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The Concept of Systemic Risk

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SRC Special Paper No 5

August 2014

SRC Systemic Risk Centre

Special Paper Series

ISSN 2055-0375

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Keywords: systemic risk, contagion, macroprudential policy, financial stability

JEL codes: E50, E61, G21

This paper is published as part of the Systemic Risk Centre's Special Paper Series.
The support of the Economic and Social Research Council (ESRC) in funding the SRC is gratefully acknowledged [grant number ES/K002309/1].

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Published by
Systemic Risk Centre
The London School of Economics and Political Science
Houghton Street
London WC2A 2AE

The concept of systemic risk

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Abstract

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1. Introduction

Although systemic risk and procyclicality had been present before the outbreak of the global financial crisis, the extent of their negative effects abruptly increased the interest of researchers in exploring their nature and ways to mitigate them. Despite the variety of studies on this topic, this paper attempts to structure the different aspects of systemic risk and provides a concept to understand it.

The aim of the study is to analyze the concept of systemic risk in the context of the global financial crisis that began in mid-2007. The paper analyzes systemic risk definitions as well as possible outcomes of the materialization of systemic risk. Based on the results, the author proposes own systemic risk definition. The analysis of systemic risk covers factors contributing to its accumulation, the spreading of contagion and provides a conceptual

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blueprint linking these phenomena. The model can be used to distinguish between accumulation, materialization and spreading of systemic risk (e.g. stemming from FX lending in CEE countries as in Annex 2).

Main contributions of this paper include identifying most common features of systemic risk definitions, as well as elaborating a new one. Moreover, the paper introduces a "way of thinking" about systemic risk that intends to clarify this phenomenon and make it easier to analyze, as well as select appropriate policy action.

The subject of the study does not include possible forms of quantification and measurement of the above-mentioned phenomena as an extensive review can be found in Bisias (et al., 2012). The study uses the following methods: a literature review, comparative method and deductive method.

The paper attempts to answer three research questions and presents a conceptual model of systemic risk. Research questions include:

1) How is systemic risk defined in the literature and by central banks?

2) What is the concept of systemic risk and what factors contribute to its accumulation?

3) What is contagion and how it is related to systemic risk?

The structure of the paper is as follows. After introduction, section two focuses on reviewing systemic risk definitions in the literature and those used by central banks. The third section deals with the concept of this phenomenon, while in section four main types and dimensions of systemic risk are elaborated. Section five covers the analysis of contagion, as a key feature of systemic risk. All the discussed aspects of systemic risk are brought together in section six which introduces the blueprint for systemic risk analysis. Last section concludes while answering the abovementioned research questions.

The scope of the study mainly covers activities of banks, as the banking sector is potentially the greatest source of systemic risk, particularly in the continental banking model. The study concludes with a summary containing answers to the research questions and pointing to further research areas.

2. Defining systemic risk

There is no consensus regarding the concept of financial stability and systemic risk. The materialization of systemic risk during the recent global financial crisis demonstrated that the financial safety net and financial institutions significantly underestimated it. Systemic risk turned out to be much more than just the composition of individual types of risks affecting financial institutions. While credit risk, liquidity risk, operational risk, etc. can be directly attributed to a given institution, systemic risk can only be attributed indirectly. Before the

financial crisis those types of risk were usually considered separately. However, the interaction (correlation) between them leads to undesired and unexpected consequences and when aggregated to systemic risk. Systemic risk evolves along with the development of financial markets, regulations and collective behavior of market participants, and it may be prompted by regulatory arbitrage.

Hitherto comparative studies of systemic risk definitions emphasize the wide scope of the features of systemic risk. Based on the literature review and case studies, Dow (2000) indicates that in the most common type of systemic risk, moral hazard plays a key role in disrupting the motives of financial institutions. Systemic risk arises from: excessively risky activities of a single or a group of traders, an aggressive type of organizational culture (drive towards short-term profits), a collective failure of management in the bank (or across the financial system), which leads to inertia and the inability to respond to changed economic circumstances and high (over)exposure of banks to the same type of risk (symmetric shock) in the system as a whole. A systemic risk literature review by Galati and Moessner (2010) concludes that despite the wealth of research on the subject, there is still no consensus on the definition of systemic risk. As in the case of financial stability[2], there are many systemic risk definitions[3], but it remains difficult to operationalize them. Nevertheless, the operationalization would be most useful from the perspective of conducting macroprudential supervision, aiming at systemic risk prevention.

Reviews by Bisias et al. (2012) and by Oosterloo and de Haan (2003) conclude that definitions focus on different aspects of the phenomenon, i.e. imbalances, collapse of confidence, correlated exposures of financial institutions, negative impact on the real economy, information asymmetry, feedback effects, asset bubbles, contagion and negative externalities. A lack of consensus in the literature and the complex nature of systemic risk imply the need for various measures and principles to measure it[4]. A selection of systemic risk

[2] According to Smaga (2013), a comparison of financial stability definitions in the literature proves that emphasis is placed primarily on proper fulfilling of functions by the financial system, in particular the efficient allocation of resources. Equally often the impact of financial instability on the real economy is emphasized. On the other hand, too little attention is paid to the risks arising from misalignments in assets prices and interrelationships between various elements of the financial system, through which contagion may spread. Financial stability definitions began to appear in the literature of the late twentieth century and early twenty-first century. After bursting of the dot-com bubble, this process has somewhat intensified. In the literature, before the outbreak of subprime crisis, most definitions pointed to the impact of the financial (in)stability on the real economy. After the crisis began, focus shifted to financial stability understood as proper fulfillment of financial system's functions.

[3] Sheldon and Maurer (1998) offer a non-standard definition by considering systemic risks to be for financial market participants what Nessie, the monster of Loch Ness, is for the Scots (and not only for them). Everyone knows and is aware of the danger. Everyone can accurately describe the threat. Nessie, like systemic risk, is omnipresent, but nobody knows when and where it might strike. There is no proof that anyone has really encountered it, but there is no doubt that it exists. A noteworthy, two-tier definition of systemic risk is also offered by the ECB (2010). Systemic risk is the risk of experiencing a systemic event. Systemic events can be understood broadly as financial instabilities spreading to the extent that the financial intermediation process is impaired and economic growth and welfare suffer materially.

[4] The construction of systemic risk measure may follow one of two approaches: top-down or bottom-up. In the top-down approach, systemic risk can be inferred from examining the historical behavior of time series data for variables that economic intuition suggests are related to systemic risk. In the bottom-up approach, estimates of the risk of individual firms is assembled from accounting data and market prices, and serve as input in

definitions by Eijffinger (2012) points out that systemic risk, regardless of in which form it materializes, causes a loss in confidence and increased uncertainty about the functioning of the financial system and its parts. The concept of systemic risk lies in the contagion effect and negative impact on the real economy.

