Trade Credit, Bank Credit and Financial Crises: The Case of Taiwan

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June 19, 2013

Abstract

This paper studies the trade credit of Taiwan manufacturing firms during the times of financial crisis. We investigate whether trade credit plays a role mitigating the impact of the crisis, or amplifies the impact of the crisis on the Taiwan economy. We examine the extent to which financial crisis affects the relationship between trade credit and bank credit. Using 38,885 observations for 707 Taiwan manufacturing firms in the period 1999Q1 -2012Q3, we find that firms acts as customers use trade credit as a substitute for bank credit and firms acts as suppliers who have better access in bank credit provide trade credit to their customers. Our results suggest that trade credit has mitigated the impact of the 2008-09 subprime mortgage crisis on the Taiwan economy, while the trade credit has amplified the impact of the 2000-01 dot-com bubble by propagating liquidity shocks through the supply chains. We also find that the time-varying responses of trade credit in the 2008-09 subprime mortgage crisis have a dynamic pattern, while the response are monotonic in the 2000-01 dot-com bubble.

Keywords: trade credit; bank credit; financial crisis
JEL classification: E44; G01; G32

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1 Introduction

Trade credit refers to the credit that customers obtain from their suppliers in the form of delayed payments for purchased goods.[1] This credit is widely used and represents an important source of short-term external finance from suppliers to customers in Taiwan's economy, a well-known example being the large number of small and medium-sized enterprises (SMEs) that drive the economy. The average scale of trade credit usage accounts for more than 10 percent of the total assets of Taiwan's manufacturing firms, which is greater than the bank credit ratio of 7.6 percent.[2] The existence of a large volume of trade credit may play an important role in Taiwanese firms' financing behaviors and the economy, especially in times of financial crisis such as when there is a large collapse in financial assets and banks are reluctant to lend. Many studies have stated that firms rely more on trade credit when they face a difficulty in obtaining of external finance from financial institutions, and the use of trade credit maintains business growth opportunities. For example, Meltzer (1960) first proposes the redistribution hypothesis, stating that suppliers with better access to the credit market pass short-term funding to their customers who suffer from bank credit rationing when monetary policy is tightened. Nilsen (2002) shows that both small and large but poorly rated firms are likely to be financially constrained and that they use more trade credit to keep their businesses operating during monetary contractions. Since financially constrained firms use trade credit as an alternative for bank credit in response to a monetary tightening, the use of trade credit offsets the traditional bank-lending channel (see Choi and Kim, 2005; Mateut,

[1] Suppliers offer credit terms to allow their customers to obtain goods and delay the payment for an agreed number of days. In the common two-part terms of a 2/10 net 30 contract, a supplier offers its customers a two percent discount if they pay the bill within ten days of delivery. Otherwise, there is no discount and the bill is due in thirty days after delivery. This enables customers receive credit at a 2 percent discount rate on the purchase price for 20 days. Thus, the annualized interest rate of this contract is about 44.59 percent (see Ng et al., 1999, for more details).

[2] The figures are from a sample of 707 Taiwan manufacturing firms in 13 industries over the period 1999Q1 - 2012Q3.

2005; Mateut et al., 2006).[3] Such a point of view is supported in the theoretical literature (Norrbin and Reffett, 1995; Huang et al., 2011). Several pieces of empirical evidence suggest that this mechanism is likely to be relevant (Nadiri, 1969; Schwartz, 1974; Fisman and Love, 2003; Danielson and Scott, 2004; Guariglia and Mateut, 2006; Rodríguez-Rodríguez, 2006; Love et al., 2007; Yang, 2011b). Moreover, Cuñat (2007) claims that trade credit can be viewed as a natural consequence of a commercial relationship, positing that suppliers and customers are both interested in long-term business relationships due to the costs involved in breaking up such relationships. To ensure their mutual survival, suppliers act as liquidity providers to help their customers who have problems accessing funds from banks. That is, trade credit as an alternative source of finance that flows to financially constrained firms mitigates the impact of a contraction in bank credit supply. Based on this line of the literature, one may expect that when the economy experiences a severe credit crunch associated with a financial crisis, the internal capital market of business groups can help in the recovery of the economy by increasing the amount of trade credit since trade credit and bank credit are substitutes.

However, some studies have argued that the existence of supply chains within firms that simultaneously grant and receive trade credit raises some concerns that trade credit may amplify the impact of a small negative liquidity shock during periods of crisis. Kiyotaki and Moore (1997) first bring an idea that an unanticipated default in payments may cause a chain reaction in which firms that experience defaults are themselves more likely to default in the case of firms that take trade credit from suppliers and offer trade credit to their customers. This implies that trade credit acts as a mechanism that propagates liquidity shocks along a supply chain hit by external liquidity shocks, and generates greater potential risk among firms.

[3]The bank-lending channel posits that a monetary contraction reduces the reserves of the banking sector and thereby the amount of loanable funds, which worsen conditions for firms, particularly small firms, in accessing bank credit (Mishkin, 1995; Kashyap et al., 1994; Bernanke and Gertler, 1995, for a survey on the literature). A vital assumption behind the bank-lending channel is that financially constrained firms depend on banks to access the credit market and they have no alternative forms of external finance.

The propagation mechanism is enhanced if firms are heavily reliant on trade credit and unable to raise finance from outside. Boissay (2006) who is credited with the idea develops a theoretical model of credit contagion. His simulation results suggest that credit contagion across firms has been higher during economic downturns. In this scenario, the provision of trade credit and bank credit are complementary. This credit-chain propagation mechanism has received some empirical support (Raddatz, 2010; Love and Zaidi, 2010; Yang, 2011a). Boissay and Gropp (2013) extend Kiyotaki and Moore (1997)'s theory and state more clearly that the chain of defaults stops when it reaches financially unconstrained firms because of the existence of symbiotic relationships between suppliers and their customers, as in Cuñat (2007)'s theory of trade credit. They argue that credit constrained customers pass liquidity shocks to their suppliers by defaulting on payments, but financially unconstrained suppliers ultimately provide the liquidity to their customers against liquidity shocks. This implies that suppliers not only insure their direct customers but also other indirect firms with which they do not have business relations. As a result, liquidity shocks may be propagated in the economy by the use of trade credit and payment default chains may serve a useful role in allocating liquidity from credit financially unconstrained firms to credit constrained firms. Motivated by these arguments, our attention is more focused on the response of trade credit during times of financial crisis accompanied by economic downturns, and the relationship between trade credit and bank credit in Taiwan. The purpose of this paper is to answer the question of whether the role of trade credit amplifies or moderates the impact of a negative liquidity shock on Taiwan's economy. More precisely, we seek to answer the question as to whether firms use more trade credit as a substitute for bank credit or whether they reduce the use of trade credit because of the chain reaction during times of financial crisis in Taiwan's economy.

In fact, little is known about whether trade credit can serve as a substitute for bank credit during the crisis, or whether the collapse in one may exacerbate the collapse in

the other because they are complementary in Taiwan's economy. To the best of our knowledge, there is only limited empirical evidence on the impact of trade credit on monetary policy transmission or supply chains for Taiwanese firms. The closest we can find on this subject is where they link credit rationing conditions to trade credit (Hsieh and Wang, 2010), and where they study the role of trade credit in sales performance during the 2008-09 subprime mortgage crisis (Coulibaly et al., 2013). Hsieh and Wang (2010) examine how the credit ratings of firms affect their trade credit and bank credit using 307 Taiwan manufacturing firms during 1998-2005. They find that there exists a bank lending channel of monetary policy in Taiwan, and that those firms with high credit risk receive less trade credit but more bank credit due to the severe information asymmetry problems in the credit market. However, these results are contrast with the finance motive theory of trade credit (see Smith, 1987; Cuñat, 2007) and the trade credit channel (see Nilsen, 2002; Mateut et al., 2006), and they do not provide coherent explanations for their finding that banks restrict some firms' loans when monetary tightening takes place, but lend more to financially constrained firms. In particular, they do not answer the question as to whether Taiwanese firms use trade credit as an alternative source of bank credit. Coulibaly et al. (2013) explore the relationship between trade credit and sales performance for 6,000 publicly-traded manufacturing firms from six emerging market economies in Asia. They show that financially constrained firms with intensive exports, e.g., those in Taiwan, use less trade credit as an alternative source of finance due to the large declines in sales during the 2008-09 subprime mortgage crisis. However, they ignore the large increase in accounts payable after the first quarter of 2009 for Taiwanese firms, since the variable trade credit is constructed as the peak-to trough change in accounts payable between the third quarter of 2008 and the first quarter of 2009. In addition, it is necessary to investigate the provision of trade credit, in the form of accounts receivable, for the largest publicly-traded manufacturing firms that are more likely to act as the providers of trade credit. Consequently, the role of trade credit in monetary policy transmission or as a mechanism for propagating liquidity

shocks in Taiwan's economy still remains questionable.

