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THE IMPACT OF CARBON RISK ON TRADE CREDIT

BY

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ABSTRACT

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Global climate change presents a growing danger to the environment, economies, and human population as well as disrupting sophisticated ecological systems. Several nations have enacted rules and measures to reduce and regulate firms' carbon emissions in response to these concerns. With the growing attention being paid to carbon emissions, corporations are increasingly concerned about their exposure to carbon risk. Indeed, investors are aware of carbon risk and require higher compensation to bear this risk (e.g., Bolton and Kacperczyk, 2021). This research paper aims to analyze the influence that carbon risk has on a companies' trade credit using a sample of selected companies in the US from 2001-2019. We argue that companies with high carbon risk are not well reputed, hence are less likely to obtain informal finance. Therefore, we anticipate a negative relationship between a company's carbon risk and trade credit. The findings we obtained are robust to a set of robustness tests and to addressing endogeneity issues. The results provide propositions for corporations and policymakers since it highlights the importance of reducing carbon risk for the the access to informal financing.

DEDICATION

I would like to dedicate this thesis to my mother and to everyone that supported and motivated me throughout my whole educational journey. Thank you for your endless love and guidance.

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" I would like to acknowledge the huge support of my supervisor Prof. Hamdi Bennasr, and I would like to thank him for his contentious guidance, encouragement, motivation, and encouragement"

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Chapter 1: Introduction

During the past three decades, the world's economy has expanded quickly, which has boosted greenhouse gas concentrations and led to a series of unpredictable and catastrophic weather patterns (Phan et al., 2022). The catastrophic economical, ecological, and public health consequences of climate change and global warming raised the concern of public and environmental activists (Jung et al., 2018). In order to combat global warming, regulators and institutions around the world have been forced to create regulations and initiatives that require businesses to quantify, manage, and announce their carbon emissions to combat the widespread impacts of global warming on both the environments and the global economies. Examples of these initiatives include the 2018 Carbon Disclosure Project and the 2020 Task Force on Climate-Related Financial Disclosures. Therefore, increased regulatory scrutiny brought by national and global attention on carbon emissions resulted in stricter regulations and compliance costs for businesses. Regulations were largely implemented in response to the 2016 Paris Accord, which raised concerns about climate change and tightened restrictions. According to Jung et al. (2018), Ullman (2016), and Subramaniam et al. (2015), companies' decreased profitability and future cash flows because of higher regulatory compliance requirements and expenditures; could reduce their ability to payback their loans. Li et al. (2014) explains how it would be challenging for companies that produce high level of carbon emissions to honor their debt, as the cost of debt increases for emissions-liable companies. Furthermore, companies with high carbon emissions have a negative image, which might have an adverse effect on their cash flows, operations, and competitive advantages (Labatt & White, 2011).

Several recent studies examine the determinants of informal finance. For instance, social trust (Levine et al., 2018; Wu et al., 2014; Allen et al., 2005; Fisman and Love, 2003), corporate social responsibility (Saeed & Zureigat, 2020; Cheung & Pok, 2019), Digital transformation (Liu & Wang, 2023), stakeholder orientation and customer concentration (Li et al., 2023; Kim et al., 2022), national culture (Hoang et al., 2023; Xiu et al., 2023), Suppliers' listing status (Abdulla et al., 2020), bargaining power (Parviziomran & Elliot, 2023), transaction motive (Schwartz, 1974; Emery, 1987; Ferris, 1981), information costs (Emery, 1984), market structure and product attributes (Mian and Smith, 1992; Frank and Maksimovic, 1998; Brennan et al., 1988), product quality (Cunat, 2000; Emery and Nayar, 1998; Malitz and Ravid, 1994; Lee and Stowe, 1993), market imperfections (Aktas et al., 2012; Ng et al., 1999; Smith, 1987), market power of suppliers (Wilner, 2000; Petersen and Rajan, 1997), firm's lifecycle (Hasan et al., 2021), and tax brackets (McMillan & Woodruff, 1999; Brick & Fung, 1984). However, while there is an increased global focus on climate change mitigation and a growing pressure on firms to reduce their carbon footprint; till this day, there is no research that examines the impact of carbon risk on the provision of trade credit. Thus, our thesis fills the gap and provides new insights into the firms' ability to obtain trade credit considering the level of carbon they emit.

We investigate the impact of carbon risk on trade credit using US data for several reasons. First, the United States has the largest economy, and it tops all nations when it comes to the cumulative CO2 emissions produced since the Industrial Revolution (1750 – 2020), with 24.5% megatons of CO2 (Ovaska et al., 2021), and its currently the second highest emitter in the world (Gabbatiss, 2021). Additionally, the country's greenhouse gas emissions rose between 2020 and 2021 by 6.8%, as reported by the United States Environmental Protection Agency, making around 6,347,700,000 metric tons of greenhouse gas emissions in 2021. After taking land-sequestration into account, the metric tons of carbon dioxide would be equivalent to about 5,593,500,000 million. Second, data on emissions on a global scale is mostly not sufficient. Third, focusing on one country helps avoid many country-country-specific factors driving the results. The US is a good example to start. It can be extended internationally, for China and India, which we leave for future research. China is currently emitting the most, however, the US has the highest total emission over the years. Fourth, two other close countries in terms of emissions (China and India) are emerging countries. The required financial accounting information for the model is less reliable for an emerging market. However, it is still a limitation of the study.

A major factor in the rise in overall greenhouse gas emissions was the burning of fossil fuels which caused the rise in carbon dioxide emissions. In 2021, fossil fuels burning in the United States produced 7.0% more carbon emission than it has in the previous year (US EPA, 2023). The economic recovery following the COVID-19 epidemic is mostly to blame for this rise in emissions from fossil fuel usage (US EPA, 2023). Second, in an effort to achieve the Paris Agreement's target of reducing the country's emissions by twenty-six to twenty-eight percentage throughout the next 20 years after 2005, the Environmental Protection Agency of the American government created a clean power plant strategy in 2015 (UNFCCC, 2015). However, in 2017 the United States government under the Trump administration eliminated the clean power plant strategy and formally withdrew from the Paris climate agreement (Yozwiak, 2021), which illustrate how the United States experienced uncertainty in the environment governing the climate change policy. Finally, according to Garcia et al. (2019) and Petersen and Rajan (1997), trade credit is quite substantial in America as it represents the most significant source of short-term financing for businesses. Over 4.5 trillion dollars’ worth of outstanding trade credit, or 21 percent of U.S. GDP, was held by non-financial U.S. companies in 2019. More than 80% of American businesses, or a significant component of their balance sheets, sell their goods on trade credit (Tirole, 2006). Today, the total liabilities include 553 billion US dollars in trade credit (Fed, 2023). Carbon emissions and their impacts on businesses' financial outcomes are becoming increasingly popular as the worldwide movement to minimize carbon emissions gains traction. Several studies investigate how the cost of bank loan were influenced by carbon risk (e.g., Zhu & Zhao, 2022; Ehlers et al., 2022; Herbohn et al., 2019), financing costs (e.g., Wang et al., 2020; Jung et al., 2018; Zhou et al., 2018), financial performance (e.g., Wang et al., 2021; Trinks et al., 2020; Nguyen, 2018), dividend policy (e.g., Zhu & Hou, 2022; Balachandran & Nguyen, 2018; Nguyen & Balachandran, 2017), capital structures (e.g., Shu et al., 2023; Nguyen & Phan, 2020), equity value(e.g., Clarkson et al., 2023; Görgen et al., 2020; Kim et al., 2015), and other economic outcomes (e.g., Zhang et al., 2023; Stern & Stiglitz, 2021; Bernardini et al., 2021; Pindyck, 2019). By examining the impact of carbon risk on an important informal finance tool, namely trade credit, our study will contribute and add to the existing literature. We show that carbon emissions significantly reduce the company's capability to acquire trade credit financing. We use a sample of companies that submitted their carbon emissions data from the period 2001 to 2019, and that are based in the United States. We further categorize total carbon emissions into scope 1 and scope 2 emissions, and we find that scope 1 emissions which are the direct carbon emissions have a greater impact on trade credit than scope 2 emissions which are the indirect carbon emissions. According to our findings, carbon emissions might be viewed by trade credit suppliers as a part of the company's financial risk, which means that companies that release more carbon will receive fewer trade credit extensions.

Moreover, when using an instrumental variable methodology to deal with endogeneity issues, we find consistent and robust results. Our findings remain robust when performing additional tests such as excluding banking and utility firms as well as the time surrounding the financial crisis.

This is how our research moves forward. Chapter 2 introduces the literature review and hypothesis development. Chapter 3 describes the variables used, the sample, and specifies the model. Chapter 4 examines the summary statistics, correlation matrix, main evidence, endogeneity tests, and additional robustness tests, respectively. Finally, chapter 5 illustrates the conclusion and states the policy implications.

Chapter 2: Literature review

2.1. Carbon Risk

2.1.1. Overview

Nations from all over the world have participated in the Paris Agreement, United Nations Framework Convention on Climate Change global climate governance framework, and the Kyoto Protocol (Zhu & Hou, 2022). At the end of 2015, the United Nations Framework Convention on Climate Change endorsed the Paris Agreement to maintain the global temperature under the 2 degrees Celsius limit over pre-industrial levels. Achieving the worldwide 2 degrees Celsius target will need a very rapid reduction in CO2 emissions with daily attaining of severe minimum greenhouse gas emission values for many locations of the world (Rogelj et al., 2016; IPCC, 2015). Global warming worries are directly related to CO2 emissions (Bolton & Kacperczyk, 2021). The rising concern over carbon emissions has led businesses to focus more on how to reduce their carbon footprint, especially emitter industries (Subramaniam et al., 2015; Hoffmann & Busch, 2008; Labatt & White, 2007). Our definition of carbon risk is as outlined by Hoffmann and Busch (2008, page 514): "Any corporate risk connected to climate change or the usage of fossil fuels, which is a subset of environmental concerns". Now, the subject over whether carbon emissions currently constitute a significant risk to firms that is reflected in their capacity to get informal financing or trade credit extensions is posed in light of rising temperatures and increased legislative initiatives to decrease carbon emissions. Carbon risk can be found in a company's day-to-day operations in many forms such as: production risk, physical danger, legal risk, competitive risk, reputation risk, and regulatory risk (the Intergovernmental Panel on Climate Change study from 2007). Also, a company's reputation may be at danger as a result of emissions behavior (Bose et al., 2021). In other words, GHG emissions with a large carbon footprint can harm a firm's image. There are two main categories of carbon emissions from an organization's economic and business activities. First, scope 1 emissions which are also called direct emissions; resulting from the organization owned and controlled activities such as manufacturing and production. Second, scope 2 emissions, also called indirect emissions; resulting from activities conducted off site yet bought and consumed by the organization such as the use of heat, electricity, steam, or waste disposal.

