Who puts our financial system at risk? A methodological approach to identify banks with potential significant negative effects on financial stability

"…man war schon ganz süchtig danach, dass irgendein nächstes Institut kurz vor dem finalen Exitus, dem Supercrash, dem totalen Endzusammenbruch stand, dann aber gerade noch, da es, wie es jetzt dauernd so selbstverständlich soziologenhaft hieß, systemrelevant war, vom Staat mit soundsovielen Hunderten von Millionen, bald Milliarden Dollars und Euro GERETTET werden musste…"[1]

Rainald Goetz: loslabern, Suhrkamp 2009

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Since the outbreak of the global financial crisis, a number of regulations have been issued to cope with the too-big-to-fail problem and its devastating effects on financial markets, government budgets and the broader economy in general. The aim of these regulations is to contain the risks stemming from large institutions which potentially jeopardize not only these institutions' own existence but other institutions and segments of the economy as well. In particular, new legislation in macroprudential supervision and resolution that refers to systemically relevant institutions addresses the too-big-to-fail problem. Still, in practice, it is difficult for supervisory authorities to answer the question which institution may really compromise financial stability. The identification of systemically relevant banks is particularly important for banking systems (like the Austrian) with large numbers of banks, where even medium-sized banks might put stress on the entire financial system. Bringing together macroprudential regulations as well as recovery and resolution planning, this methodological paper aims to contribute to the literature and supervisory practice on the identification of systemically relevant banks. We develop a consistent and comprehensive framework that consists of more than 30 quantitative indicators reflecting four key stability criteria: financial market conditions, economic importance, direct contagion and indirect contagion. A particular challenge in this context is the setting of explicit thresholds for each of these indicators. To resolve this issue, we design a methodological approach to calibrating thresholds for different types of indicators: stress indicators, risk exposure indicators, system share indicators and network indicators. We identify thresholds based on quarterly panel data (from 1999 to 2016) for the Austrian banking sector. One basic assumption of our calibration is the idea of substitutability: If market activities of a failing bank can be absorbed promptly by other market participants, financial stability will not be at risk. As the substitution of bank activities also depends on the current phase of the economic cycle, we account for bust phases by developing stress scenarios.

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[1] *"…there appeared to be an addictive desire to watch yet another bank facing its imminent demise, a super crash, a total and irreversible collapse, and then needing to be SAVED by the government, at the last minute, with hundreds of millions and soon billions of dollars or euro because it was systemically important, as was now habitually being pointed out to us in smooth sociology-speak…"*

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One major lesson learned from the recent global financial crisis was that regulators and policymakers should pay greater attention to systemically important banks. The crisis revealed that some banks were too large and too interconnected, so that their failure (market exit) would have been risky for the financial system and the economy. Hence, public money was used to bail out troubled banks. To prevent taxpayers from paying for bank rescues in the future, various new regulations and instruments have been implemented at the European and national levels. In particular, the Banking Recovery and Resolution Directive was adopted in 2014 (BRRD, Directive 2014/59/EU). The BRRD provides a framework for authorities to manage bank failures and allow an orderly resolution without disrupting the financial system or the real economy. The BRRD was implemented in Austrian law through the Bank Recovery and Resolution Act (Bundesgesetz über die Sanierung und Abwicklung von Banken, BaSAG) and entered into force in 2015.

In addition, the macroprudential buffer regime – similar to resolution planning – has been established with the aim of ex ante identifying those banks whose failure might have significant negative effects on financial stability. Macroprudential capital buffers[3] were introduced in the euro area to increase the resilience of systemically important banks. In this context, the Basel Committee on Banking Supervision (BCBS) published a methodology for identifying global systemically important banks in 2013.[4] In addition, the Financial Stability Board (FSB) publishes annually a list of global systemically important banks (G-SIBs).[5] At the national level, so-called other systemically important institutions (O-SII) need to be identified based on the European Banking Authority (EBA) Guidelines (EBA/GL/2014/10).[6]

Both the BRRD and the regulations on macroprudential capital buffers for systemically important banks (G-SIB and O-SII) aim at safeguarding financial stability by identifying in advance those banks which might put the financial system at risk. These regulations use similar terminology[7] (e.g. financial stability and criticality) and list similar indicators, as for both purposes, a bank must be classified either as systemically important or not. This notwithstanding, what is still missing is a consistent definition of systemically important banks that takes into account macroprudential and resolution matters. A consistent identification of SIBs in different supervisory fields is also important to banks themselves, not least because this enables them to predict legal and supervisory decisions.