Based on the author's comparison of systemic risk definitions in the literature (see Annex 1), which assesses definitions according to most popular aspects used) the following conclusions can be drawn:

- It is frequently emphasized that systemic risk concerns a large part of the financial system or a significant number of financial institutions and is considered to disrupt the performance of the financial system and its functions, such as financial intermediation. On the other hand, only a small fraction of researchers take into account the loss of confidence as a feature of systemic risk and its evolving nature.
- A key element of systemic risk is the transmission of disturbances (shocks) between interconnected elements of the system, which may ultimately have a negative impact on the real economy.
- In the literature, systemic risk definitions began to appear in the mid-'90s of the XX century, but their "creation" has clearly intensified after the outbreak of the global financial crisis.
- Before the crisis, definitions put more emphasis on the contagion effect and the large scale of this phenomenon. However, after the outbreak of the crisis, in addition to the significant scale of the phenomenon, more attention has been paid to disturbances in financial system functions. This result in defaults and has a negative impact on the real economy, which in turn was rarely underlined before the crisis.

Central banks rarely propose systemic risk definitions (Smaga, 2013). The survey by Oosterloo and de Haan (2003) points out that central banks often focus on elaborating definitions of financial (in)stability rather than definitions of financial crisis and systemic risk. Even though the study was conducted in 2003, these conclusions are still valid. When central banks have systemic risk definitions, they appear to be rather narrowly defined, i.e. a threat to the entire financial system (Czech National Bank, Bank of Canada, Riksbank) or the inability to fulfill obligations in a payment system, leading to its impairment (Bank of Luxembourg, Bank of Greece). Analyzing systemic risk definitions, Ostalecka (2012) emphasizes that regardless of the differences in definitions, it remains undisputed that the emergence of systemic risk in the financial system causes enormous risks to financial stability. This causes severe disturbances to spread (including financial crises) to other entities, markets and countries.

3. The concept of systemic risk

determining the interconnectedness or "too-interconnected-to-fail" risk in the system. Afterwards, a portfolio approach is used to assign a systemic risk measure to each institution (Chan-Lau, 2013).

Systemic risk varies substantially and encompasses a broad range of features. This means that a financial instrument, institution, market, market infrastructure, or segment of the financial system may be the source of systemic risk, the transmitter of it, as well as be affected by it. It is not easy to determine whether the scale of an event is (will become) systemic, since in turbulent periods, assessing the extent to which it affects other parts of the system may be subject to dynamic changes and the assessment might be prone to an underestimation bias. Systemic risk can have its source in or outside the financial system or it can result from the interconnectedness of particular financial institutions and financial markets and their exposure to the real economy (Szpunar, 2012).

However, classifying given phenomenon as systemic risk cannot be dependent on whether it is endogenous to the financial system or whether it has an impact on the real economy. This impact is probably always present through the disturbance of financial system functions. Thus it is important to quantify the systemic risk impact as a degree of the financial system functions' impairment. Systemic risk can be both endogenous, i.e. resulting from the collective behavior of financial institutions (or one of them – SIFI), or exogenous when its source is outside the financial system, e.g. imbalances in the real economy. According to Zigrand (2014), systemic risk comprises the risk to the proper functioning of the system as well as the risk created by the system. Of course, these two risks can overlap, and a shock within the system that is amplified by the system can lead to the auto destruction of large components of the system and even the entire system, or indeed as far as the real economy that embeds the system from which the shock emanates. Owing to numerous macrofinancial linkages between the real economy and the financial system it is difficult to clearly disentangle the sources of systemic risk.

Types of systemic risk can be classified into various groups. Allen and Carletti (2011) identify six types of systemic risk, namely: (i) common exposure to asset price bubbles, particularly real estate bubbles; (ii) liquidity provision and mispricing of assets; (iii) multiple equilibria and panics; (iv) contagion; (v) sovereign default; (vi) currency mismatches in the banking system. Although these events can indeed create systemic risk, they are usually identified ex-post and potential sources of systemic risk should not be treated as a closed catalogue.

Based on the above-mentioned enumeration, systemic risk can have a macro- or microeconomic dimension. Nier (2009) indicates that macro-systemic risk arises when the financial system becomes exposed to aggregate risk, resulting from, e.g. growth of correlated exposures. Micro-systemic risk arises when the failure of an individual institution has an adverse impact on the financial system as a whole (default of a SIFI). Macro and micro dimensions are closely related. The materialization of systemic risks caused by accumulated imbalances not only increases the micro-risk (probability of financial institution's default), but also the extent of its impact on the financial system. Should a major part of the system be unstable, especially in highly concentrated banking systems, the default of another institution may hamper access to financial services. So it seems more probable (or at least more common) for macro-risk to increase micro-risk, than the other way round. Similarly, micro-

risk may also materialize irrespective of the “level” of systemic risk in macro dimension, e.g. as a result of SIFI’s default.

Apart from the distinction between micro and macro, one can also divide systemic risk into three general types (Bancarewicz, 2005): macro shocks, failure chains and reassessment failures. The first type is simply the negative external disturbance preventing financial system from fulfilling its functions properly. The second type refers to the spreading of risk - losses incurred by one entity lead to losses in related institutions. This can be interpreted as contagion effect. On the other hand, the third type is based on an increase in information asymmetry concerning the correlation in institutions risk exposure and limited possibilities to differentiate them. The more there is a similarity between the exposure profiles of a defaulting institution to other institutions, the greater the contagion.

The evolving nature of systemic risk means that the exposure of financial institutions to systemic risk does not depend on their activities, but also on external factors and procyclicality, i.e. exposure to systemic risk may in general increase during recessions. It is therefore difficult to permanently distinguish systemic from non-systemic events and predict the extent to which the systemic risk will materialize. Hence the conclusion that identified potential sources of systemic risk should be periodically reviewed by the macroprudential authority[5].

Systemic risk can also arise from the existence of financial institutions that are necessary for the proper performance of financial system functions, which may be the case in highly concentrated systems. Risk of idiosyncratic shocks spreading through the system is substantially higher in concentrated systems than in decentralized ones (Cifuentes, 2003). Thus, high level of concentration increases financial system exposure to systemic risk arising from the default of a single institution, e.g. SIFI, systemic non-bank financial institutions and CCP.

