environmental protection sectors, and jointly send signals to the capital market to strengthen the environmental supervision of enterprises. As a result, external creditors may be less willing to lend money to heavily polluting businesses. Yao&Wang (2016) contend that the high cost of debt for polluting companies is inversely related to the high caliber of environmental information disclosure of companies, and that the adverse relationship between the two is strengthened in the context of green credit policy, which aims to restrain polluting companies' excessive emissions. Bouma et al. (2003) argue that the financial system is also able to incentivize the transformation of enterprises with backward capacity through pricing mechanisms and incentive effects (2003) suggest that the financial system can also incentivize the transformation and upgrading of enterprises that are lagging behind through pricing mechanisms and incentives, thus achieving harmonious economic and environmental development. According to Yang (2011), the implementation of green credit policies will force businesses to consider the growth and transformation of their operations, and major polluters will decrease their investments in production and increase their investments in emissions control in light of environmental management policies. Ma et al. (2020) came to the conclusion that the implementation of green credit policy can significantly inhibit the emission behavior of enterprises, but not via active R&D and technological upgrading, but rather through the financing constraint to cause a negative impact on the physical operation of heavy polluting enterprises, which in turn forces them to passively scale down their production and thus achieve emission reduction. In order to empirically test the impact of green credit on corporate environmental information disclosure, Kim (2021) analyzed the influence mechanism of green credit on corporate environmental information disclosure and subsequently

proposed hypotheses related to impact transmission channels and heterogeneity characteristics. Kim came to the conclusion that green credit significantly contributes to corporate environmental information disclosure (Albitar, 2020). The effect mechanism test revealed that finance restrictions and environmental performance channels are the key ways that green credit influences business environmental information disclosure. Ni & Kong (2016) and Wang et al. (2019) also mentioned in their study that the implementation of green credit policies prompted financial institutions to pay full attention to the fulfillment of corporate environmental responsibility, and prompted enterprises to disclose environmental information proactively by effectively linking their financing needs to their environmental responsibilities.

2.4 Ownership property

Given that it reflects the company's capital situation, ownership structure is taken into consideration when determining how to disclose GHG emissions. State-owned and non-state-owned firms make up the majority of businesses in China, with the former having a significant executive power in implementing national policies. Previous research has demonstrated that government-controlled businesses are more focused on social and environmental problems, such as reducing GHG emissions (Amran & Devi, 2008; Haji, 2013; Tagesson et al., 2009). According to a study by Mei, et al. (2020), private enterprises are more likely to share information while under pressure from outside environmental legitimacy concerns because of the nature of equity. The study shows that state-controlled enterprises, due to their special nature, besides maximizing profits, their greatest role is to reflect the government's utility goals and pursue the maximization of social interests, in addition, the management position of state-owned enterprises is somewhat political and the environmental and social responsibilities undertaken by the enterprises are directly linked to their political performance (Philipp, 2017), therefore, in order to form role models, the management of SOEs due to political aspirations, Guanz & Li (2016), an empirical analysis found that both the number of analysts followed up and the nature of state ownership have a positive impact on carbon disclosure. The government will be more worried about how a firm will be affected by regulations as the owner of that company (Habbash, 2016). According to Reid&Toffel (2009), when new GHG disclosure rules are passed, the government may serve as a catalyst for change. By revealing GHG emissions, managers' propensity to resist governmental pressure can be lessened. According to earlier research, the company's status as a state-owned enterprise significantly improves the sharing of carbon information. As a result, SOEs are more involved in energy efficiency and carbon disclosure than non-SOEs.

3. Theoretical framework and hypothesis development

3.1 Stakeholder theory and legitimacy theory

A variety of theories have been used to justify and explain why businesses disclose certain environmental and social data, such as stakeholder theory, which describes how businesses are oriented towards environmental responsibility in response to the divergent stakeholder desires (Macve&Chen, 2010). Stakeholder theory (Roberts, 1992) suggests that carbon disclosure may be seen as a reaction to stakeholders' informational demands about climate change as a crucial societal issue. Companies provide information on their carbon emissions in response to stakeholder demand. As a result, the effect of many stakeholders on the urgency of a company's reaction (Deegan, 2006). Stakeholder thinking, according to Freeman et al. (2010), encourages socially and ethically responsible accounting, auditing, and reporting. This theory's proponents contend that managers utilize disclosure as a starting point for conversations with various audiences. Companies have a strong incentive to react to stakeholder inquiries regarding their actions that result in pollution since doing so would show that they live up to investment expectations. Due to global warming, different stakeholders, such as governments, creditors, investors, regulators, and other individuals or groups, will demand carbon disclosure in order to legitimize their environmental performance.

The incentives for carbon disclosure are also explained by legitimacy theory (e.g., Suchman, 1995). According to the legitimacy hypothesis, environmental disclosure in general and carbon disclosure specifically are responses to demands from outside sources (Patten, 2000). Agency theory, signaling theory, and institutional theory One of the many sub-branches of legitimacy theory is institutional theory (Faisal et al., 2018). According to institutional theory, companies are motivated to progressively modify their conduct to fulfill demand by external institutional expectations (Meyer&Rowan, 1977). Both Prado&Garcia-Sanchez (2010) and Grauel&Gotthardt (2016) effectively used it in their investigations. The national institutional context affects how businesses behave in CID. Agency theory states that CID makes it easier to lessen the knowledge asymmetry between insiders and outside shareholders, which lowers the cost of agency (Healy, 2001; Giannarakis et al., 2018). According to signaling theory (Connelly et al., 2011), corporate management can use CID to communicate "low-carbon" signals to stakeholders, reducing information asymmetry between the firm and stakeholders, enabling outside investors to fully comprehend the relevant firm's development, and altering how investors view the firm and the decisions that are made in relation to it. This improves investors' impressions of the company and its actions while also reducing the information asymmetry between the company and its stakeholders. It also creates the necessary framework for external investors to completely comprehend the company's current state of development. Therefore, in order to improve their reputation or gain resources, relevant businesses frequently release good news or positive information to the market (Luo et al., 2012; Ben-Amar et al., 2017).

