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The Impact of Monetary Policy and Agent Heterogeneity on Firm Financing Structure: Evidence from the USA*

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Abstract

Using panel modelling and firm-level data for 222 US listed companies I investigate how changes in monetary policy approximated by the three-month US LIBOR interest rate and its combined effect with firm-specific characteristics influenced firms' financing decisions and their liability structure during the period 2005−2014. Reported findings suggest that despite the Zero Lower Bound on the Federal Funds Rate, the three-month US LIBOR has retained its impact on firm total debt, long-term bank debt and short-term trade credit. Monetary policy changes were found to have affected firm's liability structure, especially through parameters such as size, collateral and profitability.

Keywords: balance sheet channel, LIBOR rate, ZLB, monetary policy, liabilities, corporate debt
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1. Introduction

For decades now, academic literature has discussed the effects of monetary policy shocks on the real economy. Growing opaqueness of financial markets has progressively limited the interest rate channel's capacity to explain output fluctuations in a satisfactory way progressively, so academic focus has gradually shifted towards the credit channel of monetary transmission. Both theoretical and empirical in nature, such research addresses the aspects of monetary policy transmission overlooked by the interest rate channel (see e.g., Bernanke and Blinder 1988; Romer and Romer 1990; Friedman and Kuttner 1993; Bernanke and Gertler 1995). Specifically, the focus is on informational asymmetries and market frictions − and the way these factors, combined with monetary policy shifts, affect the liability structure of market agents.

This paper addresses two problems: firstly, it verifies the effects of monetary policy changes as approximated by the three-month US London Interbank Offered Rate (US LIBOR), on the liability structure of US real-sector companies in the years 2005−2014; secondly, it analyses how firm-specific indicators reacted to monetary policy shocks while controlling for agent heterogeneity and its influence on firm debt. The selected timeframe encompasses a three-year period before the Zero Lower Bound (ZLB), as well as the period during which the impact of interest rate changes on the real economy may have been weaker due to uncertainty around the ZLB.

The core contribution made by this paper is a discussion on the role of firm-specific characteristics during the Great Financial Crisis (GFC), and an evaluation of the impact of short-term interest-rate changes on these parameters, in relation to shifts in firms' debt structure. With the primary channel of monetary transmission seemingly inoperative, the credit channel – including the balance sheet channel – has become one of the most important routes that monetary shocks to the real economy may take. The current analysis extends the existing literature by offering insights on a very recent period – a few years before and after the GFC, thereby filling the scientific gap in this field created by the fact that most papers dealing with this subject were published just before or during the GFC. This research also touches on the subject of the interest-rate channel, by looking at how fluctuations in the three-month US LIBOR affected firm debt.

This paper is structured as follows: in Sections 2 and 3, I discuss the mechanisms of the balance sheet channel and the impact of firm-specific indicators on firm debt structure; Section 4 presents methodology and highlights the most common estimation problems. Results from the baseline and modified models are as presented in Section 5, while Section 6 concludes.

2. The balance-sheet channel of monetary transmission

Monetary policy shifts affect real economic activity via several major channels, such as the interest rate channel, changes in equity and housing markets, or firms' balance sheets (Bernanke, Gertler and Gilchrist 1996). An ever-expanding body of literature, both theoretical and empirical, has identified several mechanisms of the broad credit view. Most of these studies distinguish between the effects of bank-level or firm-level characteristics − the credit channel affects agents through their balance sheets (Gertler and Gilchrist 1994). Influence of monetary policy shifts is also felt through the bank-lending channel (Kashyap, Stein and Wilcox 1993, 2000), and accelerator effects (Bernanke and Gilchrist 1999).

The broad credit view addresses the role of financial frictions and imperfections in the process of monetary transmission. Financial markets, both private and public, have always suffered from informational asymmetries and opaqueness. Recently, progressive layering of financial markets and developments in financial engineering has exacerbated this phenomenon. Moreover, in response to rising economic uncertainty and strengthening monetary policy shocks, the agency costs borne by all market agents have amplified. Usually, private markets are more prone to such difficulties because they lack the institutional and legal framework of public equity markets.

The balance sheet position of any agent, be it a household or firm, determines its access to internal and external financing. Following a monetary tightening, indicators such as employment, profits, size, production, and investment – to mention but a few, become affected by both higher interest rates and reduced access to loans. These idiosyncrasies limit firms' access to external financing and are reflected in their debt structure. The strength of a firm's balance sheet approximates its credit risk and determines the availability of bank loans in comparison with other sources of funding (Fazzari, Hubbard and Petersen 1988; Guariglia 1999; Bougheas, Mizen and Yalçın 2004). Hence, agents' access to financing depends on their specific attributes, which shape the impact and strength of a monetary contraction on their liability structure. For this reason, this phenomenon is likely to be heterogeneous. Credit rationing notwithstanding, when the level of economic uncertainty rises, all lenders tend become more risk-averse, and tighten their lending standards. Following a monetary contraction, firms' debts may decrease, not only due to augmenting costs, but also because of stricter credit policies.

The potential effects of monetary policy shifts on agents' financing decisions have been widely discussed in the literature. Identification of the influence exerted requires that the impact of the credit channel be isolated from other routes of monetary transmission. The study Kashyap, Stein and Wilcox (1993) was the first to address this problem. Their aggregated analysis capturing the effects of monetary policy contractions on bank lending provided strong support for the credit channel in the US. The research focused on a relative measure defined as the ratio

