

Credit Market Shocks and Firm Behavior towards Liquidity Needs

March 2011

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JEL: G14, E0, F0

Key words: Balance sheet effects, trade credit, differentiated products, financial system efficiency

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Abstract This paper provides an empirical analysis showing that the type of credit market shocks and the nature of market institutions are important in understanding the firm behavior towards liquidity needs. Firms are less exposed to the liquidity premium shock when the industry-specific investment of supplier-customer relationship is large because the industry internalizes better the balance sheet externality in its supply chain. Firms are more exposed to the flight to quality shock when the financial system is inefficient because the channeling of funds functions even poorer during financial panic. The paper offers international firm-level panel data and aggregate time-series evidence in support of these conjectures.

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1. Introduction

This study provides new evidence on the behavior of firm towards liquidity needs, a comparison of firms across industries and countries, and the importance of credit market shocks. Our objective is to inform the real effects of credit market condition on the firm behavior, based on systematically compiled micro-level data, and accounting for the influence of industry-specific and country-level factors. We conjecture that (a) firms are less exposed to the liquidity premium shock when the industry-specific investment of supplier-customer relationship is large because the industry internalizes better the balance sheet externality in its supply chain; (b) firms are more exposed to the flight to quality shock when the financial system is inefficient because the channeling of funds functions even poorer during financial panic.

Our sample focuses on the years 2001-2010, a tail end of the Great Moderation in macroeconomic volatility and financial risks. Using a large firm-level information, this investigation adds to a growing literature on the funding illiquidity and economic fluctuations in a context of the 2007-09 global crisis experience. Given the study period, our sample is timely and comprehensive with respect to the tranquility (2001-06) and the ensuing credit crunch. Studies thus far show that the 2007-09 crisis has caused a widespread corporate adjustment in various markets and settings. These include, for instance, that the crisis accounts for a significant proportion of the decline in equity prices worldwide and the stock markets priced severely on firms highly dependent on external finance for the working capital [(Calomiris, Love and Peria (2010)); (Tong and Wei (forthcoming))¹]; that on average the credit-constrained firms drew heavily on cash and lines of credit (Campello, Graham and Harvey (2010))²; and that several large and investment-grade non-financial firms hoarded more cash after the fall of Lehman (Kahle and Stulz (2010))³. By and large, these findings point broadly to the effects of an abrupt change in credit market condition, the importance of working capital needs, and the

¹ Calomiris et al. cover 17,000 firms in 44 countries; Tong and Wei study 3,823 manufacturing firms in 24 emerging countries.

² Campello et al. conducted a survey-based measure of financial constraint from a sample of 1,050 chief financial officers (CFOs) in the U.S., Europe, and Asia.

³ Kahle and Stulz study 3,198 U.S. firms.

contingent firm responses, in determining the economic exposure of firms to the 2007-09 global financial crisis.

Our point of departure is to delve into both the real and financial details, by recognizing that the firm behavior towards liquidity needs is determined not only by the credit market condition, but also by the financial system efficiency and the nature of credit provision up and down the supply chain - - the real and financial effects of credit crunch are propagated through the components of working capital, the function that they carry out, and the relationship of input suppliers, the firm, and its customers. Grounded with this insight, we examine in details the relevant financial obligations and interconnected balance sheet variables. Using the measures of credit market shocks and the 2007-09 global crisis experience, we show that a combined knowledge of balance sheet and production structure can provide a useful basis for understanding the dynamics of corporate responses to credit market conditions. Our findings also highlight the similarities and the differences across industries and countries that have emerged from the analysis.

We summarize in Section 2 related theories and empirics. While there are a number of real and financial variables that may transmit economic shocks to the firm behavior, we focus on the balance sheet channel and the credit market shocks. Our study is built on a well-researched literature on balance sheet contagion in the supply chain [e.g. (Kiyotaki and Moore (1997))], and our empirical interests can be related to a vast literature on financial dependence, financial development, and economic growth [e.g. (Fisman and Love (2003))]. We are particularly interested in understanding the channels that credit market shocks are propagated through the firm behavior towards liquidity needs, in different industries and countries. This section also addresses some shortcomings of the available firm-level data sets and drawbacks of the typical estimation technique, which motivate us to devise a causal relation approach in order to sort the dynamic and recursive patterns of firm behavior in the data.

Section 3 describes the data and variable construction. The sample comprises firm-level information of the balance sheet variables at quarterly frequency, covering a large number of industries and countries. We explain several reasons for our industry and country classification, and their limitations. The main variables of interests are trade

receivables, trade payables, inventories, and short-term debt. Our interest in trade receivables, trade payables, and short-term debt is underlined by their role during the emerging market crises of the 1990s (Love, Preve and Sarria-Allende (2007)). Our interest in inventories is driven by the tradeoffs between trade payables and inventories (Bougheas, Mateut and Mizen (2009)). The choice of these variables is also based on the financial accounting consideration: inventories plus trade receivables minus trade payables is the net working capital, which, essentially, reflects the firm's liquidity needs. We also describe the two types of the credit market shocks: liquidity premium shock and flight to quality shock, as well as their evolution over time. Both are related to the TED spread; the former is calculated from the LIBOR term spread and the latter as the gap between the Fed funds target and the yield on 3-month T-Bill.

Section 4 reports the econometric analysis. Using the firm-level data, our panel estimates suggest that following the credit market shocks, firms decrease both trade receivables and trade payables, while inventories and short-term debt are piled up. Industries with higher contract intensity of supplier-customer relationship are associated with higher use of trade receivables and trade payables, as well as more holdings of inventories and short-term debt -- following the credit market shocks, these associations are strengthened for trade receivables and trade payables. Emerging markets firms are associated with higher trade receivables, but lower trade payables, inventories and short-term debt -- the effects of credit market shocks on these associations appear inconclusive. We argue that our reduced form panel estimation technique, like other studies in this vein, is subject to the identification problem. The credit market shocks may influence the firm behavior via the liquidity demand channel, the liquidity supply, or both, plus other common factors. To systematically sort the possible dynamics of the firm behavior over time, we construct the industry aggregate and the country aggregate firm series. Using the in-sample causal orderings derived from unrestricted vector autoregressions, we enter the filtered aggregate balance sheet series into the recursive time-series system and study their structural impulse responses to the credit market shocks.

The structural estimates are supportive to the panel estimation evidence in many cases, but differ in some important aspects. We find that trade receivables, trade payables,

inventories and short-term debt of the high contract industries firms are less responsive, and actually increase, on the credit market shocks; whereas for the low contract industries firms, these same variables are volatile to the negative impact of the liquidity premium shock. We also find that trade receivables, trade payables, inventories and short-term debt of the emerging markets firms are more responsive to the negative effect of the credit shocks, and, intriguingly, trade receivables and short-term debt increase after the flight to quality shock. The panel results, the structural estimates and the in-sample causal orderings suggest that following the credit market shocks, (i) trade payables appear to be influenced mainly by inventories, while the short-term debt is driven by the operating cash flows; (ii) the effects of flight to quality shock tend to be larger than the effects of liquidity premium shock on the dynamic adjustment of firm behavior towards liquidity needs. Conclusion is in Section 5.

2. Background

This section describes how the interaction between credit market shocks and liquidity needs may influence the firm behavior. In the present context, 'liquidity needs' refers to the corporate financing demand that could arise due to either the nature of firm operation or the inefficiency of financial system. After discussing related theoretical and empirical studies, we outline some possible implications and a priori expectations on the behavior of firm across industries and countries. We then explain our empirical approach to untangle the effects of credit market shocks and causal relations among relevant balance sheet variables in the firm-level data.

There are at least three ways of projecting credit market shocks onto the firm behavior and liquidity needs. The first is the redistribution view of interfirm credit [i.e. (Petersen and Rajan (1997)); (Nilsen (2002))]. During the strain in credit markets, bank finance, short-term debt and commercial papers may become more difficult for the firm to tap on. According to the redistribution view, firms with a relatively better credit position have a greater incentive to offer interfirm credit, specifically trade receivables, to meet the liquidity needs of their customers. Similarly, firms suffering financial illiquidity are more likely to ask for more trade payables from their suppliers. Evidence of the small and large

U.S. firms during monetary contractions (Nilsen (2002)); recent experiences of firms in the emerging market crises of the 1990s (Love, Preve and Sarria-Allende (2007))⁴; and international co-movement of equity returns influenced by trade credit links (Albuquerque, Ramadorai and Watugala (forthcoming)), are in supportive of this view.

The second is the balance sheet contagion view [i.e. (Bernanke and Gertler (1989)); (Kiyotaki and Moore (1997))]. According to this view, the credit market shocks have both direct and indirect effects on the firm's liquidity needs. The credit market shocks can directly affect the liquidity needs through the disordering of interconnected financial obligations across firms, in particular between the upstream firms and the downstream firms in the supply chain. Indirectly, the credit market strains can deteriorate the financial capacity and collateral values of asset prices, which in turn negatively affect the balance sheet. The empirical evidence offered along this line include the asymmetric effects of monetary policy on small versus large firms in the U.S. (Gertler and Gilchrist (1994)); the effect of inter-locking loans on the business cycles in the U.S. and Japan (Kiyotaki and Moore (2002)); the output correlation amplified by the use of trade credit in the supply chain (Raddatz (2010)); and the cross prediction of equity returns among the economically related supplier and customer industries (Menzly and Ozbas (2010)).

The third view is related to the linkages between inventory holdings and interfirm credit. Typically, inventories are purchased on open account and financed partially or entirely by trade payables. As a result, inventory policy and trade payable decision are interrelated, and required simultaneous planning from the firm [e.g. (Haley and Higgins (1973)); (Bougheas, Mateut and Mizen (2009))]. Further, within the supply chain, inventory decisions of a downstream firm can impose informational externality on its upstream firm (Lee, Padmanabhan and Whang (2004)), which can be resolved by the upstream firm optimally extending trade receivables to the downstream (Daripa and Nilsen (2011)). Some empirical evidence on a positive relationship between trade payables and inventory holdings is consistent with this view (Fisman (2001)).