Because GHG emissions are ongoing and widespread and because climate change may have a positive or negative impact on businesses directly or indirectly, this study makes use of stakeholder and legitimacy theories (Liao et al., 2015). Businesses must take comprehensive strategic decisions that will impact their future growth in order to mitigate the effects of climate change. Some stakeholders, including as governments and creditors, will support these climate change policies in order to improve their reputation or gain access to financial and governmental resources, and these decisions may have a variety of effects on various interest groups (Luo et al., 2012; Ben-Amar et al., 2017).

3.2 Hypothesis development

The hypothesized correlations between the study's dependent variable, independent factors, control variables, and moderating variable are shown in Figure 1.

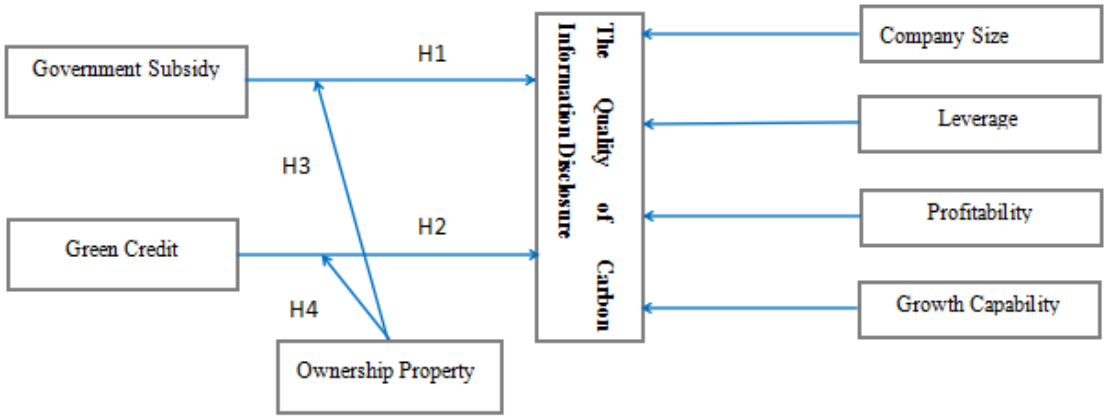

Fig.1: Quality Model

Government subsidies as an effective means of financial as incentive can directly or indirectly make transfer payments to microeconomic agents, bring more disposable financial resources to enterprises, including direct financial special funds as well as indirect financial support from other channels (Guo, 2018), alleviate the financial shortage barrier of enterprise green governance, and enhance the awareness of environmental responsibility and environmental protection investment capacity of enterprises (Shi et al., 2016; Lu et al. 2019). Second, government subsidies have a capital

supplementation effect and signaling effect, which to a certain extent widens the financing channels of enterprises, alleviates the financial constraints of their environmental protection activities, and provides diversified financial support for their environmental protection investments. After receiving government subsidies, enterprises tend to maintain their environmental investment, take the initiative to assume environmental responsibility, and "return the favor" through reciprocal behavior, strengthening the government-enterprise bond (Can et al., 2015). Therefore, government subsidies aid in raising the standard of carbon information disclosure by agriculture-related enterprises.

H1: Government subsidy is positively correlated to the carbon information disclosure quality.

The essence of green credit operation lies in guiding the direction of enterprise development from the source of capital, reducing credit support for high pollution enterprises or adopting high interest rate credit for their credit and stopping new credit support, cutting off bank support for their capital chain from the source and forcing the enterprises to withdraw from the market or transform. Commercial banks will gradually scale down their financing to businesses that produce a lot of pollution and use a lot of energy, while increasing their lending to businesses that do not produce as much pollution, use less energy, and safeguard the environment, so it can produce varying degrees of incentives for the capital formation of different types of enterprises. Using financial tools to affect how businesses behave in terms of social responsibility and environmental protection, and ultimately achieve long-term, green and sustainable development. Therefore, if the more environmental information companies disclose, the more environmentally conscious they are, financial institutions will increase their loan support to these companies and lower their loan interest rates during loan review. As a result, businesses will frequently take the initiative to disclose carbon information and try to enhance the quality of disclosure in order to gain a competitive edge in the capital financing market and get more bank loans.

H2: Green credit is positively correlated to the quality of carbon information disclosure.

The different nature of enterprise equity can lead to many differences in, for example, business models and investment decisions. Depending on whether they represent the interests of the state, classified as state-owned or non-state-owned, with state-owned businesses often disclosing more information than non-state-owned businesses.In SOEs, the state acts as the owner and entrusts entrepreneurs with management and supervision by the government, which represents the state, and thus SOEs differ significantly from non-SOEs in terms of day-to-day operations and governance structures. Government subsidies usually include national policy orientation and research on the expected value of enterprises, and the management status of SOEs is somewhat political, and the environmental and social responsibilities undertaken by enterprises are directly linked to their political performance (Philipp, 2017); therefore, government subsidies have a greater impact on whether SOEs disclose carbon information and the level of disclosure. Banks and other financial institutions have long responded positively to the call of the Party Central Committee to widely promote green credit policies and attach great importance to the environmental information disclosure of enterprises. If an enterprise has high environmental risks and inadequate disclosure of environmental information, then it is likely that banks and other financial institutions will refuse to lend. Since the controlling shareholders of SOEs and most banks are the government, whether SOEs disclose carbon information and the level of disclosure have little impact on obtaining bank loans; on the contrary, since non-SOEs have long been discriminated against by credit, it is difficult to obtain loans if they do not disclose environmental information in accordance with the green credit policy. The more banks can comprehend the environmental performance of non-SOEs, the easier it is for them to receive credit funds. This is due to the increased level of carbon information disclosure. Therefore, the level of disclosure and whether non-state firms report carbon information are more influenced by green credit.

H3: The ownership property has a negative moderating effect between government subsidy and carbon information disclosure quality.

H4: The ownership property has a positive moderating effect between green credit and carbon information disclosure quality.