2.1.2. The impact of carbon risk on corporate decisions

A growing body of research on carbon risk suggests that enterprises with substantially higher emissions are more at risk than those with lower emissions, which may be accounted for by several factors. According to Clarkson et al. (2004) and Karpoff et al. (2005), companies that pollute must pay for management accounting costs connected to carbon, such as, costs of reputation management, compliance and legal fees, and research and development; hence emitting would require them to pay substantial compliance costs. Bolton and Kacperczyk (2021) further clarify this by pointing out that businesses with extraordinarily high greenhouse gas emissions may be vulnerable to the risk of carbon pricing and the legal efforts to reduce carbon discharges. They argue that companies most reliant on fossil fuels are also more at risk from the technological risks posed by less expensive renewable energy sources. Therefore, investors that look to the future might demand return for holding the shares of firms with excessively big carbon dioxide emissions and the greater carbon risk they face, which might lead to a positive link in the cross-section between a firm's own carbon dioxide emission and its stock returns. Another argument is that investors consider companies with high carbon emissions immoral and unreliable, which increases their carbon risk. In other words, investors care about the firm’s corporate social responsibility status, which is a concept introduced in 1953 by Howard Bowen, in which he described corporate social responsibility (CSR) as, “the obligations of businessmen to pursue those policies, to make those decisions, or to follow those lines of action, which are desirable in terms of the objectives, and values of our society” (Bowen, 2013). For instance, Bolton and Kasperczyk (2021) argue that ethical or socially responsible investors avoid corporations with large greenhouse gas emissions to the extent that their stock returns are higher. According to Porter and Kramer (2006), a company's social responsibility is crucial for both its competitiveness and relationships with the broader community. They contend that for CSR to have a meaningful influence on a company's competitiveness, it must be "anchored" and fully incorporated into the company's strategy. In a similar vein, Porter and Kramer (2011) assert that businesses "may produce economic value by providing societal benefit," again highlighting the significance of sound social responsibility as a competitive advantage. As a result, a firm's corporate actions are influenced by its significant stockholders since it is crucial for a business to take its stakeholders' expectations into account.

Dumrose and Höck (2023) examine the implications of a company's carbon risk performance on credit risk while taking into account the firms' exposure to federal climate policies. Their research shows that lower credit spreads are a result of greater carbon-risk performance. Although better management lowers credit spreads and more exposure increases them, respectively. They argue that as a firm's subjection to carbon risk grows, so does the significance of carbon risk management. Lastly, they discover that wider yield spreads are more in enterprises operating under highly constricting governing frameworks. Yet, under a more ambitious climate regulation framework, the relevance of a firm's emissions reduction efforts and capabilities increases. Their finding indicates that the overall rise in yield spreads triggered by a more stringent legal environment for climate change can thus be mitigated by firms through improving their carbon risk management.

Hence, we argue that corporate decisions are affected by carbon risk, which is correspondingly influenced by the companies' stakeholders. This argument is supported by several papers. For instance, Bolton and Kacperczyk (2021) examine whether climate risk is priced. They report evidence suggesting that investors are seeking compensation to bear carbon risk. In the same vein, Jung et al. (2018) explored if companies may reduce the price by illustrating a mindfulness of their greenhouse gas emissions and related hazards. Additionally, Jung et al. (2018), examined whether carbon-related risk affects lending decisions by including it in financing costs. For companies that opted out of the Carbon Disclosure Project study, they note a strong association between the cost of debt and carbon risk. The firm's previous carbon emissions were used as the key indicator of carbon risk awareness since they reflect the firm's desire to participate in the Carbon Disclosure Project survey. Furthermore, they discover that for companies that demonstrate knowledge of carbon risk, this penalty is substantially reduced. The authors' findings hold up when they take into account alternative indicators of carbon awareness disclosure via channels other than the Carbon Disclosure Project and enterprises' yearly cash investments in "cleaner" technologies. Their findings show how important carbon awareness is for polluting industries' business strategies, as well as for lenders exposed to customer defaults and reputational risks.

Moreover, Kim et al. (2015) used data on greenhouse gas emissions to examine how the price of equity capital was influenced by a firm's carbon risk. Their investigation followed the 2010 introduction of the Greenhouse Gas Energy Target Management

System by the Korean government, which required selected enterprises to submit independently validated Greenhouse Gas statistics. Their results show that the price of equity capital is significantly associated with carbon intensity, a proxy for carbon risk. In addition, firms that volunteer in disclosing sustainability reports face no difference in regard to how their cost of equity capital is impacted by carbon intensity, from firms that did not disclose their sustainability reports. Moreover, they show that carbon intensity does not significantly impact the price of equity capital for certain companies in sectors that emit high amounts of greenhouse gases.

Amin et al. (2021) investigated whether carbon emissions have an impact on the financial reporting decisions made by businesses in the context of corporate decisions. They report a positive correlation between enterprises' real earnings management (REM) and carbon emissions, which is in harmony with companies' efforts to generate greater revenue in times of high discharges to mitigate their negative effects. According to cross-sectional experiments, companies located in states with stricter environmental regulations have a greater link between carbon emissions and REM. Moreover, they show that strong corporate governance mitigates the adverse effects of carbon risk on REM. Moreover, Bose et al. (2021) investigated whether the amount of carbon emissions an acquirer produces affects the firm's choice to make acquisitions and realize a profit from such acquisitions. The study sheds light on how shareholder value might be increased by focusing on lowering carbon risk. Their findings indicate that companies with high levels of carbon emissions aim to acquire other companies in regions with low environmental, regulatory, or governance requirements. Moreover, they demonstrate that high carbon emitting companies that seek to acquire firms in countries with liberal environmental regulations or policies, report higher returns. They also demonstrate that acquirers who promote Corporate Social Responsibility while concurrently producing significant levels of carbon dioxide are penalized by investors, which lowers abnormal returns. This is because shareholders are concerned about the relationship between CSR and carbon emissions.

Examining the impact of a company's carbon emissions on a its credit ratings might provide more insightful information. In their investigation of this in the context of the United States, Safiullah et al. (2021) used a sample of 3116 firm-year data from the years 2004 to 2018. Their channel tests suggest that businesses with high carbon emissions have greater cash flow unpredictability, which has a negative impact on credit ratings. This conclusion suggests that direct carbon emissions from businesses are a significant input component for corporate credit rating, according to credit rating agencies.

Phan and Nguyen (2020) examine how a business capital structure is affected by carbon risk. This study uses a sample of Australian enterprises to offer new evidence that carbon risk affects firms' capital structure decisions. They find that increasing carbon risk raises the likelihood of financial difficulty for polluters, which leads to a reduction in their financial leverage. This is because large banks are less inclined to fund polluters when it comes to borrowing. To lower the risk of refinancing, they are also more inclined to get new loans and loans with longer terms. In a comparable setting, Phan et al. (2022) used data from 41 nations for the years 2002–2017 to study the impact of carbon risk on business investment. They report a negative and statistically significant impact of carbon risk on business investment. In addition, they show that carbon risk reduces inefficient investment. They discovered that businesses with a high carbon footprint are more negatively impacted than those with a low carbon emission.

This study contributes to this strand of literature by examining the impact of carbon risk on an important source of financing which is informal finance (i.e., trade credit from suppliers).

2.2. Trade credit

2.2.1. Overview

Trade credit is an important informal financing tool. Trade credit is a short-term loan given by a supplier to a client after the latter purchases the provider's products. Trade credit is a crucial source of short-term finance (Seifert et al. 2013). It may be used as a multifaceted relationship management tool and to communicate information about the company, its goods, and its prospects and commitments to the market or to customers (Soni et al., 2010). Moreover, trade credit is an instrument that separates money transactions between two parties. Also, it enables better control of net money accumulation and a decrease in precautionary money holdings (Ferris, 1981). Trade credit is offered by large companies with easy access to capital markets as well as small suppliers that are usually in a tight financial situation across sectors (Giannetti et al., 2011). This raises the question about the motives behind firms excessively offering trade credit throughout the years.

2.2.2. The determinants of trade credit

2.2.2.1. Transaction motive

There are a variety of hypotheses that explain why trade credit is given. According to Schwartz (1974), there are two justifications for offering trade credit. The finance motivation comes first, followed by the transaction motive. He argues that the purpose of the transaction is to simplify cash management, allowing purchasers to prepare for unplanned purchases more conveniently, and improve their ability to predict future cash outlays. Credit can be sold by both buyers and sellers. It is likely that the transactions motivation represents a considerable element of the overall share of trade credit. Furthermore, according to Schwartz (1974), larger and more financially stable manufacturers would extend trade credit to their relatively smaller clients with lower financial security. Moreover, he argues that during a credit crunch, larger and more financially sound companies gradually provide more informal finance to keep their connections with smaller clients. Ferris (1981) further contends that by dividing the trade of commodities and their payment, businesses may increase operating efficiency and decrease costs. Emery (1987) contends that this separation decreases cash uncertainty in payments and gives enterprises greater flexibility to adjust to changes in demand.