The framework developed in this paper attaches great importance to consistency between crisis prevention and crisis resolution. In practice, supervisors' degree of prudence differs not only between countries but also within countries (microprudential, macroprudential and resolution authorities). Some supervisors are more prudent and tend to be more risk averse as they do not want to overlook any potential risk source (including a risky bank). Hence, they have an incentive to ex ante identify

[3] *The European CRD IV and CRR came into force in January 2014. Macroprudential buffers are defined in Articles 130, 131, 133 CRD IV. The buffer regime was implemented in national law, for Austria in the Austrian Banking Act (BWG, Bankwesengesetz).*

[4] *Basel Committee on Banking Supervision (2013).*

[5] *http://www.fsb.org/2018/11/fsb-publishes-2018-g-sib-list/*

[6] *https://eba.europa.eu/documents/10180/930752/EBA-GL-2014-10+%28Guidelines+on+O-SIIs+Assesss ment%29.pdf/964fa8c7-6f7c-431a-8c34-82d42d112d91*

[7] *Unfortunately, the BRRD provides no definition of the term "financial stability."*

more banks as systemically important. Others want to work with a narrow definition of systemically important banks, also for reasons of proportionality.

Another drawback of the existing framework is that it includes guidelines on indicators, but no explicit thresholds for the individual indicators (O-SII thresholds are determined implicitly[8]). This leads to divergent national supervisory practices and limits regulatory harmonization and comparability between EU Member States. Even at the national level, macroprudential and resolution authorities may choose different thresholds for the same indicators.

Furthermore, the current regulations and guidelines do not even contain any methodological suggestions on how to calibrate these thresholds. Therefore, supervisors run a risk of setting inconsistent thresholds and facing legal action. We contribute to the literature and supervisory practice by putting these indicators in a comprehensive framework and – this is a novelty – show a methodological approach to how these thresholds can be calibrated.

In the literature, different approaches to define thresholds can be found: for example, thresholds based on multivariate quantiles (e.g. Serfling, 2002), thresholds based on historical distribution (e.g. Venditti et al., 2018) and bubble detection based on time series analysis (e.g. Diba and Grossman, 1988; Astill et al., 2018). We follow the historical distribution approach.

By establishing a both consistent and comprehensive framework and by presenting a methodological approach for a reliable threshold definition, we provide supervisory advice on how to assess the systemic importance of banks. We suggest a potential list of indicators and thresholds and present a methodology that can be applied specifically to individual countries. For countries with a small or concentrated banking system, the identification of systemically important banks may be more intuitive. However, for countries with a large banking sector, like Austria (which has more than 600 banks), a sound methodology is of high relevance.

The rest of the paper is organized as follows: In section 2 we present general considerations of an ex ante assessment framework. In section 3 we elaborate more specifically on the framework to identify Austrian banks with potential significant negative effects on financial stability. Here we integrate the entire set of indicators into a comprehensive framework, and – as a major contribution – we reveal the methodology for calibrating thresholds for selected indicators. In section 4 we conclude.

1 General considerations of an ex ante assessment framework

One of the key questions for supervisors is which banks' market failure and resulting market exit would jeopardize financial stability. Financial stability is defined as a financial system being "capable of ensuring the efficient allocation of financial resources and fulfilling its key macroeconomic functions even if financial imbalances and shocks occur."[9] A significant negative impact on financial stability can arise if the core function of banks (risk allocation and financial intermediation) is disrupted. It is important to distinguish between a considerable impact on financial stability and large economic losses on the one hand and minor market disruptions

[8] *The systemic importance of each bank is assessed by scoring the four indicators size, complexity, relevance for the economy and interconnectedness. The relative share of the bank within the financial system equals the score for the indicator. Banks with an average score above 350 basis points are classified as O-SII.*

[9] *OeNB definition, see https://www.oenb.at/en/financial-market/financial-stability.html*

or negative spillovers to some market participants on the other hand. The latter are part of the natural workings of the financial system and the economic cycle and are not intended to be avoided.

The ex ante identification of banks with potential significant negative effects on financial stability is the basis for a detailed analysis when a specific event of a likely failure occurs. Faced with the imminent threat of a bank's failure, authorities will assess the effects of the bank's market exit or resolution in more depth, using more detailed and very recent data (partly provided by the bank itself).

A key aspect in our methodology is substitutability. We argue that if a bank can exit the market suddenly without causing turmoil because other financial institutions step in to provide this bank's services (such as payment services, granting loans, taking in deposits, acting as derivative counterparts, etc.), financial stability is not at risk. More specifically, we assess substitutability by comparing the volume of services provided by each bank with the average historical market changes of the aggregated volume. For example, we assess the substitutability of new loans, as it is essential that a bank's market exit does not cause a credit supply shock that may threaten financial stability.

One major challenge of this ex ante assessment framework is the uncertainty about the future market environment. The specific stage of the economic and financial cycle strongly influences a bank failure's consequences for the economy and the financial system. In a boom phase, the economy and the financial system are less vulnerable, and a bank failure is more likely to be absorbed by other market participants without strong negative effects on financial stability. Yet the market's capacity to substitute for the business of a failing bank might be lower in periods of stress in the financial markets. In an already tense market environment, the failure of a bank might put the broader economy at risk, while the same market exit would have no drastic effects in a prospering environment.