of bank lending to total external lending, the latter consisting of bank and commercial paper financing. Oliner and Rudebusch (1996) contested this view, arguing that the approach taken by Kashyap, Stein and Wilcox (1993) was too narrow, and failed to account for differential sources of financing and agent heterogeneity. Their paper reported significant differences between the financing behaviour of large and small firms, the latter being more likely to face negative consequences of informational asymmetries stemming from market frictions. According to Oliner and Rudebusch (1996), as bank loans constituted a major source of financing for small firms, their decisions were likely to be insensitive to monetary policy changes – a trait seemingly missed by Kashyap, Stein and Wilcox (1993). Their criticism notwithstanding, the analysis from Oliner and Rudebusch (1996) supported a more generalised broad credit view, suggesting that access to all sources of financing diminshes in the wake of monetary tightening. Empirical evidence presented by Mizen and Yalçın (2002) corroborated this view. Results from Atanasova and Wilson (2004) and later Bougheas, Mizen and Yalçın (2004, 2006) implied that company's perceived level of risk, size, and assets capable of serving as collateral, affected its access to credit markets, especially at times of tight monetary conditions. De Haan and Sterken (2000) focused on the effects of corporate governance. They argued that private companies depended more on bank financing and other external sources of financing − a trait leaving them more sensitive to monetary policy changes. Their later research (De Haan and Sterken 2006) highlighted the importance of market structure and suggested that firms in bank-based economies might be less affected by interest rate shifts than companies operating in more market-based systems.

3. The impact of firm-specific characteristics on the structure of liabilities

International studies on the subject suggest four indicators which may play the most important role in shaping a firm's debt structure, i.e. liquidity level, size, profitability, and collateral. To analyse how these parameters respond to monetary policy changes and impact upon firms' financing decisions; and to control for agent heterogeneity, I introduce relevant cross-terms. Along with an appropriate monetary policy variable, all of these are discussed below.

A three-month inter-bank offered rate, in this case the US LIBOR 3M, often approximates changes in monetary policy. Bougheas, Mizen and Yalçın (2006) suggested using the Federal Funds Rate (FFR), or a spread calculated as the difference between the FFR and ten-year US Treasury bonds. However, the LIBOR 3M rate is free from the discrete jumps characteristic of the FFR. All the company-specific indicators could be calculated on the basis of the end-of-year balance sheets. I use the yearly average for the three-month LIBOR values so as to obtain an

automatic lag in impact on firm's decisions. According to the interest rate channel mechanism interpretation, an increase in the price of external financing translates into a reduction in firm's debts. An upward shift in short-term rates does not necessarily translate into a raise in longer-term rates, hence the influence on total debts and longer-term debts remains ambiguous.

A company's liquidity level (LIQ) was calculated as the ratio of the most liquid assets to total assets. The higher the level of this parameter, the smaller a firm's demand for short-term external financing, because its current needs may be easily financed from its internal resources. Higher liquidity recorded in the previous period (t-1) may mitigate this demand. This implies, in line with the pecking order model, that companies prioritize internal funding over external sources. Conversely, higher liquidity may encourage an increase of longer-term debts because it provides means for timely repayment. Low liquidity escalates the probability of credit rationing, so the parameter may correlate positively with trade credit and other sources of non-bank financing. The literature provides mixed results: Atanasova (2007), and Kestens, Cauwenberge and Vander Bauwhede (2012) reported a positive correlation between debts and liquidity. However, the results of Huang, Shi, and Zhang (2011) as well as Marzec and Pawłowska (2011) implied otherwise.

According to the latest research (e.g., Bougheas, Mizen and Yalçın 2004, 2006; Aliyev, Hájková and Kubicová 2015), the impact of a company's size (SIZE), measured as the natural logarithm of total assets, remains unclear. Large companies run better-diversified businesses and are less opaque informationally, so they are perceived by prospective lenders as less likely to default. This suggests a positive correlation between firm size and its debts. On the other hand, Alonso *et al.* (2005) argued that a positive correlation between the use of credit and firm size is characteristic of bank-based financial systems, while in market-based ones this relationship is likely reversed. Białek-Jaworska, Dzik, and Nehrebecka (2014) added that, in non-Anglo-Saxon (i.e. bank-based financial systems), large firms could switch from bank loans to various forms of direct market financing, such as corporate bonds. However, they later remarked that even large agents seemed to prefer bank financing. The impact of company size may differ in line with maturity of debt: Ghosh (2010) claimed that smaller companies were more likely to finance business by means of short-term credit, while large ones would use long-term loans. It is thus probable that the correlations between short- and long-term debt ratios will be negative and positive respectively. Provided short-term trade credit is considered an acceptable substitute for short-term bank financing, its correlation with firm size could be negative. On the other hand, large companies, as more creditworthy, may have better access to all kinds of external financing, including this kind. I expect a negative impact of the cross-term approximating the reaction of this parameter to monetary policy shifts. The greater the value of its total assets, the easier it is for a company to shift between sources of financing; smaller agents have more re-

stricted access to longer-term market financing and are generally more dependent on bank and short-term lending.

A greater share of tangible assets in total assets (COLLATERAL) in the current period encourages greater longer-term debt, also in the form of bank loans: Ghosh and Sensarma (2004)'s evidence corroborated this claim. Białek-Jaworska, Dzik and Nehrebecka (2014) suggested that a higher collateral ratio in the (t-1) period might reduce the level of long-term firm debt in the following period. The researchers claim that this negative correlation may stem from companies whose COLLATERAL indicator was higher in the preceding period (t-1) having more limited resources with which to provide collateral in the current period (t), because these resources have already been used up as investment decisions in the period (t-1) were taken. This view is debatable – one may argue that assets used for investment are still on a firm's balance sheet, and therefore available as collateral.

The literature regarding capital structure and financing decisions has firm profitability as one of the most important factors determining resort to internal and external sources of financing. However, it does not provide a definite answer as to the direction of the variable's impact on a firm's debt structure. According to the pecking--order model, the greater a firm's profitability, the more limited its demand for external financing. Conversely, more retained profits in previous periods and higher capital reserves make a firm less likely to default. Greater profitability both in the previous and current periods, in this case measured as the return on equity (ROE), may encourage firms to incur debts of either maturity. Higher profits mean that a company's ability to make timely repayments rises, this not only mitigating its aversion to external financing but also limiting credit rationing by banks. Therefore, contrary to the pecking-order model, a positive correlation cannot be precluded. In the case of the cross-term I expect the estimated coefficient sign to be positive as well. The research results of Dewaelheyns and Van Hulle (2007) and Ghosh (2010) suggest that a firm's profitability correlates positively with bank loans. Provided short-term bank loans and trade credit are substitutable, profitability should affect the level of trade credit negatively. Conversely, results reported by Cole (2010) and Huang, Shi and Zhang (2011) implied that low profits increased credit rationing.