In the context of credit market shocks and firm's liquidity needs, the implications of these three views are overlapping and complementary to each other. More important, the

⁴ Love et al. conduct a panel analysis on six emerging market countries.

intersection of these views imposes the empirical challenge as it suggests that the credit market shocks can have confounding effects on trade receivables, trade payables, inventories and short-term debt. For instance, depending on the efficiency of financial system and contractibility, trade payables and short-term debt can be either complements or substitutes (Burkart and Ellingsen (2004)). Generally, the implicit interest rates of trade payables are higher than the interest rates of the short-term debt. The interest differentials may be justified by insurance and default premiums that tend to be amplified whenever suppliers face a relatively high cost of funds (Cunat (2007)) -- which is more likely the case with credit market shocks. At the same time, the credit market shocks may also influence the firm's inventory holdings, more heavily on the liquidity-constrained firms without immediate access to the credit market (Kashyap, Lamont and Stein (1994)). Motivated by these perplexing implications, we attempt to approach the data and relevant information in the most appropriate way possible.

Because most of the firm-level data sets, including the one that we use, do not contain much details on the input-out information and the credit market accessibility, our approach is to untangle firm responses to the credit market shocks by accounting for the important industry and country factors. Two considerations are in order. At the industry level, the use of interfirm credit is dependent on product-market competition and type of products (Burkart, Giannetti and Ellingsen (forthcoming)), as well as industry-specific nature of operation, i.e. inventory management, relationship specificity, product quality, and supplier-customer credit worthiness (Ng, Smith and Smith (1999)). These industry-specific factors may explain the extent that some firms tend to be more responsive to the credit market shocks, adjusting intensively their trade receivables, trade payables, inventories, and short-term debt. At the country level, credit market access and the use of interfirm credit tend to be easier for incorporated firms and firms operating in well-developed financial and legal institutions (Demirguc-Kunt, Love and Maksimovic (2006)). Further, industries with higher dependence on external finance, particularly the trade payables, exhibit higher rates of growth in countries with less efficient financial institutions (Fisman and Love (2003)).

In our firm-level data, rather than resorting to the scattered firm's input-output, and credit access or rating information, we gauge (a) the importance of input-output structure from the industry-specific contract intensity of supplier-customer relationship; and (b) the influence of financial market inefficiency by comparing the evidence of emerging markets firms versus advanced economies firms. In addition, the approach in all studies to date implicitly impose some sort of reduced-form restrictions on the data, which makes it inflexible in handling the concomitants and confounding factors mentioned above. Instead, we allow here for differences of the coefficients across industries and countries, and address the potential reverse causality and feedbacks between the interconnected balance sheet variables.

3. Sample

We construct the sample from several sources. The balance sheet variables are obtained from the *Compustat Fundamental Quarterly* (CFQ). These real and financial time series are reported quarterly at the firm level from 1994:Q4 to 2010:Q4. From the CFQ series, we construct the variables of interests: Trade Receivables/Total Sales (*trectos*), Trade Payables/Cost of Goods Sold (*tpaytoc*), Inventories/Cost of Goods Sold (*invtoc*), Short-Term Debt/Total Assets (*stdtoa*), Cash Stock/Total Assets (*cashta*), Sales Growth (*growth*) and Operating Cash Flows/Total Assets (*cfwtoa*). After this variable construction, we restrict the sample to 2001:Q3 to 2010Q3 as this period provides the core set of observations, covering 2,437 to 10,033 firms quarterly, for 334 NAICS 4-digit industries in 93 countries.⁵

The advantages of the CFQ sample include (i) real and financial information at quarterly frequency at length and (ii) large country and industry coverage. These allow us to make a comparison of firm response to liquidity needs and credit market shocks at a relatively high frequency for a large number of industries and countries. Other firm panel data sets previously studied are either restricted to a smaller number of countries, or constrained to annual frequency data, and therefore cannot capture the quantitative

⁵ Appendix A.1 provides sample coverage of firms, countries, and industries; A.2 reports the histograms of quarterly firm observations in the sample.

significance of the aggregate credit market shocks on the firm behavior as we intend. Two limitations with the CFQ data are in order. First, the CFQ data include only listed firms, without credit accessibility and rating details. Second, the CFQ data has no information on the multinational/affiliate status, as well as the domestic/export market sources of firm revenue. These two considerations affect our assessment of firm behavior considerably since the credit market access, the reliance on different kinds of credit, and the inventory policy tend to vary with the credit worthiness, nature of firm operation and business environment. However, we are unaware of any international firm-level data sets at high frequency that may provide all of these information.

To answer our research questions and address these shortcomings in the data set, we aggregate firms into two groupings. In the first grouping, firms are classified into 'high contract intensity industries' versus 'low contract intensity industries.' We use the industry-specific measure of contract intensity of supplier-customer relationship.⁶ This measure is due to the differentiated product classification (Rauch (1999)) and the proportion of an industry's inputs (weighted by value) that require relationship-specific investments, i.e. differentiated products, in the production (Nunn (2007)).⁷ In the second grouping, we separate firms into two groups, 'emerging markets' versus 'advanced economies,' based on their localities according to the World Bank's country classification -- firms in high-income countries (OECD and non OECD) are classified as the advanced economies firms.⁸ Together, these industry-specific contract intensity and country-income classification groupings provide a reasonable proxy to the financial system efficiency and

⁶ The relationship-specific investment, and the resultant interconnected financial obligations, may also be viewed as a trade cost between the firm and its supplier.

⁷ One half (.498) of the sample is classified as the high contract industries firms, with a cutoff at .36. The contract intensity measure (Nunn (2007)) is constructed at 6-digit NAICS. We average this measure into 4-digit NAICS (CFQ industry level) and assign it according to the industries of firms in our sample. For some industries not being classified at the 4-digit NAICS, we assign the mean of 2-digit NAICS; for the rest, mostly services-related industries, we assign the lowest value of contract intensity (.024).

⁸ The emerging markets firms make up 36 percent of the observations in the sample. There are some overlapping between the industry grouping and the country grouping: 37 percent of low contract industries firms is emerging markets firms, and 65 percent of high contract industries firms is advanced economies firms.

the nature of operation for our firms across industries and countries, consistent with the theoretical and empirical background discussed in Section 2.

[TABLE 1]

Summary statistics in Table 1 suggest that our two groupings of the firms are in line with the industry-level nature of operation and the country-level financial system efficiency. For the balance sheet variables of interests, the table reports their weighted (by lagged sales, in USD) average of the quarterly firm observations across industries and countries, from 2001q3 to 2010q3. The first two columns present the firm characteristics of the low contract industries firms versus the high contract industries firms. In the sample, a proportion of industry's inputs that require relationship-specific investments of supplier-customer in the production for the high (low) contract group is, on average, 0.63 (0.10). Table 1 suggests that the high contract industries firms rely more on trade receivables and trade payables, hold larger inventories, carry more short-term debt and cash, with a higher rate of sales growth, though with similar level operating cash flows, relative to the low contract industries firms. The next two columns present the firm characteristics for the advanced economies versus the emerging markets. On average, the emerging markets firms in our sample use proportionately (with respect to lagged sales) less trade receivables and trade payables, have smaller inventories, hold more cash, grow faster, and with larger level of operating cash flows. Nonetheless, these are simply the average firm characteristics. It is testable whether these average differences of firms across industries and countries may translate into differences of the firm behavior towards liquidity needs and the credit market shocks. We pursue this in the next section.

4. Findings

We are interested in the dynamics of four balance sheet variables: trade receivables/sales, trade payables/costs, inventories/costs, and short-term debt/assets. Together with the background in Section 2, we argue that these variables capture the firm behavior towards liquidity needs. Also, in the financial accounting, the firm's net working capital is made of these first three variables, while the fourth reflects the firm's short-term intermediary finance and, if too large, financial vulnerability. In the formal regression analysis, we focus

on these four variables, together with three interrelated balance sheet variables -- cash stock/assets, sales growth, and operating cash flows/assets. Finally, the responses of these variables to credit market shocks are assessed using several empirical techniques. The analysis proceeds in three stages. First, we provide a descriptive analysis of these variables. Second, we use the firm-level data and panel estimation to obtain, as a first pass, the reaction of firms to credit market shocks. As the panel regression of the dependent on the set of explanatory variables imposes a priori reduced form constraint and does not allow for possible feedbacks among the variables, we explore next the causal relations of the aggregate balance sheet series to untangle the dynamic firm responses to credit market shocks in a recursive system. Finally, we provide the best-case scenario of the empirical association between credit market shocks, liquidity needs, and the firm behavior, using structural estimation with the in-sample causal orderings.

4.1 *Descriptive analysis of liquidity needs*

To gain some perspectives on the macro view of firm behavior, we construct the aggregate time series of trade receivables, trade payables, inventories, and short-term debt, for each of the firm groupings described in Section 3. To obtain the aggregate quarterly series, the firm-level observations are weighted by lagged sales and averaged quarter by quarter.⁹ We then de-seasonalize and smooth the aggregate quarterly series by a moving average using four lagged terms, three forward terms, and the current observation in the filter. The procedure is accounting for seasonal pattern, serial correlation and forward-looking nature of the financial variables. Figure 1 provides the plots of these aggregate series for trade receivables, trade payables, inventories, and short-term debt, with all in the same vertical scale and a vertical line marking 2007q3, the onset of the 2007-09 global financial crisis. Appendix B provides additional plots for cash stock, sales growth, and operating cash flows over the same time frame.

[FIGURE 1]

⁹ As the raw CFQ series are reported in local currency, we convert the sales variable into US dollars using the quarterly official exchange rates from the IMF's *International Financial Statistics*.

The top panel of Figure 1 shows the relative growth rates of the variables from their 2007q3 values, for the high contract industries firms (solid lines) and the low contract industries firms (dash lines). Trade receivables and trade payables of the high contract industries firms increased after 2007q3 relative to the low contract industries firms. Inventory growth of the high contract industries firms increased for a few quarters then fell, while there was not much difference in the growth of short-term debt between the two groups. Post 2007q3, a notable difference is the relative adjustment of interfirm credit and inventories of the high contract industries firms versus the low contract industries firms.

