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CONNECTEDNESS OF VIETNAMESE BANK STOCK RETURNS UNDER THE IMPACT OF THE COVID-19 PANDEMIC

Abstract

The COVID-19 pandemic highlighted the sensitivity of connectedness among bank stock returns in Vietnam. The aim of this study is to examine the strength of this connectedness along with the effect of government lockdown policy and COVID-19 cases on the total connectedness index (TCI) of 16 listed banks on Vietnamese stock exchanges. They are assessed using the database of FiinPro on the banking sector between January 2020 and July 2022, Vietnam Center for Disease Control and Prevention (CDC), and The World Health Organization (WHO) on the COVID-19 pandemic, employing a time-varying-parameter vector autoregressive (TVP-VAR) connectedness framework and the conditional quantile regression model.

The results show that at the firm level, there is strong interdependence among bank stock returns with the average TCI being as high as 90.66%. It is also revealed that medium and large-sized banks are receivers of shock, while smaller banks are transmitters. As far as the impact on TCI is concerned, the widespread of the pandemic with the increasing number of COVID-19 cases is significantly negative, whereas the tightening of lockdown is significantly positive. Besides, the degree of the impact varies according to the 95th, 75th, 50th and 25th levels of conditional quantile regression. Based on the study's findings, individual investors are recommended to thoroughly analyze the connectedness of banks before making investment decisions, while bank regulators should strengthen controls on credit relationships with small banks. Regarding policy makers, it is proposed to apply flexible restrictions and short-term lockdown depending on the actual outbreak of the pandemic.

Keywords banks, stock returns, COVID-19 pandemic, connectedness, TVP-VAR

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INTRODUCTION

The constant development of financial products offered on the financial markets, as well as the increasing volume and complexity of risk transfer, have led to a highly interconnected network of financial institutions, including banks in Vietnam. As the most representatives of the banking network, listed Vietnamese banks have been active with promoting the movement of capital flows between Ho Chi Minh Stock Exchange (HOSE) and Hanoi Stock Exchange (HNX), however, external shocks such as the unprecedented outbreak of COVID-19 had caused disruptions in credit provision and accelerated the vulnerability of bank stocks.

In the context of accelerating tensions caused by the COVID-19 disease, individual investors who hold majority of bank stocks were observed to have the most behavioral biases, leading to strong fluctuations in the market. In the meanwhile, concerns about concentration risks in the banking sector due to nonperforming loans and systemic risks were intensified among bankers and regulators. Bank stocks his-

torically exhibit market volatility, and the COVID-19 pandemic exacerbated the impacts on the connectedness among Vietnamese bank stock returns.

To better understand the behavior of bank stocks and provisioning effective management for banks, a study of Vietnamese banks should be taken into consideration, especially since the Vietnamese stock markets has been upgraded from the frontier level to emerging market status (FTSE Russell, 2022).

1. LITERATURE REVIEW

In the last ten years, studies on the connectedness among bank stock returns have been carried out at both national and global levels, and different methodological approaches have been applied. Using directional spillover and tail-event driven network risk, Apostolakis et al. (2022) conclude that the connectedness of bank stock returns in the Economics and Monetary Union of Europe is stronger during the sovereign debt crisis, while Hernandez et al. (2020) emphasize that shock transmission tends to be stronger in developed markets compared to emerging markets. Niţoi and Pochea (2022) employ the Granger causality test with confirmation that American banks are transmitters of idiosyncratic return spillovers and European banks are net receivers, especially those having strong links with American financial markets such as the UK and Switzerland. Tabak et al. (2022) utilize the generalized value at risk to establish the mean spillover effect of banking network and discover that markets in developed countries tend to be the transmitters of shock, whereas those in emerging countries tend to be the receivers. Rehman et al. (2022) use partial correlation and minimum span tree with similar conclusions that scale expansion of international banks during the 21st century promotes transmission of shocks from the parent corporations headquartered in developed markets to their international branches located in emerging markets. With the same objectives to examine transmitter of shocks, Qian et al. (2022) apply the partial cross-quantile (PCQ) method concentrating more on the correlation to varying quantiles between two-time series, and Diebold and Yilmaz (2014) employ the time varying parameters vector autoregressive (TVP-VAR) model to measures the spillover during the whole period rather than focusing on quantiles. Both PCQ and TVP-VAR have advantages over other traditional approaches because they improve capacity to accurately depict the interconnectedness of bank stock returns while fully accounting for the time-varying connection among various components of the return distributions.

A number of factors have been examined to explain the interrelationship among bank stock returns. For example, linkages among banks are affected by bank characteristics, market share, economic restrictions, trade controls, size of the economy (Aliani et al., 2022; Foglia & Angelini, 2020, Song et al., 2020). Some studies conclude that due to these determinants, the connectedness among bank stocks increased during the Global Financial Crisis 2007–2009 and the European Debt Crisis 2009–2010 (Demirer et al., 2018), as well as the stock market crashes (Chen et al., 2020).

Recently, research on proximity and degree of interconnectedness among bank stock returns highlights the severity of the COVID-19 pandemic as an exogenous factor among all the others (Khalfaoui et al., 2023; Mensi et al., 2023; S. F. Razmi & S. M. Razmi, 2023; Tran & Uzmanoglu, 2023). Specifically, the pandemic led to dramatic volatility in stock prices and increased risks in both global and individual stock markets (Zhang et al., 2020). The appearance of COVID-19 contributes to an increase in the total connectedness among stock markets (Rizwan et al., 2022; Uddin et al., 2022), among stock sectors (Shahzad et al., 2021), and among financial assets (Mensi et al., 2023). These findings, therefore, indicate a strong return integration among financial assets and a rise in systematic risk during the COVID-19 pandemic. Moreover, Uddin et al. (2022) emphasize that the increase in interconnectedness due to the outbreak of COVID-19 tends to be more considerable over one to two months. According to these researchers, the daily new COVID-19 confirmed cases and the daily new COVID-19 death cases are representative indicators for the severity of COVID-19 (Dong et al., 2022; Hanif et al., 2021). Besides, a combination of the TVP-VAR

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and frequency connectedness method to measure the effect of the COVID-19 on the connectedness among stock returns can interpret more clearly the effect in daily time series basis (Akyildirim et al., 2022; Bouri et al., 2021).

The extant literature lays the foundations for this study on the connectedness of Vietnam bank stock returns applied to cases of listed banks during the COVID-19 pandemic. First, empirical evidence shows that the financial sector contributes to systemic risk owing to its many counterparts, among which banks are the largest emitters of risk. Second, the spillover effect measured by the changes of the bank connectedness index is clearly applied in emerging countries and intensified during the COVID-19 pandemic. While there is a variety of quantitative research applied for similar objectives, there is a paucity of studies focusing on connectedness among bank stock returns at firm level and incorporating with indicators of COVID-19 as an exogenous factor.

