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Research article

Evaluating the nonlinear relationship between nonfinancial corporate sector leverage and financial stability in the post crisis era

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Abstract: This paper analyzes the relationship between the nonfinancial corporate sector leverage (NFCL) and financial stability in the post crisis era, revealing considerable heterogeneity across the level of financial intermediation (FI). First, we use the financial soundness indicators proposed by the IMF and the generalized dynamic factor model (GDFM) to measure the financial stability represented by the FSI of OECD countries. Second, in a panel quantile regression framework, we examine the effects of NFCL on FSI for different quantiles of FSI. The result shows that the impact of NFCL on financial stability at different levels is asymmetric, which reflects differences in the supply and demand of debt. Third, this paper further discusses the transmission mechanism of FI between NFCL and FSI based on the panel smooth transition regression model (PSTR). We find that the transmission channel of NFCL to financial stability depends on the level of financial intermediation, but with diverging magnitude for the different levels of FI.

Keywords: nonfinancial corporate sector leverage; financial stability; post crisis era; financial Intermediation
Mathematics Subject Classification: 62G08, 91G45

1. Introduction

Financial soundness indicators (FSIs) in the aftermath of the global financial crisis provided meaningful support for financial stability. FSIs are indicators of the current financial health and soundness of the financial institutions in a country and of their corporate and household counterparts [1].

There are complex links between institutional sectors and feedback loops between other sectors and the financial sector [2]. However, systemic risk analytics have supported that the role of financial institutions, and banks in particular, remains central to financial stability in the economy. Broader challenges to forecasting and monitoring financial stability became apparent after the financial crisis [3]. The financial crisis is considered to be a suicidal zeroing of the financial system, which has a significant impact on energy, stock returns, exchange rates and so on [4–13]. At the same time, it has aroused new international thinking about the financial system, such as the emergence of bitcoin [14,15]. The Basel Committee on Banking Supervision (BCBS) has supported that we should enhance the usefulness of surveillance as well as weaken the dependence of ratings. Over the past 10 years, the International Monetary Fund (IMF) has assessed the effect of shocks on macroeconomic developments and financial institutions' sustainability in terms of the manner in which macrofinancial linkages are analyzed. The overarching aim has been to build a more robust and favorable indication system that can include the real economy sector instead of only financial institutions [16]. FSIs are suitable from the financial stability perspective. They are calculated and disseminated for the purpose of supporting macroprudential analysis. This is the assessment and surveillance of the strengths and vulnerabilities of financial systems, with the objective of enhancing financial stability and, in particular, limiting the likelihood of failure of the financial system. They include both aggregated individual institution data and indicators that are representative of the markets in which the financial institutions, real estate, nonfinancial corporation sector and households operate. FSIs have become increasingly popular in both academia and the business press. Surprisingly, however, these indicators have not been extensively studied and hence are not well applied.

The nonfinancial corporate sector leverage level can be growth enhancing, but it may also be a precursor to economic distress. In recent times, there has been a growing body of literature exploring the role of nonfinancial corporate sector leverage in the economy [17]. On the one hand, nonfinancial corporations' borrowing costs have been reduced by central banks in the economic recession, as they were designed to support real economic activity. To recover from recessions, leverage in the nonfinancial corporate sector has increased significantly since the financial crisis [18]. On the other hand, sectoral leverage is negatively related to financial stability. Higher leverage amplifies the effect of unexpected macroeconomic shocks on financial stability; the idea is that higher leverage makes the economy more fragile [19]. Before the financial crisis, leverage reached unprecedented levels. The crisis revealed the fragility of many highly indebted nonfinancial corporations, and it triggered the sharpest global recession since the 1930s. Therefore, nonfinancial corporate sector leverage identifies the key variable about the link between financial institutions and real activity that can be used to impact the economic risk of a nation.

Organization for Economic Co-operation and Development (OECD) countries have a very long history of supporting innovation in the real economy. OECD countries are composed of market economies, with the main goals of promoting the economic and social development of member countries and promoting world economic growth. As early as World War II, technologically advanced countries began to focus on supporting large-scale technological transformation and system upgrades, involving support for nuclear energy, etc. Subsequently, in response to the structural adjustment brought about by the economic recession in the 1970s, various countries introduced a series of "protective" industrial policies to rescue the troubled corporations. However, by the late 1980s and 1990s, this "protective" overtone of policy had diminished, gradually shifting to a focus on science, technology, and innovation. In the 1990s, as the world entered a period of accelerated development,

the scope of industrial policy gradually expanded, with more emphasis on business-friendly conditions and innovation support. At this time, while not completely giving up support for specific industries, the government imposed less restrictive conditions on R&D investment (R&D) compared with direct government subsidies, which is conducive to industrial development and small and medium-sized corporations and start-ups. Enterprise innovation provides maximum support. In 2019, to better cope with technological progress and social changes, OECD countries introduced a series of special innovation policies to support innovation in the real economy.

The paper proceeds as follows. Section 2 provides a brief review of the literature on financial stability, nonfinancial corporate sector leverage and financial intermediation. Section 3 describes the impact of nonfinancial corporate sector leverage on financial stability. Section 4 details how nonfinancial corporate sector leverage influences financial stability. Section 5 draws conclusions and policy implications.

2. Literature review

Risk measurement has been proposed as a key contributing factor to financial stability evaluation. There is a corresponding diversity of measures that emphasize different aspects of financial stability. A plethora of studies have supported that the role of financial institutions remains central to financial stability in the economy, especially banks. One of the major research streams takes as there are significant signs of distress in the financial system, evidenced through a capital shortfall and negative externalities. There are systemic expected shortfall (SES) measures in response to each financial institution's contribution to systemic risk, i.e., its propensity to be undercapitalized when the system is undercapitalized [20]. However, systemic financial risk depends not only on the expected capital shortfall but also explicitly on the size and degree of leverage of a financial firm. Brownlees and Engle [21] developed an SRISK model in which merges market and balance sheet information when times of distress is undercapitalized measures all financial corporations of systemic risk. A second stream in the literature measures the contagion of bank risks using a popular network. Financial institutions are so interconnected and large that they can generate negative risk spillover effects on others. Catastrophic events can trigger financial contagion in the network of bank lending and borrowing relationships. Peng and Yan [22] introduced the impact susceptibility index in a complex network to identify potential targets and sources of financial contagion.

2.1. Financial stability

Financial stability generally refers to the ability and characteristics of a financial system to fluctuate within an acceptable range. It is a reciprocal indicator of financial fragility and financial crisis, showing the benign development of the financial system from different perspectives. The concept of financial soundness indicators (FSI) first came from the report "Banking System Soundness and Macroeconomic Policies" issued by the International Monetary Fund in 1996. In 2006, the IMF issued guidelines for the compilation of financial soundness indicators, aiming to guide countries to pay attention to and prevent financial risks that may be exposed in various sectors of the economy under the premise of macroprudence. And enhance the ability of the financial system to promote economic operations, manage risks and absorb shocks.

