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SYSTEMIC FINANCIAL RISKS OF CHINA'S ECONOMY: SELF-ENFORCING CYCLES

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ABSTRACT

The paper focuses on the acute problems of systemic financial risk in the economy of China posed by the real estate sector. In the event of its collapse, the world's second-largest economy of this Asian giant, deeply integrated into the global system, can trigger spillover effects and a new global economic crisis. It is therefore important to deepen understanding of the internal mechanisms of systemic financial risk accumulation in the Chinese economy. We research the microfinancial roots of systemic financial risk and macroeconomic mechanisms of its accumulation and materialisation after it has reached a critical level. Microfinancial roots of systemic risks are connected with excessive growth of financial leverage. We suggest a mathematical model of the optimal level of financial leverage and its safety threshold for the companies in the real sector including the construction and development sector. On the macro level, the paper presents a comprehensive dynamic scheme of non-linear relationships in the real estate industry, which unwind self-reinforcing cycles and lead to the accumulation of systemic financial risks. The main driving force of these processes is the institutional mechanism that we call collateral accelerator. Under certain conditions, it plays the role of a powerful internal destabiliser of the economic system and provokes the unwinding of self-reinforcing cycles in the real estate market, the households' finance, development companies, and the banking system. The results of the research can help shape the optimal macroprudential regulatory measures to minimise systemic financial risks and ensure financial stability without suppressing economic growth.

Keywords: systemic financial risks, China's economy, real estate industry, optimal financial leverage, self-enforced financial cycles, collateral accelerator, Macroprudential policy, financial stability

JEL Classification: C6, E5, F4, G3, P4

INTRODUCTION

The world media have been extensively covering alarming estimates of risks in China's economy, from reporting a sharp slowdown of economic growth [9] to forecasting recession and systemic collapse.

According to the National Bureau of Statistics of China (NBSC) [27], in the second quarter of 2022, the Chinese economy grew by just 0.4% year-on-year, not reaching the 1% market consensus forecast and slowing down sharply after picking up by 4.8% in the first quarter. The NBSC described the results in the first quarter as "hard-won achievements" and warned of the continuing impact of epidemic outbreaks and reduction in domestic demand. In general, in the first half of 2022, the economy grew by 2.5%.

The Chinese government set an economic growth target of 5.5% in 2022. However, many of the world's analytical centres have given worse forecasts for China's GDP growth this year: Goldman Sachs lowered it from 3.3% to 3%, and Nomura from 3.3% to 2.8% [24]. According to the World Bank, GDP growth in China is forecast to decrease to 2,8% in 2022. The rest of the 23-country Asia Pacific region is expected to grow to 5,3% on average. So, as "The Guardian" noticed, China's divergent path placed its GDP growth behind its neighbours for the first time since 1990.

In the event of its collapse, the world's second-largest economy of this Asian giant, deeply integrated into the global system, can trigger a new global economic crisis. It is therefore important to understand the nature of internal and external risks in the Chinese economy and the ways they intertwine and reinforce each other. Such a rigorous analysis will help avoid a simplistic approach to anti-crisis measures when the state financial interventions and some conventional changes in individual type risks regulations are thought to be a panacea instead of undergoing systemic structural changes. Without in-depth research of the internal mechanisms that exacerbate risks, this approach may become the "cure" worse than the disease itself.

Tightening regulations to reduce individual risks can lead to sharp deleverage, a fall in aggregated demand, and various depressive scenarios, such as the Fisherian debt-deflation crisis and depression [21], the Minsky moment [18; 19], and the balance sheet recession described by Koo [33].

It appears necessary to rely on a rather complex concept of systemic risk to find acute pain points and identify effective anti-crisis measures. Niels Bohr highlights that understanding complex phenomena requires using tools for the analysis of an appropriate level of complexity. In the case of China's large economy, with its complex global forward and backward linkages, one should think in categories of complex systems and systemic risks. In this paper, we focus on systemic financial risks in China's economy, structural problems in the real estate industry, and their sources at the micro- and macro levels.

LITERATURE REVIEW

The essence of systemic financial risk and existing approaches to its assessment

What is the difference between systemic financial risk and any other types of financial risks such as exchange rate risk, credit, liquidity, insolvency risks and others? The difference is profound [41].

To understand the essence of systemic risk, it is worth thinking beyond usual analytical stereotypes and statistical forecasting methods based on time series analysis. When systemic risk materializes, there occurs a breakdown of past trends in the economic system and a sharp shift to a qualitatively different state, which cannot be revealed by such analysis. That is why the traditional models could not forecast the exacerbation of systemic risks of the global financial crisis in 2008, not only at the primary stage but even at its onset in 2006-2007. Furthermore, in 2007 before the global crisis, many of their models projected economic growth and stability.

The nature of systemic risk is deeply concealed under a visible layer of observed phenomena. The concept of systemic risk has its roots in the essence of system viability. Systemic financial risk has certain common features with systemic risk in different systems: biological, physical, socio-political, geological systems, etc. The key concepts for thinking and analysis are complex systems, complex networks, holistic approach, the viability of a system, phenomena of emergency, bifurcation points, self-enforcing cycles and other concepts of complex system theory. Structural and dynamic non-linear models of such systems can be suitable mathematical tools for systemic risk modelling, assessment, and forecasting.

For instance, if we consider a biological organism as a complex system, the systemic risk for this system is the risk of death, in other words – the risk of complete termination of its biological life and existence as a whole. The causes of it may differ as triggers of systemic risk, but the main idea is the destruction of the system's vital connections and functions, which makes its whole existence impossible.

Thus, systemic risk is a risk to the system that threatens its viability, its existence and its functioning as a whole.

With regard to economic systems, systemic risk can be triggered by individual types of financial risks, such as exchange rate risks, credit, default, liquidity risks, etc. However, the "launch" of the scenario of systemic risk materialization occurs when the system is in a state of internal fundamental structural vulnerability to external or internal shocks. In this case, even minor external or internal shock can have a spillover effect on the whole system and bring it to a loss of viability.

For example, if a banking system has deep structural disproportions, even small shocks of different types can trigger a domino effect and avalanche-like destructive processes in the complex network of the banking system and undermine its functioning as a whole.

In these conditions, the attempts of the banks to reduce their individual risks by the urgent sale ("fire sale") of collateral assets can pour gas on the fire. These efforts can lead to a massive collapse of the collateral asset market and have an explosive effect of collective risk increase and materialization of systemic risk. This happened in 2008 when the sharp

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structural disproportions in the financial systems of many developed countries under influence of initial shock in the US mortgage market, led to a domino effect and a global financial crisis.

In the context of new geopolitical and technological challenges, the high level of interconnectedness and speed of processes in the global economy is perilously exacerbating systemic risk accumulation. Therefore, one of the most important tasks for economic science and researchers around the world is to diagnose the accumulation of systemic risk at an early stage and develop methods to prevent or reduce them. A new area of economic science – an assessment and forecasting of systemic risks – is intensively developing.

Economic sciences have achieved considerable progress in financial systemic risk understanding and measuring. A profound and detailed review of the different measures of financial systemic risks is provided in the fundamental research paper by Adrian & Brunnermeier (2016) [2]. The authors mentioned, that "Xin Huang, Hao Zhou and Haibin Zhu (2012) develop a systemic risk indicator that measures the price of insurance against systemic financial distress from credit default swap (CDS) prices. Viral Acharya, Lasse Pedersen, Thomas Philippon and Matthew Richardson (2010) focus on high-frequency marginal expected shortfall as a systemic risk measure. Christian Brownlees and Robert Engle (2015) and Viral Acharya, Robert Engle and Matthew Richardson (2012) develop the closely related SRISK measure which calculates the capital shortfall of individual institutions conditional on market stress. Monica Billio, Mila Getmansky, Andrew W Lo and Loriana Pelizzon (2012) propose a systemic risk measure that relies on Granger causality among firms. Stefano Giglio (2014) uses a nonparametric approach to derive the bounds of systemic risk from CDS prices. Another important strand of the literature, initiated by Alfred Lehar (2005) and Z. Bodie, D.F. Gray and R.C. Merton (2007a), uses contingent claims analysis to measure systemic risk. Z. Bodie, D.F. Gray and R.C. Merton (2007b) develop a policy framework based on contingent claims. M.A. Segoviano and C. Goodhart (2009) use a related approach to measure risk in the global banking system".

Tobias Adrian and Markus K. Brunnermeier suggested their approach – the ΔCoVaR method that became the basis for the development of its applications in different financial sectors.

The ideas of non-linear interrelationships between a real estate sector and a banking system that can provoke systemic financial risk were described in many papers and some books by well-known economists. In particular, these processes have been analysed in Adair Turner's meaningful book "Between Debt and the Devil: Money, Credit, and Fixing Global Finance" (2015), in papers of Huthaifa Algaralleh and Alessandra Canepa "Housing market cycles in large urban areas" (2020) [20], Yener Coskun, Nicholas Apergis, Esra Alp Coskun "Non-linear responses of consumption to wealth, income, and interest rate shocks" (2022) [9], Hui Eddie Chi-Man and Wang Ziyou "Can we predict the property cycle? A study of the securitized property market" (2015), Richard Barras "A Building Cycle Model for an Imperfect World" (2005) [34] and others. The insightful paper of Kenneth Rogoff and Yuanchen Yang (2021) "Has China's Housing Production Peaked?" [23] and supplement in the form of a statistical data file on the Chinese economy stimulated our research and helped us to understand the role of China's real estate sector.

The problems of collateral for credit processes and the financial market's smooth functioning were developed and presented in the paper by Patrick Schaffner, Angelo Ranaldo and Kostas Tsatsaronis "Euro repo market functioning: collateral is king" (2019) [29], in the European Systemic Risk Board's report "Vulnerabilities in the residential real estate sectors of the EEA countries" (February 2022) [16], in papers Maximilian Zurek "Real estate markets and lending: does local growth fuel risk?" [46], Satyajit Das "Markets insight: misuse of collateral creates systemic risk" [16] and others. Continuing this research further, we suggest new analytical concepts and tools for a deeper understanding the systemic financial risk. One of such concepts we shall call collateral accelerator and give a quantitative description of its nature and mechanisms of its functioning in the process of systemic financial risk accumulation.

