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Influence of institutional differences on trade credit use during pandemics

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ABSTRACT

This study examines the formal and informal institutions that affected trade credit during the pandemic periods. To this end, we analyze 590,025 firm-year observations across 107 countries during six recent pandemic crises: SARS (2003), H1N1 (2009), MERS (2012), Ebola (2014), Zika (2016), and COVID-19 (2020). The study finds that formal legal institutions and firms' information transparency during pandemic periods act as a "brake" for trade credit usage. By contrast, informal institutions with religious connotations or attributes, social trust, and policy stability play a "cushion" role in softening the impact of pandemic crises when a firm applies for trade credit. These results remain robust after alternating the estimation techniques, trade credits, pandemic variables, and different samples. This study offers new evidence on the role of trade credit from the perspectives of formal and informal institutions during pandemic crises. The outcomes thus provide information worthy of consideration by policymakers when faced with informal institutional conditions and support government efforts to improve unstable formal systems and prevent severe shocks in the future.

1. Introduction

Trade credit (TC) is generally considered an essential form of informal financing when firms experience difficulties in obtaining external funding from formal financial institutions (Ferrando and Mulier, 2013; Levine et al., 2018). The redistribution theory of TC highlights the relationship between formal and informal finance (Ogawa et al., 2013; Hasan and Habib, 2019). This theory states that when TC is used, suppliers agree to allow customers to defer payments for delivered goods under the promise that the incurred amounts will be paid later (Wu et al., 2014; Boissay et al., 2020). In addition, financial formal intermediaries (e.g., banks) can offer this TC channel to firms, thereby providing better lending facilities and redistributing credit to firms with lower privileges (Ferrando and Mulier, 2013). However, during extreme crises, this redistribution mechanism shuts down when all potential sources of funds dry up (Love et al., 2007).

A pandemic is a serious health crisis leading to uncertainty that severely affects the global economy (Al-Thaqeb et al., 2020; Hasan et al., 2021). This uncertainty may push individuals and firms to behave more conservatively in their consumption and financial

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decisions, raising the cost of loans and inducing a more severe economic crisis (Baker et al., 2016; Hasan et al., 2021). Therefore, economies dramatically affected by these crises shift from issuing loans to using the TC channel for firms (Ferrando and Mulier, 2013), which in turn influences a firm's profitability (Grau and Reig, 2018). For example, Coulibaly et al. (2013) found that small and medium-sized enterprises (SMEs) in the textile industries of emerging markets increased their use of TC instead of borrowing from banks during the 2008–2009 global financial crisis. Similarly, Boissay et al. (2020) found that, in the case of COVID-19, where buyers and suppliers were shocked simultaneously, the TC channel may have been used by firms as a cushion to avoid negative economic impacts (Dubey et al., 2022). Gofman and Wu (2022) further showed that firms positioned further away from final consumption goods would provide more TC and obtain higher profits within the TC supply chain.

Despite research investigating pandemics' effect on firms' TC behavior, few studies have examined the reverse to gauge the response of formal and informal institutions to TC during pandemic periods. Accordingly, following these events provides us with a unique opportunity to examine formal and informal policies for TC that policymakers should consider in light of their influence on the outcome of policy interventions.

These formal conditions relate to financial intermediaries and the legal, informational, political, cultural, and social environments. For example, Ferrando and Mulier (2013) suggested that firms might use the TC mechanism to deliver goods and services to their consumers without immediate payment when a bank no longer offers sufficient loans. In addition, differences in legal protection for creditors, other relevant laws, and court decisions could help explain why suppliers offer TC to buyers (Wu et al., 2014; Psillaki and Eleftheriou, 2015; Su et al., 2020; Chen et al., 2021). Furthermore, information transparency affects a firm's TC decisions. More information disclosure is a positive signal that predicts better financial performance. Meanwhile, information transparency helps creditors make timely assessments of debtors' repayment ability (Wang et al., 2022) to avoid the risk of default on TC, which may lead to creditor bankruptcy (Yang and Birge, 2018).

In addition to formal conditions, informal institutions are a profound factor influencing firms' TC decisions. Such informal aspects include customs, religion, language, and culture (Karaibrahimoglu and Cangarli, 2015). As Hilary and Hui (2009) and Chen et al. (2016) pointed out, religion affects both legal and political institutions and economic attitudes. Firms with strong religious attributes generally tend to have lower risk exposure, loan interest spread, and upfront fees when using more TC (Kanagaretnam et al., 2015; Chen et al., 2016; Chen et al., 2018). In periods of high uncertainty, social trust is another factor that affects firms' financial behavior. Therefore, some studies have investigated the effects of social trust on firm default risk (Ho et al., 2020), observing the motives that trigger firms' usage of TC (Wu et al., 2014; Chen et al., 2018; Levine et al., 2018). Finally, policy uncertainty also influences firms' short-term credit policies (D'Mello and Toscano, 2020), making it difficult for firms to predict changes accurately and decide whether to borrow funds (Su et al., 2020). High policy uncertainty often leads to greater stock price volatility (Baker et al., 2016) and decreased firm account receivables and payables from customers and suppliers on TC (Jory et al., 2020; Su et al., 2020).

Consequently, this study verifies formal and informal institutions that affect TC based on pandemic crises and fills the research gap by addressing the following research questions: (1) What are the impacts of formal and informal institutions on TC channels due to pandemic crises? (2) To what extent are these results robust when alternative measures of other variables and samples are used?

To identify formal and informal institutions associated with firms' use of TC, we selected samples from more than 590,000 firms across 107 countries. The data were collected from 1990 to 2020. After referencing Prabhakaran et al. (2017) and recent events, we define six global pandemics: SARS (2003), H1N1 (2009), MERS (2012), EBOLA (2014), Zika (2016), and COVID-19 (2020). Our main findings show that formal institutions act like a "brake," slowing down firms' applications for TC during pandemic crises. By contrast, informal institutions act as a "cushion" for TC, expanding the available finance channels that allow firms to cope with the pressures arising from pandemics. Notably, the results remain robust even after replacing them with estimation methods, TC, pandemic variables, and different samples.

The contributions of this study are as follows. (1) Our study extends the research related to TC in two ways. First, compared to financial crises, we provide different perspectives from various pandemic periods to examine how formal and informal institutions influenced firms' TC. This expands the impact of the different types of crises on TC. Second, the results expand the scope of formal and informal institutions' perspectives to comprehensively examine TC use, considering broader factors that impact TC. (2) This study reveals that formal and informal institutions play different roles during pandemics. The former slow down firms using TC during crises, whereas the latter release pressure on firms caused by these pandemics. These findings may provide new evidence for governments to construct formal systems and determine the role of informal systems in ameliorating the impact of pandemic shocks.[1] While steadily building and advancing the development of formal institutions, policymakers should recognize the role of informal institutions in relieving economic stress on businesses during a pandemic and regulate informal institutions. Preparing for a rainy day is a good way to relieve economic stress on companies and guard against systemic risk in the event of a crisis.[2]

The remainder of this paper is organized as follows. Section 2 reviews the existing literature. Section 3 describes the data and research design. Section 4 presents the empirical results. Section 5 describes the robustness analysis. Finally, Section 6 concludes the study.

[1] Pandemics not only cause damage to the health of individuals but can also be a hindrance to the smooth running of the economy. It is difficult to predict the timing and duration of the next pandemic, and prevention is the best course of action. Thus, we believe insights for policymakers when faced with future crises are important.

[2] Our paper has some limitations. For example, we did not go on to discuss the impact of factors such as the duration and lethality of a pandemic crisis on the conclusions. These limitations are the direction of our next research.

2. Literature review and hypothesis development

2.1. Link between pandemic crises and trade credit

Several studies have examined the relationship between pandemics and economic behavior. For instance, McTier et al. (2013) found that pandemics with higher growth rates lead to a sharp decline in market trading activity. After simulating seven economic scenarios that impacted the COVID-19 pandemic, McKibbin and Fernando (2021) stated that even a contained outbreak could significantly influence the global economy in the short run. Under these circumstances, a firm generally faces higher borrowing costs and smaller loan amounts, which may result in increased financial constraints and reliance on debt financing during a pandemic (e.g., Devpura and Narayan, 2020; Iyke, 2020; Narayan, 2020a, 2020b, 2021; Phan and Narayan, 2020; Salisu and Akanni, 2020; Sha and Sharma, 2020; Sharma, 2020; Sharma and Sha, 2020; Shen et al., 2020; Gong et al., 2021; Hasan et al., 2021).

Therefore, TC is beneficial because it potentially enables firms to reduce their transaction[3] and financing costs[4] (Mateut, 2005; Seifert et al., 2013). Such a TC operation implies that the bank is indirectly financing the firm's customers (Ferrando and Mulier, 2013) and is a closer substitute for a firm's short-term loan needs (Klapper et al., 2012).

Although TC has an advantage in financing activity, it may have highly heterogeneous economic effects that accelerate with pre-existing trends during pandemics (Duchin and Harford, 2021). For example, Boissay et al. (2020) observed that inter-firm lending using TC was severely diminished during pandemics. In particular, at the beginning of a pandemic, firms usually increase their adjustment in short-term liquidity using TC and are highly heterogeneous across sectors (Bureau et al., 2021). This could lead to a pandemic crisis whose impact on TC is difficult to estimate.