The bottom panel shows the relative growth rates from 2007q3 values of the same variables for the advanced economies firms versus the emerging markets firms. Trade receivables of the emerging markets firms increased sharply relative to the advanced economies firms after 2007q3. There was not much discernible difference in the patterns of trade payables and inventories between the two groups. Similar to the pattern of trade receivables, the difference of short-term debt growth between the two groups was distinctive. The short-term debt of the emerging markets firms increased sharply relative to the advanced economies firms, and remained steady through 2010q3.

To summarize, the descriptive time series analysis suggests that post 2007q3, trade receivables and trade payables of the high contract industries firms increased relative to the low contract industries firms. At the same time, trade receivables and short-term debt of the emerging markets firms increased relative to the advanced economies firms. As the post 2007q3 period was characterized by the high volatility in the credit markets, we examine the evolution of credit market shocks pre and post this period in the next section.

4.2 *Credit market shocks*

[FIGURE 2]

We study two measures of credit market shocks. Both are frequently followed, used to quantify the credit market condition, and associated with the TED spread (the 3-month LIBOR – the 3-month Treasury Bill). Figure 2 provides the time series of the overnight LIBOR (USD) – the 3-month LIBOR (USD) on vertical bars, and the Fed Funds Target – the

3-month US Treasury Bill as connected line, from 2001q1 to 2011q1.¹⁰ The former reflects 'liquidity premium' shock and the latter 'flight to quality' shock (Hamilton (2008)).

Dickey-Fuller test and Phillips-Perron test both reject the null of unit root for these two series. As shown, the variables are anything, but stable. Notable is the early part of the 2007-09 crisis that was filled with the flight to quality shock, increased sharply in 2007q3 and peaked at 2008q1. In the mid of 2008, around the fall of Lehman, the liquidity premium shock took over the stage. Both series subsequently fell and fluctuated around their prevailing levels before 2005. We examine shortly the effects of these credit market shocks on the liquidity needs and firm behavior. We shall also analyze whether firms in different industries (i.e. high contract versus low contract intensity) and countries (i.e. emerging markets versus advanced economies) react differently to these credit market shocks.

4.3 The firm-level response to credit market shocks

Projecting the firm-level data onto the measures of credit market shocks, this section provides a second piece of evidence based on the firm-level panel regressions. Trade receivables, trade payables, inventories and short-term debt continue being the variables of interests. We repeat the panel estimation exercise on each of these variables using the same set of controls. The objective is to identify here the effects of credit market shocks on the firm behavior towards liquidity needs, in the simplest possible approach. The controlling variables include the two measures of credit market shocks – liquidity premium shock and flight to quality shock; emerging markets indicator; industry-specific contract intensity of supplier-customer relationship; cash stock/total assets; sales growth; operating cash flow/total assets; post 2007q3 dummy and time trend; and quarterly and country fixed effects. The estimation period is 2004q2 to 2010q3 -- a balanced sample around 2007q3. We include firms that appear at least 8 quarters in the period before 2007q3 and at least 8 quarters the period on and after 2007q3. The estimating model is specified as

¹⁰ The series are compiled from the Datastream.

$$Y_{ijt} = \alpha_i + \gamma_j + \eta_t + \beta X_{ijt} + \varepsilon_{it}$$

where i denotes firm, j country, and t quarterly period; Y is one of the four dependent variables, including trade receivables/total sales, trade payables/total cost of goods sold, inventories/cost of goods sold, and short-term debt/total assets; α is the firm-specific effects; γ country fixed effects; η quarterly fixed effects; X is the set of controls, and ε is the error term. The dependent variables, the industry-specific contract intensity variable, the lagged (four-quarter mean) values of cash stock, sales growth, and operating cash flow variable all enter the regression in natural log. We use Newey-West estimation, allowing the error structure to be heteroskedastic at firm level and autocorrelated up to 4 lags.

[TABLE 2]

Table 2 reports the estimation results. We find that the liquidity premium shock and the flight to quality shock are both negatively associated with the adjustment of trade receivables and trade payables, while the shocks are positively associated with inventories and short-term debt. This suggests that the credit market shocks, be they liquidity premium or flight to quality type, weaken the interfirm credit channel and cause the piling up of inventories and short-term debt. The effects of flight to quality shock tend to be larger than the effects of liquidity premium shock. Firms in emerging markets are associated with higher trade receivables, but lower trade payables, inventories, and short-term debt than the advanced economies firms. The coefficients of the interaction between the credit market shocks and the emerging markets indicator (rows 5 and 6) suggest that following the liquidity premium shock, the emerging markets firms increase the reliance on trade payables relative to the advanced economies firms. On the other hand, following the flight to quality shock, the emerging markets firms decrease the reliance on trade payables relative to the advanced economies firms. The effects of credit market shocks on liquidity needs appear inconclusive for the emerging markets firms versus advanced economies firms in the firm-level data panel estimation.

The coefficients on the industry-specific contract intensity (row 4) suggest that this variable is positively associated trade receivables, trade payables, inventories, and short-term debt. For trade receivables and trade payables, this association are strengthened in the strained credit market, as can be seen from the interaction between the contract

intensity variable and both types of the credit market shocks (rows 7 and 8), but weakened for the short-term debt. This evidence is consistent with the redistribution view of interfirm credit. Facing the shortage of supply in credit markets, firms extend more trade receivables to their customers, and use more trade payables from their suppliers.¹¹ Following the credit market shocks, the importance of supplier credit is more pronounced for firms operating in the industries with a high degree of relationship-specific investment between supplier and customer. This evidence is also consistent with the balance sheet contagion view that the interfirm credit can influence the supply chain production.

The next five rows in Table 2 provide the evidence of preconditioning and interconnected balance sheet controls in the model. In our sample, firms with larger cash stock carry smaller inventories and short-term debt. High sale growth is associated with greater trade receivables, trade payables, and inventories, and lower short-term debt. All else equals, firms with more cash flow capacity tend to use less interfirm credit as well as short-term debt. We also find that, independent of the liquidity premium shock and the flight to quality shock, the period after 2007q3 is associated with a higher level of interfirm credit, consistent with descriptive evidence in the previous section. Further, the inventories and short-term debt tend to be lower post 2007q3, but the trend since has been positive for these two variables.

The firm-level panel estimation explains reasonably well the variables of interests, accounting for a quarter of variation in our sample of 62,241 quarter-firm observations. Nonetheless, the findings may have been confounded with the identification problem -- the preconditioning controls (i.e. cash stock, growth, operating cash flows) may simultaneously be influenced by the same common factors that affect the dependent variables. For instance, following the credit market shocks, sales may drop, which consequently increase the firm's liquidity needs (i.e. trade receivables, short-term debt, operating cash flows), that in turn influence the sales growth. Generally, these balance sheet characteristics, be they contemporaneous or lagged values, can be serially and fundamentally connected among

¹¹ The evidence of the emerging markets crises of the 1990s suggests that liquidity is redistributed via trade payables from financially stronger firms to weaker ones in the period during and following the financial crises (Love, Preve and Sarria-Allende (2007)).

each other, as well as affected by the credit market conditions. Because the firm-level panel regressions cannot address this identification problem directly, we proceed with the causality and structural estimates in the next section.

4.4 *Causal orderings in the aggregate firm behavior*

We now address the identification problem by analyzing the aggregate balance sheet time series in a system of equations. How can the causal relations between these interconnected balance sheet variables be untangled in dynamic economic systems? The above firm-level panel results are consistent with many possible causal structures. To gain further insights, we investigate the time series behavior of the aggregate firm series. As described in Section 4.1 (and illustrated in Figure 1), these time series are constructed for each variable from the firm-level series, weighted by lagged sales, de-seasonalized and smoothed by moving average of the lagged, contemporaneous and forward terms. To account for the relative importance of the financial system efficiency and the nature of industry operation on the firm behavior, we aggregate firms into the two groupings, high contract intensity firms versus low contract industries firms, and advanced economies firms versus emerging markets firms.

There have been many approaches to determining causal structure in multivariate time series settings. The first approach is to assume one—either through *a priori* restrictions applied to structural VARs or through the choice of a specific recursive ordering or Cholesky factorization. Once the investigator has chosen a causal structure, it is possible to derive impulse response function and variance decompositions, but ultimately these results are all based on the *a priori* assumptions that went into the choice of causal model. Other approaches rely on the time series themselves. Economists use granger causality (or ‘incremental predictability’) frequently. But it is well known that in inter-temporal models, Granger causality can give the incorrect answer to casual ordering. Since the firm behavior inferred from the balance sheet variables are, in part, forward looking, this method is not fitting with our task.

There is another method for indentifying the causal structure, which is based purely on the underlying data and is increasingly being used in the econometric literature. This is

the approach based on the insights of graph theory [i.e. (Pearl (2009)) and (Spirtes, Glymour and Scheines (2001))] and have been used in economic applications [e.g. (Granger and Swanson (1997)), (Demiralp, Hoover and Perez (2008)), and (Jinjarak and Sheffrin (2011))]. This approach restricts the class of models to recursive models, just as in the original VAR literature. It uses some results from graph theory to reduce the set of possible causal structures by examining correlations and conditional correlations in the data—in our empirical time-series framework, the residuals from unrestricted VARs of the aggregate balance sheet time series. While the restriction to recursive settings does limit the class of models that can be examined, this method can handle multiple time series in a straightforward manner.

To identify the causal orderings from conditional correlations in the aggregate series, we use the TETRAD search algorithm, developed by Spirtes, Glymour, and Scheines and maintained at Carnegie Mellon. The algorithm has the ability to search in the presence of unobserved common factors and linear feedbacks in the models. In econometric VAR applications, we first estimate the unrestricted VARs. Then, following the practice pioneered by Granger and Swanson (1997), we use the residuals from the unrestricted VARs to determine what causal structures are present in the data. Once we have identified a causal structure, then we can give a structural interpretation to the VAR through an appropriate transformation.