Ultimately, the study aims to evaluate the strength of connectedness among bank stock returns with the application of the TVP-VAR method, then evaluate the impact of COVID-19 on the total connectedness of the bank stock return using the conditional quantile regression during the time between January 2020 to July 2022. Based on test results, it addresses important issues on providing insights for individual investors, bank regulators and policy makers to assist their understanding of changes in connectedness of bank stock returns under external shocks.

2. DATA AND METHODOLOGY

2.1. Data

For the purposes of measuring the connectedness among Vietnamese bank stock returns, data on 16 out of 19 listed banks[1] were collected from the *FiinPro Database*, one of the comprehensive and insightful financial databases in Vietnam. For the estimation of COVID-19, the number of SARS-CoV-2 cases and the government's lockdown policy in Vietnam is sourced from the website of the *World Health Organization*[2] *(WHO)*. The study sample running from January 30, 2020 to July 29, 2022 is selected since it covers the time period from the first emergence of SARS-CoV-2 cases in Vietnam to one year after the Vietnamese government implemented the "new normal"[3] or "living with epidemic" solution (Vietnamese Government, 2021). The data on lockdown and restrictions are collected from the *Vietnam Center for Disease Control and Prevention (CDC).* After one year of implementing the "new normal", Vietnamese residents have become familiar with the SARS-CoV-2 epidemic in society; therefore, the effects of the epidemiological disease are no longer as pronounced as in the previous period.

2.2. Methodology

This study is carried out in two phases. The first establishes the connectedness index among bank stock returns, which includes three steps. First, the TVP-VAR technique developed by Antonakakis and Gabauer (2017) is exploited to investigate the connection among bank stock returns in a time-varying way. The TVP-VAR(p) model is as follows:

$$\begin{aligned} y_t &= \beta_t z_{t-1} + \varepsilon_t, \\ \varepsilon_t &\mid F_{t-1} \sim N\left(0, S_t\right), \end{aligned} \tag{1}$$

$$\begin{aligned} vec\left(\beta_t\right) &= vec\left(\beta_{t-1}\right) + v_t, \\ v_t &\mid F_{t-1} \sim N\left(0, R_t\right), \end{aligned} \tag{2}$$

where y_t and $z_{t-1} = [y_{t-1}, ..., y_{t-p}]'$ respectively represent $N \times 1$ and $Np \times 1$ dimensional vectors. β_t is an $N \times Np$ dimensional coefficient matrix and ε_t is an $Np \times 1$ dimensional vector of serially uncorrelated error terms.

Second, the Wold representation theorem is used to transform the TVP-VAR into time varying pa-

1 At the time of the study, there are 03 new listed banks, namely MSB, OCB and SSB, that do not have much impact since their total market capitalization merely accounts for 4.8 percent of the whole banking industry. The list of 16 candidates includes 13 private banks and 03 state-owned banks. The listed stock codes include ACB, BAB, EIB, HDB, LPB, MBB, NVB, SHB, STB, TCB, VIB and VPB, while these of 03 state-owned banks include BID, CTG and VCB.

2 Data is collected from the website https://covid19.who.int/data.

3 The "new normal" strategy means that people are fighting against the COVID–19 pandemic while at the same time recovering and developing the economy.

rameter vector moving average (TVP-VMA) model. Then, the generalized impulse response functions (GIRF) (Pesaran & Shin, 1998) can be computed as

$$\omega_{j,t}^{g}(H)=\frac{A_{J,t}S_t\varepsilon_{j,t}}{\sqrt{S_{ij,t}}}\frac{\delta_{j,t}}{\sqrt{S_{ij,t}}},\quad \delta_{j,t}=\sqrt{S_{ij,t}}, \tag{3}$$

where $\omega_{j,t}^{g}(H)$ is the GIRFs of variable j, H is the forecast horizon. The GFEVD gives insights into the variance share that one variable has on others, and is demonstrated as:

$$\tilde{\omega}_{ij,t}^{g}(H)=\frac{\sum_{t=1}^{J-1}\omega_{ij,t}^{2,g}}{\sum_{j=1}^{N}\sum_{t=1}^{J-1}\omega_{ij,t}^{2,g}},$$
$$\text{with}\quad \sum_{j=1}^{N}\tilde{\omega}_{ij,t}^{g}(J)=1, \tag{4}$$
$$\text{and}\quad \sum_{i,j=1}^{N}\tilde{\omega}_{ij,t}^{N}(J)=N.$$

Next, the Total Connectedness Index (TCI) is established as follows:

$$TCI_t^{g}(H)=\frac{\sum_{i,j=1,i\neq j}^{N}\tilde{\omega}_{ij,t}^{g}(H)}{\sum_{i,j=1}^{N}\tilde{\omega}_{ij,t}^{g}(H)}\cdot 100=$$
$$=\frac{\sum_{i,j=1,i\neq j}^{N}\tilde{\omega}_{ij,t}^{g}(H)}{N}\cdot 100. \tag{5}$$

Third, as it was shown in the study by Antonakakis and Gabauer (2017), changes in one variable spillover on other variables can be analyzed via the below indicators:

- The total directional connection to others (TO), or the shock from variable i to all other variables j, is calculated as:

$$C_{i\to j,t}^{g}(H)=\frac{\sum_{i,j=1,i\neq j}^{N}\tilde{\omega}_{ij,t}^{g}(H)}{\sum_{j=1}^{N}\tilde{\omega}_{ij,t}^{g}(H)}\cdot 100. \tag{6}$$

- The total directional connectivity from others (FROM), or the shock that variable i receives from all other variables j, is derived as:

$$C_{i\leftarrow j,t}^{g}(H)=\frac{\sum_{i,j=1,i\neq j}^{N}\tilde{\omega}_{ij,t}^{g}(H)}{\sum_{j=1}^{N}\tilde{\omega}_{ji,t}^{g}(H)}\cdot 100, \tag{7}$$

- The NET total directional connectedness (NET) is calculated as the difference between TO and FROM:

$$NET_{i,t}^{g}=C_{i\to j,t}^{g}(H)-C_{i\leftarrow j,t}^{g}(H). \tag{8}$$

A variable with a positive NET influences the network more than being influenced by the network. In this case, this variable is called a shock transmitter, otherwise, it is called a shock receiver.

The second phase examines the impact of COVID-19 on the connectedness among bank stock returns and includes two steps. First, the role played by COVID-19 in the spillover of bank stock returns is investigated and the regression model is suggested as follows:

$$TCI_t=\beta_0+\beta_1 COVIDCASE_t+$$
$$+\beta_2 LOCKDOWN_t+ \tag{9}$$
$$+\beta_3 TURNOVER_t+\varepsilon_t,$$

where TCI_t, $COVIDCASE_t$, $LOCKDOWN_t$, $TURNOVER_t$ and ε_t are proposed and explained in Table 1.