4. Research design and methodology

4.1. Empirical model

It is reasonable to employ a fixed effects model to test our hypotheses because our sample is imbalanced. The adoption of a fixed effects panel data model enhances control for unobserved firm heterogeneity and the precision of inference of model parameters, which increases estimation efficiency (Hsiao2007), while increasing the variability of the sample and reducing the covariance among variables, while adding a greater degree of freedom than time series and cross-sectional data (Baltagi2008).

To test the research hypotheses H1 and H2, regression model (1) is set up in this paper. Model (1) is a multiple regression model of government subsidy and green credit on the quality of carbon information disclosure.

Model(1):

$$cid = \beta_0 + \beta_1 * sub + \beta_2 * grc + controls + \varepsilon$$

In order to verify the research hypotheses H3 and H4, regression model (2) is set up in this paper. Model (2) is a multivariate regression model to verify the moderating effect of the ownership property on government subsidy, green credit and carbon information disclosure quality.

Model(2):

$$cid = \beta_0 + \beta_1 * sub + \beta_2 * grc + \beta_3 * \mathrm{pr} + \beta_4 * \mathrm{grcpr} + \beta_5 * \mathrm{subpr} + controls + \varepsilon$$

In the above model, *cid* represents the quality of carbon disclosure, *sub* represents government subsidy, *grc* represents green credit, *pr* represents the ownership property, *controls* represent the control variables, and ε represents the error term.

4.2 Measurement of variables

Government subsidy and green credit are the study's independent variables, while carbon disclosure which is determined by how much carbon information is disclosed is the dependent variable. Firm size, leverage, profitability, and growth potential are the control variables. Table 1 provides details on the measurement of these variables.

Table 1 Details of Variables

Variable Types	Variables	Measurement	Data source
Dependent Variable	cid	CID Index	Annual Report, Social Responsibility Report and Sustainability Report
Independent Variables	sub	Logarithm of total government subsidies	CSMAR
	grc	Ratio of industrial sectors' overall interest costs to those of non-energy-consuming industries	China Energy Statistical Yearbook, China Statistical Yearbook, and statistical yearbooks of each province
Control Variables	siz	Total assets' natural logarithm at the conclusion of the time period	CSMAR
	lev	The proportion of total liabilities to total assets at the conclusion of the term	CSMAR
	roa	Net profit to Net Assets Ratio	CSMAR
	gro	Growth rate of operating income	CSMAR
Moderating Variable	pr	1 if the entity is a government or a government-controlled entity; 0 otherwise (Ruiqi et al., 2017)	CSMAR

4.2.1 Measurement of the dependent variable

The dependent variable in this study is the standard of carbon disclosure. We employed content analysis techniques that are frequently employed in carbon disclosure studies (e.g., Clarkson et al., 2008; Freedman&Jaggi, (2011); Dwyeret al., 2009; Haque & Deegan, 2010; Yu,2015; Kiliç & Kuzey, 2019) to evaluate carbon disclosure. Its basic methodology is to convert the textual, non-quantitative valuable information in the medium into quantitative data, measure the complexity of the information by creating meaningful categories, and use it to analyze specific characteristics of the information. Content analysis is a specialized technique for the objective and systematic quantitative analysis of the content of literature. Content analysis is widely used in performance and disclosure studies in the financial, social, and environmental fields. This study will utilize content analysis to examine how listed agricultural companies disclose information about carbon in their annual reports, social responsibility reports, and sustainability reports. (Friedman & Jaggi, 2005; Clarkson et al., 2008; Li et al. 2017). Based on the descriptions of carbon disclosures in CDP (Carbon Disclosure Project), CDSB (Climate Disclosure Standards Board), and CRDI (Climate Risk Disclosure Initiative) documents, as well as on earlier studies using carbon disclosure indices (e.g., Haque & Deegan, 2010; Choi et al., 2017), this study gives varying scores to the indicators in the corporate carbon disclosure evaluation index. Table 2 displays the 30 indicators that were established in this study's carbon information disclosure evaluation index system across its six aspects. The carbon information obtained from the content analysis method is divided into quantitative information with data disclosure and non-quantitative information with textual content, and each public quantitative information is assigned a value of "2" and each public qualitative information is assigned a value of "2". Each publicly available quantitative information is assigned a value of "2", each publicly available qualitative information is assigned a value of "1", and "0" is used for non-disclosure.

Table 2 Content Details

Disclosure content	Disclosure items	Assignment
Carbon risks, strategies and targets	Climate-related risks	0=no description; 1=qualitative description; 2=quantitative description (monetary/numerical description)
	Climate-related opportunities	0=no description; 1=qualitative description; 2=quantitative description (monetary/numerical description)
	Low carbon strategy	0=no description; 1=qualitative description; 2=quantitative description (monetary/numerical description)
	Energy efficiency goals	0=no description; 1=qualitative description; 2=quantitative description (monetary/numerical description)
Disclosure of greenhouse gas emissions	CO2 emissions	0=no description; 1=qualitative description; 2=quantitative description (monetary/numerical description)
	SO2 emissions	0=no description; 1=qualitative description; 2=quantitative description (Monetary/numeric type description) (Chemical Oxygen Demand)
	COD emissions	0=no description; 1=qualitative description; 2=quantitative description (monetary/numerical type description)
	Soot and dust emissions	0=no description; 1=qualitative description; 2=quantitative description (monetary/numerical description)
	Industrial solid waste generation	0=no description; 1=qualitative description; 2=quantitative description (monetary/numerical description)