2.2.2.2. Information costs

Emery (1984) focuses his explanation of the rationale for trade credit on information costs. He suggests that enterprises with greater liquidity will provide trade credit as a substitute for purchasing marketable assets. As a result, selling businesses can continue to keep sufficient liquid reserves to either invest in marketable securities or extend trade credit. This is necessary due to capital market flaws. Despite flaws, selling companies can find out cheaply how much their consumers can afford. It gives sellers an informational edge over third-party intermediaries and allows them to extend trade credit at a higher implied rate than what a purchaser could earn on short-term, low-risk commercial paper, but lower than what they could receive elsewhere.

2.2.2.3. Market structure and product attributes

The characteristics of the market structure and product attributes have been cited by several academics as justifications for extending trade credit. Brennan et al. (1988) claim that informal finance providers' motivation to extend trade credit may be driven by price discrimination. They contend that limited supplier competition in an input market may encourage discrimination between customers who pay with cash and those who pay with credit. It has been shown by Frank and Maksimovic (1998) and Mian and Smith (1992) that credit provisions are more commonly employed in situations where reselling of the object being sold is easier.

2.2.2.4. Product quality

The relevance of trade credit as an assurance of the quality of the goods in particular businesses is one reason why it is offered, according to some academics (Emery & Nayar, 1998; Malitz & Ravid, 1994; Lee & Stowe, 1993). In other words, the suppliers will voluntarily give trade credit extensions in order for customers to have enough time to evaluate the goods, the product's quality may be indicated by the trade credit conditions that the suppliers give. While Cunat (2000) contends there is a rise in the quantity of credit that trade creditors are ready to extend based on the relationships between suppliers and customers who have bespoke products, learning through experience, or other causes of sunk costs, which will create surpluses that rise over time.

2.2.2.5. Market imperfections

Existing research suggests that the main driving force behind the usage of trade credit are market imperfections. For instance, Ng et al. (1999) analytically analyzed the corporation's fundamental credit strategy decision, and their findings produced data revealing the drivers behind the acceptance of informal finance. They present data indicating that businesses often do not alter trade-credit conditions in place of product pricing in response to changes in the market demand. In a similar vein, businesses seldom ever manage inventory using trade credit terms, and they hardly ever adjust credit terms in reaction to changes in market interest rates. Also, they show that buyer and seller reputation determine the firm’s choice to extend credit. Aktas et al. (2012) believes that the use of trade credit gives prospective investors useful information. They arrive at a theoretical model that forecasts a favorable relationship between the firm's investment decisions and the degree to which trade credit is used. When businesses have inadequate corporate governance systems, are opaque, and are led by CEOs whose main objective is to increase shareholder wealth, this positive association is more likely to occur. Their empirical results validate these hypotheses. In fact, they demonstrate that trade credit has a favorable relationship with both long-run anomalous returns and the Z-score change. As Smith (1987) points out that trade credit conditions imply a high rate of interest that acts as an effective screening tool and is asymmetrically kept as information regarding buyer default risk. A seller who grants trade credit can spot potential defaults earlier than if banking institutions were the only sources of short-term finance. In situations when the seller has made no recoverable investments in the purchasers, he discovered that the knowledge is significant since it enables the seller to take action to safeguard such assets.

2.2.2.6. Market power of suppliers

Petersen and Rajan (1997) provide a comprehensive practical test concerning trade credit and find evidence suggesting that when financing from banking institutions is unavailable, companies seem to rely more on trade credit. Suppliers lend to restricted companies due to their comparative advantage in learning about potential customers, can sell assets more quickly, and have an implied ownership position in the businesses. And lastly, businesses that have easier access to credit provide more trade credit. According to Wilner (2000), reliant suppliers of informal finance make greater reductions in debt renegotiations than non-reliant suppliers because of long-term ties with their firm's informal finance suppliers. Because of these stronger negotiation concessions, firms with lower financial stability choose informal finance, and for trade credit, companies' approval to paying a higher interest rate. The method justifies the presence of teaser rates of interest and convenience classes as well. Based on his findings, businesses in highly dependent relationships may develop optimal pricing, financing, and renegotiation strategies.

2.2.2.7. Firm lifecycle

Hasan et al. (2021) looks at the connection between trade credit and business life cycle. They present information that suggests trade credit is utilized substantially more frequently by businesses in the stages of start-up, development, and decline than by businesses in the mature stage. Different from other pathways suggested in the research, the company's trade credit provision is affected by its life cycle in a unique way. Their findings held up well under several regression assumptions, various trade credit and life cycle indicators, and the endogeneity issue. Compared to other firms, the stages of start-up and fall, swiftly modify trade credit to the desired amount.

2.2.2.8. Tax Bracket

Brick and Fung (1984) hypothesize that purchasers favor trade credit when they have a lower tax rate than that of the suppliers. Even though enterprises in lower tax brackets allow companies in relatively high tax brackets benefit. When a supplier extends trade credit, there is a higher probability to do so when the relationship with the customer has been ongoing for a longer period of time, the client has less sources of supply available to them, or the client is known to the supplier through a business network, as McMillan and Woodruff found in their in 1999 study on factors influencing the use of trade credit amongst private Vietnamese companies. Moreover, trade credit is more common in nations with weaker legal systems (Demirguc-Kunt & Maksimovic, 2001).

2.2.2.9. Social trust

Prior research shows that trade credit represents a significant source of informal lending and that it is a situation where confidence is crucial (Allen et al., 2005; Fisman & Love, 2003). According to Wu et al. (2014), private corporations functioning in more socially trusted environments use more trade credit from suppliers, provide more trade credit to customers, and rapidly collect receivables and settle payables. For enterprises located in provinces with lax property rights protection, these findings are enhanced. Overall, their findings demonstrate that social trust aids private businesses in overcoming institutional barriers to funding their operations. Likewise, Levine et al. (2018), using firm-level data from 34 countries from 1990 to 2011, they show that enterprises that depend on liquidity in high-trust nations are more likely to acquire trade credit and experience less loss of employment and profit during banking crises. Consequently, one of their key results is that access to informal financing is easier in societies with high social trust.

2.2.2.10. Corporate Social Responsibility (CSR)

Several papers show that corporate social responsibility (CSR) positively affects the company's ability to obtain trade credit. For instance, Saeed and Zureigat (2020), using a sample of US firms, show a strong relationship between CSR and trade credit in both the customer and supplier sides. Also, they show that during the global financial crisis, corporate social responsibility demonstrated a positive relationship with trade credit.

2.3. Hypothesis Development

We argue that high carbon emissions will reduce a firm's ability to obtain trade credit, since suppliers will view the firm as risky. In other words, companies with higher carbon emission have higher carbon risk since they incur substantial environmental compliance costs to reduce their greenhouse gas production, that in turn will reduce their ability to obtain informal financing from suppliers or get trade credit extensions since a high carbon risk is a good sign of defaulting. For example, governments around the globe are imposing regulatory expenses and fees in an effort to combat global warming. These laws are translated into incurred expenses to firms, such as, carbon taxes, cap-and-trade system, fuel efficiency, and expenses related to research and investments in clean technologies. Moreover, firms with higher greenhouse gas emissions will incur costs related to corporate reputation management, which can be defined as the costs paid to sustain positive perceptions and assessments of all relevant stakeholders (Wiedmann & Buxel, 2005).

High carbon risk as a result of these additional expenses and costs has the potential to harm a company's profitability and hinder its capability to repay its credit on time; thus, climate-related added expenses, also known as carbon risk, could be an indicator of the company's likelihood of defaulting on its financial obligations. The volume and intensity of a firm's carbon emissions, according to Kabir et al. (2021), is a substantial positive driver of its risk of default. Subsequently, Shi and Zhang (2010) discovered that for suppliers, the chance that a company would be unable to repay its loan functions as a screening criterion for identifying firms acceptable for trade credit providing. This is due to the fact that the granting of trade credit exacerbates negative consequences such as cash flow constraints and default risk, which can significantly harm suppliers' profitability or even lead to financial bankruptcy (Wang et al., 2018).Hence, suppliers will be more reluctant to extend credit to such high emitting companies, as their increased climate-related expenses increase their carbon risk and reduce their ability to honor their obligation.

Moreover, drawing on the signaling theory, we argue that decreasing greenhouse emissions reduces a firm's carbon risk by communicating its ethical behavior to its suppliers (Zerbini, 2017). Corporations that reduce their carbon emissions to minimal levels send a signal that they are socially responsible, which promotes strong morality and enhances the reputation among suppliers. As a result, suppliers are more inclined to offer trade credit to clients that behave ethically, and suppliers are more supportive of firms with lower carbon emissions. Based on this, we argue that firms with higher carbon emissions are perceived as unethical and untrustworthy, implying that they may not be committed to meeting their obligations, which can affect their ability to obtain informal financing. Therefore, our hypothesis stated that:

H1: Carbon risk has a negative association with trade credit.

Chapter 3: Methodology

3.1. Dependent variable: Trade Credit

Trade credit is the dependent variable in this study. We use the ratio of accounts payable over cost of goods sold (AP/COGS) as our main proxy for trade credit, as accounts payable are bundled to purchases of goods. This measure of trade credit is the usual measure to assess the relative importance of trade credit extension and it has been widely used in prior literature (Shenoy & Williams, 2017; Garcia-Appendini & Montoriol-Garriga, 2013; Molina & Preve, 2012; Love et al., 2007). The numerator (accounts payables) represents the receipt of trade credit from suppliers, while the cost of goods sold (COGS) captures the average purchase costs. Hence, this ratio represents the proportion of total purchases financed by trade credit.