As the size of bank loans decreases (Gong et al., 2021), the cost of borrowing to finance credit increases (Halling et al., 2020; Tran and Uzmanoglu, 2022), and TC may become more costly during a pandemic. Thus, the total TC ratio decreases (Love et al., 2007). Meanwhile, firms may reduce TC during a pandemic due to concerns about corporate liquidity risk as market demand for products and services shrinks or fluctuates (Khieu et al., 2021). In addition, Jha et al. (2021) showed that finance sentiment declines after pandemics, because it is harder to share risk via insurance for pandemic crises than for other natural disasters.

Based on the above observations, it can be surmised that pandemics lead to a dramatic decline in market trading activity and a severe economic breakdown, and firms may cut back on TC because of difficulties in accessing capital and concerns about risk. Thus, we expect that pandemic crises and firms' use of TC are related and construct the following hypothesis:

Hypothesis 1. Pandemic crises are associated with decreasing a firm's TC.

2.2. Formal institutions

As discussed by Duchin and Harford (2021), pandemics have highlighted a variety of distortionary forces that could influence things to work well. Therefore, this section discusses which factors of formal institutions may affect firms' TC through these forces. Based on previous studies, we divided formal institutions into legal and law, and information transparency categories (Wu et al., 2014; Cheng et al., 2020; Su et al., 2020).

2.2.1. Legal protections and regulations

Ferrando and Mulier (2013) considered that financial intermediaries and TC channels have an interactive relationship based on the redistribution view. Similarly, Danielson and Scott (2004) found that firms are more likely to increase their TC when bank loans are constrained. Several studies have discussed the complementary and substitute relationships between bank loans and TC. Using Psillaki and Eleftheriou (2015) as an example, TC generally complements bank credit for SMEs during financial crises when budgets are tight. Firms with better access to bank financing can redistribute credit to other firms through TC. Therefore, bank loans and TC can be viewed as complementary (Boissay et al., 2020). In contrast, others claim that TC acts as a substitute for bank loans for firms. Huang et al. (2011) noted that bank loans and TC have a substitutive relationship and counter the GDP cycle. Ogawa et al. (2013) examined the redistribution hypothesis from the demand side of TC with SMEs, indicating that bank loans and TC have a substitution effect. Similarly, Hasan and Habib (2019) reckoned that financing from formal institutions and supplier-provided TC could easily substitute each other.

In addition, researchers have hypothesized that TC and bank loans may be defined as complementary or substitutes under specific conditions. For example, Danielson and Scott (2004) indicated that the use of TC and bank loans in capital structures is determined by how quickly a firm can pay off new balances. Thus, if a firm makes timely payments, it plays a complementary role in bank loans; otherwise, it can substitute bank loans when payments are delayed. Furthermore, TC and bank loans complement each other when firms' debt capacity constrains investment; otherwise, TC substitutes bank loans to overcome this limitation (Burkart and Ellingsen, 2004).

The above studies have shown that formal financial institutions, such as banks, may directly or indirectly influence firms' TC use.

[3] TC reduces costs by forming a mutual agreement on terms of purchase, thus allowing firms to better match the timing of cash outlays for the cost of goods sold with cash receipts from sales (Petersen and Rajan, 1997; Atanasova, 2007; Seifert et al., 2013).

[4] It has been shown that when buyers' firms restrict bank loans, sellers' TC becomes a relatively important source of funds for firms during severe recessions and monetary contractions (Atanasova, 2007; Psillaki and Eleftheriou, 2015).

Ge and Qiu (2007) and Ferrando and Mulier (2013) pointed out that firms in poorly developed formal financial sectors tend to rely more on TC channel finance. Thus, legal protections and regulations affecting the development of these financial intermediaries may make their operations more effective and influence firms' TC behavior.

In addition, poorer legal rules and quality of law affect investor protection and create smaller and narrower capital markets (La Porta et al., 1997). However, different legal jurisdictions encourage investors to adopt very different bundles of rights. These various commercial laws stem from two broad traditions: common law originates from English society, while civil law derives from the Roman Empire (La Porta et al., 1998). Prior research has emphasized that TC is related to this law. For example, TC is expected to be used more broadly when there are weaker legal protections for creditors (Psillaki and Eleftheriou, 2015; Su et al., 2020; Chen et al., 2021), but inefficient regulations and judicial reviews decrease the number of suppliers offering TC to buyers (Wu et al., 2014). Overall, we expect the strength of legal protection and regulations to be negatively related to the provision.[5]

2.2.2. *Information transparency*

Cheng and Pike (2003) indicated that banks charge high-risk borrowers higher interest rates when they cannot clearly classify borrowers as low-risk because of information asymmetries, but this is a useless practice because risky borrowers can usually bear higher interest rates. However, suppliers in the TC system may act as intermediaries between buyers and financial intermediaries (Seifert et al., 2013). In the selling process, suppliers have an information advantage that allows them to offer buyers lower rates and faster solutions than financial intermediaries can (Petersen and Rajan, 1997; Atanasova, 2007); they can also reduce information asymmetry (Goto et al., 2015). Simultaneously, buyers' inability to use prompt payment discounts may signal to the supplier the vital need for more monitoring and control efforts where buyers are concerned (Petersen and Rajan, 1997).

Another example is Zhang et al. (2018), who considered the information asymmetry of the manufacturer offering TC to the retailer. Their study assumed that the retailer has complete market information, whereas the manufacturer does not. Thus, when a TC occurs, the harm to the manufacturer is always greater than that to the retailer. In summary, an informational advantage may explain why some firms provide TC (Atanasova, 2007).

Given the importance of information, many studies have attempted to examine the formal practice mechanism corresponding to the degree of firm information disclosure, such as the topics of information disclosure associated with corporate social responsibility (Ho et al., 2020), environmental information disclosure (Yu et al., 2018), and financial disclosure (Pevzner et al., 2015). Consequently, firms with better information disclosure practices are more likely to reduce information asymmetry and enhance performance, especially during the downturn market phase (Cheng et al., 2020). Here, we expect that a high level of information disparity may influence a firm's TC and financial behavior.

In short, we predict that these formal institutions take on a firm's TC during pandemic periods if they operate within a perfect standard legal and regulatory system and a better information disclosure environment, which brings us to our next hypothesis:

Hypothesis 2. Formal institutions affect a firm's TC during pandemic crises.

2.3. *Informal institutions*

In addition to formal factors, informal institutions influence firms' use of TC (Levine et al., 2018). Based on prior studies, we divide informal institutions in terms of three characteristics: religious attributes, social trust, and policy stability (Chen et al., 2018; D'Mello and Toscano, 2020; Ho et al., 2020). Each of these is discussed in further detail below.

2.3.1. *Religious attributes*

Religion is a belief system and part of a tradition carried, endorsed, and transmitted by people's communal activity (Vermeer and Kregting, 2020) that influences both legal and political institutions, organizational behavior, and economic attitudes (Hilary and Hui, 2009; Chen et al., 2016). Firms in regions where religion plays a prominent role tend to have lower risk exposure, higher return on assets (ROA), lower investments in capital and R&D, and slower long-term growth (Hilary and Hui, 2009). Similarly, Chen et al. (2016) showed that firms in regions with stronger religious tendencies enjoy lower loan interest spreads, which affect loan contract terms such as a larger facility amount, accounting-based performance pricing, and lower upfront fees.

The literature suggests a relationship between crises and religiosity. For example, Kanagaretnam et al. (2015) found that banks in more religious countries revealed decisions with lower risk and were less likely to encounter credit defaults by firms during the 2007–2009 financial crisis. In contrast, during the COVID-19 period, Vermeer and Kregting (2020) posited that church attendance was related to the spread of pandemic risk in both direct (e.g., worship services) and indirect ways (carnivals, non-religious social bonds). In addition, Chen et al. (2018) indicated that it is generally easier for religious countries to use TC.

2.3.2. *Social trust*

The effects of informal factors, like social trust, could replace formal institutions when a country has poorer investor protection and weaker disclosure requirements (Pevzner et al., 2015). Unlike the concept of personal trust, social trust is influenced by a person's

[5] Stronger regulation may also mean less TC. Regulatory enforcement on banks can cause banks to contract their lending (Peek and Rosengren, 1995), so TC becomes an alternative to short-term bank lending. Additionally, the regulation of banks implies more restrictions (e.g., interest rate caps), which may also directly reduce TC use (Chen et al., 2019).

cultural and religious background and rooted in deeply held beliefs about people in general (Dudley and Zhang, 2016). Several studies examining social trust have found that it affects firms' financial behavior. Su et al. (2020) revealed that firms' trustworthiness is crucial for accessing financial resources in periods of high uncertainty. Ho et al. (2020) investigated the effects of social trust on firm default risk and found that trust reduces corporate default risk by mitigating adverse selection and moral hazard problems. Moreover, socially reputable countries with better earnings quality generate stronger investor reactions (Pevzner et al., 2015; Chen et al., 2022). Firms in countries with higher levels of social trust hold less cash (Dudley and Zhang, 2016) and have a smaller firm-specific stock price crash risk (Li et al., 2017).