We consider two methodological options to capture lower substitutability during stress periods: threshold calibration based on historical stress periods and scenario analysis. The first option follows an approach similar to that for the overall threshold calibration but considers only stress periods. We opt for the scenario analysis, because only a limited number of observations for stress periods are available in Austria. Furthermore, statistical measures (like standard deviations) are less significant for volatile stress periods, making threshold calibrations less reliable.[10]

Hence, we suggest considering different economic scenarios suitable for a specific country when setting thresholds. These scenarios need to reflect the characteristics and the relevant vulnerabilities of the banking system and the wider economy. The starting point is a baseline scenario based on average market conditions. This view can be complemented by country-specific severe, but plausible, scenarios. Austria has a large banking sector, which is highly interconnected with Central, Eastern and Southeastern European (CESEE) countries, therefore we calibrate thresholds for scenarios such as "macroeconomic downturn in CESEE with negative implications for the Austrian banking sector." Other scenarios for Austria are "stress in the real estate market" and "tense market after a bank failure triggered a deposit insurance payout."

[10] *Because of the limited number of observations within stress periods, statistical measures are less reliable.*

2 A framework to identify Austrian banks with potential significant negative effects on financial stability

2.1 Indicators

The starting point for the assessment framework is the synopsis of three frameworks: first, the internal assessments used by the OeNB to evaluate the systemic relevance of banks; second, indicators introduced by the Single Resolution Board (SRB) to identify banks whose failure is likely to result in "significant adverse effects on financial stability;" and third, indicators listed by the EBA to assess institutions that are more likely than others to create risks to financial stability due to their systemic importance. Based on this framework, we set up four main criteria (financial market conditions, economic importance, direct contagion and indirect contagion) and a total of ten subcriteria. Table 1 gives an overview of all criteria and subcriteria.

The indicators must meet several consistency tests to be included in the framework: They need to be economically relevant, quantifiable and consistent over different regulatory guidelines. Bringing together macroprudential and resolution regulations, we come up with an overall list of more than 30 indicators to assess potential financial stability effects caused by Austrian banks (see annex).

The first main criterion evaluates the current *financial market conditions* in Austria and the euro area. They are captured using the Austrian Financial Stress Index (AFSI)[11] for Austria and the Composite Indicator of Systemic Stress (CISS) for the euro area. These two indicators are based on data from relevant stock, money and bond markets and reflect current financial market risks. An increase denotes an increase in instability. Ceteris paribus, the more stable financial market conditions are, the smaller the negative effects of a given insolvency on financial stability and the real economy will be.

The stress indices have an inversely proportional effect on the thresholds of indicators used for all other criteria. This means that the higher the stress indices are, the lower the thresholds for the remaining indicators will have to be set.

Table 1

Overview of criteria and subcriteria to assess banks with potential significant negative effects on financial stability

Main criteria	Financial market conditions	Economic importance	Direct contagion	Indirect contagion
Subcriteria	Financial market conditions indicators	Size	Network indicator	Common exposure
		Significance		Risks stemming from covered deposits
		Nature and amount of liabilities	Type, complexity, amount and composition of risk	Risk density
		Nature and amount of cross-border business		

Source: Authors' compilation.

[11] *For a detailed explanation of the indicators and their calculation, see Eidenberger et al. (2013).*

The second criterion assesses the *economic importance* of the bank in question. We apply four subcriteria: First, the *size* of the credit institution in relation to the Austrian banking sector as a whole provides information about the gap in the Austrian banking system that will have to be closed by other banks if this credit institution fails. This gap is approximated by the relevant institution's share of the Austrian banking sector's total assets.

The second subcriterion reflects the bank's *significance to the real economy*. It measures the bank's significance for supplying banking services, which provides information about the potential effects of its insolvency on the real economy. Market share is used as a proxy for importance, and the number of individual services is used for the time needed to substitute for the service. Indicators for such bank services are the volume of private sector deposits and loans as well as the volume of domestic payments, the number of depositors, the number of lenders, and the number of payment transactions.

The third subcriterion is the *nature and amount of the credit institution's liabilities to other credit institutions and to other financial institutions*. This criterion provides information about the financial importance of the institution as well as its interlinkages with other institutions and therefore gives some indication of direct contagion. Suitable indicators are the share of interbank liabilities and claims and the share of outstanding debt and equity securities.

The fourth subcriterion – *nature and amount of a credit institution's cross-border business* – is relevant because cross-border business makes insolvency proceedings significantly more complex, which may, in turn, give rise to significant negative effects on financial stability and on the real economy. Furthermore, cross-border effects should be reduced to avoid negative spillovers or contagion risks.[12] Cross-border effects are estimated by using the volume of cross-border claims and liabilities and the share of cross-border business in aggregated total assets of the Austrian banking system.

The third main criterion focuses on the *direct contagion* channels of the institution to counterparties both in Austria and abroad, particularly within the EU. Direct contagion describes a situation where the direct losses caused by a bank's insolvency or resolution have negative effects on the entire financial system. Such negative effects may include the default or likely default of the counterparties or a significant impact on their ability to perform their macroeconomic functions efficiently for an extended period.