As early as the beginning of the 21st century, Borio [23] selected a monitoring system based on

macroeconomic tools, which included only private credit in GDP, real asset prices and investment, and successfully predicted 60% financial instability within three years. Subsequently, the IMF's financial stability index and the European Central Bank's macroprudential index became widely recognized indicators of financial market stability monitoring. After comparing the advantages and disadvantages of these two indices, Adam [24] constructed a simplified version of the financial stability index containing only six basic indicators and studied the financial stability of the Czech Republic from 1997 to 2006. Puddu [25] constructed a bank stress index containing six indicators to measure the stability of the American financial system. Chirila et al. [26] selected the index representing the stability of the stock market to synthesize the financial stability index. Different from the above scholars, other scholars chose to build an index framework and synthesize the financial stability index by incorporating as many indicators as possible. Albulescu [27] proposed the framework of the financial stability index system, including the four dimensions of financial development, financial vulnerability, financial soundness and world economic prosperity. Morris [28] constructed a three-dimensional integrated financial system stability index system for Macao's banking system, including the financial soundness index, financial vulnerability index and regional economic environment index.

For the calculation method, Davis and Karim [29] used the logit model and signal method (KLR) to build an early warning system for financial risks. Morales and Estrada [30] evaluated and analyzed the stability of financial institutions in Colombia by using the equal variance weighting method, principal component analysis method and quantitative response method. Among them, the macro stress test method, financial crisis early warning model and financial stability index construction method are also used to synthesize the financial soundness composite index with time-varying characteristics [31].

The early warning systems enable forecasts related to the probability of financial crisis appearance, but they neither offer the possibility to include in the calculations all the risks to which the system is exposed nor provide information related to the shock response capacity [32,33]. The stress-test techniques allow the identification of potential shocks and estimate the financial system resistance but give no possibility to compare the stability level during different periods or the stability level of two or more financial systems. Therefore, the construction of an aggregate financial stability index represents one of the quantitative methods for measuring the stability of a financial system. Albulescu [27] used a stochastic simulation model to forecast the financial stability level.

However, academic circles have not reached a unified conclusion regarding the construction of a financial soundness index system or the synthetic method of a comprehensive financial soundness index.

2.2. Factors affecting financial stability

Financial stability is conducive to the full use of financial functions and the improvement of financial efficiency, and it is also the foundation of financial risk prevention and financial security as well as social stability. Some scholars have discussed the influencing factors of financial stability from the macro level, including financial intermediation, open markets, sovereign debt, macro leverage ratio, etc.

As an important financial intermediary, the systemic risk of banks significantly affects the stability of the entire financial system [28,34]. In the traditional paradigm of economics, financial openness is believed to help promote institutional reform and contribute to financial stability [35]. The study of Mishkin [36] shows that financial openness may make capital flow easier and lead to financial

institutions with much more risks. Risk linkage between different segmented markets, such as the stock market and bond market, also exacerbates financial market volatility [37]. In addition, the risk of sovereign debt also strengthens mutual transmission with the financial sector, forming the so-called "doom cycle" [38,39]. A higher leverage ratio magnifies the impact of macroeconomic shocks on financial stability and increases economic vulnerability [19]. And the increasing credit leverage ratio of financial institutions during the boom leads to post boom financial leverage volatility and deleveraging, which causes a significant destructive impact on the stability of the financial system.

Financial risks are always present in different areas; the macro and micro levels accumulate risks from the real sector to the entire financial system, such as the real estate market, aging shock, and nonfinancial sector leverage ratio. The mortgaged property of real estate makes the risk of volatile housing prices easily transfer to the financial system through the mortgage effect [40,41]. Therefore, a stable real estate market plays an important role in maintaining financial stability [42,43]. Takats [44] used panel data of 22 developed countries from 1970 to 2009 to find that population aging significantly reduces the stability of housing prices and aggravates financial vulnerability. Büyükkarabacak and Valev [45] adopted the transnational panel data of 35 economies from 1990 to 2007 and found that compared with the corporate sector, the growth rate of household leverage had a more significant impact on the financial crisis. This is because the enterprise sector has a stronger capacity to transform capital, while the excessive debt of the household sector is more likely to restrain consumption, thus leading to a chain reaction of economic recession and financial instability [46]. Rapid increases in the corporate leverage ratio and household leverage ratio were considered precursors of the crisis in the banking system and easily caused asset bubbles.

2.3. Leverage effect

Regarding the economic effect of leverage, the literature mainly focuses on the leverage of banks or other financial institutions and its risk contagion at the macro level, while at the micro level, it mainly studies the financial status and operating leverage of enterprises through the balance sheet. There are few studies covering the leverage of various institutions and sectors. Different institutional sectors leading leverage fluctuations will bring different economic effects. Due to structural differences in economic sectors, policies aimed at reducing leverage to prevent risks may catalyze risks and exacerbate crisis contagion.

The economic effects of financial sector leverage can be divided into domestic and transnational studies. From a domestic perspective, some scholars believe that the leverage of the financial sector affects macroeconomic instability and welfare [47]. With the procyclical enhancement of bank leverage, financial cycle changes are more drastic [48,49]. The impact of the financial sector on the economy is heterogeneous over time. Shadow banking leverage became an important economic indicator after 2000 because it influences the ability of key macroeconomic variables [50]. The impact of the financial sector on the economy is asymmetric, with more capital inflows from highly leveraged financial institutions. Negative asset shocks in such periods lead to greater deleveraging and deterioration of asset prices [51,52]. In addition, the transmission mechanism of financial sector leverage is also the focus of scholars. Akinci and Chahrour [53] proposed that the influence of financial sector leverage on output, consumption and investment is nonlinear. The interaction of procyclical leverage with lagging output and employment enhances the durability of financial shocks [54]. Other scholars believe that leverage in the financial sector is just a transmission channel, and leverage is

meaningless to the study of financial banks. Nonperforming loans are the key to influencing leverage on financial risks [55]. From an international perspective, countries are independent of traditional trade links through the interdependence of financial markets and institutions, and financial sector leverage has an impact on cross-border trade. Devereux and Yetman [56] found that shocks caused by investment portfolios under leverage constraints were transmitted internationally.

There are few studies on the economic effects of leverage in nonfinancial sectors. The research on the economic effects of leverage in nonfinancial firms mainly considers temporal heterogeneity. In theory, leverage levels in the nonfinancial corporate sector can promote growth but can also be harbingers of economic distress [17,57]. On the one hand, central banks have lowered borrowing costs for nonfinancial companies during the recession to support real economic activity. To recover from the recession, leverage in the nonfinancial corporate sector increased significantly [18,58]. On the other hand, there is a negative relationship between nonfinancial corporate sector leverage and financial stability. Higher leverage magnifies the impact of unexpected macroeconomic shocks on financial stability; therefore, high leverage makes the economy more vulnerable [19]. Research on government sector leverage has focused on the economic effects of developing countries. A high leverage ratio of the government sector is a common feature in developing countries. In most developing countries, governments are committed to developing projects that are both profitable and significant to macroeconomic development but are unable to take advantage of high profits from these projects. Government borrowing in international markets leads to high leverage and makes the economy more vulnerable to exchange rate changes [59,60]. In addition, Liang et al. [61] found that the expansion of local government debt significantly squeezed the leverage of nonstate-owned enterprises. Consumption leverage and mortgage leverage are two aspects that are mainly considered in the study of the economic effects of household sector leverage. On the one hand, private sector debt is increasing, raising concerns about financial instability and inequality [62]. Lacoviello [63] believed that the increase in consumption leverage might be a direct response to higher risks and better group risk sharing, and this mechanism directly caused the exacerbation of inequality. Mortgage leverage, on the other hand, played an important role in the spread of the housing bubble and subsequent collapse. In boom times, macroprudential policies are likely to be partially offset by looser fiscal policies, and limiting private sector leverage helps stabilize employment [64].