Building on the evidence presented in Angelopoulou and Gibson (2009) and Masuda (2015), I have included Tobin's Q parameter as a measure of a firm's assets in relation to its market value. A negative correlation with long-term financing would be in line with the pecking-order theory. A positive impact of the Q parameter on trade credit would mean that short-term financing is better accessible to these agents, whose market value is higher and whose debts are characterised by a lower risk associated with defaulting.

Shifts in the level of bank debt may also be caused by changes in the supply of commercial loans. The issue of identification of the loan supply and demand channels in relation to shifts in monetary policy has been present in the relevant

literature since the 1990s (see discussion in: Kashyap, Stein and Wilcox 1993, 1996; Oliner and Rudebusch 1996). Given the limited access to loan-level data, I have chosen to control for the aggregate change in the supply of commercial and industrial loans in all US commercial banks by introducing a $\Delta LOANS_{t-1}$ variable and a real economic activity variable − ΔGDP_{t-1}. Both are provided by FRED, the Federal Reserve Bank of St. Louis and US Bureau of Economic Analysis respectively, and are calculated with a one-year lag. Additionally, I control for the level of firm internationalisation by reference to the level of the given firm's international revenues (Dörrenbächer 2000). I introduce a binary variable (US_REV), which assumes a value of 1 where domestic revenues exceed 50% of total firm revenues.

4. Empirical methodology

I construct my sample using firm-level data retrieved from the Infinancials database for 222 US real-sector public companies quoted on stock exchanges across the USA. I follow the methodology presented in Bougheas, Mizen and Yalçın (2006), de Haan and Sterken (2006) and Aliyev, Hájková and Kubicová (2015). To analyse the reaction of financial indicators to shifts in monetary policy I construct two baseline equations. Firstly, I consider the impact of monetary policy changes approximated by a three-month US LIBOR rate and firm-specific characteristics on its debt ratios (equation 1). Secondly. I introduce cross-terms reflecting the impact interest rates exert on company-specific indicators (equation 2). This may allow for a better identification and greater control of effects caused by monetary policy changes and firm-specific characteristics (equation 1) and their combined impact (equation 2) on firm debt.

$$Y_{i,t} = \alpha_1 + \alpha_2 \Delta GDP_{t-1} + \alpha_3 \Delta LOANS_{t-1} + \alpha_4 X_{i,t} + \alpha_5 MP_t + \varepsilon_{i,t} \quad (1)$$

$$Y_{i,t} = \alpha_1 + \alpha_2 \Delta GDP_{t-1} + \alpha_3 \Delta LOANS_{t-1} + \alpha_4 X_{i,t} + \alpha_5 MP_t + \alpha_6 \left(X_{i,t} * MP_t\right) + \varepsilon_{i,t} \quad (2)$$

Where:

$X_{i,t}$ stands for a vector of the variables discussed in the previous section, MP_t is the monetary policy variable, and $Y_{i,t}$ denotes one of the three debt ratios of firm "i" in period "t".

- TDEBT is the total debt of a firm to total assets ratio.
- LDEBT is the total interest-bearing long-term debt to total assets ratio.
- TCRED is the total short-term trade credit to total assets ratio.

As relevant studies indicated a possible endogeneity problem, I ran a GMM panel estimation (Arellano and Bond 1991). The outcome, including the results of the Sargan test, was not satisfactory, so the model was promptly discarded. Aliyev, Hájková and Kubicová (2015) encounter an identical problem in their analysis of the credit channel in the Czech Republic, which they solve by using static models.

In the case discussed in the current paper, the results of the Hausman test suggested that a random-effects panel model be used to estimate both equations.

A relatively strong correlation was found between the LIQ and COLLATERAL variables, and this could represent a potential bias (see Table 1 in the next subsection). A trial model was constructed with the LIQ variable excluded and, as this change did not affect the results significantly, I do not report on it in this paper[1], for brevity's sake.

5. Results and discussion

5.1. Correlation matrix

Table 1 presents covariations of the main variables. The correlation between total and long-term debt is positive and very strong. A slightly weaker correlation is found between total debt and short-term debt. In line with theory, interest rates correlate negatively with firm total and long-term debt ratios, though the relationship is relatively weak. On the other hand, the LIBOR 3M correlates positively with short-term debt. Liquidity is the subject of a strong negative correlation with all debt ratios. This invalidates the assumption that the more cash and its equivalents to which a firm has an immediate access, the lesser its needs regarding external debt.

Firm size only correlates positively with the long-term debt ratio, which is in line with arguments presented previously. Economic activity influences short-term debt positively. Its correlation with total and long-term debt is inverse, and slight. This suggests that, in more prosperous periods companies need less external financing. On the other hand, during economic booms short-term financing may be obtained more easily. The supply of loans correlates positively with all three debt ratios.

The two variables approximating firm's profitability correlate differently with the total and long-term debt ratios – ROE's correlation is negligible, but positive. Given its null correlation with the total debt ratio, it is difficult to speculate about the variable's influence on the total debt ratio. ROE also correlates inversely with short-term debt. While ROE correlates weakly with the debt variables, the TOBIN Q parameter correlation is stronger. Unlike ROE, it correlates positively with trade credit. In line with expectations, its correlation with long-term and total debt is negative.

COLLATERAL correlates positively with all debt ratios; while the US_REV indicator is only inverse for the short-term debt. It is noteworthy that the correlation between the COLLATERAL and LIQ variables is very strongly inverse. This may cause a bias in the estimation process – a problem I have addressed in Section 4.