Other studies discuss how social trust plays an informal role in prompting firms to use TC. For example, Wu et al. (2014) evinced that social trust has a stronger influence on TC when firms are in poor legal environments. Thus, higher levels of social trust lead to firms' increased propensity to offer and use TC. Similarly, Levine et al. (2018) indicated that high social trust could facilitate firms' access to TC during systemic banking crises because TC suppliers are more confident about the trustworthiness of those who demand such credit. Chen et al. (2018) found that social trust in a country enhances its positive relationship with the use. Overall, as Guiso et al. (2004) pointed out, whether TC is extended depends on the legal enforceability of the contract and the extent to which suppliers trust their customers. Ergo, trust plays an essential role in TC.

2.3.3. Policy stability

Policy uncertainty, such as economic decisions related to taxes, government spending, regulatory practices, and monetary policies, affects firms' short-term credit policies (D'Mello and Toscano, 2020). Economic policy uncertainty (EPU) makes it difficult for firms to make precise predictions and decisions about whether to borrow funds (Su et al., 2020). Prior literature has discussed EPU from various perspectives, such as Caggiano et al. (2014), who investigated the impact of uncertainty shocks on unemployment during the U.S. post-World War II recession. Baker et al. (2016) found that policy uncertainty leads to greater stock price volatility, reduces investment, and lowers employment rates. Subsequently, firms quickly shift their accounts receivable and payable ratios and update the levels determined by the previous uncertainty level to match the new reality (D'Mello and Toscano, 2020). When EPU is higher, a firm shortens its receivables from customers and faces shorter payables from its suppliers (Jory et al., 2020), significantly negatively affecting a firm's TC (Su et al., 2020). The COVID-19 pandemic is a classic example of how uncertain economic policies have distorted the vision of the economy, affecting all market participants and illustrating the complex interconnectedness of the global economy (Al-Thaqeb et al., 2020).

In addition to economic impacts, policy uncertainty also induces several political risks and affects the country's ability and willingness to meet its financial obligations (Hoti, 2003). The other is internal conflict, which measures political violence in a country and its actual or potential impact on governance, such as civil war, political violence, and civil disorder. Taken together, this implies that the government should stabilize economic policies and diminish firms' short-term financial activities.

In conclusion, we expect that these three categories of informal institutions will affect a firm's TC behavior during extreme pandemic periods. Thus, we propose the following hypothesis:

Hypothesis 3. Informal institutions affect a firm's TC during pandemic crises.

3. Data and research design

3.1. Sample and data sources

This study considers the 107 countries discussed by Ma et al. (2020) to maximize the number of countries covered by the analysis. As a result of the procedures based on our designed filtering standards, we yielded a final sample of 590,025 firm-year observations. The empirical financial data of each firm are mainly obtained from the Thomson Reuters Worldscope Database over a 30-year period from 1990 to 2020. We also collected data from the International Country Risk Guide (ICRG)[6] database to obtain the related variables for formal and informal institutions.

3.2. Research design

The regression in Eq. (1) is estimated to test Hypothesis 1 on how the pandemic influenced firms' TC.

$$TC_{cit} = \beta_0 + \beta_1 Pandemics_c + \gamma\, X_{cit} + \varepsilon_{cit}, \tag{1}$$

where TC_{cit} represents the TC levels of country c in firm i in year t and $Pandemics_{ct}$ is the number of pandemic events in country c. X_{cit} denotes the control variables, including several variables, to be discussed in Section 3.3.4.

To examine Hypothesis 2, that is, whether formal institutions could affect firms' TC during pandemic crises, we have designed a regression model in Eq. (2):

$$TC_{cit} = \vartheta_0 + \vartheta_1 formal_{c,t} {}^{*} Pandemics_{c,t} + \vartheta_2 Pandemics_{c,t} + \vartheta_3 formal_{c,t} + \gamma\, X_{cit} + \varepsilon_{cit}, \tag{2}$$

[6] https://www.prsgroup.com/explore-our-products/international-country-risk-guide/

where $formal_{c,\,t}$ refers to some formal institutions in country c during year t, including BASEL, LEGSYM, LAW, and CIFAR— variables to be discussed in Section 3.3.3. ($formal_{c,\,t}$ * $Pandemics_{c,\,t}$) is an interaction term that shows the cross-effect of formal institutions and pandemic crises.

Similarly, we use the regression model in Eq. (3) to test Hypothesis 3, but focus on the effects of informal institutions during pandemic crises.

$$TC_{cit} = \vartheta_0 + \vartheta_1 informal_{c,t} * Pandemics_{c,t} + \vartheta_2 Pandemics_{c,t} + \vartheta_3 informal_{c,t} + \gamma X_{cit} + \varepsilon_{cit} \quad (3)$$

In Eq. (3), $informal_{c,\,t}$ represents several informal institutional proxies via five variables: ReligiousTensions, Trust, GovernmentStability, InternalConflict, and ExternalConflict, as discussed in Section 3.3.3.

3.3. Variable construction

3.3.1. Trade credit measures

According to the redistribution view, the firm's supplier offers TC to a firm that it views as a customer when its accounts payable are borrowed from its supplier. Subsequently, a firm views another firm as a supplier when its accounts receivables are a proxy for how much it lends to its customers in the TC system (Petersen and Rajan, 1997; Love et al., 2007; Ferrando and Mulier, 2013). However, the main problem is that we cannot interpret the coefficients as structural TC because of a lack of customer data (Petersen and Rajan, 1997). Love et al. (2007) indicated that the supply-side effect of TC is consistent with a demand-side pattern. For example, firms that lack access to bank financing reduce the credit supply they are willing to extend to their customers. Simultaneously, customers of these firms are less willing to accept more credit. For the above reasons, we focus on defining supply-side TC as financing that upstream suppliers offer to their firms in the form of delayed payments for the transfer of goods and services.

Consequently, we use the TC ratio of accounts payable scaled by total assets (TC1) as a proxy for the supply-side TC. This measure of TC is most widely used in multiple studies, such as Love et al. (2007), Giannetti et al. (2011), Wu et al. (2014), and Hasan and Habib (2019). Moreover, to check the robustness of our model, we use alternative TC as accounts payable scaled by total assets (TC2) and accounts payable scaled by the cost of goods sold (TC3) to capture the use of TC by a firm. These alternative measures have been used extensively by Wu et al. (2014), Levine et al. (2018), and Hasan and Habib (2019). All the variables are defined in Table 1.

Fig. 1 shows the worldwide distribution of TC1. The darker colors indicate higher TC density, focusing on a few areas in Africa and South America. In addition, North America (e.g., the U.S.) and East Asia (e.g., China and Japan) more frequently present TC behaviors than others. This means that, in both developed and developing countries, firms use informal TC in business activities.

3.3.2. Modern pandemic measures

The pandemic events considered in this study were identified in Volume 9 of Disease Control Priorities (Prabhakaran et al., 2017), published by well-known global health experts. Considering this volume as our guide, the five pandemics that we selected are SARS (2003), H1N1 (2009), MERS (2012), Ebola (2014), and Zika (2016). Moreover, at the time of writing this paper, the COVID-19 (2020) pandemic was gradually spreading worldwide, causing severe damage. Thus, we also refer to this pandemic in the analysis and identify six modern pandemics in our timeline. The timing of these events is derived from the dates when the World Health Organization (WHO) officially declared them a "Public Health Emergency of International Concern."

Two types of variables are produced to capture pandemic events in each country. The first considers the frequency[7] with which each country has suffered from these six pandemics. Detailed information on these pandemic numbers is provided in the Appendix. The second type of pandemic variable is a binary dummy variable that calculates the mean of the pandemic frequencies in all countries. If the number of pandemics in a country is higher than the mean, it is recorded as 1; otherwise 0. We use this variable in the robustness analysis in Section 5.2.

Fig. 2 plots the frequency distribution of pandemics that have occurred in each country. The analysis finds that larger countries, such as the U.S., China, Brazil, and Russia, are more prone to pandemics, while Africa and Central Asia are less likely to be affected. This result demonstrates that larger countries with bigger populations are more likely to be exposed to these global pandemics due to country differences.

3.3.3. Formal and informal institutional measures

We use proxy variables representing formal and informal institutions to examine how these factors react to TC during pandemics. As discussed in Section 2.2, we first construct formal proxy variables of BASEL, LEGSYM, and LAW, which represent the "Legal and law" category, and a CIFAR variable, which indicates a firm's level of "Information transparency."

BASEL is a dummy variable equal to 1 if the country adopted the Basel Agreement; otherwise 0. The Basel Agreement is based on the Basel Accord adopted by many countries and is considered a benchmark for banking regulation and supervision. Implementing Basel standards increases the risk difference between Islamic and conventional banks (Zins and Weill, 2017) and reduces bank lending due to increased capital requirements (Behn et al., 2016). Two other variables, LEGSYM and LAW, which are proxies for a country's strength and weakness in legal and regulatory environments, respectively, show a country's soundness in terms of its legal system.

[7] In most cases, there are significant time gaps between the initial appearance of an outbreak and the official declaration. Reported time gaps and discrepancies between the Centers for Disease Control, Prevention (CDC) and the WHO do not affect our key identification variable—a dummy that is equal to 1 when the WHO declares a pandemic/epidemic for an affected country and otherwise 0.

Table 1
Variable definitions.