2.4. Financial intermediaries

Financial intermediaries play the function of financing in the financial market, mainly including the forms of commercial banks, securities companies and insurance companies. Traditional theories believe that financial intermediaries balance information asymmetry and the rational allocation of resources, which have positive impacts on economic growth [65].

Some scholars believe that the imperfection of the financial market leads to the loss of collateral and liquidity constraints of small and medium-sized enterprises, which reduces the allocation efficiency of resources [66,67]. A high level of financial intermediation releases financing constraints from alleviating information asymmetry, improves financial stability and promotes the development of the real economy. On the other hand, an excessive level of financial intermediaries also hinders economic development, and its procyclical leverage aggravates the volatility of the financial market. Adrian and Shin [68] found that financial intermediaries could adjust the leverage ratio by changing the balance sheet, such as increasing leverage when asset prices rise and reducing leverage when asset

prices fall, which adversely affected financial stability. Mendoza [52] pointed out that when the leverage ratio of the real economy rose to a certain extent, financial intermediaries reduced the quantity and price of credit collateral and worsened the availability of credit, which had an adverse impact on the real economy as well as financial stability.

This paper is a contribution to the literature that analyzes the effect of nonfinancial corporate sector leverage on financial stability. As described above, the systemic financial risk measurement in the previous literature is mainly based on banks, but there is no research to measure multi-sector financial stability. In addition, the microeconomic effect of corporate leverage has been extensively studied by researchers, but few studies have been conducted to explore the asymmetric effect of nonfinancial corporate sector leverage at different levels of financial stability. Different levels of financial intermediation have quite different effects on the effect. Based on the above analysis, this paper has explored the measure of financial stability and further investigated the asymmetric effect and channel of nonfinancial corporate sector leverage on financial stability. First, this paper employs the general dynamic factor model to a comprehensive measure of the financial soundness index that takes into account the synergy of multiple sectors by IMF financial soundness indicators. Second, this paper applies the panel quantile regression approach to reveal the extent of the relationship between nonfinancial corporate sector leverage and financial stability on different quantiles. This approach allows us to assess the differences in the NFCL influence across the FSI distribution to shed light on the asymmetric shock of the supply and demand of debt. Third, we employ a panel smooth transition regression model to test the transmission mechanism of the level of financial intermediation. Our empirical results reveal the nonlinear channel of financial intermediation in which high levels of financial intermediation reduce the impact of leverage on financial stability, which could provide new insights for the protection of financial risks brought by leverage.

3. Impact of nonfinancial corporate sector leverage on financial stability

3.1. Quantile regression model

The relationships between nonfinancial corporate sector leverage and financial stability are likely to perform discriminately at different quantiles. When there is a shock of distress in real activity, an increase in nonfinancial corporate sector leverage signifies a high chance of business default rates, which makes the economy more fragile [18]. However, a stable financial system reduces liquidity risk but also increases the net worth of entrepreneurs, thereby reducing the aggregate default rate and hence lowering financial risk [19]. Traditional regression techniques concentrate on the mean effects, which may cause under- or overestimation of the correlative effect. In this regard, quantile regression allows the coefficients to vary with multiple quantiles and has distinct advantages in detecting the variation in the effect of nonfinancial corporate sector leverage on the distribution of financial stability. A quantile model for panel data can be used to empirically document the nonlinear and heterogeneous effects of covariates:

$$Y_{it} = Q_Y(X_{it}, \alpha_i, \varepsilon_{it}) \; i = 1, ..., N, t = 1, ..., T. \tag{1}$$

To explore the asymmetric impact of the nonfinancial corporate sector leverage on financial stability within the OECD countries, this study utilizes the quantile regression model with fixed effects,

which provides a more detailed description. It is significant to understand the behavior of leverage to assist center banks in developing more effective monetary policies. Thus, the fixed effect panel quantile regression model is conceived as follows:

$$Q_\tau(FSI_{it} \mid NFCL_{it}) = \alpha_i + \gamma_\tau NFCL_{it} + \lambda_\tau C_{it} + \varepsilon_{it}^\tau \tag{2}$$

where $Q_\tau(FSI_{it} \mid \bullet)$ denotes a conditional quantile function of FSI evaluated at the τ th quantile, where $\tau \in [0,1]$. FSI_{it} is the annual financial stability for country i and in time period t. $NFCL$ represents the nonfinancial corporate sector leverage of OECD countries. The coefficient vector γ_τ measures the dependence degree of FSI_{it} at the τ th quantile to $NFCL$, which is the focus of this study. C represents a set of control variables. γ_τ differs depending on the quantile being estimated.

3.2. Selecting variables

3.2.1. Measures of FSI

There are complex links between the financial sector and other sectors, including real estate markets, the nonfinancial corporate sector and households. Spillovers across sectors can occur directly due to direct contractual links and heightened counterparty credit risk or indirectly through price effects and liquidity risk. These indices, such as the financial conditions index (FCI) and systemic expected shortfall (SES), are also reported and generally focus on a financial sector without much regard for spillovers from other sectors. Indicators of financial risk monitoring were widely questioned with the emergence of the 2008 financial crisis. Therefore, the IMF proposed after the financial crisis that the financial soundness indicators (FSIs) must be more comprehensive and robust to assess systemic risk [1,2,69–71]. Systemic risk may be seen as extreme financial instability. This paper's efforts were aimed at estimating a broad set of financial soundness indices (FSIs), comprising deposit takers and other indicators associated with financial system vulnerability, real estate market variables, and other financial corporate and household-based indicators to support dynamic systemic risk monitoring. Specifically, capital adequacy, asset quality, earnings and profitability, and liquidity provide vital first-hand information on the performance and fragility of the financial industry. Residential real estate loans to total gross loans, total debt to equity of the nonfinancial corporate sector, and household debt to GDP are all important indicators of macroeconomic performance and fragility. The financial soundness indictors are listed in Table 1. The index system of FSI includes regulatory capital to risk-weighted assets, regulatory Tier I capital to risk-weighted assets, nonperforming loans to total gross loans, nonperforming loans net of provisions to capital, return on assets, return on equity, interest margin to gross income, noninterest expenses to gross income, liquid assets to total assets, residential real estate loans to total gross loans, total debt to equity and household debt to GDP. The data are obtained from the annual IMF financial sector statistics in the postcrisis era. The choice of FSIs is determined by their availability for the largest set of OECD countries, and then the missing data are modified with linear interpolation.

Table 1. Financial soundness indicators.

Market	Indictors
Deposit Takers	Regulatory capital to risk-weighted assets
	Regulatory Tier I capital to risk-weighted assets
	Nonperforming loans to total gross loans
	Nonperforming loans net of provisions to capital
	Return on assets
	Return on equity
	Interest margin to gross income
	Noninterest expenses to gross income
	Liquid assets to total assets (liquid asset ratio)
Real Estate Markets	Residential real estate loans to total gross loans
Nonfinancial Corporate Sector	Total debt to equity
Households	Household debt to GDP

Financial stability is justified by looking at the common components of financial soundness indicator volatilities. As a result of sector shock, the measured comovement of others' assets and risk tends to rise above and beyond levels purely justified by fundamentals. Systemic risk measures gauge the increase in comovement that can arise due to the spread of instability shock across sectors. Measures of financial stability are interested in the common components of FSIs and not in a single sector itself because systemic risk wants to focus on that spillover of sectors. Therefore, this paper measures a financial soundness index of sectors that predicts financial stability. The index measures the aggregate level of stability taking in all sectors (rather than an individual financial risk exposure) and is calculated using the general dynamic factor model (GDFM). The GDFM allows for the possibility that more than one single common shock captures the comovement of the FSIs. In fact, this is relevant whenever there is more than one source of sector fluctuations. We estimate the GDFM using a large panel including FSIs for each OECD country and equal weight aggregation of common components to measure FSI. This paper utilizes the measure denoted FSI to forecast the likelihood that systemic risk-taking in the macroeconomic system will have detrimental real activity effects. Appendix A provides a detailed description of FSI by OECD countries. The larger the FSI is, the more stable the financial environment.