Carbon performance and carbon governance disclosure	Exhaust gas emission reduction governance	0=no description; 1=qualitative description; 2=quantitative description (monetary/numerical description)
	Dust and fume management	0=no description; 1=qualitative description; 2=quantitative description (monetary/numerical description)
	Solid waste utilization and disposal	0=no description; 1=qualitative description; 2=quantitative description (monetary/numerical description)
	Cleaner production implementation	0=No description; 1=Qualitative description; 2=Quantitative description
Regulatory and Certification Disclosure Form	Key Pollution Monitoring Unit	The report discloses that the company is a key monitoring unit and assigns a value of 1, otherwise it is 0.
	Pollutant emission standards	Pollutant emission standards are assigned a value of 1, otherwise 0
	Sudden environmental accident	If there is a sudden major environmental pollution incident, the value is 1, otherwise it is 0
	Environmental violations	Environmental violations occur, the value is 1, otherwise it is 0
	Environmental petition case	If there is an environmental petition case, the value is 1, otherwise it is 0.
	ISO14001 certification or not	ISO14001 audit, the value is 1, otherwise it is 0
	ISO9001 certification or not	If the company had passed the ISO9001 audit, the value is 1, otherwise it is 0
Carbon Management Disclosure	Low Carbon Philosophy	If the company had disclosed the company's low carbon philosophy, policy, low carbon management organization structure, circular economy development model, green development, etc., assign a value of 1, otherwise 0
	Carbon Management System	If the company had disclosed carbon management system, system, rules, obligations, and other management systems, assign a value of 1, otherwise 0
	Low carbon education and training	The low carbon related education and training that the company had participated in disclosed and are given a value of 1, otherwise 0
	Environmental protection special action	The company's participation in environmental protection special activities, environmental protection and other social welfare activities are given a value of 1, otherwise 0
	Environmental Emergency Response Mechanism	The company's emergency response mechanism for major environmental emergencies, the emergency measures taken, and the treatment of pollutants, are given a value of 1, otherwise 0
	Environmental honors or awards	If the company had disclosed the honors or awards received by the company in environmental protection, assign a value of 1, otherwise 0
	"Three simultaneous" system	If the company had disclosed the implementation of the "three simultaneous" system by the company, assign a value of 1, otherwise 0
Listed company's carbon information disclosure carrier information	Listed company's annual report	1=yes; 0=no; whether listed company's annual report discloses carbon-related information
	Social responsibility report	1=Yes; 0=No; whether the listed company's social responsibility report discloses carbon-related information
	Environmental report	1=Yes; 0=No; whether listed company discloses environmental report separately

4.2.2 Measurement of independent variables

Government subsidy and green credit are the explanatory variables in this study. Government subsidy was measured as the logarithm of total government subsidies. Scholars such as Xu (2014), He&Liu (2016) consider government subsidies items in non-operating income as government subsidies. This paper refers to this approach and uses the logarithm of total government grants as the measure. The data are extracted from the CSMAR database "Notes to Financial Statements" under "Specific Items" of "Non-operating Income or Expenses", and the line items related to government grants are manually screened to obtain Total government grants. This paper chooses the ratio of interest expenses to total interest expenses of industrial industries for non-six energy-consuming industries in each province where the enterprises are located to measure green credit, referring to the study by Xie&Liu (2019) (Jiang et al., 2020). For this reason, the ratio of interest spending of low-energy-consumption companies to total interest expenditure of industrial industries can, to a certain extent, evaluate the amount of green credit. Interest expenditure can indicate the size of credit. Data are taken from the China Energy Statistical Yearbook, the China Statistical Yearbook, and the province-specific statistical yearbooks.

4.2.3 Measurement of control variables

In this study, we refer to researchers in relevant disciplines such as Xing&Zhang (2014), Chen et al. (2016), and Jing (2015) and incorporate four control variables in the regression model to control for company characteristics that may drive the analyzed connection. Four factors were chosen as additional factors influencing the quality of carbon information disclosure: business size, financial leverage, profitability, and expansion capability. Firm size comes first. In comparison to small businesses, large corporations are more likely to attract public attention. For major organizations, investors have higher standards for the quality of the information. To boost their reputation, large corporations will publicly release carbon information. (Prado et al., Luo et al., 2013; Stanny&Ely, 2008) The natural logarithm of the total assets at the conclusion of the period, which is how we calculate firm size, is taken into account. Data are taken from the "Total Assets" section of the "Financial Statements" database in the China Securities Market and Accounting Research Database (CSMAR). The second factor is monetary risk. Highly indebted enterprises are more likely to provide inaccurate carbon information since they are under higher financial strain. (Adams & Hardwick, 1998; Brammer & Millington, 2004; Giannarakis, 2014). Financial leverage is measured by the debt ratio of listed companies. Data are obtained from the CSMAR database under "Financial Statements" for "Liabilities" and "Total Assets". The ratio of total liabilities to total assets at the conclusion of the period is used to measure financial leverage.which is a visual and comprehensive measure of the level of indebtedness of the company. Again, it is profitability. High-profitability businesses have enough cash on hand to guarantee they can pay the expenditures related to CID. In contrast, the release of carbon data promotes a positive business reputation, which in turn draws in additional investors. Because of their own resource limitations, less profitable companies are less inclined to willingly divulge pertinent information. Return on Net Assets is a metric used to assess profitability for listed corporations. Data is taken from "Net Income" and "Net Assets" in the CSMAR database "Financial Statements". Return on assets, often known as profitability, which is calculated as the ratio of net profit to net assets, is a key metric for determining the profitability of publicly traded organizations. Lastly, growth capability. The rate of operational income growth illustrates a company's capability for expansion. The data is taken from the "Operating Income Growth Rate" in the CSMAR database "Financial Statements", and this indicator measures the company's future growth ability.

4.2.4 Measurement of moderating variable

Ownership property is the moderating factor. As a mediator of the link between government subsidy, green credit, and carbon disclosure quality, we depend on ownership property (SOEs vs. non-SOEs). State-owned firms and privately run enterprises make up the two primary divisions of ownership in Chinese businesses. If the government or a government-controlled entity is the final owner, pr is an

indicator variable that is equal to 1 and 0 respectively (Ruiqi et al., 2017). The CSMAR was used to get this data. The data was extracted from the CSMAR database under "Shareholder Information".

4.3 Sample selection

All agriculturally-related listed firms that were listed on the Shanghai Stock Exchange and the Shenzhen Stock Exchange as A-shares from 2012 to 2019 are included in our initial sample. In accordance with the SFC's industry categorization rules for listed businesses, China's agriculture-related listed companies are mainly distributed among all listed companies in the nine industries: a-class agriculture, forestry, animal husbandry and fishery and C-class manufacturing under the agriculture, food manufacturing, leather, fur, and feather items as well as footwear, wood processing and the production of wood, bamboo, rattan, palm, and grass products, as well as the production of wine, beverages, and exquisite tea. Companies that did not publish annual reports, st, st * listed companies, companies acquired by another company, and companies that did not have complete financial data were excluded. A total of 1252 companies met all these selection criteria (Table 3).