Variable	Explanation	Source
Trade credit		
TC1	Trade credit, measured as accounts payable scaled by total assets.	Love et al. (2007)
TC2	Trade credit, measured as accounts payable scaled by total sales.	Giannetti et al. (2011)
TC3	Trade credit, measured as accounts payable scaled by the cost of goods sold.	Wu et al. (2014) Hasan and Habib (2019)
Pandemic	Six modern pandemic crises: SARS (2003), H1N1 (2009), MERS (2012), Ebola (2014), Zika (2016), and COVID-19 (2020).	Prabhakaran et al. (2017)
Formal institutions		
Legal and law		
BASEL	BASEL adoption = 1; BASEL non-adoption = 0.	Zins and Weill (2017)
LEGSYM	English (Common Law) equal 1; else equal 0.	La Porta et al. (1997)
LAW	This variable assesses total score from 0 to 6 points, while a country can enjoy a higher rating of 6 points representing its judicial system.	ICRG database
Information transparency		
CIFAR	It is the index for transparency. The Transparency score /100.	Center for International Financial Analysis Research CIFAR)
Informal institutions		
Religious		
ReligiousTensions	The variable describes a single religious group seeking to replace civil law with religious law and exclude other religions from the political and/or social process. It is an index ranging from 0 to 6 points, while the higher the index (which tends to be 6 points) shows that a country is more religious.	ICRG database
Social trust		
Trust	Societal trust score (100 + (% "Most people can be trusted") – (% "Cannot be too careful")) / 100.	World Value Survey (WVS)
Policy stability		
GovernmentStability	Government stability is an index ranging from 0 to 12 and measuring the ability of the government to stay in office and carry out its declared programs. The higher the index (tends to be 12 points), the more stable the government.	ICRG database
InternalConflict	This is an assessment of political violence in the country and its actual or potential impact on governance. A total score tends to be 12 points at lower risk, while a score of 0 points is a higher risk.	ICRG database
ExternalConflict	The external conflict measure is an assessment of both of the risk to the incumbent government from foreign action, ranging from non-violent external pressure to violent external pressure. A total score tends to be 12 points at lower risk, while a score of 0 points is a higher risk.	ICRG database
Control variables		
Country-level variables		
INFLATION	Inflation rate: the annual rate of change on the consumer price index.	World Bank
GGDP	GDP growth rate.	World Bank
FREEDOM	Worldwide Governance Indicators.	Economic Freedom of the World (EFW) database
Industry characteristics		
HHI	The Herfindahl Hirschman index: the sum of squared market shares of all the firms in a particular industry.	Jory et al. (2020)
LITIGATION	Dummy variable defined to be one if a firm operates in a high-litigation industry (SIC codes 2833–2836, 3570–3577, 3600–3674, 5200–5961, 7370–7374, 8731–8734) and zero otherwise.	Levine et al. (2018)
Firm's characteristics		
LEV	Debt to total assets.	Hasan and Habib (2019)
MB	Market value of equity to book value of equity	Hasan and Habib (2019)
ROA	Return on assets: Net income divided by the book value of assets.	Brogaard et al. (2017)
CASH	Cash and marketable securities are scaled by total assets.	Hasan and Habib (2019)
SIZE	Natural log of sales.	Ho et al. (2020)
TANG	The ratio of property, plant, and equipment (PPE) to the book value of total assets.	Brogaard et al. (2017)
GROWTH	The sales growth rate, calculated as the ratio of the difference between sales in the current year and prior year to sales in the prior year.	Brogaard et al. (2017)
RD	Research and development expenses are scaled by total assets. We replace missing research and development by 0.	Hasan and Habib (2019)
RE_TE	This variable is a life cycle proxy, measured by retained earnings as a proportion of total equity.	

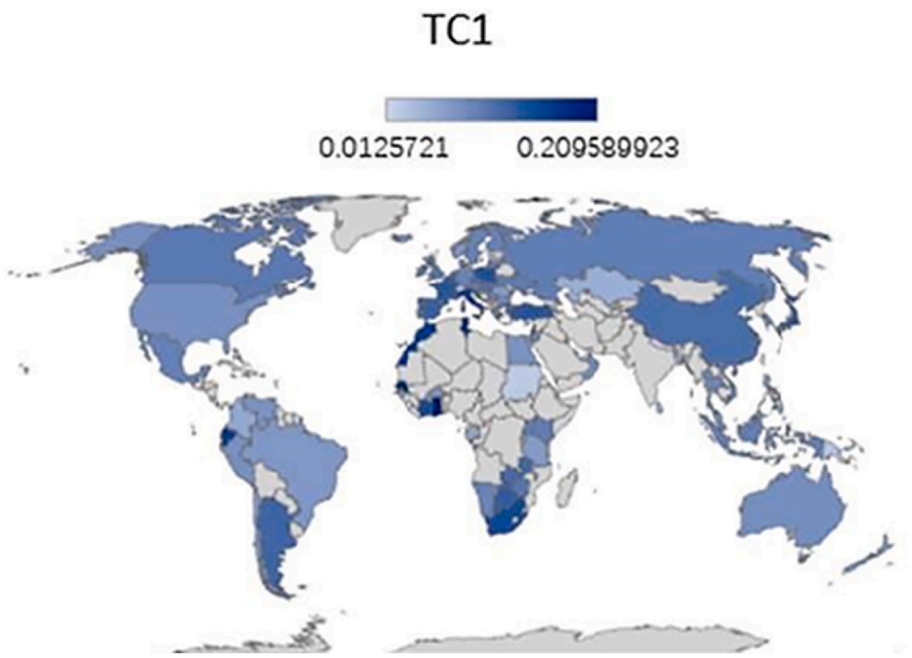

Fig. 1. The distribution of TC1 in the world.

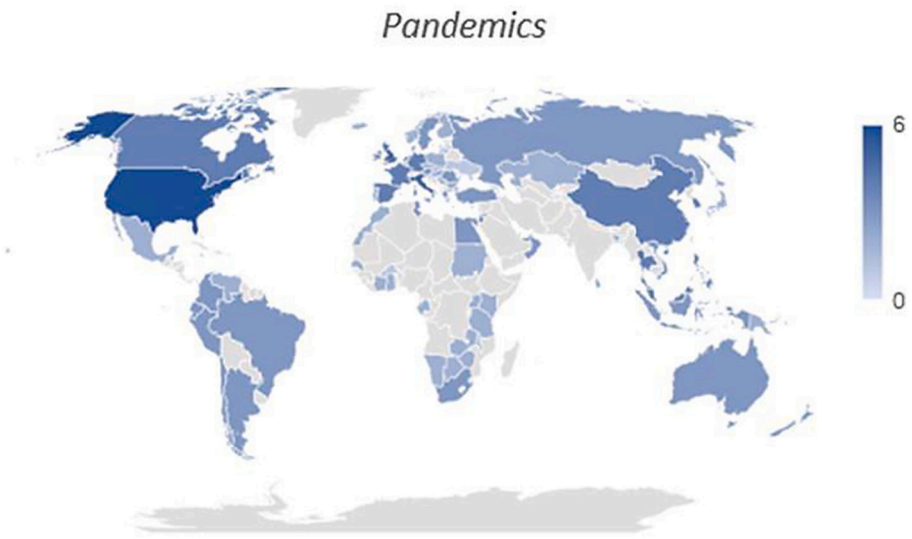

Fig. 2. The frequency distribution of pandemics in the world.

These two variables are derived from La Porta et al. (1997) and Howell (2013), respectively. Finally, the CIFAR variable, an index built by the Center for International Financial Analysis Research, can capture a firm's transparency level (Bushman et al., 2004). Detailed definitions of all variables are listed in Table 1.

Under Section 2.3, we use five variables as proxies for three categories of informal institutions (religious attributes, social trust, and policy stability). The first variable, "ReligiousTensions," considers a country's religious tensions, for which we apply the ICRG index, which was introduced by Howell (2013). For the social trust category, we use the "Trust" variable, which encapsulates two forms of social trust derived from the World Value Survey (WVS) questions: trust in major companies and trust in the government (Ho et al., 2020).

The last variable is associated with policy stability, consisting of the three aspects of government, internal, and external environments, the data on which are obtained from the indices of ICRG. First, the "GovernmentStability" variable describes the government in office and carrying out its functions. Next, "InternalConflict" presents political violence occurring within the country and its

Table 2
Sample and Correlation coefficients.