3.2.2. Data

We build a country-level balanced panel dataset that includes information on nonfinancial corporate sector leverage, household leverage, inflation, interest rates, the volatility of the real effective exchange rate and GDP per capita. The data are annual, range from 2009 to 2020, and include 19 OECD countries. In fact, leverage is defined as the sector's total debt scaled by total assets. Similarly, the nonfinancial corporate sector leverage measures, NFCL and, are defined as the nonfinancial corporation debt to GDP ratio. Domestic credit to the private sector over GDP measures the level of financial intermediation (FI) [2]. NFCL and FI data are taken from the Bank for International Settlements (BIS). The BIS leverage series are drawn from individual country sectoral accounts and are fairly comparable across OECD countries. The original data are processed by taking natural

logarithms to correct for potential heteroscedasticity and dimensional differences between series. Then, to obtain measures of inflation, capital flows and economic growth, we utilize a dataset developed by the OECD statistics. The consumer price index (CPI) reflects inflation, which is measured by the percentage change year-on-year and compiled by the key short-term economic indicators. Changes in monetary policy can lead to significant financial stability. We use the short-term interest rates (INR), its key policy rate, as a proxy for market liquidity from the OECD Monetary and Financial Statistics. GDP per capita is considered the most important indicator of economic growth. In addition, exchange rate volatility could measure financial risks by international market spillover effects. We select the real effective exchange rate based on unit labor costs, which we obtain from the International Monetary Fund (IMF) for International Financial Statistics, and we model the volatility of the exchange rate based on the ARMA-ARCH specification. The real effective exchange rate (ER) is a trade-weighted average of the exchange rates of different countries. It could better depict the flexibility of exchange rates.

Table 2 shows the summary statistics of the dependent and explanatory variables, includes the value of mean, maximum, minimum, standard deviation, coefficient of variation and Jarque–Bera. Regarding the dependent variables, the annual level of the financial soundness index is 0.062 percent with a standard deviation of 6.719. Not surprisingly, the Jarque–Bera test rejects normality for the financial soundness index series at the 1% significance level. This prompts us to employ the quantile regression (QR). Furthermore, we focus on NFCL and FI, which represent key factors affecting financial stability. The maximum value of the rate of change of NFCL is 5.588, and the minimum value is 3.638, which is maintained at a relatively stable level. The average FI is 4.331, and the Jarque–Bera test rejects normality at the 1% significance level. Thus, the nonlinear model should be considered according to the distribution characteristics when studying FI as a mechanism.

Table 2. Descriptive statistics.

	Mean	Max	Min	Std. Dev.	CV	Jarque–Bera
FSI	0.062	13.668	−17.660	6.719	109.217	4.975*
NFCL	4.635	5.588	3.638	0.396	0.085	4.305
FI	4.331	4.927	3.453	0.362	0.084	21.960***
INF	1.238	4.713	−4.478	1.224	0.989	100.157***
INR	0.737	4.875	−0.784	1.139	1.545	205.792***
EXR	−1.608	52.969	−25.110	12.657	−7.870	20.814***
GDP	4.538	9.345	1.907	1.271	0.280	13.500***

Note: Significance levels: *10%, **5%, ***1%.

3.3. Empirical results

In this section, we present quantile regression estimates of the effect of NFCL on financial stability. We estimate the model at the 10%-90% quantiles by FSI. The results are presented in Table 3.

Table 3. Quantile regression estimation results.

	10%	20%	30%	40%	50%	60%	70%	80%	90%
NFCL	−15.334	−15.369*	−15.397**	−15.414***	−15.434***	−15.448***	−15.466***	−15.487**	−15.520
	11.292	8.394	6.517	5.683	5.22	5.323	5.951	7.112	9.635
FI	18.223*	16.83**	15.749***	15.081***	14.278***	13.727***	12.999**	12.202*	10.878
	10.182	7.572	5.883	5.129	4.712	4.804	5.368	6.412	8.686
INF	0.347	0.51	0.637	0.715*	0.809**	0.873**	0.959**	1.052**	1.207*
	0.853	0.635	0.493	0.43	0.395	0.403	0.45	0.537	0.727
INR	−2.074	−1.798	−1.584*	−1.452*	−1.293*	−1.184	−1.04	−0.882	−0.62
	1.603	1.192	0.926	0.808	0.742	0.757	0.845	1.01	1.368
EXR	−0.006	−0.013	−0.019	−0.022	−0.027	−0.03	−0.034	−0.038	−0.045
	0.093	0.069	0.054	0.047	0.043	0.044	0.049	0.058	0.079
GDP	6.574***	6.394***	6.254***	6.168***	6.064***	5.993***	5.899***	5.796***	5.625***
	2.282	1.697	1.318	1.149	1.056	1.076	1.203	1.437	1.947

Note: The numbers below the coefficient are standard errors and p values, respectively. Significance levels: *10%, **5%, ***1%. The benchmark regression in this paper adopts a panel fixed effect model and selects the heterogeneity component in the generalized dynamic factor as an instrumental variable for the robustness test, and the results are consistent with those reported in this table. In generalized dynamic factors, the common component (FSI) and the heterogeneity component (IV) are orthogonal. Supplementary provides the robustness test.

There is an asymmetric impact of nonfinancial corporate sector leverage on financial stability. The results, reported in Table 3, show that the nonfinancial corporate sector leverage has a negative and nonlinear effect on financial soundness. The deterioration of the profitability and solvency of real corporations increases the risk of credit default, which in turn leads to an increase in financial risks, so the risk is mainly transmitted from the real sector to the financial sector. Credit risk is an important part of bank risk. The increase in the leverage ratio of loan corporations increases the bankruptcy risk of the company and transmits it to the related lending banks, increases the bank's nonperforming loan ratio, and then increases the financial risks. Moreover, except for extreme quantile points (10% and 90%), with the increase in FSI, the negative impact of NFCL on FSI gradually increases. That is, the more stable the financial environment is, the greater the leverage of nonfinancial corporations, which makes the financial environment more unstable. This is the result of the combined effect of credit supply and credit demand. At the lower quantile of the FSI, both credit supply and demand decline, and corporate leverage is low, so corporate sectoral leverage has a less negative impact on financial stability. Specifically, financial market risks are high, and both the increased volatility and decreased value of financial assets may result in a depreciation of the bank's asset value, and nonfinancial corporations provide lower credit supply. At the same time, macroeconomic weakness increases corporate risk aversion, corporations tend to maintain lower levels of leverage, and corporate credit demand is also lower. The lower level of corporate leverage narrows the scope of credit default risk, further reducing its impact on driving financial risks. However, when the financial soundness quantile is high, both the supply and demand for corporate credit together increase financial risks. From the perspective of corporate credit demand, in times of financial stability, corporations want to maximize their leverage to obtain greater profits. However, the high level of leverage reduces the liquidity of corporations and increases the probability of bankruptcy of corporations, which in turn leads to a substantial increase in bank credit risk and nonperforming loan ratios. In terms of bank credit supply, in a stable financial environment, banks tend to expand loans, corporate leverage ratios passively rise, and corporate default risks increase. Corporate financing still relies mainly on bank loans, and bank loan losses may increase significantly, thereby pushing up financial risks.