Table 3 Samples details

	Samples								
	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**Total**
Agriculture	13	13	13	14	15	15	15	13	111
Forestry	4	3	5	5	5	5	5	5	37
Animal Husbandry	8	8	9	11	11	11	10	12	80
Fishery	7	7	8	8	8	8	8	8	62
Agricultural and food processing industry	32	30	34	33	36	46	47	47	305
Food Manufacturing	21	20	26	29	36	41	42	51	266
Wood processing industry	5	4	5	5	6	7	7	7	46
Leather processing industry	5	5	5	6	8	10	10	10	59
Wine, beverage and refined tea manufacturing	30	29	32	32	39	40	42	42	286
Total	125	119	137	143	164	183	186	195	1252

5. Results and Discussion

5.1 Descriptive statistics and independent sample t-test

Each variable's descriptive statistics, including the mean, maximum value, lowest value, skewness, and standard deviation, are shown in Table 4. The overall amount of carbon information disclosure of the sample firms is low, as evidenced by the total carbon information disclosure index's mean value of 0.2569 and median value of 0.1667. The data on the right side of the mean are more dispersed, as shown by the higher-than-zero skewness of 1.120, which also indicates that there are fewer companies with high quality disclosure. The mean value of government subsidy is 6.8092, the standard deviation is 0.91230, the highest value is 9.02, the minimum value is 2.61, and the majority of the agriculture-related businesses can get various degrees of government subsidies. The sample firms' levels of green credit are unequal, as shown by the mean value of green credit, which is 0.4775, the highest value of 0.91, the minimum value of 0.03 and the standard deviation of 0.14532. Regarding the control variables, the sample firms' average company size is 21.8744, with a maximum value of 25.93 and a minimum value

of 19.22. The standard deviation for this sample is 1.03084, showing some variance with a moderate range. The average debt ratio is 38.5%, the average profitability rate is 3.93%, and the average ROA is 12.68%.

The quality of carbon information disclosure scores for several years is displayed in Table 5. From 2012 to 2019, the average carbon information disclosure index increased from 0.1914 to 0.3429, showing that the average carbon information disclosure quality score generally increases on an annual basis. It can also be seen from the median, which increased from 0.1000 in 2012 to 0.3333 in 2019, demonstrating that listed agricultural corporations are becoming more and more concerned with the accuracy of carbon information disclosure. The change in the standard deviation of the scores by year can also be seen, which increased from 0.16982 to 0.24521 from 2012 to 2019, indicating that there is also an increase in the unpredictability of carbon information disclosure year by year.

The quality of carbon information disclosure across various businesses is scored in Table 6 for each industry. The industry that produces wine, beverages, and fine tea has the highest rating, with an average score of 0.38. Agriculture receives the lowest rating, 0.1222. The manufacturing sector as a whole has higher ratings, with an average value over 0.2, than the food manufacturing, leather, fur, and footwear sectors, wood processing and the production of wood, bamboo, rattan, palm, and grass products, and agro-food processing industries. This is because the production process of these industries has a greater impact on the environment. Agriculture, forestry, animal husbandry and fishery industries, on the other hand, do not have high scores, with the average value below 0.165. The scores of the food manufacturing industry, the leather, fur, feather and feather product manufacturing industry, and the manufacturing of refined tea, wine, and beverages differ significantly from each other, as do the maximum and minimum values of the scores for each industry. Agriculture, forestry, animal husbandry, and fisheries all have minor score differences.

The results of the independent sample t-test between the samples from state-controlled and privately-held companies are displayed in Table 7. With a t-value of 5.046 and a significance of 0.000, the findings demonstrate a substantial difference in the quality of carbon information disclosure between state-controlled and privately-held businesses. Further comparing their means, the state-controlled enterprises' carbon information disclosure quality score is 0.2740, which is significantly higher than the privately-held enterprises' score of 0.2216, demonstrating that state-controlled enterprises have better carbon information disclosure quality. If its standard deviation is compared to that of private firms, which is 0.19111, it is also discovered that the standard deviation of state-controlled enterprises is 0.25766, which is much larger., indicating that the difference in the score of carbon information disclosure quality of state-controlled enterprises is greater than that of private ones. The T-value for the difference in government subsidies between state-controlled and privately held is 1.714, with a significance level of 0.087, which is higher than 0.05 and does not pass the significance test. According to the T-value for green credit, which is 3.867 and has a significance level of 0.000, there is a significant difference between state-controlled and privately held businesses' green credit at the 0.05 level of significance. Further comparing its mean value, it is discovered that state-controlled firms' mean value of green credit is 0.4959, which is much greater than that of privately held enterprises' mean value of 0.4647.Comparing its standard deviation it can be found that the standard deviation of state-controlled enterprises is 0.15671, which is significantly higher than that of privately held 0.13545, indicating that the difference in green credit of state-controlled enterprises is greater.

The correlations (Spearman coefficients) between the variables are shown in Table 8. The table demonstrates that all correlation coefficients in the research are less than 0.7 and that the correlation matrix does not indicate a significant degree of connection between the variables. This suggests that multicollinearity is not a concern in this investigation.