Table 1. Variables used in regression models

Variables	Details
TCI_t	The total connectedness of stock returns of 16 listed banks measured on day *t*, obtained from Equation (5)
$Q_{qt}(y\|x)$	The conditional quantile point for the distribution of TCI on day *t* with a set of x covariates, including $COVIDCASE_t$, $LOCKDOWN_t$, and $TURNOVER_t$
$COVIDCASE_t$	The number of SARS-CoV-2 cases in Vietnam, which is reported by The World Health Organization on day *t*
$LOCKDOWN_t$	The dummy variable, which equals 1 if the lockdown policy is enacted at the time *t*, otherwise it is equal to 0 if the lockdown policy is lifted
$TURNOVER_t$	The ratio calculated by dividing the total number of 16 listed bank stocks traded during day *t* by the average number of bank shares outstanding for day *t*
ε_t	The error term applied on day *t*

Second, the conditional quantile regression is applied based on research results found in previous studies by Ampofo et al. (2023) and Hashmi et al. (2021) that the impact of COVID-19 on the stock market is shown to vary across different quantiles. In a similar vein, the effect of COVID-19 on the

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stock return connectedness might also be different across various market conditions. Therefore, the conditional quantile regression is adopted to further examine the heterogenous impact of the SAR-CoV-2 pandemic on the spillover among bank stock returns, and the model is specified as:

$$Q_{qt}(y \mid x) = \beta_{0q} + \beta_{1q} COVIDCASE_t + \\ + \beta_{2q} LOCKDOWN_t + \\ + \beta_{3q} TURNOVER_t + \varepsilon_t, \quad (10)$$

where $Q_{qt}(y|x)$ is the conditional quantile point for the distribution of TCI_t. The given condition is a set of x covariates, including $COVIDCASE_t$, $LOCKDOWN_t$, and $TURNOVER_t$. Specifically, the impact of the COVID-19 pandemic is tested on the 95th quantile of TCI (q = 0.95), the 75th quantile of TCI (q = 0.75), the 50th quantile of TCI (q = 0.50), and the 25th quantile of TCI (q = 0.25).

3. RESULTS AND DISCUSSION

3.1. Descriptive statistics

Table 2 described summary statistics of bank stock returns and COVID-19 cases. The positive mean values reflect an increase in all bank stock returns during the study period, and the skewness and kurtosis measures indicate that all stock returns are leptokurtic and significantly left-skewed. In addition, the JB and ERS statistics show that all variables do not follow a normal distribution; however, they are stationary at the 1% significance level.

Furthermore, the series are autocorrelated and exhibit ARCH/GARCH errors, making the choice of a TVP-VAR model with time-varying covariances legitimate. The pairwise correlation of the variables described in Appendix A further confirms that all bank stock returns are statistically and positively correlated with each other, ranging between 0.088 and 0.519, whereas that of COVID-19 cases and each variable of stock returns is primarily negative but insignificant. Further details about fluctuation of bank stock returns are presented in Appendix A. Most bank stock returns tend to decline in the first quarter of 2020, and the larger decline is found in the group of 03 state-own bank stocks. This pattern can be explained by the fact that before lockdown policies were implemented, investors were constantly worried about the development of COVID-19. After lifting the first lockdown by the end of April 2020, the return of all bank stocks increased rapidly. The COVID-19 spike was controlled effectively between June 2020 and March 2021 with mask mandates in pub-

Table 2. Summary statistics of bank stock returns and COVID-19 cases

Bank	Mean	Variance	Skewness	Excess Kurtosis	JB	ERS	Q (20)	Q^2(20)
ACB	0.001	0.001***	–0.91**	8.67***	2,111.68***	–11.59***	11.67	9.934
BAB	0.000	0.001***	0.92***	12.87**	4,519.33***	–11.03***	69.31***	252.97***
BID	0.000	0.001***	–1.10**	7.52***	1,643.25***	–9.67***	11.42	6.260
CTG	0.001	0.001***	–1.12**	8.61***	2,115.95***	–7.84***	16.243*	8.973
EIB	0.001	0.001***	0.53***	1.96***	132.70***	–4.02***	9.25	78.332***
HDB	0.001	0.001***	–0.69**	5.81***	953.21*	–8.52***	8.17	11.017”
LPB	0.002	0.001***	–0.36***	3.89***	418.27***	–10.82***	13.44	33.271***
MBB	0.001	0.001***	–1.65***	13.41***	5,097.39***	–10.83***	7.54	6.247
NVB	0.002	0.001***	0.36***	4.12***	467.85***	–10.52***	6.69	143.36***
SHB	0.002	0.001***	–0.07	2.57***	177.22***	–5.31***	39.68***	101.63**
STB	0.002	0.001***	–0.03	0.61***	9.96***	–10.50***	8.00	120.99***
TCB	0.001	0.001***	–0.31***	1.78***	95.03***	–8.49***	10.79	58.40***
TPB	0.001	0.001***	–1.03***	9.31***	2,432.01***	–9.00***	12.99	4.44
VCB	0.000	0.000***	–2.02***	20.97***	12,204.37***	–7.37***	18.94**	5.48
VIB	0.002	0.001***	–1.29***	11.57***	3,756.80***	–8.94***	7.58	6.82
VPB	0.001	0.001***	–4.31***	57.67***	90,935.98***	–9.43***	16.65*	0.62
No of Cases	11,591	1419229368***	5.13***	29.28***	25,237.19***	–2.29***	4,071.88***	2,075.65***

Notes: ***, **, and * denote significance at 1%, 5%, and 10% levels, respectively. Tests of skewness, kurtosis, JB, ERS, and Q (20) and Q2(20) are adopted in D'Agostino (1970), Anscombe and Glymm (1983), Jarque and Bera (1980), Stock et al. (1996), Fisher and Gallagher (2012), respectively.

lic places. Most bank stock returns just slightly decrease between April 2021 to June 2021 when the prolonged lockdown was enacted. It seems to exhibit a significant and positive influence on Vietnam bank stock returns during the research time frame, and this evidence contrasts with earlier conclusions found in studies by Baig et al. (2021) and of Alexakis et al. (2021). According to some researchers, Vietnamese bank stocks gained more interest from the public due to the more reliable and transparent financial disclosure. While real estate or commodity markets have existing problems with transparency, the fear of missing out among Vietnamese investors to risks of investment channels during the COVID-19 pandemic becomes more severe, but many investors still trust in the banking system (Luong et al., 2022). From the second half of 2021 onwards, banks' stock prices tend to fluctuate differently. In 2022, when the lockdown policies were lifted, as the number of COVID-19 cases increases, bank stock prices tend to decrease gradually. The second tightened and prolonged lockdown policy due to sharp increase in number of COVID cases and deaths in the southern region and spreading out of COVID to the north.