To assess the criterion of direct contagion, we use *network indicators* to measure the interconnectedness of a bank with other institutions and with foreign countries. We study its relative importance for the interbank market to measure the amount of direct contagion risk. As a first subcriterion, we use a set of network metrics including debt rank, Katz centrality and eigenvector centrality.[13] These indicators are calculated based on Austrian central credit register data.

[12] *The BaSAG states that Austrian authorities need to consider potential negative effects in other Member States for all resolution (planning) decisions.*

[13] *In network analysis, indicators of centrality identify the most important vertices within a graph. Examples are betweenness centrality, closeness centrality, eigenvector centrality, node strength centrality, degree centrality, harmonic centrality and Katz centrality. These measures identify the most influential actor in a network. Centrality concepts were developed in network analysis to identify the degree of connectivity of each participant of the network. We use an exposure-weighted directed network. For the network of Austrian banks with other countries, we use inverse Katz centrality because it is stable regarding changes and also reflects the vulnerability of banks which are connected with the most important nodes.*

The subcriterion *type, complexity, amount and composition of risk* identifies institutions with higher contagion risk. *Complexity of business* is considered because the valuation of complex businesses is particularly difficult in the event of a crisis. As there is no uniform definition of complexity, we focus on complex financial instruments. The recent financial crisis has shown that complex instruments are sources of substantial risk and that some banks suffered high losses or even went insolvent because of complex instruments. The last crisis experience has also shown that in times of stress, banks sell complex instruments first. Complexity of business is measured by the volume of derivatives and OTC derivatives and the share of OTC derivatives in a bank's total assets. Complexity can also stem from complex ownership structures or complex equity interests such as special purpose vehicles.[14]

Indirect contagion (the fourth main criterion) occurs when banks' actions generate externalities that affect other institutions through noncontractual channels.[15] Through this contagion channel, the insolvency of an institution may cause a negative reaction from other market participants that leads to a severe disruption of the financial system with the potential to harm the real economy. Indirect contagion is assessed by three subcriteria: common exposure, risk from covered deposits and risk density.

To assess *common exposure*, we divide the balance sheet (assets and liabilities) of each bank into nine main items. On the asset side, we identify interbank loans, securities held, mortgage loans, SME loans, consumer loans and cross-border business. On the liability side, we identify interbank deposits, other deposits and securities issued. The common exposure criterion clusters the banks along these main balance sheet items. This clustering reveals which banks are indirectly connected via common exposures or similar business models. Indirect contagion can only be a threat to financial stability if caused by the failure of banks which are significant for the system because of their size.[16] Cont and Schaaning (2018) have shown that effects of indirect contagion are more relevant for large banks than for smaller banks.[17]

Another subcriterion for indirect contagion is *risks from covered deposits*. Even though the EU Directive on deposit guarantee schemes (Directive 2014/49/EU) has been transposed into Austrian law and supervision in Austria is sound and strict, a deposit guarantee scheme payout event triggered by a bank with a high volume of covered deposits would be very costly for the banking system. Covered deposits are a main channel for indirect contagion due to the risk-sharing framework of the deposit guarantee system. If a failed bank's covered deposits exceed the amount of ex ante funds in the deposit guarantee scheme, all other banks have to contribute: first, by providing ex post funds, second, by refilling the ex ante funds, and third, by providing a loan to the deposit guarantee scheme. If a bank's ratio of covered deposits to total assets is high, the probability that insolvency proceeds will cover all expenses and completely compensate for funds provided by the banking sector is smaller. Hence, this bank's insolvency will weaken the entire banking sector. We

[14] *Finally, all banks identified under this subcriterion are not allowed to apply the exemption for small trading book business in line with Article 94 CRR.*

[15] *In contrast to direct contagion, which occurs via contractual channels, e.g. loan contracts or derivatives contracts, indirect contagion channels show spillover via noncontractual channels, e.g. common exposure or similar business model.*

[16] *Depending on the indicator, it can be the market share of the bank measured by total assets or measured by the specific risk category.*

[17] *This paper does not address the issue of indirect contagion via "too many to fail" (simultaneous failure of many small banks).*

use a bank's share in total covered deposits in Austria and the ratio of covered deposits to total assets for each bank as indicators for this subcriterion.

The third subcriterion is the *risk density* for each bank, which is estimated as risk-weighted assets (RWAs) in percent of total assets. Risk density is a general proxy for the risks taken by an institution.

The illustrated framework incorporates indicators applied for an ex ante assessment. If a bank is failing or likely to fail (FOLTF), a more in-depth analysis of the specific bank will be necessary. Additional indicators, e.g. regarding the liquidity situation and contagion via the liquidity channel, are of relevance in that case.[18] Furthermore, authorities might have additional data sources (provided by the bank) at their disposal.