In this paper, we study the impacts of two different types of financial crises which affected the Taiwan economy the most in recent years, namely, the dot-com bubble in 2000-01 and the subprime mortgage crisis in 2008-09, on trade credit. These two crises had different patterns of recoveries and recessions. We investigate whether the trade credit mitigates the impact of the crisis through the provision of trade credit to their financially constrained customers, or exacerbates the impact of the crisis by propagating liquidity shocks through the supply chains in Taiwan. We then examine the extent to which a financial crisis affects the relationship between trade credit and bank credit. The following features differentiate our empirical analysis from the literature. First, we use a large data set containing 707 Taiwan manufacturing firms covering the period 1999Q1-2012Q3, which is longer than the above two studies and makes it possible to compare the effects of two financial crises had on trade credit. Second, we look at the provision and the use of trade credit at the firm level which makes it possible to study both sides of trade credit in which firms act as suppliers extend trade credit to their customers and firms act as customers obtain trade credit from their suppliers. Third, we study both the responses on the amount and length of trade credit during the two financial crises. Fourth, we capture the effect of economic growth on trade credit. Finally, we analyze both the one-time stepwise changes and the time-varying responses of trade credit during the two crises. Using 38,885 observations for 707 Taiwan manufacturing firms in the period 1999Q1 -2012Q3, we find that firms acts as customers use trade credit as a substitute for bank credit and firms acts as suppliers who have better access in bank credit provide trade credit to their customers. Small firms are more likely to use trade credit and large firms are tend to offer trade credit to their customers. In particular, the increases in the provision and the use of trade credit during the period following the 2008-09 subprime mortgage crisis suggest that trade credit has mitigated the impact of the crisis on the Taiwan's economy. However, we show that trade credit amplifies

the impact of the 2000-01 dot-com bubble by propagating liquidity shocks through the supply chains. The strong substitution effect between the amount of accounts payable and bank credit can be observed at the beginning and at the end of the 2008-09 subprime mortgage crisis, which reflects the strong demand for trade credit. We also find that the time-varying responses of trade credit in the 2008-09 subprime mortgage crisis have a dynamic pattern, while the responses are monotonic in the 2000-01 dot-com bubble.

The remainder of this paper is organized as follows. Section 2 provides a general background of trade credit and bank credit in Taiwan. Section 3 describes the data, variables, empirical specifications and estimation methods used in this paper. Section 4 presents the empirical results and Section 5 concludes the paper.

2 Trade credit and bank credit in Taiwan: 1999-2012

Taiwan is unique in that its industries consist of many small and medium-sized enterprises (SMEs) that are engaged in international export trade.[4] Taiwanese SMEs are believed to contribute to economic stability due to their flexible operations in business. According to the Small and Medium Enterprise Administration of the Ministry of Economic Affairs in Taiwan, SMEs account for more than 97 percent of the total number of enterprises in Taiwan and they are the most significant contributors to Taiwan's economic growth. SMEs tend to be more bank dependent than larger firms and are also more sensitive in terms of facing liquidity problems due to the decline in bank lending (see Berger and Udell, 1998; Gertler and Gilchrist, 1993, 1994). Chen and Wang (2008) provide empirical evidence and show that, in Taiwan, small

[4]The criteria for identifying SMEs according to the Small and Medium Enterprise Administration, Ministry of Economic Affairs in Taiwan are as follows: (1) in the manufacturing, construction, mining and quarrying industries, SMEs are those with a paid-in capital less than NT$80 million (US$2.42 million) or with fewer than 200 regular employees; (2) in the agriculture, forestry and fisheries, water, electricity and gas, commercial, transportation, warehousing and communications, finance, insurance and real estate, industrial and commercial services or social and personal services industries, SMEs are those with sales revenue of less than NT$100 million (US$3.03 million) in the last year or with fewer than 100 regular employees.

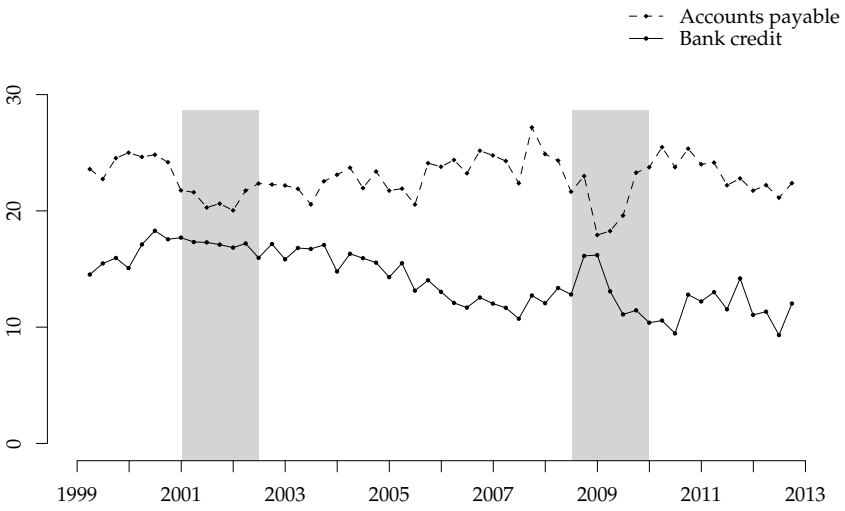
firms are affected the most by the bank credit slowdown. In such a situation, SMEs seek alternative finance from suppliers, as already discussed in the Introduction. They use trade credit in the substitute form of bank credit to finance their business operations when they get into financial difficulty, in line with the redistribution theory of Meltzer (1960). This enables SMEs to rely more on trade credit. According to a survey of the financial conditions of private and public enterprises published by the Central Bank of Taiwan in 2010, trade credit and bank loans were the major external finance of enterprises in Taiwan. They accounted for more than 88 percent of debt and the proportion of trade credit was relatively high, 52.79%. Thus, the extension of bank credit and trade credit that directly boosts lending to SMEs in Taiwan may contribute to the economic growth and recovery.

Why are suppliers willing to extend SMEs trade credit? The literature provides several theories to explain the existence of trade credit based on the transactions motive, pricing motive and financial motive. First, the transactions cost theories suggest that trade credit lowers transaction costs between suppliers and customers, and simplifies their cash management undertaking regular exchanges of goods by separating the exchange of goods from the payment for them (Ferris, 1981; Ng et al., 1999). With trade credit, suppliers and customers can improve operational efficiency since trade credit helps them to reduce the costs from matching the time pattern of payment and the time pattern of the receipt of goods. Furthermore, firms are able to reduce the uncertainty regarding the precautionary level of cash holdings to settle payments by receiving trade credit. Second, the price discrimination theories posit that trade credit provides a way for suppliers to engage in price discrimination by lengthening a credit period or decreasing the discount, which is an implicit price reduction (Brennan et al., 1988; Petersen and Rajan, 1997; Pike et al., 2005; García-Teruel and Martínez-Solano, 2010).[5] For example, suppliers can offer standard

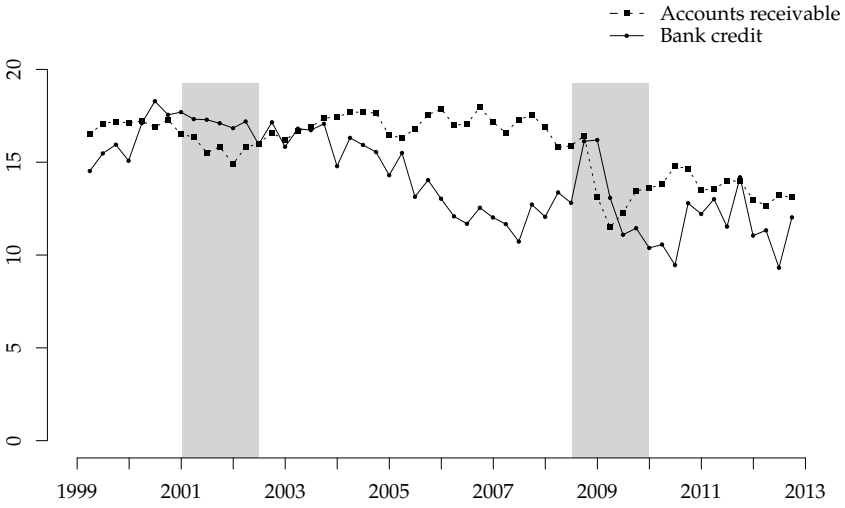
[5]The annualized trade credit interest rate is given by $r = [1/(1-\rho)]^{365/T} - 1$, where ρ is the discount rate if customers pay the bill within a certain number of days and T is the credit period. Thus, we have $(\partial r/\partial \rho) > 0$ and $(\partial r/\partial T) < 0$.

credit terms for all customers but provide creditworthy firms with longer credit terms. In this way, price discrimination is possible since suppliers sell the sample product at different prices to different types of customers. Transaction costs and price discrimination theories can explain the existence of trade credit, but they do not account for the widely observed phenomenon of credit rationing and the response of trade credit flows to borrowing constraints. Some studies focusing on financial advantages have attempted to fill this gap. They suggest that suppliers may have three major advantages over banks in (1) acquiring information about the creditworthiness of their borrowers (Smith, 1987; Mian and Smith, 1992; Biais and Gollier, 1997; Burkart and Ellingsen, 2004; Giannetti et al., 2011); (2) enforcing debt repayment because they hold a credible threat of stopping the future supply of customized goods (Petersen and Rajan, 1997; Cuñat, 2007), and (3) liquidating goods due to having product knowledge in selling (Mian and Smith, 1992; Petersen and Rajan, 1997; Fabbri and Menichini, 2010).

Figure 1 provides an overview of the trends in the ratio of accounts payable over total liabilities, bank credit over total liabilities and accounts receivable over total assets based on a sample of Taiwan manufacturing firms from the first quarter of 1999 to the third quarter of 2012. The accounts receivable ratio can be thought of as the supply of trade credit by the supplier and the accounts payable ratio as the demand for trade credit by the customer (Petersen and Rajan, 1997). We observe that the accounts payable ratio was greater than the bank credit ratio for the overall sample period, which is consistent with the statement that firms depend more on trade credit for short-term financing. It can be seen from the graph that accounts payable is likely to have been a substitute for bank credit as the bank credit ratio moved downward and the accounts payable ratio tended to move in the opposite direction. The correlation between the accounts payable ratio and the bank credit ratio was -0.21. The opposite direction was not obvious in the case of the accounts receivable ratio. The accounts receivable ratio did not increase much if the bank



(a)



(b)

Figure 1: The accounts payable ratio, the accounts receivable ratio and the bank credit ratio for Taiwan manufacturing firms from 1999Q1 to 2012Q3. The accounts payable ratio and the bank credit ratio are divided by the total liabilities. The account receivable ratio is divided by the total assets. Shaded areas in 2001Q1-2002Q2 denote the period of the 2000-01 dot-com bubble and 2008Q3-2009Q4 represents the period of the 2008-09 subprime mortgage crisis.

credit ratio declined. The correlation between the accounts receivable ratio and the bank credit ratio was 0.45 for the sample.