Systemic risk from a micro-risk perspective, can be regarded as the degree to which a single financial institution "pollutes" financial stability (as a public good), through the production of negative externalities (systemic risk contribution of a given institution). According to De Nicolò et al. (2012) negative externalities caused by systemic risk include the following effects. Firstly, the externalities resulting from the strategic complementarities and similarities in business strategies - the tendency for the simultaneous increase in credit and liquidity risk exposure during booms, resulting from lowering credit standards as a result of increased competition in a boom. This can result from: asymmetric information, competitive pressure, reputational concerns and the incentives structure of bank managers (including performance assessment based on benchmarking) and the prospect of a government bailout in the event of financial distress (which leads to excessive risk-taking and growth of correlation between exposures of individual institutions). Secondly, the negative externality

[5] Macroprudential policy should cover all potential sources of systemic risks and the whole financial system, as well as interconnectedness between its parts and between the system and the real economy (Dobrzańska, 2012).

resulting from fire sales, when overleveraged financial institutions are forced to liquidate an asset at a time when potential buyers are also troubled and therefore the market as a whole experiences a sharp decline in asset prices due to mass sales, especially during a downturn. Thirdly, the negative externality resulting from high degree of interconnectedness, i.e. interlinkages between institutions serving as shock transmitting channels, particularly between SIFIs.

In case of risk at the level of particular institution (e.g. credit, operational, liquidity, etc.), it is created simultaneously at this level and the costs are borne by the individual institutions. On the other hand, in case of systemic risk, it is generated as the aggregation of all types of risks arising from financial institutions, as well as links and correlations between them. The costs associated with its materialization, however, are borne by all participants in the financial system and the real sector. These costs of systemic risk are not sufficiently taken into account ("internalized") by a financial institution that contributes to systemic risk. This may encourage financial institutions to "free-ride" resulting in excessive risk-taking – profitable from the perspective of the institution, yet at the expense of increase in systemic risk. Systemic risk costs are distributed unevenly across the financial system and disproportionately to the institutions systemic risk contributions.

The systemic risk contribution of an institution (defined as its "systemic" importance) can vary significantly, depending on current market conditions. Institutions with little systemic importance during a boom may be highly "systemic" during a recession. Therefore, an analysis of institutions systemic risk contribution should not solely rely on its size (because is not possible to change it in the short term), but also on other criteria such as the degree interconnectedness, which during a crisis may serve as contagion channel. Owing to the asymmetric information and lack of informational efficiency of financial markets, systemic risk arising from contributions of financial institutions is not sufficiently reflected in financial market variables.

Systemic risk usually arises from collective activities of financial institutions, except in cases where its source is derived from a SIFI failure. Banks can collectively increase their credit risk during booms, and despite the diversification at the micro-level, systemic risk may develop at the macro level. Systemic risk can materialize not only as a result of the SIFI failure, but from the instability of a group of smaller banks, yet exposed to a symmetric shock. Default of a SIFI[6] or group of institutions adversely affects the ability of other financial system participants to deliver critical financial services and products to the real economy. This can be viewed as a negative externality and therefore poses a threat to the entire system.

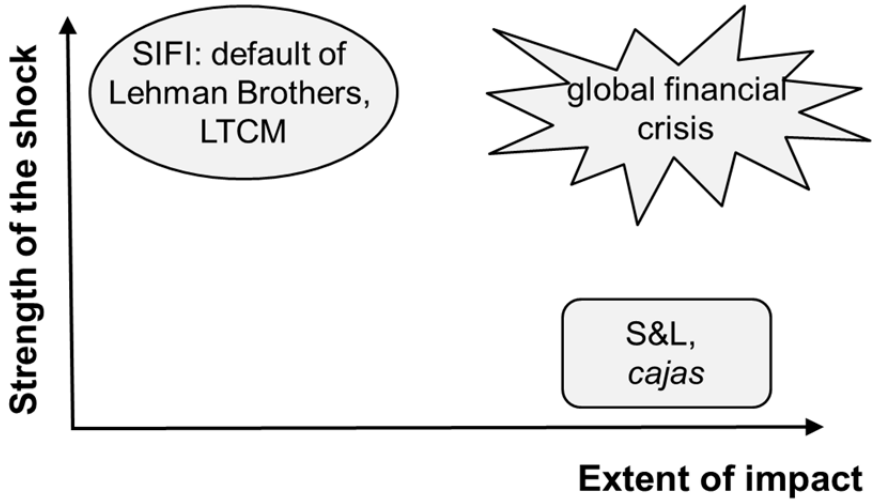
De Bandt and Hartmann (2000) distinguish between a horizontal and vertical view of the concept of systemic risk. The horizontal view is limited to events in the financial sector alone (through the bankruptcy of financial intermediaries or the crash of financial markets). The

[6] SIFI's default can trigger a domino effect, market panic, increase in financial market concentration (potential rise in systemic risk), limit financial intermediation (macro dimension) and/or (in a highly concentrated market) worsen the availability of financial services and products to customers (micro dimension).

vertical view focuses on systemic risk, in which the impact of a systemic event on output is taken to gauge the severity of such an event. However, in practice it may be difficult distinguish between the extent to which systemic risk affects the real economy, and to what extent only the financial system, as it also depends on the timeframe of the observation. In the long term, limiting the proper functioning of the financial system, in the end systemic risk is likely to always have an indirect, yet negative impact on the real economy.

Based on the concept by De Bandt and Hartmann (2000), one can conclude that systemic risk can be allocated within a matrix showing the relationship between the strength of the shock (the scale of negative impact on the financial system as a whole) and the extent (scope) of the impact (understood as the combination of both institution's systemic importance and the number of institutions being the source of the shock to the system). This is illustrated in Graph 1. On the one hand, the source of systemic risk can constitute a single institution of great systemic importance, whose default (or potentially even a longer period of illiquidity) creates a large shock to the financial system. On the other hand, the risk may also result from a number of institutions of less systemic importance on their own, yet interconnected and with similar exposures and subject to symmetric shocks. Such an understanding of systemic risk allows classifying systemic risk and selecting the appropriate preventive and remedial measures.

Graph 1. Systemic risk matrix



Source: own work

An important distinction is also between systemic and systematic risk. Systematic risk cannot be managed and is associated with undiversified elements related to the risk of securities, which is determined by market trends. It is regarded as the speculative risk impacting only through changes in the prices of financial instruments (Niedziółka, 2011). Systemic risk can be understood as a risk of one financial institution's problems spreading to the other (or the whole system). Coexistence of both risk types may occur in the case of bear markets, which contributes to the deterioration of the financial standing of institutions active in that market. So it seems reasonable to place systemic risk (and not systematic risk) in the focus of the financial safety net, especially of macroprudential authority.