Broadly speaking, there are four general approaches to systemic risk measuring and assessment:

- the network approach (The Network Approach);
- risk correlation analysis-based approach (Co-risk Model)
- the method of matrices of the interdependence of distresses (Distress Dependence Matrix);
- the approach based on default intensity models Intensity (Default Intensity Model).

Each of these approaches has advantages and limitations and reflects one or another aspect of systemic risks and many authors agree on the necessity to improve them further.

We have developed several new analytical tools that can complement existing methods and shed some light on the internal complex mechanisms of systemic risk accumulation and implement them for a deeper understanding of China's economic and financial problems.

AIMS AND OBJECTIVES

The main goals of our research are to provide a deeper understanding of systemic financial risk and the mechanisms of its accumulation for a profound analysis of the crisis processes in China's economy.

It can help improve macroprudential regulation of the economy in China for the minimization of systemic financial risks, mitigation of crisis and attaining financial stability in the long-term period.

METHODS

There are a number of general approaches to systemic risk measuring and assessment and these approaches have been developing intensively. For instance, the network approach (The Network Approach); the risk correlation analysis-based approach (Co-risk Model); the method of matrices of the interdependence of distresses (Distress Dependence Matrix); the approach based on default intensity models Intensity (Default Intensity Model), and others. Each of these approaches has advantages and limitations and reflects one or another aspect of systemic risks and many authors agree on the necessity to improve them further. We have developed several new analytical tools that can complement existing methods and shed some light on the internal complex mechanisms of systemic risk accumulation and implement them for a deeper understanding of China's economic and financial problems. We use statistical analysis of China's economic data, logical analysis of non-linear complex systems with feedback loops and mathematical modelling of dynamical structural relationships at the micro- and macro levels.

RESULTS

We develop a number of analytical tools that permitted us to shed some light on the mechanisms of systemic financial risk accumulation and find several new results:

- mathematical model for the optimal level of financial leverage of non-financial corporations particularly for real estate companies; it permits a deeper understanding of microeconomic roots for systemic financial risks accumulation;
- macroeconomic dynamic integrated model of interrelationships between self-enforcing cycles in China's economy;
- a new conception of "collateral accelerator mechanism" as the main driver for the self-enforcing cycles of systemic risk accumulation; we provide the mathematical basis for understanding the "strange state" of China's economy when equilibrium in the real estate market is unattainable and systemic risk increase.

These results can help macroeconomic regulators in China to improve macroprudential policy.

1. Alarming symptoms and structural disproportions in the economy of China.

Against the backdrop of the economic growth slowdown (Figure 1), as reported by the National Institute of Finance and Development of China, the debt of the non-financial sector exceeded 268% of GDP and the non-financial corporations' debt reached 158.9% of GDP (Figure 2) [28].

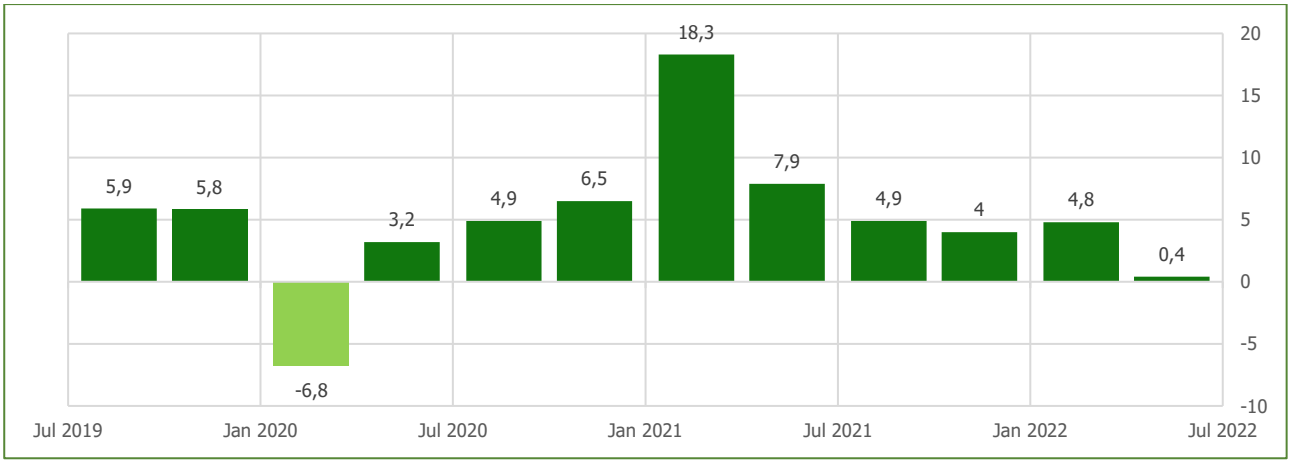

Figure 1. Growth of China's GDP (%) *(Source: Data of Tradeconomics.com https://tradingeconomics.com/china/indicators , National Bureau of Statistics of China)*

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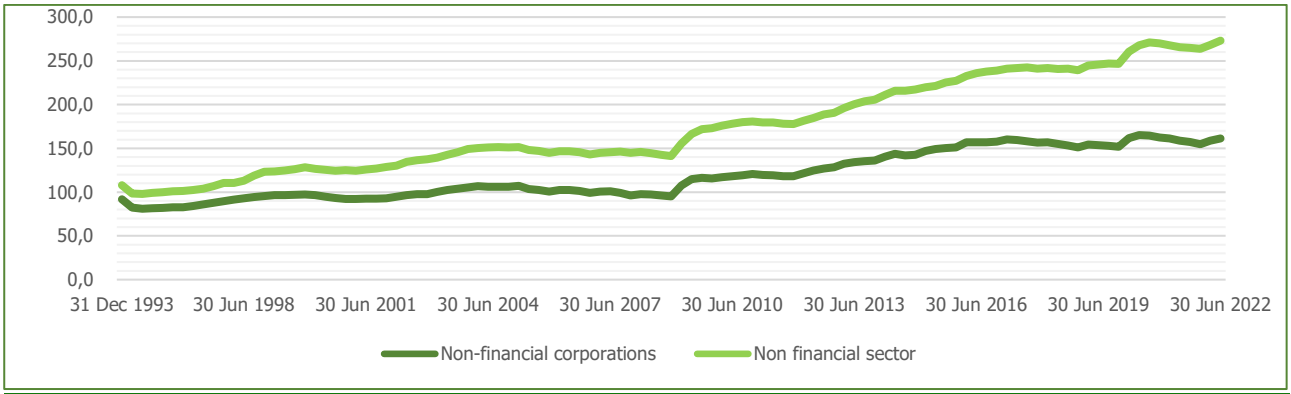

Figure 2. Debt of Non-financial sector to GDP (%). *(Source: Data of the National Institute for Finance and Development China)*

The household debt-to-GDP ratio has also surged sharply over the past three years (Figure 3) and reached 62.1% of GDP at the end of the first quarter of 2022.

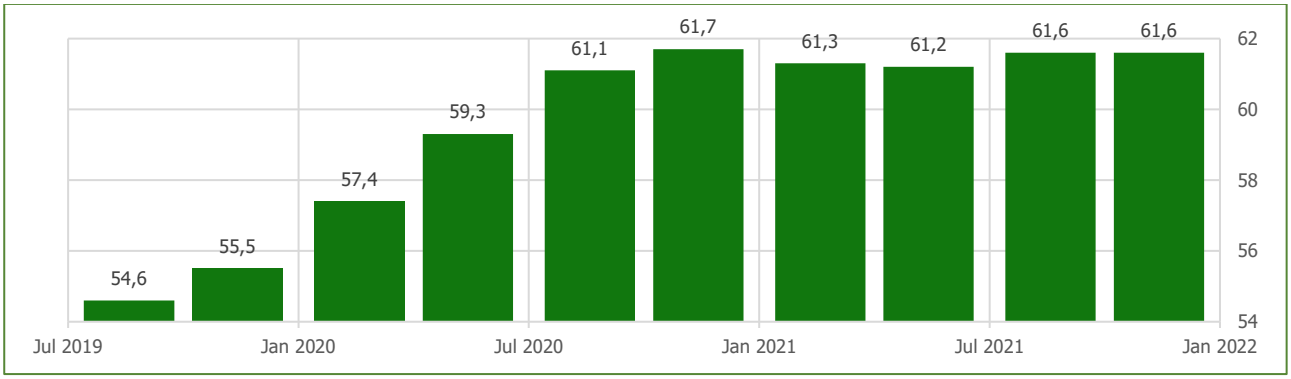

Figure 3. Debt of Households to GDP (%) *(Source: Data of Tradeconomics.com https://tradingeconomics.com/china/indicators, Bank of International Settlement)*

Available data from the National Bureau of Statistics of China indicate that the household debt-to-disposable income ratio reached 99.9% at the end of 2018. A recent study by He. Huifeng gave estimates of this ratio at the record level, namely 130.9% at the end of 2021 [36]. This indicator in China has already exceeded a similar figure reached in the United States before the global financial crisis of 2008, which was then 128% [35]. The boom of consumer credit in China began in 2010. According to the People's Bank of China, the total volume of consumer credits reached 54.9 trillion CNY by July 2022 (Figure 4).