3.2. Independent Variables: Carbon emissions

We use total emissions over total assets (CETT), direct emissions over total assets (CEDT) and indirect emissions over total assets (CEIT) as our proxies for carbon emissions. Safiullah et al. (2021) used total carbon emissions over total assets, direct carbon emissions, and indirect carbon emissions from Refinitiv's Asset 4 database as proxies for carbon risk. These variables are also used in climate and carbon risk papers such as Capasso et al. (2020) and Safiullah et al. (2022). We expect that direct carbon emissions (CEDT) and indirect carbon emissions (CEIT) to be negatively related to trade credit, as we believe that suppliers perceive high direct and indirect carbon emissions as a financial risk factor. For example, if a firm emit higher CO2 from direct sources such as the burning of fossil fuels to manufacture goods or from its own vehicles; it will incur higher compliance expenses which could lead to cashflow uncertainty (Ding & Shahzad, 2021), this in turn will lead suppliers to consider this increase in direct carbon emissions as a financial risk and will refrain from extending trade credit to that firm. Similarly, a firm with a higher indirect emission, in the form of electricity purchased from a utility for example, will need to pay higher prices for the electricity purchased, since the utility itself will need to pay higher compliance costs for their increased emissions. Therefore, the higher electricity cost could affect the firm’s cashflow status and in turn the suppliers will view the increase in indirect carbon emissions as a risk factor to refrain from providing or extending trade credit.

3.3. Control variables

To capture business characteristics that may affect trade credit, we use a set of control variables used in previous studies. First, we control for firm size because it is an important factor in a firm's ability to obtain informal funding. (Summers & Wilson, 2002). Following prior research on trade credit (Al-Hadi & Al-Abri, 2022; Cao, 2022; Islam et al., 2022; Li, 2021; Saeed & Zureigat, 2020; Lawrenz & Oberndorfer, 2018; Yazdanfar & Öhman, 2016; Martínez-Sola et al., 2014; Casey & O'Toole, 2014; Ahmed et al., 2014; Casey & O'Toole, 2014; Wu et al., 2014; Tang, 2014; Summers & Wilson, 2002; Long et al., 1993); we control for the firm’s size (SIZE) which is calculated as the natural logarithm of total assets. The size of the company can be used as a proxy for its corporate reputation, as large established corporations may be regarded as less risky. Furthermore, larger enterprises have more bargaining power (Draganskaet al., 2010; Jónsson, 2007; Wilner, 2000). As a result, we anticipate that larger enterprises will have a better bargaining power, and hence will be more prepared to hold significant sums of trade payable and may secure more flexible payment terms from their suppliers. As a result, we anticipate a positive relationship between size and trade credit.

Second, we control for the firm’s leverage (LEV) following past papers (e.g., Islam et al., 2022; Cao, 2022; Al-Hadi & Al-Abri, 2022; Berloco et al., 2021; Abuhommous & Almanaseer, 2021; Li, 2021; Khan et a., 2020; Tsuruta & Uchida, 2019; Goto, 2015;

Tang, 2014; Tsuruta & Uchida, 2013; Zhang, 2011; Zhu & Jiang, 2009), which is computed as total debt over total assets. We expect a negative coefficient for LEV because trade credit is an alternative for loans for companies that find it more difficult to obtain financing from the bond market (Cull et al., 2009). In general, firms with good financial performance find it easier to obtain capital market financing than firms in financial trouble. In other words, because they have a reduced default risk and better monetary conditions, financially robust enterprises have more access to capital and confront less expensive external financing (Kim, 2016). Firms in financial trouble use a much greater quantity of trade credit to replace alternative financing sources (Molina & Preve, 2012).

Third, following related studies (e.g., Cao, 2022; Al-Hadi & Al-Abri, 2022; Li, 2021; Pham & Huynh, 2020; Zhang et al., 2020; Saeed & Zureigat, 2020; Harris & Dudney, 2018; Xia, 2016; McGuinness & Hogan, 2016; Tang, 2014; Casey & O'Toole, 2014; Wu et al., 2014), we control for the firm's sales Growth (SG) calculated by dividing the difference between current year sales and previous year sales divided by previous year sales. Trade credit is more likely to be given extended to companies with a higher sales growth (Afrifa & Gyapong, 2017). The underlying assumption is that enterprises experiencing rapid sales development require financing in general, and trade credit in particular (Garca & Martnez, 2010). As a result, we can expect enterprises with faster increasing sales to use more trade credit to finance new investments in current assets. Furthermore, suppliers are willing to extend trade credit to companies with quicker expanding sales (Ahmed et al., 2014). As a result, we anticipate a positive link between growth and trade credit.

Fourth, following prior research (e.g., Cao, 2022; Hasan & Alam, 2022; Islam & Wheatley, 2021; Li, 2021; Osinubi, 2020; Khan et al., 2020; Chemmanur & Toscano, 2019; Carbo-Valverde et al., 2016; Zhang, 2011), we control for tangibility (TANG) using the ratio of property plant and equipment over total assets. The link between company tangibility and trade credit is a one-way street. On the one hand, we may expect a positive association between trade credit and tangibility since suppliers are more willing to lend trade credit to firms with a lower level of present tangible assets in accordance with past research (e.g. Petersen and Rajan, 1997; Fabbri and Menichini, 2010). Firms with more tangible assets, on the other hand, have greater access to external finance and less demand for trade credit since actual assets can be used as collateral for bank loans (e.g., Shleifer and Vishny, 1992; Dass et al., 2015).

Fifth, following Li, 2021; Saeed & Zureigat, 2020; Ahmed & Farooq, 2020; Pham & Huynh, 2020; Martínez-Sola et al., 2014; Casey & O'Toole, 2014; Wu et al., 2014; Bastos & Pindado, 2007), We use the net income over total assets ratio to control for company profitability (ROA). For numerous reasons, firms with higher profitability are more likely to secure a trade credit extension from suppliers. First, high profitability is valued by suppliers because it decreases the risk of default (Chen et al., 2011). Second, business reasons may induce suppliers to offer credit (Brennan et al., 1988; Smith 1987; Nadiri 1969); for example, trade credit may be used to create and maintain long-term commercial partnerships (Wilner, 2000; Ng et al., 1999). Profitable businesses live longer, so suppliers are more likely to invest in long-term relationships.

Sixth, several past papers on trade credit control for the firm's cash holdings (e.g., Cao, 2022; Tosun & Yildiz, 2022; Singh, 2022; Al-Hadi & Al-Abri, 2022; Li, 2021; D'Mello et al., 2020; Wu et al., 2019; Fuller et al., 2018; Dass et al., 2015; Casey & O'Toole, 2014; Zhang, 2011). In accordance with this body of work, we control for cash holdings (CASH) using the cash and equivalents ratio over total assets. We expect CASH to have a positive coefficient since cash holding promotes access to trade credit (King et al., 2014). According to the signaling theory, enterprises with large cash holdings are wealthy, which may induce suppliers to provide them trade credit (Bias and Gollier, 1997; Burkart and Ellingsen, 2004).

Seventh, we control for the company's growth using Tobin's Q measure (TOBIN_Q) calculated as the difference between the sum of market value of equity and total assets and book value of equity over total assets. Tobin's Q is used in several recent research that linked a firms' growth, value, and performance to trade credit provision (Luo et al., 2023; Li et al., 2023; Liu & Wang, 2023; Shahbazian et al., 2022; Cao et al., 2022; Zhang, 2022; Lai, 2022; Zhang et al., 2020; Norden et al., 2020 According to Evans and Gentry (2003), Tobin's Q is a reliable and widely accepted measure for assessing a firm's growth. This measure has the advantage of reducing any misrepresentations caused by taxes or accounting laws since it uses the market value of capital (Chen & Lee, 1995). We expect a positive correlation between (TOBIN_Q) and trade credit, since a company with a good growth opportunity is more likely to obtain trade credit from suppliers (Zhang et al., 2020).

Eighth, the level of a firm's financial distress has an influence on its ability to obtain informal financing. To measure financial distress, we follow prior literature (Norden et al., 2020; Shenoy & Williams, 2017; Aktas et al., 2012) and use Altman (1968)'s Z-score (Z_SCORE The Z-score formula was introduced by Altman in 1968, in which he used multivariate discriminant analysis to select the five most significant variables and their weights for measuring the financial distress of firms (Chouhan et al., 2014). Thus we control for financial constraints using Altam Z-score (Z_SCORE) calculated as (0.012×working capital + 0.014×retained earnings + 0.033×earnings before interest and taxes + 0.999×sales)/total assets + 0.006×(market value of equity/book value of debt) (Altman, 1968, p. 594). A higher Z_SCORE indicates a lower bankruptcy risk. We expect a negative coefficient for Z_SCORE, suggesting that companies that are far from financial distress are less likely to use trade credit since they are more able to raise other forms of financing such as long-term debt (Molina & Preve, 2012).

3.4. Sample

The data used in this study could be divided into two main groups. First, we use data to account for carbon risk using Refinitv database, which specifically report the level of carbon emissions produced by each firm on the sample. We collected data of the companies' total carbon emissions, direct carbon emissions, and indirect carbon emissions. Second, we use Compustat North America database to collect companies' market based and financial accounting data to utilize them as a measurement for trade credit, and other control variables. After matching the emission data with our accounts payable proxy and controls, we end up with a sample of firm-year observations over the period between 2001-2019.

Table 1 demonstrates our sample's industry composition. We studied a sample that consists of 3063 large, listed firms in 11 non-financial industries in the United States. We exclude firms from the financial sector to alleviate any concerns regarding the impact of these financial corporations on our results since these types of corporations have special regulatory circumstances. The distribution of our sample firms by industry is reported in Table 1 of the current version of the thesis. As can be seen, basic industries account for the largest number of observations in our sample (i.e., 17.52%). These industries are composed usually of corporations with different levels of carbon emissions such as oil and gas extraction (Alvarez et al., 2018), steel manufacturing (Hoffmann et al., 2020), and chemical production (US EPA, 2011). Moreover, our sample includes other high emitting industries such as transportation, which represents 4.4% of our total number of (US EPA, 2023), petroleum (EIA, 2022), which represents

7.31% of our total number of observations and construction (Center for Climate and Energy Solutions, 2020), which represents 2.12% of our total number of observations. Our sample also include the utility sector, which a major CO_2 emissions contributor in the United States (US EPA, 2011). As can be seen in Table 1, this sector accounts for 13.51% of our total number of observations. Being inspired by this table, we re-run our basic regressions (Models from 1 to 3 in Table 4) separately for high-emitter and low-emitter firms. High emitter firms are firms having the following two digit sic codes: 01, 10, 13, 26, 28, 40, 45 and 49, in line with Nguyen and Pham (2020). The results reported Table 6 show that firms belonging to emitter industries are less likely to obtain informal finance in the form of trade credit from the suppliers.