3.2. Strength of connectedness among bank stock returns

The values shown in Table 3 reflect the static connectedness among bank stock returns on average. Each row corresponds to individual contribution of connectedness to other stock and to the whole network and each column displays the prediction error variance that each individual received from other individuals and from the whole network. While off-diagonal components display the impact of/on others, ones on the main diagonal reflect own-variable effects. A strong interdependence among the bank stock returns with a total connectedness measure of 90.66% is computed, suggesting a high level of integration and a high degree of systemic risk among bank stock returns. Besides, either a net transmitter of shocks or a net receiver is shown in Table 3. It is further visualized in Figure 1, and each node in blue/yellow color is the net shock transmitter/net shock receiver. Notably, the size of NVB's node reflects that this bank stock is the largest transmitter, whereas VPB's is the largest receiver[4]. It can be explained by the fact that stock returns of major banks, which hold bonds from smaller lenders, was heavily influenced by the performance of these smaller borrowers during the COVID-19 pandemic. Either outperform or underperform of borrowers can transmit the effect on the lenders and it can apply to the pair NVB and VPB. Interestingly, all of 03 state-owned bank stocks are presented with small size nodes. This finding can be explained by similar cases of Chinese banks found in the study by Wang et al. (2018). These authors discover that a "too big to fail" bank may not obviously be "too interconnected to fail" in China. Greene et al. (2010) provide another evidence in the U.S. that mid-sized banks can have knock-on effects on the whole financial system, for instance, the bailout of Long-term capital management in 1998 in the United States. For the case of Vietnam, 03 state-own bank stocks account for more than 50% of market capitalization in the banking network (FiinPro, 2022).

Values in Figure 2 illustrate the total dynamic connectedness of 16 bank stock returns in the study period. There was a sharp drop in the early stage of COVID-19 from January 2020 to March 2020, then a gradual decrease between April 2020 to November 2021. It is explained by the fact that the Vietnamese stock market had experienced an inexplicable period of rapid growth despite the significant impact of the pandemic and the implementation of lockdowns. During the lockdown periods, investors worked from home and tended to trade more than in normal condition.

With an increasing number of individual investors participating in the stock market, transaction volume increased dramatically. Bank stock returns were improved along with the increase in most of bank stock prices. The transmission of shocks decreases because there is an increasing trend in the stock market. Based on behavior finance, this situation can be explained by

4 Based on Ph.D. dissertation of Nguyen (2022), listed banks are classified into three groups, which include small banks with total assets ranging between 73,714-226,239 billion VND, medium size banks having total asset in the range between 359,550-439,865 billion VND, and large size banks with total assets ranging between 1,122,783-1,390,973 billion VND.

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Table 3. The average connectedness measures of individual bank stock returns for the study period

Variable	ACB	BAB	BID	CTG	EIB	HDB	LPB	MBB	NVB	SHB	STB	TCB	TPB	VCB	VIB	VPB	FROM
ACB	7.0	5.6	7.2	6.9	5.1	5.8	6.2	7.3	8.2	3.7	5.6	7.2	6.0	6.2	6.4	5.7	92.9
BAB	5.6	15.2	6.2	4.9	5.7	5.0	4.7	5.2	7.6	3.6	5.3	5.5	6.1	7.3	6.8	5.2	84.8
BID	4.7	8.8	9.5	6.0	4.9	4.5	5.5	5.7	8.7	4.3	4.6	7.9	9.2	6.0	5.2	4.2	90.5
CTG	4.6	7.6	7.1	6.1	4.5	6.0	7.4	6.1	9.7	4.1	5.5	7.4	8.0	5.1	6.3	4.3	93.9
EIB	4.9	8.5	3.9	3.6	9.9	7.0	4.9	4.3	9.1	4.7	6.4	4.4	7.1	8.9	9.0	3.4	90.0
HDB	4.6	7.2	5.1	4.8	5.3	8.0	7.7	5.9	9.8	4.4	6.8	6.4	7.1	5.2	7.8	3.9	91.9
LPB	3.9	6.2	6.4	5.7	2.9	7.0	9.9	6.8	10.9	4.9	5.6	8.1	8.8	3.0	5.9	3.9	90.0
MBB	5.4	6.6	6.5	5.9	4.8	6.2	7.2	6.9	9.6	3.6	5.9	7.5	7.1	5.3	6.7	4.6	93.0
NVB	4.6	7.3	5.4	3.8	7.9	6.3	4.9	4.3	13.9	5.6	5.3	4.9	8.5	8.1	6.2	3.2	86.1
SHB	4.5	4.5	8.6	4.8	4.5	5.2	7.6	5.6	9.9	10.6	4.3	7.3	9.1	5.5	4.8	3.2	89.4
STB	5.3	7.1	6.8	5.2	5.4	6.0	6.5	5.8	9.2	5.6	6.5	6.0	6.8	6.7	6.9	4.3	93.6
TCB	5.2	5.9	7.8	6.2	3.8	5.8	7.7	7.2	9.5	4.3	5.5	8.6	7.8	4.5	5.8	4.4	91.4
TPB	3.8	5.1	8.6	4.6	4.4	4.3	8.4	5.2	12.1	9.4	2.9	7.6	13.0	5.0	3.0	2.4	86.9
VCB	5.6	6.3	6.3	5.0	6.4	5.9	6.5	5.4	9.5	5.9	5.8	5.5	7.2	7.9	6.8	4.2	92.1
VIB	6.5	5.7	3.9	5.1	6.7	7.7	6.4	6.2	7.7	3.5	8.1	5.2	4.4	7.4	10.5	5.1	89.6
VPB	5.8	4.6	6.4	6.1	4.6	5.7	8.4	6.7	9.0	5.7	5.1	6.8	7.7	5.9	5.7	5.8	94.2
TO	75.1	96.9	96.1	78.6	76.9	88.1	99.9	87.6	140.6	73.5	82.9	97.7	110.9	90.2	93.2	62.1	450.5
Inc. Own	82.1	112.2	105.6	84.7	86.9	96.2	109.9	94.6	154.5	84.1	89.4	106.3	123.9	98.0	103.6	67.6	TCI
NET	–17.9	12.2	5.59	–15.2	–13.1	–3.8	9.9	–5.4	54.5	–15.9	–10.7	6.30	23.9	–1.96	3.63	–32.15	90.66

the fear of missing out and herding behavior adopted from studies by McGinnis (2004) and Przybylski et al. (2013) with the findings that missing out is an individual's fear, and others might gain rewards in an individual's absence, which leads to a desire to join others. Besides, the fear of missing out and herding behavior in Vietnamese stock market by the end of 2020 is also explained in the study by Luong et al. (2022).