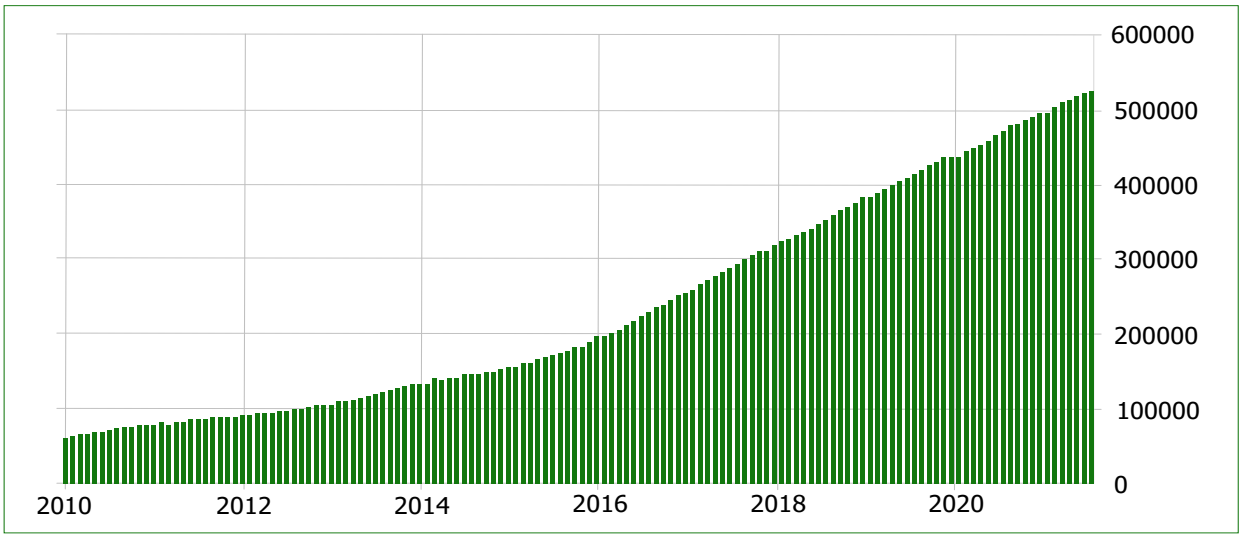

Figure 4. Dynamics of consumer credits (CNY HML). *(Source: Data of Tradeconomics.com https://tradingeconomics.com/china/indicators, Peoples Bank of China)*

Households' disposable income continued to grow (Figure 5). However, comparing their dynamics with the dynamics of consumer credits appears rather alarming (Figure 6), and signals about the accumulation of insolvency risks of the households.

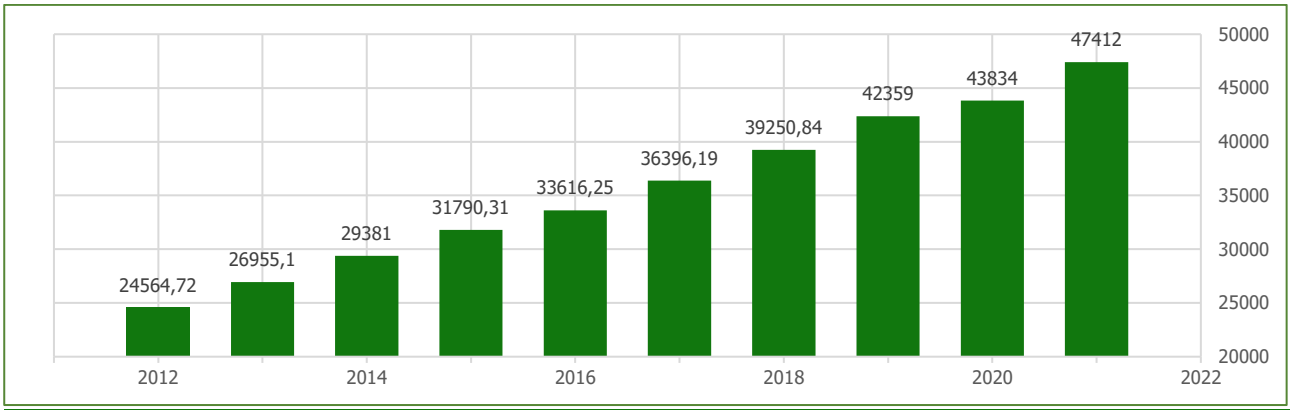

Figure 5. China Urban Households Disposable Income (CHY). *(Source: Data of Tradeconomics.com https://tradingeconomics.com/china/indicators, National Bureau of Statistics of China)*

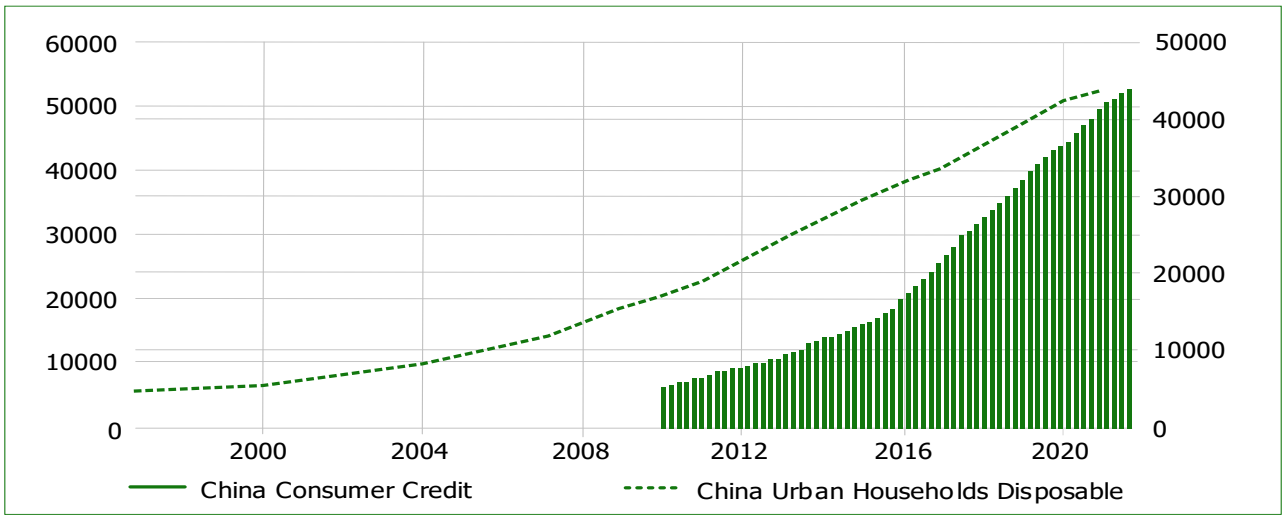

Figure 6. Comparing dynamics of China consumer credits (left scale, CHY HML) and households' disposable income (right scale, CNY). *(Source: Data of Tradeconomics.com https://tradingeconomics.com/china/indicators, Peoples Bank of China, National Bureau of Statistics of China)*

As for the corporate debt in the real sector, it reached 158.9% of GDP by the end of March 2022, which indicates that the situation with risks is also tense. One of the key driving forces of China's economy over several decades has been the explosive growth of the real estate sectors and related industries. In 2021, the GDP, contributed by the construction sector, exceeded 8 trillion CNY (Figure 7).

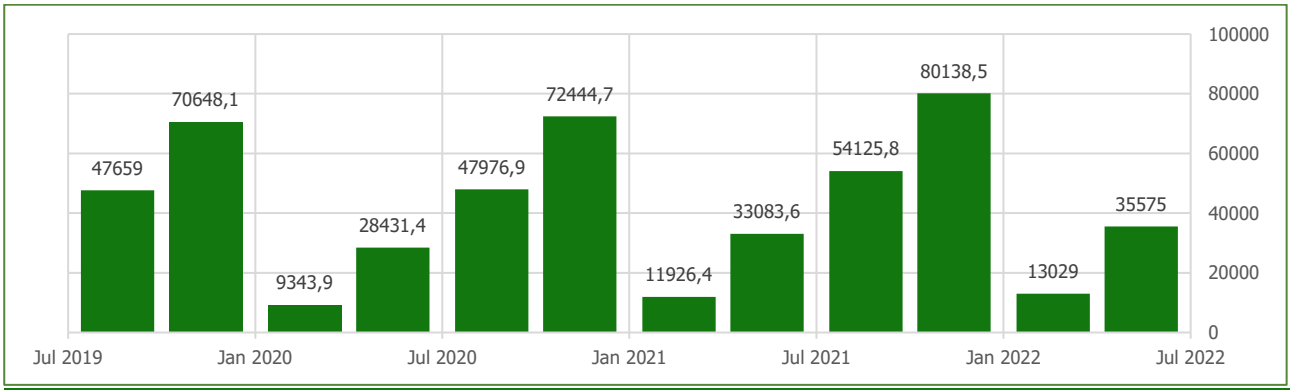

Figure 7. GDP of China from Construction (CHY HML). *(Source: Data of Tradeconomics.com https://tradingeconomics.com/china/indicators, National Bureau of Statistics of China)*

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This volume in the economy is quite high, especially given the connectedness of the construction industry with other sectors such as banking system, insurance, industrial production, households, financial market, consumption and investment.

Kenneth S. Rogoff and Yunchen Yang concluded that China is now more dependent on housing construction than even Ireland and Spain before the global financial crisis of 2008, and much more dependent than the United States at its peak in 2005.

In the paper of Kenneth S. Rogoff и Yunchen Yang "Peak China Housing" (2021) [22], the authors developed an important indicator for measuring the impact the real estate industry has on GDP and applied it to the Chinese economy. Using China's input-output matrix until 2017, published in 2020, they estimated the share of real estate industries in GDP at 29%. These industries include both construction and real estate-related services.

The indicator included not only the primary effects of the real estate industry on the economy but also the systemic second round spillover effects. Additionally, the authors calculated and compared this indicator for different countries and presented the obtained data in the graph (Figure 8).