In the last two decades, the Taiwan economy has suffered two financial crises accompanied by recessions.[6] One was the dot-com bubble in 2000-01, which as triggered by the collapse of the stock market in relation to the Internet companies, and the other was the subprime mortgage crisis in 2008-09, which was triggered by the collapse of the subprime mortgage market in the US. The 2000-01 dot-com bubble occurred in March 2000, but most prominently affected Taiwan from the first quarter of 2001. Based on data complied by the Directorate-General of Budget, Accounting and Statistics (DGBAS), Taiwan's economic growth rate fell from the first quarter of 2001 (0.95%) and turned negative in the second quarter of 2001, falling to -2.98 percent. It exhibited a stable recovery in the second quarter of 2002 (6.5%). We define the 2000-01 dot-com bubble period from the first quarter of 2001 to the second quarter of 2002 since the economic growth rate continuously shrank and showed a recovery in the second quarter of 2002. The subprime mortgage crisis erupted in August 2007 in the US and led to a financial crisis that began in 2008. It dealt a major blow to Taiwan economy from the third quarter of 2008. The economy experienced a sharp decline in the third quarter of 2008 (-1.23%), and remained negative for five successive quarters, falling in particular to -8.12 percent in the first quarter of 2009. It started to exhibit a strong recovery in the fourth quarter of 2009 (8.82%). Thus, we define the 2008-09 subprime mortgage crisis period as extending from the third quarter of 2008 to the fourth quarter of 2009. The recession shapes are different between the two financial crises. The 2000-01 dot-com bubble was followed by several quarters of mild and slow downturns, whereas the 2008-09 subprime mortgage crisis relatively caused a deep recession followed by a quick

[6]The Taiwan economy was much less vulnerable to the East Asian Financial Crisis in 1997-98. The stock and foreign exchange markets did not react with panic and the economy still had a positive growth rate in 1998 (3.47 percent) since Taiwan had large foreign exchange reserves relative to short-term debt and excess domestic savings (see Radelet and Sachs, 2000). The growth rate of bank lending declined, but still remained positive, ranging between 13.29% (1998Q1) and 5.33% (1998Q12).

and remarkable recovery on the Taiwan economy. In both cases, defaults are more likely to occur and banks are more likely to adopt more prudent lending due to bankruptcies and the collapse of asset values, causing panic in financial markets. Banks and suppliers are subject to liquidity shocks in their role as liquidity providers, in particular when the economy falls into recession (Boissay, 2006).

Our primary goal is to track how trade credit reacted to the financial crisis. As shown in Figure 1, the shaded areas in 2001Q1-2002Q2 denote the period of the 2000-01 dot-com bubble and 2008Q3-2009Q4 represent the period of the 2008-09 subprime mortgage crisis. The substitution effect between trade credit and bank credit is likely to appear in the period of the 2008-09 subprime mortgage crisis, whereas it is quite a different story in the period of the dot-com bubble. During the period of the dot-com bubble, bank credit (-2.79%), accounts payable (-7.2%) and accounts receivable (-8.88%) all declined in the first four quarters of the period, followed by the slightly increases in accounts payable and accounts receivable in 2002. Trade credit and bank credit were more likely to be complementary in the period of the dot-com bubble. The contraction of trade credit was greater than that of bank credit in the first four quarters of the period, supporting the view that trade credit may amplify the impact of an adverse liquidity shock to the economy along a supply chain (Kiyotaki and Moore, 1997; Raddatz, 2010; Love and Zaidi, 2010). Firms that provide trade credit may become exposed to default risk by their financially constrained customers in the case of a default of payment and cut back on trade credit to their customers (McMillan and Woodruff, 1999; Menichini, 2011). Liquidity shocks tended to be propagated along the trade credit chains during the time of the dot-com bubble. However, when the quantity of trade credit and bank credit both shrank, the days for accounts receivable were lengthened in 2001 but shorten in 2002, as shown in Figure 2. This implies that firms were less likely to raise the volume of finance either from banks or suppliers as liquidity shocks could have been be propagated in the credit market but some suppliers still provided

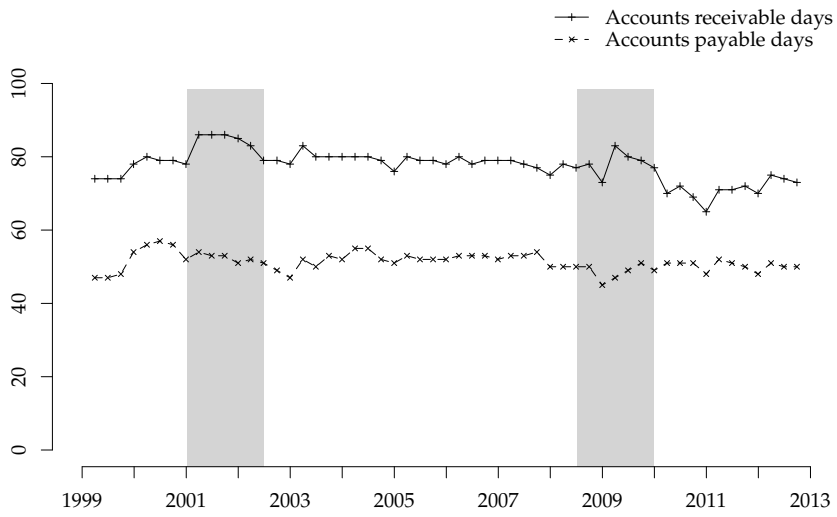


Figure 2: The days for accounts payable and accounts receivable for Taiwan manufacturing firms from 1999Q1 to 2012Q3. Shaded areas in 2001Q1-2002Q2 denote the period of the 2000-01 dot-com bubble and 2008Q3-2009Q4 represents the period of the 2008-09 subprime mortgage crisis.

trade credit by lengthening the receivable days in order to maintain a long-term relationship and mutual survival during the time of the dot-com bubble, which could be consistent with Boissay and Gropp (2013). During the period of the 2008-09 subprime mortgage crisis, bank credit increased in the first two quarters of the period and then declined sharply by 35.9 percent in 2009, while accounts payable and accounts receivable decreased sharply in the fourth quarters of 2008 but increased in 2009. In addition, accounts payable days and accounts receivable days increased in 2009, as shown in Figure 2. These observations are therefore tentative evidence of a dynamic pattern of substitution effect between trade credit and bank credit in the aftermath of the 2008-09 subprime mortgage crisis. The substitution effect signals that firms with more liquidity may have helped other firms which face difficulty in accessing external finance from banks after the 2008-09 subprime mortgage crisis, which is consistent with the redistribution hypothesis. It seems very likely that the role of trade credit as a substitute form of bank credit may soften the impact of

the 2008-09 subprime mortgage crisis on Taiwan's economy by allocating liquidity from financially unconstrained firms to financially constrained firms. Based on the graphical analysis, we can observe that the different responses of trade credit in the two financial crises. A comprehensive compare of different effects that the two financial crises had on trade credit is needed.

3 Data and methodology

In this section we first provide a brief description of the data and the variables used in this paper. We then illustrate the empirical model and strategy adopted to examine whether the role of trade credit amplifies or moderates the impact of a financial crisis on the Taiwan economy.

3.1 Data

We use the quarterly firm-level data of Taiwanese firms that are retrieved from the Taiwan Economic Journal (TEJ) database and restrict our focus to the manufacturing sector as this sector is most likely to use bank credit and trade credit. The dataset contains detailed accounting information, financial reports and a finer industry disaggregation on publicly traded companies. According to the TEJ's description, those companies are mostly listed on the Taiwan Stock Exchange, on the Over-the-Counter Securities Exchange or in emerging stock markets in Taiwan. Our study excludes all financial firms.

As some of the observations from the original dataset are missing and erroneous, we should deal with such issues and construct the sample by taking the following steps. First, we observe financial information on manufacturing firms after 1995Q1 (before this date the information was not completely recorded). Second, we exclude firms whose financial data were obviously not recorded. Firms with at least thirty

observations are kept in the sample. Third, we fill in our data by replacing missing observations with linear interpolations in which each missing value is replaced by a linear approximation between the missing data points. If there are no earlier non-missing values or later non-missing values, the missing observation is dropped.[7] We then extract the longest continuous time periods without gaps for each firm. Fourth, the pooled sample is balanced by the number of firms and the length of the sample period by choosing the largest sample size. After these screenings, we are left with a balanced panel data set that consists of 707 firms in 13 industries, a total of 38,885 observations, and cover the period 1999Q1 - 2012Q3 in the final sample. Finally, to avoid having results affected by outliers, we record the highest percent of values to the 99th percentiles of the distribution when the distribution of a variable is highly right-skewed, and the lowest percent of values to the 1st percentile when it is left-skewed for small values.[8] In particular, we check the sample structure by computing our data with accounting formulas to avoid a bias occurring in the data collection. Our sample has a relatively large number of firms, which is more reliable and accurate in terms of the quality of financial data. Since our data set contains only the observations of publicly-traded companies that tend to be larger in size, there may be a concern that the estimates regarding the overall use of trade credit in Taiwan would be biased. However, the variation in the use of trade credit across firms would bias the level of the estimates but not their relative position. If the importance of the trade credit channel can be captured for this sample of larger firms, then it would be relatively significant for small firms.

Trade credit is the dependent variable in the estimation specifications. Four dependent variables are used as proxies for trade credit in this paper. We look at both the supply and demand sides of trade credit at the firm level, and consider the changes in the quantity and length of trade credit. The amount of accounts

[7]The proportion of the data that we fill in by using the imputation technique is about 10 percent of the total number of the sample.