The impact of financial intermediation on financial stability at different levels is asymmetric. The results, reported in Table 3, show that the effect of the FI is positive and significant for all quantiles, except for the 90% quantile. The main purpose of financial intermediation is to collect and process social resource reallocation information and balance information asymmetry. On the one hand, financial intermediations are, to a certain extent, an alliance of borrowers with specialized information advantages. Since the rate of increase in “signal cost” is much lower than the scale of financial cooperation, financial intermediation can integrate the information of borrowers and lenders as quickly as possible and provide financial services with optimal resource allocation. On the other hand, financial intermediation also gains the advantage of economies of scale in surveillance, especially banks, which have the information and scale to overcome asymmetric information as they transform individual transactions of borrowers and investors into centralized transactions through intermediation information advantage. Therefore, the agglomeration of the financial industry can drive the development of other industries in the economic system. Moreover, the greater the financial stability is, the smaller the impact of financial intermediation on financial stability. Especially when the financial situation is unstable, the increase in the scale of banks’ financial intermediary can further reduce the information asymmetry between banks and the corporate sector, optimize the capital allocation efficiency of the economic system, and effectively weaken the amplifying effect of financial

friction on financial risks. In times of financial instability, as banks tend to overallocate credit to efficient and qualified corporations and continuously push up the leverage of qualified corporations. Financial intermediaries can alleviate the problem of excessive leverage and financial mismatch, thereby reducing financial risks

4. Model extension: nonlinear transmission mechanism

4.1. Model setup: the panel smooth transition regression (PSTR) model

It is very important to explore the appropriate range of nonfinancial corporate sector leverage for financial stability. On the one hand, raising the leverage of the nonfinancial corporate sector can leverage resources and inject greater vitality into the economy. Higher debt leverage can provide sufficient financial support for enterprise operations, thus bringing greater vitality to enterprise operations and improving enterprise profitability. On the other hand, the economic prosperity brought by increased leverage is accompanied by greater financial risks. When faced with a sudden shock, highly leveraged corporations may have liquidity risk, capital chain fracture, credit default and a series of additional problems. High leverage reflects the vulnerability of dealing with economic crises. It is crucial for a country's economy to prevent financial risks while maintaining stable economic growth.

The level of financial intermediation plays a nonlinear role between the nonfinancial corporate sector and financial stability. The role of financial intermediation is to solve the problem of information asymmetry and lending efficiency that can be used to pool funds, transfer risks, produce information and provide incentives. We investigate the nonlinearity of the relationships between FI, NFCL and FSI by estimating panel smooth transition (PSTR) models. First, they capture the nonlinearity transmission mechanism, since it allows for a smooth transition between the extreme regimes. Second, the threshold of financial intermediation helps to balance the impact of leverage on financial stability. The threshold value is not given a priori, but it is calculated in the model. Finally, they offer a parametric method to examine the individual heterogeneity and time variability of NFCL elasticity in OECD countries. Therefore, capturing nonlinearities and regime switching makes the PSTR a good tool for the study of "the role of financial intermediation". The model can be expressed as follows:

$$FSI_{it} = \mu_i + \beta_0 NFCL_{it} + \beta_1 NFCL_{it} g(s_{it};\gamma,c) + \delta C_{it} + \upsilon_{it} \tag{3}$$

where $i = 1,...,N$, and $t = 1,...,T$. N and T denote the cross-section and time dimensions of the panel, respectively. In this model, the dependent variable is FSI_{it} , and μ_i indicates the vector of the individual fixed effects. Financial intermediation (FI) is the transition variable. FI is the financial intermediate development level, C_{it} is the control variable, and υ_{it} is the error term. The PSTR model is based on a function of transition $g(s_{it};\gamma,c)$. This function of transition is dependent on a transition variable denoted s_{it} . γ and c represent the parameter of the threshold and the smooth transition parameter, respectively. β_0 and β_1 indicate the parameter vector of the linear model and the nonlinear model, respectively.

To determine this transition function, the logistic form of m orders is shown in Eq (4):

$$g(s_{it};\gamma,c)=[1+\exp(-\gamma\prod_{j=1}^{m}(s_{it}-c_j))]^{-1} \quad (4)$$

where $\gamma>0$, $c_1<c_2<...<c_m$ and $c=(c_1...c_m)$ is a vector of the level parameter. γ represents the supposed positive smooth parameter. The small γ value imposes a slow transition, and the function changes quite fast when the γ value is large.

4.2. The role of financial intermediation

We begin by testing the null hypothesis of linearity using the test with financial intermediation as the relevant transition variable. In other words, we test whether there exists a different leverage effect of financial stability when facing high and low levels of financial intermediation. The results are reported in Table 4, which displays the p values of the Lagrange multiplier and other tests for the null hypothesis of linearity against the alternative of a logistic (m = 1) PSTR specification. The remaining nonlinearity test is mainly used to identify whether the setting of the PSTR model transfer function is appropriate and to determine the optimal number r of the model transfer function. Our finding shows that the null hypothesis cannot be rejected, so there is no need to further choose m=1 or m=2, and the case of m=2 can be directly selected for empirical analysis. Table 4 shows that the remaining nonlinear test results do not reject the null hypothesis, which means that it is appropriate to set a transfer function for the model; that is, the model contains only one transfer function. This result shows that NFCL impacts the FSI differently, depending on the level of the FI.

Table 4. LM tests based on transition variable FI.

Results of the linearity (homogeneity) tests			
LM_X	LM_F	HAC_X	HAC_F
15.68***	6.94***	5.93*	2.63*
No remaining nonlinearity (heterogeneity) test			
LM_X	LM_F	HAC_X	HAC_F
2.94	0.36	3.91	0.48

Note: Significance levels: *10%, **5%, ***1%.

Table 5 presents the estimation of the PSTR model for 19 OECD countries during the 2009-2020 period. This estimation is done by applying nonlinear least squares to eliminate the individual effects.

The transmission mechanism of the impact of financial intermediation in nonfinancial corporate sector leverage on financial stability is nonlinear. When the level of financial intermediation exceeds 3.58, the level of financial intermediation weakens the impact of NFCL on FSI. That is, the level of financial intermediation can weaken the impact of nonfinancial corporate leverage on FSI and reduce financial risks. The speed of the smooth transition of the two mechanisms is 4.99. The results in Table 5 indicate that below the optimal threshold, the effect of NFCL is negative and statistically significant. However, surpassing these optimal thresholds, the level of FI positively and statistically significantly responds to NFCL. For example, a 1.00% increase in NFCL increases FSI by 15.19%. When the level of financial intermediation in an economy is low, its ability to optimize

resource allocation is not effectively exerted, and the problem of adverse selection is enlarged. When the market is not perfect, financial intermediaries can take advantage of poor information to provide loans to corporations with poor credit qualifications and earn high commissions from them. It not only increases the borrowing cost of corporations and increases the risk of corporate default but also promotes the increase of nonperforming leverage and increases financial risks. The higher the level of financial intermediation, the more intense the competition in the financial market and the stronger the risk transfer and management functions of the financial system. In a fiercely competitive market, the improvement of bank financial intermediation efficiency can greatly reduce the information asymmetry between banks and SMEs, improve the efficiency of credit allocation, and thus significantly alleviate the negative impact of corporate leverage on financial stability. Financial intermediaries can reduce transaction costs in financial markets through economies of scale, and growing corporations and microcorporations can more easily borrow and further diversify the risks borne by financial institutions.

