

ORIGINAL ARTICLE

INTERNATIONAL
REVIEW OF FINANCE

WILEY

Analyzing time-varying tail dependence between leveraged loan and debt markets in the U.S. economy

Aviral Kumar Tiwari¹  | Nader Trabelsi^{2,3}  |
Emmanuel Joel Aikins Abakah⁴  | Chi-Chuan Lee⁵ 

¹Indian Institute of Management Bodh Gaya,
Bodh Gaya, India

²Imam Mohammad Ibn Saud Islamic
University (IMSIU), Riyadh, Saudi Arabia

³LARTIGE – ASTURIMA, University of Sousse,
Sousse, Tunisia

⁴University of Ghana Business School, Accra,
Ghana

⁵Southwestern University of Finance and
Economics, Chengdu, China

Correspondence

Chi-Chuan Lee, School of Public
Administration, Southwestern University of
Finance and Economics, Room 1105, Gezhi
Building, No. 555 Liutai Ave, Wenjiang
District, Chengdu, China.
Email: leechichuan@swufe.edu.cn

Funding information

The Deanship of Scientific Research at Imam
Mohammad Ibn Saud Islamic University,
Grant/Award Number: RP-21-10-03

Abstract

This study analyzes the time-varying dependence between U.S. leveraged loan and debt markets within a highly linked financial system using a quantile-based time-varying connectedness framework to determine the hedging benefits of leveraged loans for financial investors at various quantiles. Based on daily closing price data from November 28, 2008 to October 3, 2023, the evidence demonstrates considerable (moderate) spillovers across the leveraged loan and debt markets for severe (normal) occurrences, with additional results indicating symmetric interaction. In terms of risk spillover, we also affirm the dominance of short-term fixed-income instruments over leveraged loans and long-term bonds. These findings indicate that no hedging or diversification occurred among the investigated markets.

KEYWORDS

dynamic connectedness, fixed income securities, leveraged loans, quantile analysis, treasury bonds, TVP-VAR

JEL CLASSIFICATION

C32, G11, G20

1 | INTRODUCTION

The connectedness between financial markets has attracted considerable attention in recent years because of its practical and policy repercussions on asset allocation decisions and risk management strategies for market

participants, portfolio investors, and policymakers (Abakah, Tiwari, et al., 2023; Lee et al., 2021, 2022, 2023; Mensi et al., 2019; Tiwari, Abakah, Adewuyi, & Lee, 2022; Tiwari, Abakah, Gabauer, & Dwumfour, 2022; Zhang et al., 2021). Among the related discussions, the interdependence and contagion among debt markets are of major importance to many theoreticians and practitioners and can shed light on the future path of interest rates and associated risk (Zaremba et al., 2022). One primary strand of research in this area has mainly examined international spillovers in fixed-income markets across emerging and advanced countries (Ahmad et al., 2018; Tsang et al., 2021; Umar et al., 2021). For example, Umar et al. (2021) employ a time-varying parameter vector auto-regression (TVP-VAR) approach to assess the return and volatility spillover effect between U.S. and emerging bond markets during the COVID-19 crisis. Their empirical evidence reveals that strong connectedness exists between these markets. Another branch of contemporary study examines the interaction of conventional bonds with other innovative financial instruments, such as green investment bonds (Nguyen et al., 2021; Reboredo, 2018; Reboredo & Ugolini, 2020; Tiwari, Abakah, Gabauer, & Dwumfour, 2022; Tiwari et al., 2023) and Sukuk bonds (Balli et al., 2022; Pirgaip et al., 2021). Using copula-based models, Reboredo (2018) explores the dependence between green bonds and other financial asset classes and finds strong (weak) co-movement between green and corporate bond and Treasury bond markets (stock and energy commodity markets).

While the literature has examined the dynamic association between debt markets and other financial markets from cross-asset, cross-market, and cross-country perspectives, one crucial but often disregarded area is the rise of the leveraged loan market, which plays a significant role in corporate finance, mergers and acquisitions, and leveraged buyout landscapes. In recent decades, the market for syndicated bank debt has witnessed a silent evolutionary change leading to the rise of the leveraged loan market as the catalyst for the growth of syndicated bank debt. For the United States, by 2023, approximately 40% of the total syndicated bank debt volume was comprised of leveraged loans, and by the end of 2019, its leveraged loan market had reached \$1.2 trillion (Abakah et al., 2022; Hogan et al., 2006; Mählmann, 2022). However, there is still a relative dearth of empirical studies that provide quantitative analysis focusing on the dynamic association between U.S. leveraged loan and debt markets. This knowledge gap provided the initial motivation for this study. We propose our analysis as a contribution to outline some potential components of portfolio opportunities in leveraged loan and debt markets. In doing so, we contribute to the swiftly expanding empirical literature on leveraged loans, which has drawn significant attention of late.

Leveraged loans refer to bank loans that possess a speculative grade and are commonly traded among various financial institutions and institutional investors. Unlike their natural peers, high-yield bonds, leveraged loans are senior secured; consequently, they are less susceptible to a decline in the credit rating of a corporation. Furthermore, leveraged loans are floating-rate instruments that avoid the interest rate risk exposure of holding high-yield fixed-rate bonds. Leveraged loans also offer lower volatility than high-yield bonds. In sum, leveraged loans provide debt financing for borrowers at lower expense and with greater efficiency and have become a means for enterprise borrowers to obtain loans by using banks and other institutional capital providers. Gold et al. (1997) and Hogan et al. (2006) find that leveraged loans give a higher rate of return on investment per unit of risk than fixed-income assets. Given that price changes in these instruments cause spillover effects that affect major financial asset markets, it is critical to explore the connectedness of such instruments in order to obtain optimal asset allocation and risk management.

Several questions about leveraged loans remain unsolved, including the risk and return characteristics, as well as their predictability. Because Abakah, Nasreen, et al. (2023) have previously investigated the predictability question, this study concentrates on the following research questions: (i) Can financial investors use leveraged loans as a hedge against general debt markets in a diversified portfolio? (ii) What is the nature of connectedness between leveraged loan and general debt markets? (iii) How does time-varying dependence evolve across quantiles? (iv) What are the sources of net transmitters or receivers of spillovers between leveraged loan and general debt markets, and how does this evolve over a period of time? Undoubtedly, these problems are of significant importance, as leveraged loans and bonds function as financial instruments for corporations with non-investment-grade ratings.

The existing body of work mostly centers on the dynamic correlation between traditional financial assets (e.g., stocks and bonds) or emerging asset classes, including Bitcoin and financial technology (Abakah et al., 2021; Bouri et al., 2022; Gil-Alana et al., 2020; Hu & Sun, 2021; Le, Abakah, & Tiwari, 2021; Le, Do, et al., 2021; Tiwari, Abakah, Gabauer, & Dwumfour, 2022; Tiwari et al., 2023; Yunus, 2023). In addition, existing research places significant emphasis on the crucial elements of mean-based return spillovers in driving financial markets during normal periods but ignores the arrangement of extraordinary spillovers. To address this omission, we utilize Ando et al.'s (2022) quantile vector autoregression (QVAR) technique to assess the extent of spillover effects on market circumstances, including bullish, bearish, and normal states. The present methodology builds upon the mean-based VAR approach proposed by Diebold and Yilmaz (2012), as well as the TVP-VAR technique developed by Antonakakis et al. (2017). The latter technique represents a significant improvement on the standard paradigm of examining spillovers, since it avoids the subjective estimation of the rolling window and eliminates the loss of observations. Furthermore, because it concentrates on extreme events and tail risks, which occur frequently when asymmetric linkages between financial assets and markets become more prominent, this technique is well suited to capturing asymmetric connectivity.