4. Systemic risk dimensions

Often in the literature systemic risk is described in two dimensions (BIS, 2010, see Table 1):

- cross-sectional (structural) dimension, understood as the allocation of systemic risk (its sources) in the financial system at a given moment; it includes risks to financial stability arising from, i.a. instability of particular institutions, concentration (similarities) of their risk exposure or funding sources, size, structure and concentration level of the financial system and the links (direct and indirect) between financial institutions;
- time (cyclical, time-varying, time series) dimension, understood as a build-up (aggregated) of systemic risk over time; it includes risks which don't directly result from activities of a single institution, but from the collective behavior, which leads to amplification of volatility in the financial sector and the real economy, feedback effects, and excessive debt burden, leverage and underestimation of risk during booms and its overestimation during recessions, thus leading to deleveraging and procyclicality.

Table 1. Two dimension of systemic risk

	Cross-sectional dimension	**Time dimension**
Aim of the analysis	Shock transmission mechanism	Build-up of macrofinancial imbalances
Approach	Point-in-time	Over the given period
The main area of analysis	Size of the financial system, its structure and the degree of interconnectedness, SIFI	Procyclicality
The role of macroeconomic factors	Exogenous	Endogenous
Objective of macroprudential measures	The increase in financial system resilience to shocks	Reducing the rate of imbalances accumulation and mitigating their impact
Examples of risk sources	Interconnectedness and similarities in risk exposures of financial institutions leading to exposure to symmetric shock, excessive concentration	Interlinkages between the financial system and the real economy, financial system regulation

Source: own work

Those two types of systemic risk are closely related. For example, an increase in the financial system concentration level (cross-sectional dimension), leading to the creation of SIFIs can drive them to take excessive risks over time (time dimension) as a result of the increased moral hazard and expectations of bail-out. In addition, excessive lending during booms fosters increased risk taking (time dimension), which can lead to the accumulation of bank risk exposures and their concentration in given market segments (cross-sectional dimension) at the micro level (e.g. real estate market). At the macro level, procyclicality may lead to the development of new, more complex interlinkages within the financial system and between the financial system and the real economy. At the same time, results of the analysis from each perspective may differ, i.e. during booms profitability and the capital of banks increases, strengthening their resistance to shocks (cross-sectional dimension - a decrease in

systemic risk), while - at the same time - imbalances accumulate by excessive lending and the simultaneous build-up of asset prices (time dimension - an increase in systemic risk) .

Therefore, when analyzing systemic risk, it seems crucial to distinguish between the current and the future (in)stability of the financial system (Solarz, 2001). Financial institutions take to a large extent current instability into account and base their actions on this assessment, but the accumulation of future imbalances are hardly taken into account. They tend to "overreact" in recessions and deleverage. They also "exaggerate" during booms, disregarding the prospect of a coming bust and do not build sufficient capital buffers. This leads to pro-cyclicality. The key is therefore for the central bank or another macroprudential authority to analyze systemic risk in both current and future dimensions. However, there is a question of objectivity in systemic risk assessment, as the macroprudential authority will assess the phenomenon it can (significantly) influence, thus can be biased in the assessment. Therefore it seems that collegial body acting as a macroprudential authority might be less prone to assessment bias than a single macroprudential authority (e.g. central bank or supervisory authority).

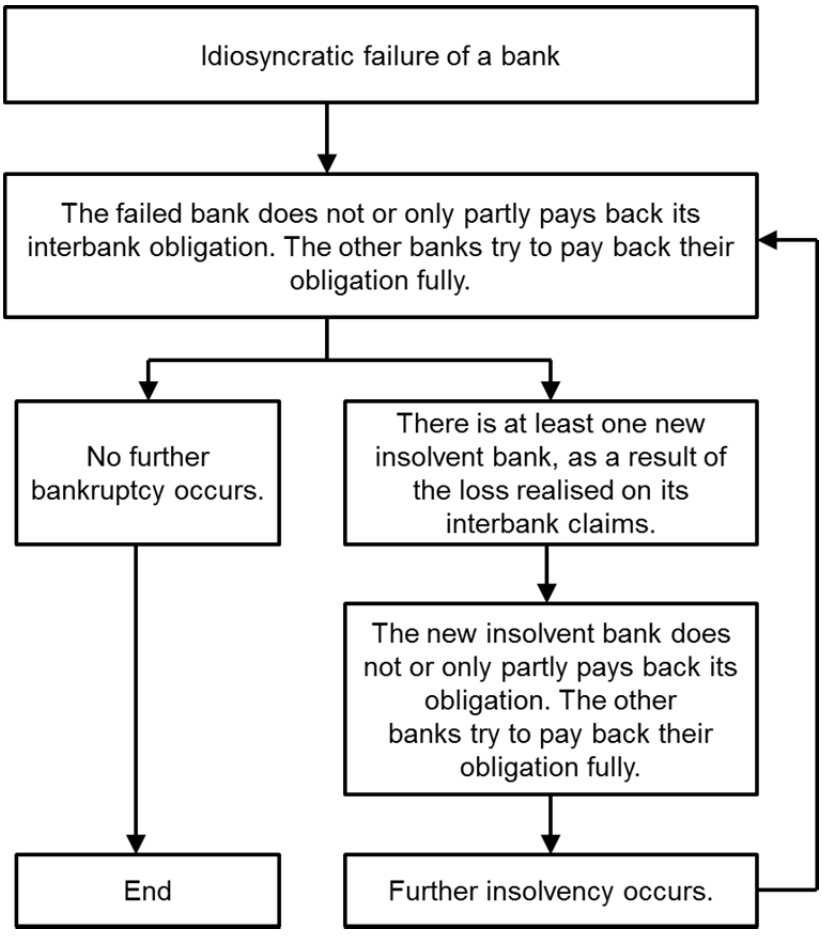
Distinguishing time and cross-sectional dimensions of systemic risk determines which macroprudential tools are appropriate to prevent systemic risk in specific dimensions. In broad terms, time-varying risks motivate tools that affect the balance sheets of financial institutions or influence the terms and conditions of financial transactions, while tools affecting market structures relate more closely to cross-sectional or structural risk (Bank of England, 2011). In case of time dimension, tools should be counter-cyclical. On the one hand they should reduce excessive risk-taking during booms and on the other reduce the scale of deleveraging during recessions. The tools should also aim at strengthening the resilience of the financial system to shocks, reducing the potential for contagion, e.g. by improving financial market infrastructure.