		Mean	STD	VIFs	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
(1)	*TC1*	0.10	0.10		**1**																				
(2)	*Pandemics*	0.13	0.34	1.09	**−0.04**	**1**																			
(3)	*SARS*	0.02	0.15		**−0.01**	**0.38**	**1**																		
(4)	*H1N1*	0.04	0.19		**0.00**	**0.51**	**−0.03**	**1**																	
(5)	*MERS*	0.02	0.14		**−0.01**	**0.36**	**−0.02**	**−0.03**	**1**																
(6)	*Ebola*	0.01	0.09		**−0.02**	**0.22**	**−0.01**	**−0.02**	**−0.01**	**1**															
(7)	*Zika*	0.01	0.09		**−0.03**	**0.22**	**−0.01**	**−0.02**	**−0.01**	**−0.01**	**1**														
(8)	*COVID-19*	0.04	0.19		**−0.03**	**0.51**	**−0.03**	**−0.04**	**−0.03**	**−0.02**	**−0.02**	**1**													
(9)	*SIZE*	6.88	3.11	1.49	**0.18**	**−0.02**	**−0.06**	**−0.01**	**−0.01**	**−0.03**	**−0.02**	**0.04**	**1**												
(10)	*LEV*	0.48	0.22	1.32	**0.35**	0.00	0.00	0.00	**−0.01**	**0.01**	**0.01**	**−0.01**	**0.24**	**1**											
(11)	*MB*	0.91	2.73	1.16	**−0.02**	**0.03**	**0.03**	**−0.02**	**0.00**	**0.06**	**0.07**	**0.00**	**−0.18**	**0.08**	**1**										
(12)	*ROA*	0.00	0.17	1.16	**0.00**	**−0.02**	**−0.02**	0.00	**0.01**	**−0.01**	**−0.01**	**−0.01**	**0.27**	**−0.08**	**−0.18**	**1**									
(13)	*TANG*	0.30	0.23	1.23	**−0.18**	**−0.01**	0.00	**0.01**	**−0.01**	**−0.02**	**−0.01**	**−0.01**	**0.12**	**0.12**	**−0.08**	**0.06**	**1**								
(14)	*GROWTH*	0.20	0.74	1.02	**0.00**	**−0.04**	**0.01**	**−0.03**	**−0.01**	0.00	**−0.01**	**−0.04**	**−0.10**	**−0.03**	**0.08**	**−0.03**	**−0.05**	**1**							
(15)	*RD*	0.02	0.22	1.03	**−0.01**	0.00	**0.00**	**0.00**	0.00	**0.01**	**0.01**	**0.00**	**−0.06**	**−0.03**	**0.08**	**−0.12**	**−0.06**	**0.02**	**1**						
(16)	*CASH*	0.16	0.17	1.51	**−0.11**	**0.03**	**0.00**	**0.00**	**0.01**	**0.01**	**0.00**	**0.04**	**−0.15**	**−0.40**	**0.13**	**−0.11**	**−0.39**	**0.07**	**0.10**	**1**					
(17)	*RE_TE*	0.01	7.08	1.00	0.00	**0.00**	0.00	0.00	**0.01**	0.00	0.00	0.00	**0.00**	**0.01**	**0.01**	**−0.01**	0.00	**−0.01**	0.00	0.00	1				
(18)	*HHI*	0.11	0.15	1.10	**−0.04**	**−0.01**	**−0.02**	**0.02**	**0.00**	**−0.03**	**−0.02**	**0.01**	**−0.08**	**−0.01**	**−0.11**	**0.03**	**0.05**	**0.02**	**−0.02**	**−0.05**	0.00	11			
(19)	*LITIGATION*	0.25	0.43	1.11	**0.02**	0.00	**0.00**	**−0.01**	**0.00**	**0.01**	0.00	0.00	**−0.08**	**−0.11**	**0.09**	**−0.09**	**−0.22**	**0.03**	**0.08**	**0.25**	0.00	**−0.08**	**1**		
(20)	*GGDP*	0.03	0.02	3.10	**−0.03**	**0.04**	**0.02**	**−0.01**	**0.00**	**0.08**	**0.07**	0.00	**−0.10**	**0.02**	**0.14**	**−0.14**	**−0.14**	**−0.02**	**0.04**	**0.13**	**0.00**	**−0.08**	**0.09**		
(21)	*INFLATION*	0.09	0.02	1.19	**0.05**	**−0.25**	**0.06**	**0.01**	**0.03**	**0.04**	**0.04**	**−0.56**	**−0.06**	**0.01**	**0.04**	**−0.02**	**−0.05**	**0.02**	**0.01**	**0.03**	0.00	**−0.10**	**0.04**	**0.27**	
(22)	*FREEDOM*	68.56	10.66	3.31	**−0.09**	**0.02**	**0.03**	**−0.01**	**−0.03**	**0.05**	**0.05**	**0.01**	**−0.18**	**−0.02**	**0.19**	**−0.16**	**−0.11**	**−0.01**	**0.04**	**0.13**	**0.00**	**−0.07**	**0.07**	**0.78**	**0.19**

This table presents the variance inflation factor (VIF) and the Pearson correlation coefficient between each variable. Numbers in bold are statistically significant at the 10% confidence level.

actual or potential impact on governance. Finally, "ExternalConflict" illustrates the risk to the incumbent government from foreign action, ranging from non-violent to violent external pressure. The details of all variables are provided in Table 1.

3.3.4. Control variables

In order to eliminate possible confounding effects, we consider several control variables that potentially influence a firm's TC behavior. Referring to the relevant literature, we divide these control variables into three categories: country-, industry-, and firm-level characteristics (Pan et al., 2015; Hasan and Habib, 2019).

The first set controls for country characteristics. Here, we focus on macroeconomics in a country, because macro-level factors significantly influence TC (D'Mello and Toscano, 2020). To that end, we use standard variables, including inflation rate (INFLATION), the growth rate of GDP (GGDP), and economic freedom (FREEDOM), to control for promoting or decreasing a firm's TC behavior in one country. These macro-level variables have been used in several studies, such as Atanasova (2007) and Ho et al. (2022).

Subsequently, we control for industry characteristics using the Herfindahl Hirschman Index (HHI) and standard industrial classification (SIC) to represent market power and litigation risk. As Dass et al. (2015) and Jory et al. (2020) pointed out, the greater the market power of the upstream firm, the less TC it will provide to the downstream firm. Thus, a firm with expanded market power can obtain extended credit from its suppliers. Using the HHI, we control for the industry's market concentration, which influences a firm's TC behavior. SIC codes allow us to handle notable differences in a firm's TC across industries (Danielson and Scott, 2004; Levine et al., 2018) and distinguish the homogenous subsample from a group sector (Hilary and Hui, 2009).

Finally, based on prior studies, we consider a wide array of firm characteristics. These control variables comprise firm financial conditions such as leverage (LEV), equity ratio (MB), profitability (ROA), and working capital (CASH). This is because TC can be utilized by firms as a short-term leverage tool (Klapper et al., 2012) and is a crucial source of working capital funds when restricted by the unavailability of bank loans (Psillaki and Eleftheriou, 2015). Additionally, a firm with high short-term debt offers less TC to prevent bank loan contracts (Love et al., 2007). TC also plays a crucial role in determining a firm's profitability during a crisis (Wu et al., 2014;

Table 3
The effect of health pandemics crises on TC.

Dependent variable	TC1									
	Model 1		Model 2		Model 3		Model 4		Model 5	
constant	0.1052	***	0.0898	***	0.0620	***	0.0516	***	0.0133	***
	(739.20)		(166.66)		(61.29)		(39.57)		(4.72)	
Pandemics	−0.0107	***	−0.0070	***	−0.0065	***	−0.0045	***	−0.0057	***
	(−28.73)		(−18.97)		(−18.37)		(−6.77)		(−9.52)	
SIZE									0.0028	***
									(47.82)	
LEV									0.1553	***
									(258.43)	
MB									0.0000	
									(−1.01)	
ROA									−0.0091	***
									(−12.15)	
TANG									−0.1110	***
									(−195.95)	
GROWTH									0.0020	***
									(13.02)	
RD									0.0004	
									(0.83)	
CASH									−0.0227	***
									(−28.31)	
RE_TE									(−0.00)	**
									(−2.11)	
HHI									−0.0060	***
									(−5.68)	
LITIGATION									−0.0007	**
									(−2.19)	
GGDP									0.1748	***
									(10.89)	
INFLATION									0.3624	***
									(18.45)	
FREEDOM									−0.0002	***
									(−4.32)	
Country Fixed Effect	No		Yes		Yes		Yes		Yes	
Industry Fixed Effect	No		No		Yes		Yes		Yes	
Year Fixed Effect	No		No		No		Yes		Yes	
Adj. R^2	0.0014		0.0504		0.1190		0.1221		0.2869	
Obs.	590,025									

Noted: The t-statistics are reported in parentheses. ***, **, * denote statistical significance at 1%, 5%, and 10%, based on robust standard errors clustered by country, respectively.

Grau and Reig, 2018).

Further, we address firm size (SIZE), tangibility (TANG), research and development (RD), production cycle (RE_TE), and sales growth rate (GROWTH) as the micro-level characteristics of a firm. These control variables are set because TC is a crucial source of external finance for firms of different sizes, such as large firms, small start-ups, and SMEs with limited capital (Zhang et al., 2018). In particular, young and small firms can rely more easily on the TC channel to grow (Ferrando and Mulier, 2013); in contrast, larger firms can more easily satisfy TC underwriting standards, that is, they have substantially more access to TC (Danielson and Scott, 2004). Moreover, Hasan and Habib (2019) pointed out that a firm with growth and relatively more advanced R&D is associated with more information asymmetry; the higher the information asymmetry, the more TC a firm uses. All control variables are defined in Table 1.

3.4. Summary statistics

Table 2 reports the descriptive statistics and correlations for the variables used in the regression. The mean of H1N1 and COVID-19 are greater than those of other pandemics, implying that these two health crises spread widely and influenced most countries. These are followed by SARS and MERS, which are both more severe than Ebola and Zika. FREEDOM has the most significant standard deviation of all variables, implying significant differences in countries' economic freedom factors. Moreover, the SIZE, MB, and RE_TE variables associated with a firm's characteristics are more prominent than the other country and industry variables. Thus, we attempt to control firms' heterogeneity to achieve stable results in our model.