[1] Results of the estimation are available upon request.

Table 1. Correlation matrix

LDEBT	TDEBT	TRCRED	GDP	LIBOR	LIQ	SIZE	US_REV	COLLATERAL	SUPPLY OF LOANS	ROE	TOBIN	
1.00	0.68	0.13	–0.004	–0.07	–0.45	0.03	0.20	0.32	0.04	0.01	–0.11	**LDEBT**
	1.00	0.31	–0.03	–0.05	–0.36	–0.06	0.19	0.26	0.04	0.00	–0.12	**TDEBT**
		1.00	0.01	0.03	0.30	–0.002	–0.05	0.002	0.03	–0.02	0.10	**TRCRED**
			1.00	0.20	0.01	0.00	0.00	–0.01	0.26	–0.01	0.07	**GDP**
				1.00	0.03	0.02	0.06	0.01	0.10	–0.04	0.06	**US LIBOR**
					1.00	0.03	–0.16	–0.55	–0.03	–0.06	0.29	**LIQ**
						1.00	–0.03	0.03	–0.01	0.00	0.01	**SIZE**
							1.00	0.23	0.00	–0.05	0.03	**US_REV**
								1.00	0.00	–0.02	–0.11	**COLLAT-ERAL**
									1.00	–0.02	0.03	**SUPPLY OF LOANS**
										1.00	–0.21	**ROE**
											1.00	TOBIN

Source: author's own calculations.

5.2. Estimation results

Tables 2 and 3 present detailed estimation results for equations 1 and 2 respectively.

Table 2. Estimation using a GLS estimator

$Y_{i,t}$ =	(1)	(2)	(3)
	TDEBT	**LDEBT**	**TCRED**
Const	0.5484 (21.05)***	0.1913 (10.63)***	0.1904 (15.82)***
ΔGDP_{t-1}	–0.2268 (1.468)	0.0498 (0.389)	0.0111 (0.167)
US LIBOR 3M	–0.4132 (–3.211)***	–0.5015 (–4.710)***	0.1828 (3.310)***

$Y_{i,t}$ =	(1)	(2)	(3)
	TDEBT	**LDEBT**	**TCRED**
LIQ	–0.2649 (–8.683)***	–0.2296 (–9.531)***	0.0561 (4.201)***
SIZE	–0.0045 (–4.356)***	–0.0004 (–0.531)	−0.0002 (−0.504)
US_REV	0.0199 (0.732)	0.0498 (2.563)**	−0.0201 (−1.650)*
COLLATERAL	0.1600 (4.529)***	0.0931 (3.667)***	−0.0570 (−3.588)***
$\Delta LOANS_{t-1}$	0.0555 (3.343)***	0.0384 (2.856)***	−0.0005 (−0.069)
ROE	–0.0032 (–3.691)***	0.0005 (0.737)	−0.0010 (−2.626)***
TOBIN Q	0.0003 (0.161)	0.0004 (0.269)	0.0035 (3.894)***
R-squared	0.0852	0.1184	0.0697

Source: author's own calculations using a GLS estimator; heteroscedasticity-consistent t-statistics in parentheses; ***, **, * report statistical significance at the 1%, 5% and 10% levels respectively.

In the case of total debt (column 1), most variables are statistically significant at the 1% level. Most of them also have the expected sign. A higher short-term interest rate influences company's overall debt negatively, making it more costly than internal sources of funding. LIQ's negative coefficient signals that easier access to cash and its equivalents lowers a company's demand for external financing. Relevant studies found that firm size usually impacts positively upon its debt structure. In this case however, the obtained result confirms the hypothesis argued by Alonso *et al.* (2005), who differentiated the effects of a firm's size on its debts according to whether the economy was market- or bank-based. Larger companies may record higher profits and have more internal financing at their disposal. This invalidates somewhat the claim that small companies are usually more leveraged, as Bougheas, Mizen and Yalçın (2004, 2006) argue. The demand for external financing of relatively smaller firms is usually less flexible. Additionally, such companies face fewer financing options in comparison with larger firms.

Firm asset structure, as approximated by COLLATERAL, affects total debt positively. This result corroborates the hypothesis that firms with a better capital base can raise more and better-quality external funds. ROE's reported negative coefficient is in line with the pecking-order theory, and implies that more-profitable firms are less likely to require external financing, because of their greater capacityto finance their businesses with internal funds.

$\Delta LOANS_{t-1}$ correlates positively with total debt, suggesting that, the greater the availability of loans and the more accommodating the credit policies applied by lenders, the easier companies find it to incur debts.

As regards long-term debt, all statistically significant variables have the expected signs, which are the same as in the case of total debt. Relevant explanations discussed above apply. Interestingly, company size has become irrelevant. US_REV correlates positively with long-term debt, this implying that companies with higher domestic revenues hold greater shares of long-term debts. The impact

of changes in the loans supply is weaker than in the previous case. The influence of the short-term interest rate is visibly stronger than in the case of a company's overall debt. As the evidence discussed below corroborates, this implies that, in the case of total debt, the impact of the US LIBOR 3M is mitigated by its positive correlation with trade credit.

The demand for trade credit and other forms of short-term financing is less flexible, and so may be less sensitive to changes in short-term interest rates and the monetary policy stance – hence a positive impact of monetary policy on trade credit. Relevant studies present ambiguous results regarding the impact of liquidity on short-term financing (see: Atanasova 2007; Kestens, Cauwenberge and Vander Bauwhede 2012). The positive impact of the LIQ variable on trade credit may be explained by the fact that, the higher the liquidity ratio, the smaller the risk of default on short-term loans of either provenance.