Table 4

Variables	N	Minimum	Maximum	Mean	Median	Std. Deviation	Skewness	Kurtosis

cid	1252	0.03	1.07	0.2569	0.1667	0.22194	1.120	0.476
sub	1252	2.61	9.02	6.8092	6.9420	0.91230	-1.048	1.851
grc	1252	0.03	0.91	0.4775	0.4583	0.14532	0.611	0.006
siz	1252	19.22	25.93	21.8744	21.7397	1.03084	0.642	0.813
lev	1252	0.01	4.60	0.3850	0.3484	0.24289	5.323	76.776
roa	1252	-1.88	0.53	0.0393	0.0396	0.11051	-6.376	90.998
gro	1252	-0.63	10.74	0.1581	0.0831	0.46924	13.319	262.435
Valid N	165							

Table 5

	cid 2012	cid 2013	cid 2014	cid 2015	cid 2016	cid 2017	cid 2018	cid 2019
N	125	119	137	143	164	183	186	195
Mean	0.1914	0.1938	0.1954	0.1979	0.2311	0.2805	0.3419	0.3429
Median	0.1000	0.1333	0.1333	0.1333	0.1333	0.2000	0.3000	0.3333
Std. Deviation	0.16982	0.18740	0.19398	0.20222	0.20348	0.23166	0.23272	0.24521
Skewness	1.371	1.697	1.684	1.419	1.446	1.062	0.571	0.680
Kurtosis	1.468	2.837	2.709	1.292	1.447	0.294	-0.654	-0.361
Minimum	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Maximum	0.80	0.90	0.90	0.93	0.97	1.00	1.03	1.07

Table 6

Industries	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	Kurtosis
Agriculture	111	0.03	0.50	0.1222	0.10302	1.732	2.653
Forestry	37	0.03	0.47	0.1514	0.09832	1.625	2.676
Animal Husbandry	80	0.03	0.73	0.2317	0.18210	1.119	0.446
Fishery	62	0.03	0.50	0.1263	0.09993	1.722	3.435
Agricultural and food processing	305	0.03	1.03	0.2264	0.18652	1.054	0.551
Food Manufacturing	266	0.03	0.97	0.2858	0.22991	1.020	0.143
Wood processing	46	0.03	0.57	0.1630	0.13864	1.442	1.197
Leather processing	59	0.03	0.83	0.2514	0.21756	0.867	-0.300

Table 7

Independent Samples Test

	pr	N	Mean	Std. Deviation	Std. Error Mean	T	Sig. (2-tailed)
cid	1.00	489	0.2740	0.25766	0.01165	5.046	0.000
	2.00	763	0.2216	0.19111	0.00692		
sub	1.00	489	6.8633	0.91660	0.04215	1.714	0.087
	2.00	763	6.7679	0.90757	0.03648		
grc	1.00	489	0.4959	0.15671	0.00654	3.867	0.000
	2.00	763	0.4647	0.13545	0.00472		

Table 8

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) cid	1.000	0.049*	0.072*	0.427**	0.004	0.113**	-0.021
(2) sub	0.049*	1.000	0.005	0.265**	0.097*	0.077	-0.022
(3) grc	0.072*	0.005	1.000	-0.055	0.148**	-0.120**	-0.052
(4) siz	0.427**	0.265**	-0.055	1.000	0.082*	-0.274**	0.073**
(5) lev	0.004	0.097**	0.148**	0.082	1.000	-0.525	-0.027
(6) roa	0.113**	0.077*	-0.120**	0.274**	-0.525*	1.000	0.158**
(7) gro	-0.021	-0.022	-0.052	0.073*	-0.027	0.158*	1.000
*Correlation is significant at the 0.05 level (two-tailed)							
**Correlation is significant at the 0.01 level (two-tailed)							

5.2 Panel Regression Analysis

Table 9 displays the panel regression results for model (1). The value of the F-test, which is 18.95, is significant at the 5% level, and the value of the Hausman-test, which is 18.06, is significant at the 1% level, showing that this regression is appropriate for the fixed effects model. The value of R-squared is 0.207, which means that the total of predictors to explain can account for 20.7% of the variation in the quality of carbon information disclosure. We discover that the regression coefficient of government subsidies (sub) is 0.0338, which is strongly positively connected at the 1% level based on the regression coefficients and significance results in Table 8. The findings are consistent with hypothesis 1 that government subsidies are positively correlated with the level of carbon information disclosed by companies involved in agriculture. Our findings are consistent with those reached by previous researchers: for example, Cheng (2015) suggests that firms' investment in carbon reduction strategies increases with the coefficient of government over-subsidy. Baietal (2018) finds that energy-intensive and pollution-intensive firms actively engage in environmental investment activities with substantial financial support provided by the government. Yue (2018), Liu&Wang (2019), and Hong et al. (2019) concluded that government subsidies can improve a company's environmental performance. This indicates that government subsidies can directly or indirectly transfer payments to microeconomic agents, bring more disposable financial resources to enterprises, broaden their financing channels to a certain extent, provide diversified financial support for their environmental protection investments, alleviate the financial constraints of their environmental protection activities, and enhance their awareness of environmental responsibility and their ability to invest in environmental protection. After receiving government subsidies, enterprises will tend to maintain environmental protection investment, take the initiative to assume environmental responsibility, and strengthen the government-enterprise bond. As a result, our research demonstrates how government assistance enhances the quality of carbon information disclosure by agriculture-related businesses.

The green credit regression coefficient is 0.139, and at the 5% level, it is significantly positively connected. This supports H2, according to which the quality of carbon information disclosure is favorably correlated with green credit. Our findings are consistent with those reached by previous researchers: for example, green credit, according to Wu et al. (2012), may improve the connection between the financial and environmental sectors and boost the openness of company information. The introduction of green credit programs can dramatically reduce business emissions behavior, according to Ma&Yu (2020). Jim&Hua (2021) discovered that green credit can considerably encourage listed companies in China's heavy pollution business to provide corporate environmental information. According to this, commercial banks may be able to use financial instruments to have an impact on businesses' environmental and social responsibility behavior under the guidance of green credit policy. If more environmental information is disclosed by enterprises, the more environmentally conscious the enterprises are, financial institutions will increase their loan support to these enterprises and lower their

loan interest rates during loan review. As a result, businesses will frequently take the initiative to disclose carbon information and try to enhance the quality of disclosure in order to gain a competitive edge in the capital financing market and secure more bank loans.