[8]The return on sales is winsorized at the 1st percentile. The inventory turnover ratio and the long-term debt to equity ratio are winsorized at the 99th percentile.

payable (AP) is used as a measure of trade credit received from suppliers and accounts receivable (AR) is used as a measure of trade credit provision, as is usual in the literature (see Petersen and Rajan, 1997; Choi and Kim, 2005; Love et al., 2007; Love and Zaidi, 2010; Coulibaly et al., 2013, among others). In order to ensure comparability among different types of firms, we normalize the amount of accounts payable by total liabilities and the amount of accounts receivable by total assets.[9] These ratio terms give better information about the volumes of trade credit as one source of funds. Giannetti et al. (2011) have stated that the willingness of a supplier to extend trade credit is reflected not only in the amount of trade credit, but also in the contract terms. Thus, we also consider accounts payable days and accounts receivable days as dependent variables to understand how the contract terms are related to our variables of interest.[10] Accounts payable days (APD) measure the number of days in which a firm repays trade credit to its suppliers and accounts receivable days (ARD) measure the length of time in which a firm gets paid by its customers.

In the set of explanatory variables, our main variable of interest is bank credit. We use short-term bank loans scaled by total liabilities as a proxy for bank credit. For control variables, we use firm size, firm age, the return on sales, asset turnover, inventory turnover and the long-term debt to equity ratio, as suggested by the trade credit literature (e.g., Petersen and Rajan, 1997; Choi and Kim, 2005; Mateut et al., 2006; Rodríguez-Rodríguez, 2006; Cuñat, 2007; Love et al., 2007; Huang et al., 2011; Yang, 2011b). Firm size (Size) is defined as the logarithm of the total assets of a firm. Firm age (Age) is defined as the number of years since the incorporation of a firm. We include the return on sales as the measure of the firms' profitability. The return on sales (ROS) is defined as the ratio between operating profit and sales.

[9] Some studies in the literature involve trade credit as the ratio of accounts payable over sales (see Petersen and Rajan, 1997; Nilsen, 2002). However, if we use this method for the definition of trade credit, there will be large short-term changes as the result of a financial shock since the data on sales obtained from the TEJ does not involve a seasonal adjustment.

[10] In the data set from the TEJ, contract terms are observed only for the credit period.

Asset turnover and inventory turnover are used to measure operating performance for each firm. Asset turnover (AT) is calculated as the ratio of net sales divided by total assets, measuring a firm's efficiency in terms of using its assets to generate sales. Inventory turnover (IT) is calculated as the cost of goods sold divided by the average inventory, and reflects a firm's investment in inventory and its sales performance. The long-term debt to equity ratio (LDE) is employed as a measure of financial leverage, which quantifies the firm's ability to repay long-term debt. In addition, we consider the growth rate of gross domestic product (DY) as explanation variables in estimate models to control for the effect of economy prosperity on trade credit. This enables us to control for the effect of demand on trade credit and the possibilities that firms are able to replace external finance with trade credit when the economy grows. The data of gross domestic product (GDP) is from the DGBAS. Table 1 provides detailed definitions of the variables. In Table 2 we present the

Table 1: Definitions of variables

Variable	Definition
Dependent variables:	
AP	Accounts payable divided by total liabilities $\times 100$
AR	Accounts receivable divided by total assets $\times 100$
APD	The number of days that it takes a firm to pay its accounts payable
ARD	The number of days that it takes a firm to receive its accounts receivable
Independent variables:	
STB	Short-term bank credit [short-term bank loans divided by total liabilities $\times 100$]
Size	Firm size [the natural logarithm of total assets]
Age	Firm age [the number of years since the foundation]
ROS	Return on sales [operating profit divided by sales $\times 100$]
AT	Asset turnover [net sales divided by average total assets $\times 100$]
IT	Inventory turnover [cost of goods sold divided by average inventory]
LDE	Long-term debt to equity ratio [long-term debt divided by stockholders' equity $\times 100$]
DY	The growth rate of GDP

matrix of Pearson correlations. The correlation coefficients indicate that all of our independent variables are not highly correlated with each other. This suggests that

multicollinearity is not likely to be a serious concern in our study. Table 3 provides

Table 2: Correlation table of variables

	AP	AR	ARD	APD	STB	Size	Age	ROS	AT	IT	LDE
AR	0.51	1									
ARD	0.03	0.28	1								
APD	0.37	0.12	0.41	1							
STB	−0.33	0.10	0.08	−0.14	1						
Size	−0.19	−0.25	−0.18	−0.15	−0.15	1					
Age	−0.27	−0.26	−0.13	−0.17	0.04	0.37	1				
ROS	0.10	0.18	−0.20	−0.21	−0.10	0.14	0.05	1			
AT	0.43	0.60	−0.26	−0.14	0.08	−0.09	−0.16	0.18	1		
IT	0.10	0.11	0.01	−0.01	−0.03	0.03	0.00	−0.02	0.10	1	
LDE	−0.30	−0.15	−0.04	−0.04	0.01	0.08	0.02	−0.12	−0.11	−0.05	1
DY	0.03	0.01	0.00	0.01	−0.02	−0.02	−0.02	0.00	0.00	−0.01	0.00

Notes: This table reports the correlation coefficient between paired samples using Pearson's method. The variables AP AR, APD and ARD are dependent variables, while the others are independent variables. The definitions of the variables are provided in Table 1.

the summary statistics of the variables employed in our study.

We define a binary dummy variable as referring the 2000-01 dot-com bubble period or the 2008-09 subprime mortgage crisis period. The 2000-01 dot-com bubble period extends from the first quarter of 2001 to the second quarter of 2002, while the 2008-09 subprime mortgage crisis period extends from the third quarter of 2008 to the fourth quarter of 2009. In particular, we create a set of dummy variables to account for the outbreak and the aftermath of the crisis. The variable outbreak is equal to one for the first crisis quarter and zero otherwise. The variables post 1 to post 5 denote five post-crisis periods, where each dummy equals one for the corresponding quarter and zero otherwise, following Love et al. (2007).

Table 3: Summary statistics

Variable	Mean	Median	Maximum	Minimum	Std. Dev.
Dependent variables:					
AP	27.619	22.779	98.746	0.000	20.009
AR	17.930	15.712	84.750	0.000	11.563
ARD	83.342	77.000	1078.476	0.000	52.485
APD	57.735	51.000	1108.816	0.000	47.541
Independent variables:					
STB	18.516	14.179	94.607	0.000	18.095
Size	15.021	14.862	21.147	9.260	1.400
Age	23.990	22.200	66.400	0.200	12.190
ROS	2.229	4.507	63.465	−225.770	22.861
AT	88.981	74.000	826.000	0.000	64.276
IT	13.688	6.020	286.617	0.000	34.181
LDE	16.771	7.551	370.708	0.000	30.077
DY	4.294	4.220	21.280	−18.780	7.970

Notes: This table presents variable means, medians, maximums, minimums and standard deviations for the period 1999Q1-2012Q3 with 707 Taiwanese manufacturing firms, a total of 38,885 observations for each variable. See Table 1 for the definitions of the variables.

3.2 Empirical specification

To study the effects of a financial crisis on the relationship between trade credit and bank credit we use a standard panel model written as follows:

$$y_{it} = \mathbf{x}_{it}'\boldsymbol{\beta} + \gamma_i + u_{it} \tag{1}$$

where y_{it} presents the dependent variables, $\mathbf{x}_{it}$ is the covariate vector, $\boldsymbol{\beta}$ is the coefficient vector, γ_i is an unobservable firm-specific effect and u_{it} is the error term. We have $i = 1, \ldots, N$ firms observed over $t = 1, \ldots, T$ time periods. We consider the fixed-effects panel model, i.e., $Cov(x_{it}, \gamma_i) \neq 0$. Controlling the impact of unobserved heterogeneity among firm units is important since they account for persistent differences across firms that affect trade credit. This enables us to more accurately assess

the relationship between trade credit and bank credit and guard against omitted variables bias.

The estimation method used in this study is ordinary least squares (OLS) based on within transformation where variables are measured as deviations from individual means. This is referred to as a fixed effect estimator or within estimator.[11] We justify our choice of model specifications by performing the Chow test and the Hausman test. The Chow test can help determine whether the fixed effects are really needed by comparing the fixed effects and the pooled ordinary least squares (OLS) fits. Accordingly, the Hausman test is performed for adopting fixed-effects or random-effects models by comparing fixed-effects and random-effects estimators. We adjust standard errors clustered by time to account for the correlation between observations for different firms in the same period, the so-called time effect (i.e., $E(u_{it}u_{jt}|\mathbf{x}_{it}, \mathbf{x}_{jt}) \neq 0$ for $i \neq j$).[12]

We examine how the contraction in bank credit affected trade credit during the financial crisis in two steps. We first show the relationship between trade credit and bank credit for the sample period, and test how the relationship changes during the crisis period. Next, we separate the effect of the financial crisis into the effects of the outbreak and in the aftermath of the crisis. Together, these steps allow us to gauge the magnitude of the effect that financial shocks had on trade credit and the time-varying behavior of trade credit as one source of short-term external finance during the time of the financial crisis.

We look at four dependent variables that reflect both the supply and demand side of the trade credit volume and contract terms: the accounts payable ratio (AP), the accounts receivable ratio (AR), accounts payable days (APD) and accounts receivable

[11] A fixed-effects estimator is computationally equivalent to the LSDV estimator, but we need to correct the degrees of freedom for the number of individuals or the length of time period when we use the within transform method.