Our system of vector autoregression is made of seven balance sheet variables: 1) trade receivables/sales (trestos); 2) trade payables/costs (tpaytoc); 3) inventories/cost (invtoc); 4) short-term debt/assets (stdtoa); 5) cash stock/assets (cashta); 6) sales growth (growth); and 7) operating cash flow/asset (cfwtoa). Starting with a structural VAR representation:

$$A_0 Y_t = A(L)Y_{t-1} + E_t$$

where Y_t is an $n \times 1$ vector of the contemporaneous variables, A_0 is $n \times n$ matrix; $A(L)$ is a polynomial in the lag operator, L ; E_t is an $n \times 1$ vector of error terms. The SVAR yields the unrestricted VAR, or reduced form, that is observable in the data.

$$\begin{aligned}
Y_t &= A_0^{-1}A(L)Y_{t-1} + A_0^{-1}E_t \\
&= B(L)Y_{t-1} + U_t
\end{aligned}$$

The sample period is 2001q3-2010q3. We perform a number of lag-order selection tests. Given that there are 7 variables and 37 quarterly periods available, we keep the model parsimonious and use 2 lags, following the lag selection based on the final prediction error (FPE).

From the unrestricted VARs, the resultant covariance matrices of the estimated U_t are then entered into the TETRAD search algorithm. Based on these filtered series, the algorithm then links the structure of causal models to conditional independence relations among the variables. We repeat this empirical procedure for the 4 aggregate firm series: (a) high contract industries firms; (b) low contract industries firms; (c) emerging markets firms; and (d) advanced economies firms. Using $Y = [\text{trectos}, \text{tpaytoc}, \text{invtoc}, \text{stdtoa}, \text{cashta}, \text{growth}, \text{cfwtoa}]'$, the in-sample estimated causal orderings can be succinctly summarized in the matrix below:

$$A_0 = \begin{bmatrix}
1 & (a) & (a) & \cdot & \cdot & \cdot & \cdot \\
\cdot & 1 & (a,c) & \cdot & \cdot & (c) & \cdot \\
\cdot & (b,d) & 1 & \cdot & (b) & \cdot & \cdot \\
\cdot & \cdot & \cdot & 1 & (c) & \cdot & (a,c) \\
(c) & (c) & \cdot & (d) & 1 & \cdot & (b) \\
(a) & \cdot & \cdot & \cdot & \cdot & 1 & \cdot \\
\cdot & (d) & (d) & \cdot & \cdot & \cdot & 1
\end{bmatrix}$$

Note that we skip here the signs of causal orderings between these variables. Because this algorithmic causal search is based purely on the data, the signs need not be consistent with a priori expectations. The graph theoretic methods do not rely on the sign of correlations, just their presence. Thus, whether or not the signs of these conditional correlations are consistent with a priori theoretical expectations has nothing to do with the validity for this identification method. The conditional correlations among these variables, calculated for each of the aggregate balance sheet series, are reported in Appendix C.1. The estimated causal orderings are illustrated in Appendix C.2.

Coming back to the structural estimation, we can now develop the structural models by populating the A_0 matrices, with non-zero, off-diagonal entries corresponding to the appropriate casual chains. We then configure structural vector autoregressions based on these causal orderings. In the structural VARs, we feed in the two credit market shocks – the liquidity premium shock and the flight to quality shock. To illustrate the configuration: the populated A_0 matrix above gives the equation for trade payables/sales ($tpaytoc$; row 2 of A_0) for the emerging markets firms [group (c)] as the following

$$\begin{aligned} \Delta tpaytoc_t = & \sum_{s=1}^l b_{2,s} \Delta tpaytoc_{t-s} + \sum_{s=1}^l b_{3,s} \Delta invtoc_{t-s} + \sum_{s=1}^l b_{6,s} \Delta growth_{t-s} \\ & + \sum_{s=1}^l c_s LP_{t-s} + \sum_{s=1}^l d_s FQ_{t-s} + \varepsilon_t \end{aligned}$$

where LP is the liquidity premium shock and FQ the flight to quality shock. The equations for other variables are similarly constructed with respect to the matrix A_0 of each of the firm groupings. Now we have a system of 9 variables with 37 quarterly periods, l is set to 2 to allow for the largest degree of freedom (an appendix, available upon request, provides this exercise for other lag order specification). The structural impulse responses, calculated for a 50 basis point jump in the credit market shocks, are reported in Figures 3 and 4.

[FIGURE 3]

Figure 3 illustrates the impulse responses of the industry aggregate firm behavior for the high contract industries firms versus the low contract industries firms. The point estimates suggest that trade receivables of the high contract industries firms increase, whereas trade receivables of the low contract industries firms fall, after the flight to liquidity shock. For liquidity premium shock, trade receivables of both industries increase. Trade payables follow the same pattern, though the effects of credit market shocks are larger for the low contract industries firms. For inventories, the most pronounced effect is due to the liquidity premium shock on the low contract group. For short-term debt, the effect of the flight to quality shock is positive on the high contract industries group, whereas it is negative for the low contract industries firms. The negative effect of liquidity

premium shock on the short-term debt is small relative to that of the flight to quality shock. Liquidity needs of the high contract industries firms are generally less responsive than the low contract industries firms.

Based on the causal orderings, the dynamics can be traced as the following: after the liquidity premium shock, the high contract industries firms pile up inventories, thereby increasing trade payables; the higher level of inventories and trade payables are jointly associated with the subsequent increase in trade receivables extended to the firms' customers; independently, a decline of operating cash flow due to the shock is associated with a higher level of short-term debt.

[FIGURE 4]

To examine the impact of credit market shocks on emerging markets firms versus advanced economies firms, Figure 4 plots a set of impulse functions estimated for these two groups. The flight to quality shock has a large positive impact (though also with a large error band), on trade receivables of the emerging markets firms. Notable are the adjustment of trade receivables, trade payables, inventories and short-term debt of the emerging markets firms. Trade payables and inventories of the emerging markets firms fall significantly following the flight to quality shock (but less so with the liquidity premium shock) relative to the advanced economies firms. We also find that after the credit market shocks the short-term debt mildly declined in the case of the advanced economies firms. On the other hand, trade receivables and short-term debt of the emerging markets firms increased sharply following the flight to quality shock. The results suggest that the financial system inefficiency increases the firm's reliance on net trade receivables and short-term debt, and a reduction of inventories, in responding to the credit shocks, particularly the flight to quality type.

Based on the causal orderings, the dynamics can be traced as the following: after the flight to quality shock, the emerging markets firms shred inventories, thereby decreasing trade payables; in subsequent periods, the firms also extend more trade receivables to customers; independently, a decline of operating cash flow due to the shock is associated with a higher level of short-term debt.

These aggregate firm impulse responses are, in many cases, supporting the firm-level panel evidence in Section 4.3. These structural estimates are systematically derived from the in-sample causal orderings and recursive system of regressions. The main objective of these structural estimations is to address the identification issue in the reduced form firm-level panel estimation. Because these balance sheet time series are the weighted average of the firm-level series, our results here may be viewed as the behavior of the average (or representative) firm towards liquidity needs in the presence of credit market shocks.

From the structural estimates, we can calculate the proportion that each firm group contributes to the total adjustment in the variables of interests, following the credit market shocks. We report this calculation for the case of emerging markets firms versus advanced economies firms. Table 3 provides the percentage change in trade receivables, trade payables, inventories, and short-term debt for each firm group, and the total, for four, eight, and twelve quarters following the credit market shocks. The second row and the third row of each variable break down the proportion of total change contributed by each group of firms.

On average, the effects on liquidity needs of the flight to quality shock are negative and much larger in absolute term than the positive effects on liquidity needs of the liquidity premium shock. The emerging markets firms account for a larger contribution in the total decline of trade receivables following the liquidity premium shock, and the total increase following the flight to quality shock. The emerging markets firms also dominate the total decline in trade payables and inventories after both the liquidity premium shock and the flight to quality shock. Finally, the emerging markets firms account for most of the total drop in short-term debt following the liquidity premium shock, and most of the total increase in short-term debt after the flight to quality shock. These calculations are based on the mid point estimates and provide the best-case scenario.

[TABLE 3]

5. Conclusion

We find supportive evidence that (a) firms are less exposed to the liquidity premium shock when the industry-specific investment of supplier-customer relationship is large because the industry internalizes better the balance sheet externality in its supply chain; (b) firms are more exposed to the flight to quality shock when the financial system is inefficient because the channeling of funds functions even poorer during financial panic. By exploring the causal relations between credit market shocks and interconnected balance sheet variables, we sort systematically the dynamics of firm behavior and offer new evidence based on a large international firm-level data. Not only do firms differ in the way they handle liquidity needs with respect to the type of industries and countries they are in, but also their economic exposure can be quite different according to the type of credit market shocks.

We focus on the four balance sheet variables that capture the firm behavior towards liquidity needs: trade receivables, trade payables, inventories and short-term debt, together with cash stock, sales growth, and operating cash flows. The estimates suggest that the financial system efficiency and the industry-specific contract intensity of supplier-customer relationship both weaken the effects of credit market shocks on liquidity needs. Our analysis shows that drawing conclusion solely from a reduced form estimation may be misplaced. We use the in-sample causal orderings to clarify complex relations between the credit market shocks and the interconnected balance sheet variables. Following the credit shocks, trade payables appear to be influenced mainly by inventories, while the short-term debt is driven by the operating cash flows. We also find that the effects of flight to quality shock tend to be larger than the effects of liquidity premium shock on the dynamic adjustment of firm behavior towards liquidity needs.

The estimates from structural VARs serve as the best possible case for the credit market shocks – liquidity needs channel. In practice, firms have other price and non-price measures to offset liquidity constraints that may arise from the types of credit market shocks examined here, or other types of market shocks. This study should be considered complementary to other possible explanations.

[APPENDIX A]

[APPENDIX B]

[APPENDIX C]

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Table 1: Firm Characteristics by Industry and Country Groups.

Industries classified as high (low) contract intensity have the mean proportion of industry's inputs (weighted by value) that require relationship-specific investments in their production of 0.63 (0.10), with the cutoff at 0.36. Countries are classified as advanced economies if they are high-income (OECD and non OECD) according to the World Bank income classification.