2.2 Calibration of thresholds

What is fundamental in any threshold calibration is a solid database with long time series. For our calibration, we use OeNB reporting data which allow us to assemble panel data with quarterly observations between 1999 and 2016. For some indicators, only shorter time periods are available.[19] Threshold calibration differs depending on the type of indicator. The following types of indicators can be distinguished:

- stress indicators: the stress level in the financial market (e.g. indicators for the criterion financial market condition)
- risk exposure indicators: banks' risk exposure (e.g. for indicators covering indirect contagion)
- system-share indicators: banks' significance in the market (e.g. for indicators covering economic importance)
- network indicators: interconnectedness of financial institutions (e.g. for indicators revealing direct contagion)

The thresholds are set for the various indicators (see section 2.1) depending on their type. The stress indicators are the basis for all thresholds as they determine if the threshold level is lowered in periods of observed stress. The risk exposure indicators are similar to stress indicators as they are not analyzed in isolation but in combination with other indicators (mainly system-share indicators). These indicators are used for banks which are heavily exposed to a specific risk. But the bank will be identified as potentially putting financial stability at risk only if the size of the bank (or the size of the risk) is significant enough to threaten financial stability. System-share and network indicators will identify a bank as systemically important if a threshold is breached. To assess substitutability, it is not just economic and technical feasibility that is relevant; how quickly a service can be substituted is crucial as well. Therefore, "number of ..." indicators like the number of clients or the number of transactions that need to be substituted are analyzed as well. Chart 1 illustrates the types of indicators and their relation. In this paper, we focus only on the economic perspective.

Indicators for financial market conditions like the Austrian Financial Stress Indicator (AFSI) are stress indicators. They reflect the current financial market conditions and help to determine the current economic cycle. These stress indicators do not determine per se whether a bank is systemically important or not. If the stress indicator shows no sign of turmoil, the baseline scenario thresholds can be

[18] *In that case, liquidity stress tests are implemented to assess spillover effects to other banks using the reporting template: Additional Maturity Ladder, C66.00.*

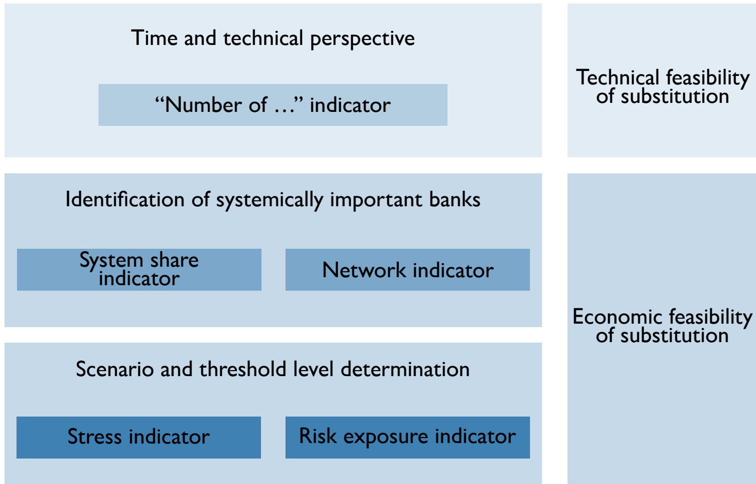
[19] *For some indicators, reporting requirements were established only after 1999.*

applied. In the case of a tense market environment, stricter thresholds should be used as defined later in this article.

Indicators reflecting a bank's economic importance are mostly of the system share indicator type. The thresholds for these system share indicators are set based on a substitutability assessment. The basic idea behind this approach is that the financial system is not at risk if the market activities[20] of a failing bank can be absorbed without frictions by other market participants. We compare an individual bank's value for a given indicator (*Ind*)[21] with the quarterly change of the same indicator throughout the entire banking system. To that end, we look at the empirical distribution of quarterly changes of the selected system share indicator based on banks' regulatory reporting data over a long time horizon. We assume that the time series of each system share indicator i is a random variable for each bank j and for the aggregated banking system A. We calculate the aggregated empirical distribution of the quarterly changes of each indicator and its expected value (E) and standard deviation (σ). The individual distributions (of quarterly changes for each indicator per bank from the panel data set) are helpful for robustness checks of the aggregated distribution.

Chart 1

Overview of indicator types in determining systemically important banks from an economic and technical perspective



Source: OeNB.

Based on that assessment, we derive four equations to estimate quantitative thresholds.

$$Ind^{T}_{i_f,j} \le E\left(\Delta Ind^{A}_{i\ t}\right) \ldots \text{low (L)} \tag{1}$$

$$E\left(\Delta Ind^{A}_{i\ t}\right) < Ind^{T}_{i_f,j} < E\left(\Delta Ind^{A}_{i\ t}\right) + \sigma\left(\Delta Ind^{A}_{i\ t}\right) \ldots \text{medium low (ML)} \tag{2}$$

$$E\left(\Delta Ind^{A}_{i\ t}\right) + \sigma\left(\Delta Ind^{A}_{i\ t}\right) \le Ind^{T}_{i,j} < E\left(\Delta Ind^{A}_{i\ t}\right) + 2\sigma\left(\Delta Ind^{A}_{i\ t}\right) \ldots \text{medium high (MH)} \tag{3}$$

$$Ind^{T}_{i_f,j} \ge E\left(\Delta Ind^{A}_{i\ t}\right) + 2\sigma\left(\Delta Ind^{A}_{i\ t}\right) \ldots \text{high (H)} \tag{4}$$