[12] Since the panel's cross-sectional dimension is far large compared to the time dimension in our sample and the individual-specific effects included in the model regression remove the correlation between observations for the same firm in different periods, it is more likely that the bias comes from omitting the time effect (see Petersen, 2009; Thompson, 2011, for more detail).

days (ARD). We regress one of the dependent variables on bank credit (STB) and on the control variables, which include firm size (Size), firm age (Age), the return on sales (ROS), asset turnover ratio (AT), the inventory turnover ratio (IT), the long-term debt to equity ratio (LDE), the economic growth (DY), crisis dummies (D), seasonal dummies (SD) and unobserved individual effects. The model to be estimated becomes:

$$\begin{aligned} \mathrm{TC}_{it} = {} & \beta_0 + \beta_1 \mathrm{STB}_{it-1} + \beta_2 \mathrm{Size}_{it-1} + \beta_3 \mathrm{Age}_{it} + \beta_4 \mathrm{ROS}_{it-1} + \beta_5 \mathrm{AT}_{it-1} \\ & + \beta_6 \mathrm{IT}_{it-1} + \beta_7 \mathrm{LDE}_{it-1} + \beta_8 \mathrm{DY}_{it} + \sum_k \theta_k D_k + \sum_k \eta_k D_k \times \mathrm{STB}_{it-1} \\ & + \sum_{j=1}^{4} \alpha_j SD_j + \gamma_i + u_{it}, \end{aligned} \tag{2}$$

where TC_{it} is one of the trade credit variables, i indexes an individual firm, t is a time period, γ_i is an unobservable individual-specific effect which may be correlated with the explanatory variables and u_{it} is a stochastic disturbance term. The seasonal dummy SD_j for $j = \{1, 2, 3, 4\}$ controls for time-series variation in the availability of trade and quarterly seasonality in the data. The definitions of independent variables are discussed in Section 3.1. Explanatory variables are lagged by one period to mitigate possible concerns of simultaneity and reversal. We define D_k as one of two crisis-period dummies where $k = dotcom$ denotes the 2000-01 dot-com bubble period and $k = subrpime$ represents the 2008-09 subprime mortgage crisis period. The interaction term ($D_k \times \mathrm{STB}_{it-1}$) in turn tests whether the relationship between bank credit and trade credit changes during the period of the crisis. The coefficient η_k captures the added effect of financial shocks on the relationship that observed in the crisis period.

Our main estimation of Equation (2) assumes that the crisis resulted in a one-time stepwise change in the volume and length of trade credit. To illustrate how the effect of bank credit on trade credit evolved after the crisis, we relax this assumption and

employ a more flexible regression specification:

$$\begin{aligned} \mathrm{TC}_{it} &= \beta_0 + \beta_1 \mathrm{STB}_{it-1} + \beta_2 \mathrm{Size}_{it-1} + \beta_3 \mathrm{Age}_{it} + \beta_4 \mathrm{ROS}_{it-1} + \beta_5 \mathrm{AT}_{it-1} \\ &+ \beta_6 \mathrm{IT}_{it-1} + \beta_7 \mathrm{LDE}_{it-1} + \beta_8 \mathrm{DY}_{it} + \sum_{q=0}^{5} \phi_q D_q^k + \sum_{q=0}^{5} \psi_q D_q^k \times \mathrm{STB}_{it-1} \\ &+ \sum_{j=1}^{4} \alpha_j SD_j + \gamma_i + u_{it}, \end{aligned} \tag{3}$$

where $q = \{0, 1, 2, 3, 4, 5\}$, D_0^k is a binary dummy variable for the outbreak of the crisis and D_1^k to D_5^k are five post crisis dummies for $k = \{dotcom, subprime\}$. This allows the impact of the crisis and the effect of bank credit on trade credit to vary over time during the crisis by using a set of quarterly dummies to account for the outbreak and the aftermath of the crisis, D_q^k, instead of the crisis indicator.

4 Empirical results

This section discusses the estimation results for Equations (2) and (3) described above. The empirical results that evaluate the response of trade credit during the two financial crises are reported in Tables 4 to 7.

4.1 The reaction of trade credit during the crisis

Table 4 presents the results of Equation (2) with four dependent variables and their corresponding standard errors reported in parentheses, from which we can observe the relationship between trade credit and bank credit and the added effect of financial shocks during the period of the financial crisis. The first two columns give the estimation for the demand side of trade credit (accounts payable) and the next two columns show the supply side of trade credit (accounts receivable). Columns 1 and 3 correspond to the volume of trade credit, and columns 2 and 4 represent the length of the credit period. The Chow test, Hausman test, adjusted R-squared, the

number of firms and the number of observations are displayed at the bottom of the table. To conserve on space, the estimates of seasonal dummies and fixed effects are not reported here.

Table 4: Effects of financial crises on trade credit

Variable	Accounts payable		Accounts receivable	
	volume	length	volume	length
	(1)	(2)	(3)	(4)
Bank credit	-0.2642^{***}	-0.1777^{***}	0.0244^{***}	0.1896^{***}
	(0.0097)	(0.0159)	(0.0041)	(0.0253)
Firm size	-3.0429^{***}	-2.7724^{**}	0.2208^{*}	10.4722^{***}
	(0.2364)	(0.9596)	(0.1062)	(0.9180)
Firm age	0.2293^{***}	$0.1893^{\dagger}$	-0.2911^{***}	-1.1628^{***}
	(0.0375)	(0.1078)	(0.0260)	(0.1642)
Return on sales	0.0422^{***}	-0.3955^{***}	0.0353^{***}	-0.3147^{***}
	(0.0045)	(0.0509)	(0.0029)	(0.0856)
Asset turnover	0.0857^{***}	-0.0960^{***}	0.0823^{***}	-0.1738^{***}
	(0.0032)	(0.0093)	(0.0022)	(0.0093)
Inventory turnover	$0.0053^{\dagger}$	$-0.0206^{\dagger}$	0.0003	-0.0092
	(0.0029)	(0.0120)	(0.0017)	(0.0097)
Long-term debt to equity	-0.0977^{***}	-0.0120	-0.0048^{***}	-0.0484^{***}
	(0.0047)	(0.0106)	(0.0012)	(0.0096)
GDP growth rate	0.0831^{***}	0.0127	$0.0264^{\dagger}$	0.0090
	(0.0192)	(0.0425)	(0.0137)	(0.0682)
Dot-com bubble period	-1.1937^{*}	0.2085	-1.1050^{***}	6.8558^{***}
	(0.5019)	(1.7655)	(0.2041)	(1.5814)
Subprime crisis period	-0.4311	-1.4777	-0.4439	5.4662^{*}
	(1.0322)	(1.5949)	(0.5339)	(2.4693)
Bank credit $\times$ dot-com bubble period	0.0316^{**}	0.0230	0.0184^{***}	-0.0607^{**}
	(0.0100)	(0.0242)	(0.0050)	(0.0232)
Bank credit $\times$ subprime loan crisis period	-0.0014	-0.0099	-0.0164^{**}	0.0093
	(0.0182)	(0.0305)	(0.0055)	(0.0334)
Chow test	65.7251^{***}	32.8747^{***}	94.6464^{***}	40.3403^{***}
Hausman test	259.1174^{***}	113.6841^{***}	156.5347^{***}	326.9188^{***}
Adjusted R^2	0.7212	0.4449	0.7721	0.4992
Number of firms	707	707	707	707
Number of observations	38178	38178	38178	38178

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\dagger}p < 0.1$

Notes: Independent variables, except for firm age and GDP growth rate, are one-period lagged. Standard errors clustered by time are reported in parentheses. Firm fixed effects and seasonal dummies are included in all models. Dot-com bubble period is a dummy variable with a value equal to one for the period of the 2000-01 dot-com bubble, from the first quarter of 2001 to the second quarter of 2002, and zero otherwise. Subprime crisis period is a dummy variable with a value equal to one for the period of the 2008-09 subprime mortgage crisis, from the third quarter of 2008 to the fourth quarter of 2009, and zero otherwise.

We first look at the relationship between trade credit and bank credit. The first row of the table clearly shows that bank credit and accounts payable (both the volume

and the length) are negatively related, while bank credit and accounts receivable (both the volume and the length) are positively related for whole sample period across firms. The estimates are highly significant. These results indicate that the trade credit is regarded as a substitute for bank credit for Taiwan manufacturing firms, and suppliers with better access to bank loans pass funding to their customers who experience bank borrowing shortfalls by mans of trade credit, which is consistent with the redistribution hypothesis (Meltzer, 1960; Mateut et al., 2006; Rodríguez-Rodríguez, 2006; Huang et al., 2011; Yang, 2011b, among others). Our results suggest that, on average, the demand for trade credit increases by 0.264% when banks reduce short-term lending to firms by 1%. The supply of trade credit increases by 0.024% when suppliers are able to obtain one more percent of bank borrowing. In the second row of the table report estimated coefficients for firm size. The estimated effects of firm size on the amount and length of accounts payable are both negative and statistically significant at the 0.1% level, while the effects of firm size on the amount and length of accounts receivable are significant positive. The negative relationship between firm size and accounts payable suggests that small firms seem more likely to use trade credit, consistent with those of other studies (Petersen and Rajan, 1997; Berger and Udell, 1998; Nilsen, 2002; Mateut et al., 2006; Love and Zaidi, 2010). Small firms are believed to face more challenges in terms of borrowing from banks and therefore they are likely to seek short-term finance through suppliers. The positive relationship between firm size and accounts receivable suggests that large firms who are believed to have better access to credit are more likely to extend trade credit to their customers in order to maintain their long-term commercial relationship. These findings indicate that the use and provision of trade credit are significantly associated with firm's size for Taiwan manufacturing firms. Firms in different size face different degrees of credit rationing and have asymmetric financing behavior on trade credit. One thing deserves to be mentioned is that our model predicts the pro-cyclical pattern of trade credit volumes. This reflects the significant and positive relationship between the amount of accounts payable and GDP growth rate, and

between accounts receivable and GDP growth rate in the eight row of the table. This finding suggests that firms are able to replace external finance with trade credit in the time of economic prosperity.