Variable	acronym	Industries		Countries	
		Low Contract	High Contract	Advanced	Emerging
Trade Receivables/Total Sales	trectos	0.10	0.18	0.34	0.12
Trade Payables/Cost of Goods Sold	tpaytoc	0.15	0.18	0.42	0.16
Inventories/Cost of Goods Sold	invtoc	0.12	0.14	0.35	0.13
Short-Term Debts/Total Assets	stdtoa	0.08	0.12	0.10	0.09
Cash Stock/Total Assets	cashta	0.14	0.18	0.09	0.15
Sales Growth	growth	0.20	0.56	-0.07	0.28
Operating Cash Flows/Total Assets	cfwtoa	0.08	0.08	0.05	0.08
number of quarterly firm observations		106,985	106,376	136,639	76,722

Table 2: Panel Firm-Level Response to Credit Market Shocks.

Newey-West estimation with standard errors in parentheses (***, **, * denote statistically significant at 1, 5, 10%).

The error structure is assumed to be heteroskedastic at firm level and autocorrelated up to 4 lags.

	<u>Trade Receivables</u>	<u>Trade Payables</u>	<u>Inventories</u>	<u>Short-Term Debt</u>
	Total Sales	Cost of Goods Sold	Cost of Goods Sold	Total Assets
Liquidity Premium (LP)	-.113*** (.021)	-.106*** (.016)	.021 (.031)	.100*** (.032)
Flight to Quality (FQ)	-.088*** (.032)	-.046** (.023)	.115** (.048)	.131*** (.047)
Emerging Markets	.725*** (.156)	-2.187*** (.154)	-.583*** (.089)	-9.545*** (.048)
High-Contract Intensity Industries	.356*** (.016)	.187*** (.013)	.672*** (.022)	.103*** (.026)
Emerging Markets x LP	-.007 (.020)	.033* (.017)	.003 (.029)	.046 (.032)
Emerging Markets x FQ	-.027 (.030)	-.052** (.024)	-.066 (.043)	.022 (.046)
Contract Intensity x LP	.191*** (.034)	.085*** (.029)	-.035 (.059)	-.104* (.060)
Contract Intensity x FQ	.239*** (.048)	.119*** (.037)	-.028 (.079)	-.142* (.077)
<u>Cash Stock (lagged)</u> Total Assets	.001 (.007)	-.003 (.006)	-.067*** (.010)	-.410*** (.013)
Sales Growth (lagged)	.065*** (.011)	.100*** (.009)	.077*** (.016)	-.038** (.017)
<u>Operating Cash Flow</u> Total Assets (lagged)	-.146*** (.007)	-.035*** (.005)	-.109*** (.010)	-.138*** (.011)
Post 2007q3	.397** (.197)	.588*** (.162)	-1.903*** (.325)	-1.790*** (.340)
Trend since 2007q3	-.091 (.128)	-.101 (.095)	1.159*** (.190)	.633*** (.203)
R ²	.241	.252	.168	.181
Observations	62,241	62,241	62,241	62,241
Quarterly effects	Yes	Yes	Yes	Yes
Country effects	Yes	Yes	Yes	Yes

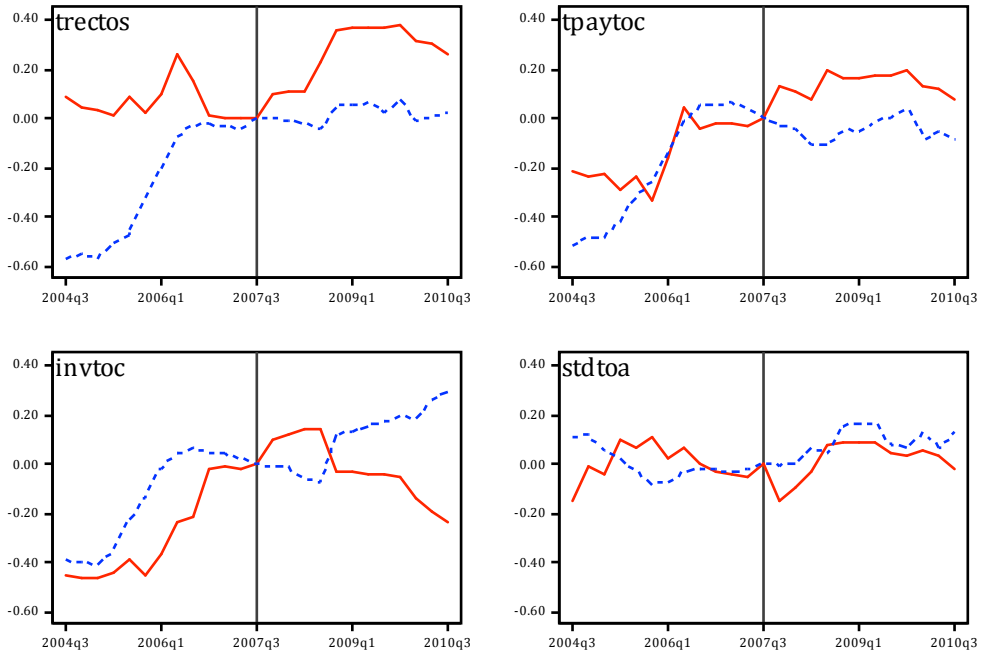
Table 3: Contribution of Emerging Markets versus Advanced Economies Firms following Credit Market Shocks.

	proportion contributed	<u>Liquidity Premium Shock</u>			<u>Flight to Quality Shock</u>		
		4 qtr	8 qtr	12 qtr	4 qtr	8 qtr	12 qtr
A. Trade Receivables %Sales	Total change	-1.6	-3.9	-5.7	10.9	18.7	18.0
	Advanced	-.2	-.5	-.5	-.2	-.3	-.3
	EM	1.2	1.5	1.5	1.2	1.3	1.3
B. Trade Payables %Costs	Total change	-2.6	-3.2	-2.6	-14.8	-21.0	-19.7
	Advanced	-.3	-.9	-1.7	.2	.3	.5
	EM	1.3	1.9	2.7	.8	.7	.5
C. Inventories %Costs	Total change	-4.3	-3.7	-2.6	-17.7	-32.0	-35.7
	Advanced	-.2	-.5	-.9	.1	.1	.1
	EM	1.2	1.5	1.9	.9	.9	.9
D. Short-Term Debt %Assets	Total change	-1.3	-4.8	-7.7	22.8	40.3	44.3
	Advanced	-.2	-.1	.1	-.1	.0	.0
	EM	1.2	1.1	.9	1.1	1.0	1.0

For each variable, the first row reports a total change, equals to the percentage adjustment that follows a 50 basis point credit market shock. The second and third row break down the proportion of the total change between a contribution of advanced economies firms and emerging markets firms. The calculation is based on mid-point estimates of the structural VARs.

Figure 1: Liquidity Needs.
 trectos (trade receivables); tpaytoc (trade payables); invtoc (inventories); stdtoa (short-term debt)
 All series are shown as log deviations from their values at 2007q3.

High Contract Industries v.s. Low Contract (---)



Emerging Markets v.s. Advanced Economies (---)

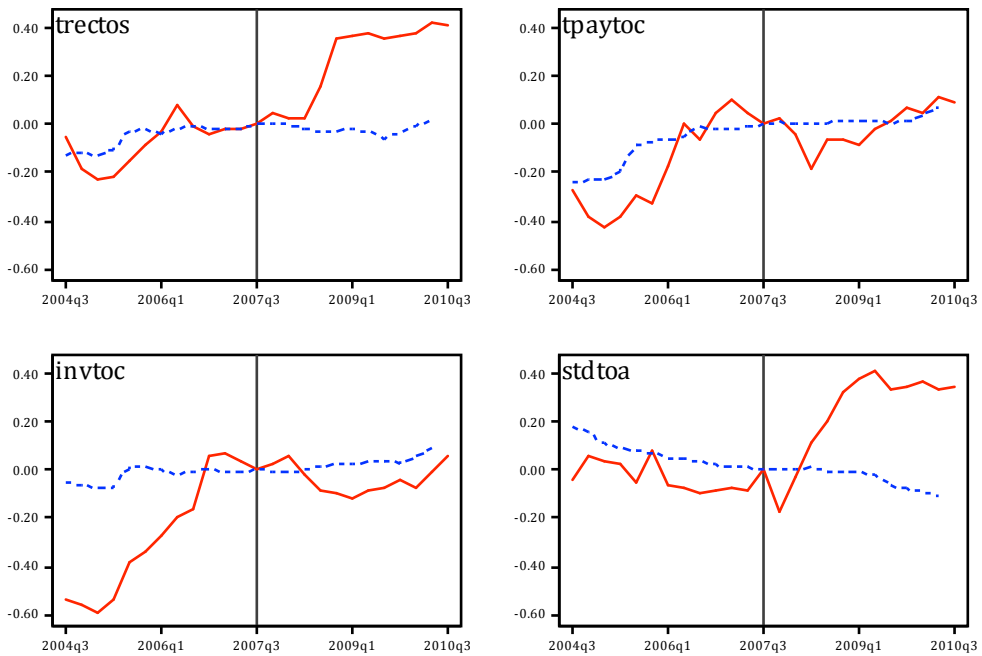


Figure 2: Credit Market Shocks.
Both series shown are quarterly means, in percent.

