Institute of Economic Studies, Faculty of Social Sciences
Charles University in Prague

Family Matters: Concurrent Capital Buffers in a Banking Group

Michal Skořepa

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Institute of Economic Studies,
Faculty of Social Sciences,
Charles University in Prague

[UK FSV – IES]

Opletalova 26
CZ-110 00, Prague
E-mail : ies@fsv.cuni.cz
http://ies.fsv.cuni.cz

Institut ekonomických studií
Fakulta sociálních věd
Univerzita Karlova v Praze

Opletalova 26
110 00 Praha 1

E-mail : ies@fsv.cuni.cz
http://ies.fsv.cuni.cz

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Family Matters: Concurrent Capital Buffers in a Banking Group

Michal Skořepa[a]

[a]Czech National Bank
Email: skorepa@cnb.cz

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Abstract:

We simulate how the probability of failure of a subsidiary and the group changes after a capital buffer is imposed on the group as a whole and/or the subsidiary. The simulation takes into account the relative sizes of the parent and the subsidiary, the parent's share in the subsidiary, the similarity between the business models of the parent and the subsidiary, and the preparedness of the parent to support the subsidiary if the latter is in danger of failing.

Keywords: capital, buffers, Basel III, probability of bank failure, banking group, parent, subsidiary, regulatory consolidation
JEL: F23, G21, G28

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1. Introduction

One of the main innovations of the Basel III global regulatory framework for banks (BCBS, 2011) is the concept of capital buffers. In this context, "buffer" means a bank-specific capital requirement (in relation to the bank's risk-weighted assets) imposed on top of the minimum requirement under certain conditions. If a bank's capital falls below the sum of the minimum and the buffer, the bank has to observe certain restrictions on actions (such as the payment of dividends) that would further reduce its capital or hinder it in rebuilding its capital to the required level.

The general logic of any Basel III capital buffer is that if the imposition of a buffer on a banking group leads to growth in the group's total capital adequacy, then – other things being equal – the probability of the bank incurring a loss that will fully deplete its capital will decrease, hence the probability of failure of the group will also be reduced.[1] The same logic applies to the probability of failure of a subsidiary in the group if a buffer is imposed on that subsidiary. The imposition of a buffer on the group will also probably lead to growth in the parent's capital above the minimum requirement imposed on the parent alone. This gives rise to issues regarding the impacts of a group or subsidiary buffer on the parent's capital and on the probability of failure of the group and the subsidiary.[2]

In this paper we examine the above issues using a set of simulations. We investigate how the answers change depending on the relative sizes of the two members of the group, on the size of the parent's share in the subsidiary and on the similarity between the business models of the parent and the subsidiary. By contrast, we abstract from any changes in the parameters of the environment in which banks operate (such as borrowers' ability to repay their loans) and from the effects of changing capital requirements on banks' lending and other activities and on their profitability.

The existence of concurrent buffers in a group is clearly a relevant topic for macroprudential and microprudential policy-makers wherever a banking sector they regulate contains members of banking groups – parents, subsidiaries or both.

In these circumstances, frictions can arise between home and host regulators over what capital buffer rates should be set for the group as a whole and for the subsidiary so that the probability of failure of both falls to the desired level. For example, after imposing a global systemically important bank buffer on a group, the home regulator may conclude that this buffer in itself ensures that the subsidiary bank is also sufficiently stable. Consequently, it may put pressure on the host regulator not to impose any additional buffer on the subsidiary. By contrast, the host regulator, whose primary objective is to ensure that the subsidiary, not the group, is stable, may feel that the buffer imposed on the group does not in fact ensure that the subsidiary is sufficiently stable. The point of imposing a buffer on a subsidiary is to increase its resilience to the risks it faces, because the experience of recent years has shown that the parent's capital may not sufficiently protect the subsidiary and so taxpayers in the country where the subsidiary operates may have to foot the bill if it becomes distressed. Our

[1] For a survey of views on how capital requirements influence banks' attitudes to risk, see Van Hoose (2007).

[2] For the sake of brevity, throughout this paper a requirement applying to the group will mean a requirement applying to the group at the consolidated level, and a requirement applying to the parent alone (or to the subsidiary) will mean a requirement applying to the parent (or the subsidiary) at the stand-alone level.

simulations are intended to shed some light on these highly topical issues.[3] We will focus on Basel III at the general level and therefore abstract from the specifics of how this framework has been transposed into EU legislation (in CRD IV and CRR).

The remainder of this paper is structured as follows. Section 2 analyses the logic of each of the three types of capital buffers introduced in Basel III and explains that only the buffer based on systemic importance leads to meaningful differentiation of probabilities of failure for different banks, so our subsequent simulations can be viewed as relating primarily to this type of buffer. Section 3 presents the simple banking group model on which our simulation are based and derives formulas for the probability of bank failure for the subsidiary and for the whole group. Section 4 describes the simulation results, i.e. our estimates of the necessary increase in the parent's capital on top of the stand-alone minimum requirement for various combinations of capital buffers for the group and for the subsidiary, and then our estimates of the probability of failure of the subsidiary and the group assuming that the parent is prepared to provide assistance to the subsidiary where necessary. Section 5 summarises all the main findings as well as describing some of the (tentative) implications for regulatory practice.

2. Capital buffers introduced by Basel III

Basel III introduced three types of capital buffers. The first is the capital conservation buffer, which is applicable equally to all banks. The second is the countercyclical buffer, which should be imposed on each bank commensurately with its contribution to any credit boom that the competent regulator regards as unhealthily strong (BCBS, 2010; Repullo and Saurina, 2011). The third type is a buffer based on systemic importance, usually referred to as the SIB (systemically important bank) buffer. The higher the macroeconomic losses that would be generated by a bank's distress or failure, the larger this buffer should be (BCBS, 2012, 2013a). This concept can be applied either to the global economy or to the domestic economy, so this buffer can be said to have two subtypes: a buffer for global systemically important banks (G-SIB buffer) and a buffer for domestic systemically important banks (D-SIB buffer).

All three types of reserves have the same impact in terms of the conservation and rebuilding of capital: all three buffers applicable to the bank are summed, and if its actual capital is less than the sum of the combined buffer and the traditional minimum capital requirement, the bank must put in place the restrictions referred to above. The bank must fill all three buffers with capital in the form of Common Equity Tier 1 (CET1).