The regression coefficient of firm size siz is 0.0953, which is strongly positive correlated at the 1% level among the control variables. It indicates that larger firms pay more attention to carbon information disclosure. Our results are in line with those of other earlier studies. For instance, Freedman&Jaggi (2005) found that large firms are more willing to disclose detailed pollution information, Stanny&Ely (2008) found that larger firms are more likely to respond to CID, Prado et al. (2009) found that firm size is positively associated with disclosure of GHG information. This is also in line with stakeholder theory and legitimacy theory, where big businesses are more likely to please their stakeholders in order to win their support since they have more of them. Concerns about legitimacy motivate large companies to report on environmentally responsible practices because they have greater visibility and economic impact (Andrikopoulos&Kriklani, 2012). The financial leverage of Chinese listed businesses that are engaged in agriculture is not significantly impacted by financial leverage, according to the regression coefficient of financial leverage lev, which is -0.0122 but does not pass the significance test. The company profitability regression coefficient, which is 0.000429, likewise fails to meet the criteria for significance. This is in line with the findings of academics like Freedman&Jaggi (2005), Kuo&Chen (2013), and Eleftheriadis&Anagnostopoulou (2015), who claim that there is no statistically significant correlation between profitability and GHG disclosure. This suggests that the profitability of listed Chinese agricultural companies has little bearing on the quality of carbon information disclosure. Growth capacity's (gro) regression coefficient is -0.0239. This value is highly negative correlated at the 10% level. In keeping with Luo et al (2013). This implies that businesses with strong growth prospects are less likely to use carbon disclosure. This is contrary to our prediction, which can be explained by the fact that agriculture-related enterprises with high growth capacity may have neglected the issue of carbon disclosure during the development process and did not pay enough attention to green and low-carbon upgrades in order to pursue rapid development of their own economic interests.

Table 9 displays the regression results for model (2). When the interaction terms government subsidies*ownership property (subpr) and green credit are included, the R-squared value rises from 0.207 to 0.237. *Ownership property (grcpr), which indicates that the sum of predictors may account for 23.7% of the variation in the quality of carbon disclosure. The type of government subsidies*ownership property(subpr) as an interaction factor has a regression coefficient of -0.0215 in the findings, which is statistically inversely associated at the 10% level. The coefficient of government subsidy (sub) is 0.0445, which is greater than 0, and the coefficient of government subsidy * ownership property(subpr) is -0.0215, which is less than 0. This supports H3, that the ownership property has a negative moderating effect between government subsidy (sub) and carbon information disclosure quality. It indicates that in state-owned enterprises, government subsidies are more correlated with carbon information disclosure. In private firms, government subsidies have a reduced link with carbon information disclosure. This may be because SOEs have relatively political management status, their political performance directly affects the environmental and social responsibilities they take on, and government subsidies have a bigger influence on whether and how much SOEs reveal about their carbon emissions. The green credit * ownership property (grcpr) regression coefficient is 0.332, which at the 1% level indicates a significantly positive correlation. The coefficient of 0.559 for green credit (grc) is greater than 0, and the coefficient of 0.332 for green credit * ownership property (grcpr) is greater than 0, which backs up the claim in hypothesis 4 that owned property has a beneficial moderating influence on both the quantity of carbon information disclosed and the quality of green credit (grc). It shows that private companies have a better association between green credit and carbon disclosure. The relationship between green credit and carbon disclosure is less strong among state-owned businesses. This may be due to the fact that non-SOEs have narrower access to financing than SOEs, suffer from greater credit discrimination, and have difficulty in obtaining loans if they do not disclose environmental

information in accordance with green credit policies. The better banks can comprehend the environmental performance of non-SOEs, and consequently, the more helpful it is for them to get credit facilities, the greater the degree of carbon information disclosure.

To assess the sensitivity of the empirical results to the model, we conducted robustness checks. Considering the possible dynamic lagged effects of the financial characteristic factors, governance characteristic factors, and external pressure factors in the current period, this paper refers to Zhong (2019), Li (2020), Huang, (2015), and Gu (2018) to introduce a dynamic panel with a one-period lag of the dependent variable as a robustness check. The estimated results (not reported here for brevity) are not substantially different from those given in the previous paper.

Table 9

VARIABLES	(1)	(2)
sub	0.0338***	0.0445**
	(0.00609)	(0.0214)
grc	0.139**	0.559***
	(0.0687)	(0.135)
siz	0.0953***	0.102***
	(0.0158)	(0.00708)
lev	-0.0122	-0.0792**
	(0.0514)	(0.0366)
roa	0.000429	0.00947
	(0.0851)	(0.0946)
gro	-0.0239*	-0.0297*
	(0.0136)	(0.0153)
pr		-0.0306
		(0.0977)
subpr		-0.0215*
		(0.0130)
grcpr		0.332***
		(0.0851)
Constant	-1.546***	-1.643***
	(0.361)	(0.220)
R-squared	0.237	0.237
F-test	18.95**	19.87**
Hausman-test	18.06***	19.09***
Model-selection	Fixed-effect	

Standard errors in parentheses;*** p<0.01, ** p<0.05, * p<0.1

6. Conclusion

How to address the issue of climate change has recently been high on the political and corporate agendas of many nations. The major factor for global warming is a large volume of greenhouse gas emissions. The carbon information that businesses reveal is a crucial foundation for evaluating the reduction of carbon emission processes and fostering the successful growth of carbon emission trading systems. To reach the carbon neutral aim of carbon peak, it is crucial to have accurate information on their carbon emission decrease. This paper selected Chinese listed agriculture-related companies as a research sample during 8 years from 2012 to 2019, empirically examined the moderating impact of real estate

ownership on the relationship between government subsidies, green credit, and the quality of Chinese agricultural-related enterprises' carbon information disclosure. Additionally, we manually compiled the carbon information disclosed in the external disclosure reports of businesses, such as annual reports, social responsibility reports, and sustainability reports. Finally, using content analysis method and index method, we quantitatively evaluated and analyzed the current state of carbon information disclosure quality of Chinese agriculture-related businesses. This study demonstrates that every business, including those involved in agriculture, is accountable for reducing emissions and saving energy. Unlike businesses with high energy and emissions costs, which have traditionally been regulated by regulatory authorities and have become a common sample for academic research on carbon emissions, the carbon emissions of agriculture-related enterprises have not received sufficient attention. Both a crucial component of China's low-carbon economy and a means of advancing the country's agricultural sector are low-carbon agriculture. In order to encourage the development of low-carbon agriculture, government agencies, academia, and other stakeholders should pay attention to the problem of carbon information disclosure of farm-related firms. After assessing the caliber of Chinese agriculture-related firms' submission of carbon information, it is also clear that although the mean value of the scores generally shows an increasing trend, the quality of most disclosures is still at a low level, indicating that the low-carbon awareness of China's agriculture-related enterprises still needs to be improved. The food manufacturing industry, leather manufacturing industry, wood processing industry, agro-food processing industry, and other manufacturing categories have the highest disclosure scores by industry, while agriculture, forestry, animal husbandry, and fishery industries have lower disclosure scores, indicating that there are still significant discrepancies in the perceptions of enterprise carbon information.