The current study seeks to shed new light on the time-varying tail dependence between U.S. leveraged loan and debt markets. As the connectedness of financial markets has increased over time since the 1980s (Dahlquist & Hasseltoft, 2013; Gil-Alana et al., 2018), linkages among financial assets have tended to grow tighter during volatile market conditions (Lee & Lee, 2023; Tiwari, Abakah, Adewuyi, & Lee, 2022; Tiwari, Abakah, Gabauer, & Dwumfour, 2022). Such turbulent periods are often accompanied by significant interest rate fluctuations due to rising risk premia and expected monetary policy changes aimed at curtailing frictions in financial markets. Given the crucial importance of interest rates in affecting economic and financial activities, we use a newly introduced quantile connectedness framework to investigate the direction and magnitude of connectedness between the leveraged loan and debt markets.

Our study builds upon the work of Abakah, Nasreen, et al. (2023), who have also explored the relationship between U.S. leveraged loan and debt markets by employing non-parametric causation in quantiles and cross-quantilogram correlation. However, our study differs in several aspects: First, we present quantitative evidence for the first time on the relationship between leveraged loan and debt markets in the United States by investigating (i) whether the impact of extreme positive or negative changes in market states is symmetric or not, (ii) the role of each market as a net recipient or transmitter of spillover shocks across the variables in the system network, and (iii) the impact of leveraged loan changes on the magnitude of connectedness in U.S. debt markets. Second, we utilize Ando et al. (2022) quantile VAR (QVAR) technique to determine the extent of spillover impacts under various market scenarios, such as bullish, bearish, and normal. Thus, the extreme lower and upper quantile impacts are taken into consideration and evaluated in relation to the median quantile impact for the QVAR measurements. Third, our study uses a longer and more recent sample (2008–2023) that covers more of the COVID-19 period compared to Abakah, Nasreen, et al. (2023), who employed sample data from 2013 to 2021. Our primary findings reveal significant shock transmissions across the leveraged loan and debt markets. We further validate short-term fixed-income instruments' dominance over other markets, as well as the fact that the degree of connection varies with time and event.

The remaining sections of the work are arranged as follows. Section 2 introduces the research design and methodology, while Section 3 outlines the data and their sources. We then provide comprehensive discussions on the empirical results and conclude the paper with several policy suggestions in Sections 4 and 5, respectively.

2 | METHODOLOGY

Previous research evaluating the characteristics and magnitude of interconnections within financial markets mostly relies on conventional conditional mean estimators and mainly estimates the average network structure. The connectedness measurement based on the variance decomposition frame proposed by Diebold and Yilmaz (2012) is one

of the most widely used network-based approaches to exploring the average shocks and how they spread within the connectivity system. However, systemic shocks may be substantially larger than average and may propagate differently. To address this possibility, Ando et al. (2022) extend the mean-based measure of Diebold and Yilmaz (2012) and propose the quantile-based time-varying connectedness framework (i.e., the QVAR approach) to assess the quantile propagation mechanism.

To assess the time-varying tail dependence between the leveraged loan and debt markets, we conduct a number of measures of return connectedness at each quantile using the abovementioned QVAR approach. We start by defining an infinite moving-average representation of the m -variable QVAR process with the lag order p , i.e., QVAR (p) as follows:

$$y_t = \mu(\tau) + \sum_j^p \Phi_j(\tau) y_{t-j} + u_t(\tau) = \mu(\tau) + \sum_{i=0}^{\infty} \Omega_i(\tau) u_{t-i}, \quad (1)$$

where, y_t denotes $m \times 1$ dimensional endogenous variable vectors; $\mu(\tau)$ and $\Phi_j(\tau)$ represent the $m \times 1$ conditional mean vector and the $m \times m$ QVAR coefficient matrix, with quantile τ being between 0 and 1, respectively; and $u_t(\tau)$ denotes the $m \times 1$ error vector with an $m \times m$ variance-covariance matrix. Then, the K -step-ahead generalized forecast error variance decomposition (GFEVD) is defined as the impact a shock in factor j has on factor i , that is:

$$\Theta_{ij}^g(K) = \frac{\sum(\tau)_{jj}^{-1} \sum_{k=0}^{K-1} (e_i' \Omega_k(\tau) \sum(\tau) e_j)^2}{\sum_{k=0}^{K-1} (e_i' \Omega_k(\tau) \sum(\tau) \Omega_k(\tau)' e_i)}, \quad (2)$$

where, e_i stands for a selecting zero vector with unity located at the i th position. The decomposition matrix is then normalized for each element as follows:

$$\tilde{\Theta}_{ij}^g(K) = \frac{\Theta_{ij}^g(K)}{\sum_{j=1}^M \Theta_{ij}^g(K)}, \text{ with } \sum_{j=1}^M \tilde{\Theta}_{ij}^g = 1 \text{ and } \sum_{i,j=1}^N \tilde{\Theta}_{ij}^g(K) = M. \quad (3)$$

Based on the GFEVD specifications outlined above, we can formulate the following pertinent indicators of connectedness measures at each quantile:

$$TO_{j,t} = \sum_{i=1, i \neq j}^M \tilde{\Theta}_{ij,t}^g(K), \quad (4)$$

$$FROM_{j,t} = \sum_{i=1, i \neq j}^M \tilde{\Theta}_{ji,t}^g(K), \quad (5)$$

$$NET_{j,t} = TO_{j,t} - FROM_{j,t}, \quad (6)$$

$$TCl_t = \frac{\sum_{i,j=1, i \neq j}^M \tilde{\Theta}_{ij}^g(H)}{N-1}, \quad (7)$$

$$NPDC_{j,t} = \tilde{\Theta}_{j,t}^g(K) - \tilde{\Theta}_{j,t}^g(H), \quad (8)$$

where, $TO_{j,t}$ represents the total directional connectedness to other influencing elements, quantifying the extent to which a shock in variable j propagates to all other variables within the system; $FROM_{j,t}$ quantifies the total directional connectedness originating from external influencing factors, indicating the extent to which variable j is affected by shocks from all other variables within the investigated network; $NET_{j,t}$ is utilized to quantify the difference between the above two measures, with a positive value signifying that variable j is perceived as a net transmitter of shocks to the system and a negative value indicating that variable j is a net receiver of shocks from other markets; TCI_t stands for the total connectedness index indicating the interconnectedness of the network. Finally, the net pairwise directional connectedness is denoted by $NPDC_{ij,t}$ with a positive value indicating that variable i dominates variable j and a negative value suggesting the opposite.

3 | DATA AND DESCRIPTIVE STATISTICS

We use daily closing prices from November 28, 2008 to October 3, 2023 of the U.S. leveraged loan and debt market indices acquired from DataStream. This is a daily index for capitalization-weighted syndicated loans in the U.S. market, which aims to measure the performance of the largest facilities in the leveraged loan market. Table 1 describes the variable labels and definitions for each market utilized in this study.

The dynamic trends of the daily closing prices and their returns are depicted in Figure 1. Throughout the study period, the level graphs demonstrate long increasing trends in the leveraged loan index, with a notable reduction at the start of the COVID-19 crisis at the beginning of 2020. This is also evident when we look at short-term fixed-income securities, with a period of stagnation during the COVID-19 crisis (i.e., 2020–2022). Long-term Treasury bills and bonds, on the other hand, have been volatile partners during the sample period, with a significant drop at the onset of the COVID-19 crisis and a strong decreasing trend since 2022. Regardless of the return graphs, while bonds appear more irregular, leveraged loan indices and short-term Treasury bills exhibit stable behavior, with significant spikes and drops during the global financial crisis and the COVID-19 crisis, as well as long memory perturbations during the global economic recession period of 2015–2019 and after the COVID-19 crisis. These findings demonstrate that the behaviors of the leveraged loan and debt markets are time and event dependent.