The conservation buffer – if introduced in the banking sector at all – applies equally to every bank. This type of buffer can therefore be interpreted as a non-selective, simple "soft" extension of the "hard" Pillar 1 minimum capital requirement. By contrast, the remaining two types of buffer allow the regulator to take into account, among other things, a bank's exposure to its parent or subsidiary and the capital adequacy ratio of that parent or subsidiary when choosing the rates for these buffers.

Under Pillar 1 of Basel II, the same minimum capital requirement of 8% of risk-weighted assets (RWA) was applied to all banks. This can be interpreted in very simplified terms as an effort to anchor the probability of failure of all banks (stemming from the risks covered by

[3] The relevance of these issues to regulatory practice is illustrated in Skořepa and Seidler (2013), which describes the main features of the approach chosen by the CNB for determining the capital buffer rate based on banks' domestic systemic importance. Some qualitative issues complementary to this paper are discussed in Skořepa and Seidler (2014).

Pillar 1) at the same level, specifically at the 0.1% level stipulated as desirable in Basel II. Kuritzkes and Schuermann (2010, p. 125), for example, interpret this probability as the "implied solvency standard of the Basel capital requirements".[4]

This logic also seems to underlie the countercyclical buffer. In the growth phase of the financial cycle, the risks get increasingly underestimated, so that the reported RWA level – i.e. essentially the quantification of a bank's risks – steadily slips below the real level of risks faced by the bank. The true probability that the minimum required capital will not be enough to cover the bank's future losses thus rises above the level required under Basel II. The countercyclical buffer is mentioned directly in Basel III as one of several measures to address "cyclicality of the minimum requirement". Also, the passage in Basel III summarising the motives for this buffer begins by asserting that "losses incurred in the banking sector during a downturn preceded by a period of excess credit growth can be extremely large" (BCBS, 2011, p. 7); "extremely large losses" here can be interpreted as meaning "losses greater than the minimum requirement is capable of covering with the probability required under Basel II". The main aim of the countercyclical capital buffer therefore seems to be to help ensure that the probability of future failure of a bank stays close to the level required under Basel II when the RWA level is underestimated in the growth phase of the financial cycle.

The buffer based on a bank's systemic importance departs from the logic described above (i.e. the anchoring of the probability of failure for all banks at the level required under Basel II). The point of this buffer is to reduce the probability of future failure of a bank below the level required under Basel II. The main recommendation given in the relevant official documents (BCBS, 2012, 2013a) is that the reduction in the probability of failure of a bank by means of this reserve should be commensurate with the bank's systemic importance, i.e. with the costs that the bank's failure would mean for the whole economy. BCBS (2013a) calls this recommendation the "expected impact approach": the buffer rate should be set so as to offset the expected impact of the bank's failure, calculated as the probability of failure multiplied by the macroeconomic costs given failure.

We will assume for simplicity that RWAs are measured correctly, thus ignoring the doubts that have been voiced repeatedly (see references in Annex I of BCBS, 2013b). The arguments set out above imply that our simulations of the intra-group concurrence of capital buffers will relate primarily to the capital buffer based on systemic importance rather than on the conservation buffer or the countercyclical buffer.

The BCBS's official document on D-SIB capital buffers (BCBS, 2012, p. 8) recognises the possibility of imposing one buffer based on systemic importance on the parent and another on the subsidiary within a (cross-border) banking group: "Home authorities should impose HLA [systemic importance-based capital] requirements that they calibrate at the parent and/or consolidated level and host authorities should impose HLA [systemic importance-based capital] requirements that they calibrate at the sub-consolidated/subsidiary level. The home authority should test that the parent bank is adequately capitalised on a stand-alone basis, including cases in which a D-SIB HLA requirement is applied at the subsidiary level." This provision, however, is pitched at a general level. The aim of the simulations in this paper is to examine this issue in more detail. Specifically, we will try to determine what impacts the imposition of a buffer on a group or subsidiary has on the parent's capital and on the

[4] In reality, however, this logic is significantly impaired by various implementation problems (see, for example, Kiema and Jokivuolle, 2013, and Zimper, 2013).

probability of failure of the subsidiary and the group. We will assume throughout that the competent regulators have all the necessary information.

3. Probability of bank failure

In our simulations we will look primarily at how the buffers sizes and selected other factors influence the probability of bank failure, by which we will mean the probability that the loss recorded by a given bank (the whole group or the subsidiary) will equal or exceed *L*, the bank's loss absorption capacity measured as the sum of the bank's capital and loan loss reserves. We thus need, first, to determine the formula for determining this probability.

3.1. Probability of bank failure in the model with a single systematic risk factor

The literature on the probability of bank failure works mostly with a single systematic risk factor model (Vasicek, 2002). We will actually work with a pair of two-factor extentions of the basic single-factor model. Nevertheless, we start by briefly outlining the main features of the single-factor model, including the expression it gives for the probability of failure of a bank. Further details can be found, for example, in Schönbucher, 2000, Vasicek (2002) and Martinez-Miera (2009).

First we introduce the following definitions, conventions and assumptions about the bank, be it the parent, the subsidiary, or the banking group as a whole:

- Let's consider just one time period. The bank provides all its loans at the start of this period; at the end of the period the loans should be repaid.
- The bank's loss is due solely to credit risk. Apart from loans, the bank has no actual or conditional (off-balance sheet) assets.
- The bank's portfolio is composed of a large number *N* of small loans, each provided to a different obligor. The loans (and therefore the obligors) are indexed by *i*.
- The profit A_i of obligor *i* is given by the value of a single systematic factor, *X*, common to all obligors, and the value of the obligor's idiosyncratic shock, ε_i, according to the following formula:[5]

$$A_i = \sqrt{R}.X + \sqrt{1-R}.\varepsilon_i \qquad (1)$$

  Higher values of *X* can be interpreted as a sign that the economy as a whole (i.e. all obligors) is enjoying "better times". For any two obligors *i* and *j*, the square root of *R* captures the dependence of A_i and A_j on the systematic factor, and it can be shown that if (1) holds, *R* is equal to the correlation between A_i and A_j.
- *X* and ε_i follow standard normal distribution (with zero mean and unit variance); *X* and ε_i and ε_j are all mutually independent for all *i* and *j*.[6] These assumptions (and general

[5] This formula can be shown to be consistent with geometric Brownian motion, a standard model for the evolution of asset prices (Vasicek, 2002, Bluhm et al., 2002).