The total connectedness index continued to decrease under tightening condition of the lockdown policies that were prolonged from January 2021 to July 2022. It can be explained by the overconfidence because there is an increasing number of individual investors joined the stock market at this time with strong belief that they can estimate the value of stocks better than others, thereby exaggerating the accuracy of their information and trading patterns (Ackert & Deaves, 2010). It is also consistent with the finding by Tabak et al. (2022), who found a high level of spillover between the countries' banking markets in 2020 and lower level from 2021 onwards.

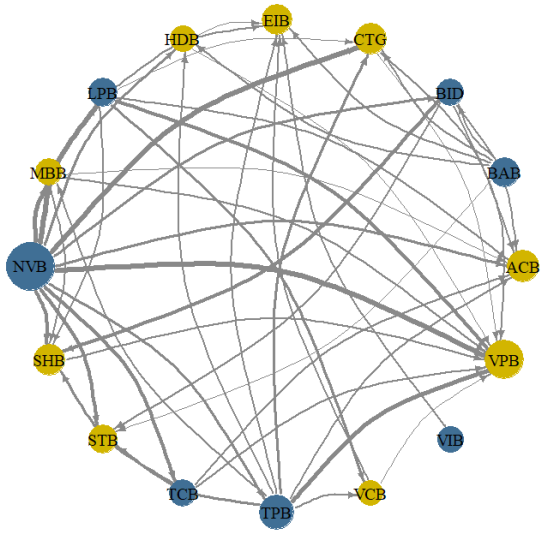
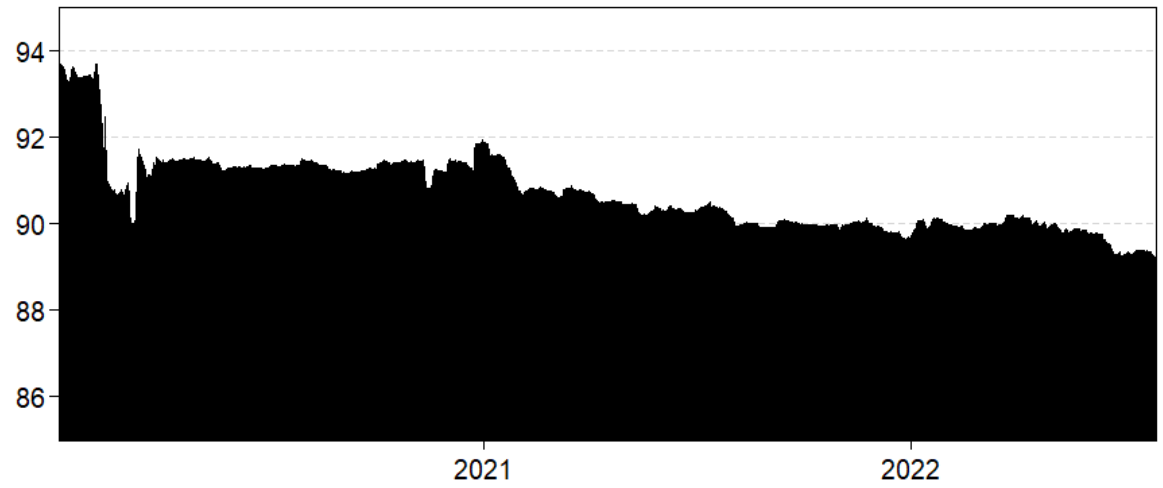


Figure 1. Connectedness network of stock returns of 16 Vietnamese banks



Note: Results are based on the TVP-VAR (1) model with the lag length selected by BIC and a 12-step ahead generalized forecast variance decomposition.

Figure 2. Total dynamic connectedness of 16 bank stock returns

Next, the time-varying NET directional connectedness of bank stocks is presented in Figure 3. Largest banks (i.e., VCB, BID, CTG and MBB) are net receivers of shocks, while smaller banks (i.e., NVB, TPB and LPB) are net transmitters. The results show that more variables tend to switch their role at the end of 2020, and some variables tend to persist throughout the sample period.

3.3. The impact of the COVID-19 pandemic on the return connectedness of bank stocks

Table 4 illustrates the impact of the pandemic on the connectedness of bank stock returns. First, a significantly negative impact of the number of cases on TCI in both linear regression and quantile

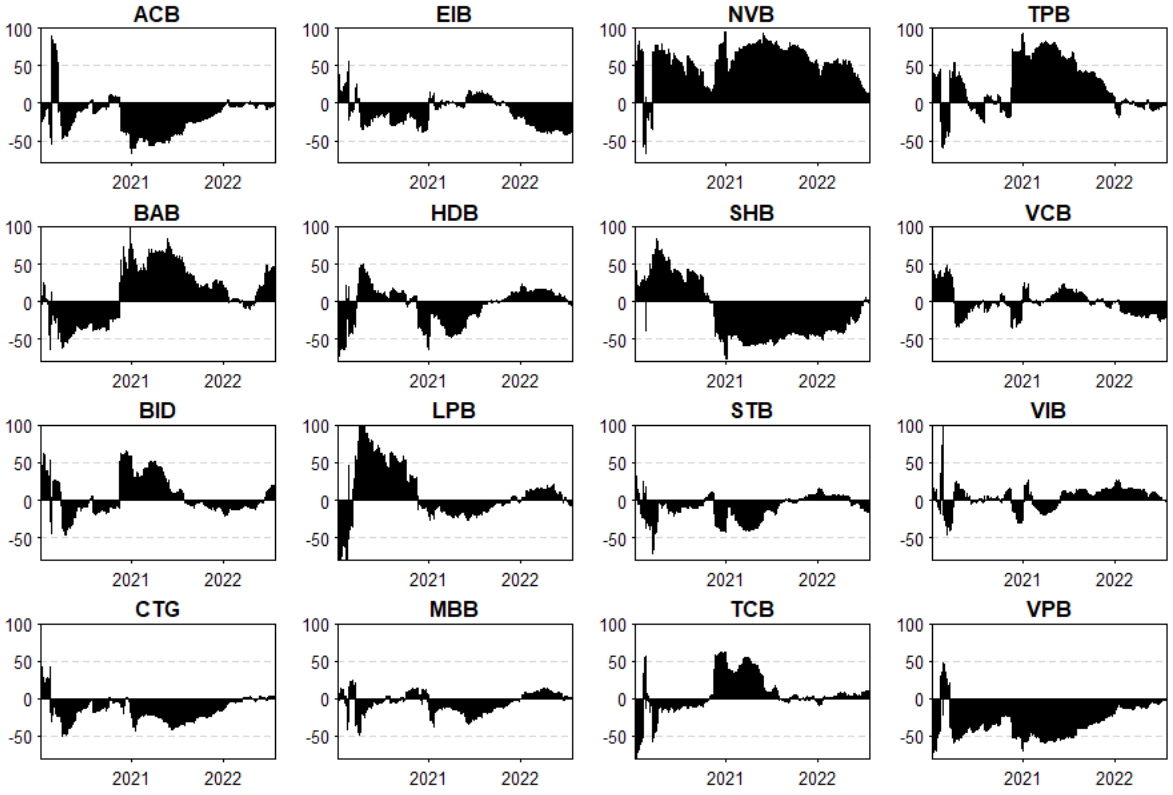


Figure 3. Change of net directional connectedness of individual bank stock returns in the study period