TABLE 1 Variable descriptions.

Market	Label	Description
Leveraged loans	LSTA.LLI	LEVERAGED LOAN INDEX ^a
Treasury bonds (long term)	S&P.T.BOND.I	S&P U.S. TREASURY BOND INDEX
	S&P.ABI	S&P US AGGREGATE BOND INDEX
	S&P.TBC10Y.I	S&P US TREASURY BOND CURRENT 10 YEAR INDEX
Fixed income securities (short term)	S&P.TBI	S&P US TREASURY BILL INDEX
	S&P.T.BILL.0-3M.I	S&P US TREASURY BILL 0-3M INDEX
	S&P.T.B.C.3M.I	S&P US TREASURY BILL CURRENT 3M INDEX
	S&P.T.BILL.3-6M.I	S&P US TREASURY BILL 3-6M INDEX
	S&P.T.BILL.C.6M.I	S&P US TREASURY BILL CURRENT 6M INDEX
	S&P.T.BILL.6-9M.I	S&P US TREASURY BILL 6-9M INDEX
	S&P.T.BILL.9-12M.I	S&P US TREASURY BILL 9-12M INDEX
Green bonds	S&P.G.BOND.I	S&P GREEN BOND INDEX
Corporate bonds	S&P500.BI	S&P 500 BOND INDEX

^aThere is no longer an S&P Leveraged Loan index available. The MorningStar Leveraged Loan index has taken its place.

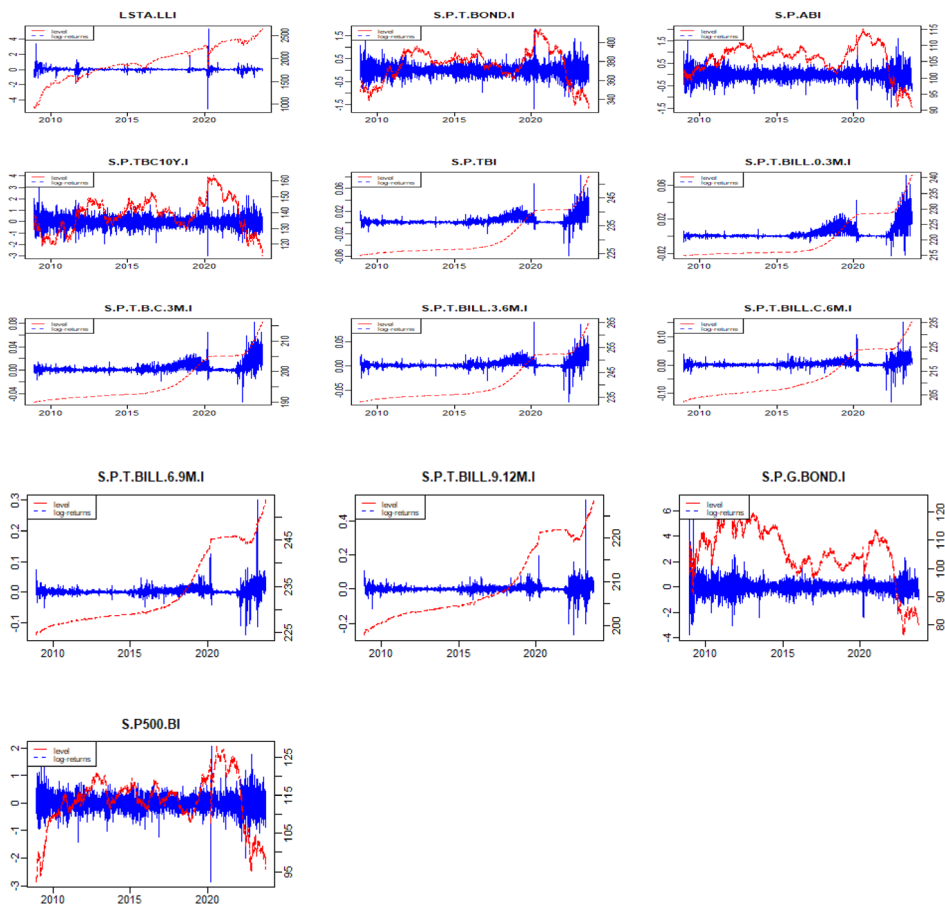


FIGURE 1 Plots for dynamic trends of daily price series and returns. We use 13 time series to characterize the U.S. economy's leveraged loan market, fixed-income T-bills, and long-term bonds from November 28, 2008 to October 3, 2023.

The descriptive statistics for each daily return series across the sample period are shown in Table 2. The leveraged loan index and the majority of short-term fixed securities have a positive mean value, whereas long-term bonds, including green bonds, have a negative mean value. Green bonds likewise have a high standard deviation, whereas short-term fixed income securities have a low standard deviation, demonstrating their performance in terms of the mean-risk couple measure when compared to the other instruments analyzed.

We also find that the skewness values are mainly positive (with the exception of LSTA.LLI, S&P.ABI, and S&P500.BI), and the kurtosis values are quite high, indicating that the examined series have asymmetric heavy tails. The Jarque–Bera test results also show a robust rejection of the null hypothesis for all series, suggesting deviations from normality. We use the conventional ADF, PP, ZA unit root test by Zivot and Andrews (1992) and the KPSS stationarity test by Kwiatkowski et al. (1992) to determine whether our data are stationary. These test statistics show that our return series are indeed stationary. As a result, these findings not only support that linear models are ineffective for studying the type and degree of financial market connections but also validate the usage of the quantile approach to capturing asymmetry.

Figure 2 depicts the cross-correlations among the investigated series. The leveraged loan indices and the various maturities of T-bills, as well as the considered long-term bonds, exhibit low and negative relationships. Furthermore, T-bills and long-term bonds have a positive correlation, reducing the diversification spectrum. Nonetheless, because

TABLE 2 Descriptive statistics.

	Mean	Median	Max	Min	Std. dev.	Skewness	Kurtosis	Jarque-Bera	ADF	PP	KPSS	ZA	L-B	L-B ²	ARCH- LM(10)	Obs.
LSTALLI	0.026	0.025	5.262	-5.146	0.278	-0.855	129.564	2,581,429.736***	-15.576***	-2587.897***	0.595**	-18.77***	1463.64***	4290.909***	1730.416***	3867
S&P.T.BOND.I	-0.001	0.000	1.783	-1.694	0.246	0.181	7.423	3172.921***	-15.7***	-3814.479***	0.657**	-18.187***	30.92***	1503.473***	659.926***	3867
S&P.ABI	-0.002	0.000	2.015	-1.521	0.248	-0.049	7.091	2698.461***	-16.184***	-3736.253***	0.74***	-18.653***	23.093***	1020.273***	484.231***	3867
S&P.TBC10Y.I	-0.003	0.000	4.043	-2.965	0.482	0.127	6.257	1719.842***	-15.869***	-3825.626***	0.349*	-18.338***	21.548***	645.652***	361.629***	3867
S&P.TBI	0.003	0.001	0.083	-0.059	0.007	3.103	23.662	74,991.898***	-4.993***	-4471.219***	11.214***	-9.309***	7777.019***	2810.369***	1656.131***	3867
S&P.T.BILL.0-3M. I	0.003	0.001	0.071	-0.023	0.006	3.689	22.491	69,982.449***	-2.407	-4444.05***	13.509***	-6.689***	12,683.149***	4809.285***	2626.233***	3867
S&P.T.B.C.3M.I	0.003	0.001	0.083	-0.054	0.007	3.111	21.002	58,456.327***	-5.015***	-4688.898***	11.576***	-9.452***	7354.276***	2994.184***	1741.504***	3867
S&P.T.BILL.3-6M. I	0.003	0.001	0.091	-0.075	0.008	2.532	24.224	76,715.376***	-6.707***	-4396.076***	10.071***	-10.978***	5343.62***	2174.563***	1293.416***	3867
S&P.T.BILL.C.6M. I	0.004	0.002	0.153	-0.131	0.011	1.852	33.169	148,859.572***	-8.671***	-4785.432***	6.596**	-12.678***	1575.928***	1740.612***	879.199***	3867
S&P.T.BILL.6-9M. I	0.003	0.001	0.299	-0.139	0.014	3.11	80.599	976,472.685***	-10.655***	-4696.791***	3.472***	-14.212***	729.134***	974.466***	598.503***	3867
S&P.T. BILL.9-12M.I	0.004	0.002	0.523	-0.268	0.023	2.937	94.138	1,343,881.837***	-13.187***	-4112.325***	1.416**	-16.499***	181.679***	1089.777***	655.04***	3867
S&P.G.BOND.I	-0.006	0.000	6.815	-3.782	0.519	0.843	20.041	47,246.391***	-15.833***	-3756.917***	0.31*	-19.755***	38.036***	1297.423***	850.942***	3867
S&P500.BI	0.001	0.001	2.051	-2.854	0.314	-0.57	10.475	9212.43***	-15.776***	-3841.36***	0.751***	-17.929***	55.146***	2107.214***	988.722***	3867