[6] Assuming that A_i has a non-zero expected value would give rise to no change, because in fact the key parameter in the following calculations is not the expected value itself, but rather its distance from the level (c_i) that leads to failure of the obligor. The assumption of normality (and independence between *X* and ε_i and ε_j) is in line with most of the literature. Other probability distributions that would better capture the fat tails observed for actual asset returns are investigated, for example, by Chen et al. (2008). Like relation (2), the Basel II internal ratings-based (IRB) approach is based on a normal one-factor model. As actual asset returns deviate from the normality assumption, Basel II contains some features aimed at offsetting the impact of those deviations. For example, the required probability of bank failure is anchored at the very low level of 0.001. This implies one failure every

properties of the normal distribution) imply that A_i given by (1) has a standard normal distribution too.

- Obligor i defaults if $A_i \leq c_i$ for a certain constant $c_i < 0$; hence

$$PD_i = \text{prob}[A_i \leq c_i]. \quad (2)$$

Equation (1) implies that prob[$A_i \leq c_i$] will be lower for higher X, i.e. in "better times".

- The loss given default LGD_i, R and c_i are constants and each takes the same value for all i.
- The interest and other income accruing to the bank from a loan granted to obligor i is contained in the nominal value of the loan that enters the calculation of the bank's RWA.[7]
- We measure the bank's loss absorption capacity L as a percentage of its RWA. As indicated above, L denotes the sum of capital and expected loan reserves, that is, the portion of the liabilities in the bank's balance sheet intended to absorb unexpected losses and expected losses, respectively. Given that we will assume loan loss reserves to be constant, changes in L will be equivalent to changes in capital.[8]
- The value of RWA is normalised to 1.

To be able to determine a given bank's probability of failure, we will proceed in three steps. In the first step we will assume that the systematic factor X takes specifically the value x and we will determine the implied default rate $D_{X=x}$, that is, the implied share of defaulted loans in the portfolio conditional on $X = x$. The law of large numbers implies that if the number of loans in the portfolio becomes very large, then the proportion of loans that will default approaches $PD_{i,X=x}$, the specific or "conditional" value that PD_i obtains for $X = x$. Given (1) and (2), we thus know that

$$D_{X=x} = PD_{i,X=x} = \text{prob}[\sqrt{R}.x + \sqrt{1-R}.\varepsilon_i \leq c_i] =$$
$$= \text{prob}[\varepsilon_i \leq \frac{c_i - \sqrt{R}.x}{\sqrt{1-R}}] = F[\frac{c_i - \sqrt{R}.x}{\sqrt{1-R}}], \quad (3)$$

where F is the cumulative standard normal distribution function.

In the second step we will determine the value of π, the bank's average profit, taking the average across the whole portfolio. For any single non-defaulted loan the profit is 0, for any single defaulted loan it is $-LGD_i$. Conditional on $X = x$, the average profit is then

$$\pi_{X=x} = D_{X=x}.(-LGD_i) + (1-D_{X=x}).0 = -LGD_i.D_{X=x} = -LGD_i.PD_{i,X=x}. \quad (4)$$

Let's now drop the assumption $X = x$ and face the fact that X may take various values according to its (standard normal) probability distribution. From (4) we know that the unconditional value of average profit, π, is distributed like $-LGD_i.PD_i$. Let's focus specifically on the "bad-news" cases where $\pi \leq -L$ such that the bank fails. The probability of bank failure

thousand years, which in itself would probably be viewed as an excessively strict solvency standard (Thomas and Wang, 2005).

[7] This assumption, implying that the bank's profit will always be non-positive, is made purely for analytical simplicity. The expected positive profit that in reality banks tend to make on their loan portfolios can be viewed as included in the loan loss reserves, that is, as a part of L.

[8] Definition of capital as including also loan loss reserves takes us back to the pre-Basel era. Here we use this definition purely for the sake of simplicity. Separation of loan loss reserves (which are assumed at the same level in all our simulations) from capital would not change our conclusions.

(PBF), that is, of $\pi \leq -L$ can formally be expressed as the value that the cumulative probability distribution function of π obtains at $-L$:

$$PBF = \text{prob}[\pi \leq -L] = \text{prob}[-LGD_i.PD_i \leq -L]. \tag{5}$$

Already above we observed that with X rising the value of PD_i falls. Define as $x(L)$ that specific value of X for which $LGD_i.PD_{i,X=x(L)} = L$; that is, $x(L)$ is that specific state of the economy which, if it occurs, will imply credit losses just sufficient to wipe out all of the bank's capital and loan loss reserves and thus to tip the bank into failure. Then PBF found in (5) can be expressed equivalently as prob[$X \leq x(L)$] which, in turn, can be rewritten as $F[x(L)]$. Using (3), the equation $LGD_i.PD_{i,X=x(L)} = L$ that defines $x(L)$ can be rewritten as

$$LGD_i.F\left[\frac{c_i - \sqrt{R}.x(L)}{\sqrt{1-R}}\right] = L.$$

After some rearrangement this leads to

$$x(L) = \frac{c_i - G(L/LGD_i).\sqrt{1-R}}{\sqrt{R}}, \tag{6}$$

where G is the inverse of F.

In the last step, we plug $x(L)$ from (6) into $PBF = F[x(L)]$, getting the expression for PBF in terms of L (and the constants LGD_i, R and c_i):

$$PBF = F\left[\frac{c_i - G(L/LGD_i).\sqrt{1-R}}{\sqrt{R}}\right]. \tag{7}$$

This probability is, intuitively enough, increasing in LGD_i, c_i (and thus also PD_i) and R, and decreasing in L.

Expression (7) states the probability of bank failure as implied by a model with a single systematic risk factor X. However, for our purposes of calculating PBF of the banking group and of the subsidiary we will actually need two versions of (7) extended for the case of two systematic factors which co-determine, in the sense of equation (3), the default rates relevant for the parent and for the subsidiary, respectively. Determination of these two extensions of (7) is the subject of the following sub-section.

3.2. Probability of bank failure in the model with two systematic risk factors

We will now look at the case of two banks, the parent and the subsidiary, indexed p and s; the whole group will be indexed g. The parent and the subsidiary have separate credit portfolios. If the parent and the subsidiary are based and operate in different countries (different economies and jurisdictions), then evolution of their portfolios is likely to be subject to mutually more or less different macroeconomic and other systematic forces. For this reason, we will need to move from a single systematic factor model to a model containing two systematic factors - one for the parent, another one for the subsidiary. We will capture the potential linkages between the environments in which the two parts of the group operate by assuming that the systematic factor relevant for one portfolio is more or less correlated - positively or negatively - with that relevant for the other portfolio, similar to the two-portfolio model of Céspedes and Martín (2002).