5. Contagion as a key feature of systemic risk

Contagion is inherent to the systemic risk and occurs when systemic risk materializes (Martínez-Jaramillo et al., 2010). Contagion is the main mechanism through which financial instability becomes so widespread that a crisis reaches systemic dimensions and is the focal point in this section. Other mechanisms that constitute sources of systemic risk might comprise unwinding of financial imbalances and the occurrence of severe macro shocks (Constâncio, 2012). Criteria that have been used in the literature to identify contagion include: (i) the transmission is in excess of what can be explained by economic fundamentals; (ii) the transmission is different from regular adjustments observed in tranquil times; (iii) the events constituting contagion are negative extremes; and (iv) the transmission is sequential, for example in a causal sense. But there is no agreement about which ones of these four criteria are necessary or sufficient to characterize a contagion event (Constâncio, 2012). Nevertheless, one should also take into account that the "normal" conditions are subject to (structural) change as well.

Contagion effect can therefore be defined as the probability that the instability of the given institution (instrument, market, infrastructure, financial system sector) will spread to other parts of the financial system with negative effects, leading to a system-wide crisis. Contagion effect is thus understood as the transmission of systemic risk through various channels. Such a definition is based on two assumptions, i.e. contagion cannot occur without the initial shock, and both the scale and pace of its transmission between institutions (markets) exceed those one would expect under "normal" market conditions. Domino effect, often synonymous with contagion, can be understood as an example of systemic risk materialization. Domino effect is based on the negative impact of the failure of a single financial institution (e.g. a bank) on the entire financial system, causing a chain reaction of further defaults. These in turn can cause further (iterations of) bankruptcies. This is due to the transmission of shocks through different channels, depending on the number of interlinkages between institutions (see Graph 2).

Graph 2. The procedure of domino effect



Source: Lublóy (2004)

Systemic risk can therefore be analyzed through two principal components: a shock that affects one or more of institutions and transmission mechanism that multiplies the shock. However, the impact of the shock can be non-linear and can change rapidly. This may depend in the short and medium term on the current state of the financial markets and economic conditions, and in the longer term, on the development and structural changes in the financial

system. It is therefore important to attempt to measure the scale of the shock, e.g. the increase in the number of standard deviations that would require intensifying macroprudential policy measures.

Contagion effect is due to market participants insufficiently taking into account negative externalities (increase systemic risk) caused by their activities and interconnectedness. Contagion effect can therefore affect all institutions, not just those with weaker financial conditions, but also those in ex-ante sound condition that are affected by second-round effects of domino effect and changing financial market conditions (e.g. fire sale causes falling asset prices that are valued mark-to-market). Examples of contagion include: SIFI failure, a significant decrease in confidence (increased uncertainty) in the financial system, unsustainable increase in asset prices (e.g. leading to a bursting of the real estate market bubble).

The banking system is inherently more vulnerable to contagion. According to Kaufmann (1992), bank failure contagion occurs faster, spreads more broadly within the industry, results in a larger number of failures, results in a larger losses to creditors (depositors) at failed banks and spreads further beyond the banking industry, causing substantial damage to the financial system as a whole and the macroeconomy. This is because banking sectors perform the function of intertemporal and maturity transformation - financing long-term assets (loans) with short-term liabilities (deposits). Vulnerability to contagion is mainly due to high leverage, interconnectedness, growth of shadow banking, risk of confidence loss, and the use of an aggressive liquidity management strategy, i.e. high reliance on funding from interbank market. This increases the risk of contagion and bank run, also caused by behavioral factors in an environment of asymmetric information, which can lead to coordination failure (Diamond and Dybvig, 1983).

Sources of underestimation of the risk of contagion may be due to (Lublóy, 2004):

- ignoring the repo positions,
- ignoring the systemic effect of cross-holding of shares,
- ruling out the imported contagion,
- assumption of dispersed bilateral exposures,
- definition of default (tier 1 capital),
- using end year data,
- ignoring the off balance sheet items,
- neglecting the risk stemming from the payment and settlement systems.

On the other hand, sources of overestimation of the risk of contagion include:

- ignoring the reaction of the central bank,
- ignorance of netting agreements,
- neglecting the potential measures of the regulatory authorities,
- neglecting the potential reactions of banks (withdrawal of interbank exposures, raising capital).

Apart from contagion, the other two key elements of systemic risk include connectedness and correlation - the so-called "3xC" (Scott, 2012). This concept refers to the cross-sectional dimension of systemic risk and interconnectedness between financial institutions (and more broadly, economic agents), which may constitute contagion channels. These links may take the form of balance sheet exposures in assets (e.g. loans - direct exposure to credit risk) or in liabilities (sources of financing - a sudden loss of funding leading to a bank run or the collapse of the whole interbank market). The source of contagion may not only be the default of a SIFI, but also a sudden decrease in market liquidity, escalating asymmetric information, bank run and fire sale. Correlation may refer to multiplication of losses caused by initial shocks. Therefore both correlation and interconnectedness contribute to the transmission and increase of scale of systemic risk.

Contagion effect can be based on fundamental factors or the behavior of investors (Ostalecka, 2009). The first type occurs when shocks move through trade and financial links, and symmetric shocks. The second type, in turn, refers to the situation where the shocks affecting a particular market are transferred to other markets despite no direct links among them. This results from a change in risk perception among investors of countries with a similar economic situation. The second type of contagion spreads through liquidity and information channels.

The increase in diversification of bank exposures may reduce systemic risk, reducing concentration in a given sector (which can cause instability). The main result from the literature review (Allen and Carletti, 2010) is that, on one hand, greater connectivity reduces the likelihood of widespread default. On the other hand, shocks may have a significantly larger impact on the financial system when they occur. Financial systems display a *robust-yet-fragile* tendency – while the probability of contagion may be low, the effects can be extremely widespread when problems occur (Gai, 2013). Therefore, diversification at the micro level is beneficial, but it can lead to an increase in the probability of systemic risk materialization, if portfolios/exposures are correlated or similarly structured, thus amplifying contagion in case of a symmetric shock.

6. A blueprint for systemic risk

Basing on the analysis above one can suggest a definition of systemic risk, combining its most important features, as mentioned in the literature. Systemic risk is the risk that a shock will result in such a significant materialization of (e.g. macro-financial) imbalances that it will spread on a scale that impairs the functioning of the financial system and to the extent that it adversely affects the real economy (e.g. economic growth). Adopting a too broad systemic risk definition reduces the chances of effectively managing it, while narrowing its scope (to a domino effect) allows disregarding (Solarz, 2008). In case of systemic risk, we have to deal with the uncertainty concerning the occurrence and timing of the systemic event.