Note: The table provides an overview of the statistical properties regarding the daily returns of variables.

p* < 0.1; *p* < 0.05; ****p* < 0.001.

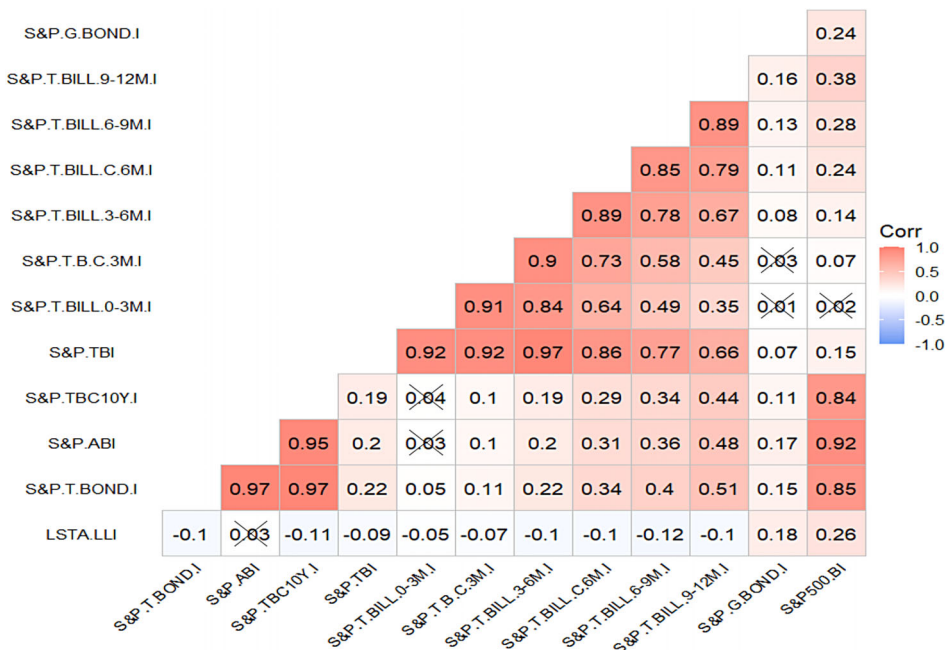


FIGURE 2 Cross-correlations among the U.S. economy's leveraged loan market, fixed-income T-bills, and long-term bonds from November 28, 2008 to October 3, 2023.

the cross-correlation measure does not account for the non-linear characteristics of the time-series or the extreme changes, we take a different approach in our empirical results.

4 | EMPIRICAL DISCUSSION

4.1 | Quantile connectedness measures

To gain a comprehensive understanding of the overall dynamic connectedness between the leveraged loan and debt markets, we utilize the QVAR approach to gauge the degree of spillover effects under different market conditions, such as bullish, bearish, and normal. Figure 3 provides a heat map visualization for the total dynamic connectedness, where the hotter shades indicate a high level of connectedness.

The substantial proportion of hot shades in the dynamic total connectedness plot implies significant interconnection across the leveraged loan market and the debt markets overall during the sample periods. An exception is detected around 2015, which coincides with the U.S. economy's imminent recession and a weaker global economy. Only the extreme market states are strongly connected during this time period. Otherwise, under different market conditions, there is a significant degree of interconnectedness between the leveraged loan and debt markets. For instance, we observe enhanced connectedness during the ongoing COVID-19 crisis, which is consistent with the literature for other asset markets (e.g., Khalfaoui et al., 2022; Naeem & Karim, 2021; Tiwari, Abakah, Adewuyi, & Lee, 2022; Tiwari, Abakah, Gabauer, & Dwumfour, 2022; Tiwari et al., 2023). As noted by Adekoya and Oliyide (2021), the epidemic has a negative impact on capital flows, credit transactions, and financial liquidity. These results can be attributed to fundamentals-based contagion (real and financial links) and pure contagion (spread of uncertainty and shocks) effects (Calvo & Reinhart, 1996; Eichengreen et al., 1996).

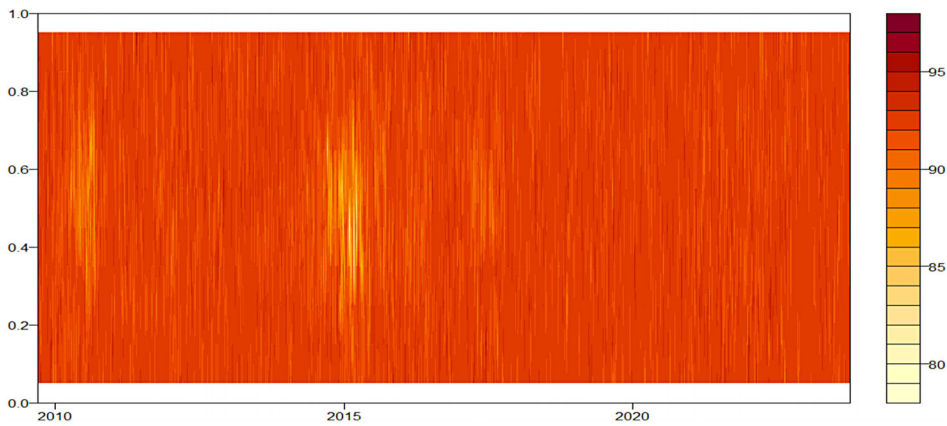


FIGURE 3 Dynamic total connectedness. The QVAR method is used to generate estimates with the specification of $k = 20$ and $p = 1$ in accordance with Ando et al. (2022).

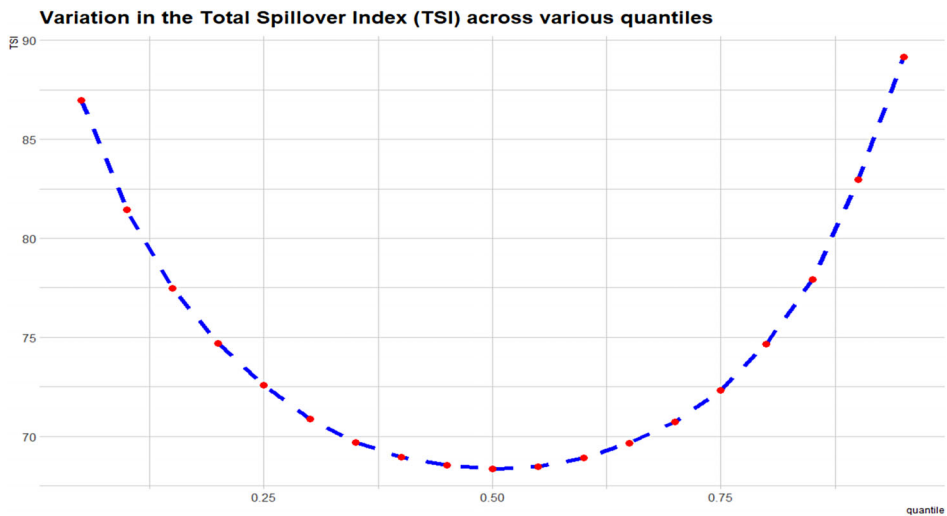


FIGURE 4 Variation in the total spillover index across different conditional quantiles.