Ind…: indicator as a share in total banking sector volume of the indicator for all i… type of indicator and i_f for the flow (new business) of indicator i for bank j, if flow data is available; if not, our conservative approach is to use stock

[20] *Market activities of relevance are reflected by the criteria, subcriteria and indicators described in section 3.1.*

[21] *The indicator is measured as a share at an aggregated level to be comparable with the quarterly changes. If a flow quantity is used, the flow indicator is also measured as share of the stock of the aggregated value (to ensure comparability).*

data
for all banks j
for a fixed time T
ΔInd…changes over t: quarterly time series
A… banking system

Equation (1) means that an individual bank j's share of an indicator's aggregated volume is smaller than the expected value (E) of the quarterly changes of the indicator. In that case, the market exit of the bank probably has no effect on financial stability.

Equation (2) means that the bank j's share is higher than (E) but lower than (E) plus its standard deviation. It describes an event that might be noticeable but will not put financial stability at risk in normal times.

For illustration purposes only, assume for the moment a standard normal distribution[22] of an indicator: under this assumption, the category "medium high" with a higher than expected value plus one standard deviation would be reached or exceeded in 15.9% of cases. Category "high" (equation (4)) would be obtained in 2.2% of cases, meaning an average occurrence every 10 to 11 years. We consider these probabilities to be conservative but adequate to approximate a potential impact on financial stability.

We illustrate the approach for the indicator *total loans to the private sector*, which is part of the subcriterion *significance of the credit institution for the real sector.* We use time series of loans to the private sector for each bank (volume) and of the percentage quarter-on-quarter changes in absolute[23] terms (quarter-on-quarter changes). Second, to estimate the expected value of quarterly changes, we calculate the arithmetic mean of the changes of the banking system over the entire period (average change) and the standard deviations of the changes. Quarterly changes are used because time is critical, and the exit of the bank must be absorbed unexpectedly and quickly. Third, we compare the bank's average volume of new loan production[24] with the average change computed in step two. We use the new loan flow rather than the loan stock because the crucial question is whether other banks can substitute for the typical volume of new loans. If the failing bank's typical new loan production is lower than the average change of the loan stock of all banks in the system, the loan demand that would be met by this bank can easily be absorbed by other lenders. Therefore, it can be concluded that this bank's failure is unlikely to threaten financial stability (low impact). Applied to Austrian private sector loans, this threshold would be 1.2%.

The failure of a bank with a new loan production that is lower than this value would not be considered to have a significant negative effect on financial stability. If the value is higher than the mean plus two standard deviations, the failure would be considered to have potentially significant negative effects on financial stability, as timely and frictionless substitution is less likely (high impact). For Austria this would equal a threshold for private sector loans of 3.1%.

[22] *In practice, we use empirial distributions when applying our framework for system share indicators.*

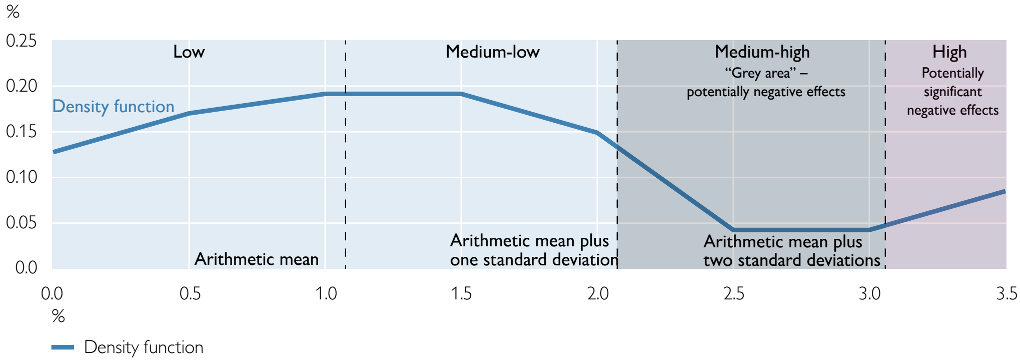
[23] *We use absolute terms as we postulate that positive and negative market changes should be treated similarly, as both had no negative effects on financial stability.*

[24] *We apply a two-year average period. The last year reflects current information. The average period should emphasize this current information on the one hand but needs to control for volatility over time on the other hand.*

Chart 2

Thresholds for the indicator "total loans to private sector"

Density function of Austrian bank loans to the private sector, quarter-on-quarter change (Q3 2004 – Q1 2016)



Source: Authors' calculations.

Less clear is the handling of banks that are between low and high impact. We define a "grey area" that is between the arithmetic mean plus one standard deviation (medium-high impact) and the threshold for high impact (arithmetic mean plus two standard deviations). For the chosen indicator of private sector loans in Austria, this medium-high threshold would be at 2.2%. Very prudent authorities might also consider these banks as likely to threaten financial stability (although not severely).