3.5. Model

In order to investigate the association between carbon risk and trade credit, we developed the following regression model:

(1) 〖AP/COGS〗_(i,t) = α0 + α1 〖EMISSIONS〗_(i,t-1) + α_2

CONTROLS + Ɛ_(i,t)

where AP/COGS is our dependent variable, EMISSIONS is either CETT or CEDT of CEIT, CONTROLS include SIZE, LEV, SG, TANG, ROA, CASH and Z_SCORE. These variables are defined in sections 3.1, 3.2, and 3.3. We also control in all regression for industry and year dummies to control for industry and year fixed effects. Ɛ is the error term. The variables definitions and data sources are available in the Appendix. We use pooled OLS regression to examine the impact of carbon emission on accounts payable, in line with Safiullah et al. (2021). This approach has been widely used in trade credit studies such as Hasan and Nurl Alam (2022) and Hasan et al. (2022), D'Mello and Toscano (2020), Shang (2020), Hasan and Habib (2019), Gonçalves et al. (2018), El Ghoul and Zheng (2016). Moreover, we use a random effects model to examine the impact of carbon emission on accounts payable, in line with (Hoang et al., 2023; Moro et al., 2021; McGuinness et al., 2018; El Ghoul & Zheng, 2016; Mateut et al., 2015). This approach is motivated by a Hausman test performed to check whether random or fixed effect model is suitable for our panel data. The results of the Hausman test are included in table 4, 7, and 8.

Chapter 4: Results

4.1. Descriptive statistics

The descriptive statistics for the variables utilized in the regression analysis are shown in Table 2. The average of accounts payable over cost per good sold (AP/COGS) is 16.86% (median: 13.13%), with a standard deviation of 20.16%. These data are consistent with earlier research in the same field (e.g., Hasan & Habib, 2019; Dass et al., 2015). Total carbon emissions as a percentage of all assets are on average 26.26%. Indirect carbon emissions over total assets are averaged at 5.09%, whereas direct emissions over total assets are averaged at 19.63%. Our findings imply that direct carbon emissions from our sample companies exceed indirect carbon emissions. Also, we discovered that 16.44% is the average business size in our dataset. The average tangibility is 32.65%, leverage is 61.55%, and sales growth is 5.35%. The average of ROA is 7.38%, CASH is 1.23%, and Tobin's Q is 1.171%. Also, according to the Altman bankruptcy model, sample businesses appear to be, on average, in the "green zone", with a 4.285 Z-Score value. They are in the safe zone because when the company gets a Z-Score above 3; it would be classified as having a low possibility of filing for bankruptcy.

4.2. Correlation Matrix

Correlations between the variables utilized in the regression analysis are shown in Table 3. As expected, we find a negative and highly significant correlation between trade credit (AP/COGS) and carbon emission over all assets (CETT) (coefficient = -0.074 for AP/COGS; significant at p 0.01). This offers some preliminary evidence in favor of our hypothesis, suggesting that shorter and stricter trade credit policies are related to increased carbon emission. This conclusion also applies to the ratio of direct and indirect carbon emissions to total assets since trade credit is also found to be considerably statistically significant and adversely associated with both measurements (CEDT and CEIT) -0.061 and -0.076, respectively. Moreover, we discover that trade credit is negatively connected with firm leverage (LEV), meaning that businesses with more debt are less likely to receive extensions of trade credit from suppliers. Trade credit has a negative relationship with financial instability (Z SCORE), profitability (ROA), and tangibility (TANG), and growth (TOBIN_Q). On the other hand, trade credit is significantly and positively associated with both firm size (SIZE), sales growth (SG) and the ratio of cash to total assets ratio (CASH), indicating that extending trade credit would be more likely to be offered to larger companies and companies with faster sales growth and large cash holdings (CASH).

4.3. Main Evidence

The estimation results for the association between carbon emissions and trade credit are reported in Table 4. As the primary indicator of trade credit, we utilize accounts payable scaled by cost of goods sold (AP/COGS) as the dependent variables. We present the findings in Columns (1) through (3) using OLS regression estimates. The coefficient for carbon emission over total assets (CETT) in the first column is negative and highly significant at the 1% level (t-statistic: -3.773), indicating that companies with higher carbon emissions obtain less trade credit. In other words, our research reveals that high carbon emissions are perceived by a business's suppliers as a feature that increases credit risk in their evaluation of a firm's trustworthiness, leading to a greater unwillingness to provide informal financing. We check if the effect of carbon emissions on trade credit stands true for both direct and indirect carbon emission measurements. There is a negative correlation between direct carbon emissions (CEDT) and trade credit that are highly statistically significant at the 1% level (t-statistic: (-3.532) shown in the second column. Moreover, the coefficient of indirect carbon emissions (CEIT) continues to load negative and statistically significant at 5% level (t-statistic: -2.). Consistent with our expectations, our findings in columns (2) and (3) demonstrate that suppliers consider both direct and indirect carbon emissions as factors when determining a firm's eligibility for trade credit provision.

The estimated company SIZE coefficient is positive and highly statistically significant in all specifications at the 1% level, in column (1) (t-statistic: 4.139), column (2) (t-statistic: 3.585), and column (3) (t-statistic: 3.664). This finding suggests that large firms receive more informal finance. Even though, this finding contradicts earlier literature such as Schwartz (1974), however, it supports our prediction and suggest that larger firms, which have higher relative bargaining power in trade relations, can hold large amounts of trade payables and obtain favorable trade credit policy, hence have better access to informal finance (Draganskaet al., 2010; Jónsson, 2007; Wilner, 2000; Deeg, 1999).

The fact that SG is positive and significant at the 5% level in column (1) (t-statistic: 2.174) and column (2) (t-statistics: 2.009), while positive and highly significant at 1% level (t-statistics: 3.215) in column (3); further supports the idea that companies with rapid growth in revenue are expected to get informal funding. Fast growing firms are more favored by suppliers and have higher demand for financing and thus will use more trade credit to finance their investment in current assets (Afrifa and Gyapong, 2017; Ahmed et al., 2014; García and Martínez, 2010).

Also, we find a negative and statistically significant coefficient for TANG in the third columns at 10% level (t-statistics: -1.646), suggesting that companies that have high tangible assets are less likely to use informal finance. This might be explained by the fact that such firms have more access to external financing, hence need informal financing such as trade credit (Dass et al., 2015; Shleifer & Vishny, 1992). The other control variables were not statistically significant.

4.4. Addressing endogeneity issues

Our findings suggest that high carbon emission is associated with less informal finance in the form of trade credit. It is possible that our findings are driven by omitted variables that affect both trade credit and carbon emissions, which may lead to inconsistent estimates. Therefore, we take into account the possibility that carbon emissions be endogenous.The support is from (Wu et al., 2023; Tanthanongsakkun et al., 2023; Wu & Tian, 2022; Safiullah et al., 2021; Bose et al., 2021; Lee et al., 2015). It is also possible that firms that are more able to obtain informal finance which are more transparent are more committed toward environmental responsibility (i.e., firms that have the same are less pollutant). To address endogeneity issues, we use the instrumental variable approach discussed in Wooldridge (2010), which is a general approach for the estimation of causal relations using observational data, that provides a way to obtain consistent parameter estimates, it is used when standard regression estimates of the relation of interest are biased (Smelser & Baltes, 2001). This approach is widely used in trade credit studies (e.g., El Ghoul and Zheng, 2016, Gonçalves et al., 2018, Hasan and Habib, 2019, D'Mello and Toscano, 2020, Shang, 2020, Hasan and Nurl Alam, 2022, and Hasan et al., 2022). The key concept is to employ a third instrumental variable to capture differences in the (IV) variable that are relevant and not related to these issues, and to quantify their causal impact on an outcome measure using this variation (Smelser & Baltes, 2001). We follow Safiullah et al. (2021) and CSR studies (e.g., Jiraporn et al., 2014) and use the average emissions of the neighboring firms (i.e., firms having the same ZIP code with three digits in the US) in a given year (GEOG_EMISSIONS) as an instrument for emissions. The reason behind using this instrument is that geographical proximity affects the firm's corporate social responsibility initiatives (Jiraporn et al., 2014), which include environmental responsibility that is the focus of the present thesis. In this case, this instrument is exogenous because it has no connection with trade credit but is instead determined on the basis of postal delivery efficiency.

In the first stage, we regress our emission variables on GEOG_EMISSIONS and the control variables, in line with Safiullah et al. (2021). The predicted value of emissions from the first stage will serve as our proxy for emissions in the second stage. Table 5 presents the findings of the two-stage regression model. The findings of stage one regression are described in Panel A of Table 5. The coefficient of our instrument (GEOG_EMISSIONS) is substantially positively and significantly related to firm-level carbon emission proxies. The coefficient on carbon emission (CETT), according to the second-stage regression findings in (Panel B), is still negative and highly significant at the 1% level. Both direct carbon emissions (CEDT) and indirect carbon emissions (CEIT) have negative and highly significant coefficients. We also use the industry average of total emissions over total assets (IND_EMISSIONS) in a given year while excluding the concerned firm as an instrument for firm-level carbon risk. Industries are based on Campbell's (1991) two digit sic code classification. When calculating the industry average emissions, we omit the concerned firm. The unreported results for the sake of brevity show that our findings are robust to the use of this alternative instrument for carbon emissions. Collectively, our findings show that our results are not driven by endogeneity issues.