The coefficients on the crisis period dummies (dot-com bubble period and subprime crisis period) apparently show the different effects that the two financial crises had on trade credit. The coefficients on the amounts of the accounts payable and accounts receivable for the dot-com bubble period are both significantly negative, while the coefficient on the accounts receivable days for the dot-com bubble period was positive. These results imply that liquidity shocks might be propagated along the supply chains during the period of the 2000-01 dot-com bubble since firms cut the credit they provide to their customers. In particular, the days for accounts receivable were significantly extended during the period of the 2000-01 dot-com bubble. This finding does not support the empirical result by Love and Zaidi (2010) who study the impact of the East Asian Financial Crisis in 1997-98 had on trade credit. They find that the days for accounts receivable and accounts payable were both shorten during the time of the East 1997-98 Asian Financial Crisis. One interpretation of the asymmetric behaviors on the amount and length of trade credit in our result is that although liquidity shocks were propagated in the credit market, some suppliers still provided trade credit by lengthening the credit period in order to maintain the long-term relationship with customers, in line with Boissay and Gropp (2013) and Cuñat (2007). During the period of the 2008-09 subprime mortgage crisis, we find that the length of the credit period that the suppliers offered was extended which shows a similar behavior during the time of the 2000-01 dot-com bubble. However, the amounts of accounts payable and accounts receivable did not exhibit significant declines when firms faced liquidity shocks. The time-varying behaviors of the trade credit of Equation (3) could provide an explanation for this finding. We will discuss this in more detail in the next subsection.

We further test whether the relationship between bank credit and trade credit

changes during the period of the crisis by examining the coefficients on the interaction terms. We find that the substitution effect between bank credit and the accounts payable is relatively small in absolute value terms, but the complementary effect between bank credit and the accounts receivable is relatively large during the period of the 2000-01 dot-com bubble. It suggests that for a decline in bank credit, the demand for trade credit did not increase as much as for the whole sample period, and the supply of trade credit decreased sharply during the period of the 2000-01 dot-com bubble. This result is consistent with the decline in trade credit during the period of the 2000-01 dot-com bubble, and supports the view that trade credit amplifies the impact of the 2000-01 dot-com bubble by propagating liquidity shocks through the supply chains. During the period of the 2008-09 subprime mortgage crisis, we show that the substitution effect between bank credit and the accounts payable did not significantly change, but the complementary effect between bank credit and accounts receivable was relatively low, which is the opposite of the effect of the 2000-01 dot-com bubble. It implies that the supply of trade credit decreases less for a decline in bank credit during the period of the 2008-09 subprime mortgage crisis. It seems that trade credit did not shrink significantly during the 2008-09 subprime mortgage crisis, in comparison with that during the 2000-01 dot com bubble.

4.2 The time-varying behaviors of trade credit during the crisis

Tables 5 and 6 present the estimation results of Equation (3) for the impact of the 2000-01 dot-com bubble and the 2008-09 subprime mortgage crisis, respectively. The coefficients on the outbreak of the crisis (dot-com bubble 0 and subprime crisis 0) and five posts of the crisis (post 1 to post 5) show the time-varying effects that the financial crisis has on trade credit since the onset of the crisis.

In Table 5, we first find that the volumes of accounts receivable and accounts payable shrank heavily upon the outbreak and during the five post-crisis points intimate of the 2000-01 dot-com bubble, except for post 2 and post 4 periods of

the crisis for accounts payable. Second, firms act as suppliers kept the trade credit for a longer length of time during the 2000-01 dot-com bubble, while firms act as customers paid the bill with longer periods to their suppliers at the beginning of the crisis and with shorter periods from the post 3 to post 5 periods of the crisis. Since the accounts payable days increased first and decreased later during the 2000-01 dot-com bubble, the estimated effect of the 2000-01 dot-com bubble on accounts payable days is not significantly observed when we apply the one-time stepwise change of the crisis in Equation (2). Third, the magnitudes of the substitution effect between the accounts payable and bank credit were weak during the time of the 2000-01 dot-com bubble except for the post 4 period of the crisis, and the coefficients of the complementary effect between accounts receivable and bank credit were greater during the five post periods of the 2000-01 dot-com bubble. Moreover, the magnitude of the substitution effect between accounts payable days and bank credit was at first greater in absolute value terms but became smaller from the post 2 period of the 2000-01 dot-com bubble, which is consistent with the dynamic behaviors of accounts payable days during the crisis. We observe that a asymmetric behavior on the credit period of trade credit which the credit period of accounts payable were shorter from the post 3 period of the 2000-01 dot-com bubble, while the credit period of accounts receivable were extended during this period. One possible interpretation for this finding is that the companies in our sample are more likely to act as relatively financially unconstrained firms since our data set mostly contains information on publicly-traded companies that are relatively large in size. They provide trade credit to their customers by lengthening the credit period instead of extending the amount of trade credit and slightly absorb the liquidity shocks from their constrained suppliers (i.e., the reduction in their accounts payable) during the time of the 2000-01 dot-com bubble. Finally, even if the economy recovery took place, i.e., in the post 5 period of the 2000-01 dot-com bubble, the provision and the use of trade credit also declined except for the accounts receivable days. These findings are consistent with the result of Table 4 and again emphasize that liquidity shocks were propagated

along the supply chains during the period of the 2000-01 dot-com bubble since the volume of trade credit shrank greatly due to the weaker substitution effect and the stronger complementary effect. Given that the reduction in the accounts payable volumes was significantly higher and the substitution effects between accounts payable and bank credit became smaller during the time of the 2000-01 dot-com bubble, even in the time of economic recovery, it seems that the demand for trade credit was not strong in our sample.

Table 6 provides the time-varying pattern that the 2008-09 subprime mortgage crisis had on trade credit. The results are more complicated than those during the 2000-01 dot-com bubble. We observe a similar pattern that emerges in the graphical analysis of Figures 1 and 2. We observe the remarkable asymmetric behaviors and dynamic patterns on the amount and length of trade credit during the 2008-09 mortgage crisis. When the 2008-09 subprime mortgage crisis hit the Taiwan economy, we find that firms used and extended more trade credit but paid the bill with shorter period. The magnitude of the substitution effect between the amount of accounts payable and bank credit was stronger and the coefficients of the complementary effect between the amount of accounts receivable and bank credit were weaker on the outbreak of the crisis, supporting the increases in the amounts of accounts payable and accounts receivable. However, the provision and the use of trade credit sharply dropped from the post 1 to post 3 periods of the crisis, which is the time that the economy experienced a severe depression.[13] This result indicates the liquidity shocks were propagated from the post 1 to post 3 periods of the 2008-09 mortgage crisis. In particular, the length of the credit period was shorten at first and lengthened from the post 2 period of the crisis. This suggests that firms act as suppliers were more likely to provide trade credit to their customers by lengthening the credit period from the post 2 period of the crisis. The days for accounts payable had a significant increase only for the post 2 period of the crisis. These findings indicate a asymmetric

[13]The economy's growth rate range from -6.58% to -8.12%.

reaction on the credit period of trade credit from the post 3 of the 2008-09 mortgage crisis, which is a similar behavior during the 2000-01 dot-com bubble. In addition, in the post 4 to post 5 periods of the 2008-09 mortgage crisis which is the time of the economy recovery, we find that firms act as customers used more trade credit and firms act as suppliers offered the longer length of the credit period to their customers. The amount of accounts receivable, however, exhibited a significant decrease in the post 5 of the crisis, which shows a asymmetric behavior on the amount of trade credit. Our results suggest that the demand for trade credit was relatively stronger during the 2008-09 subprime mortgage crisis, in particular at the beginning and at the end of the 2008-09 subprime mortgage crisis. This finding are more likely to support the view that trade credit has mitigated the impact of the 2008-09 crisis on the Taiwan economy due to the increases in the provision and the use of trade credit.

In sum, the increases in the provision and the use of trade credit during the 2008-09 subprime mortgage crisis suggest that trade credit has mitigated the impact of the 2008-09 subprime mortgage crisis on the Taiwan economy. However, we find evidence that trade credit has amplified the impact of the 2000-01 dot-com bubble by propagating liquidity shocks through the supply chains as trade credit shrank heavily during the 2000-01 dot-com bubble. Why did the trade credit play the different role during the two financial crises? One possible interpretation is due to the fact that the different patterns of recessions and recoveries during the two financial crises cause the different magnitudes of the demand for trade credit. The 2000-01 dot-com bubble was followed by several quarters of slow downturns and a mild recovery, whereas the 2008-09 subprime mortgage crisis relatively caused a deep recession followed by remarkable recovery on the Taiwan economy. The slow downturns and a mild recovery caused a weak demand for trade credit, which firms were less willing to engage in additional investment and demand for external finance, during the 2000-01 dot-com bubble. At the same time, the supply of trade credit declined due to the liquidity shocks. These enable the amount of trade credit shrink

heavily during the 2000-01 dot-com bubble and highlight the role of trade credit as a mechanism that propagates liquidity shocks along a supply chain. However, the demand for trade credit was strong during the 2008-09 subprime mortgage crisis due to the deep recession and the rapid recovery. Although liquidity shocks might be propagated along the supply chains, suppliers were more likely to extend trade credit to their customers who have a great need for trade credit by providing the amount of trade credit or lengthening the credit period of trade credit during 2008-09 subprime mortgage crisis in order to main the long-term business relationships. Thus, we observe the strong substitution effect between the amount of accounts payable and bank credit are at the beginning and at the end of the 2008-09 subprime mortgage crisis, which reflects the strong demand for trade credit. The results are quite similar and robust when the test model applies both the quarterly dummies in the periods of the 2000-01 dot-com bubble and the 2008-09 subprime mortgage crisis, as shown in Table 7.