Table 5. Results of the PSTR estimation.

	Linear Part	Nonlinear Part	Second Extreme Regime
NFCL	−36.24***	15.19***	−21.05***
	7.93	5.66	3.99
FI	−1.97**	2.98**	1.01**
	0.99	1.34	0.50
INR	−0.29		
	0.58		
EXR	−0.056		
	0.039		
GDP	8.54***		
	1.05		
Nonlinear parameter estimates			
gamma	4.99***	c1	3.58***
	1.27		0.14

Note: The numbers below the coefficients are standard errors and p values, respectively. Significance levels: *10%, **5%, ***1%.

5. Conclusions and policy implications

Nonfinancial corporate leverage plays a “double-edged sword” role in promoting high-quality economic development. On the one hand, increasing leverage can leverage resources and bring greater vitality to the economy. On the other hand, while bringing economic prosperity, increased leverage is also accompanied by greater financial risks. For an economy, it is crucial to guard against financial risks while maintaining stable economic growth. This paper first uses the generalized dynamic factor model to measure the financial soundness index (FSI) of OECD countries according to the financial soundness indicators proposed by the IMF in the post crisis era. Then, we study the impact of nonfinancial corporate leverage on financial soundness and the transmission mechanism through which financial intermediation plays. According to the empirical analysis, the conclusions are as

follows. First, leverage in the nonfinancial corporate sector has asymmetric effects on financial stability. Nonfinancial corporations have a negative and significant impact on financial stability. As the FSI rises, nonfinancial corporate leverage has a greater impact on financial stability, which is mainly affected by the supply and demand of credit. Second, the level of financial intermediation attenuates the impact of nonfinancial corporate leverage on financial stability. The threshold for financial intermediation as a mechanism is 3.58. When the level of financial intermediation is higher than the threshold, financial intermediation can promote resource allocation, reduce information asymmetry, provide borrowing efficiency, and then reduce financial risks caused by nonfinancial corporate leverage.

Based on the above research conclusions, this paper draws the following policy implications. In periods of financial stability, the financial risks posed by nonfinancial corporate leverage are greater. Excessive leverage can accelerate the breakdown of financial soundness when the economy suffers. Central banks should focus on monitoring nonfinancial corporate leverage in boom times to prevent bubbles caused by excessive credit. Furthermore, the level of financial intermediation is critical to financial stability. To curb the negative impact of nonfinancial corporate leverage and actively and steadily promote economic growth, it is necessary to reduce the information asymmetry between the financial market and loan corporations, regulate financial intermediation, and form a competitive financial intermediary industry. Formal financial intermediaries can reduce the cost of corporate loans, allocate financial assets reasonably, improve credit efficiency, and reduce financial risks to a greater extent.

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Conflict of interest

The authors declare no conflict of interest.

References

1. International Monetary Fund Staff, Financial soundness indicators: compilation guide, International Monetary Fund, 2006. Available from: https://www.imf.org/en/Publications/Manuals-Guides/Issues/2016/12/31/Financial-Soundness-Indicators-Compilation-Guide-17619.
2. M. T. Kasselaki, A. O. Tagkalakis, Financial soundness indicators and financial crisis episodes, *Ann. Finance*, **10** (2014), 623–669. https://doi.org/10.1007/s10436-013-0233-6
3. T. Adrian, J. Kiff, H. S. Shin, Liquidity, leverage, and regulation 10 years after the global financial crisis, *Annu. Rev. Financ. Econ.*, **10** (2018), 1–24. https://doi.org/10.1146/annurev-financial-110217-023113
4. L. M. Chen, Z. Q. Du, Y. Tan, Sustainable exchange rates in China: Is there the heterogeneous effect of economic policy uncertainty?, *Green Finance*, **1** (2019), 346–363. https://doi.org/10.3934/gf.2019.4.346

5. L. M. Chen, Z. Q. Du, Z. H. Hu, Impact of economic policy uncertainty on exchange rate volatility of China, *Financ. Res. Lett.*, **32** (2020), 101266. https://doi.org/10.1016/j.frl.2019.08.014
6. L. M. Chen, Z. Zhang, Z. Q. Du, L. L. Deng, Heterogeneous determinants of the exchange rate market in China with structural breaks, *Appl. Econ.*, **53** (2021), 6839–6854. https://doi.org/10.1080/00036846.2021.1949432
7. M. Hong, X. L. Wang, Z. H. Li, Will oil price volatility cause market panic?, *Energies*, **15** (2022), 4629. https://doi.org/10.3390/en15134629
8. Z. Huang, H. Dong, S. Jia, Equilibrium pricing for carbon emission in response to the target of carbon emission peaking, *Energ. Econ.*, **112** (2022), 106160. https://doi.org/10.1016/j.eneco.2022.106160
9. Z. H. Li, Z. M. Huang, P. Failler, Dynamic correlation between crude oil price and investor sentiment in China: heterogeneous and asymmetric effect, *Energies*, **15** (2022), 687. https://doi.org/10.3390/en15030687
10. G. K. Liao, P. Hou, X. Y. Shen, K. Albitar, The impact of economic policy uncertainty on stock returns: The role of corporate environmental responsibility engagement, *Int. J. Financ. Econ.*, **26** (2021), 4386–4392. https://doi.org/10.1002/ijfe.2020
11. M. N. Utomo, S. Rahayu, K. Kaujan, S. A. Irwandi, Environmental performance, environmental disclosure, and firm value: empirical study of non-financial companies at Indonesia Stock Exchange, *Green Finance*, **2** (2020), 100–113. https://doi.org/10.3934/gf.2020006
12. S. Xu, Z. Q. Du, H. Zhang, Can crude oil serve as a hedging asset for underlying securities?—Research on the heterogenous correlation between crude oil and stock index, *Energies*, **13** (2020), 3139. https://doi.org/10.3390/en13123139
13. Z. H. Li, J. H. Zhong, Impact of economic policy uncertainty shocks on China's financial conditions, *Financ. Res. Lett.*, **35** (2020), 101303. https://doi.org/10.1016/j.frl.2019.101303
14. Z. H. Li, H. Dong, C. Floros, A. Charemis, P. Failler, Re-examining Bitcoin volatility: a caviar-based approach, *Emerg. Mark. Financ. Trade*, **58** (2022), 1320–1338. https://doi.org/10.1080/1540496x.2021.1873127
15. Z. H. Li, L. M. Chen, H. Dong, What are Bitcoin market reactions to its-related events?, *Int. Rev. Econ. Financ.*, **73** (2021), 1–10. https://doi.org/10.1016/j.iref.2020.12.020
16. International Monetary Fund, Global financial stability report: responding to the financial crisis and measuring systemic risks, 2009. Available from: https://www.imf.org/en/Publications/GFSR/Issues/2016/12/31/Responding-to-the-Financial-Crisis-and-Measuring-Systemic-Risks
17. T. Adrian, E. Etula, T. Muir, Financial intermediaries and the cross-section of asset returns, *J. Financ.*, **69** (2014), 2557–2596. https://doi.org/10.1111/jofi.12189
18. F. Smets, S. Villa, Slow recoveries: any role for corporate leverage?, *J. Econ. Dyn. Control*, **70** (2016), 54–85. https://doi.org/10.1016/j.jedc.2016.06.003
19. R. Kollmann, S. Zeugner, Leverage as a predictor for real activity and volatility, *J. Econ. Dyn. Control*, **36** (2012), 1267–1283. https://doi.org/10.1016/j.jedc.2012.03.010
20. V. V. Acharya, L. H. Pedersen, T. Philippon, M. Richardson, Measuring systemic risk, *The Review of Financial Studies*, **30** (2017), 2–47. https://doi.org/10.1093/rfs/hhw088
21. C. Brownlees, R. F. Engle, Srisk: a conditional capital shortfall measure of systemic risk, *The Review of Financial Studies*, **30** (2017), 48–79. https://doi.org/10.1093/rfs/hhw060