4.5. High versus low emitter industries

High emitter industries may be more affected by the adverse effects of carbon risk. It is common for them to be sued for environmental violations and to pay fines. They also have bad reputation, hence are penalized by fund providers. They are less likely to obtain external financing (e.g, Nguyen and Pham, 2020). Therfore, we expect that firms from emitter industries are less likely to obtain external financing. To test this conjecture, we re-run our basic regressions (Models from 1 to 3 in Table 4) separately for high-emitter and low-emitter firms. High emitter firms are firms having the following two digit sic codes: 01, 10, 13, 26, 28, 40, 45 and 49, in line with Nguyen and Pham (2020). The results reported Table 6 show that firms belonging to emitter industries are less likely to obtain informal finance in the form of trade credit from the suppliers, supporting our prediction.

4.6. Additional Tests

4.6.1 The impact of carbon risk on trade credit: eliminating utility firms

We do a few more sensitivity analysis in this part to demonstrate the reliability of our regression findings. First, we exclude firms from the financial industry and the utilities sector to test the validity of our earlier findings on the impact of carbon risk on informal financing in the form of trade credit. The purpose of this action is to alleviate any concerns regarding the impact of the sample made up of financial and utility companies with special regulatory circumstances. By using this method, the number of observations for total carbon emissions, direct carbon emissions, and indirect carbon emissions are reduced. Using this new subsample, we re-estimate our basic regressions. The results reported in Table 7 demonstrate that CETT and CEDT are negative and statistically significant at 1% level (t-statistics: -4.414) and (t-statistics: -3.610), respectively. While CEIT is negative and statistically significant at 5% level (t-statistics: -2.177). These findings support our initial conclusion that enterprises' access to informal finance is reduced because of carbon emissions, even after removing firms in the utility sector. The findings of the control variables are consistent with our main results reported in section 4.3.

4.6.2 The impact of carbon risk on trade credit: eliminating the global financial crisis period

We rerun the baseline regressions after removing the global financial crisis period (2008-2009) to ensure that our results are not driven by the financial crisis. The results reported in Table 8 show that our previous findings remain qualitatively unchanged.

4.6.3 Firm Fixed effects

To further address endogeneity issues, we re-run our basic models using firm, industry, and year random effects instead of only using industry and year fixed effects. The results reported in Table 9 show that CETT, CEDT, and CEIT continue to load negative and significant, confirming our earlier results.

Chapter 5: Conclusion

Our thesis explores the association between trade credit usage and carbon risk. Whether suppliers will include carbon emissions while evaluating trade credit extensions is the main research topic addressed by our study. Our findings show that carbon risk is negatively related to trade credit. If carbon risk is measured through direct carbon emission, this negative relationship seems to be stronger. The result show that suppliers judge a firm's trustworthiness by its direct carbon emissions when providing informal finance. Also, we support our prediction by considering the adverse effects of carbon risk on high emitter industries, our results show that firms belonging to emitter industries are less likely to obtain informal finance in the form of trade credit from the suppliers. We also consider the impact of utility companies and remove them from our sample. Our results remain robust when excluding utility firms. Lastly, we account for the effects of the 2008-2009 global financial crisis and remove that period from our sample. The findings continue to be consistent when we exclude the financial crisis. Our findings are also robust to addressing endogeneity issues using the instrumental variable approach and including firm-fixed effects.

Our study adds to the body of knowledge (e.g., Kouloukoui et al., 2019; Pérez-Cornejo et al., 2019; Langenmayr & Lester, 2018; Acharya, 2011; Servaes et al., 2009; Merna & Al-Thani, 2008; Fatemi & Luft, 2002; Solomon et al., 2000; Clifford & Smith, 1995; Bromiley, 1991) by offering fresh perspectives on how short-term loan providers view firms' carbon emissions. Many variables have been found in earlier research, such as financial and transactional drivers (e.g., Emery, 1987; Ferris, 1981; Schwartz, 1974), information costs (e.g., Emery, 1984), market structure and product features (e.g., Frank & Maksimovic, 1998; Mian & Smith, 1992; Brennan et al., 1988), product quality (e.g., Cuant, 2000; Emery & Nayar, 1998; Malitz & Ravid, 1994; Lee & Stowe, 1993), market flaws (e.g., Aktas et al., 2012; Ng et al., 1999; Smith, 1987), supplier market power (e.g., Wilner, 2000; Petersen & Rajan, 1997), firm's lifecycle (e.g., Hasan et al., 2021) tax brackets (e.g., Demirguc-Kunt & Maksimovic, 2001; McMillan & Woodruff, 1999; Brick & Fung, 1984), social trust (e.g., Levine et al., 2018; Wu et al., 2014; Allen et al., 2005; Fisman & Love., 2003), and corporate social responsibility (e.g., Saeed & Zureigat, 2020). We add to the literature by underlining carbon emissions as a further crucial factor that influences a firm's capacity to secure informal finance.

Our research has significant policy implications for corporate managers and academic literature. First, it is important for corporate managers because they can improve the firm’s reputation and build a good relationship with suppliers via implementing carbon reduction policies and action plans to improve their standing and credibility with suppliers; thus, the trade creditors will be more willing to extend informal financing and trade credit to them as a result, which will increase earnings and help the company reach its long-term operational goals. Second, the significance of our findings to academic literature is that it supports the literature on climate change management that highlights the significance of greenhouse gas emission reduction, which will aid in the growing efforts of global warming reduction, and in saving the planet.

However, our research has some limitations that can be accounted for in future research. For example, since the carbon emissions reported by Refintiv are based on declarative data, it’s possible that firms with unfavorable carbon emissions level do not declare their carbon emissions status, thus our sample might suffer from selection bias. This is issue could be fixed in future research by using data from KLD or CDP reports. Also, by using methods like Heckman test that could fix the selection bias problem. Also, we only used data based in the US which is a country that withdrew from the Paris agreement and thus went through some fluctuations regarding their environmental regulations, and data from one country could give narrow insights, so future research can use more comprehensive international data which includes countries like China and India.

Appendix

Variable	Definition and Measurement	Source
AP/COGS	Trade credit, measured as accounts payable over costs of goods sold	Compustat North America
CETT	Total carbon emissions over total assets	Refinitv
CEDT	Total direct carbon emissions over total assets	Refinitv
CEIT	Total indirect carbon emissions over total assets	Refinitv
SIZE	The natural logarithm of total sales in US$	Compustat North America
LEV	The ratio of total debt over total assets	Compustat North America
SG	The ratio of the current year sales minus previous year sales over previous year sales	Compustat North America
TANG	The ratio of property plant & equipment over total assets	Compustat North America
ROA	The ratio of net income over total assets	Compustat North America
CASH	The ratio of cash and equivalents over total assets	Compustat North America
TOBIN_Q	The difference between the sum of market value of equity and total assets and book value of equity over total assets.	Compustat North America
Z_SCORE	Bankruptcy risk estimated by Altman's Z-score of the firm	Compustat North America

TABLES

Table 1 Sample Industry Decomposition

SIC_CAM	Industry	N	%	*AP/COGS*	*CETT*	*CEDT*	*CEIT*	*SIZE*	*LEV*	*SG*	*TANG*	*ROA*	*CASH*	*TOBIN_Q*	*Z_SCORE*
1	Basic industries	537	17.52%	20.49	33.47	21.67	10.77	16.37	61.23	5.59	32.19	8.71	1.05	1.99	4.64
2	Capital goods	437	14.26%	14.54	3.82	1.29	2.22	16.10	57.63	4.30	12.54	7.34	1.78	1.72	4.48
3	Construction	65	2.12%	10.94	20.39	11.35	8.64	15.92	62.41	3.02	34.10	6.71	1.19	1.62	3.99
4	Consumer durables	414	13.51%	15.36	6.21	2.06	4.57	16.02	59.23	5.11	20.91	8.52	1.89	1.81	5.40
6	Food/tobacco	258	8.42%	13.34	10.48	4.73	5.11	16.45	66.50	4.28	23.23	9.73	0.59	2.01	5.29
7	Leisure	90	2.94%	8.54	13.84	2.25	10.25	16.05	74.33	4.53	42.76	8.54	1.04	2.29	3.39
8	Petroleum	224	7.31%	27.96	27.25	22.52	5.54	17.08	52.24	8.06	55.21	5.51	0.80	1.39	3.29
9	Services	320	10.44%	18.88	1.67	0.47	1.25	16.17	55.89	9.45	11.99	7.88	2.30	2.23	6.36
10	Textiles/trade	171	5.58%	12.24	6.90	2.64	4.56	16.49	61.48	5.30	30.09	7.67	1.06	1.56	5.51
11	Transportation	135	4.40%	7.80	46.27	45.31	1.11	17.00	64.65	4.87	64.99	6.84	0.97	1.37	2.97
12	Utilities	414	13.51%	18.17	95.59	84.51	4.13	17.16	70.90	3.15	64.13	3.70	0.23	0.91	1.29
	Total	3036	100.00%												

This table presents the distribution of our sample based on Campbell's (1996) two-digit code industries as well as the average of our trade credit variable (*AP/COGS*), the carbon emission variables (*CETT*, *CEDT*, and *CEIT*), and control variables (SIZE, LEV, SG, TANG, ROA, CASH, TOBIN_Q, and Z_SCORE). The financial industry is excluded because financial firms have their own capital structure policy.