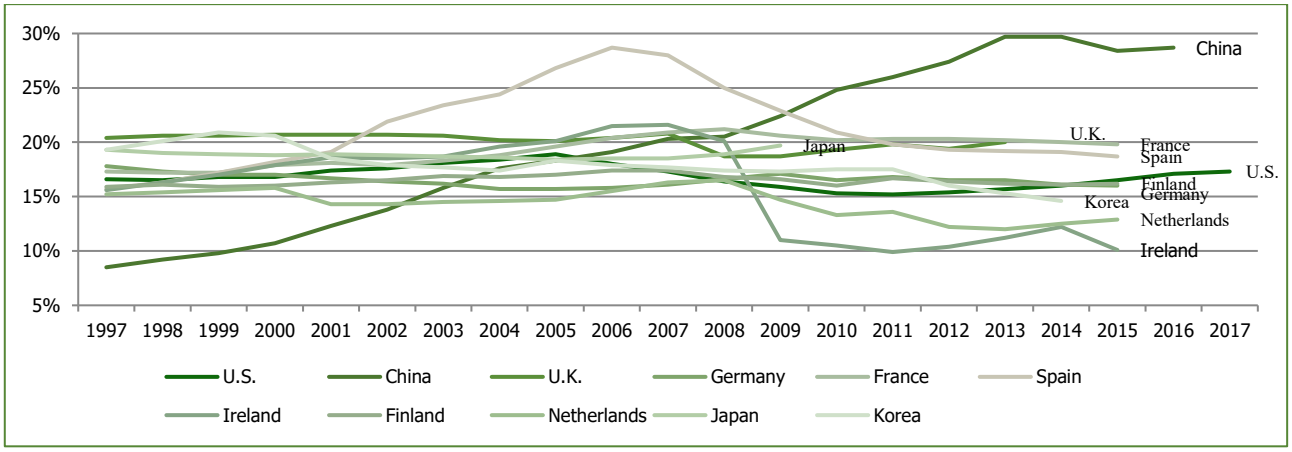

Figure 8. Share of industries connected with real estate market, in GDP of China and other countries, %. *(Source: K. Rogoff, Y. Yang (2021)*

Therefore, if the Chinese real estate market collapses due to the bankruptcy of companies in the development sector, at least 29% of China's GDP will face the strong financial shock. Kenneth S. Rogoff and Yunchen Yang demonstrated that the situation with price dynamics and volume of investment in China's real estate market is not only overheated but also much more critical than the condition in developed countries before the global crisis of 2008 (Figures 9, 10).

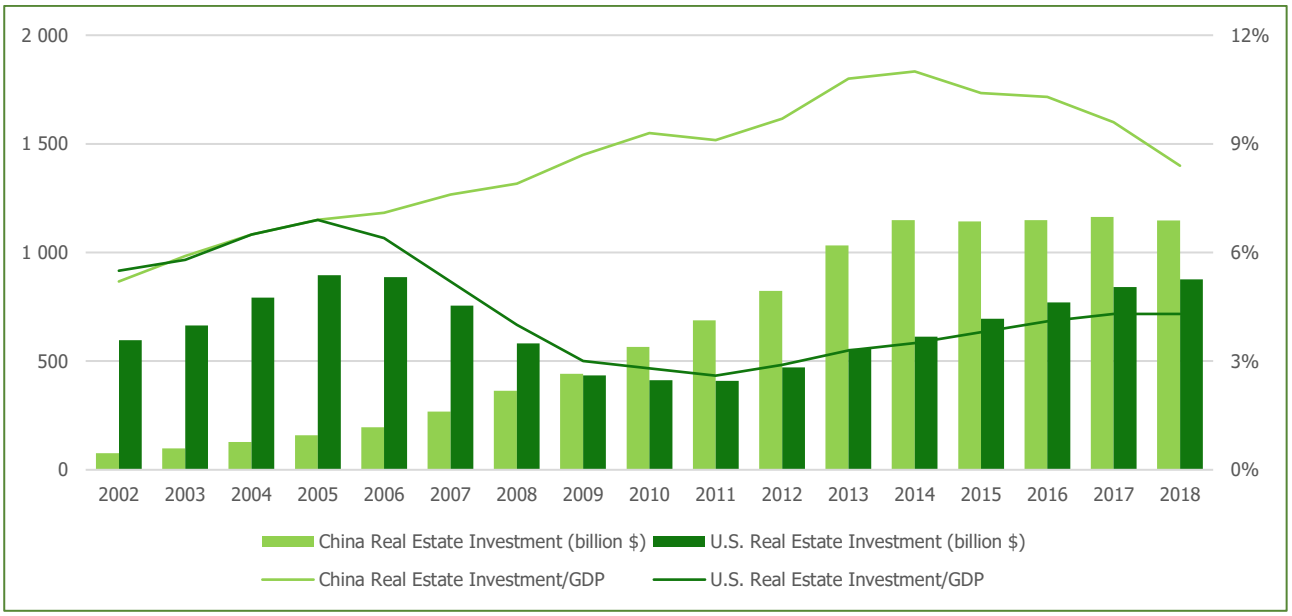

Figure 9. Real Estate Investment in China and USA (bln USD, % of GDP). *(Source: K. Rogoff, Y. Yang (2021)*

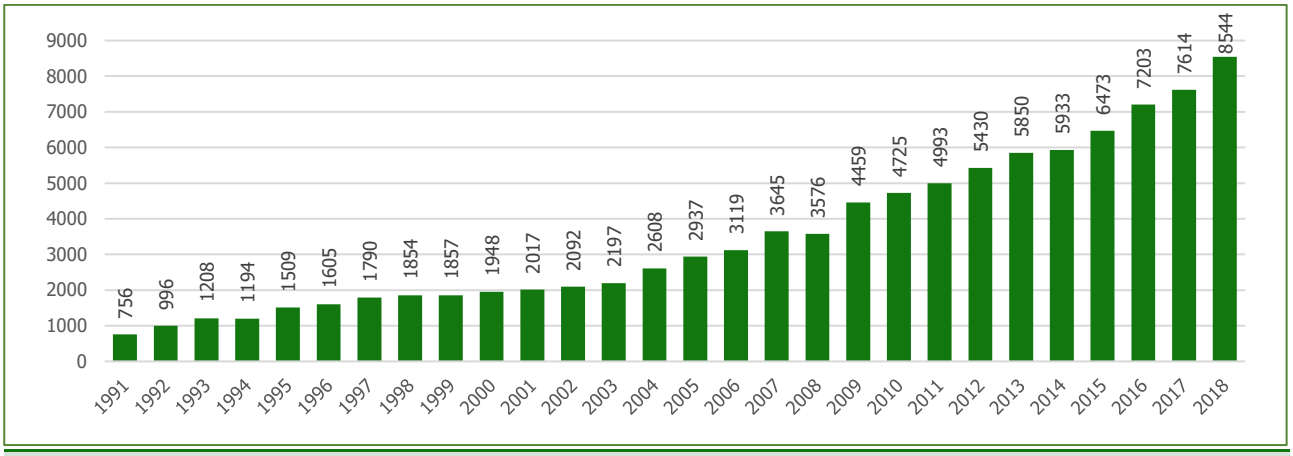

Figure 10. Growth of the Average Selling Price of Residental Buildings, (CHY for sq. m) during 27 years. *(Source: data from K. Rogoff, Y. Yang (2021)*

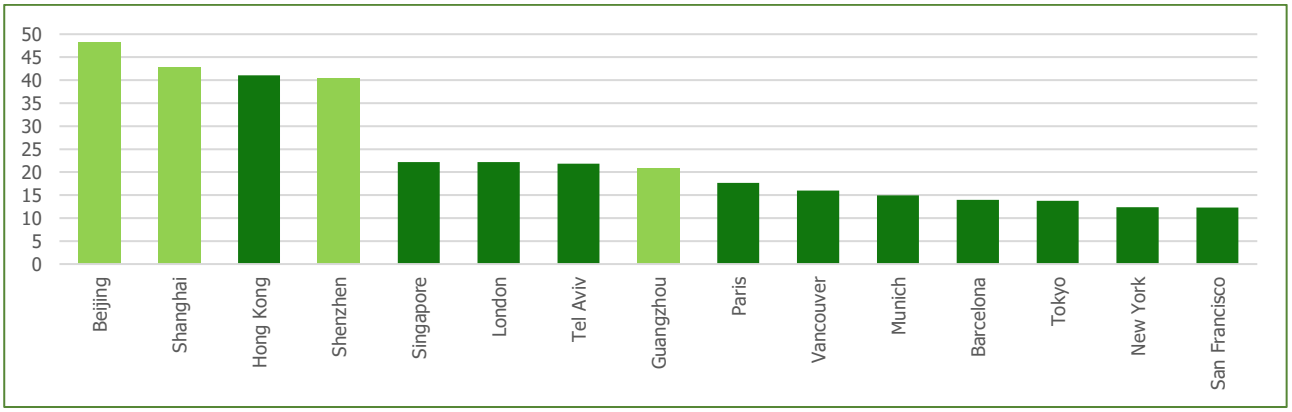

Figure 11. Dynamics of the Home Price-to-Income Ratio (in years). *(Source: data of K. Rogoff, Y. Yang (2021)*

According to Moody's credit ratings the leverage of the Chinese construction companies, measured as the ratio of debt-to-EBITDA, was estimated at more than 600% in 2021, which was similar to the previous year's figure when the leverage ratio stood at 602% [26]. This means that the debt exceeded revenues (EBITDA) more than sixfold. At the same time, the profit margin of the rated companies, according to Moody's, decreased. Such a tense debt situation and overheating of prices in the real estate market demonstrate extremely high risks.

In order to gradually deflate the bubble in the real estate market and to ensure a "soft landing" for the economy, the People's Bank of China and the Ministry of Housing announced in August 2020 the "Three Red Lines Program" [37]. The program introduced a number of toughening measures for the development industry to decrease the level of financial leverage for companies and increase their liquidity ratio:

- the Debt-to-Assets ratio of less than 70%;
- a Net Gearing ratio: Net Debt-to-Equity ratio of less than or equal to 100%;
- Cash-to-Short-term Borrowing ratio of more than 1.

In addition, for some over-indebted companies, credit access has been tightened.

According to China Banking News, only in the first half of 2018, 177 Chinese real estate companies went bankrupt; 235 companies – in the following year and by the end of June 2020 – 228 companies declared bankruptcy [7]. Total corporate debt in real estate-related industries in 2020 reached 1.46 trillion CNY.

In September 2021, many of the world's financial media reported alarming news about the possible default of one of the largest development companies in China, the construction giant – China Evergrande Group. The company failed to make interest payments on corporate bonds, and its total debt exceeded USD 305 billion.