More specifically, and analogously to the single-factor case, assume that obligors of the parent and of the subsidiary are indexed by i and j, respectively, and that the profit A_i of any obligor i and the profit A_j of any obligor j follow these relationships (cf. expression (1)):

$$A_i = \sqrt{R}.X^p + \sqrt{1-R}.\varepsilon_i,$$
$$A_j = \sqrt{R}.X^s + \sqrt{1-R}.\varepsilon_j, \tag{8}$$

where X^p and X^s are the two systematic factors, both following the standard normal distribution, so that $\mu^p = \mu^s = 0$, $\sigma^s = \sigma^s = 1$, and ε_i and ε_j are idiosyncratic factors, again following the normal distribution with zero mean and unitary variance. Continuing the analogy with the single-factor case, (8) implies

$$D^p{}_{X^p=x^p} = \text{prob}[\sqrt{R}.x^p + \sqrt{1-R}.\varepsilon_i \leq c_i] = \text{prob}[\varepsilon_i \leq \frac{c_i - \sqrt{R}.x^p}{\sqrt{1-R}}] = F[\frac{c_i - \sqrt{R}.x^p}{\sqrt{1-R}}], \tag{9}$$

and

$$D^s{}_{X^s=x^s} = \text{prob}[\sqrt{R}.x^s + \sqrt{1-R}.\varepsilon_j \leq c_j] = \text{prob}[\varepsilon_j \leq \frac{c_j - \sqrt{R}.x^s}{\sqrt{1-R}}] = F[\frac{c_j - \sqrt{R}.x^s}{\sqrt{1-R}}]. \tag{10}$$

In what follows, we will assume for simplicity that $c_i = c_j$ and $LGD_i = LGD_j$ for all i and j in both portfolios and that the same equivalence holds also for R.

Now we want to use our knowledge of (9) and (10) to arrive at the probability of observing certain specific "scenarios" in the sense of specific combinations of values of X^p and X^s. Assume that the joint distribution of X^p and X^s is (bivariate) normal so that the probability of a scenario where x^p is in interval A and x^s is in interval B is

$$\text{prob}[x^p \in A, x^s \in B] = \int_{x^s \in B} \int_{x^p \in A} \phi(x^p, x^s).dx^p.dx^s, \tag{11}$$

where ϕ denotes bivariate normal probability density and the conditions below the integrals signal that the double integration should be executed over all those and only those combinations of the values of x^p and x^s for which $x^p \in A$, $x^s \in B$.

Assume we are able to somehow obtain correlation ρ between the two systematic factors, X^p and X^s. To see the intuition, $\rho > 0$ means that the parent's obligors are more likely to face bad times, that is, x^p is more likely to be rather low (and so the default rate in the parent's loan portfolio is more likely to be high) at a time when the subsidiary's obligors face bad times, that is, when x^s is rather low (and so the default rate in the subsidiary's loan portfolio is high), and vice versa. Conversely, $\rho < 0$ means that the parent's portfolio is likely to fare well when the subsidiary's one suffers, and vice versa. The specific value of ρ can be interpreted as a numerical expression of the extent to which the financial results of the parent and the subsidiary are influenced by the same risk factors as a consequence of similarity of their business models (geographical and sectoral specialisation in lending and suchlike).[9]

[9] An evaluation of empirically relevant values of this correlation is beyond the scope of this paper, but we can obtain a rough estimate by looking, for example, at data on the correlation of pre-tax profits. As regards the three largest subsidiaries active in the Czech Republic (Česká spořitelna, ČSOB and Komerční banka), the correlations

Knowing the value of ρ, we can write the formula for general bivariate normal probability density (see, e.g., Kotz et al., 2000, Céspedes and Martín, 2002) as follows:

$$\phi(x^p, x^s) =$$
$$= \frac{1}{2.\pi.\sigma^p.\sigma^s.\sqrt{1-\rho^2}}. \tag{12}$$
$$.\exp\left\{-\frac{1}{2.(1-\rho^2)}\left[\frac{(x^p-\mu^p)^2}{(\sigma^p)^2} - 2.\frac{\rho.(x^p-\mu^p).(x^s-\mu^s)}{\sigma^p\sigma^s} + \frac{(x^s-\mu^s)^2}{(\sigma^s)^2}\right]\right\}.$$

Recalling our earlier assumptions $\mu^p = \mu^s = 0$ and $\sigma^p = \sigma^s = 1$, we can simplify (12) into

$$\begin{aligned}\phi(x^p, x^s) &= \frac{1}{2.\pi.\sqrt{1-\rho^2}}.\exp\left\{-\frac{(x^p)^2 - 2.\rho.x^p.x^s + (x^s)^2}{2.(1-\rho^2)}\right\} \\ &= \frac{1}{\sqrt{2.\pi}}.\exp\left[-\frac{(x^s)^2}{2}\right].\frac{1}{\sqrt{2.\pi}.\sqrt{1-\rho^2}}.\exp\left[-\frac{(x^p-\rho.x^s)^2}{2.(1-\rho^2)}\right] \\ &= \frac{1}{\sqrt{2.\pi}}.\exp\left[-\frac{(x^s)^2}{2}\right].q(x^p|x^s),\end{aligned} \tag{13}$$

where $q(x^p \mid x^s)$, conditional on x^s, is a normal probability density with x^p as the single argument (so q is univariate) and with mean equal to ρx^s and variance equal to $1 - \rho^2$ (so q is not standard).

The expression for $\phi(x^p, x^s)$ that we obtain on the last line of (13) will allow us, in our simulations, to evaluate the probability in (12) numerically by iterated integration:

$$\text{prob}[x^p \in A, x^s \in B] = \int_{x^s \in B} \frac{1}{\sqrt{2.\pi}}.\exp\left[-\frac{(x^s)^2}{2}\right].\left\{\int_{x^p \in A} q(x^p|x^s).dx^p\right\}.dx^s, \tag{14}$$

where, at the first stage, we evaluate the integral in the braces for a given $x^s \in B$, that is, we integrate $q(x^p \mid x^s)$ with respect to x^p such that $x^p \in A$, and then, in the second stage, we integrate the whole function $\phi(x^p, x^s)$ with respect to x^s where $x^s \in B$. We will use this approach for two separate purposes: first to determine the probability of bank failure for the subsidiary and then to determine the probability of bank failure for the group. These two purposes differ in the contents of sets A and B.