Examples of factors that contribute to the build-up of systemic risk include:

- collective actions taken by financial institutions (coordination failure, bank run, fire sale, credit crunch, benchmarking);
- information factors (myopia, greater willingness to take risks, information asymmetry, incomplete financial markets efficiency, incomplete contracts and markets);
- system of incentives (guarantees/subsidies from the public sector that implicitly or explicitly support moral hazard, remuneration structure in financial institutions that supports excessive risk-taking in the short term);
- system of regulation and supervision (e.g. government bonds as "risk-free" assets, lack of systemic approach to financial stability risks arising, risks arising from shadow banking, procyclicality of capital adequacy).

Taking into account the definition adopted above, one can propose a conceptual model of systemic risk, combining the processes of accumulation of imbalances and their materialization (Graph 3). The model consists of the following elements:

- shock (type, source, duration, scope)
- channels of contagion,
- institutions (affected by systemic risk) and
- structural vulnerabilities (increasing exposure to systemic risk).

The whole process starts with a shock. The more systemically significant institutions it initially affects are, the stronger its influence on the financial system. Shocks can be classified as:

- endogenous or exogenous,
- resulting from the materialization of micro (understood as credit risk, liquidity risk, etc.) or macro risk,
- due to instability (default) of a single institution (e.g. SIFI) or problems of multiple institutions.

The shock is then transferred through interrelated contagion channels, which include:

- bilateral[7]: balance sheet exposures (e.g. on the interbank market) and off-balance sheet exposures (e.g. derivatives), trade channel (export/import);
- market[8] (informative): confidence/behavioral factors (e.g. irrational behavior, herding, moral hazard, asymmetric information), fire sale, collapse of the whole market as a result of negative external shock,
- structural: similarity in the structure of assets/liabilities (exposure to symmetric shocks) and risk management techniques or diversification methods[9],

[7] Bilateral channel can be endogenous - applying only to those institutions that are linked.
[8] Market channel can be seen as exogenous to the institution - market failures that affect all institutions. In the market channel contagion may be especially destructive if institutional investors behave irrationally.
[9] It is generally better for financial institutions to develop their own models internally. This is more likely to lead to a healthy competition in model design and more protection for the financial system, because model quality will improve over time. If each bank develops its own models, and models are different across the industry, when the next shock arises some banks may view it positively and buy the underlying asset, whilst other banks take the opposite view and sell. In aggregate their actions cancel out, resulting in stable markets where extreme

- international: foreign banks[10] (withdrawal of funding/lending during the crisis, exposure of the domestic financial system to external shocks), financing from global financial markets, capital flows,
- product: use of derivatives and securitization (results in opaque interconnectedness in the financial system and excessive leverage),
- payment system: links between (direct and indirect) participants in the payments and settlement systems, type of system.

Shock (of varying strength) through contagion affects a single institution or multitude of them. Institutions can be of different sizes and interconnected. When the shock affects a given institution, it is assumed to deteriorate its financial condition, often causing default. This in turn triggers feedback effects and a failing institution or group of institutions becomes a source of shock to other institutions (second round shocks). The entire process thus leads to the materialization of systemic risk through contagion.

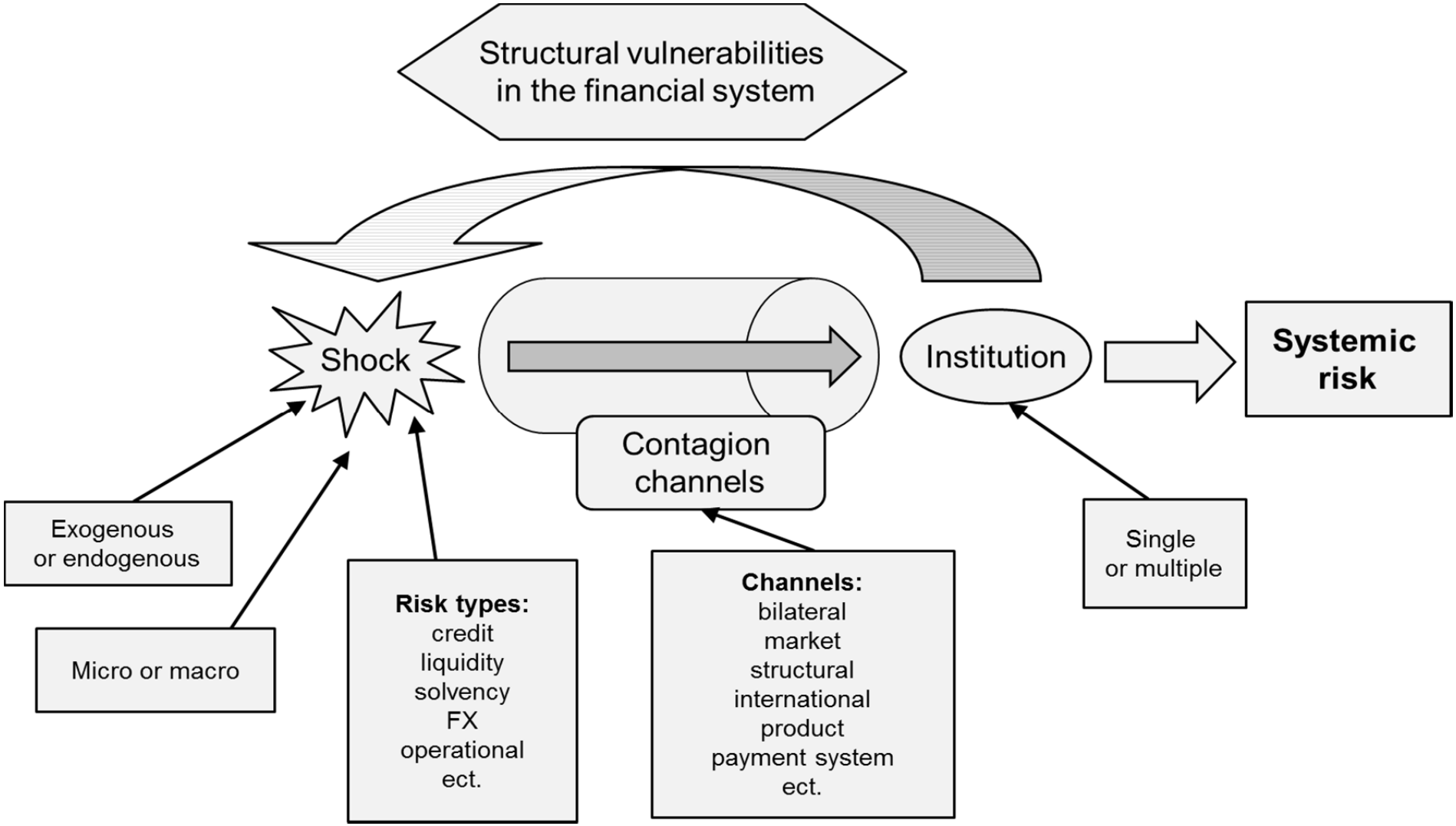
The financial system may be also subject to structural vulnerabilities, independent from the initial shock that increase system's exposure to shocks and exacerbate their strength and feedback effects[11]. Those vulnerabilities can be understood as a necessary but not sufficient condition for systemic risk materialization, which is possible in conjunction with the shock. Very often those factors reinforce each other.

movements are unlikely. If however the banks are forced to have the same models, they will all analyze the shock in the same way, and react in the same way, amplifying price movements. In a worst-case scenario it causes extreme price movements. Model homogeneity is therefore procyclical and undermines market integrity (Danielsson, 2013).