We now focus on analyzing the evolution of total spillover index (TSI) averages across different quantiles. Figure 4 shows that the scale of connectivity between quantiles differs significantly. For quantile $q = 0.5$, the total average connectedness of the entire period is roughly 65%, indicating moderate connectedness under normal conditions. This degree of TSI climbs as we move to the extreme quantiles, indicating that large negative and positive shocks strengthen the network connectivity and accelerate the spread of risk spillovers among the considered markets. It is also observed that the connectedness across both markets is close to being symmetric. This is consistent with the findings of Angbazo et al. (1998), who showed that larger loans are connected with high-yield bond markets. Several factors can explain the strong interconnectedness between the syndicated and debt markets, such as changes in interest rates, credit market conditions, and investor behavior. When T-bill rates are low, for example, investors may seek bigger yields in the form of leveraged loans, which are more appealing. In contrast, rising T-bill rates diminish the degree of leveraged loans, which become less appealing.

Next, we shift to the net directional accuracy of each market in the system. Figure 5 presents the net directional results. The warmer shades on these graphs indicate a net-transmitting asset. The figure shows that the receiving/transmitting function of each asset varies according to several criteria (i.e., features of asset, state dependence, and events). During the period of study, short-term fixed-income securities (S&P.TBI, S&P.T.BILL.9-12M.I, and S&P.T.BILL.0-3M.I) exhibit more warm shades than any other asset, suggesting that they operate as net transmitters of shocks in the system. This result is consistent with the findings of Khalfaoui et al. (2022) during the COVID-29 crisis. In fact, shifts in short-term T-bill rates have an impact on the long-term bond and leveraged loan markets due to shifts in investor behavior, particularly when those investors alter their best portfolios and long-term expectations.

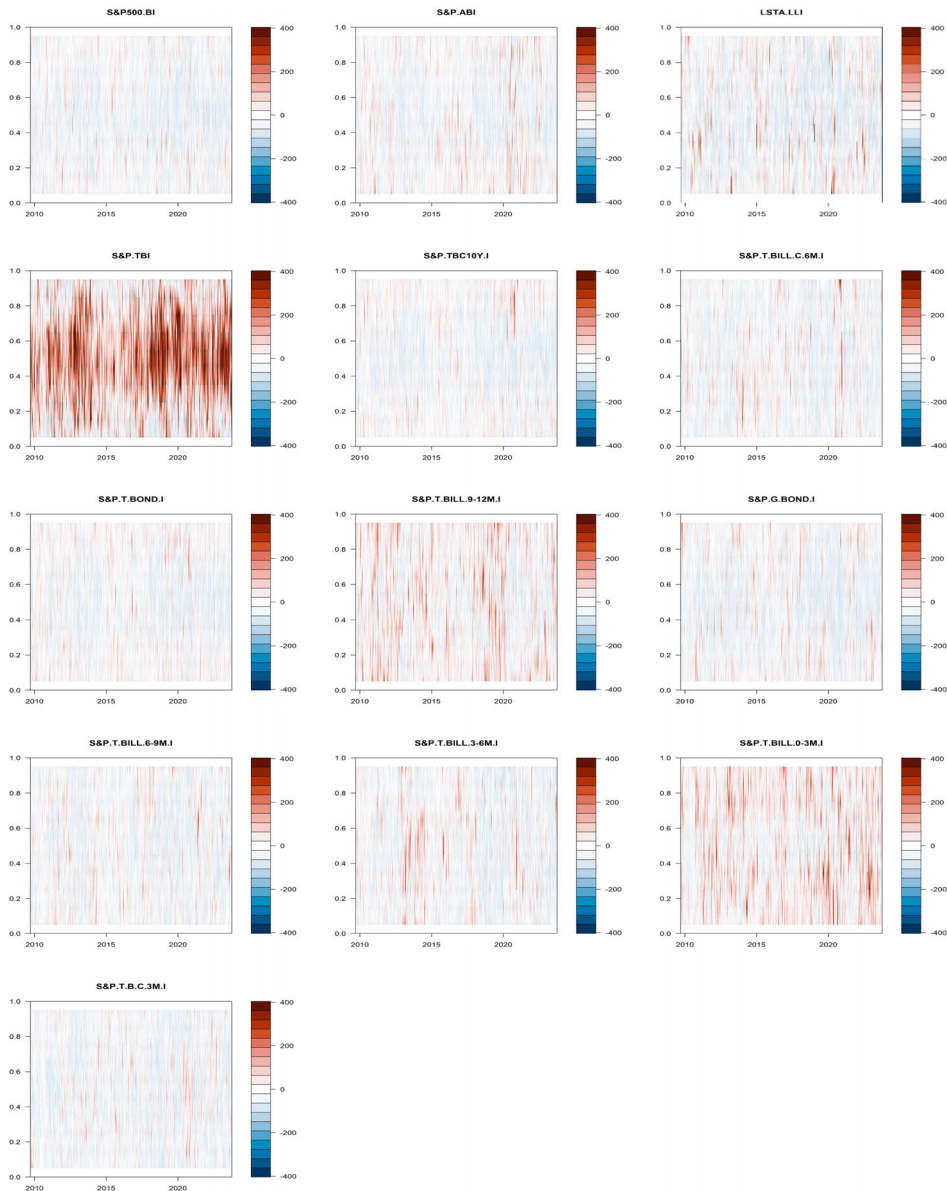


FIGURE 5 Net total directional connectedness. The 200-day rolling window QVAR method was used to generate estimates with the specification of $k = 20$ and $p = 1$ in accordance with Ando et al. (2022).

connection in both directions with the shortest- and longest-term bonds, with the exception of green bonds. Thus, from the portfolio construction perspective, investors should avoid using long-term bonds and leveraged loan indices together to form their portfolio in a normal market scenario, while green bonds are useful as a diversifier under bearish trends. Finally, under a bullish market situation, the pairwise linkages among pairs are complicated,¹ indicating that shocks propagate more intensely, which can be viewed as a threat to market price efficiency (Baumöhl & Shahzad, 2019). As a consequence, when determining an asset portfolio strategy and making hedging decisions, investors and fund managers should take into consideration these fluctuating relations among the examined markets.

We next focus on the behavior of the markets during the COVID-19 crisis in order to better comprehend the complicated connectedness between the investigated markets. It is well known that the recent health catastrophe was followed by a distinct economic crisis. During the initial outbreak of the pandemic catastrophe, the debt market and leveraged loans responded differently. While leveraged loans have faced challenges throughout the COVID-19 pandemic, the debt market has enjoyed a time of expansion. In order to encourage economic activity and maintain financial stability, the U.S. government and several firms expanded their borrowing to assist various relief initiatives and stabilize their finances. As a result, the issue of Treasury securities, corporate bonds, and municipal bonds increased dramatically. The Federal Reserve also dropped interest rates to historically low levels. Rates on U.S. government bonds fell as a result, which affected borrowing costs throughout the debt market. Investors, on the other hand, sought safety in U.S. Treasury bonds as a hedge against economic instability. This increased demand for government debt while keeping returns low.