Chart 2 illustrates the distribution of quarterly changes of private sector loans of the Austrian banking system for the period Q3 2004 to Q1 2016. The threshold marking the area with potential significant negative effects on financial stability is set at the mean plus two standard deviations. The "grey area" is defined as the area between the arithmetic mean plus one standard deviation and the mean plus two standard deviations.

This approach (comparing the median quarterly rate of change for the banking system with the relevant bank's volume) can be applied in the same way to the other system share indicators. One example is the indicator *total assets* (reflecting the subcriterion *size*). Here, too, one can argue that it is not the whole stock (in that case, the entire balance sheet) that needs to be substituted for by other (Austrian) market participants for a frictionless market exit. Actually, only new business of some parts of the balance sheet is of relevance. Hence, authorities could apply a haircut on the total assets to estimate more realistically the sum of assets that needs to be substituted for.

For the assessment of a bank's interconnectedness, network indicators are used. The methodology differs from that used for system share indicators, while the threshold setting works similarly. For network indicators, a broad range of literature exists (see Allen and Gale, 2000; Eisenberg and Noe, 2001). Generally speaking, a network is defined as a set of nodes (in our case, banks) and a set of linkages between them. Different centrality measures exist to evaluate these linkages (for an application to the Austrian banking system, see Puhr et al., 2012). For example, node strength centrality, the simplest centrality measure, is defined as the number of links from a node. We use a set of different centrality measures for the Austrian interbank network, based on Austrian central credit register data. For cross-border linkages, we use the Katz centrality (Katz, 1953). Thresholds for network indicators can be set in the same manner as thresholds for system share indicators, but the random variable is the indicator at a fixed time T (not a time series) over all banks in Austria. For robustness checks of the statistical figures, we use all available calculations of the network indicators for the last years.

$$E(Ind_{i,j}^{T}) + \sigma(Ind_{i,j}^{T}) \leq Ind_{i,j}^{T} < E(Ind_{i,j}^{T}) + 2\sigma(Ind_{i,j}^{T}) \ldots \text{medium high (MH)} \quad (5)$$

$$Ind_{i,j}^{T} \geq E(Ind_{i,j}^{T}) + 2\sigma(Ind_{i,j}^{T}) \ldots \text{high (H)} \quad (6)$$

Ind…random variable: indicator
for all i…type of indicator
over j banks in the AT banking system
at a fixed time T

Risk exposure indicators measure the significance of certain risks to a bank. They are particularly important to assess indirect contagion caused by common exposures prevalent across the system. Similarly to the stress indicators, these indicators need to be analyzed not in isolation but in combination with a corresponding system-wide indicator. They help identify banks that are highly exposed to certain risks (e.g. banks with a business model strongly dependent on real estate loans).

We start by evaluating whether this risk exposure could threaten financial stability if the bank fails or is likely to fail. We identify a bank as heavily exposed to a certain risk (e.g. real estate loans, covered deposits or OTC derivatives) if that risk as a share of total assets meets equation (8). The bank is seen as "highly" exposed if the risk exposure is higher than the average plus two standard deviations. Banks whose exposure is lower than that but higher than the average plus one standard deviation are, again, seen as part of a "grey area."[25]

$$E(Ind_{i,j}^{T}) + \sigma(Ind_{i,j}^{T}) \leq Ind_{i,j}^{T} < E(Ind_{i,j}^{T}) + 2\sigma(Ind_{i,j}^{T}) \ldots \text{medium high (MH)} \quad (7)$$

$$Ind_{i,j}^{T} \geq E(Ind_{i,j}^{T}) + 2\sigma(Ind_{i,j}^{T}) \ldots \text{high (H)} \quad (8)$$

Ind… random variable: indicator
for each i type of indicator
over j banks in the AT banking system
at fixed time T

Based on the assessment of the risk exposure indicators, we reconsider the corresponding system share indicator. For instance, if a bank is heavily exposed to OTC derivatives, the threshold for the system share indicator measuring the volume of derivatives is set one standard deviation lower than it is for banks that are not heavily

[25] *To evaluate common exposure, further analysis can be done to define robust thresholds depending on the riskiness and the volume of the exposure for/in the banking sector.*

exposed.[26] In this case, a bank is already classified as "high risk" as measured by the system share indicator if equation (3) is met.

Finally, the thresholds for both the system share and the network indicators also depend on the *stress indicators*, as mentioned above. If the stress indicators are higher than the long-term average plus two standard deviations, we consider the market to be under stress. In the case of an adverse market environment, even the failure of a bank exposed to lower risk might cause market turmoil (i.e. there is a lesser degree of substitutability). We suggest shifting all thresholds for system share and network indicators down by one standard deviation in that case.

"Number of…" indicators evaluate how many clients or services will potentially be affected if a bank fails. This can have an impact on how quickly time-critical services such as payment services can be substituted for by other market participants. Thresholds for these indicators can be calibrated similarly to the thresholds for system share indicators. For some of these indicators, thresholds must be set due to operational or technical limitations.