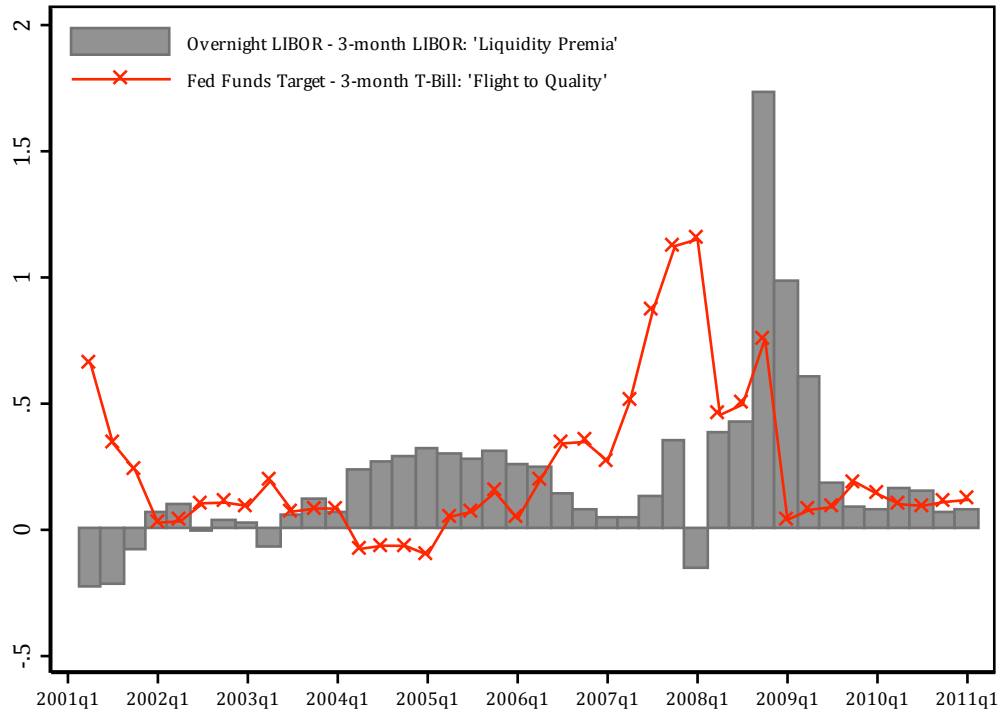


Figure 3: Industry Aggregate Firm Impulse Response to Credit Market Shocks, Sample: 2001Q3-2010Q3. Each column represents a separate structural VAR. All figures report the cumulative response to a 50 basis point shock. One standard error bands included.

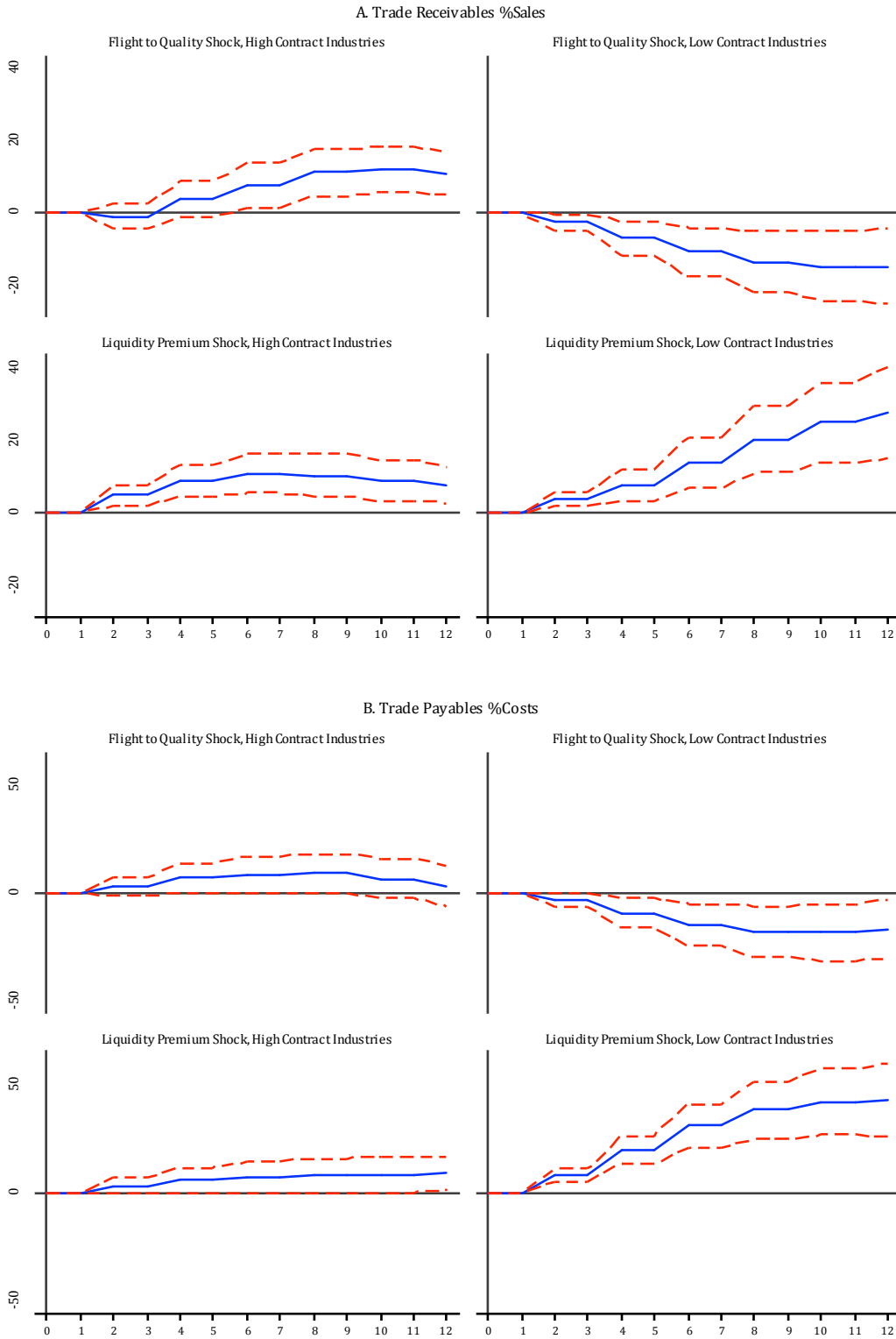


Figure 3: Industry Aggregate Firm Impulse Response to Credit Market Shocks, Sample: 2001Q3-2010Q3 (continued).

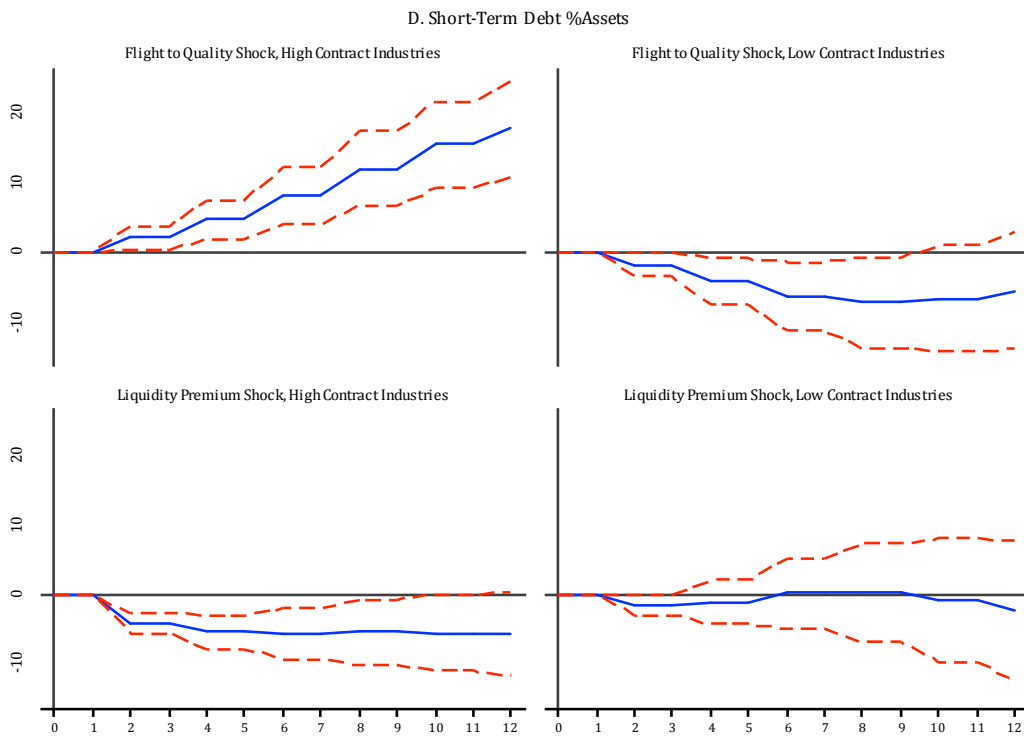
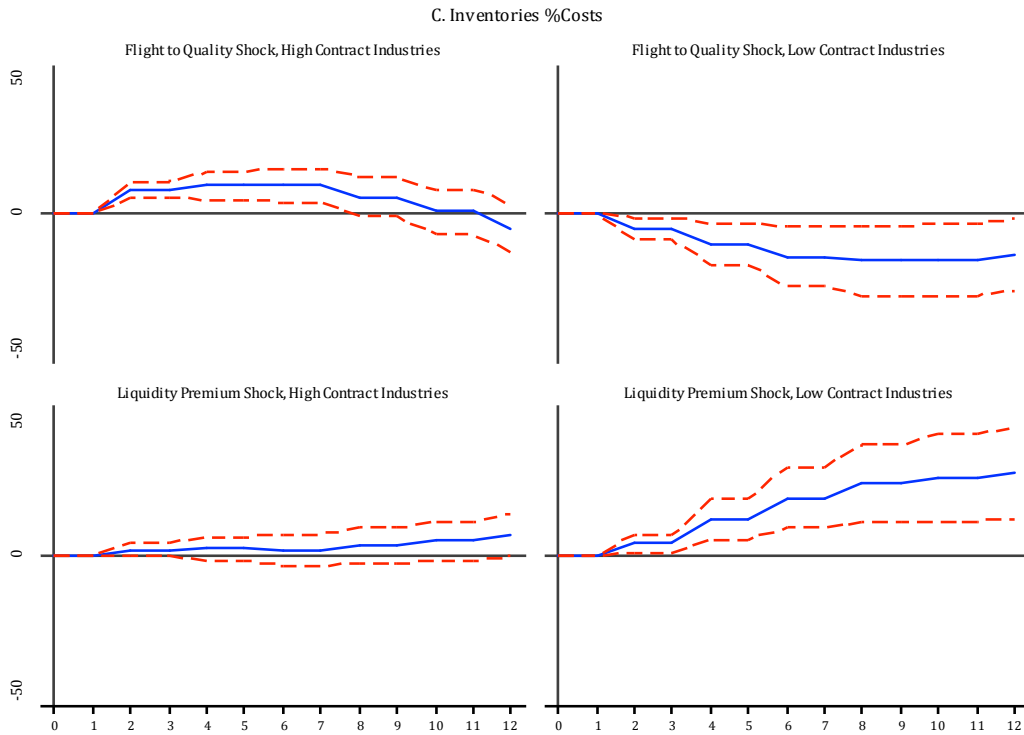


Figure 4: Country Aggregate Firm Impulse Response to Credit Market Shocks, Sample: 2001Q3-2010Q3. Each column represents a separate structural VAR. All figures report the cumulative response to a 50 basis point shock. One standard error bands included.