The problem is that its default is fraught with long-term systemic consequences such as the financial collapse of the entire development sector, its related corporations, banks, insurance companies and the household sector, which could ultimately

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lead to a deep crisis in the entire Chinese economy. On September 25, 2021, The Economist announced: "China's vast and opaque financial system has long posed a threat to its economy and the world. The agonies of Evergrande, a property firm with towering debts, are a reminder of how hard it is to manage the risks. The government is attempting to impose an orderly default on some of its creditors but faces the risk of contagion" [14].

To prevent this scenario, the Chinese government was trying to take emergency measures. There comes a plan of a state-owned company Shenyang Shengjing Finance Investment Group to buy Shengjing Bank shares from Evergrande for approximately USD 1.5 billion to provide liquidity for debt repayment and become the largest Evergrande shareholder [44]. However, so far these measures have not been effective, and the company announced default. In March 2022, the trading of its shares in the stock market was brought to a halt. There are currently sales of its assets, attempts at debt restructuring and litigation [17].

April 2022 saw the emergence of a new sensational but still local banking crisis, related to the real estate market [25]. Four banks of Henan province announced a deposit freeze in the amount of 40 billion CNY (about USD 6 billion), which led to social protests of the local population. Moreover, a social protest turned into a boycott over mortgage payments on numerous unfinished housing projects. Eventually, the government managed to contain the situation. But on the whole, such disasters, occurring in different places, erode the confidence of the population in the banking system and increase the risks of deposit runs, which can become another trigger of systemic crisis.

These adverse events are likely to be solved by government financial support or debt restructuring; however, they reveal serious structural problems in China's economy.

China's government may be able to "deflate the real estate bubble" and achieve a softer landing for the economy compared to what happened in the US mortgage market and led to the global financial crisis of 2008. The Chinese government has a powerful administrative impact on the economy. Nevertheless, in addition to the research of Rogoff and Yang (2021), we would like to highlight the fact that the accumulation of systemic financial risks qualitatively transforms economic conditions into a state of high-level fragility to any shocks. Under these conditions, a cautious and non-standard approach to macroprudential regulation is required.

When the entire economic system falls into the zone of high systemic risk, in other words, hits a bifurcation point, conventional regulatory methods aimed at reducing individual risks of companies or banks, such as the Five Red Lines Program, may not reduce systemic risks, but on the contrary, provoke their aggravation. This is currently happening.

In such circumstances, even a minor trigger can provoke a chain reaction of crisis events in different parts of China's economic system, "getting them into resonance" and materializing systemic risks that lead to an economic collapse. This, in its turn, can have a negative impact on global finance. To prevent this scenario from happening, an understanding of internal mechanisms of systemic risk accumulation and new approaches and tools of regulation are required. It is highly likely that the Chinese macro regulators don't take into account these complex non-linear processes. In the next paragraphs, we provide some insights into internal mechanisms of systemic risk accumulation and a number of new analytical tools.

2. Internal mechanisms of systemic financial risks accumulation in the economy of China

The default of China's developer giant Evergrande Group, intertwined deeply with millions of counterparties in the economy, indicates that the anti-crisis measures taken by the Chinese authorities were not effective to minimize systemic risks.

The Five Red Lines Program is an attempt to reduce individual risks to development companies, though it does not take into account the processes that determine an optimal level of financial leverage. Our research helps shed some light on determining an optimal level of financial leverage and threshold of safety for leverage of non-financial corporations by taking into account real estate market prices, profitability, interest rates and other parameters.

2.1. Microlevel: optimal level of financial leverage for non-financial corporations

In the insightful paper of Gauti Eggertsson and Paul Krugman (2010) Debt, Deleveraging, and the Liquidity Trap: A Fisher-Minsky-Koo Approach [11], the authors proposed the New Keynesian-style model of crisis as a consequence of a sharp deleveraging. They pointed out that "Formalizing this concept integrates several important strands in economic thought. Fisher's famous idea of debt deflation emerges naturally, while the deleveraging shock can be seen as our version of the increasingly popular notion of a "Minsky moment". And the process of recovery, which depends on debtors paying down their liabilities, corresponds quite closely to Koo's notion of a protracted "balance sheet recession" (p.23).

While the authors did not seek to quantify the optimal level of financial leverage and specific safety threshold of leverage, they indicated that this level is not fixed and can change depending on the economic situation, real estate prices, interest rates and other parameters. We agree with the authors and aim to go further in the research and quantify the optimal level of financial leverage and its safety threshold in relation to real estate prices, interest rates and other parameters of the economy.

We have developed a number of analytical tools to define the optimal level of financial leverage for non-financial corporations and its safety threshold. These tools can be applied to the assessment of Chinese companies operating in the real estate industry.

There are several indicators of financial leverage that characterise the ratio of corporate debt to its various parameters of activity (EBITDA, capital, assets and equity). We will use the understanding of financial leverage (l – leverage) as the ratio of the corporate debt (D) to its equity (E):

$$\iota = \frac{\mathrm{D}}{E}$$

One of the most important indicators for shareholders and creditors of the company is ROE (Return on Equity), also called financial profitability (F), which is expressed as the ratio of Net Profit after tax and interest payments (NP – Net Profit) to the company's equity.

In financial management, it is known that [38]:

$$ROE = F = \frac{NP}{E} = \frac{(1-T)\cdot(EBIT - iD)}{E} = \frac{(1-T)\cdot(R(D+E) - iD)}{E}$$

where T is the tax rate, i is the interest rate on company debt, EBIT (Earning Before Interests and Taxes) are earnings before payments of interest and taxes, and R is economic profitability: $R = \frac{EBIT}{D+E}$.

Thereby, the relation of ROE (financial profitability F (l)) to the level of financial leverage is expressed as follows:

$$F(l) = (1-T)\cdot R + (1-T)\cdot(R-i)\cdot\frac{D}{E} = (1-T)\cdot R + (1-T)\cdot d\cdot l \quad (1)$$

where $d = (R - i)$ *– is the differential of financial leverage, that is the difference between economic profitability R and interest rate i by the debt of company.*

If the differential of financial leverage is greater than zero, $\mathrm{d} = (\mathrm{R} - \mathrm{i}) > 0$,i.e. the economic profitability exceeds the interest rate, an increase in financial leverage brings an additional rise in financial profitability F(L) of ΔF:

$$\Delta F = (1-T)(R-i)\cdot l \quad (2)$$

If, in the result of a decrease in economic profitability R or/and an increase in interest rates i, the differential of financial leverage becomes less than zero:

$d = (R - i) < 0$,

then ΔF is also negative. In this case, an increase in the level of financial leverage only exacerbates the situation and reduces financial profitability.

We suggest calling the ΔF the delta-effect of financial leverage (or Δ-effect).

The well-known equation (1) can be applied only in a short-term specific case when the company's economic profitability and interest rate are constant and ROE is linearly dependent on the level of financial leverage.

But from a medium-term or a long-term perspective, the interest rate can be changed. It depends on the base rate in the economy (i0) and the credit policy of a bank:

$$i = i_0 + \pi(l) = i_0 + \vartheta l$$

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where $\pi(l) = \vartheta l$ is a risk premium, which bank imposes on a borrower in dependence on its insolvency risk that can be measured by the existing level of financial leverage.

If we take it into the account, the delta-effect of leverage and financial profitability function can show a more realistic picture: their non-linear dependence on the level of financial leverage. The non-linear delta-effect of financial leverage (Figure 12) can be expressed as follow:

$$\Delta F = (1 - T) \cdot [(R - i_0)l - \vartheta l^2] \quad (3)$$

and thus, a non-linear ROE function on financial leverage is:

$$ROE = F\ (l) = (1 - T) \cdot R + (1 - T) \cdot (R - i_0 - \vartheta l) \cdot l \quad (4)$$

Using equation (4), we find the level of financial leverage that gives maximum to the financial profitability ROE:

$$F = (1 - T) \cdot \underbrace{R + (1 - T)[(R - i_0) \cdot l - \vartheta l^2]} \rightarrow \max_l F(l) \quad (5)$$

Non-linear delta-effect of financial leverage $\frac{dF}{dl} = (1 - T)(R - i_0) - 2\vartheta l = 0$

$$l^{opt} = \frac{R - i_0}{2\vartheta} \quad (6)$$

We obtained the formula for the optimal level of financial leverage at which the company's ROE, its financial profitability, reaches the maximum.

The maximal level of a company's ROE (financial profitability) is expressed by the equation:

$$ROE_{max} = F\ (l^{opt}) = (1 - T) \cdot R + (1 - T)\frac{(R - i_0)^2}{4\vartheta} \quad (7)$$

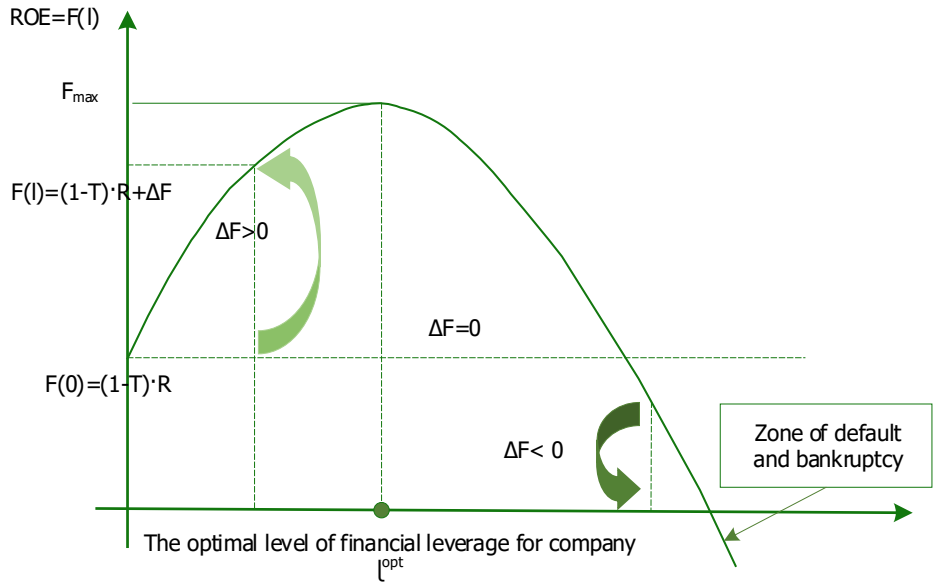

Figure 12. Dependence of company's ROE (Financial Profitability) on the level of financial leverage.