COLLATERAL retains its coefficient sign and affects trade credit negatively. Its influence is easily explained: provided short-term bank loans and trade credit are perceived as acceptable substitutes, better collateralised firms may access short-term bank loans with greater ease. The results also suggest that a higher share of domestic revenues mitigates the demand for trade credit. The reported effect of ROE on trade credit is in line with the pecking-order theory. Greater profits mitigate firms' demand for external financing because of their greater capacity to finance their businesses with internal funds. Trade credit is the only debt ratio for which the Q parameter proved significant statistically. Its sign is positive, which suggests that companies whose market worth approximated by Tobin's Q is higher (and whose financial standing is consequently better and risk of default lower) have better access to trade credit.

Estimation of the extended model (equation 2) controls for the effects of monetary policy shifts on firm-specific characteristics. Table 3 reports the results obtained. Introduction of the five cross-terms had only a slight impact on the overall results, which suggests that the model may be considered robust and stable.

In most cases, the significant variables retained their coefficient signs reported in Table 2, so arguments discussed earlier apply.

Table 3. Estimation using a GLS estimator

$Y_{i,t}$ =	(1)	(2)	(3)
	TDEBT	**LDEBT**	**TCRED**
Const	0.5627 (20.59)***	0.2156 (11.27)***	0.1782 (14.21)***
ΔGDP_{t-1}	–0.2881 (–1.854)***	–0.0063 (–0.0501)	−0.0003 (−0.005)
US LIBOR 3M	–1.1953 (2.603)***	–1.0148 (2.758)***	0.3797 (1.993)**
LIQ	–0.2865 (–7.356)***	–0.2467 (–8.094)***	0.0784 (4.752)***
LIBOR*LIQ	1.0576 (1.014)	0.7971 (0.9551)	−0.2891 (−0.6667)

$Y_{i,t}$ =	(1)	(2)	(3)
	TDEBT	**LDEBT**	**TCRED**
SIZE	0.0045 (0.8449)	0.0083 (1.935)*	0.0001 (0.0685)
LIBOR*SIZE	–3.3732 (1.704)*	–3.2635 (–2.061)**	−0.1525 (−0.185)
US_REV	0.0313 (1.159)	0.0460 (2.402)**	−0.0145 (−1.211)
COLLATERAL	0.0978 (2.588)***	0.064 (2.337)**	−0.064 (−3.841)***
LIBOR * COLLATERAL	2.7182 (3.866)***	0.7605 (1.346)	0.5298 (1.815)*
$\Delta LOANS_{t-1}$	0.0577 (3.436)***	0.0419 (3.088)***	−0.0011 (−0.158)
ROE	–0.007 (–4.751)***	–0.0072 (–6.296)***	−0.0029 (−4.629)***
LIBOR * ROE	0.1214 (3.153)***	0.2143 (7.003)***	0.0700 (4.323)***
TOBIN Q	0.0010 (0.711)	–0.0041 (–1.82)*	0.0054 (4.743)***
LIBOR*TOBIN Q	0.563 (0.5809)	0.0965 (1.250)	−0.0998 (−2.530)**
R-squared	0.1418	0.1716	0.0908

Source: author's own calculations using a GLS estimator; heteroscedasticity-consistent t-statistics in parentheses; ***, **, * report statistical significance at the 1%, 5% and 10% levels respectively.

Firm size has lost its effect on total debt (column 1). With regard to the influence of monetary policy changes, the evidence shows that larger companies deleverage more in times of tight monetary policy. This sustains the hypothesis that relatively smaller firms have less flexible demand for external financing, and are thus less likely to reduce their debt when costs rise. Higher interest rates impact upon asset structure – the positive coefficient implies that better collateralised companies not only record higher overall debts in such periods, but also need not deleverage. Similarly, more-profitable firms are able to acquire external financing even when its cost rises.

In the case of long-term debt (column 2) all statistically significant variables retained the coefficient signs reported in Table 2. Additionally, a positive effect of firm size suggests, in line with the evidence reported in earlier studies, that larger, more diversified firms have better access to long-term external financing. The coefficient sign of the interaction term implies that larger agents may deleverage more when interest rates rise. This is in line with the result reported for the total debt ratio.

Introduction of the cross-terms allowed for the capture of effects relating to-company profitability and its financial condition. ROE affects long-term debts negatively, which accords with arguments discussed earlier. The sign of the LIBOR*ROE coefficient implies that, when interest rates rise, more profitable firms retain relatively better access to long-term debts. Tobin's Q affects the long-term debt negatively – this corresponds with the ROE's impact and remains in line with the pecking-order theory. It also invalidates the supposition that companies whose Q parameter is higher have a greater capacity to finance their business and investments from internal sources.

Estimation results for the trade credit ratio (column 3) remain mostly in line with those reported in Table 2. There is a slight impact of monetary policy shifts on firm-specific characteristics. While COLLATERAL retained its negative impact, the relevant cross-term affects trade credit positively. This suggests that better collateralised agents retain better access to short-term financing when monetary policy tightens. A company's profitability approximated by its ROE parameter impacts negatively upon trade credit. Greater profits grant market agents better access to short-term financing when interest rates rise. The impact of Tobin's Q remains positive, which corroborates the hypothesis that the higher the Q parameter of a company, the better its access to trade credit – as prospective lenders perceive more profitable entities as less likely to default. On the other hand, in times of tight monetary policy, firms whose Q is higher tend to reduce their trade credit more.

5.3. Robustness check

An unchanged impact of interest rate on firm debt before, during, and after the GFC seems unlikely. In an attempt to verify whether unconventional monetary policy associated with the crisis period affected the manner in which the three-month US LIBOR influenced firm debt, I introduce a CRISIS dummy. It takes on a value of 1 for the years 2008–2013 and of 0 for the years before and after this period. This tackles the problem superficially – for an in-depth analysis of this issue the attention would have to turn to deviations in interest-rate volatility and distortions in the transmission mechanism itself caused by ultra-expansionary monetary policy.

I use the CRISIS dummy to construct an interaction term CRISIS*LIBOR, which may help to verify the combined effect of the financial crisis and three-month interest rate change on a firm financing structure. Given the complexity of this problem, which extends beyond the scope of the current analysis, the introduction of a new cross-term will have to suffice.