The simple probability of bank failure for the subsidiary is given directly by the PBF formula in (7). But we are interested in the *support* probability of bank failure for the subsidiary, that is, in the probability that the subsidiary fails even though the parent is willing to save the subsidiary. Naturally, the parent will actually provide support to the subsidiary only if such a rescue does not imply failure for the parent itself - and this is the condition that makes the support probability of bank failure for the subsidiary, or PBF^s, sensitive to the correlation ρ between the fortunes of the subsidiary and of the parent. As will become clear shortly, another

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of the quarterly pre-tax profits of these subsidiaries and their parents over the last decade range approximately between -0.25 and +0.4 (according to data from the Bankscope database and the banks' websites).

relevant parameter will be the size of the subsidiary relative to the parent, r, expressed as a percentage of RWA^p.

PBF^s is equal to the probability of all scenarios in which X^s and X^p take a combination of values (x^s, x^p) such that the following two conditions are both met:
(I) x^s is so low that it implies $D^s \geq L^s/LGD_i$, that is, without support, the subsidiary fails;
(II) x^p is so high that it implies $D^p < [L^p - r.(D^s.LGD_i - L^s)]/LGD_i$, that is, assuming that the parent covers the subsidiary's financing gap ($D^s.LGD_i - L^s$), scaled by r, what will remain of the L^p (the sum of the parent's capital and loan loss reserves) is still more than what the parent needs to cover its own total losses.

Using (9), condition II (and thus the set A of relevant values of x^p) can, for a given level of D^s implied by a given x^s, be expressed as

$$x^p > \frac{c_i - \sqrt{1-R}.G\{[L^p - r.(D^s.LGD_i - L^s)]/LGD_i\}}{\sqrt{R}}.$$

Now we are ready to flesh out the first stage of iterative evaluation of (11). For a given x^s,

$$\begin{aligned} \int_{x^p \in A} q(x^p | x^s).dx^p &= \int_{x^p > \frac{c_i - \sqrt{1-R}.G\{[L^p - r.(D^s.LGD_i - L^s)]/LGD_i\}}{\sqrt{R}}} q(x^p | x^s).dx^p \\ &= 1 - \int_{x^p \leq \frac{c_i - \sqrt{1-R}.G\{[L^p - r.(D^s.LGD_i - L^s)]/LGD_i\}}{\sqrt{R}}} q(x^p | x^s).dx^p \\ &= 1 - Q(\frac{c_i - \sqrt{1-R}.G\{[L^p - r.(D^s.LGD_i - L^s)]/LGD_i\}}{\sqrt{R}} | x^s), \end{aligned} \quad (15)$$

where Q is the cumulative distribution function corresponding to q. Using (10), condition I (and thus the set B of relevant values of x^s) can be expressed as

$$x^s \leq \frac{c_i - \sqrt{1-R}.G(L^s / LGD_i)}{\sqrt{R}}.$$

Denoting as $V(x^s)$ the value of the integral in (15) for a given x^s, PBF^s can then be found as

$$\int_{-\infty}^{\frac{c_i - \sqrt{1-R}.G(L^s / LGD_i)}{\sqrt{R}}} \frac{1}{\sqrt{2.\pi}}.\exp\left[-\frac{(x^s)^2}{2}\right].V(x^s).dx^s.$$

Turning now to the probability of bank failure for the group, PBF^g is equal to the probability of all scenarios in which X^s and X^p take a combination of values (x^s, x^p) which implies failure of the group, that is, $D^g \geq L^g/LGD_i$, where D^g is the default rate for the group. This group-wide default rate is equal to a weighted average of default rates of the two parts of the group (parent and subsidiary), the weights being the shares of the two parts in the group's RWA:

$$D^g \equiv \frac{r}{1+r}D^s + \frac{1}{1+r}D^p. \quad (16)$$

We will calculate PBF^g again through iterated integration along the lines of (14). This time, however, the set A will, for a given value of X^s, consist of all values of X^p such that the implied D^s and D^p produce in (16) a value of D^g in the interval $\langle L^g/LGD_i, 1\rangle$, while set B consist of all "relevant" values of X^s, that is, all values for which there is at least one value of X^p that will lead to D^g lying in the interval $\langle L^g/LGD_i, 1\rangle$. At one extreme, if D^g is to be higher than $1/(1+r)$, then the parent's portfolio is not, by itself, able to deliver this result even if it were to experience the worst times possible (x^s infinitely low and the implied value of D^p equal to 1); as a result, the subsidiary's portfolio must experience bad enough times (low enough x^s) such that it covers the gap left after D^p reaches its maximum of 1. At the other extreme, if D^g is to be lower than $r/(1+r)$, the subsidiary's portfolio must not experience the worst possible times (infinitely low x^s and the implied value of D^s equal to 1) since that would keep D^g above $r/(1+r)$ even after D^p reaches its minimum of 0.

4. Simulation results

The two capital buffer rates we study, B^g and B^s, will be expressed as a percentage of the risk-weighted assets of the bank, i.e. of RWA^g and RWA^s respectively. The parent's share in the subsidiary, w, expressed as a percentage of RWA^s will also influence some of the results. We will assume that compared to the size of the group, direct intra-group accounting exposures are negligible, so that RWA^g can be calculated simply as $RWA^p + RWA^s$. We abstract from qualitative differences between different types of capital, and in the case of total capital we will assume the properties of common shares. In all cases we will assume that the changes in the size or structure of balance sheets resulting from the imposition of capital buffers are so small, or are realised in such a way, that w, r and RWA are constant for all three entities. The loan loss reserves actually held are equal to the expected loan losses.

We will start by examining the consequences of imposing buffers from the perspective of the necessary increase in capital (through subscription or retention of earnings). We will then move to the issue of the consequences of imposing buffers from the perspective of banks' probability of failure.

4.1 Impact of buffers on the necessary increase in capital

We first need to clarify how the loss absorbing capacity of the group, L^g, is derived from that of the parent and of the subsidiary, L^p and L^s. The consolidation principle implies that when determining L^g we need to completely exclude the portion of L^s held by the parent. The remaining portion of L^s held by the minority shareholders is not controlled by the group. It should therefore be recognised in L^g only to the extent to which it can be relied upon to meet the group's loss absorption obligation by covering any losses incurred by the subsidiary or the parent.