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Table 4. Impact of the number of COVID-19 cases on TCI-linear regression and quantile regression

Variable	Linear regression	Quantile regression			
		95th quantile	75th quantile	50th quantile	25th quantile
Intercept	91.41***	92.24***	91.80***	91.51***	90.94***
COVID-19 case	–0.14***	–0.11***	–0.14****	–0.15***	–0.12***
Lock-down	0.01	–0.27***	–0.03	–0.02	0.07***
Turnover	–25.53**	–93.62***	–68.46***	–39.20***	–12.03
Observations	535	535	535	535	535
R-squared	0.56	–	–	–	–
Pseudo R-squared	–	0.30	0.45	0.45	0.32

Note: *** p < 0.01; ** p < 0.05; * p < 0.10.

regression models is indicated. In other words, the number of cases increases/decreases as the TCT decreases/increases, which is highly inconsistent with the findings found in studies by Rehman et al. (2022), Rizwan et al. (2022) and Uddin et al. (2022), and Shahzad et al. (2021), implying that the examination of spillover among individual bank stocks at the firm level is in contrast to the spillover of banking stock indices at the national level. Second, the results from linear regression show the positive impact of the lock-down policy on the TCI, suggesting that the degree of linkage between bank stock returns increases when investors are under directives ranging from "shelter in place" or "stay at home".

This finding corroborates the ideas of Caporale et al. (2022) that stock market lockdown policies have a more significant impact than the pandemic itself. Third, the results from quantile regression in Table 4 and Table 5 show that the impact of the lock-down policy depends on the level of connectedness among bank stocks. The coefficient of the lock-down variable tends to increase from –0.24 for the 95th to 0.07 for the 25th quantile of the TCI, indicating the periods of the highest TCI among bank stock returns corresponds to the highest systematic risk in the banking sector.

This situation might be explained by using the case study found in Ouyang et al. (2022). When bank stock returns are highly connected, and the market is extremely risky, the lock-down policy will reduce the systematic risk as the promulgation of the government restrictions can suppress the existing systemic risks, but the restrictions will not eliminate all potential systemic financial risks. It also might be explained using a case study by Baig et al. (2021) that when bank stock returns are less connected, the government's lock-down policies have increased risk and the close linkages between bank stocks.

Further, results presented in Appendix C support the findings of the reactions associated with each bank stock return under the pandemic. This indicates that although Vietnamese bank stocks exhibit a high level of connectedness, there are still heterogeneities across banks. This finding can be attributed to differences in banks' size, capital structure (Wang et al., 2018), and response to external shocks (Alaganar & Bhar, 2002). In addition, despite differences in the impact of the lock-down policy on the NET connectedness value, the results of quantile regressions show that the coefficient of the lock-down variable tends to increase from the 95th quantile to the 25th quantile of the NET directional connectedness, reflecting when a bank stock plays an influential transmitting role, the government's lock-down policy will help to contain the shock, and vice versa.

CONCLUSION

In order to evaluate the strength of connectedness among bank stock returns during the COVID-19 pandemic, the cases of 16 listed banks in Vietnam associated with the study period between January 30, 2000 and July 29, 2022 were utilized. The results show strong interdependence with the average TCI of bank stock returns being as high as 90.66%. Based on the TVP-VAR framework, the net connectedness of each individual bank stock returns to the total network decreases rapidly in the early stage when the

pandemic firstly appears from January, 2020 to March, 2020; slightly decreased after the first government lockdown and during the second lockdown between the second half of 2020 to the end of 2021, then fluctuated during the first half of 2022 depending on how the market interacts with economic gloom. As far as transmission of shock is concerned, a smaller-sized bank, such as NVB, is the transmitter, while the medium one such as VPB is the receiver based on static connectedness. The four largest banks, including VCB, BID, CTG and MBB, are net receivers of shocks, while three smaller banks, including NVB, TPB and LPB, are net transmitters, based on the net directional connectedness. Further, the interdependence among bank stock returns indeed changes over time.

The study also aims to evaluate the impact of COVID-19 on the TCI of bank stock returns. Results from the conditional quantile regression prove a significantly negative impact of the number of COVID-19 cases on the TCI of bank stock returns. The impact of the pandemic on TCI is weakened or strengthened, also depending on the status of tightening or lifting of the lockdown policy. Moreover, this impact only reduces the degree of connectedness between bank stock returns when they are significantly linked. It is also explained by sentiments of Vietnamese investors, including herding behavior, fear of missing out, and overconfidence.

These findings provide helpful insights for individual investors and bank regulators. It shows a strong interdependence of bank stock returns in an emerging country. For individual investors, improving knowledge and skills on analysis of connectedness among individual banks and the total banking network is important for making accurate decision. They should be cautious with medium and large-sized banks embedded with strong credit relationship with smaller banks. For bank regulators, credit relationship policy among banks in the network not only causes risk concentration, but also leads to systemic risks. Since systematic risk is always hidden in the banking sector of Vietnam, it requires stringent monitoring to prevent potential crashes. For policy makers, as the significantly adverse impacts of the pandemic are revealed, lock-down policies do affect the systemic risk in bank stock returns and the level of interdependence among bank stock returns. Therefore, instead of imposing prolonged lockdown and based on the widespread and deadly outbreak of disease, they should consider the short-term lockdown and all restrictions should vary from the north to the south of Vietnam.

AUTHOR CONTRIBUTIONS

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Formal analysis: Nguyen Phu Ha, Luong Tram Anh, Le Hong Thai.
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Validation: Luong Tram Anh, Le Hong Thai.
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Writing – reviewing & editing: Nguyen Phu Ha.