Delta-effect of financial leverage also depends on the change in company's economic profitability (R). If the development company's sales fall or real estate market prices decline (for example, in the United States real estate prices dropped by 36% after the beginning of the global crisis in 2008), a decrease in economic profitability R below the interest rate i can lead to a negative delta-effect of financial leverage, as well as a decrease in level of F (0). The National Bureau of Statistics of China forecasts a decrease in real estate prices in China until 2023 in accordance with Figure 13.

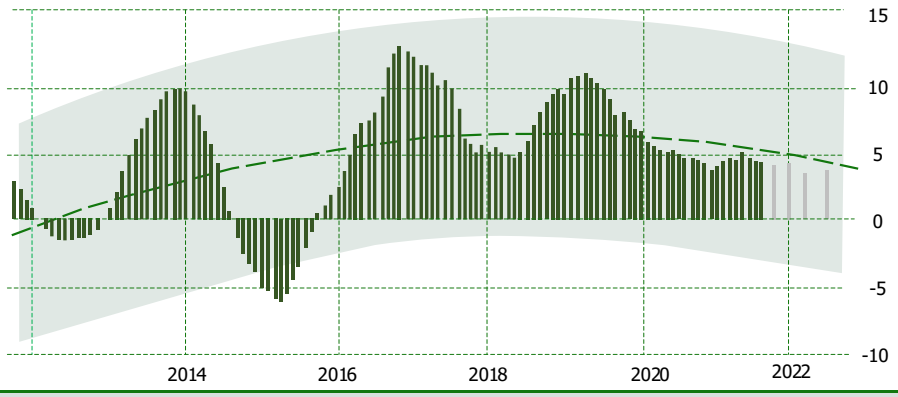

Figure 13. Forecast of decrease in index of real estate prices of the National Bureau of Statistics of China. *(Sources: Tradingeconomics.com, National Bureau of Statistics of China)*

Under these circumstances, the risks of defaults for many development companies increase. The dependence of ROE on the real estate prices at different levels of financial leverage is described as follows:

Since $R\ (p) = \frac{pQ-C}{E+D}$, where p is the real estate sale prices, Q is the physical volume of sales (in square metres) and C is the cost excluding loan repayments, then

$$\mathrm{F(p,}\iota) \quad = (1-\mathrm{T}) \cdot [\frac{\mathrm{pQ}}{\mathrm{E}} - \frac{\mathrm{C}}{\mathrm{E}} - \mathrm{i} \cdot \iota]$$

In order for the financial break-even condition to be met (break-even condition including loan repayments), that is:

$$F(p,l) > 0$$

real estate prices must be above the price limit of financial break-even condition ($p_{\text{break-even line}}$):

$$p > p_{\ break-even\ line}$$

where $p_{break-even\ line}(l) = \frac{i \cdot l \cdot E+C}{Q}$

The higher the level of financial leverage, the higher the sales prices should be (all other things being equal) in order for them to exceed the break-even price level (Figure 14).

The proposed analytical tools allow a more in-depth assessment of the insolvency risks for companies in the real estate industry in China.In addition to analytical tools for assessing the individual risks for corporations, it is crucial to consider internal mechanisms of systemic financial risk accumulation at the macroeconomic level.

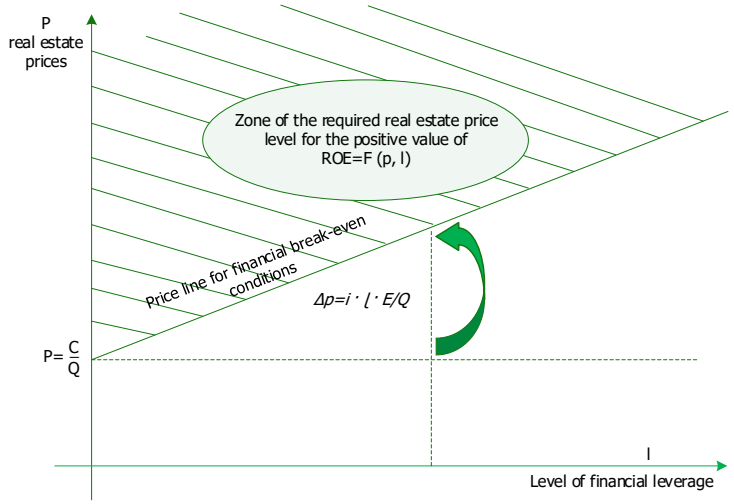

Figure 14. Relations between the required level of real estate prices for financial break-even conditions and the level of financial leverage.

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2.2. Macroeconomic level: mechanisms of systemic financial risk accumulation

To support economic growth, the People's Bank of China keeps its key rates, which are benchmarks for the credit policy of banks, at a quite low level.

According to the data of the People Bank of China and Tradingeconomics.com, the PBC cut the key rates two times in August 2022. In September fixing the 1-year Loan Prime Rate (LPR) was held at 3,65% and the 5-year LPR, a reference for mortgages, was maintained at 4,3%. But the indicator of China Composite PMI, which characterizes business activity, was the lowest in the last three months (Figure 15).

Thereby, PBC is making an effort to support the economy by low-interest rates, however, economic activity continues to decline.

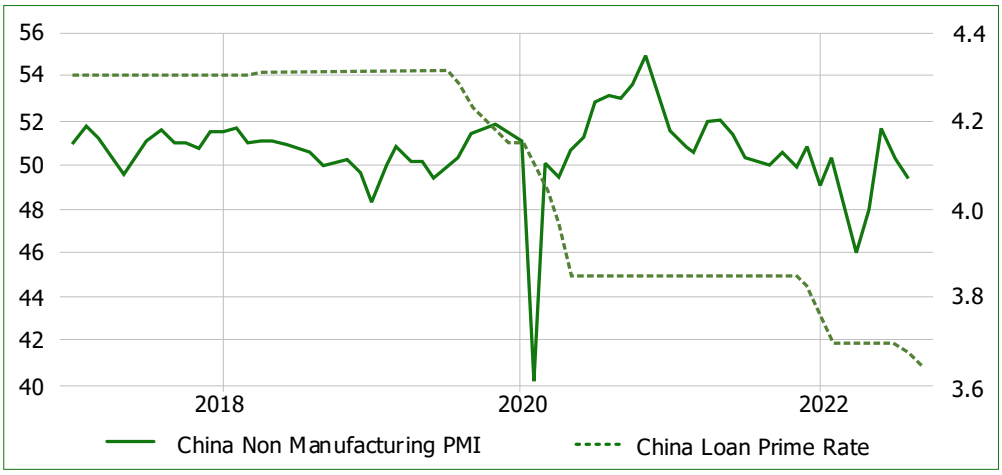

Figure 15. 1-year Loan Prime Rate (%, right scale) and China Composite PMI (points, left scale).

To design appropriate anti-crisis macroprudential measures, that provide financial stability without suppressing economic growth it is necessary to understand the mechanisms of systemic financial risk accumulation.

We developed the integrated diagram to demonstrate the complex processes that form self-reinforcing cycles of systemic financial risk accumulation (Figure 16).

The diagram illustrates two phases in the dynamics of systemic financial risk:

1) Phase A is the stage of gradual accumulation of systemic financial risk concealed by the credit and construction boom, real estate price increase, and high speed of economic growth; when the systemic financial risk reaches a critical level, the probability of its materialisation rises and under the conditions of any internal or external shock the economic system jumps to Phase B;
2) Phase B is the stage of the materialization of systemic risks after it has reached a critical threshold and shifted the economy to the systemic crisis following the Fisherian Debt-Deflation depression, Minsky moment or Koo Balance Sheet depression scenarios.

It is worth highlighting that the key driving force for triggering self-reinforcing cycles of systemic financial risk accumulation is the institutional mechanism of banks' lending for buying assets, which become the collateral for these lending agreements. We call this institutional mechanism the collateral accelerator.

This mechanism of secured lending is conventional and widespread. It is seen as not only an acceptable but mostly necessary tool for guaranteeing to reduce the bank's credit risks in case of client insolvency. This can be obvious and accepted when we limit our analysis to the individual risks of the bank. Besides, collateral is an important instrument of financial markets, in particular for interbank operations repo. The paper by Patrick Schaffner, Angelo Ranaldo and Kostas Tsatsaronic "Euro repo market functioning: collateral is king" (2019) convincingly shows the fundamental role of collateral in a stable functioning of financial markets. In this paper, we consider another specific type of secured lending when collateral (particularly, real estate) has also another function: it is an object of purchase at the expense of the received loan. In this case, from a macroeconomic perspective this institutional mechanism is a "ticking time bomb" under financial stability that starts ticking when the credit boom and real estate prices are just picking-up steam and explodes at the moment that nobody can predict. This mechanism of systemic financial accumulation as consequence of collateral accelerator is illustrated in Fig.16. We developed this scheme in more details compare with our previous finding.