This idea is expressed in Basel III (BCBS, 2011, paragraphs 62–64) by a capital consolidation rule which says that the group's consolidated capital should be calculated recognising the lower of the following two items:
(a) the portion of the subsidiary's obligatory capital (including B_s) held by the minority shareholders, and
(b) the sum that we obtain if, within the group's obligatory capital (including B_g) which relates to the subsidiary, we focus on the portion that is attributable to the subsidiary's minority shareholders.
It is trivial to show that in our simple case (a) will be lower than (b) when $B^s < B^g$.

We will assume from here on that the total loss absorbing capacity of the group L^g is exactly equal to B^g plus the minimum requirement applied to the group (where, as stated earlier, this requirement is taken to mean the sum of the actual Basel II minimum capital requirement of 8% and the requirement to hold reserves equal to expected loan losses); in other words, at the group level there is no “surplus” capital. For now let us also assume B^g = 0% and B^s = 0%. The above-mentioned consolidation rule implies that L^g must be replenished through an increase in L^p above the minimum requirement applying to the parent alone.

For example, let’s assume that the minimum requirement (including the requirement to hold reserves equal to expected loan losses) is 9% and that the parent owns 50% of the subsidiary, which is 10% of the size of the parent, so that $RWA^g = 1.1*RWA^p$ and the requirement applying to the group of 9% of RWA^g corresponds to 9.9% of RWA^p. The subsidiary’s minority shareholders – in an effort to retain their 50% share in the subsidiary – have already satisfied half of the requirement applying to the subsidiary (either by providing new capital or by using their share of the subsidiary’s retained earnings), thereby contributing sum equal to 4.5% of RWA^s, i.e. 0.45% of RWA^p, to L^g; the parent’s shareholders have already satisfied the requirement applying to the parent, thereby contributing sum equal to 9% of RWA^p to L^g (likewise in the form of new capital or retained earnings of the parent); to make up the remaining portion of L^g of 0.45% of RWA^p, the parent’s shareholders must increase L^p (above the minimum requirement applying to the parent alone) by this 0.45% of RWA^p; the minority shareholders cannot make up this remaining portion of L^g because even if they decided to provide the subsidiary with some capital beyond the requirement on the subsidiary, the above consolidation rule implies that this added capital could not be counted towards L^g. It is clear that if we increase w, i.e. the parent’s share in the subsidiary, the capital increase burden will shift further towards the parent.[10]

Let us now allow B^g and B^s to take non-zero values. Chart 1 shows, for B^g = 1% and for various levels of B^s, w and r, by what amount (in % of RWA^p) L^p must be increased above the level the parent has to attain in order for the group to satisfy the requirement on L^g when both buffers are zero.

The results in the chart are intuitive. For w = 100% (a wholly owned subsidiary) the above-mentioned burden falls fully on the parent in all cases; this burden decreases somewhat as the share of minority shareholders in the subsidiary increases (as w declines). The relative position of the curves corresponding to B^s = 0% and B^s = 3% for each level of r (the size of the subsidiary relative to the parent) suggests that imposing B^s will lead to growth in the volume of the subsidiary’s obligatory capital held by its minority shareholders, thereby relieving the parent of part of the burden of satisfying the requirements applying to the group.

Let us now look at the specific example where the parent’s share in the subsidiary is 60% (i.e. w = 60%), the size of the subsidiary is 5% of that of the parent (r = 5%) and the buffer required for the group is B^g = 1%. The imposition of B^s = 3% will result in an increase in the subsidiary’s capital held by minority shareholders (assuming that their percentage share in the subsidiary stays constant). The capital of the group will increase by the same amount, and thanks to this the parent’s loss capital held in the interests of fulfilling B^g can be reduced by the same amount. Chart 1 shows that the capital held at parent level in the interests of satisfying B^g can be lowered specifically from 1.05% of RWA^p to around 1.03%, i.e. by approximately 0.02 percentage point. If RWA^p is at, say, EUR 200 billion, that would mean a decrease of EUR 40 million in the parent’s capital held in order to satisfy the L^g requirement. Another (this time extreme) example would be a wholly owned subsidiary (w = 100%), in which case imposing B^s does not lead to any change in L^p.

[10] We should emphasise that this burden cannot be lifted by converting the subsidiary into a branch. This change will have no effect on RWA^g and so will not reduce the amount of capital of the parent maintained in the interests of satisfying the requirement applying to the group.

An important consequence of the above effect for regulatory practice is that the imposition of a buffer on the subsidiary does not change the probability of depletion of capital at the group level (and therefore the desirable capital buffer rate for the group). This is because the increase in L^g when the buffer is imposed on the subsidiary (if the buffer leads to a rise in the capital usable for the group at all) is exactly offset by a decrease in L^g through a reduction in the parent's capital.

Chart 1: Increase (in % of RWA^p) in the parent's capital as a result of imposing B^s

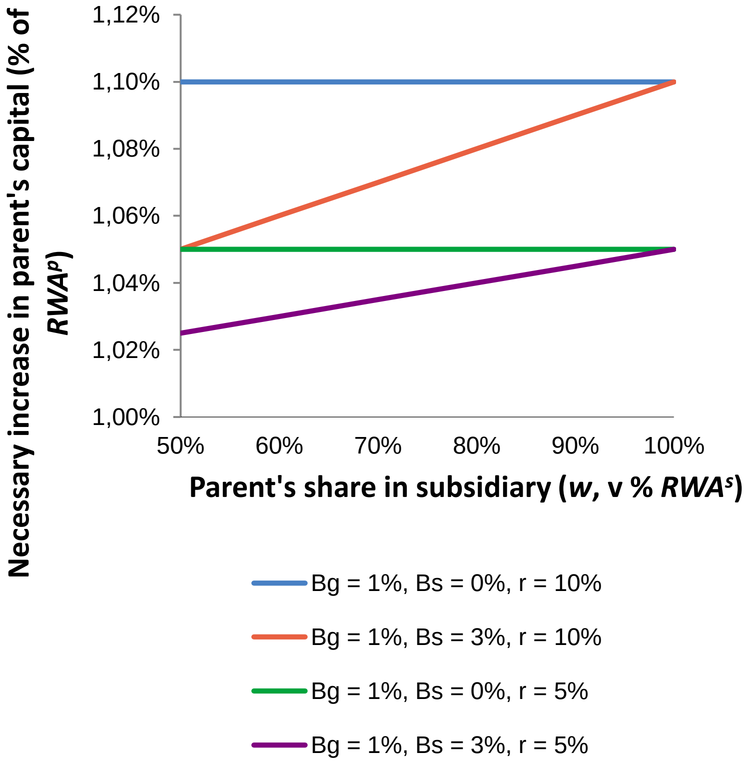
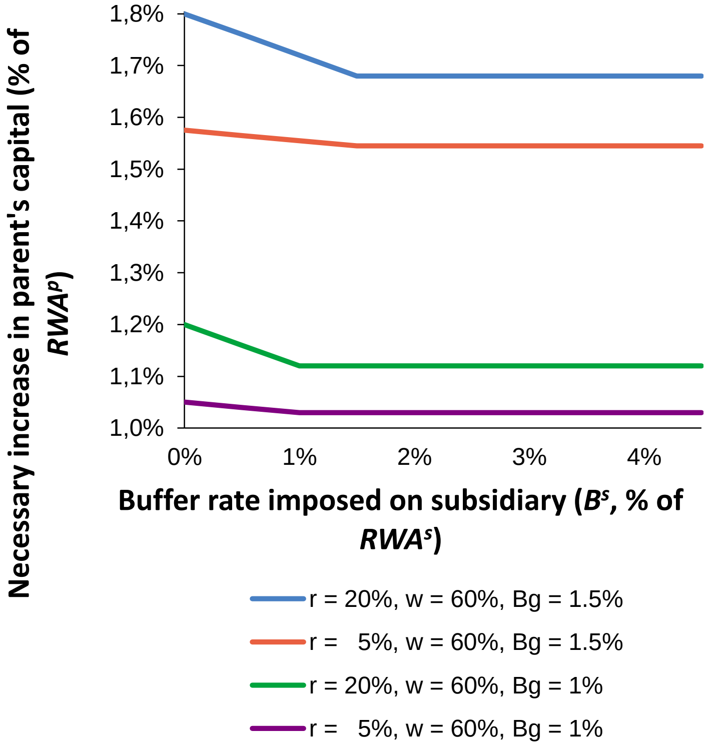