Finally, the individual indicators need to be brought together into an overall assessment. Our basic aim is not to miss any single source of financial stability risk. Therefore, we argue that one single indicator identified as "high" should be enough to judge the bank as systemically relevant.

2.3 Thresholds under stress scenarios

As already mentioned above, one major challenge is to determine specific thresholds for periods of stress. In addition to market-induced stress, we suggest additional adverse but plausible stress scenarios that could occur even while markets are stable. For the Austrian banking sector, we have identified three scenarios (see section 1): (1) a macroeconomic downturn in CESEE with negative implications for the Austrian banking sector, (2) stress in the real estate market and (3) tensions after a deposit insurance event. To develop the scenarios, we look into historical evidence to understand their economic drivers. In a first step, we identify similar historical crises (in Austria and globally) and quantify contagion channels. In a second step, we identify Austrian banks that are heavily exposed by way of the common exposure indicator (see risk exposure indicators above). In a third step, we assess the contagion channels to the Austrian banking sector for each of these banks in the event of a likely failure (FOLTF). As a result of the first three steps, we identify those banks that are additionally relevant under the given scenario.

For example, under the scenario "tense market after deposit insurance event in Austria," we first assess historical deposit guarantee events for similar banking systems and their effects on financial stability and the real economy. Second, we identify Austrian banks with high shares of guaranteed deposits. Third, we capture the contagion channels, e.g. the remaining funds in the deposit guarantee funds and the remaining risk mitigating capacities of the banking system. As a result, we are able to identify additional banks that potentially threaten financial stability under this scenario.

[26] *Banks need to be of a substantial size so that their failure has severe contagion effects. Hence, the trade-off between proportionality and the degree of a bank's risk exposure is considered for indicators of the type "risk exposure."*

3 Conclusions

We develop a comprehensive framework to identify banks with potential significant negative effects on financial stability. The framework consists of more than 30 quantitative indicators grouped under the four main criteria financial market conditions, economic importance, direct contagion and indirect contagion.

Also, the paper aims to establish a consistent approach to macroprudential supervision by emphasizing the consistency between crisis prevention and crisis resolution. For the Austrian banking system with more than 600 banks, a quantitative indicator-based framework with consistent thresholds across banks and indicators is crucial. The quantitative assessment of thresholds should enable macroprudential and resolution authorities to identify systemically important banks in a transparent and plausible way. While setting thresholds entails some supervisory discretion and expert judgment of the risk appetite of the institution, our framework can help authorities to be more reliable, consistent and transparent. Moreover, the disclosure of criteria for threshold settings contributes to avoiding unintended biases.

The main idea behind our methodological approach is that if market activities of a failing bank can be substituted for without frictions by other market participants, the financial system is not at risk. We have shown that the substitutability and therefore the thresholds depend on the economic environment and that lower thresholds are appropriate for country-specific stress scenarios.

The application of our framework could reduce the probability of public bailouts. Our results help us to understand the risks the Austrian banking system is faced with and to address them with adequate macroprudential instruments or through recovery and resolution planning, in order to reduce the probability and the impact of the next crisis.

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Annex

Table A1 provides an overview of quantitative indicators within the four main criteria financial market conditions, economic importance, direct contagion and indirect contagion.

Table A1

Overview of quantitative indicators

Criteria and subcriteria	Indicators
Financial market conditions	
Financial market conditions	Austrian Financial Stress Index (AFSI) for the stress level in Austria Composite Indicator of Systemic Stress (CISS) in the euro area
Economic importance	
Size of the credit institution and its share in the Austrian banking sector	Total assets
Significance of the credit institution for the real sector	Total value of deposits Total loans outstanding Total number of depositors Value of domestic payment transactions Loans (number of borrowers, percentage share of the institution's borrowers in total number of borrowers)
Nature and amount of the credit institution's liabilities to other credit institutions, interconnectedness with other financial market participants	Interbank liabilities Interbank assets Debt securities issued
Nature and amount of the credit institution's cross-border business	Cross-border liabilities Cross-border claims Share of cross-border business in consolidated total assets
Direct contagion	
Type, complexity, amount and composition of risk accepted by the credit institution	Derivatives in the trading book "Small trading book" Value of OTC derivatives Volume of OTC derivatives as a percentage of total assets
Network indicator for direct contagion risks	Network indicator for direct contagion within the Austrian banking sector Network indicator for direct contagion within the network of the banking sector's cross-border linkages Contagion rank
Indirect contagion	
Common exposure	Interbank loans as a percentage of total assets Securities held as a percentage of total assets Mortage loans as a percentage of total assets SME loans as a percentage of total assets Consumer loans as a percentage of total assets Cross-border business as a percentage of total assets Interbank deposits as a percentage of total assets Other deposits as a percentage of total assets Securities issued as a percentage of total assets
Risks stemming from covered deposits	Risk exposure associated with covered deposits Risk exposure associated with the share of deposits covered by deposit guarantee schemes (DGSs) Impact of DGS event on the credit institution
Risk density	Risk density percentage share of risk-weighted assets in total assets

Source: Authors' compilation.