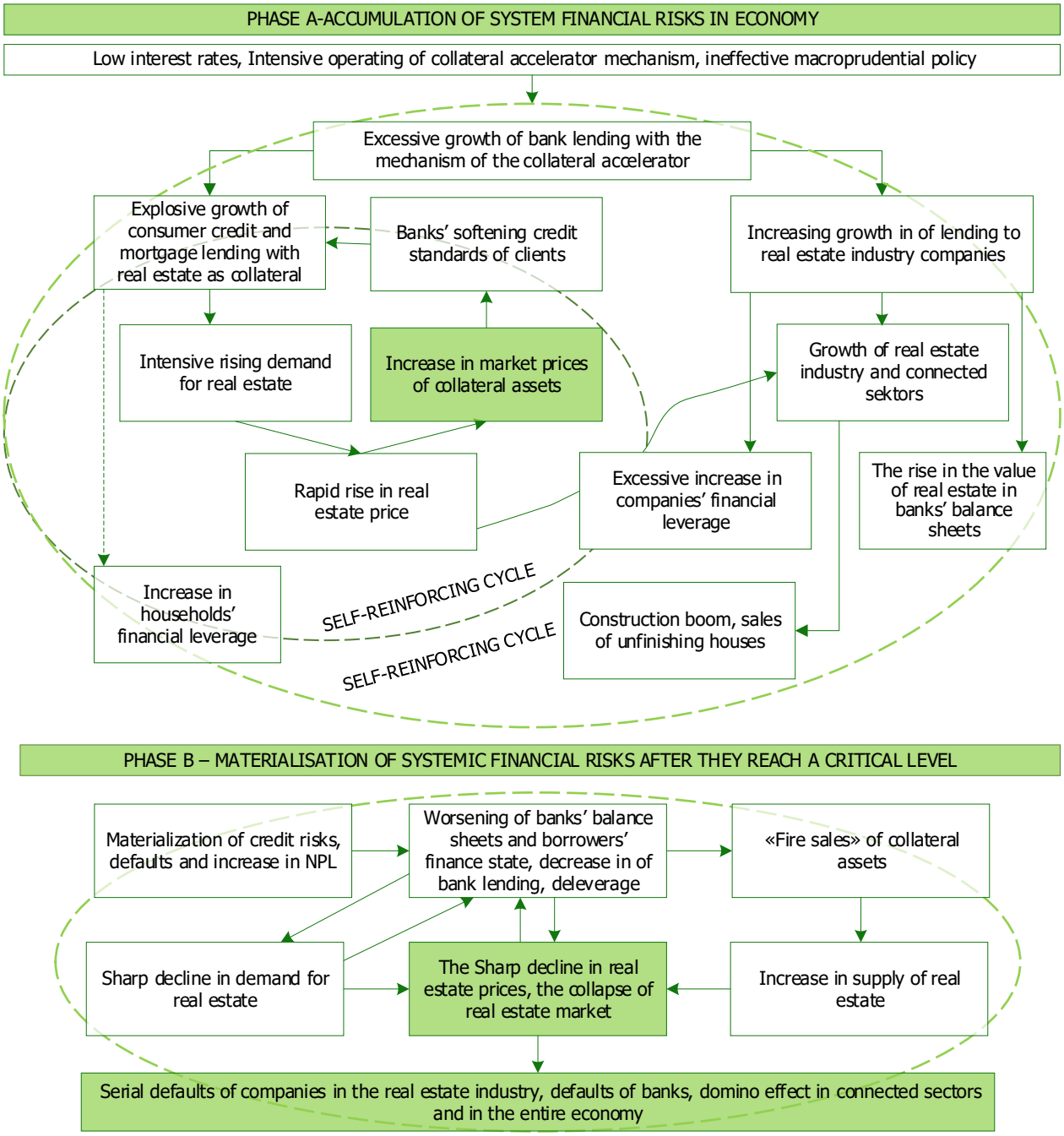

Figure 16. Dynamic schema of systemic financial risk accumulation and materialization. *(Sources: Unkovska T. Chapter "Systemic risks in the banking sector" in collective monography Arzhevitin S, Unkovska T, Dzhus M "Systemic crisis of banking system in Ukraine and ways for overcoming it" – Kyiv National Economic University, 2019).*

Why does this mechanism deeply transform the economy and turns it from being financially stable to structurally disproportionate and highly vulnerable to even small shocks?

The answer is that the mechanism of collateral accelerator fundamentally changes the market environment and the classical macroeconomic conditions of supply and demand stop working in the real estate market. A collateral accelerator turns the real estate market into a "strange state", where achieving market equilibrium becomes principally impossible. We shall illustrate this by using a number of structural equations.

In the classical macroeconomic theory, supply S(P) and demand D(P) for goods depend on the price P in a standard manner: when the price of goods rises, its demand falls and supply increases. A market transit to an equilibrium when supply and demand on a good equalise and the price of this product reaches the equilibrium level P*, that is, classical relations fulfil (Figure 17):

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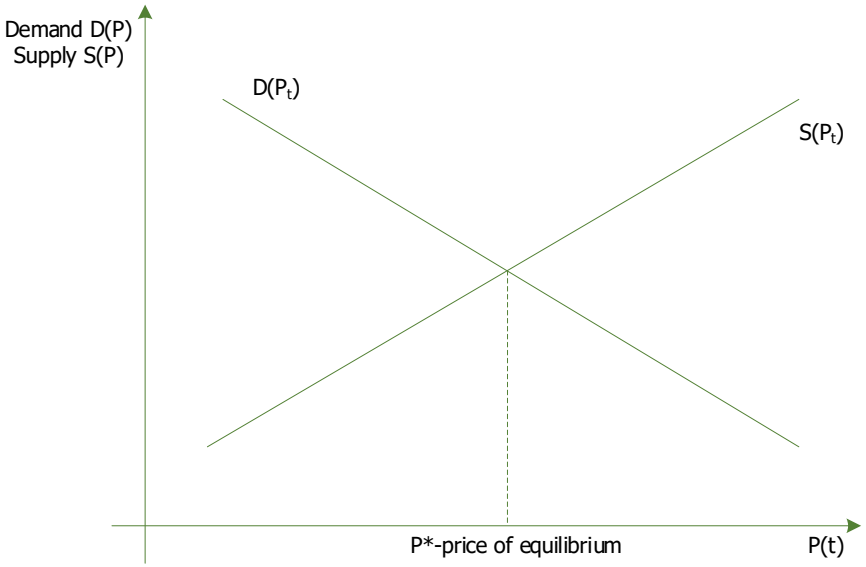

Figure 17. Classical macroeconomic diagram of market equilibrium between demand and supply for goods.

$$\frac{dP}{dt} = \alpha[D(P_t) - S(P_t)] \rightarrow 0 \ (P_t \rightarrow P^*)$$

$$D(P_t) = a - bP_t,$$

$$S(P_t) = c + mP_t,$$

where a and c are the structural parameters of the market, and b and m are the ratios of elasticity of demand D(P) and supply S(P) with respect to changes in price P. The equilibrium price P^* *is expressed as follows:*

$$\mathrm{P} * = \frac{\mathrm{a} - \mathrm{c}}{\mathrm{m} + \mathrm{b}}$$

However, this classic model is irrelevant when it comes to a real estate market with banking lending and asset that is bought on credit against that asset, i.e., when the collateral accelerator mechanism comes into action.

In such conditions, the classic budget constraints of buyers, determined by their savings and income limits (mainly, the level of households' dispensable income) become irrelevant in shaping the demand for real estate. Households' wealth is generated not so much as by income streams from productive activities but by increases in the prices of the houses they buy. As long as real estate prices go up (as they inevitably do during the credit boom because readily available credit resources increase the demand for real estate), the wealth of property owners are constantly on the rise and they receive more and more opportunities for secured loans and purchases of real estate.

Real estate turns from a means to improve living conditions into a financial asset that ensures the growth of the owner's wealth. In accordance with the Chinese Sociological review housing assets, which accounted for over 70 per cent, were the largest component of households' wealth in China [43].

Under these conditions, the formation of demand D(P) and supply S(P) in the real estate market can be described by the ratios:

$$D(P) = a - bP + K(Q, h, P) - f(K)$$

$$Q = S(P) = c + mP,$$

where K (Q, h, P) is the volume of loans received by the households against real estate as collateral; h is the collateral coefficient, i.e. the ratio of the obtained loan to the volume of the market value of the collateral; Q is the volume of real

estate (in square metres) offered for purchase in the economy, which can be used as collateral to obtain loans; P is the market price of a square metre of real estate, f(K) is the function reflecting the volume of loan repayments by borrowers.

$$K(P) = hQP = h(c + mP)P; f(K) = kK(P)$$

k is the repayment ratio, which is determined by the interest rate and other terms of the loan agreement, including the bank's margin call requirements in case the price of the property falls to a level where the value of the collateral on the bank's balance sheet becomes lower than the amount of the outstanding loan. In this case, the bank may demand additional funds. Hence,

$$D(P) = hm(1 - k)P^2 + (h(1 - k)c - b)P + a \quad (8)$$

$$S(P) = c + mP \quad (9)$$

If h=0, the collateral accelerator mechanism is absent, and equation (8) turns into the standard classical equation for demand.

If h>0, the collateral accelerator works, and the economy transit to a "strange state" when the increase in the market prices of real estate raise the demand for it. Thus, during Phase, A (Figure 16), the demand grows faster in accordance with the ascending part of a parabola corresponding to equation (8) for D(p) (Figure 18). It thereby spurs new rounds of increasing real estate prices, volumes of loans, demand for real estate, and the level of financial leverage for development companies and households.

This is self-enforcing spiral or cycle of systemic financial risk accumulation.

The main driving forces for the increase in demand for real estate are:

- coefficient h – the higher the collateral ratio is - i.e. the higher the loan amount in relation to the value of the collateral - the greater the demand for real estate becomes, which in turn increases its price;
- the dynamics of the real estate price (notably, in quadratic measurement) in accordance with equation (8); thus, an upward self-reinforcing cycle emerges: a rise in demand increases the price, and an increase in the price further raises demand;
- the structural parameters of the real estate supply (c and m). Rapid growth in solvent demand spurs development companies and the entire construction industry into a construction boom, as an increase in supply tends to keep up with a rapid growth in solvent demand. Development companies raise loans to finance the necessary pace of construction, thereby also fuelling the collateral accelerator mechanism and their own level of financial leverage. Due to rising real estate prices, their economic profitability increases and the visible safety threshold of financial leverage rises (Figures 12, 14);

The race for supply to meet accelerating demand results in many development companies selling properties in the unfinished construction stage. But even this does not ensure that equilibrium will be reached in the real estate market, because as long as the collateral accelerator mechanism is operating and the value of h is large enough, market equilibrium cannot be reached in principle (Fig.18).

Thus, the phenomenon of the collateral accelerator mechanism turns the real estate market and the economy as a whole into a highly unstable economic system. The collateral accelerator plays the role of powerful internal destabiliser, which rocks the economic system:

- at the start of the credit boom the system enters phase A of the systemic risks graduated accumulation (Figure 16) and the build-up of a credit boom and a price bubble in the real estate market;
- later, after the systemic risks have reached a critical level, there occurs a painful and abrupt shift to phase B of the systemic risk materialization; after that – deleverage, falling demand and a drop in real estate market price in a downward self-reinforcing cycle which together can lead to economic depression.