In contrast, the leveraged loan sector, which involves lending to enterprises with poor credit ratings, had significant difficulty during the COVID-19 pandemic crisis. Many leveraged debtors failed to pay their financial obligations as the economy deteriorated. Furthermore, the economic uncertainties and business disruptions caused by the pandemic exacerbated the risk associated with leveraged loans. Companies with a high level of debt were more likely to default or be downgraded. As a result, some enterprises in need of liquidity participated in debt restructuring, including refinancing existing leveraged loans. Their judgment was influenced by the availability of low interest rates in the larger debt market. On the other hand, risk perceptions and economic forecasts influenced investor mood in both the U.S. debt and leveraged loan markets. The willingness of investors to take on risk, as well as their expectations for future economic situations, influenced the pricing and demand for leveraged loans and bonds. Government intervention through massive fiscal stimulus packages backed by debt issuances has also altered the relationship between the U.S. debt market and leveraged lending. These steps aimed to stabilize the overall economy while also indirectly assisting certain leveraged debtors by averting a total economic disaster.

5 | CONCLUSION

The dynamic connectedness between debt markets and other financial markets has been extensively studied in the past from cross-asset, cross-market, and cross-country perspectives because of its economic and financial significance. Among the related discussions, however, the leveraged loan market has seldom been mentioned in the literature. With the rapidly expanding leveraged loan market, there has been rising curiosity regarding how the leveraged loan market interacts with the various other debt markets. This paper fills this gap by using the QVAR technique to detect tail dependence between the U.S. leveraged loan and debt markets from November 28, 2008 to October 3, 2023. Unlike the mean-based connectivity measurements employed in the extant literature, the quantile connectedness approach is capable of capturing how different markets influence each other under different market conditions.

Overall, our empirical results reveal that the magnitude of connectedness is time and event dependent. We observe significant interconnection across the leveraged loan market and the debt markets overall during the sample periods, especially during the period of the COVID-19 pandemic. This is influenced by government interventions,

investor behavior, and economic conditions, and it had substantial ramifications for both the public and private sectors' financial stability throughout the crisis. Market participants and portfolio investors can benefit from the connectedness mechanism between markets to construct investment strategies with better portfolios under different market scenarios. These findings imply that the leveraged loan markets' diversification potential and safe haven properties are not available to investors in the U.S. debt markets. Policymakers should also be aware of the network structure and dynamic changes of shock spillovers, particularly during extreme market conditions.

In addition, we also find the dominance of short-term fixed-income instruments over leveraged loans and long-term bonds suggesting that short-term fixed-income instruments act as a price discovery tool for other markets. These findings present vital implications as they can provide insight to investors that adequate attention should be paid to the shock spillover effects transmitted from the short-term fixed-income market in investment practice. They should closely monitor shocks in the short-term fixed-income instruments and adjust their investment portfolios accordingly in order to minimize or eliminate market risks. Policymakers should be aware of the network structure and dynamic changes of shock spillovers, particularly during extreme market conditions.

ACKNOWLEDGMENTS

We would like to thank the editor and anonymous referees for their highly constructive suggestions. Nader Trabelsi and Aviral Tiwari extend their appreciation to the Deanship of Scientific Research at Imam Mohammad Ibn Saud Islamic University (IMSIU) for funding and supporting this work through Research Partnership Program no. RP-21-10-03.

CONFLICT OF INTEREST STATEMENT

The authors declare that we have no relevant or material financial interests that relate to the research described in this paper.

ORCID

Aviral Kumar Tiwari  <https://orcid.org/0000-0002-1822-9263>

Emmanuel Joel Aikins Abakah  <https://orcid.org/0000-0003-1472-0722>

Chi-Chuan Lee  <https://orcid.org/0000-0003-0644-1168>

ENDNOTE

¹ Table A1 in the appendix describes the numerical pairwise directional connectivity among the different pairs.

REFERENCES

- Abakah, E. J. A., Addo, E., Jr., Gil-Alana, L. A., & Tiwari, A. K. (2021). Re-examination of international bond market dependence: Evidence from a pair copula approach. *International Review of Financial Analysis*, 74, 101678.
- Abakah, E. J. A., Gil-Alana, L. A., Arthur, E. K., & Tiwari, A. K. (2022). Measuring volatility persistence in leveraged loan markets in the presence of structural breaks. *International Review of Economics & Finance*, 78, 141–152.
- Abakah, E. J. A., Nasreen, S., Tiwari, A. K., & Lee, C. C. (2023). U.S. leveraged loan and debt markets: Implications for optimal portfolio and hedging. *International Review of Financial Analysis*, 87, 102514.
- Abakah, E. J. A., Tiwari, A. K., Lee, C. C., & Ntow-Gyamfi, M. (2023). Quantile price convergence and spillover effects among Bitcoin, Fintech, and artificial intelligence stocks. *International Review of Finance*, 23(2), 187–205.
- Adekoya, O. B., & Oliyide, J. A. (2021). How COVID-19 drives connectedness among commodity and financial markets: Evidence from TVP-VAR and causality-in-quantiles techniques. *Resources Policy*, 70, 101898.
- Ahmad, W., Mishra, A. V., & Daly, K. J. (2018). Financial connectedness of BRICS and global sovereign bond markets. *Emerging Markets Review*, 37, 1–16.
- Ando, T., Greenwood-Nimmo, M., & Shin, Y. (2022). Quantile connectedness: Modelling tail behaviour in the topology of financial networks. *Management Science*, 68(4), 2401–2431.
- Anghazo, L. A., Mei, J., & Saunders, A. (1998). Credit spreads in the market for highly leveraged transaction loans. *Journal of Banking & Finance*, 22(10–11), 1249–1282.