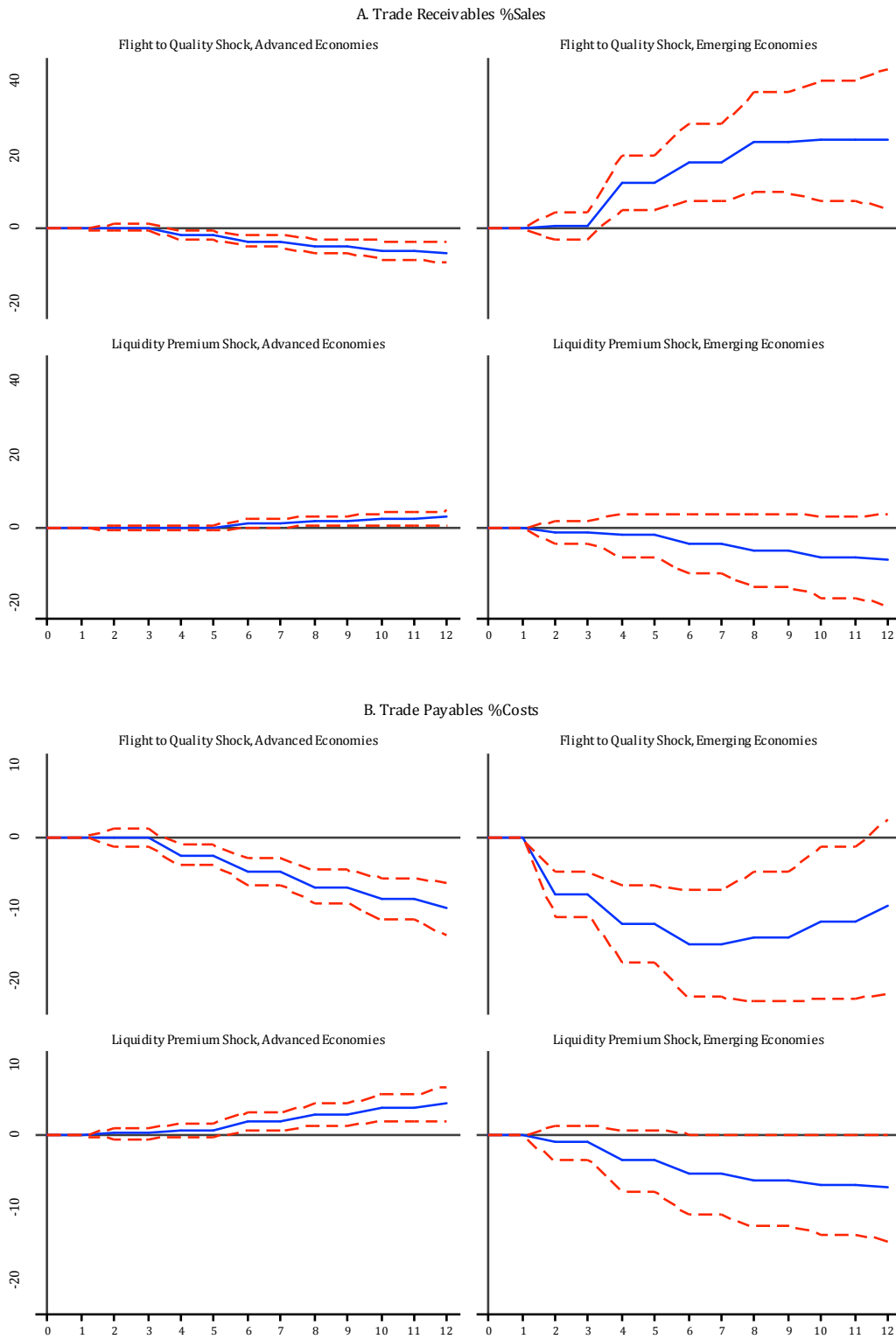
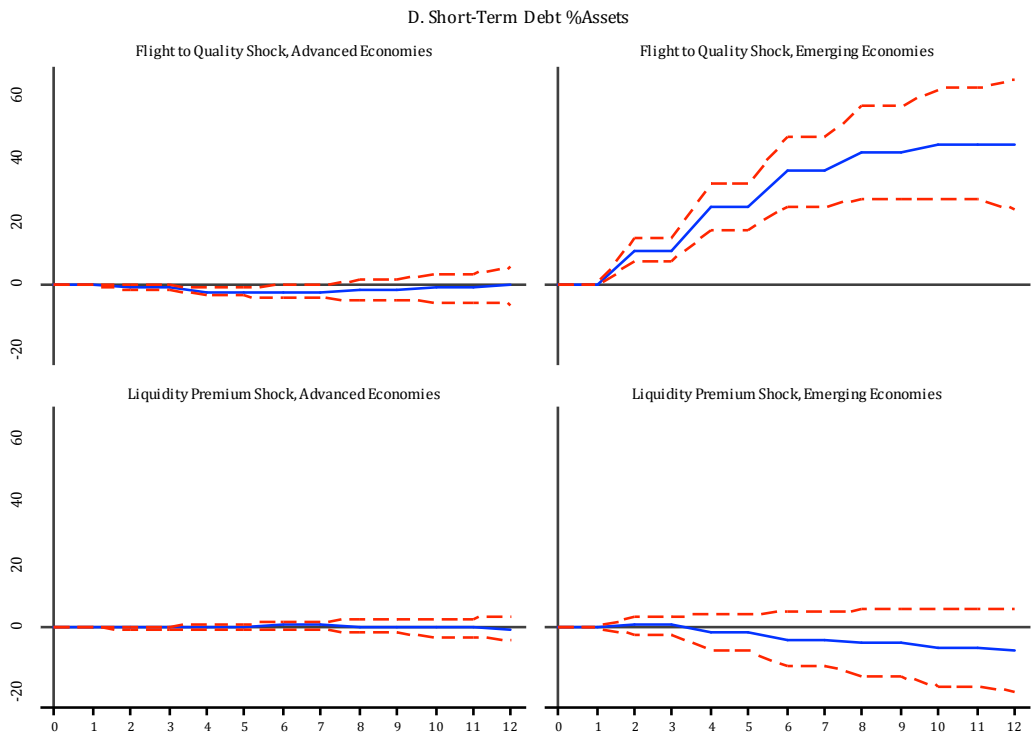
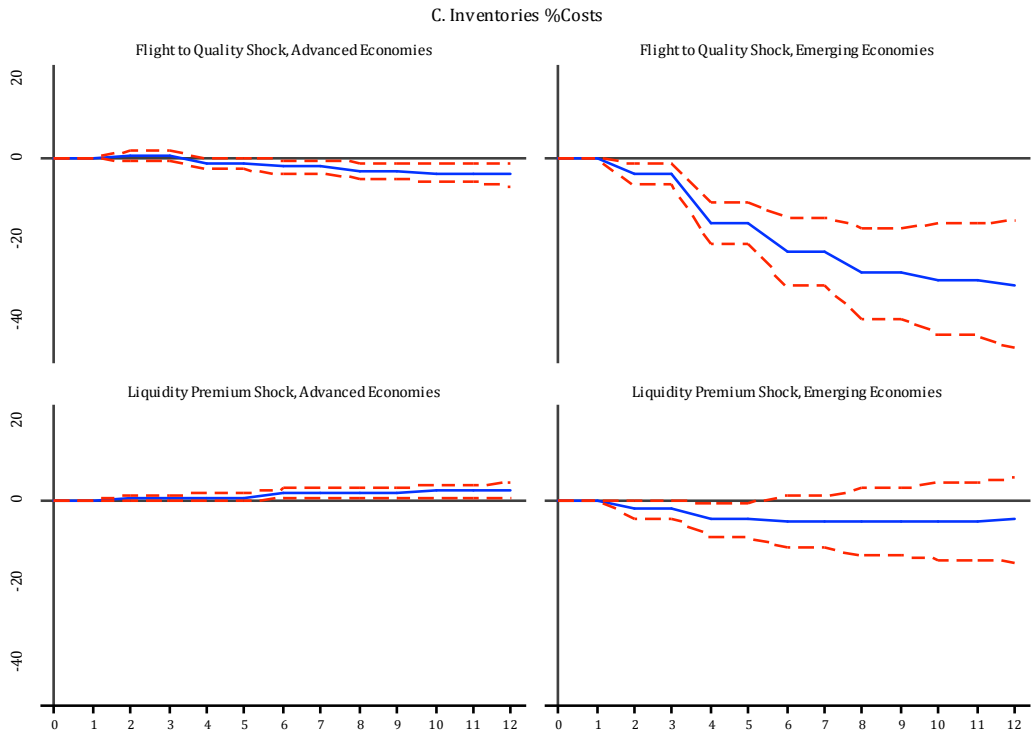


Figure 4: Country Aggregate Firm Impulse Response to Credit Market Shocks, Sample: 2001Q3-2010Q3 (continued).