Chart 2 assumes that the parent's share in the subsidiary, *w*, is 60% and that the relative size of the subsidiary, *r*, is either 5% or 20%, and illustrates how the necessary level of L^p changes as we change the two buffer rates. With rising B^s, each of the curves in Chart 2 initially declines; a higher B^s therefore reduces the amount of capital of the parent needed to ensure that the group satisfies B^g. However, beyond the kink at $B^s = B^g$ each curve is horizontal, meaning that a further increase in B^s will not generate any further decrease in the necessary level of capital of the parent. This is because under the consolidation rule described above, growth in B^s above B^g leads a switch from (a) to (b).

Chart 2: Increase (in % of RWA^p) in the parent's capital as a result of imposing B^g



4.2 Impact of capital buffers on a bank's probability of failure[11]

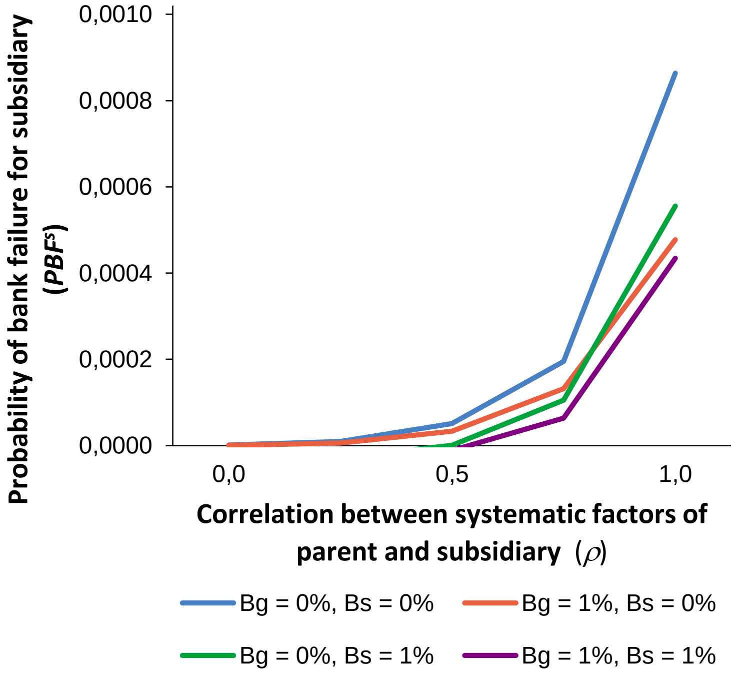
In order to be able to at least roughly estimate the probability of bank failure (2) for various combinations of the two capital reserve buffer rates, we make some further assumptions. For L^g, L^p and L^s we will initially assume a level of 9%, which we obtain as the sum of an expected loan loss of 1% (roughly in line with the long-term average given in Moody's, 2011) and the Basel II minimum capital requirement of 8%. In order to focus on one of the many possible and realistic combinations of values, we will assume that *r* (the relative size of the subsidiary) equals 5% and *w* (the parent's share in the subsidiary) equals 60%. We will also assume for simplicity that if the subsidiary is at risk of failure as a result of incurring a loss exceeding L^s, the parent will either cover the necessary difference fully (even though it is not the sole owner of the subsidiary, because $w < 100\%$), or – if such assistance would cause it to fail itself – provide no assistance and let the subsidiary fail. As for the opposite situation, in our model the subsidiary is not capable of helping to cover the parent's loss and therefore cannot be forced to do so by the parent, because any reduction in L^s (for example through a share repurchase) will automatically lead to an equal reduction in the value of the parent's investment in the subsidiary. In other words, a drowning parent has no mechanisms available by which it would increase its chances of survival at the expense of its subsidiary.[12]

[11] Given the various differences in the way Basel II and III are applied in practice (Kiema and Jokivuolle, 2013; Zimper, 2013), the bank failure probabilities given below should be taken as lower estimates of the true values.

[12] The subsidiary is therefore not capable of reducing the parent's loss by "transferring" part of its assets to the parent and reducing its capital to the corresponding extent. "Bottom-up" or "upstream" intra-group support from the subsidiary to the parent can also take other forms (European Commission, 2008; The Joint Forum, 2012). For example, the subsidiary can supply the parent with liquidity in the form of a loan. This transaction, if executed "at arm's length", does not in itself cause the subsidiary to incur an immediate loss in the form of a reduction in assets and capital, it merely changes the asset structure of the subsidiary; however, it can cause intra-group contagion in the sense, for example, of a weakening of the subsidiary's credit activity (Derviz and Podpiera, 2006; de Haas and van Lelyveld, 2014) or a reduction in the subsidiary's ability to overcome any future liquidity

Chart 3 plots PBF^s for selected non-negative levels of ρ and for two levels of B^g and B^s (0% and 1%). For any combination of these two levels of B^g and B^s it holds that PBF^s is increasing in ρ, because with higher ρ it is more likely that the subsidiary will face failure just when the parent also faces failure and is thus incapable of bailing out the subsidiary. If, for any value of ρ, we move from B^g = 0% to B^g = 1%, PBF^s will fall, because a rise in B^g means higher capital of the parent (i.e. higher L^p) and thus a higher probability that the parent will be capable of helping the subsidiary to avoid failure. This effect, however, becomes negligible for ρ close to 0 (and for cases where $\rho < 0$, which are not shown in the chart). The effect is similar if, instead of B^g, we increase B^s from 0% to 1%.