- Antonakakis, N., Chatziantoniou, I., & Gabauer, D. (2017). Refined measures of dynamic connectedness based on TVP-VAR. *Journal of Risk and Financial Management*, 13(4), 84.
- Balli, F., Billah, M., Balli, H. O., & De Bruin, A. (2022). Spillovers between Sukuks and Shariah-compliant equity markets. *Pacific-Basin Finance Journal*, 72, 101725.
- Baumöhl, E., & Shahzad, S. J. H. (2019). Quantile coherency networks of international stock markets. *Finance Research Letters*, 31, 119–129.
- Bouri, E., Demirer, R., Gabauer, D., & Gupta, R. (2022). Financial market connectedness: The role of investors' happiness. *Finance Research Letters*, 22, 102075.
- Calvo, S., & Reinhart, C. (1996). Capital flows to Latin America: Is there evidence of contagion effects? In G. Calvo, M. Goldstein, & E. Hochreiter (Eds.), *Private capital flows to emerging markets after the Mexican crisis*. Institute for International Economics.
- Dahlquist, M., & Hasseltoft, H. (2013). International bond risk premia. *Journal of International Economics*, 95(1), 17–32.
- Diebold, F. X., & Yilmaz, K. (2012). Better to give than to receive: Predictive directional measurement of volatility spillovers. *International Journal of Forecasting*, 28(1), 57–66.
- Eichengreen, B., Rose, A. K., & Wyplosz, C. (1996). Contagious currency crises. *Scandinavian Journal of Economics*, 98(4), 463–484.
- Gil-Alana, L. A., Abakah, E. J. A., & Rojo, M. F. R. (2020). Cryptocurrencies and stock market indices. Are they related? *Research in International Business and Finance*, 51, 101063.
- Gil-Alana, L. A., Carcel, H., & Abakah, E. J. A. (2018). On the linkages between Africa's emerging equity markets and global markets: Evidence from fractional integration and cointegration. *Review of Development Finance*, 8(2), 96–105.
- Gold, M. L., Leat, C. A., & Perrin, M. (1997). Senior secured floating-rate bank loans for life insurance company investment portfolios. *Financial Analysts Journal*, 53(2), 47–54.
- Hogan, K., Kish, R., & Webster, E. (2006). The benefits of holding leveraged loans as part of a diversified portfolio. *Journal of Financial Education*, 32, 97–106.
- Hu, Z., & Sun, P. W. (2021). Connectedness among stocks and tail risk: Evidence from China. *International Review of Finance*, 21(4), 1179–1202.
- Khalfaoui, R., Jabeur, S. B., & Dogan, B. (2022). The spillover effects and connectedness among green commodities, bitcoins, and US stock markets: Evidence from the quantile VAR network. *Journal of Environmental Management*, 306, 114493.
- Kwiatkowski, D., Phillips, P. C. B., Schmidt, P., & Shin, Y. (1992). Testing the null hypothesis of stationarity against the alternative of a unit root: How sure are we that economic time series have a unit root? *Journal of Econometrics*, 54(1–3), 159–178.
- Le, T. H., Do, H. X., Nguyen, D. K., & Sensoy, A. (2021). Covid-19 pandemic and tail-dependency networks of financial assets. *Finance Research Letters*, 38, 101800.
- Le, T. L., Abakah, E. J. A., & Tiwari, A. K. (2021). Time and frequency domain connectedness and spill-over among fintech, green bonds and cryptocurrencies in the age of the fourth industrial revolution. *Technological Forecasting and Social Change*, 162, 120382.
- Lee, C. C., & Lee, C. C. (2023). International spillovers of U.S. monetary uncertainty and equity market volatility to China's stock markets. *Journal of Asian Economics*, 84, 101575.
- Lee, C. C., Lee, C. C., & Li, Y. Y. (2021). Oil price shocks, geopolitical risks, and green bond market dynamics. *North American Journal of Economics and Finance*, 55, 101309.
- Lee, C. C., Tang, H., & Li, D. (2022). The roles of oil shocks and geopolitical uncertainties on China's green bond returns. *Economic Analysis and Policy*, 74, 494–505.
- Lee, C. C., Yu, C. H., & Zhang, J. (2023). Heterogeneous dependence among cryptocurrency, green bonds, and sustainable equity: New insights from granger-causality in quantiles analysis. *International Review of Economics & Finance*, 87, 99–109.
- Mählmann, T. (2022). Negative externalities of mutual fund instability: Evidence from leveraged loan funds. *Journal of Banking & Finance*, 134, 106328.
- Mensi, W., Sensoy, A., Aslan, A., & Kang, S. H. (2019). High-frequency asymmetric volatility connectedness between bitcoin and major precious metals markets. *North American Journal of Economics and Finance*, 51, 101031.
- Naeem, M. A., & Karim, S. (2021). Tail dependence between bitcoin and green financial assets. *Economics Letters*, 208, 110068.
- Nguyen, T. T. H., Naeem, M. A., Balli, F., Balli, H. O., & Vo, X. V. (2021). Time-frequency comovement among green bonds, stocks, commodities, clean energy, and conventional bonds. *Finance Research Letters*, 40, 101739.
- Pirgaip, B., Arslan-Ayaydin, Ö., & Karan, M. B. (2021). Do Sukuk provide diversification benefits to conventional bond investors? Evidence from Turkey. *Global Finance Journal*, 50, 100533.
- Reboredo, J. C. (2018). Green bond and financial markets: Co-movement, diversification and price spillover effects. *Energy Economics*, 74, 38–50.

- Reboredo, J. C., & Ugolini, A. (2020). Price connectedness between green bond and financial markets. *Economic Modelling*, 88, 25–38.
- Tiwari, A. K., Abakah, E. J. A., Adewuyi, A. O., & Lee, C. C. (2022). Quantile risk spillovers between energy and agricultural commodity markets: Evidence from pre and during COVID-19 outbreak. *Energy Economics*, 113, 106235.
- Tiwari, A. K., Abakah, E. J. A., Gabauer, D., & Dwumfour, R. A. (2022). Dynamic spillover effects among green bond, renewable energy stocks and carbon markets during COVID-19 pandemic: Implications for hedging and investments strategies. *Global Finance Journal*, 51, 100692.
- Tiwari, A. K., Abakah, E. J. A., Shao, X., Le, T. L., & Gyamfi, M. N. (2023). Financial technology stocks, green financial assets, and energy markets: A quantile causality and dependence analysis. *Energy Economics*, 118, 106498.
- Tsang, A., Yiu, M. S., & Nguyen, H. T. (2021). Spillover across sovereign bond markets between the US and ASEAN4 economies. *Journal of Asian Economics*, 76, 101343.
- Umar, Z., Manel, Y., Riaz, Y., & Gubareva, M. (2021). Return and volatility transmission between emerging markets and US debt throughout the pandemic crisis. *Pacific-Basin Finance Journal*, 67, 101563.
- Yunus, N. (2023). Co-movement among oil, stock, bond, and housing markets: An analysis of U.S., Asian, and European economies. *International Review of Finance*, 23(2), 393–436.
- Zaremba, A., Kizys, R., Aharon, D. Y., & Umar, Z. (2022). Term spreads and the COVID-19 pandemic: Evidence from international sovereign bond markets. *Finance Research Letters*, 44, 102042.
- Zhang, Y. J., Bouri, E., Gupta, R., & Ma, S. J. (2021). Risk spillover between bitcoin and conventional financial markets: An expectile-based approach. *North American Journal of Economics and Finance*, 55, 101296.
- Zivot, E., & Andrews, D. W. K. (1992). Further evidence on the great crash, the oil-price shock, and the unit-root hypothesis. *Journal of Business & Economic Statistics*, 10(3), 251–270.

How to cite this article: Tiwari, A. K., Trabelsi, N., Abakah, E. J. A., & Lee, C.-C. (2023). Analyzing time-varying tail dependence between leveraged loan and debt markets in the U.S. economy. *International Review of Finance*, 1–17. <https://doi.org/10.1111/irfi.12441>

APPENDIX A

TABLE A1 Quantile pairwise directional connection.