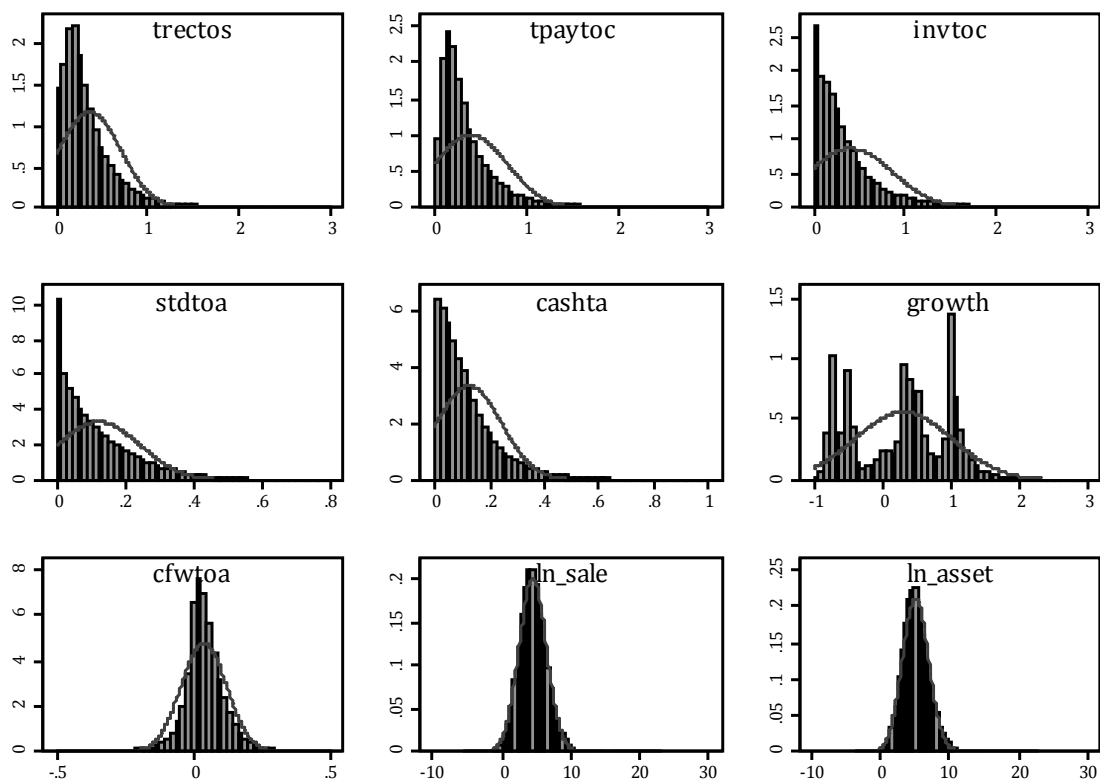


Appendix A.1: Sample Coverage.

The observations are derived from the Compustat Fundamental Quarterly.

Date	Number of Firms	Number of Countries	Number of Industries (NAICS 4 digit)
2001q3	2,650	45	263
2001q4	3,288	76	289
2002q1	3,407	50	280
2002q2	2,437	54	272
2002q3	2,861	51	267
2002q4	3,884	80	292
2003q1	4,164	55	303
2003q2	3,051	62	283
2003q3	3,565	60	291
2003q4	4,349	80	298
2004q1	5,256	62	307
2004q2	3,371	64	292
2004q3	4,659	69	306
2004q4	4,979	85	306
2005q1	6,790	72	318
2005q2	5,156	72	313
2005q3	6,828	78	320
2005q4	7,112	90	320
2006q1	8,134	80	326
2006q2	6,520	75	318
2006q3	8,149	83	330
2006q4	8,064	89	328
2007q1	9,521	84	334
2007q2	7,523	83	329
2007q3	8,824	86	333
2007q4	8,611	92	331
2008q1	9,829	87	331
2008q2	7,755	85	324
2008q3	8,997	88	326
2008q4	8,592	93	326
2009q1	10,033	87	330
2009q2	7,630	86	320
2009q3	8,744	88	327
2009q4	7,683	91	319
2010q1	9,974	93	328
2010q2	7,240	87	319
2010q3	6,481	81	312

Appendix A.2: Histograms of Quarterly Firm Observations.
Total number of observations = 213,361.

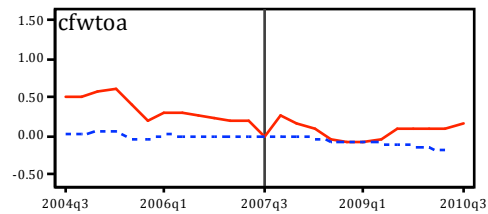
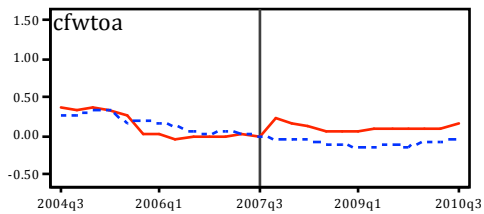
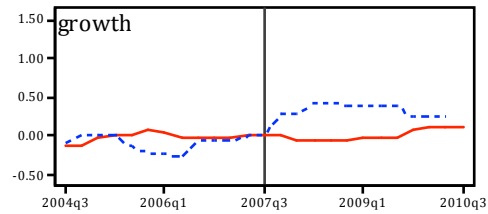
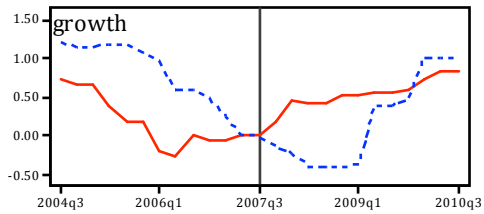
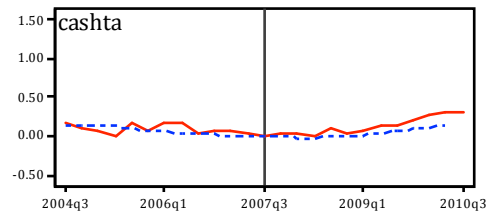
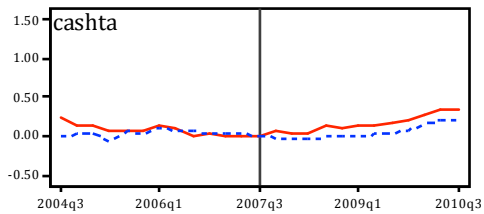


Appendix B: Additional Time-Series Plots.

cashta (cash stock/total assets); growth (sales growth); cfwtoa (operating cash flows/total assets)
All series are shown as log deviations from their values at 2007q3.

High Contract Industries v.s. Low Contract (---)

Emerging Markets v.s. Advanced (---)

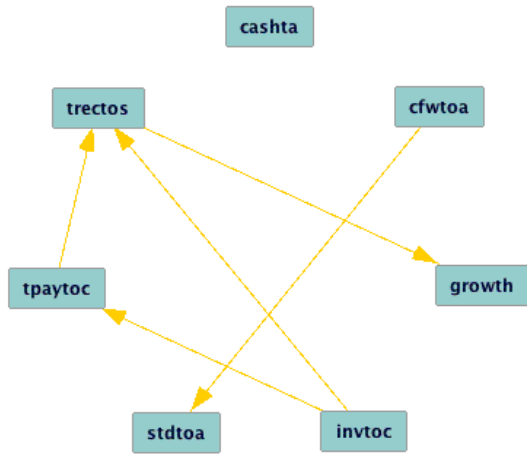


Appendix C.1: Conditional Correlations Derived from the Unrestricted VARs.

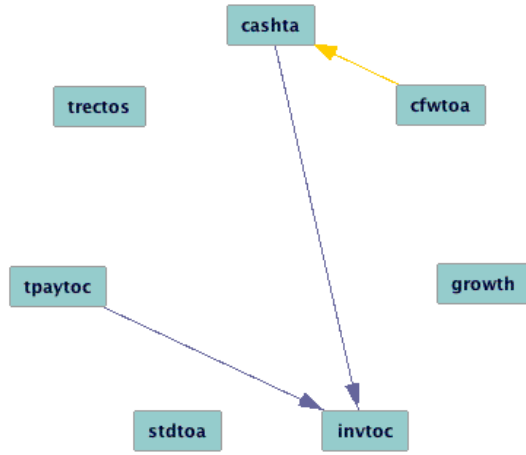
	trectos	tpaytoc	invtoc	stdtoa	cashta	growth
High Contract Industries Firms						
tpaytoc	.92					
invtoc	.76	.90				
stdtoa	-.24	-.47	-.42			
cashta	.06	.10	.06	-.08		
growth	-.68	-.54	-.50	-.18	.14	
cfwtoa	.41	.65	.67	-.67	.02	-.09
Low Contract Industries Firms						
tpaytoc	.48					
invtoc	.54	.67				
stdtoa	.03	.13	.50			
cashta	.19	.14	.58	.40		
growth	-.17	-.03	.29	.28	.27	
cfwtoa	-.36	-.52	-.64	-.46	-.61	.00
Emerging Markets Firms						
tpaytoc	.13					
invtoc	.18	.50				
stdtoa	.11	-.45	-.07			
cashta	.58	.56	.31	-.49		
growth	-.18	-.31	.04	-.11	-.03	
cfwtoa	-.27	-.02	-.16	-.70	.05	.12
Advanced Economies Firms						
tpaytoc	.79					
invtoc	.74	.94				
stdtoa	.20	.42	.43			
cashta	-.21	-.31	-.06	-.55		
growth	-.58	-.31	-.44	.16	-.23	
cfwtoa	-.50	-.68	-.50	-.18	.43	.03

Appendix C.2: Estimated Causal Orderings of the Balance Sheet Variables.

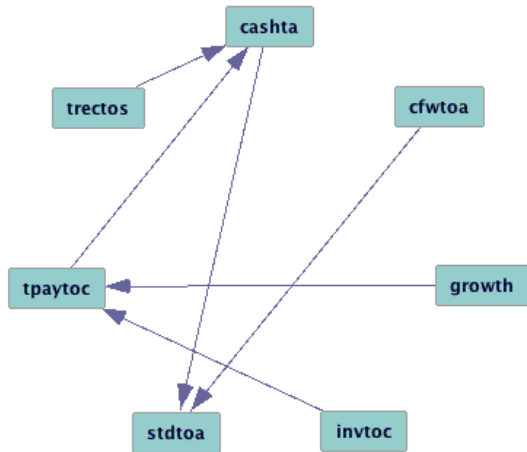
High Contract Industries Firms



Low Contract Industries Firms



Emerging Markets Firms



Advanced Economies Firms