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APPENDIX A

Table A1. Pairwise correlation among bank stock returns

Variable	ACB	BAB	BID	CTG	EIB	HDB	LPB	MBB	NVB	SHB	STB	TCB	TPB	VCB	VIB	VPB	Covid cases
ACB	1.00***	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
BAB	0.25***	1.00***	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
BID	0.41***	0.23***	1.00***	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CTG	0.47***	0.25***	0.49***	1.00***	–	–	–	–	–	–	–	–	–	–	–	–	–
EIB	0.22***	0.18***	0.18***	0.25***	1.00***	–	–	–	–	–	–	–	–	–	–	–	–
HDB	0.44***	0.25***	0.37***	0.43***	0.25***	1.00***	–	–	–	–	–	–	–	–	–	–	–
LPB	0.42***	0.26***	0.31***	0.40***	0.24***	0.37***	1.00***	–	–	–	–	–	–	–	–	–	–
MBB	0.52	0.26***	0.47***	0.51***	0.24***	0.49***	0.44***	1.00***	–	–	–	–	–	–	–	–	–
NVB	0.19***	0.13***	0.15***	0.18***	0.14***	0.18***	0.19***	0.17***	1.00***	–	–	–	–	–	–	–	–
SHB	0.34***	0.24***	0.33***	0.29***	0.17***	0.32***	0.34***	0.35***	0.12***	1.00***	–	–	–	–	–	–	–
STB	0.44***	0.23***	0.41***	0.43***	0.26***	0.43***	0.42***	0.52***	0.19***	0.35***	1.00***	–	–	–	–	–	–
TCB	0.49***	0.25***	0.44***	0.49***	0.28***	0.48***	0.43***	0.55***	0.16***	0.33***	0.50***	1.00***	–	–	–	–	–
TPB	0.43***	0.21***	0.35***	0.39***	0.23***	0.42***	0.34***	0.46***	0.16***	0.29***	0.39***	0.44***	1.00***	–	–	–	–
VCB	0.33***	0.16***	0.38***	0.35***	0.18***	0.33***	0.24***	0.35***	0.13***	0.19***	0.25***	0.31***	0.25***	1.00***	–	–	–
VIB	0.41***	0.26***	0.32***	0.37***	0.21***	0.37***	0.41***	0.43***	0.16***	0.29***	0.38***	0.42***	0.35***	0.25***	1.00***	–	–
VPB	0.44***	0.20***	0.36***	0.39***	0.21***	0.36***	0.36***	0.43***	0.09***	0.31***	0.40***	0.48***	0.37***	0.26***	0.38***	1.00***	–
No. of cases	–0.02	–0.04	0.00	–0.04	–0.02	–0.02	–0.05	–0.02	0.02	–0.05	–0.02	–0.03	–0.01	–0.01	–0.06**	–0.04	1.00***

Note: *** $p < 0.01$.

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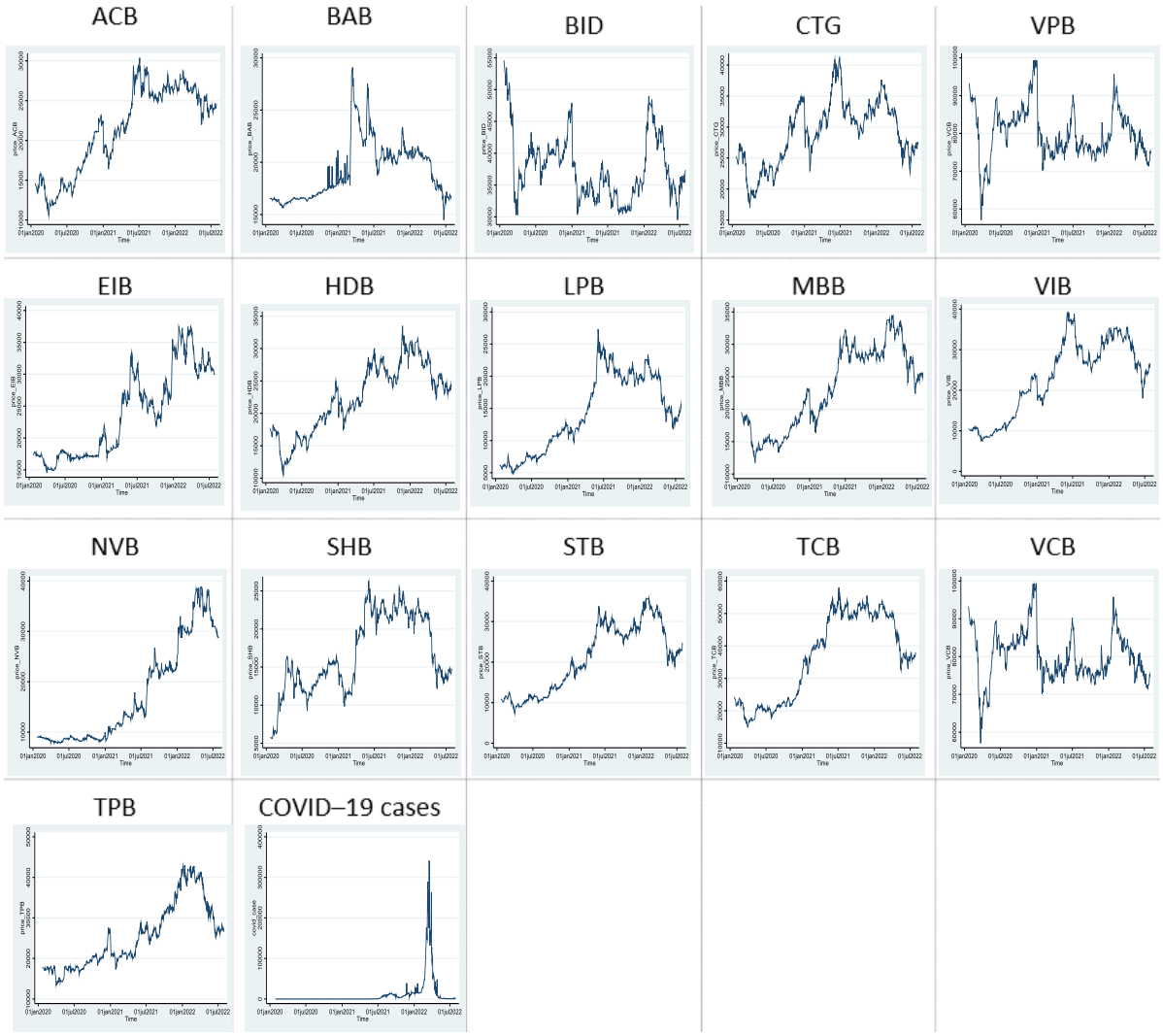
APPENDIX B

Table B1. Movements of bank stock returns and the COVID-19 cases



APPENDIX C

Table C1. Linear regression (LR) – impact of the pandemic on the NET connectedness values of listed banks (x^{th} quantile of the NET)