Tables 4 and 5 below report the results obtained for equations 1 and 2 respectively.

Table 4. Estimation using a GLS estimator

$Y_{i,t}$ =	(1)	(2)	(3)
	TDEBT	**LDEBT**	**TCRED**
Const	0.5404 (20.2)***	0.1974 (10.59)***	0.1866 (15.15)***
ΔGDP_{t-1}	–0.837 (–0.4452)	–0.0578 (–0.3694)	0.0790 (0.977)
US LIBOR 3M	–0.3457 (–2.5)**	–0.5525 (–4.818)***	0.2147 (3.618)***
LIQ	–0.2638 (–8.645)***	–0.2306 (–9.573)***	0.05655 (4.233)***
SIZE	–0.0045 (–4.385)***	–0.0004 (–0.5113)	–0.0002 (–0.0534)
US_REV	0.0204 (0.45)	0.0496 (2.559)**	–0.0198 (–1.624)
COLLATERAL	0.1584 (4.478)***	0.0937 (3.702)***	–0.0579 (–3.639)***

$Y_{i,t}$ =	(1)	(2)	(3)
	TDEBT	**LDEBT**	**TCRED**
Δ*LOANS*$_{t-1}$	0.0493 (2.859)***	0.0441 (3.073)***	–0.0034 (–0.4619)
ROE	–0.0031 (–3.615)***	–0.0005 (–0.7881)	–0.0009 (–2.554)**
TOBIN Q	0.0003 (0.17)	0.0004 (0.266)	0.0035 (3.899)***
CRISIS*LIBOR	2.005 (1.33)	–1.5045 (–1.199)	0.9437 (1.464)
R-squared	0.0868	0.1188	0.1012

Source: author's own calculations using a GLS estimator; heteroscedasticity-consistent t-statistics in parentheses; ***, **, * report statistical significance at the 1%, 5% and 10% levels respectively.

As regards the statistical significance associated with the estimation results, it has remained largely unchanged in comparison with those presented in Table 2. In a few cases, there has been a slight change in magnitude of impact. As regards total debt (column 1), the effects of the monetary policy and asset structure are weaker by approximately 16.33% and 1% respectively. The statistical significance of the monetary policy variable has diminished from 1% do 5%. The influence of the US LIBOR 3M interest rate and liquidity on long-term debt (column 2) has grown stronger by 9.2% and 0.43% respectively. The change in the supply of available loans has also strengthened its impact – by approximately 12%. In line with the tendencies observed for long-term debt, the effects of the short-term interest rate and liquidity on trade credit (column 3) also changed magnitude – by 14.8% and 0.88% respectively. While retaining its expected coefficient sign, ROE lost in statistical level, from 1% to 5%. In none of the debt ratios did the new interaction term prove to have any tangible effect.

Table 5. Estimation using a GLS estimator

$Y_{i,t}$ =	(1)	(2)	(3)
	TDEBT	**LDEBT**	**TCRED**
Const	0.5547 (19.84)***	0.2214 (11.21)***	0.1756 (13.74)***
Δ*GDP*$_{t-1}$	–0.1449 (–0.7676)	–0.1062 (–0.6954)	0.0482 (0.615)
US LIBOR 3M	–1.1175 (–2.415)**	–1.0702 (–2.884)***	0.4067 (2.117)**
LIQ	−0.2858 (–7.338)***	−0.2473 (−8.114)***	0.0786 (4.765)***
LIBOR*LIQ	1.0454 (1.003)*	0.8073 (0.9672)	–0.2929 (–0.6755)
SIZE	0.0048 (0.8993)	0.0081 (1.886)*	0.00002 (0.1137)
LIBOR*SIZE	−3.4945 (−1.763)*	–3.1811 (−2.007)**	–0.1939 (–0.2355)
US_REV	0.0319 (1.181)	0.0457 (2.39)**	–0.0143 (–1.192)
COLLATERAL	0.0959 (2.537)**	0.0649 (2.37)**	–0.0647 (–3.880)***
LIBOR * COLLATERAL	2.6979 (3.838)***	0.7757 (1.372)	0.5222 (1.789)*
Δ*LOANS*$_{t-1}$	0.0514 (2.946)***	0.0464 (3.284)***	–0.0032 (–0.4462)

$Y_{i,t}$ =	(1)	(2)	(3)
	TDEBT	LDEBT	TCRED
ROE	−0.0069 (−4.692)***	−0.0073 (−6.333)***	–0.0029 (–4.578)***
LIBOR * ROE	0.1206 (3.133)***	0.2148 (7.021)***	0.0696 (4.297)***
TOBIN Q	0.0011 (0.379)	−0.0039 (–1.824)*	0.0054 (4.750)***
LIBOR*TOBIN Q	−0.0556 (−0.5745)	0.0962 (1.246)	–0.0999 (–2.532)**
CRISIS*LIBOR	2.0278 (1.335)	–1.4114 (–1.148)	0.6808 (1.086)
R-squared	0.1438	0.1722	0.1053

Sourece: author's own calculations using a GLS estimator; heteroscedasticity-consistent t-statistics in parentheses; ***, **, * report statistical significance at the 1%, 5% and 10% level respectively.

Introduction of the new cross-term did not change the initial results reported in Table 3 for the extended model (equation 2). As under the first model (equation 1), there are changes in the magnitude of impact of some variables on the debt ratios. As regards total debt (column 1), the effects of five variables: US LIBOR 3M, COLLATERAL, LIBOR*COLLATERAL, and LIBOR*ROE have weakened. The maximum observed reduction is of approximately 10.9%, in the case of the variable; while the minimum is the 0.66% noted for LIBOR*ROE. COLLATERAL's statistical significance has also been affected, and has dropped from 1% to 5%. The inclusion of the new cross-term elevated the impact of LIBOR*SIZE on total debt by 3.47%. Fewer variables have been affected in the case of long-term debt (column 2). The effects of US LIBOR 3M and have grown by 5.18% and 9.7% respectively. Contrary to the outcome recorded for total debt, the influence of LIBOR*SIZE has diminished slightly – by 2.52%. The impact of the Q parameter on long-term debt has been reduced by approximately 4.88%. The presence of the CRISIS*LIBOR cross-term has affected only US LIBOR 3M, whose coefficient has increased by 6.64%. As with the estimation results for equation 1, CRISIS*LIBOR has proved insignificant.