Table 5: Effect of the 2000-01 dot-com bubble on trade credit

Variable	Accounts payable		Accounts receivable	
	volume	length	volume	length
	(1)	(2)	(3)	(4)
Bank credit	-0.2643^{***}	-0.1788^{***}	0.0222^{***}	0.1927^{***}
	(0.0095)	(0.0163)	(0.0042)	(0.0227)
Firm size	-3.0366^{***}	-2.7372^{**}	0.2336^{*}	10.4507^{***}
	(0.2335)	(0.9593)	(0.1025)	(0.8761)
Firm age	0.2198^{***}	0.1612	-0.3089^{***}	-1.0215^{***}
	(0.0367)	(0.1067)	(0.0243)	(0.1575)
Return on sales	0.0426^{***}	-0.3942^{***}	0.0359^{***}	-0.3190^{***}
	(0.0044)	(0.0506)	(0.0029)	(0.0858)
Asset turnover	0.0860^{***}	-0.0958^{***}	0.0827^{***}	-0.1767^{***}
	(0.0032)	(0.0091)	(0.0022)	(0.0086)
Inventory turnover	$0.0052^{\dagger}$	$-0.0211^{\dagger}$	0.0002	-0.0081
	(0.0029)	(0.0120)	(0.0018)	(0.0099)
Long-term debt to equity	-0.0977^{***}	-0.0125	-0.0049^{***}	-0.0480^{***}
	(0.0047)	(0.0106)	(0.0012)	(0.0098)
GDP growth rate	0.0943^{***}	0.0527	$0.0337^{\dagger}$	0.0242
	(0.0225)	(0.0546)	(0.0186)	(0.0736)
Dot-com bubble 0	-1.0801^{**}	6.9360^{***}	-1.2339^{***}	11.7435^{***}
	(0.3297)	(1.1575)	(0.1934)	(1.0974)
Dot-com bubble post 1	-1.6374^{***}	3.0947^{*}	-1.3096^{***}	8.8206^{***}
	(0.4287)	(1.3451)	(0.2868)	(1.4528)
Dot-com bubble post 2	-0.2646	1.1088	-0.5982^{*}	8.2347^{***}
	(0.3815)	(1.2454)	(0.2386)	(1.2850)
Dot-com bubble post 3	-2.6577^{***}	-2.7798^{*}	-1.6839^{***}	5.6269^{***}
	(0.4034)	(1.1447)	(0.2717)	(1.2379)
Dot-com bubble post 4	0.3135	-2.9902^{**}	-0.8757^{***}	4.9148^{***}
	(0.3068)	(0.9939)	(0.1495)	(0.9301)
Dot-com bubble post 5	-1.7949^{***}	-3.3378^{***}	-1.0798^{***}	2.1632^{*}
	(0.3676)	(1.0039)	(0.2396)	(1.0707)
Bank credit × dot-com bubble 0	0.0280^{***}	-0.0707^{***}	0.0041	-0.0637^{***}
	(0.0064)	(0.0140)	(0.0037)	(0.0174)
Bank credit × dot-com bubble post 1	0.0630^{***}	-0.0163	0.0367^{***}	-0.0725^{***}
	(0.0072)	(0.0128)	(0.0036)	(0.0192)
Bank credit × dot-com bubble post 2	0.0207^{**}	$0.0248^{\dagger}$	0.0253^{***}	-0.0500^{*}
	(0.0073)	(0.0131)	(0.0032)	(0.0204)
Bank credit × dot-com bubble post 3	0.0361^{***}	0.0699^{***}	0.0173^{***}	-0.0705^{***}
	(0.0074)	(0.0139)	(0.0028)	(0.0214)
Bank credit × dot-com bubble post 4	0.0101	0.0677^{***}	0.0192^{***}	-0.0312
	(0.0077)	(0.0134)	(0.0028)	(0.0206)
Bank credit × dot-com bubble post 5	0.0354^{***}	0.0573^{***}	0.0216^{***}	-0.1015^{***}
	(0.0067)	(0.0126)	(0.0031)	(0.0207)
Chow test	65.7685^{***}	32.8837^{***}	94.5919^{***}	50.3898^{***}
Hausman test	246.2114^{***}	111.6080^{***}	164.8333^{***}	328.6755^{***}
Adjusted R^2	0.7212	0.4451	0.7717	0.4985
Number of firms	707	707	707	707
Number of observations	38178	38178	38178	38178

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\dagger}p < 0.1$

Notes: Independent variables except for firm age and GDP growth rate are one-period lagged. Standard errors clustered by time are reported in parentheses. Firm fixed effects and seasonal dummies are included. Dot-com bubble 0 is a dummy variable with a value equal to one for the outbreak of dot-com bubble, in the first quarter of 2001. Dot-com bubble post 1 to post 5 refer to five post periods of the 2000-01 dot-com bubble, starting from the second quarter of 2001 until the second quarter of 2002.

Table 6: Effect of the 2008-09 subprime mortgage crisis on trade credit

Variable	Accounts payable		Accounts receivable	
	volume	length	volume	length
	(1)	(2)	(3)	(4)
Bank credit	-0.2601^{***}	-0.1747^{***}	0.0268^{***}	0.1838^{***}
	(0.0087)	(0.0157)	(0.0037)	(0.0240)
Firm size	-3.0232^{***}	-2.7201^{**}	0.2164^{*}	10.5882^{***}
	(0.2380)	(0.9712)	(0.1064)	(0.9644)
Firm age	0.2452^{***}	$0.1633^{\dagger}$	-0.2669^{***}	-1.3503^{***}
	(0.0355)	(0.0980)	(0.0246)	(0.1783)
Return on sales	0.0417^{***}	-0.3951^{***}	0.0351^{***}	-0.3123^{***}
	(0.0046)	(0.0512)	(0.0028)	(0.0862)
Asset turnover	0.0864^{***}	-0.0967^{***}	0.0830^{***}	-0.1762^{***}
	(0.0031)	(0.0094)	(0.0021)	(0.0094)
Inventory turnover	$0.0055^{\dagger}$	$-0.0208^{\dagger}$	0.0005	-0.0098
	(0.0029)	(0.0120)	(0.0017)	(0.0096)
Long-term debt to equity	-0.0976^{***}	-0.0125	-0.0047^{***}	-0.0486^{***}
	(0.0048)	(0.0104)	(0.0012)	(0.0095)
GDP growth rate	0.0729^{***}	-0.0195	$0.0263^{\dagger}$	-0.0746
	(0.0182)	(0.0479)	(0.0136)	(0.0648)
Subprime crisis 0	2.0935^{***}	-3.4196^{***}	1.7430^{***}	0.0448
	(0.4315)	(0.9536)	(0.2489)	(1.4819)
Subprime crisis post 1	$-0.9678^{\dagger}$	-8.7962^{***}	-0.8978^{**}	-4.0979^{*}
	(0.5036)	(1.1902)	(0.3127)	(1.7992)
Subprime crisis post 2	-3.8431^{***}	5.6822^{***}	-2.7472^{***}	17.0615^{***}
	(0.3441)	(0.6476)	(0.1765)	(1.1236)
Subprime crisis post 3	-3.2808^{***}	$-1.6253^{\dagger}$	-0.6189^{*}	7.9593^{***}
	(0.3958)	(0.8757)	(0.2407)	(1.3890)
Subprime crisis post 4	1.6894^{***}	-0.6147	0.2743	6.0096^{***}
	(0.3539)	(0.6614)	(0.2033)	(1.1788)
Subprime crisis post 5	1.4122^{**}	-0.5296	$-0.5627^{\dagger}$	4.4700^{**}
	(0.4714)	(1.0097)	(0.3206)	(1.5484)
Bank credit $\times$ subprime crisis 0	-0.0316^{***}	0.0667^{***}	-0.0147^{***}	0.0233
	(0.0078)	(0.0134)	(0.0020)	(0.0230)
Bank credit $\times$ subprime crisis post 1	-0.0320^{***}	0.0921^{***}	-0.0257^{***}	-0.0514^{*}
	(0.0075)	(0.0141)	(0.0019)	(0.0237)
Bank credit $\times$ subprime crisis post 2	0.0229^{**}	-0.1421^{***}	-0.0240^{***}	0.0239
	(0.0072)	(0.0125)	(0.0022)	(0.0245)
Bank credit $\times$ subprime crisis post 3	0.0773^{***}	-0.0553^{***}	-0.0024	-0.0010
	(0.0069)	(0.0120)	(0.0025)	(0.0249)
Bank credit $\times$ subprime crisis post 4	-0.0037	-0.0242^{*}	-0.0136^{***}	-0.0130
	(0.0068)	(0.0102)	(0.0026)	(0.0246)
Bank credit $\times$ subprime crisis post 5	-0.0333^{***}	0.0046	$-0.0048^{\dagger}$	0.0621^{**}
	(0.0068)	(0.0108)	(0.0028)	(0.0233)
Chow test	66.0914^{***}	32.9194^{***}	95.0740^{***}	50.1487^{***}
Hausman test	331.4898^{***}	115.2357^{***}	141.8263^{***}	332.5333^{***}
Adjusted R^2	0.7220	0.4453	0.7732	0.4999
Number of firms	707	707	707	707
Number of observations	38178	38178	38178	38178

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\dagger}p < 0.1$

Notes: Independent variables except for firm age and GDP growth rate are one-period lagged. Standard errors clustered by time are reported in parentheses. Firm fixed effects and seasonal dummies are included. Subprime crisis 0 is a dummy variable with a value equal to one for the outbreak of the 2008-09 subprime mortgage crisis, in the third quarter of 2008. Subprime crisis post 1 to post 5 refer to five post periods of the 2008-09 subprime mortgage crisis, starting from the fourth quarter of 2008 until the fourth quarter of 2009.