22. K. S. Peng, G. F. Yan, A survey on deep learning for financial risk prediction, *Quant. Financ. Econ.*, **5** (2021), 716–737. https://doi.org/10.3934/qfe.2021032
23. C. Borio, Towards a macroprudential framework for financial supervision and regulation?, *CESifo Economic Studies*, **49** (2003), 181–215. https://doi.org/10.1093/cesifo/49.2.181
24. T. Adam, V. K. Goyal, The investment opportunity set and its proxy variables, *J. Financ. Res.*, **31** (2008), 41–63. https://doi.org/10.1111/j.1475-6803.2008.00231.x
25. S. Puddu, Optimal weights and stress banking indexes, *IRENE Working Paper*, 2013, 13-02.
26. V. Chirila, C. Chirila, The steel european stock market efficiency, *CES Working Papers*, **VII** (2015), 873–880.
27. C. T. Albulescu, Forecasting the Romanian financial system stability using a stochastic simulation model, *J. Econ. Forecast.*, **13** (2010), 81–98.
28. V. C. Morris, Measuring and forecasting financial stability: the composition of an aggregate financial stability index for Jamaica, *Business, Finance & Economics in Emerging Economies*, **6** (2010), 34–51.
29. E. P. Davis, D. Karim, Comparing early warning systems for banking crises, *J. Financ. Stabil.*, **4** (2008), 89–120. https://doi.org/10.1016/j.jfs.2007.12.004
30. M. A. Morales, D. Estrada, A financial stability index for Colombia, *Ann. Finance*, **6** (2010), 555–581. https://doi.org/10.1007/s10436-010-0161-7
31. K. Virolainen, Macro stress testing with a macroeconomic credit risk model for Finland, *Bank of Finland Research Discussion Paper*, 2004, 18/2004.
32. M. Hosen, M. Y. Broni, M. N. Uddin, What bank specific and macroeconomic elements influence non-performing loans in Bangladesh? Evidence from conventional and Islamic banks, *Green Finance*, **2** (2020), 212–226. https://doi.org/10.3934/gf.2020012
33. T. T. X. Huong, T. T. T. Nga, T. T. K. Oanh, Liquidity risk and bank performance in Southeast Asian countries: a dynamic panel approach, *Quant. Financ. Econ.*, **5** (2021), 111–133. https://doi.org/10.3934/qfe.2021006
34. J. A. P. Antunes, C. O. De Moraes, A. Rodrigues, How financial intermediation impacts on financial stability?, *Appl. Econ. Lett.*, **25** (2018), 1135–1139. https://doi.org/10.1080/13504851.2017.1400647
35. J. Williamson, The Washington consensus and beyond, *Economic and Political Weekly*, **38** (2003), 1475–1481.
36. F. S. Mishkin, Global financial instability: framework, events, issues, *J. Econ. Perspect.*, **13** (1999), 3–20. https://doi.org/10.1257/jep.13.4.3
37. C. W. Granger, B.-N. Huangb, C.-W. Yang, A bivariate causality between stock prices and exchange rates: evidence from recent Asianflu, *The Quarterly Review of Economics and Finance*, **40** (2000), 337–354. https://doi.org/10.1016/S1062-9769(00)00042-9
38. E. Farhi, J. Tirole, Deadly embrace: sovereign and financial balance sheets doom loops, *The Review of Economic Studies*, **85** (2018), 1781–1823. https://doi.org/10.1093/restud/rdx059
39. T. H. Li, J. H. Zhong, Z. M. Huang, Potential dependence of financial cycles between emerging and developed countries: based on Arima-Garch copula model, *Emerg. Mark. Financ. Trade*, **56** (2020), 1237–1250. https://doi.org/10.1080/1540496x.2019.1611559
40. B. J. Moore, *Shaking the invisible hand: complexity, endogenous money and exogenous interest rates*, Basingstoke: Palgrave Macmillan, 2006.

41. F. Moscone, E. Tosetti, A. Canepa, Real estate market and financial stability in US metropolitan areas: a dynamic model with spatial effects, *Reg. Sci. Urban Econ.*, **49** (2014), 129–146. https://doi.org/10.1016/j.regsciurbeco.2014.08.003
42. C. M. Reinhart, K. S. Rogoff, Is the 2007 US sub-prime financial crisis so different? An international historical comparison, *Am. Econ. Rev.*, **98** (2008), 339–344. https://doi.org/10.1257/aer.98.2.339
43. S. Chan, G. F. Han, W. L. Zhang, How strong are the linkages between real estate and other sectors in China?, *Res. Int. Bus. Financ.*, **36** (2016), 52–72. https://doi.org/10.1016/j.ribaf.2015.09.018
44. E. Takáts, Ageing and asset prices, *BIS Working Papers*, 2010, 318.
45. B. Büyükkarabacak, N. T. Valev, The role of household and business credit in banking crises, *J. Bank Financ.*, **34** (2010), 1247–1256. https://doi.org/10.1016/j.jbankfin.2009.11.022
46. A. Alter, A. X. Feng, N. Valckx, Understanding the macro-financial effects of household debt: a global perspective, *IMF Working Papers*, 2018, 2018/076.
47. G. Phelan, Financial intermediation, leverage, and macroeconomic instability, *Am. Econ. J.: Macroecon.*, **8** (2016), 199–224. https://doi.org/10.1257/mac.20140233
48. Y. Liu, Z. H. Li, M. R. Xu, The influential factors of financial cycle spillover: evidence from China, *Emerg. Mark. Financ. Trade*, **56** (2020), 1336–1350. https://doi.org/10.1080/1540496x.2019.1658076
49. T. H. Li, X. Li, G. K. Liao, Business cycles and energy intensity. Evidence from emerging economies, *Borsa Istanb. Rev.*, **22** (2022), 560–570. https://doi.org/10.1016/j.bir.2021.07.005
50. K. Istiak, The nature of shadow bank leverage shocks on the macroeconomy, *The North American Journal of Economics and Finance*, **50** (2019), 101029. https://doi.org/10.1016/j.najef.2019.101029
51. V. V. Acharya, S. Viswanathan, Leverage, moral hazard, and liquidity, *J. Financ.*, **66** (2011), 99–138. https://doi.org/10.1111/j.1540-6261.2010.01627.x
52. E. G. Mendoza, Sudden stops, financial crises, and leverage, *Am. Econ. Rev.*, **100** (2010), 1941–1966. https://doi.org/10.1257/aer.100.5.1941
53. O. Akinci, R. Chahrour, Good news is bad news: leverage cycles and sudden stops, *J. Int. Econ.*, **114** (2018), 362–375. https://doi.org/10.1016/j.jinteco.2018.07.006
54. A. Boitani, C. Punzo, Banks' leverage behaviour in a two-agent new Keynesian model, *J. Econ. Behav. Organ.*, **162** (2019), 347–359. https://doi.org/10.1016/j.jebo.2018.12.016
55. F. Beltrame, D. Previtali, A. Sclip, Systematic risk and banks leverage: the role of asset quality, *Financ. Res. Lett.*, **27** (2018), 113–117. https://doi.org/10.1016/j.frl.2018.02.015
56. M. B. Devereux, J. Yetman, Leverage constraints and the international transmission of shocks, *J. Money Credit Bank.*, **42** (2010), 71–105. https://doi.org/10.1111/j.1538-4616.2010.00330.x
57. M. R. Xu, K. Albitar, Z. H. Li, Does corporate financialization affect EVA? Early evidence from China, *Green Finance*, **2** (2020), 392–408. https://doi.org/10.3934/gf.2020021
58. Z. H. Li, F. Q. Zou, B. Mo, Does mandatory CSR disclosure affect enterprise total factor productivity?, *Econ. Res.-Ekon. Istraz.*, in press. https://doi.org/10.1080/1331677x.2021.2019596
59. O. I. Bacha, A. Mirakhor, Funding development infrastructure without leverage: a risk-sharing alternative using innovative sukuk structures, *World Econ.*, **41** (2018), 752–762. https://doi.org/10.1111/twec.12512
60. Z. H. Li, F. Q. Zou, Y. Tan, J. H. Zhu, Does financial excess support land urbanization—an empirical study of cities in China, *Land*, **10** (2021), 635. https://doi.org/10.3390/land10060635