Pearson's correlation matrix and variance inflation factors (VIF) are among the variables listed in Table 2. Except for the H1N1 health crisis, TC1 is negatively correlated with pandemics and the other five health crises. This result implies that TC may use and offer diminishing services during pandemic crises. Regarding TC and control variable correlations, except for INFLATION, which is slightly positively associated with TC1, most country characteristics are negatively correlated with TC1. Moreover, we find that firm characteristics in LEV and TANG have the highest and lowest correlations with TC1, respectively, for all the control variables. This means that we should control for these firm attributes in our regression model to achieve valid results. In addition, we compute VIF to ascertain whether there are any issues with multicollinearity. Among the variables, the largest VIF is 3.31, which is less than the typical rule of VIF = 10, indicating that multicollinearity is unlikely to be an issue in our analysis.

4. Empirical results

4.1. The baseline specification

The five regression models presented in Table 3 reveal details of the regression results. Models 1 to 4 only consider pandemic variables, whereas Model 5 includes pandemic and control variables. In addition, we gradually add constraints on country-, industry-, and year-fixed effects to estimate Models 1 to 5. Such country- and industry-fixed effects exclude the factor that firms belong to different areas, scales, and types, while year-fixed effects mitigate the influence of overall time conditions.

Table 3 shows that, regardless of the three types of fixed effects, Models 1 to 4 have a negative and significant impact on TC. Specifically, in Model 4, for each standard deviation change in the pandemic variable, TC1 decreases by 0.00153, which is 1.53% of the standard deviation. This indicates that our results are economically significant. Subsequently, when considering the control variables, the coefficient of TC1 (in Model 5) is −0.0057, which means that a one-standard-deviation increase in the pandemic variable is associated with a decrease of 1.94% (=0.0057 × 0.34/0.10) in the standard deviation of TC as measured by TC1, ceteris paribus. This negative relationship between TC and the pandemic is both statistically and economically significant. Overall, the results support Hypothesis 1, that pandemic crises are negatively associated with a firm's TC. The significant effect between pandemics and TC forms

Table 4
Dependence of the pandemics crises on the country's formal institutions.

Dependent variable	TC1							
	Model 1		Model 2		Model 3		Model 4	
constant	0.0069	***	0.0196	***	0.0120	***	0.0119	***
	(2.42)		(6.02)		(4.24)		(4.21)	
*Pandemics*BASEL*	−0.0145	***						
	(−13.32)							
*Pandemics*LAW*			−0.2638	***				
			(−6.13)					
*Pandemics*LEGSYM*					−0.0068	***		
					(−10.32)			
*Pandemics*CIFAR*							−0.0053	***
							(−7.98)	
CONTROL	Yes		Yes		Yes		Yes	
Fixed Effect	Yes		Yes		Yes		Yes	
Adj. R^2	0.2874		0.2889		0.2871		0.2870	
Obs.	590,025		533,978		590,025		590,025	

Noted: The t-statistics are reported in parentheses. ***, **, * denote statistical significance at 1%, 5%, and 10%, based on robust standard errors clustered by country, respectively.

the basis of Hypotheses 2 and 3.

4.2. Formal and informal institutions

We generate four interaction variables: pandemic terms and formal institutional proxies for BASEL, LAW, LEGSYM, and CIFAR. Table 4 shows that these four interaction terms in Models 1 to 4 are significantly and negatively associated with TC when considering all control variables and fixed effects. These results show that in countries that are party to the Basel Accord, the soundness of law, common law originating from English society, and higher information transparency induce firms to use less TC during pandemic periods. These results also support Hypothesis 2, which examines whether formal institutions affect TC during pandemics. Thus, a country's formal institutions function like a "brake" that slows down TC operations during pandemics. The interaction term (Pandemics * LAW) has a larger marginal effect than the others. This implies that formal law institutions are crucial to TC operations during times of crisis.

Similarly, Table 5 shows the five interaction terms between pandemics and proxies for informal institutions, that is, the "ReligiousTensions," "GovernmentStability," "Trust," "InternalConflict," and "ExternalConflict" variables. We find that these five interaction terms in Models 1 to 5 are significantly and positively related to TC when considering control variables and fixed effects. This implies that these informal institutions act as a "cushion" to mitigate the impact of pandemic crises during the application of TC for firms. The results also test Hypothesis 3, showing that informal institutions influence TC during pandemics. Moreover, larger interaction coefficients are found for "GovernmentStability," followed by "ReligiousTensions." Religious Tensions. This means that stability in politics and religious beliefs helps a firm promote the use of TC during pandemics.

5. Robustness analysis

To prove the credibility of the main findings, we conduct a robustness check. The first analysis involves an alternative measure of TC using the generalized method of moments (GMM). The second test employs alternative pandemic variables, thus separating the six health crises that have an impact on TC. The last action is replacing samples, excluding those from significant countries, and observing biotechnology firms' influence on TC during pandemics.

5.1. Alternative measure of trade credit

To test the robustness of TC, we replace TC1 with alternative measures of TC2 and TC3 (defined in Table 1) in our regression models. Using TC2 in Table 6, we assume that both Model 1 (without control variables) and Model 2 (with control variables) include fixed effects. The results show that pandemics continue to have a significantly negative impact on TC2, but the marginal impact of pandemics in Model 1 is slightly smaller than that in Model 2. Similarly, Models 3 and 4 are replaced by TC3. Compared to Models 1 and 2, the results have nearly identical outcomes, showing that the marginal effects of pandemics remain significant and negative in relation to TC. Indeed, the above results are robust with prior estimations in TC1, implying that pandemic crises impact a firm's TC behavior.

Table 5
Dependence of the pandemics crises on the country's informal institutions.

Dependent variable	TC1									
	Model 1		Model 2		Model 3		Model 4		Model 5	
constant	0.0093	***	0.0083	***	0.0135	***	0.0217	***	0.0131	***
	(2.89)		(2.59)		(4.79)		(6.42)		(3.79)	
*Pandemics*ReligiousTensions*	0.1274	***								
	(4.25)									
*Pandemics*GovernmentStability*			0.1609	***						
			(6.24)							
*Pandemics*Trust*					0.0054	***				
					(7.73)					
*Pandemics*InternalConflict*							0.0710	**		
							(2.32)			
*Pandemics*ExternalConflict*									0.0023	***
									(3.02)	
CONTROL	Yes		Yes		Yes		Yes		Yes	
Fixed Effect	Yes		Yes		Yes		Yes		Yes	
Adj. R^2	0.2883		0.2881		0.2870		0.2883		0.2881	
Obs.	533,978		534,140		590,025		533,978		533,978	

Noted: The t-statistics are reported in parentheses. ***, **, * denote statistical significance at 1%, 5%, and 10%, based on robust standard errors clustered by country, respectively.

Table 6
Alternative measure of TC.

Dependent variable	TC2				TC3			
	Model 1		Model 2		Model 3		Model 4	
constant	0.1169	***	0.1340	***	0.1911	***	0.1923	***
	(79.48)		(40.02)		(87.10)		(37.57)	
Pandemics	−0.0047	***	−0.0057	***	−0.0086	***	−0.0104	***
	(−6.34)		(−8.04)		(−7.70)		(−9.52)	
CONTROL	No		Yes		No		Yes	
Fixed Effect	Yes		Yes		Yes		Yes	
Adj. R^2	0.1026		0.1905		0.0868		0.1352	
Obs.	590,025							

Noted: The t-statistics are reported in parentheses. ***, **, * denote statistical significance at 1%, 5%, and 10%, based on robust standard errors clustered by country, respectively.

5.2. Endogeneity correction

Endogeneity is a common concern among cross-country studies. It arises when factors that potentially influence the rise of pandemics affect the TC behavior of an enterprise, but it is not adequately controlled. If so, the results regarding the effects of health crises will be spurious and biased. Although this is always a potential limitation, our results are unlikely to be entirely driven by the omitted variables.

Two different approaches are implemented in this section to ease endogeneity concerns further and test the robustness of our findings. First, we estimate the regression coefficients using the two-stage least squares (2SLS) method to mitigate this endogeneity concern. We instrument for a country-level pandemic using a country's genetic distance (GENE) to the U.S. These genes may affect people's health and are unlikely to affect TC. Therefore, GENE may be a good instrumental variable.[8] This satisfies the relevant conditions. Moreover, no theory argues that a country's people's genes directly affect TC, satisfying the exogeneity assumption. Table 7 reports the 2SLS estimation results. The remaining columns present the second-stage regression, where the dependent variable is TC. The fitted Pandemic Crises_2SLS variables in the second-stage regression indicate that the positive relationship between the pandemic and TC should not be spurious.

Second, in addition to the two-stage least squares (2SLS) technique, we use a two-stage GMM estimation to access baseline specifications. After controlling for variables and fixed effects, we find that Models 1 to 3 in Table 8, corresponding to the dependent variables in TC1 to TC2, are significantly and negatively related to the pandemic variable. Therefore, as confirmed by the prior discussions, the results remain robust. (See Table 9.)

Using an approximate DID approach to set variables is also one way to solve the endogeneity problem. In this study, Pandemic Crisis is used to measure whether an epidemic occurs in a country in a certain year, and this measure reflects the idea of the DID method, which is essentially the same as the DID method. The value of a Pandemic Crisis is 1 when an epidemic occurs in a country in a specific year; 0 when no epidemic occurs. This approach compares before and after an epidemic and between countries with and without an epidemic. When a financial crisis breaks out, the financial crisis measure is taken as 1; otherwise, it is taken as 0. Our approach is similar but with more consideration of country factors. In summary, our results are robust to endogeneity issues. We can justify the casual interpretation that pandemic crises could lead to lower TC levels.