Chart 3: Probability of failure of the subsidiary

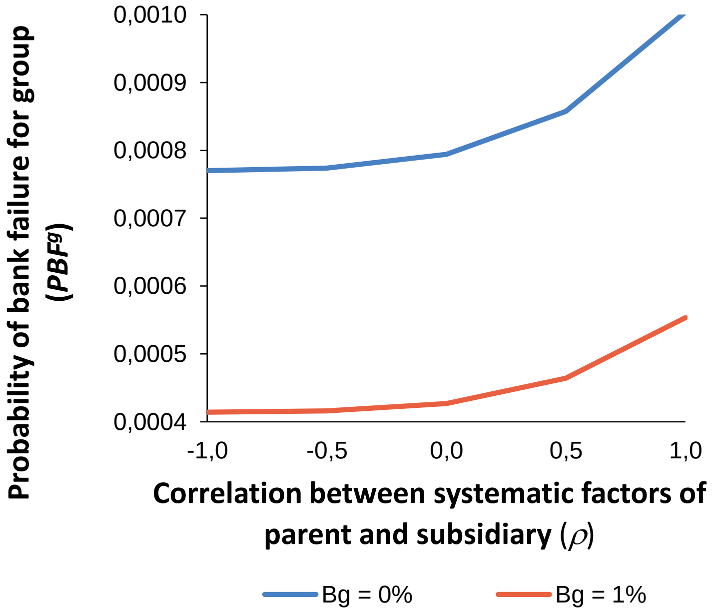


Values of PBF^g are depicted in Chart 4.[13] As could have been expected, PBF^g is increasing in ρ, i.e. in the similarity of the business models of the two group members. In the extreme case of the two business models being identical (ρ = 1), the group gains no diversification benefits and has the same risk properties as the parent and subsidiary separately. Specifically in the case of a zero buffer for the group and ρ = 1, PBF^g takes a value of 0.001, which – in line with the basic philosophy of Basel II – corresponds to a *PBF* of a stand-alone bank with L = 9% of RWA. The imposition of B^g = 1% with ρ = 1 reduces PBF^g to 0.00055, which is only slightly more than half of the level with no buffer. If instead we choose ρ = 0, the imposition of B^g = 1% reduces PBF^g from 0.00079 to 0.00043.

problems of its own. The subsidiary will of course record a direct loss in the future if the parent proves unable to repay the loan provided by the subsidiary.

[13] The chart ignores changes in B^s, because the Basel III rules for calculating consolidated capital described above imply that PBF^g does not react to B^s (we assume here that the amount of group capital to which these rules lead is the truly relevant amount of capital for determining PBF^g).

Chart 4: Probability of failure of the banking group as a whole



5. Summary and conclusions

In this paper we investigated selected consequences of the imposition of capital buffers on a banking group and/or a subsidiary in such a group. This is a highly relevant topic for all macroprudential and microprudential policy-makers who regulate a banking sector containing parents or subsidiaries of banking groups. First, we explained that of the three types of capital buffers introduced in Basel III, only the buffer based on systemic importance is targeted directly at reducing the probability of bank failure (below the Basel II standard).

Second, by way of example we investigated the situation where only the Basel II minimum capital requirement is imposed on the group, i.e. no capital buffers are imposed on the group or the subsidiary. We demonstrated that given the Basel III group capital calculation rules the group is in this case capable of satisfying the minimum capital requirement imposed on it only if the parent's shareholders increase the parent's capital above the level it would have to report if it were a stand-alone bank. Of course, a side-effect of this increase is a decrease in the parent's probability of failure (below the Basel II standard).

Third, if we assume the imposition of a buffer on the group, the capital increase burden falling on the parent's shareholders shifts partially to the subsidiary's minority shareholders when a buffer is announced for the subsidiary as well. This is because the buffer for the subsidiary forces the minority shareholders to increase the amount of the subsidiary's capital they hold (as long as they want to keep their percentage share in the subsidiary constant), and thanks to that the amount of capital the parent's shareholders have to hold in order to satisfy the group requirement falls. Given the Basel III rules for calculating the consolidated capital of the group, however, this shift of the capital increase burden stops increasing in size when the buffer rate for the subsidiary exceeds the buffer rate for the group.

The probability of failure of the group (and therefore the desirable buffer rate for the group) is not affected by the level of the buffer for the subsidiary, because the increase in capital usable at group level due to the imposition of the buffer on the subsidiary (if such an increase occurs at all) is exactly offset by a decrease in the group's capital as a result of a reduction in the parent's capital held in order to satisfy the group requirement.

Fourth, if the parent is prepared to help the subsidiary avert failure, the probability of failure of the subsidiary turns out to be similarly sensitive to the buffer rate for the subsidiary as to the buffer rate for the group. This finding speaks tentatively in favour of keeping the power to set capital requirements for subsidiaries at national level. This is because if the group's home regulator does not impose impose a group buffer that would be sufficient from the point of view of the subsidiary's required degree of resilience, she – unlike the subsidiary's host regulator – may not be sufficiently motivated to ensure that an adequate buffer is announced for the subsidiary.

This finding also casts doubt on the rationale for the CRD IV requirement that the buffer imposed on a subsidiary on the basis of its systemic importance should not exceed the buffer imposed on the group as a whole.

The results described above are based on a number of simplifying assumptions. Consequently, there are many ways in which future research might make our analyses more realistic and our conclusions more robust. For example, one could change the assumption that the probability distribution of obligors' asset yields is normal. Another option would be to examine a banking group with more than one subsidiary or with a parent that hesitates to provide support to a subsidiary in distress.

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Univerzita Karlova v Praze, Fakulta sociálních věd
Institut ekonomických studií [UK FSV – IES] Praha 1, Opletalova 26
E-mail : ies@fsv.cuni.cz http://ies.fsv.cuni.cz