61. Y. S. Liang, K. Shi, L. S. Wang, J. Y. Xu, Local government debt and firm leverage: evidence from China, *Asian Econ. Policy Rev.*, **12** (2017), 210–232. https://doi.org/10.1111/aepr.12176
62. X. H. Gu, P. S. Tam, Y. Zhang, C. K. Lei, Inequality, leverage and crises: theory and evidence revisited, *World Econ.*, **42** (2019), 2280–2299. https://doi.org/10.1111/twec.12806
63. M. Lacoviello, Financial business cycles, *Rev. Econ. Dyn.*, **18** (2015), 140–163. https://doi.org/10.1016/j.red.2014.09.003
64. P. Martin, T. Philippon, Inspecting the mechanism: leverage and the great recession in the eurozone, *Am. Econ. Rev.*, **107** (2017), 1904–1937. https://doi.org/10.1257/aer.20150630
65. E. A. Ghossoub, Financial market participation, financial intermediation, and monetary policy, *Econ. Lett.*, **117** (2012), 127–130. https://doi.org/10.1016/j.econlet.2012.04.090
66. C. A. Yepez, Financial intermediation, consumption dynamics, and business cycles, *Econ. Model.*, **60** (2017), 231–243. https://doi.org/10.1016/j.econmod.2016.09.026
67. B. McCaig, T. Stengos, Financial intermediation and growth: some robustness results, *Econ. Lett.*, **88** (2005), 306–312. https://doi.org/10.1016/j.econlet.2004.12.031
68. T. Adrian, H. S. Shin, Liquidity and leverage, *J. Financ. Intermed.*, **19** (2010), 418–437. https://doi.org/10.1016/j.jfi.2008.12.002
69. R. Babihuga, Macroeconomic and financial soundness indicators: an empirical investigation, *IMF Working Papers*, 2007, 2007/115.
70. M. C. Navajas, A. Thegeya, Financial soundness indicators and banking crises, *IMF Working Papers*, 2013, 2013/263.
71. A. San Jose, A. Georgiou, Financial soundness indicators (FSIs): framework and implementation, In: *Proceedings of the IFC Conference on "Measuring financial innovation and its impact", Basel, 26-27 August 2008*, 2009, 277–282.

Appendix

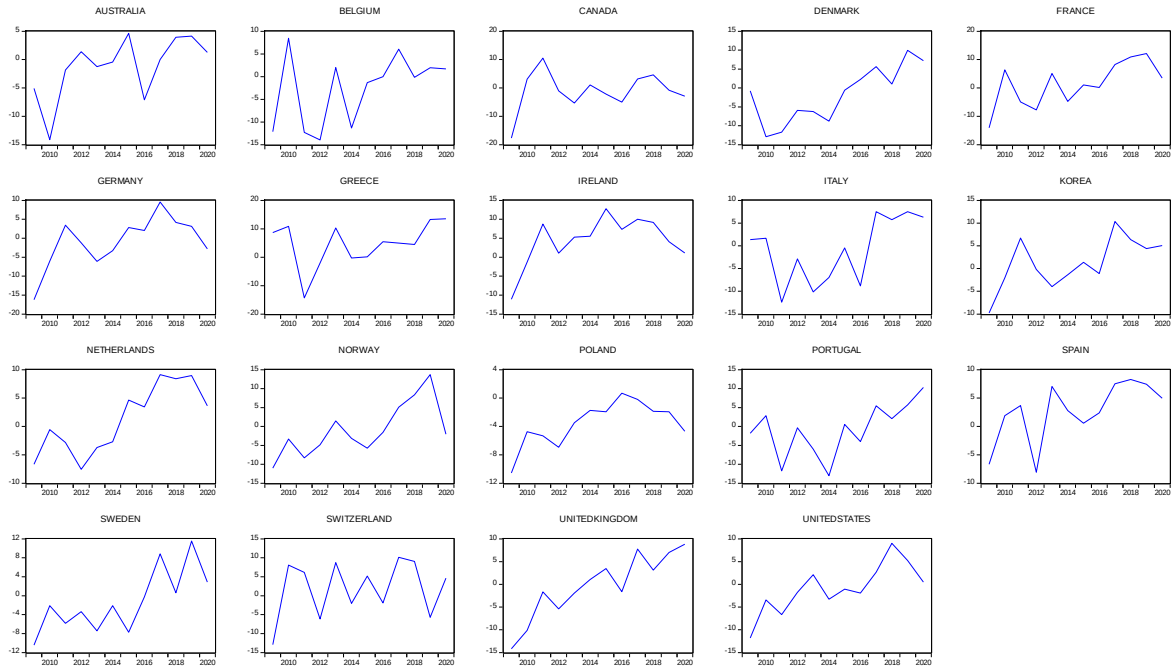

Figure A1. Financial soundness index of OECD countries in the post crisis era.

Table A1. Robustness test.

Dependent Variable: Financial Soundness Index				
	FE	FE_IV	FE	FE_IV
	(1)	(2)	(3)	(4)
NFCL	−15.428*	−249.805***	−94.587**	−1340.184***
	7.557	84.232	38.734	425.578
FI	14.501***	120.399***	−86.912	−1623.836***
	3.539	42.181	51.587	534.845
NFCL*FI			19.616*	319.863***
			9.870	103.683
INF	0.783	0.015	0.728	−0.218
	0.567	1.590	0.587	1.257
INR	−1.337	6.514*	−1.556	−3.773*
	1.009	3.357	0.927	2.269
EXR	−0.026	−0.531**	−0.013	0.110
	0.045	0.211	0.041	0.147
GDP	6.093***	26.254***	5.957***	6.798***
	1.808	7.673	1.697	2.656
_cons	−18.902969		393.26542*	
	29.872		201.902	

Note: The numbers below the coefficients are standard errors and p values, respectively. Significance levels: *10%, **5%, ***1%. The benchmark regression is a panel fixed effect model and selects the heterogeneity component in the generalized dynamic factor as an instrumental variable.