LSTALLI	S&P.T.BOND.J	S&P.ABI	S&P.TBC10Y.J	S&P.TBI	S&P.T.BILL.0-		S&P.T.BILL.3-		S&P.T.BILL.6-			S&P.T.BILL.9-		
					3M.J	S&P.T.BC.3M.J	6M.J	S&P.T.BILL.6M.J	9M.J	12M.J	S&P.G.BOND.J	S&P.500BI	FROM	
LSTALLI	86.8	1.5	0.1	1.7	0.5	0.1	0.4	0.6	0.5	0.6	4	2.5	13.2	
	(10.8, 1.2)	(7.7, 2.4)	(8.3, 1.8)	(7.4, 1)	(6.4, 19)	(6.8, 20.2)	(6.9, 13.7)	(6.8, 11.1)	(7.1, 9.2)	(8.2, 8)	(6.8, 1.5)	(8.8, 1.7)	(89.2, 98.8)	
S&P.T.BOND.J	0.4	22	20.6	20.5	2.7	0.4	0.8	2.2	3.3	4	0.6	16.5	78	
	(3.4, 1.2)	(11.9, 2.6)	(11.7, 2)	(11.5, 1.1)	(6, 18.7)	(4.4, 20.1)	(5.6, 13.7)	(6.3, 11.1)	(6.8, 9.2)	(7.1, 8.9)	(6.7, 1.6)	(11.1, 1.8)	(88.1, 97.4)	
S&P.ABI	0.4	20.7	22.1	20.1	2.3	0.3	0.6	1.9	2.9	3.5	0.8	19	77.9	
	(3.8, 1.3)	(11.5, 2.6)	(11.9, 2)	(11.3, 1.2)	(5.8, 18.6)	(4.2, 20)	(5.3, 13.6)	(6.3, 11.1)	(6.7, 9.2)	(7.2, 8.9)	(6.9, 1.7)	(11.3, 1.9)	(88.1, 98)	
S&P.TBC10Y.J	0.5	21.9	21.3	23.5	2.1	0.3	0.6	1.8	2.6	3.1	0.4	17.2	76.5	
	(3.4, 1.2)	(12, 2.6)	(12.2)	(12.3, 1.1)	(5.7, 18.7)	(4.2, 20.1)	(5.3, 13.7)	(6, 11.1)	(6.6, 9.2)	(6.9, 8.9)	(6.9, 1.6)	(11.3, 1.8)	(87.7, 98.9)	
S&P.TBI	0.1	1.7	1.5	1.2	18.3	17.8	13.5	15.7	11	9.7	0.2	1	81.7	
	(2.1, 1.3)	(5.7, 2.8)	(5.6, 2.2)	(5, 1.3)	(11.7, 18.1)	(10.5, 20.3)	(10.4, 13.7)	(11.1, 11.2)	(9.9, 9.2)	(9.8, 8.6)	(3.8, 1.8)	(5.4, 2.1)	(88.3, 81.9)	
S&P.T.BILL.0- 3M.J	0.1	0.2	0.2	0.2	20.1	34.6	18.7	13.9	6.2	3.6	2.1	0	65.4	
	(2.4, 1.9)	(4.8, 3.9)	(4.8, 3.7)	(4.1, 2.9)	(12.6, 14.5)	(15.2, 20.2)	(12.4, 13.3)	(11, 11.2)	(8.8, 8.9)	(8.5, 6.9)	(7.2, 5.7)	(3.4, 3.1)	(84.8, 79.8)	
S&P.T.BC.3M.J	0.1	0.6	0.5	0.4	17.8	22	24.1	15.7	8.9	5.7	0	0.4	75.9	
	(2.5, 2.4)	(5.8, 5.3)	(5.6, 5.5)	(5.1, 5.2)	(11, 11.7)	(10.8, 14.7)	(13, 12.4)	(10.8, 10.6)	(9.3, 8.8)	(8.6, 7.2)	(7.8, 6.4)	(3.9, 4.5)	(87, 87.6)	
S&P.T.BILL.3- 6M.J	0.1	1.5	1.3	1.1	17.8	14.3	13.5	18.2	12.7	10.2	0.2	0.9	81.8	
	(2.2, 1.2)	(5.9, 2.4)	(5.8, 1.8)	(5.2, 1.1)	(11.3, 19.5)	(9.3, 18.9)	(10.2, 13.4)	(11.8, 11)	(10.3, 9.2)	(9.7, 9.7)	(8.8, 8.9)	(4.1, 1.5)	(88.2, 89)	
S&P.T.BILL.C	0.2	2.7	2.4	2	14.8	8	9.1	15.2	18.9	13.1	0.3	1.6	81.1	
	(2.5, 1.2)	(6.7, 2.5)	(6.6, 1.9)	(5.9, 1.1)	(9.9, 19.3)	(7.7, 19)	(8.6, 13.4)	(10.3, 11)	(11.3, 9.3)	(10.1, 9.5)	(9.7, 8.7)	(4.5, 1.5)	(88.7, 90.7)	
S&P.T.BILL.6- 9M.J	0.2	3.6	3.1	2.6	14	4.9	6.2	13.1	14.1	20.1	0.4	2.1	79.9	
	(2.6, 1.2)	(6.7, 2.6)	(6.7, 2)	(6, 1.2)	(9.7, 19.2)	(7.5, 18.4)	(8.2, 13.1)	(9.6, 10.9)	(9.8, 9.3)	(11.6, 9.8)	(10.6, 9)	(4.6, 1.6)	(88.4, 90.2)	
S&P.T.BILL.9- 12M.J	0.2	5.6	5.1	4.2	12.2	2.9	4.4	10.8	13.2	16.5	0.6	3.5	79.1	
	(2.3, 1.2)	(7.4, 2.7)	(7.3, 2.1)	(6.6, 1.3)	(9.3, 19.1)	(6.5, 18.3)	(7.5, 13)	(9.2, 10.8)	(9.8, 9.3)	(10.7, 9.7)	(12, 9.1)	(4.6, 1.6)	(88, 90.9)	

TABLE A1 (Continued)

LSTALLI	S&P.T.BOND.J	S&P.ABI	S&P.TBC10Y.J	S&P.TBI	S&P.T.BILL.0-			S&P.T.BILL.3-			S&P.T.BILL.6-			S&P.T.BILL.9-			FROM
					3M.I	S&P.T.BILL.0-	S&P.T.BC.3M.I	6M.I	S&P.T.BILL.3-	S&P.T.BILL.6M.I	9M.I	S&P.T.BILL.6-	12M.I	S&P.T.BILL.9-	S&P.G.BOND.J	S&P500.BI	
S&P.G.BOND.J	3.3	2.3	3	1.3	1.1	0.1	0.2	1.1	1.4	1.6	2.5	76.7	5.4	23.3			
	(5.1, 1.2)	(9.1, 2.6)	(9.5, 2)	(9, 1.1)	(5.9, 18.7)	(5, 20.1)	(5.7, 13.7)	(6.5, 11.1)	(6.9, 9.2)	(7.6, 8.9)	(7.9, 7.9)	(12.3, 1.7)	(9.6, 1.8)	(87.7, 98.3)			
S&P500.BI	1.8	18.8	21.4	18.3	1.8	0.2	0.5	1.5	2.2	2.7	4.2	1.8	24.8	75.2			
	(4.5, 1.3)	(10.4, 2.6)	(10.8, 2)	(10.1, 1.2)	(6.1, 18.6)	(5.4, 20.1)	(6.2, 13.6)	(6.4, 11.1)	(6.9, 9.2)	(7.3, 8.8)	(7.9, 7.9)	(6.7, 1.7)	(11.2, 1.9)	(88.8, 98.1)			
TO	7.2	81	80.5	73.8	107.1	71.4	68.6	93.6	78.9	74.2	73.1	9.3	70.2	888.9			
	(36.8, 16.5)	(93.8, 35.1)	(94.7, 28.8)	(87.1, 19.7)	(99.6, 215.5)	(82.2, 230.2)	(92.1, 161.9)	(100.3, 132.4)	(99.1, 109.8)	(101.2, 105)	(100.2, 93.8)	(62.9, 23.8)	(92.9, 27.2)	(1143, 1195.7)			
NET	-5.9	3.1	2.6	-2.7	25.4	6	-7.3	11.8	-2.2	-5.7	-6.1	-14	-4.9				
	(-52.4, -82.3)	(5.7, -62.3)	(6.6, -69.1)	(-0.6, -79.2)	(11.3, 133.6)	(-2.5, 150.4)	(51.74, 2)	(12, 43.4)	(10.4, 19.1)	(12.8, 14.8)	(12.2, 2.9)	(-24.8, -74.6)	(4.1, -70.9)				
NPDC	1	5	3	3	12	11	9	10	8	7	6	1	2	TCI = 68.4			
	(0, 1)	(5, 5)	(6, 4)	(2, 0)	(11, 10)	(4, 12)	(5, 11)	(9, 9)	(10, 7)	(12, 8)	(8, 6)	(1, 2)	(5, 3)	(87.9, 92.3)			

Note: The 200-day rolling window QVAR method was used to generate estimates with the specification of $k = 20$ and $p = 1$. The values at the top, left bottom, and right bottom in the field are connectedness measures for $\tau = 0.5, 0.05$, and 0.95, respectively.