Table 7: Time-varying effects of financial crises on trade credit

Variable	Accounts payable		Accounts receivable	
	volume	length	volume	length
	(1)	(2)	(3)	(4)
Bank credit	-0.2635^{***}	-0.1774^{***}	0.0251^{***}	0.1882^{***}
	(0.0097)	(0.0160)	(0.0041)	(0.0097)
Firm size	-3.0381^{***}	-2.7389^{**}	0.2123^{*}	10.5651^{***}
	(0.2385)	(0.9600)	(0.1056)	(0.2385)
Firm age	0.2287^{***}	$0.1956^{\dagger}$	-0.2896^{***}	-1.1630^{***}
	(0.0379)	(0.1079)	(0.0261)	(0.0379)
Return on sales	0.0418^{***}	-0.3955^{***}	0.0353^{***}	-0.3139^{***}
	(0.0046)	(0.0510)	(0.0029)	(0.0046)
Asset turnover	0.0862^{***}	-0.0972^{***}	0.0828^{***}	-0.1747^{***}
	(0.0031)	(0.0093)	(0.0022)	(0.0031)
Inventory turnover	$0.0054^{\dagger}$	$-0.0210^{\dagger}$	0.0004	-0.0095^{***}
	(0.0029)	(0.0120)	(0.0017)	(0.0029)
Long-term debt to equity	-0.0974^{***}	-0.0128	-0.0044^{***}	-0.0504^{***}
	(0.0047)	(0.0104)	(0.0012)	(0.0047)
GDP growth rate	0.0843^{***}	0.0327	0.0296^{*}	0.0003
	(0.0208)	(0.0579)	(0.0142)	(0.0208)
Dot-com bubble 0	-1.1296^{***}	6.8673^{***}	-1.2099^{***}	11.5433^{***}
	(0.3411)	(1.1679)	(0.1806)	(0.3411)
Dot-com bubble post 1	-1.7696^{***}	2.8441^{*}	-1.3232^{***}	8.4750^{***}
	(0.4390)	(1.3764)	(0.2363)	(0.4390)
Dot-com bubble post 2	-0.3695	0.9058	-0.6037^{**}	8.0033^{***}
	(0.3926)	(1.2701)	(0.2001)	(0.3926)
Dot-com bubble post 3	-2.5488^{***}	-2.5592^{*}	-1.6058^{***}	5.9479^{***}
	(0.3796)	(1.1654)	(0.2382)	(0.3796)
Dot-com bubble post 4	0.3027	-3.0136^{**}	-0.8493^{***}	4.9821^{***}
	(0.3144)	(0.9959)	(0.1470)	(0.3144)
Dot-com bubble post 5	-1.7077^{***}	-3.1722^{**}	-1.0175^{***}	2.5081^{***}
	(0.3460)	(1.0152)	(0.2186)	(0.3460)
Subprime crisis 0	2.2262^{***}	-2.5261^{*}	1.7511^{***}	1.6285^{***}
	(0.4721)	(1.0906)	(0.2517)	(0.4721)
Subprime crisis post 1	-0.7721	-7.6379^{***}	-0.8667^{**}	-2.1710^{***}
	(0.5546)	(1.3838)	(0.3167)	(0.5546)
Subprime crisis post 2	-3.8030^{***}	6.0992^{***}	-2.7576^{***}	17.8926^{***}
	(0.3567)	(0.6927)	(0.1712)	(0.3567)
Subprime crisis post 3	-3.4634^{***}	-2.2640^{*}	-0.6916^{**}	7.2759^{***}
	(0.4148)	(0.9418)	(0.2493)	(0.4148)
Subprime crisis post 4	1.5587^{***}	-1.0357	0.2212	5.5998^{***}
	(0.3636)	(0.6882)	(0.2071)	(0.3636)
Subprime crisis post 5	1.1680^{*}	-1.5042	$-0.6439^{\dagger}$	3.2180^{***}
	(0.5078)	(1.1554)	(0.3328)	(0.5078)

(continued to next page)

Table 7: (continued)

Variable	Accounts payable		Accounts receivable	
	volume (1)	length (2)	volume (3)	length (4)
Bank credit × dot-com bubble 0	0.0278***	−0.0721***	0.0021	−0.0617***
	(0.0067)	(0.0141)	(0.0036)	(0.0067)
Bank credit × dot-com bubble post 1	0.0629***	−0.0179	0.0347***	−0.0702***
	(0.0074)	(0.0130)	(0.0036)	(0.0074)
Bank credit × dot-com bubble post 2	0.0206**	0.0233†	0.0233***	−0.0478***
	(0.0075)	(0.0138)	(0.0031)	(0.0075)
Bank credit × dot-com bubble post 3	0.0360***	0.0684***	0.0153***	−0.0683***
	(0.0076)	(0.0144)	(0.0028)	(0.0076)
Bank credit × dot-com bubble post 4	0.0099	0.0662***	0.0172***	−0.0287***
	(0.0079)	(0.0140)	(0.0028)	(0.0079)
Bank credit × dot-com bubble post 5	0.0353***	0.0559***	0.0196***	−0.0994***
	(0.0068)	(0.0130)	(0.0031)	(0.0068)
Bank credit × subprime crisis 0	−0.0285***	0.0691***	−0.0129***	0.0176*
	(0.0078)	(0.0136)	(0.0021)	(0.0078)
Bank credit × subprime crisis post 1	−0.0289***	0.0946***	−0.0239***	−0.0570***
	(0.0076)	(0.0142)	(0.0021)	(0.0076)
Bank credit × subprime crisis post 2	0.0260***	−0.1397***	−0.0222***	0.0184*
	(0.0073)	(0.0127)	(0.0024)	(0.0073)
Bank credit × subprime crisis post 3	0.0804***	−0.0530***	−0.0007	−0.0060
	(0.0071)	(0.0125)	(0.0027)	(0.0071)
Bank credit × subprime crisis post 4	−0.0006	−0.0218*	−0.0119***	−0.0183**
	(0.0069)	(0.0106)	(0.0028)	(0.0069)
Bank credit × subprime crisis post 5	−0.0302***	0.0069	−0.0031	0.0571***
	(0.0068)	(0.0110)	(0.0029)	(0.0068)
Chow test	65.9792***	32.9137***	95.3762***	40.5064***
Hausman test	293.1526***	116.9294***	152.2700***	330.3446***
Adjusted R^2	0.7221	0.4455	0.7735	0.5010
Number of firms	707	707	707	707
Number of observations	38178	38178	38178	38178

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\dagger}p < 0.1$

Notes: Independent variables except for firm age and GDP growth rate are one-period lagged. Standard errors clustered by time are reported in parentheses. Firm fixed effects and seasonal dummies are included. Dot-com bubble 0 is a dummy variable with a value equal to one for the outbreak of dot-com bubble, in the first quarter of 2001. Dot-com bubble post 1 to post 5 refer to five post periods of the 2000-01 dot-com bubble, starting from the second quarter of 2001 until the second quarter of 2002. Subprime crisis 0 is a dummy variable with a value equal to one for the outbreak of the 2008-09 subprime mortgage crisis, in the third quarter of 2008. Subprime crisis post 1 to post 5 refer to five post periods of the 2008-09 subprime mortgage crisis, starting from the fourth quarter of 2008 until the fourth quarter of 2009.

5 Conclusion

This paper studies the time-varying responses of trade credit during the two types of financial crises that accompanied different patterns of recession and recoveries, the 2000-01 dot-com bubble and 2008-09 subprime mortgage crisis, on the Taiwan economy. Motivated by the co-existence of arguments in the literature on the role of trade credit when the economy face a liquidity shock, we investigate whether the trade credit can mitigate the impact of a financial crisis as firms provide trade credit to their financially constrained customers, or exacerbate the impact of the crisis by propagating liquidity shocks through the supply chains by examining the extent of the dynamic effects of the financial crisis on trade credit and the relationship between trade credit and bank credit. Using 38,885 observations for 707 Taiwan manufacturing firms from the first quarter of 1999 to the third quarter of 2012, we find that firms acts as customers use trade credit as a substitute for bank credit and firms acts as suppliers who have better access in bank credit provide trade credit to their customers. Small firms are more likely to use trade credit and large firms are tend to offer trade credit to their customers. We also find that trade credit has mitigated the impact of the 2008-09 subprime mortgage crisis on the Taiwan economy, while the trade credit has amplified the impact of the 2000-01 dot-com bubble by propagating liquidity shocks through the supply chains. These results are due to the different magnitudes of the demand for trade credit during the two financial crises. We observe the strong substitution effects between the amount of accounts payable and bank credit at the beginning and at the end of the 2008-09 subprime mortgage crisis, which reflects the strong demand for trade credit. This paper complements the existing literature on the role of trade credit during a financial crisis along several dimension. First, we compare the impacts of the 2000-01 dot-com bubble and the 2008-09 subprime mortgage crisis on trade credit, and find that there exist different reactions of trade credit between two financial crises which had different shapes of recessions and recoveries. Second, many studies in the literature only involve

the accounts payable as a proxy of trade credit, but we observe the asymmetric behaviors among firms as suppliers and customers by applying both the accounts payable and accounts receivable as proxies of trade credit. Thus, it is necessary to investigate the provision of trade credit during the financial crisis, especially for the largest publicly-traded firms that are more likely to act as the providers of trade credit. Third, we shed some lights on the impacts of the two financial crises on the credit period of trade credit, and observe a asymmetric reaction on the credit period, in which the amount of trade credit decline but the time of credit period of trade credit are lengthen in some period, by studying both the amount and length of trade credit. Fourth, we apply a relatively large data set of Taiwanese firms containing 38,885 observations to those of other studies in the literature. Finally, and most importantly, we find that the time-varying responses of trade credit in the 2008-09 subprime mortgage crisis have a dynamic pattern, while the response are monotonic in the 2000-01 dot-com bubble.

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