Table 2 Descriptive Statistics

Variable	N	Average	Median	Standard deviation	Q1	Q3
AP/COGS	3036	16.862	13.131	20.160	9.585	17.809
CETT	3036	26.263	5.933	52.026	1.903	24.064
CEDT	2493	19.630	1.684	44.699	0.358	14.739
CEIT	2372	5.097	2.124	9.409	0.888	5.676
SIZE	3036	16.444	16.483	1.260	15.526	17.323
LEV	3036	61.559	61.165	18.894	49.062	72.941
SG	3036	5.355	4.210	24.031	-1.836	10.554
TANG	3036	32.653	23.091	24.877	12.035	54.254
ROA	3036	7.386	7.110	7.431	3.935	11.145
CASH	3036	1.232	0.812	1.286	0.301	1.710
TOBIN_Q	3036	1.713	1.357	1.140	0.922	2.147
Z_SCORE	3036	4.328	4.000	3.472	2.100	5.700

This table reports the descriptive statistics of the dependent variable ‘trade credit’ proxied as accounts payables over costs of goods sold (AP/COGS); the independent variable ‘carbon risk’ proxied as total carbon emissions (CETT), direct carbon emissions (CEDT), and indirect carbon emissions (CEIT); and the control variables proxied as: size (SIZE), leverage (LEV), sales growth (SG), tangibility (TANG), profitability (ROA), cash holdings (CASH), Tobin’s q (TOBIN_Q), and financial distress (Z_SCORE). All variables are defined in Appendix A

Table 3 Correlation

Variable	*AP/COGS*	*CETT*	*CEDT*	*CEIT*	*SIZE*	*LEV*	*SG*	*TANG*	*ROA*	*CASH*	*TOBIN_Q*
CETT	**-0.074**										
CEDT	**-0.061**	**0.978**									
CEIT	**-0.076**	**0.417**	**0.211**								
SIZE	**0.092**	**0.087**	**0.090**	**-0.113**							
LEV	-0.023	**0.163**	**0.166**	0.053	**0.097**						
SG	**0.118**	-0.029	-0.034	0.001	-0.009	**-0.083**					
TANG	-0.022	**0.469**	**0.469**	**0.250**	**0.202**	**0.108**	**-0.052**				
ROA	-0.013	**-0.140**	**-0.162**	-0.005	-0.017	**-0.165**	**0.112**	**-0.213**			
CASH	0.014	**-0.266**	**-0.253**	**-0.176**	**-0.155**	**-0.340**	0.039	**-0.450**	**0.214**		
TOBIN_Q	-0.002	**-0.252**	**-0.260**	**-0.070**	**-0.217**	**-0.128**	**0.083**	**-0.305**	**0.500**	**0.388**	
Z_SCORE	-0.039	**-0.291**	**-0.295**	**-0.084**	**-0.194**	**-0.441**	**0.099**	**-0.418**	**0.524**	**0.377**	**0.668**

This table reports the Pairwise Pearson correlation matrix for all the variables included in our study. A Bold value denotes a statistically significant coefficient at the 1% level.

Table 4 Main Evidence

	(1)	(2)	(3)
VARIABLES	*AP/COGS*	*AP/COGS*	*AP/COGS*
CETT	-0.031***		
	(-3.773)		
CEDT		-0.047***	
		(-3.532)	
CEIT			-0.103**
			(-2.450)
SIZE	2.033***	2.102***	1.715***
	(4.139)	(3.585)	(3.664)
LEV	-0.007	-0.013	-0.027
	(-0.336)	(-0.512)	(-1.218)
SG	0.023**	0.026**	0.041***
	(2.174)	(2.009)	(3.215)
TANG	-0.036	-0.056	-0.053*
	(-1.133)	(-1.469)	(-1.646)
ROA	0.033	-0.018	-0.031
	(1.022)	(-0.460)	(-0.829)
CASH	-37.857	-40.976	-39.142
	(-1.165)	(-1.078)	(-1.159)
TOBIN_Q	0.479	0.455	0.202
	(1.348)	(1.112)	(0.529)
Z_SCORE	-0.082	-0.107	-0.076
	(-0.716)	(-0.826)	(-0.651)
Industry Fes	YES	YES	YES
Year Fes	YES	YES	YES
Constant	-10.510	-6.387	-8.614
	(-1.202)	(-0.552)	(-0.958)
Observations	3,004	2,461	2,340
R-squared	0.084	0.083	0.134
Hausman test			
Chi-Square	27.91	31.02	18.22
Prob>chi2	0.264	0.153	0.792
Breusch–Pagan test			
Chi-Square	1798.75	1610.76	1366.73
Prob>chi2	0.000	0.000	0.000

*, **, or *** indicates significance at the 10%, 5%, or 1% level, respectively, one-tailed for directional predictions and two-tailed for all others. Beneath parentheses are t-statistics. This table reports our main results of the impact of carbon risk on trade credit. Our dependent variable is accounts payables over costs of goods sold (AP/COGS). Our proxy of carbon risk in Model (1) is total carbon emissions (CETT). Our proxy of carbon risk in Model (2) is direct carbon emissions (CEDT). Our proxy of carbon risk in Model (3) is indirect carbon emissions (CEIT). Our proxy for control variables is size (SIZE), leverage (LEV), sales growth (SG), tangibility (TANG), profitability (ROA), cash holdings (CASH), Tobin's q (TOBIN_Q), and financial distress (Z_SCORE).

Table 5 Instrumental Variable Approach

Panel A: First stage

	(1)	(2)	(3)
VARIABLES	*CETT*	*CEDT*	*CEIT*
GEOG_EMISSIONS	0.817***	0.657***	0.835***
	(11.002)	(9.781)	(6.498)
SIZE	-4.952***	-4.180***	-1.348**
	(-3.949)	(-3.151)	(-2.068)
LEV	0.176***	0.109***	0.031**
	(3.584)	(2.903)	(1.977)
SG	0.004	0.012	0.005
	(0.214)	(0.725)	(1.075)
TANG	0.047	-0.110	0.092***
	(0.474)	(-1.082)	(2.653)
ROA	0.059	0.033	0.000
	(1.242)	(0.869)	(0.011)
CASH	-31.630	0.055	0.090
	(-0.755)	(0.106)	(0.800)
TOBIN_Q	-0.046	-0.230	-0.230
	(-0.076)	(-0.544)	(-0.883)
Z_SCORE	0.057	0.074	0.062
	(0.429)	(0.875)	(1.134)
Industry Fes	YES	YES	YES
Year Fes	YES	YES	YES
Constant	88.749***	97.274***	22.662**
	(4.195)	(3.832)	(1.992)
Observations	2,980	2,437	2,324
R-squared	0.4553	0.4358	0.4004
Breusch–Pagan test			
Chi-Square	2545.11	3076.11	3222.30
Prob>chi2	0.000	0.000	0.000

Panel B: Second stage

	(1)	(2)	(3)
VARIABLES	*AP/COGS*	*AP/COGS*	*AP/COGS*
Predicted_CETT	-0.019**		
	(-2.410)		
Predicted_CEDT		-0.040***	
		(-3.920)	
Predicted_CEIT			-0.192***
			(-4.425)
SIZE	0.880***	1.412***	0.709**
	(3.078)	(4.798)	(2.345)
LEV	0.003	0.015	0.010
	(0.208)	(1.148)	(0.776)
SG	0.022***	0.019***	0.028***
	(3.425)	(2.874)	(4.043)

TANG	-0.011	0.001	0.022
	(-0.621)	(0.057)	(1.087)
ROA	0.056***	0.058***	0.060***
	(2.881)	(2.881)	(2.998)
CASH	-8.699	9.523	2.561
	(-0.458)	(0.482)	(0.130)
TOBIN_Q	0.403*	0.526**	0.167
	(1.899)	(2.409)	(0.751)
Z_SCORE	-0.074	-0.102	-0.054
	(-1.091)	(-1.477)	(-0.788)
Industry Fes	YES	YES	YES
Year Fes	YES	YES	YES
Constant	3.029	-6.838	2.740
	(0.540)	(-1.157)	(0.475)
Observations	2,980	2,784	2,726
R-squared	0.155	0.148	0.174
Breusch–Pagan test			
Chi-Square	912.13	896.40	833.28
Prob>chi2	0.000	0.000	0.000

*, **, or *** indicates significance at the 10%, 5%, or 1% level, respectively, one-tailed for directional predictions and two-tailed for all others. Beneath parentheses are t-statistics. This table reports our Instrumental variable approach results that measure the robustness of the impact of carbon risk on trade credit. For Panel A, our dependent variable in Model (1) is total carbon emissions (CETT). Our dependent variable in Model (2) is direct carbon emissions (CEDT). Our dependent variable in Model (3) is indirect carbon emissions (CEIT). Our proxy of the industry-wide average of emissions (IND_EMISSIONS). Our proxy for control variables is size (SIZE), leverage (LEV), sales growth (SG), tangibility (TANG), profitability (ROA), cash holdings (CASH), Tobin's q (TOBIN_Q), and financial distress (Z_SCORE). For Panel B, our dependent variable is accounts payable over costs of goods sold (AP/COGS). Our proxy of carbon risk in Model (1) is the estimated total carbon emissions (CETT). Our proxy of carbon risk in Model (2) is the estimated direct carbon emissions (CEDT). Our proxy of carbon risk in Model (3) is the estimated indirect carbon emissions (CEIT). Our proxy for control variables is the same as Panel A.