Bank	LR	Intercept	COVID case	Lock-down	Turnover	Obs.	Pseudo R-squared
ACB	LR	–5.65***	1.54***	–14.27***	–6338.37***	535	0.54
	95th	15.98***	–0.87***	–21.28***	–2094.76***	535	0.24
	75th	5.84**	0.29	–18.33***	–4416.88***	535	0.28
	50th	–8.22***	1.94***	–13.14***	–6866.57***	535	0.43
	25th	–25.24***	2.60***	–9.97***	–5511.54***	535	0.47
BAB	LR	–35.76***	1.62***	8.70***	13477.79***	535	0.43
	95th	49.71***	–1.69***	4.54**	4085.73***	535	0.21
	75th	20.59***	–1.73***	11.04***	7616.83***	535	0.3
	50th	–29.05***	0.65	14.93***	13284.38***	535	0.27
	25th	–67.94***	2.90***	7.77**	15130.41***	535	0.34
BID	LR	2.32	–2.66***	–2.79	6222.15***	535	0.36
	95th	68.88***	–6.44***	–4.21***	250.96	535	0.47
	75th	41.15***	–5.27***	1.70*	2534.06***	535	0.41
	50th	6.74*	–2.70***	0.67	4607.04***	535	0.23
	25th	–18.83	–0.34**	1.65	3985.31***	535	0.07
CTG	LR	–3.98**	0.25*	–14.60***	–2959.02***	535	0.54
	95th	6.98***	–0.10*	–18.97***	–1722.83*	535	0.31
	75th	6.63***	–0.25***	–18.34***	–2550.81***	535	0.37
	50th	2.27	0.1	–14.50***	–4289.67***	535	0.32
	25th	–12.76***	0.33*	–12.61***	–2736.30***	535	0.25
EIB	LR	–31.05***	–0.31*	14.29***	4788.39***	535	0.54
	95th	17.69***	–1.94***	13.54***	–17.67	535	0.12
	75th	–16.00***	–0.32*	17.88***	2737.56***	535	0.21
	50th	–36.00***	–0.31	15.96***	5331.79***	535	0.31
	25th	–47.41***	–0.14	13.42***	6392.65**	535	0.33
HDB	LR	9.14***	1.99***	–3.14*	–7208.20***	535	0.47
	95th	39.56***	–0.73	13.93*	–4403.72**	535	0.13
	75th	19.03***	0.95***	–4.32**	–5643.32***	535	0.19
	50th	4.2	1.96***	–9.06***	–5120.55***	535	0.32
	25th	–16.61***	3.89***	–7.17***	–5492.26***	535	0.46
LPB	LR	52.063***	–2.22***	–1.20	–10118.77***	535	0.36
	95th	112.43***	–5.53***	6.64	–11372.24***	535	0.38
	75th	73.552***	–3.04***	0.61	–10850.64***	535	0.3
	50th	24.60***	–0.44	–1.56***	–5733.33***	535	0.22
	25th	2.39*	0.52***	–8.58***	–3441.39***	535	0.24
MBB	LR	3.51**	0.47***	–12.19***	–2799.41***	535	0.39
	95th	19.34***	–0.20***	–19.04***	–1954.93***	535	0.31
	75th	16.28***	–0.28***	–17.77***	–2293.50***	535	0.32
	50th	8.67***	0.26	–13.82***	–3470.12***	535	0.3
	25th	–2.03	0.68***	–12.09***	–3347.92***	535	0.27
NVB	LR	31.75***	0.79***	18.90***	4834.00***	535	0.35
	95th	74.22***	–0.58*	2.96***	2091.17***	535	0.16
	75th	53.40***	–0.31	8.49***	4423.19***	535	0.18
	50th	40.12***	0.35**	18.09***	3573.70***	535	0.29
	25th	19.01***	1.40***	27.10***	3974.00***	535	0.3
SHB	LR	40.35***	–4.36***	0.18	–13025.61***	535	0.53
	95th	104.695***	–9.545***	–13.475***	–9923.625***	535	0.47
	75th	62.06***	–6.16***	6.64*	–12116.67***	535	0.46
	50th	29.20***	–4.10***	–6.38***	–10117.48***	535	0.24
	25th	–25.35***	–0.40*	–4.63***	–4860.93***	535	0.16

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Table C1 (cont.). Linear regression (LR) – impact of the pandemic on the NET connectedness values of listed banks (x^{th} quantile of the NET)

Bank	LR	Intercept	COVID case	Lock-down	Turnover	Obs.	Pseudo R-squared
STB	LR	–16.05***	2.59***	–3.56***	–2410.411***	535	0.46
	95th	11.24***	0.51***	–11.00***	–1281.63***	535	0.16
	75th	–4.81***	1.41***	–5.54***	–1114.24***	535	0.24
	50th	–17.07***	2.60***	–2.32***	–1966.44***	535	0.31
	25th	–33.30***	3.94***	–0.01	–2416.28***	535	0.45
TCB	LR	0.39	–1.63***	–1.56	6144.45***	535	0.28
	95th	66.38***	–5.21***	–5.48***	289.99	535	0.42
	75th	31.34***	–3.97***	0.83	4508.11***	535	0.38
	50th	0.18	–1.10**	–6.89***	5449.71***	535	0.11
	25th	–13.83***	0.51***	–2.58***	3007.78***	535	0.11
TPB	LR	–2.21	–1.84***	22.50***	10725.42***	535	0.55
	95th	59.47***	–4.51***	17.15***	6044.27***	535	0.31
	75th	28.58***	–3.45***	18.78***	9228.09***	535	0.4
	50th	–6.25*	–1.94***	24.16***	12240.76***	535	0.43
	25th	–20.46***	0.08	33.76***	7247.88***	535	0.31
VCB	LR	–15.39***	–0.26	5.26***	3874.73***	535	0.29
	95th	30.31***	–3.09***	8.18***	549.41	535	0.22
	75th	–3.20**	–0.51***	7.40***	2758.84***	535	0.22
	50th	–16.71***	–0.51***	5.46***	4381.56***	535	0.21
	25th	–31.90***	0.61***	12.01***	4233.89***	535	0.24
VIB	LR	–2.64	1.81***	–0.69	–888.60***	535	0.27
	95th	27.34***	–0.23	–4.04**	–1299.92***	535	0.03
	75th	2.91**	1.06***	–1.44***	416.24**	535	0.11
	50th	–3.29	1.68***	–0.22	–133.01	535	0.21
	25th	–18.54***	3.05***	–0.23	–504.53***	535	0.38
VPB	LR	–26.75***	2.22***	–15.83***	–4320.95***	535	0.61
	95th	–4.16*	0.86***	–28.54***	–2897.07***	535	0.32
	75th	–15.37***	1.62***	–24.98***	–3369.36***	535	0.46
	50th	–30.74***	2.38***	–14.10***	–3795.42***	535	0.46
	25th	–39.72***	2.50***	–10.89***	–3606.91***	535	0.43

Note: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$.