5.3. Alternative specifications of pandemics

We evaluate pandemics in two ways: first, by frequency, and second, with a binary dummy variable, as discussed in Section 3.3.2. Table reveals that no matter what kind of pandemic variable is used, the results align with previous findings that pandemics have a negative and significant impact on TC. However, we can obtain different means from these two pandemic variables. The first (Pandemics_Number) shows that a country decreases the use of TC for its firms as the frequency of pandemics increases. The second (Pandemics_Dummy) shows that in the case of a country with more pandemic events, it is easier for its firms to reduce the use of TC. Regardless of the explanation, the results again support Hypothesis 1 and are robust in the model.

Subsequently, we separate the six pandemics into independent variables to determine their relationship with TC. As shown in Table 10, all marginal effects in Models 1 to 7 are significantly and negatively related to TC. These results align with previous studies that showed that pandemics and TC have a reverse relationship. Moreover, except for COVID-19, the marginal effects gradually increase from SARS to Zika, which means that a particular pandemic can significantly influence a firm's use of TC.

5.4. Replacing samples

When conducting robustness checks on the samples, we exclude samples from large countries, that is, the U.S., Japan, and China, as

[8] We conduct a series of tests on the validity of instrumental variables (e.g., F-tests) and the results show that there are no weak instrumental variables and no over-identification problems.

Table 7
Endogeneity correction: IV.

Dependent variable	TC1		TC2		TC3	
	Model 1		Model 2		Model 3	
Pandemics_GE2sls	−0.0049	***	−0.0281	***	−0.0074	***
	(−7.44)		(−36.17)		(−6.27)	
CONTROL	Yes		Yes		Yes	
Fixed Effect	Yes		Yes		Yes	
Adj. R^2	0.2864		0.1802		0.1274	
Obs.	479,624					

Noted: The t-statistics are reported in parentheses. ***, **, * denote statistical significance at 1%, 5%, and 10%, based on robust standard errors clustered by country, respectively.

Table 8
Alternative estimation technique.

Dependent variable	TC1		TC2		TC3	
	Model 1		Model 2		Model 3	
constant	0.0461	***	0.1280	***	0.2508	***
	(11.55)		(30.82)		(38.87)	
Pandemics_GMM	−0.0128	***	−0.0132	***	−0.0195	***
	(−20.55)		(−18.33)		(−17.83)	
CONTROL	Yes		Yes		Yes	
Fixed Effect	Yes		Yes		Yes	
Adj. R^2	0.2714		0.1525		0.0979	
Obs.	534,140		534,140		534,140	

Noted: The t-statistics are reported in parentheses. ***, **, * denote statistical significance at 1%, 5%, and 10%, based on robust standard errors clustered by country, respectively.

Table 9
Alternative measure of Pandemics.

Dependent variable	TC1							
	Model 1		Model 2		Model 3		Model 4	
constant	0.1276	***	0.0302	***	0.1171	***	0.0100	***
	(398.73)		(8.65)		(463.54)		(3.50)	
Pandemics_Number	−0.0068	***	−0.0079	***				
	(−81.79)		(−10.75)					
Pandemics_Dummy					−0.0184	***	−0.0037	***
					(−62.13)		(−3.90)	
CONTROL	No		Yes		No		Yes	
Fixed Effect	No		Yes		No		Yes	
Adj. R^2	0.0112		0.2870		0.0065		0.2869	
Obs.	590,025							

Noted: The t-statistics are reported in parentheses. ***, **, * denote statistical significance at 1%, 5%, and 10%, based on robust standard errors clustered by country, respectively.

a large proportion of firm samples come from these countries, which may affect the estimated significance. Thus, Table 11 tests the samples excluding the U.S. (Model 1), U.S. and Japan (Model 2), and U.S., Japan, and China (Model 3). Considering the control variables and fixed effects, all models show that pandemic crises negatively correlate with a firm's TC. This implies that the results are consistent and robust in Hypothesis 1. In addition, we find that the marginal effects gradually increase after excluding all three large-country samples. This result implies that pandemics play a comprehensive role in influencing TC, regardless of country size.

In order to determine the direct impact of the pandemic crisis on the affected countries and to prevent the sample data in a pandemic-free period from distracting the experimental results, this study excludes the samples that are free from the pandemic out of the full sample used, and only sample data from the six years in which the six outbreaks occurred are retained. This approach can resolve the negative impact of a similar financial crisis in 2008. Finally, this study obtains 133,966 sample data points and re-estimates the baseline regression. The corresponding results are presented in Table 12. The coefficients of Pandemic Crisis in Columns 1 to 3 are significantly negative, indicating that pandemic outbreaks lead to a lower TC. The baseline results remain robust.

We further select biotechnology firms relative to pandemics to examine the impact of industry heterogeneity on TC during pandemic crises. Upon examining the interception terms of pandemic and biotechnology, we find that these terms are all negatively and significantly associated with TC1–TC3 in Models 1 to 3 in Table 13 when controlling for some variables and fixed effects. The results are robust, showing that pandemics affect biotechnology firms' use of TC and that these firms tend to have more minor TC

Table 10
Separate six pandemic crises on TC.

Dependent variable	TC1													
	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6		Model 7	
constant	0.0561	***	0.0567	***	0.0569	***	0.0565	***	0.0564	***	0.0598	***	0.0625	***
	(35.52)		(35.87)		(36.01)		(35.80)		(35.74)		(22.84)		(23.86)	
SARS	−0.0074	***											−0.0079	***
	(−5.42)												(−5.75)	
H1N1			−0.0128	***									−0.0133	***
			(−6.84)										(−7.06)	
MERS					−0.0110	***							−0.0113	***
					(−10.59)								(−10.85)	
Ebola							−0.0201	***					−0.0208	***
							(−14.68)						(−15.21)	
Zika									−0.0221	***			−0.0227	***
									(−15.66)				(−16.15)	
COVID-19											−0.0037	*	−0.0047	**
											(−1.73)		(−2.17)	
CONTROL	Yes		Yes		Yes		Yes		Yes		Yes		Yes	
Fixed Effect	Yes		Yes		Yes		Yes		Yes		Yes		Yes	
Adj. R^2	0.2606		0.2606		0.2607		0.2608		0.2609		0.2606		0.2614	
Obs.		590,025												

Noted: The t-statistics are reported in parentheses. ***, **, * denote statistical significance at 1%, 5%, and 10%, based on robust standard errors clustered by country, respectively.

Table 11
Without U.S., Japan, and China sample.

Dependent variable	TC1					
	Exclude U.S.		Exclude U.S. and Japan		Exclude U.S., Japan, and China	
	Model 1		Model 2		Model 3	
constant	−0.0066	**	−0.0070	**	0.0001	
	(−2.14)		(−2.18)		(0.03)	
Pandemics	−0.0025	***	−0.0030	***	−0.0040	***
	(−3.37)		(−3.84)		(−4.85)	
CONTROL	Yes		Yes		Yes	
Fixed Effect	Yes		Yes		Yes	
Adj. R^2	0.2974		0.2773		0.2717	
Obs.	479,936		412,112		352,927	

Noted: The t-statistics are reported in parentheses. ***, **, * denote statistical significance at 1%, 5%, and 10%, based on robust standard errors clustered by country, respectively.

Table 12
Retain sample with six health crises year.

Dependent variable	TC1		TC2		TC3	
	Model 1		Model 2		Model 3	
Pandemics	−0.0120	***	−0.0123	***	−0.0182	***
	(−16.30)		(−14.13)		(−13.84)	
CONTROL	Yes		Yes		Yes	
Fixed Effect	Yes		Yes		Yes	
Adj. R^2	0.2782		0.1923		0.1387	
Obs.	133,966					

Noted: The t-statistics are reported in parentheses. ***, **, * denote statistical significance at 1%, 5%, and 10%, based on robust standard errors clustered by country, respectively.

Table 13
The relationship between TC and biotechnology during the pandemic.

Dependent variable	TC1		TC2		TC3	
	Model 1		Model 2		Model 3	
constant	0.0134	***	0.1339	***	0.1911	***
	(4.74)		(39.98)		(37.39)	
*Pandemics*Biotechnology*	−0.0029	**	−0.0089	***	−0.0060	***
	(−2.29)		(−5.83)		(−2.58)	
CONTROL	Yes		Yes		Yes	
Fixed Effect	Yes		Yes		Yes	
Adj. R^2	0.2870		0.1905		0.1377	
Obs.	590,025					

Noted: The t-statistics are reported in parentheses. ***, **, * denote statistical significance at 1%, 5%, and 10%, based on robust standard errors clustered by country, respectively.

behaviors while facing pandemic crises.

6. Conclusion

This study verifies how formal and informal institutions influence TC during pandemics. We select annual data of 590,025 firms from 107 countries and consider six pandemic crises. In addition, we focus on legal protections, regulations, and a firm's information transparency as proxies for formal institutions, while using religious attributes, social trust, and policy stability to represent informal institutions. We then examine the relationship between TC and these formal and informal institutions to achieve three crucial findings: (1) All formal institutions are significantly negatively associated with TC. This means that these formal institutions during pandemic crises act as a "brake" in using TC for firms; (2) All informal institutions are significantly and positively related to firms' use of TC. This result implies that informal institutions act as a "cushion" supporting TC, thus expanding the finance channels for firms suffering from pandemic crises; and (3) Using several robustness tests, the above results remain consistent after substituting alternative methods, variables, and samples.