Table 6 High versus low emitter industries

	Panel A: High emitter industries			Panel B: Low emitter industries		
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	*AP/COGS*	*AP/COGS*	*AP/COGS*	*AP/COGS*	*AP/COGS*	*AP/COGS*
CETT	-0.025***			-0.017		
	(-2.411)			(-0.922)		
CEDT		-0.039**			-0.016	
		(-2.271)			(-0.536)	
CEIT			-0.130**			0.014
			(-2.288)			(0.227)
SIZE	2.798***	3.450***	1.963**	1.599***	1.646***	1.662***
	(2.582)	(2.657)	(2.057)	(3.818)	(3.348)	(3.228)
LEV	-0.082	-0.108*	-0.186***	-0.006	-0.014	-0.015
	(-1.521)	(-1.680)	(-3.525)	(-0.286)	(-0.579)	(-0.603)
SG	0.014	0.010	0.066***	0.026**	0.034**	0.036**
	(0.747)	(0.444)	(2.895)	(1.994)	(2.202)	(2.280)
TANG	-0.040	-0.050	-0.047	-0.102***	-0.133***	-0.128***
	(-0.835)	(-0.798)	(-0.907)	(-3.285)	(-3.539)	(-3.230)
ROA	0.285***	0.215***	0.153**	-0.060	-0.073	-0.069
	(4.490)	(2.767)	(2.201)	(-1.588)	(-1.604)	(-1.501)
CASH	-153.073**	-102.562	-9.651	-14.066	-33.450	-45.915
	(-1.960)	(-1.132)	(-0.124)	(-0.461)	(-0.931)	(-1.247)
TOBIN_Q	3.673***	4.707***	4.795***	0.179	0.043	-0.083
	(3.675)	(4.043)	(4.713)	(0.504)	(0.102)	(-0.195)
Z_SCORE	-2.019***	-2.497***	-2.433***	-0.006	-0.006	0.019
	(-3.915)	(-4.294)	(-4.850)	(-0.056)	(-0.046)	(0.156)
Industry Fes	YES	YES	YES	YES	YES	YES
Year Fes	YES	YES	YES	YES	YES	YES
Difference test for coefficients	7.82***	5.22**	12.82***			

Constant	-14.697	-22.129	-2.149	-8.304	-7.370	-7.105
	(-0.757)	(-0.901)	(-0.117)	(-1.185)	(-0.883)	(-0.800)
Observations	1,072	863	754	1,962	1,598	1,586
R-squared	0.067	0.066	0.125	0.049	0.061	0.064
Breusch–Pagan test						
Chi-Square	307.58	411.63	480.59	2290.34	2043.04	1953.01
Prob>chi2	0.000	0.000	0.000	0.000	0.000	0.000

*, **, or *** indicates significance at the 10%, 5%, or 1% level, respectively, one-tailed for directional predictions and two-tailed for all others. Beneath parentheses are t-statistics. This table reports our results separately for high-emitter and low-emitter firms. High emitter firms are firms having the following two digit sic codes: 01, 10, 13, 26, 28, 40, 45 and 49, in line with Nguyen and Pham (2020). Our dependent variable is accounts payables over costs of goods sold (AP/COGS). Our proxy of carbon risk in Model (1) & (4) is total carbon emissions (CETT). Our proxy of carbon risk in Model (2) & (5) is direct carbon emissions (CEDT). Our proxy of carbon risk in Model (3) & (6) is indirect carbon emissions (CEIT). Our proxy for control variables is size (SIZE), leverage (LEV), sales growth (SG), tangibility (TANG), profitability (ROA), cash holdings (CASH), Tobin's q (TOBIN_Q), and financial distress (Z_SCORE).

Table 7 Excluding Utilities

	(1)	(2)	(3)
VARIABLES	*AP/COGS*	*AP/COGS*	*AP/COGS*
CETT	-0.071***		
	(-4.414)		
CEDT		-0.090***	
		(-3.610)	
CEIT			-0.106**
			(-2.177)
SIZE	1.691***	1.780***	1.731***
	(3.684)	(3.258)	(3.408)
LEV	-0.010	-0.016	-0.027
	(-0.470)	(-0.684)	(-1.180)
SG	0.030***	0.033**	0.041***
	(2.652)	(2.382)	(2.967)
TANG	-0.045	-0.068*	-0.079**
	(-1.363)	(-1.719)	(-2.125)
ROA	0.035	-0.024	-0.033
	(1.035)	(-0.603)	(-0.850)
CASH	-29.822	-35.890	-45.430
	(-0.941)	(-0.975)	(-1.285)
TOBIN_Q	0.485	0.497	0.200
	(1.373)	(1.232)	(0.502)
Z_SCORE	-0.110	-0.144	-0.072
	(-0.965)	(-1.122)	(-0.596)
Industry Fes	YES	YES	YES
Year Fes	YES	YES	YES
Constant	-3.086	-12.713	-10.015
	(-0.380)	(-0.967)	(-0.850)
Observations	2,629	2,173	2,138
R-squared	0.148	0.135	0.141
Hausman test			
Chi-Square	21.22	30.53	17.20
Prob>chi2	0.626	0.168	0.840
Breusch–Pagan test			
Chi-Square	1493.31	1245.59	1137.25
Prob>chi2	0.000	0.000	0.000

*, **, or *** indicates significance at the 10%, 5%, or 1% level, respectively, one-tailed for directional predictions and two-tailed for all others. Beneath parentheses are t-statistics. This table reports our main results of the impact of carbon risk on trade credit excluding firms in the utility sector. Our dependent variable is accounts payables over costs of goods sold (AP/COGS). Our proxy of carbon risk in Model (1) is total carbon emissions (CETT). Our proxy of carbon risk in Model (2) is direct carbon emissions (CEDT). Our proxy of carbon risk in Model (3) is indirect carbon emissions (CEIT). Our proxy for control variables is size (SIZE), leverage (LEV), sales growth (SG), tangibility (TANG), profitability (ROA), cash holdings (CASH), Tobin's q (TOBIN_Q), and financial distress (Z_SCORE).

Table 8 Excluding 2008-2009 Financial Crisis

	(1)	(2)	(3)
VARIABLES	*AP/COGS*	*AP/COGS*	*AP/COGS*
CETT	-0.030***		
	(-3.454)		
CEDT		-0.043***	
		(-3.045)	
CEIT			-0.104**
			(-2.259)
SIZE	1.668***	1.809***	1.762***
	(3.192)	(2.921)	(3.579)
LEV	-0.004	-0.012	-0.029
	(-0.195)	(-0.463)	(-1.224)
SG	0.036***	0.036***	0.042***
	(3.165)	(2.597)	(2.967)
TANG	-0.051	-0.087**	-0.061*
	(-1.533)	(-2.168)	(-1.771)
ROA	0.042	-0.026	-0.040
	(1.178)	(-0.573)	(-0.927)
CASH	-32.307	-30.244	-22.743
	(-0.948)	(-0.755)	(-0.626)
TOBIN_Q	0.141	0.157	0.226
	(0.374)	(0.356)	(0.550)
Z_SCORE	-0.001	-0.027	-0.022
	(-0.006)	(-0.204)	(-0.177)
Industry Fes	YES	YES	YES
Year Fes	YES	YES	YES
Constant	-4.015	1.049	-8.882
	(-0.431)	(0.086)	(-0.942)
Observations	2,667	2,178	2,084
R-squared	0.082	0.079	0.133
Hausman test			
Chi-Square	19.12	12.30	13.26
Prob>chi2	0.6378	0.951	0.926
Breusch–Pagan test			
Chi-Square	1610.71	1439.13	1136.67
Prob>chi2	0.000	0.000	0.000

*, **, or *** indicates significance at the 10%, 5%, or 1% level, respectively, one-tailed for directional predictions and two-tailed for all others. Beneath parentheses are t-statistics. This table reports our main results of the impact of carbon risk on trade credit excluding the financial crisis period (2008 – 2009). Our dependent variable is accounts payables over costs of goods sold (AP/COGS). Our proxy of carbon risk in Model (1) is total carbon emissions (CETT). Our proxy of carbon risk in Model (2) is direct carbon emissions (CEDT). Our proxy of carbon risk in Model (3) is indirect carbon emissions (CEIT). Our proxy for control variables is size (SIZE), leverage (LEV), sales growth (SG), tangibility (TANG), profitability (ROA), cash holdings (CASH), Tobin's q (TOBIN_Q), and financial distress (Z_SCORE).

Table 9 Firm Fixed Effects

	(1)	(2)	(3)
VARIABLES	*AP/COGS*	*AP/COGS*	*AP/COGS*
CETT	-0.012**		
	(-2.401)		
CEDT		-0.015*	
		(-1.725)	
CEIT			-0.066*
			(-1.790)
SIZE	1.568	1.918	1.840
	(1.440)	(1.452)	(1.374)
LEV	-0.017	-0.019	-0.018
	(-0.675)	(-0.642)	(-0.591)
SG	0.023	0.030*	0.039**
	(1.632)	(1.826)	(2.265)
TANG	-0.007	-0.021	-0.005
	(-0.213)	(-0.559)	(-0.128)
ROA	0.039	-0.009	-0.030
	(0.641)	(-0.113)	(-0.384)
CASH	-0.560	-0.598	-0.536
	(-1.504)	(-1.404)	(-1.253)
TOBIN_Q	-0.055	-0.170	-0.011
	(-0.152)	(-0.438)	(-0.030)
Z_SCORE	-0.003	0.002	-0.010
	(-0.038)	(0.021)	(-0.104)
Firm Fes	YES	YES	YES
Industry Fes	YES	YES	YES
Year Fes	YES	YES	YES
Constant	-17.132	-14.498	-16.851
	(-0.916)	(-0.656)	(-0.750)
Observations	3,004	2,461	2,340
R-squared	0.812	0.821	0.742
Breusch–Pagan test			
Chi-Square	35929.57	29148.25	34320.53
Prob>chi2	0.000	0.000	0.000

*, **, or *** indicates significance at the 10%, 5%, or 1% level, respectively, one-tailed for directional predictions and two-tailed for all others. Beneath parentheses are t-statistics. This table reports our main results of the impact of carbon risk on trade credit. Our dependent variable is accounts payables over costs of goods sold (AP/COGS). Our proxy of carbon risk in Model (1) is total carbon emissions (CETT). Our proxy of carbon risk in Model (2) is direct carbon emissions (CEDT). Our proxy of carbon risk in Model (3) is indirect carbon emissions (CEIT). Our proxy for control variables is size (SIZE), leverage (LEV), sales growth (SG), tangibility (TANG), profitability (ROA), cash holdings (CASH), Tobin's q (TOBIN_Q), and financial distress (Z_SCORE).

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