The empirical findings of this study demonstrate a significant positive relationship between government subsidies and the disclosure of carbon information by agriculture-related businesses, i.e., in the current Chinese economic environment, the higher the quality of carbon information disclosure, the more government subsidies that businesses receive. It is clear that the government's actual actions play a significant part in encouraging businesses to disclose their carbon footprints. Government subsidies can bring more financial resources at the disposal of enterprises and have capital supplementation and signaling effects, which can alleviate the financial shortage barrier of enterprises' green governance, enhance the awareness of environmental responsibility of enterprises, and so raise the standard of carbon data disclosure. Second, there is a strong positive correlation between green credit and the sharing of carbon information by businesses involved in agriculture, i.e., the quality of carbon information disclosed by businesses involved in agriculture is improved thanks to green credit. It is clear that by reducing credit support, green credit can direct the growth of businesses from their source of funding to highly polluting enterprises or adopting high interest rate credit for their credit, and lowering the entry threshold for enterprises engaged in environmental protection construction, resource recycling and other enterprises with high environmental benefits, so that funds can flow into environmental protection projects and industries at lower interest rates. In this way, by influencing the environmental and socially responsible behavior of enterprises through financial instruments and increasing the transparency of corporate information, in order to maintain their competitive edge in the capital financing market, businesses will typically take the effort to disclose carbon information and try to enhance the quality of disclosure. State-owned companies (SOEs) and non-SOEs make up the majority of corporate holdings in China, with the former having significant enforcement capabilities in response to governmental directives. The management position of state-owned enterprises is somewhat political, and the environmental and social responsibilities undertaken by enterprises are directly linked to their political performance. The association between government subsidies and carbon information disclosure is stronger in SOEs, and the ownership property has a negative moderating influence on the quality of disclosure of carbon information. The association between green credit and carbon disclosure is larger in private firms, and the ownership property has a positive moderating influence between the

two.

All stakeholders can benefit from the findings of this investigation. First, government subsidies, as a policy tool, can also have certain social effects in the process of optimizing resource allocation. The government should expand the breadth and depth of support for private enterprises. In terms of scope, green and environmentally friendly enterprises with high technology levels should be included in the scope of subsidies; in terms of policy, introduce corresponding tax relief and financial support measures; in terms of project bidding, break the hidden barriers and improve the supervision of bidding procedures and information disclosure system. The central government should take into account the state of industrial development and the differences in the level of marketization in each region, and reasonably decide the amount of government subsidies allocated based on the type of property rights that businesses own. In the process of policy formulation, it should be strictly cautious, taking into account fairness and efficiency, using good steel to the edge of the knife, and truly play the role of government subsidies to support and motivate. In addition, the process of using government subsidy funds should be transparent, the information disclosure system of government subsidy should be improved, the supervision of irregular use of funds should be strengthened, and the evaluation mechanism of the efficiency of using government subsidy funds should be established. It is also necessary to track and follow up the subsidies after they are invested to create a fair market atmosphere and safeguard the long-term interests of society.

Second, support banks to develop "green credit" business, and assume the position of creditors to push for the disclosure of an enterprise's carbon information. Drawing on the "Equator Principles" and other green credit standards common in developed countries, we will incorporate carbon emission reduction into the service scope of the financial system and support banks to develop "green credit" business. Priority should be given, in terms of lending policies, to encouraging the investment and development of low-carbon and environmental protection industry projects, offering more loan facilities and preferences to businesses in this sector, increasing financing support for technological innovation and low-carbon emission reduction in small and medium-sized enterprises, implementing green credit, and removing financial obstacles to the development of a low-carbon economy. The company or project will also be penalized with the appropriate actions, such as deferment, restriction, and suspension of loans, if it violates the rules and regulations pertaining to environmental protection, energy conservation, and low-carbon emission reduction. On the other hand, it is necessary for the state to improve green financial policies as soon as possible, mobilize financial institutions to to practice "green credit" and to encourage the growth of "green credit" businesses. The government can introduce corresponding support policies for green finance business, such as tax relief policy, risk compensation policy, financial subsidy policy, etc.; establish and improve the green finance supervision index evaluation system, increase the supervision of green finance business, and comprehensively build a long-term mechanism to encourage the growth of green financing.

However, there are some limitations of this study that must be pointed out. First, with regard to the evaluation index system of carbon information disclosure quality, the selection of the evaluation indexes and the construction of the entire evaluation index system need to be further discussed as the development of corporate carbon information disclosure and the shift in the international carbon information disclosure evaluation orientation may cause the selection of the evaluation indexes and the construction of the entire evaluation index system to change. so that these possible changes in the influencing factors. Second, the limitation of sample selection. This paper selects listed agriculture-related enterprises as the research sample and eliminates companies that fail to disclose their carbon emissions in the report, which greatly reduces the sample size. Moreover, listed agricultural enterprises are only part of the agricultural industry, and there are a large number of unlisted agricultural enterprises in China, but in view of the difficulty of obtaining information, only listed companies are taken as the representative of the study. In the subsequent study, the sample size and the time span of the empirical study can be expanded and further verified by more sample data due to the growing enterprise enthusiasm for participating in carbon information disclosure and the increasing initiative of enterprises

to disclose their carbon-related information. Third, in terms of data collection, the author reads annual reports of publicly traded firms, reports on social responsibility, reports on sustainability, and information reports on company websites to gather data based on an evaluation of the quality of corporate carbon information disclosure, and there are inevitably certain scoring biases and measurement omissions in this process. Therefore, in the subsequent study, more manpower and time can be invested in data collection to minimize or avoid such data collection bias.

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