[10] Especially in new EU member states, as the sector of financial intermediaries is controlled by foreign capital, the most important factor affecting financial stability is the potential contagion from this channel. One can distinguish two types of contagion: subsidiary transferring risk to parent company and parent company transferring risk to its subsidiary (Iwanicz-Drozdowska, 2005).

[11] Examples of such factors include, but are not limited to the following: excessive reliance on short-term funding, often on unsecured interbank market; similarity of exposures to the same type of risk, despite diversification at the micro level; settlement of transactions in the OTC market, as opposed to the settlement via CCP; lack of financial markets efficiency; development of shadow banking and its links with the regulated part of the financial system; excessive size and leverage in the financial system; lowering the required standards of creditworthiness in the boom (procyclicality); increase in financial institutions exposure to sovereign bonds (home bias and negative feedback loop between banks and states); decrease in transparency of the financial system structure and of particular financial instruments; excessive maturity transformation in banks and FX maturity mismatch.

Graph 3. The blueprint for systemic risk



Source: own work.

One can also try to assess to what extent changes in factors/characteristics of the financial system potentially affect systemic risk (see Table 2). The table does not account for the possibilities of institutions hedging against volatility, safeguarding against instability and positive effects caused by given factors. It merely indicates a potentially negative impact of a given feature on financial stability - the net effect can be thus different and dependent on, i.a. type, degree of development and the structure of the financial system.

Table 2. Potential impact of financial system features on systemic risk

Feature of the financial system	Direction of change	Potential impact on systemic risk
concentration	increase	increase (growth of SIFIs)
macroeconomic imbalances	build-up	increase
financing on the interbank market	increase	increase (exposure to market collapse
globalization/cross-border activities/financial integration/capital flows	increase/development	inconclusive (exposure to foreign shocks - increase, diversification - decrease)
economic conditions	worsening/ improvement	increase/decrease
homogeneity in the way financial institutions operate	increase	increase (exposure to symmetric shock)
shadow banking	development	increase
home bias (in case of sovereign bonds)	increase	increase (strengthening of sovereign-bank nexus)
size of the financial system	increase	increase (in case of excessive size)
level of competition	increase	inconclusive
settlement of transactions via CCP	increase	inconclusive (decrease for a given institution, accumulation in CCP)
procyclicality	increase	increase
exchange rate	increase/decrease	inconclusive
interest rates	increase/ decrease	inconclusive
liquidity	increase/ decrease	inconclusive /increase
financial innovation	development	inconclusive
lending growth	increase/ decrease	increase/increase (in case of excessive increase – leveraging or decrease - deleveraging)
change in asset prices	increase	excessive (if rate of growth exceeds fundamentals)

Source: own work.

This blueprint can be used to analyze the impact of shocks in the financial system and it emphasizes the most important aspects of systemic risk materialization that should examine - the likelihood, strength and scope of shock. Risk should be analyzed not only at the level of

particular institutions, but at the level of groups of institutions and the system as a whole. It is important to assess potential contagion channels and vulnerabilities in the financial system. The model intends to break down and clearly categorize processes of accumulation, materialization and spreading of systemic risk, which should facilitate the identification of systemic risk and its subsequent mitigation by preventive financial safety net measures.

Using the proposed blueprint as a template, one can for example analyze systemic risk stemming from FX lending, especially in CEE countries (see Annex 2). Prior to the financial crisis, many households took FX mortgage loans without having any FX inflows, thus were very sensitive to exchange rate movements. As depreciation of the local currency results in a higher debt service burden for forex loans, disposable income of unhedged borrowers declines, together with their ability to service the debt. This creates an additional risk stemming from the non-linear relation between credit and market risk. Moreover, depreciation automatically increases the loan value in local currency, and higher loan-to-value ratios reduce the potential recovery ratios for banks (Szpunar and Głogowski 2012). In case of rapid currency depreciation, household's unhedged FX risk materialized as credit risk and deteriorated banks' balance sheets. Risks arising from FX landing were addressed by the recommendation of the ESRB on lending in foreign currencies (ESRB/2011/1). As a result, supervisory measures[12] were introduced that significantly reduced or prohibited FX lending.

7. Concluding remarks

In conclusion, based on the literature review and the construction of the conceptual systemic risk model, the research questions can be answered as follows.

1) How is systemic risk defined in the literature and by central banks?

In the literature it is frequently emphasized that systemic risk applies to a significant part of the financial system or a number of financial institutions and impairs the functioning of the financial system, e.g. financial intermediation. Before the crisis, more emphasis was put on contagion and the large scale of the phenomenon, while after the outbreak of the crisis, more attention is being paid to limiting the ability of the financial system to function, which results in defaults and has a negative impact on the real economy. Central banks often focus on providing definitions of financial (in)stability rather than of financial crisis and systemic risk, which is usually narrowly perceived as a threat to the entire financial system or associated with impaired functioning of the payment system.

[12] Supervisory measures included among others moral suasion (warnings/disclosure requirements), more stringent credit worthiness assessment (DtI caps, LTV), concentration limits, higher risk weights and increased provisioning, limits on open FX positions.

2) What is the concept of systemic risk and what factors contribute to its accumulation?

Systemic risk is characterized by its evolving and multidimensional nature and can both be endo- and exogenous. It can spread through contagion not only among financial institutions, but also between the financial system and real economy. Systemic risk may result from accumulation of macrofinancial imbalances and the existence of SIFI, whose functioning results in negative externalities for the financial system, the stability of which is a public good. One can distinguish between the cross-sectional and time dimension of systemic risk (associated with procyclicality). Many structural features of the financial system may increase its exposure to systemic risk.

3) What is the contagion and how it is related to systemic risk?

Contagion is inherently a mechanism of systemic risk through which it materializes and spreads in the financial system and/or outside it. Contagion cannot occur without the initial shock, and its transmission between institutions (markets) exceeds the scale and pace one would expect under "normal" market conditions. The banking system is particularly vulnerable to contagion. Contagion spreads through multiple channels such as bilateral exposures, market channel, information channel and payment systems.