The estimation results for equations 1 and 2 under the attempt to control for the effects of the GFC and unconventional monetary policy on firm debt seem stable. This might suggest that ultra-expansionary monetary policy has not influencedfirm debt structure radically. On the other hand, the impact of a potential lower bound on interest rates cannot be disregarded. Recent research results in this field imply the ZLB might have ceased to be the limit for nominal interest rates. Cœuré (2016) and Brunnenmaier and Koby (2016) discuss the limitations and implications of zero and/or negative central bank interest rates in terms of a physical lower bound and an economic lower bound. The latter is perceived as the Reversal Rate, which is determined by market structure, bank equity, the interaction with quantitative easing and prudential regulations (for further discussion, see McAndrews (2015), Cœuré (2016), and Brunnenmaier and Koby (2016))

The endogeneity problem is not addressed by Aliyev, Hájková and Kubicová (2015), with these researchers deciding to use a different interest rate to approxi-

mate the effects of monetary policy changes. This does not begin to resolve the issue. To verify the robustness of the initial results (see Tables 2 and 3), I replaced the baseline variables with their lagged versions. Tables 6 and 7 present the estimation results.

Table 6. Estimation using a GLS estimator − lagged variables

$Y_{i,t}$ =	(1)	(2)	(3)
	TDEBT	**LDEBT**	**TCRED**
Const	0.4998 (16.93)***	0.1571 (7.575)***	0.1839 (12.4)***
Δ*GDP*$_{t-1}$	0.1656 (0.9038)	0.1117 (0.8078)	–0.1522 (–2.09)**
US LIBOR 3M	–0.2356 (–0.1476)	–0.3696 (–3.084)***	0.1199 (1.95)*
LIQ	–0.0521 (–1.407)	–0.0210 (–0.7713)	0.0571 (3.56)***
SIZE	0.0036 (3.004)***	0.0008 (0.8856)	–0.0360 (–1.75)*
US_REV	0.0463 (1.434)	0.0494 (2.211)**	–0.0061 (–0.443)
COLLATERAL	0.1132 (2.808)***	0.0872 (3.102)***	–0.0486 (–2.43)
Δ*LOANS*$_{t-1}$	0.0031 (0.8783)	0.0176 (1.163)	–0.0087 (–1.14)
ROE	–0.0028 (–2.217)**	–0.0001 (0.1504)	–0.0026 (–5.13)***
TOBIN Q	–0.0042 (–1.611)	–0.0065 (–3.536)***	0.0052 (3.71)***
R-squared	0.0247	0.0817	0.0705

Source: author's own calculations using a GLS estimator; heteroscedasticity-consistent t-statistics in parentheses; ***, **, * report statistical significance at the 1%, 5% and 10% levels respectively.

Fewer variables proved statistically significant, which implies that the impact of firm-specific indicators on company debt-structure may fade over time. In the case of lagged variables, a company's size proves an important positive influence of the total debt ratio – larger agents appear less risky to creditors, because of lesser perceived informational asymmetry. Such firms are usually more diversified and better suited to repaying their debts in time. The results recorded for COLLATERAL and ROE suggest that a firm's capital base, and profits recorded in the previous period, affect the total debt ratio in an unchanged manner (compare Table 3).

The impact of monetary policy on long-term debt remains negative, which indicates that the three-month LIBOR shapes the outcomes of financing decisions taken by US companies significantly. A firm's Q parameter from the previous period impacts negatively upon its debt ratio. This result invalidates the supposition that the higher a company's Q and the better its financial standing and higher prospective profits (both long- and short-term), the lesser its need for external financing.

As regards trade credit, the effects of real economic activity and firm size remain unchanged. A lagged ROE correlates negatively with trade credit. This suggests that higher profits recorded in the previous period mitigate the need for immediate financing, because a company has greater own resources at its disposal.

The positive impact of the Q indicator implies that entities whose assets were valued more highly by financial markets and were expected to record greater profits in the (t-1) period may have easier current access to trade credit in following periods, as lenders perceive them as less likely to default.

LIBOR 3M continues to influence trade credit positively. This accords with the hypothesis formulated earlier. The impact of firm liquidity shows that companies with more cash and easily monetised assets in the previous period are perceived as less risky by credit providers, hence their easier access to this source of financing.

Table 7. Estimation using a GLS estimator − lagged variables

$Y_{i,t}$ =	(1)	(2)	(3)
	TDEBT	**LDEBT**	**TCRED**
Const	0.5078 (16.24)***	0.1725 (7.986)***	0.1780 (11.8)***
ΔGDP_{t-1}	0.03603 (0.2014)	0.0554 (0.4164)	–0.2196 (–2.71)***
US LIBOR 3M	0.0485 (0.0906)	−0.5216 (−1.31)	0.2092 (2.62)***
LIQ	−0.0882 (−1.87)*	−0.0688 (−1.992)**	0.0639 (3.82)***
LIBOR*LIQ	2.2725 (1.852)*	2.3465 (2.575)**	–0.0239 (–0.825)
SIZE	0.0156 (2.504)**	0.0055 (1.186)	–0.0437 (–2.04)**
LIBOR*SIZE	−4.4893 (−1.954)*	−1.7379 (−1.023)	0.0163 (1.22)
US_REV	0.0571 (1.799)*	0.0471 (2.142)**	–0.0013 (–0.0926)
COLLATERAL	0.0751 (1.738)*	0.0654 (2.153)**	–0.0464 (–2.32)**
LIBOR * COLLATERAL	1.2340 (1.504)	0.6626 (1.085)	0.0074 (0.605)
$\Delta LOANS_{t-1}$	0.0107 (0.546)	0.0184 (1.261)	–0.0092 (–1.20)
ROE	−0.0097 (−5.267)*	−0.0039 (−3.218)***	–0.0025 (–3.13)***
LIBOR * ROE	0.4909 (5.372)***	0.1429 (4.442)***	–0.0031 (–0.237)
TOBIN Q	−0.0014 (−0.4013)	−0.2228 (−2.666)***	0.0066 (4.30)***
LIBOR*TOBIN Q	−0.3326 (−2.916)***	−1.7379 (−1.023)	–0.0516 (–2.18)**
R-squared	0.0381	0.1068	0.0760