The findings from this study have the following implications. First, this study provides different perspectives and takes account of both formal and informal institutions to examine TC influence rather than simply calculating TC from a financial perspective. This

research helps us understand the influence of formal and informal institutions on TC during the pandemic. Therefore, policymakers should steadily construct and improve formal institutions during normal times to prepare for future pandemic crises. This finding aligns with that of La Porta et al. (1997), who showed that imperfect legal rules and law enforcement lead to a country with poorer investor protection and smaller capital markets. Correspondingly, Ge and Qiu (2007) and Ferrando and Mulier (2013) indicated that incompletely developed financial intermediaries often push TC growth among firms.

Second, previous studies have hypothesized that TC can play a crucial role by replacing bank loans in typical environments. However, we find that informal institutions assist a firm, enabling it to use TC smoothly during pandemic crises. This evidence provides a new perspective connecting TC use with informal institutions. Accordingly, governments should consider making full use of the value-added effects of informal institutions during periods of vulnerability.

Finally, as discussed in the previous literature, we address the fact that pandemics and financial crises have different effects. Accordingly, industries differ in their TC behavior depending on the type of crisis. Taking an example from one of our robustness tests, we find that TC has a significant effect on the biotechnology industry during the pandemic. This result corresponds to that of Psillaki and Eleftheriou (2015), who showed that high-tech industries, such as biotechnology, often rely on specific factors that are difficult to resell, which in turn allows suppliers relevant to these factors to offer TC terms that significantly influence these firms. Thus, we believe that these industries, which are related to preventing and controlling pandemics, should continue to support and improve their developed environments in many countries. In particular, each country can promote public health or economic development through global cooperation to prevent sudden outbreaks and gradually integrate into the global economy.

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Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent

Informed consent was obtained from all individual participants included in the study.

Declaration of Competing Interest

All authors declare that he has no conflict of interest.

Data availability

Data available on request from the authors.

Dr. Ho has published more than 50 SSCI papers in financial risk management, corporate finance, and CSR. He is a guest editor for *Emerging Markets Finance and Trade.* Some of his writings have appeared in the *Journal of Corporate Finance, Journal of Accounting, Auditing and Finance, Journal of Forecasting, Journal of Business Research, Pacific-Baisn Finance Journal, Review of Quantitative Finance and Accounting, Energy Economics, Corporate Governance: An International Review, Asia-Pacific Journal of Accounting & Economics,* and *Emerging Market Reviews*, etc. Besides, he participated in dozens of academic conferences, including American Accounting Association, Asian Finance Association, China Financial Annual Conference, China Financial Engineering Annual Conference, China Fintech Research Conference, China Management Annual Conference, CICF, European Finance Association, European Financial Management Association, Financial Management Association, Taiwan Management Institute, Western Economic Association International and so on. He also as a reviewer, includes *Asia Pacific Journal of Management, Corporate Governance: An International Review, Economic Modelling, Emerging Markets Finance and Trade, Financial Innovation, Finance Research Letters, Investment Analysts Journal, International Journal of Emerging Markets, International Review of Economics and Finance, Managerial and Decision Economics,* etc.

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Appendix A. Sample distribution by country

ISO	TC1	*Pandemics (number)*	SARS	H1N1	MERS	Ebola	Zika	COVID-19
ARE	0.06	3	0	1	1	0	0	1
ARG	0.12	3	0	1	0	0	1	1

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(*continued*)

ISO	TC1	*Pandemics (number)*	SARS	H1N1	MERS	Ebola	Zika	COVID-19
AUS	0.08	3	1	1	0	0	0	1
AUT	0.10	3	0	1	1	0	0	1
BEL	0.13	2	0	1	0	0	0	1
BFA	0.08	1	0	0	0	0	0	1
BGD	0.04	2	0	1	0	0	0	1
BGR	0.08	2	0	1	0	0	0	1
BHR	0.06	2	0	1	0	0	0	1
BHS	0.04	3	0	1	0	0	1	1
BLZ	0.04	3	0	1	0	0	1	1
BMU	0.04	2	0	1	0	0	0	1
BRA	0.08	3	0	1	0	0	1	1
BRB	0.03	3	0	1	0	0	1	1
BWA	0.13	2	0	1	0	0	0	1
CAN	0.11	4	1	1	0	0	1	1
CHE	0.08	3	1	1	0	0	0	1
CHL	0.08	3	0	1	0	0	1	1
CHN	0.12	4	1	1	1	0	0	1
CIV	0.15	2	0	1	0	0	0	1
COL	0.06	3	0	1	0	0	1	1
CYM	0.09	3	0	1	0	0	1	1
CYP	0.08	2	0	1	0	0	0	1
CZE	0.11	2	0	1	0	0	0	1
DEU	0.10	4	1	1	1	0	0	1
DNK	0.09	2	0	1	0	0	0	1
ECU	0.17	3	0	1	0	0	1	1
EGY	0.08	3	0	1	1	0	0	1
ESP	0.13	4	1	1	0	1	0	1
EST	0.09	1	0	0	0	0	0	1
FIN	0.10	2	0	1	0	0	0	1
FRA	0.14	4	1	1	1	0	0	1
FRO	0.07	1	0	0	0	0	0	1
GAB	0.06	2	0	1	0	0	0	1
GBR	0.11	5	1	1	1	1	0	1
GHA	0.21	2	0	1	0	0	0	1
GIB	0.07	1	0	0	0	0	0	1
GRC	0.09	3	0	1	1	0	0	1
HKG	0.09	2	1	0	0	0	0	1
HRV	0.11	2	0	1	0	0	0	1
HUN	0.11	2	0	1	0	0	0	1
IDN	0.10	3	1	1	0	0	0	1
IND	0.12	3	1	1	0	0	0	1
IRL	0.10	3	1	1	0	0	0	1
ISL	0.09	2	0	1	0	0	0	1
ISR	0.10	2	0	1	0	0	0	1
ITA	0.17	5	1	1	1	1	0	1
JAM	0.10	3	0	1	0	0	1	1
JOR	0.07	3	0	1	1	0	0	1
JPN	0.14	2	0	1	0	0	0	1
KAZ	0.05	2	0	1	0	0	0	1
KEN	0.10	2	0	1	0	0	0	1
KOR	0.09	4	1	1	1	0	0	1
KWT	0.05	4	1	1	1	0	0	1
LBN	0.10	3	0	1	1	0	0	1
LKA	0.06	2	0	1	0	0	0	1
LTU	0.11	1	0	0	0	0	0	1
LUX	0.09	2	0	1	0	0	0	1
LVA	0.07	1	0	0	0	0	0	1
MAR	0.17	2	0	1	0	0	0	1
MCO	0.02	1	0	0	0	0	0	1
MEX	0.10	2	0	1	0	0	0	1
MHL	0.01	2	0	1	0	0	0	1
MLT	0.05	2	0	1	0	0	0	1
MUS	0.09	2	0	1	0	0	0	1
MWI	0.05	2	0	1	0	0	0	1
MYS	0.08	4	1	1	1	0	0	1
NAM	0.09	2	0	1	0	0	0	1
NGA	0.10	3	0	1	0	1	0	1
NLD	0.11	3	0	1	1	0	0	1
NOR	0.08	2	0	1	0	0	0	1
NZL	0.08	3	1	1	0	0	0	1

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(*continued*)

ISO	TC1	*Pandemics (number)*	SARS	H1N1	MERS	Ebola	Zika	COVID-19
OMN	0.08	3	0	1	1	0	0	1
PAK	0.07	2	0	1	0	0	0	1
PAN	0.10	3	0	1	0	0	1	1
PER	0.08	3	0	1	0	0	1	1
PHL	0.07	4	1	1	1	0	0	1
PNG	0.03	2	0	1	0	0	0	1
POL	0.14	2	0	1	0	0	0	1
PRT	0.11	2	0	1	0	0	0	1
PSE	0.06	2	0	1	0	0	0	1
QAT	0.06	3	0	1	1	0	0	1
ROU	0.07	3	1	1	0	0	0	1
RUS	0.12	3	1	1	0	0	0	1
SAU	0.05	3	0	1	1	0	0	1
SDN	0.03	2	0	1	0	0	0	1
SEN	0.18	2	0	0	0	1	0	1
SGP	0.11	3	1	1	0	0	0	1
SRB	0.09	2	0	1	0	0	0	1
SVK	0.12	2	0	1	0	0	0	1
SVN	0.10	2	0	1	0	0	0	1
SWE	0.10	3	1	1	0	0	0	1
THA	0.09	4	1	1	1	0	0	1
TTO	0.08	3	0	1	0	0	1	1
TUN	0.18	3	0	1	1	0	0	1
TUR	0.14	3	0	1	1	0	0	1
TWN	0.11	0	0	0	0	0	0	0
TZA	0.07	2	0	1	0	0	0	1
UGA	0.10	2	0	1	0	0	0	1
UKR	0.10	1	0	0	0	0	0	1
USA	0.08	6	1	1	1	1	1	1
VEN	0.08	2	0	1	0	0	0	1
VGB	0.10	1	0	0	0	0	0	1
VNM	0.10	3	1	1	0	0	0	1
ZAF	0.15	3	1	1	0	0	0	1
ZMB	0.12	2	0	1	0	0	0	1
ZWE	0.11	2	0	1	0	0	0	1

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