Further research on systemic risk and contagion effect should take into account that:

- modeling contagion and systemic risk cannot be limited to being caused by a single institution’s default - in times of crisis, it is unlikely that bankruptcy would be an isolated case, and such studies may underestimate the risk scale and effects of contagion;
- default cannot be treated as occurrence of a sudden negative shock, because it is a process and bank run or severe tensions on the interbank market may be the result of a change in market's risk perception as a result of asymmetric information, behavioral factors, and financial markets inefficiency;
- it is important to identify how shocks spread through the system (through which channels and with what strength) and the extent to which an institution's collapse could affect the stability of the entire financial system.

“Way of thinking” about systemic risk has also far-reaching policy implications. It is important that the central bank analyzes financial system in order to assess the accumulation of systemic risk, identify its potential sources, and then use macroprudential tools to mitigate it. Difficulties in unambiguously defining systemic risk and the lack of adequate data are two major obstacles in the development of methods and tools for systemic risk analysis. Also communicating the results of systemic risk identification might be challenging, so as not to induce self-reinforcing mechanism leading to exacerbation of identified risks, but rather their mitigation. However, one should keep in mind that the systemic risk materialization is part of the Schumpeterian creative destruction and allows eliminating inefficient institutions. As long as it

doesn’t destabilize the whole financial system, weak institutions should be subject to resolution or allowed to fail. The purpose of regulation aimed at limiting contagion should include increasing internalization of systemic risk costs by financial institutions and at the same time limiting moral hazard and regulatory arbitrage. Possible forms of regulation targeted at reducing systemic risk comprise of i.a. the introduction of liquidity requirements, increased capital requirements, resolution, structural separation in the banking sector and imposing higher capital buffers for SIFIs.

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Annex 1. Comparison of systemic risk definitions

Author / Feature	Sudden occurence/disturbance/shock	Disturbance of financial system functions (e.g. financial intermediation)	Significant (systemic) scale	Probability (chance of) occurence	Evolving nature of the phenomenon	Contagion (chain reaction/domino effect)	Interconnectedness between financial system elements	Insolvency/defaults	Impact on the real economy	Loss of confidence
BIS (1994)			X			X		X		
Kaufmann (1995)				X		X	X			
Bartholomew and Whalen (1995)	X		X	X					X	X
Davis (1995)		X				X				
Rochet and Tirole (1996)						X	X			
G-30 (1997)	X		X						X	
De Bandt and Hartmann (1998)			X		X	X				
Lacker (1998)	X	X								
Staub (1998)	X	X		X		X	X			
G-10 (2001)	X		X	X	X				X	X
De Nicol'o and Kwast (2001)	X		X	X					X	X
Kaufman and Scott (2003)			X	X	X	X	X	X		
Cifuentes (2003)			X	X				X		
Minderhound (2003)	X	X	X							
Boss (at al., 2004)		X	X			X	X	X		
Andersen (2004)						X	X			
ECB (2004)		X				X				X
Kupiec and Nickerson (2004)	X	X	X					X		
Schinasi (2005)			X						X	X
Chan (et al., 2005)	X			X		X		X		
Bancarewicz (2005)		X		X		X	X			
EFDI (2006)			X						X	
Mishkin (2007)	X	X	X						X	
Ryan (2007)					X	X	X			
Kotyński (2007)			X			X		X	X	
Jurkowska-Zeidler (2008)			X			X				
Schwarcz (2008)	X					X	X	X		
Martínez-Jaramillo (et al., 2008)		X		X						
Solarz (2008)	X		X	X						X
IMF (2009)		X	X					X		

Huang (et al., 2009)	X		X					X		
IMF/BIS/FSB (2009)		X	X		X			X	X	
Adrian and Brunnermeier (2009)		X				X			X	
Korinek (2009)		X	X							
Kayne (2009)			X		X	X	X	X	X	
Summer (2009)						X		X		
Perotti and Suarez (2009)	X					X			X	
Acharya (et al., 2010)		X	X					X	X	
IMF (2010)			X				X	X		
Billio (et al., 2011)						X	X	X		
Moussa (2011)			X	X					X	
Giesecke and Kim (2011)			X	X		X	X	X		
Hautsch (et al., 2011)		X	X				X		X	
Selody (2011)		X		X	X				X	
Beau (et al., 2011)		X	X						X	
Tucker (2011)					X		X			
ESRB (2011)		X							X	
BIS (2011)		X			X		X		X	
Niedziółka (2011)						X		X		
Szpunar (2012)			X	X	X				X	
Maino (2012)			X		X					
Patro (et al., 2012)	X		X	X				X	X	
De Nicolò (et al., 2012)			X						X	
Zigrand (2014)		X	X	X			X			
Smaga (2014)	X	X	X	X		X			X	
Total	**16**	**22**	**34**	**18**	**11**	**24**	**17**	**19**	**23**	**6**

Source: Smaga (2014).

Annex 2. Analysis of systemic risk stemming from FX lending according to the blueprint.

1. Shock

- Type of shock: abrupt local currency depreciation, capital outflow, decline of real estate prices
- Types of risk: banks – funding, liquidity, credit, concentration and interest rate risks; borrowers (e.g. households) - unhedged FX positions, credit risk
- Source: mainly retail FX mortgage loans
- Scope: mainly CEE region

2. Channels of contagion

- bilateral: balance sheet exposures (FX mortgage loans)
- market: confidence/behavioral factors (moral hazard, asymmetric information and reassessment of risk appetite)
- structural: similarity in the structure of banks' assets/liabilities (exposure to FX loans/excessive reliance on parent funding), maturity mismatch, lack of prudent FX risk pricing
- international: foreign banks (withdrawal of FX funding during the crisis), excessive capital outflows, cross-border spillovers
- product: FX mortgage loans

3. Institutions

- affected were households and banks (mainly foreign banks' subsidiaries and branches)

4. Structural vulnerabilities (increasing exposure to the given systemic risk)

- increased presence of foreign financial groups in CEE banking sectors
- interest rate disparities
- dependence on FX funding from parent companies/interbank market, while small local FX deposit base
- expectations of local currency appreciation
- competitive pressure
- excessive credit growth (e.g. real estate loans)
- increased volatility of capital flows/exchange rate (or pegged exchange rate regime)
- real estate asset bubbles
- catching-up effect in emerging economies (CEE countries)
- global turbulences on financial markets

- mortgage loans as a relatively more profitable portfolio with lower default rates
- unstable macroeconomic conditions
- growing indebtedness of households

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