Source: author's own calculations using a GLS estimator; heteroscedasticity-consistent t-statistics in parentheses; ***, **, * report statistical significance at the 1%, 5% and 10% levels respectively

Re-estimation of equation 2 brought similar results to the baseline version of the model (see Table 3). As regards total debt, the presented results invalidate the hypotheses discussed earlier (see Section 2 and subsection 5.2); lagged variables including LIQ, COLLATERAL, ROE, and US_REV have retained their respective coefficient signs.

The estimation results of equations 1 and 2 in their lagged versions imply that a company's size exerts a positive influence on its total debt ratio. However, the impact in the current period may be negative. The effects of monetary policy on firm-specific variables, such as firm size and profitability approximated by rel-

evant interaction terms, have remained unchanged in the case of total debt. The use of lagged parameters allowed the influence of three-month interest-rate shifts on firm liquidity to be captured. Entities which held more cash in the preceding period in times of tight monetary policy seem less likely to deleverage when monetary policy is tight. Apparently, if a company has retained more liquid assets, a timely repayment of its debts is more probable, with the effect that its access to external finance is facilitated. When monetary policy contracts, companies with higher Q parameters in the previous period are more likely to reduce their debts. Firms whose overall financial standing is perceived as relatively better are more flexible in terms of demand for external funding. Shifting between external and internal financing sources is easier for them, even when the cost of the former becomes relatively higher.

In the case of long-term debt (column 2), all the significant variables retained their estimated coefficient signs, implying that the impact of firm-specific determinants does not necessarily change over time (cf. Table 3). An influence of shifts of the three-month LIBOR on firm profitability (LIBOR*ROE) and liquidity (LIBOR*LIQ) has become apparent. In line with earlier results, firms with higher liquidity ratios need not deleverage when interest rates rise. Greater retained profits also mitigate the need for debts to be reduced at times when monetary conditions are tight.

The results for trade credit (column 3) hint that only the impact of profitability on a firm's financing decisions may change from period to period. Higher ROE recorded in a preceding year seems to mitigate the demand for external short-term non-bank financing. Conversely, as is explained in Sections 2 and 5.2, high current ROE and greater retained profits might encourage higher levels of trade credit to fund a company's immediate needs.

6. Conclusions

Adding to a considerable body of literature on the effects of monetary policy on firms' financing, this paper provides new evidence on shifts in debt structure when allowance is made for agent heterogeneity and shifts in loan supply during a crisis. Using firm-level data from 222 US real sector companies form the period 2005−2014, the study's main objective was to capture changes in the liability structure of companies in response to monetary policy shifts, while controlling for characteristics heterogeneous at the level of the firm, such as size, collateral levels, profitability and liquidity. Specifically, I have identified three major debt ratios: total debt, long-term debt, and short-term trade credit.

The paper's core findings correspond to a body of evidence presented in international literature on the subject. Shifts of short-term market rates approximated by the three-month LIBOR interest rate affect company total and long-term debts

negatively. Conversely, the role of short-term trade credit increases when interest rates rise. This highlights how market agents might consider short-term trade credit and bank loans as acceptable substitutes. There remains the question of a possible distortion of the interest rate's impact on firm debt due to the ZLB during the analysed period. A re-estimation of both models while unconventional monetary policy is controlled for has not changed the initial results. This issue requires further in-depth verification, especially in the light of new evidence on the impact of negative interest rates on the real economy.

The findings also imply that firm-specific characteristics such as size, liquidity, collateral and profitability determine access to external sources of financing. Specifically, negative effects of firm size on its debts confirmed the hypothesis from Alonso *et al.* (2005), to the effect that the US economy should be considered market-based as opposed to bank-based. Size was also the only variable whose impact was uniform across the three debt ratios. The effects of other explanatory variables often shifted in the case of trade credit. These changes underpin the supposition that trade credit and bank financing are substitutable. This idea is further corroborated by the consequences of shifts in the supply of commercial and industrial loans and economic activity, the obtained evidence showing that there was a positive impact of the former on total and long-term debt, while the effect on trade credit was slight. The latter in turn suggested that, in more prosperous times, firms' demand for external financing might diminish. Although this paper does not address the bank-lending channel directly, the effects stemming from shifts in the supply of commercial loans suggest its strong presence.

There is also considerable evidence of an operative balance-sheet channel across the timeframe adopted. This mainly affected companies via their size, available levels of collateral, and returns on equity. Larger companies seemed to reduce their total and long-term debts during monetary contractions, with this corroborating the claim that smaller agents are more debt-dependent, and cannot shift easily between internal and external financing. The findings also showed that more profitable firms were less sensitive to monetary contractions, and more likely to increase their debt shares during such periods. The results further confirmed thatthe heterogeneity of companies' responses to market interest-rate shifts depends on specific balance sheet indicators. Although US financial markets are often considered relatively close to full efficiency in line with the efficient markets hypothesis (Fama 1965a, 1965b, 1970; Fama and French 2012), the paper provides general evidence suggesting market opaqueness and frictions in financial markets during the period chosen for analysis.

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