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What is the quantitative internal mechanism for an abrupt shift of the economic system from the phase A to the phase B?

If the second derivative of the demand function D(P) (8) changes it signs from "+" to "– ", that is will be a sharp transition of economic system from the state

$$\frac{d^2D}{dP^2} = 2hm(1-k) > 0$$

to a state of

$$\frac{d^2D}{dP^2} = 2hm(1-k) < 0$$

i.e. $k > 1$, a state in which there will be an abrupt transition of the demand dynamics D(P) from phase A to phase B (Figure 18).

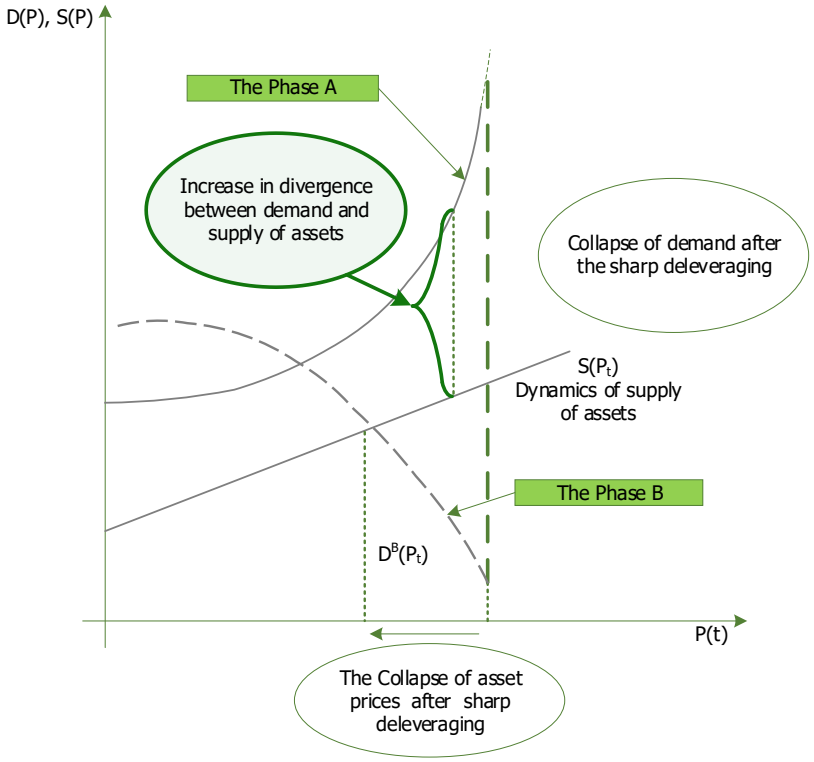

Figure 18. Diagram of two regimes - accumulation and materialization of systemic risks: 1) increase of leverage and asset prices (credit boom); 2) sharp deleveraging and collapse of aggregate demand and asset prices.

The speed of change in demand over time in relation to change of price is expressed as a non-linear equation in relation to price:

$$\frac{dD(t)}{dt} = 2hm(1-k)P\frac{dP}{dt} + (h(1-k)c - b)\frac{dP}{dt} = \frac{dP}{dt}[2hm(1-k)P + h(1-k)c - b]$$

That is, we determined multiplier γ that depends on parameters of credit processes. This multiplier amplifies the impact of assets price changes on the changes in demand for these assets (in particular real estate):

$$\frac{dD}{dt} = \gamma\frac{dP}{dt}$$

where $\gamma = 2hm(1-k)P + h(1-k)c - b$

Understanding and taking into account the processes described in this paper can improve macroprudential policy and help mitigate the systemic financial risk, that China and other countries with similar asset market problems need. It can be used widely because not only real estate but also other financial instruments can be assets, which are involved quite extensively in the unwinding of the collateral accelerator mechanism and systemic financial risk accumulation.

The equations presented in this paper are structural and quite simple; their purpose is to demonstrate the internal mechanisms of accumulation and materialization of systemic financial risks. We continue our research towards the development of a detailed network intersectoral model based on complex systems theory, which will allow the simulation of systemic financial risk accumulation in the economies of various countries, in particular, China. It is already possible to formulate a number of new insights and useful conclusions from our research that can contribute to more effective macroprudential regulation of systemic financial risks.

CONCLUSIONS

1. There are deep structural imbalances in the real estate industry of China's economy and it is in the process of systemic financial risk accumulation (Phase A).

The formation of these risks, their exacerbation to critical levels and their subsequent materialisation will follow the scheme in Diagram 16, which illustrates the unwinding of self-reinforcing cycles in the real estate market, household finance, development companies, banking system, and other sectors connected with real estate. If optimal macroprudential measures will not be taken, this could result in an economy-wide crisis. The current focus of macroeconomic and financial regulators in China concentrated only on the reduction of individual financial risks (for instance the Red Lines Program). It can provoke sharp deleveraging, with subsequent Fisherian debt deflation and recession, the onset of the Minsky moment and the balance sheet recession described by Koo.

2. The optimal level of financial leverage for development companies is determined by maximising the non-linear delta effect of financial leverage described by equations (3) – (7) and Graph 12.

These equations make it possible to understand the internal structure of the optimal level of leverage and its dependence on real estate market prices, the base interest rate in the economy and banks' credit policy. Knowing the optimal level of leverage and its internal structure may allow for improving macroprudential policy by regulators to minimize systemic financial risk and ensure financial stability.

3. The accumulation of systemic financial risks is caused by the institutional mechanism that we call collateral accelerator. It is a powerful internal destabiliser of the economy. It gradually unwinds the self-enforcing cycles of systemic financial risk accumulation and turns the economy into a state of financial instability and high vulnerability to external and internal shocks.

The action of the collateral accelerator qualitatively changes the conditions of the real estate market and brings it to a state in which classical macroeconomic supply and demand relations no longer work: the dependence of supply and demand on price is described by structural equations (8), (9) and the graph in Figure 18, reflecting the fundamental unattainability of real estate market equilibrium.

When systemic financial risk reaches a critical level, there is a high probability of a sharp shift of the economy to Phase B under the influence of some small internal or external shocks. During Phase B there is a threat of sharp deleveraging with subsequent Fisherian debt deflation and recession, the onset of the Minsky moment and the balance sheet recession described by Koo.

4. To reduce systemic financial risk and ensure the financial stability of the economy without suppressing economic growth, it is seen as reasonable that macroprudential regulators took into account the described non-linear processes and self-reinforcing cycles, the companies' optimal level of financial leverage and the effect of the collateral accelerator mechanism as an internal destabiliser of the economic system connected with the real estate industry.

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conceptual approach described in his book "Between Debt and the Devil. Money, Credit and Fixing Global Finance", which was later translated by T. Unkovska into the Ukrainian language and published in Ukraine. This approach helped us realize the importance and necessity of investigating the internal mechanism leading to self-reinforcing cycles in the real estate sector and brought us to the understanding of the phenomenon we have called "collateral accelerator". We are grateful for the discussion of our ideas at the research seminar of the Institute for Economics and Forecasting of the Ukrainian National Academy of Sciences and for the interesting ideas expressed by the Member of UNAS, Professor Dr. Andriy Grytsenko, Professor Dr. Alexander Sharov, Professor Dr. Oleg Yaremenko. We also thank Dr. Yulia Avsiukevich, a linguist and director of the Educational Center in London for her thorough work with the English version text of this paper.

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СИСТЕМНІ ФІНАНСОВІ РИЗИКИ В ЕКОНОМІЦІ КИТАЮ: САМОПІДСИЛЮВАЛЬНІ ЦИКЛИ

Стаття сфокусована на дослідженні гострих проблем зростання системних фінансових ризиків в економіці Китаю, що спровоковані кризовими процесами на ринку нерухомості та в пов'язаних секторах. У випадку колапсу другої в світі економіки цього азійського гіганта, який глибоко інтегрований у світову систему, можливі широкомасштабні наслідки для інших країн та нова глобальна економічна криза. Тому надзвичайно важливим є більш глибоке розуміння внутрішніх механізмів накопичення системних фінансових ризиків для їх мінімізації. Автори дослідили джерела зростання системних ризиків на мікрофінансовому рівні та макроекономічні механізми їх накопичення й матеріалізації після досягнення ними критичного рівня. Мікрофінансові корені системних ризиків пов'язані з надмірним зростанням фінансового левереджу. У статті запропонована математична модель оптимального рівня фінансового левереджу та його безпечної межі для компаній реального сектора економіки, зокрема девелоперських корпорацій. Автори розробили також комплексну динамічну модель нелінійних макроекономічних взаємозв'язків та внутрішніх механізмів самопідсилювальних циклів, пов'язаних із ринком нерухомості, що викликають загострення системних фінансових ризиків. Сформульовано висновок про те, що головним драйвером розкручування таких циклів є інституційний механізм, названий авторами «акселератором кредитного забезпечення» (collateral accelerator). За певних умов він стає потужним дестабілізатором економічної системи, що спричиняє розкручування самопідсилювальних циклів у сфері нерухомості, банківській системі, фінансах домогосподарств і девелоперських корпорацій. Це є основною причиною цінових бумів та різких обвалів на ринку нерухомості, накопичення системних фінансових ризиків в економіці з деструктивними наслідками різкого делевереджу. Це у свою чергу може призвести до боргової дефляції та депресії за Фішером, реалізації моменту Мінські, а також балансової рецесії, описаної Коо. Представлені авторами моделі та низка розроблених аналітичних інструментів сприятимуть більш глибокому розумінню системних ризиків та оптимізації макропруденційної політики для їх зниження.

Ключові слова: системні фінансові ризики, економіка Китаю, ринок нерухомості, оптимальний рівень фінансового левереджу, самопідсилювальні фінансові цикли, акселератор кредитного забезпечення, макропруденційна політика, фінансова стабільність

JEL Класифікація: C6, E5, F4, G3, P4