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Target Capital Ratio and Optimal Channel(s) of Adjustment: A Simple Model with Empirical Applications to European Banks

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Yann BRAOUEZEC*

Abstract

Why do banks decide to reach their target capital ratio by selling assets and/or issuing new shares when each channel of adjustment is costly ? We offer a simple framework to answer this question in which the aim of the bank is to minimize the total adjustment cost subject to the target's constraint and we derive its optimal strategy. We then compare our model's predictions to the decisions taken by two systemic banks to issue new shares in 2017 and for which the target ratio was publicly disclosed. Predictions are consistent with the observed decisions. Smaller banks are also considered.

Keywords: Equity issuance, asset sale, price impact, target capital ratio, large banks.

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1 Introduction

In 2011, the Basel Committee on Banking Supervision[1] (BCBS) published a document known as Basel 3, designed not only to strengthen the global capital framework (i.e., by introducing a capital surcharge for GSIBs, a counter cyclical buffer, a leverage ratio) but also to introduce a global liquidity standard (two liquidity ratios). The BCBS makes a distinction between two types of capital, Tier 1 capital (going-concern capital), which is the sum of Common Equity Tier 1 (CET1) and additional Tier 1 (AT1) and Tier 2 (gone-concern capital). Each financial institution (a bank or a banking group) in a jurisdiction subject to Basel 3 is assumed to maintain *at all times* their risk-based capital ratios above a critical spread. As in Basel 1 and 2, the total capital (or equity) defined as Tier 1 plus Tier 2 must be at least 8% of risk-weighted assets, the denominator of the risk-based capital ratio, but Tier 1 must be at least 6% of risk-weighted assets (RWA) while Common Equity Tier 1 ratio must be at least 4.5%.

Most large banks actually maintain their risk-based capital ratios higher than the minimum required[2] ([Berger et al., 2008, Memmel and Raupach, 2010]), and this suggests the existence of a *target capital ratio*. While this seems reminiscent to the literature on optimal capital structure that begun with the seminal paper of Modigliani-Miller, banks should deserve a special treatment[3] because, contrary to most corporations (except insurance companies), they can increase their risk-based capital ratio by reshuffling their RWA ([Cohen and Scatigna, 2016, Kok and Schepens, 2013]). In practice, this can be done by selling a portion of the bank's risky assets, with positive risk weights, and by investing the proceeds in safe ones such as cash, with no risk weights. Everything else equal, the RWA decreases so that the risk-based capital ratio increases. For systemic banks, everything else is indeed not equal because when they sell a large amount of assets, this may negatively impact the price of the assets and thus the capital of the bank. If reshuffling the risk-weighted assets is considered as too costly, the bank can also increase its capital ratio by issuing new shares. The (optimal) choice of the channel(s) of adjustment obviously depends upon the costs of each channel and the analysis of this optimal choice but also its empirical implications is the subject of this paper.

We offer a simple theoretical model in which a systemic bank seeks to increase in the short term its risk-based capital ratio by considering the two main channels of adjustment, equity issuance

[1] In December 2017, the BCBS published a document entitled Basel 3 Finalising post-crisis reforms.

[2] It suffices to look at their annual reports.

[3] In [DeAngelo and Stulz, 2015], the authors argue that banks are special corporations because their central function is to produce liquidity (just as MMF) and this explains why high leverage is optimal. See also [Miller, 1995].

and/or replacement of risky assets by safe ones when each solution is costly.

- Issuing new stocks for instance via an underwritten rights offering is costly as there are direct costs (e.g., underwriter compensation, registration and listing fees...) and indirect costs (e.g., stock price reaction to the offering announcement), see [Eckbo et al., 2007] for a comprehensive review and discussion.

- Replacing risky assets by safe ones is also costly as it contributes to decrease the expected future profit of the bank but may also decrease the market price of the risky assets due to the existence of a price impact for a systemic bank (labeled G-SIB or G-SII). As is well-known, e.g., [French et al., 2010, Shleifer and Vishny, 2011], asset sales in large amount may trigger fire sales–asset sales in cascade–that can further depress the price and so on and so forth[4].

To reach its target capital ratio, we make the assumption that the bank chooses the channel of adjustment (possibly a mix) that minimizes the overall cost of adjustment. Depending upon the parameters, it may thus be more cost-efficient for the bank to only issue new shares, to only sell the risky assets, or both and we derive the optimal strategy of the bank. To facilitate the confrontation with observed decisions, we formulate the optimal strategy in terms of two critical spreads, where the spread is defined as usual as the total issuance cost divided by the gross proceeds. We show that when the observed spread is lower than the lowest critical spread c_1, it is optimal for the bank to issue new shares only. On the other hand, when the observed spread is higher than the highest critical spread c_2, it is optimal to sell risky assets only. In between, it is optimal to both issue new stocks and sell a portion of the risky assets.

Within our framework, most parameters such as the various measures of capital, the risk-weighted assets, the value of the assets or the value of cash etc...are easy to estimate using public data contained in the annual reports banks. As remarked in [De Jonghe and Öztekin, 2015], the bank's target capital ratio, a critical parameter in our framework, remains in general unobserved and could even evolve over time. In the first quarter of 2017, two European Global Systemically Important Institutions (G-SIIs), Deutsche Bank and UniCredit decided to issue new shares via an underwritten rights offering and it turns out that they *publicly disclosed* their target capital ratio, expressed in terms of the CET1 capital ratio fully loaded. Equipped with this information, all the

[4]See [Braouezec and Wagalath, 2017] for an equilibrium analysis in a game theoretic model. It is shown that fire sales generate a game with strategic complementarities which may have more than one Nash equilibrium.

parameters of our model can be calibrated and one can now compare its theoretical predictions in terms of optimal channel(s) of adjustment with the observed ones. In both cases, the observed decisions are consistent with our theoretical predictions; given the estimation of the parameters, the observed cost is lower than the lowest critical spread so that it is optimal for the bank to issue new shares only and this is exactly what they did. It is important to note that we do not offer in this paper a theory that would explain the choice of the flotation method among the existing ones.

We also consider the smallest (non-systemic) banks listed on the website of the European Banking Authority (EBA) for which the exposure measure is between €200 billion and €250 billion. Assuming, as in [Altınkılıç and Hansen, 2000], that the spread paid is a U-shaped function of the gross proceeds, we show that our bank-by-bank result might explain the empirical finding of [De Jonghe and Öztekin, 2015], namely that it is optimal for small banks to sell their risky assets rather than to issue new shares.

This paper departs from the literature on bank's target capital ratio and/or bank's channels of adjustments, [Berger et al., 2008], [De Jonghe and Öztekin, 2015],[Kok and Schepens, 2013], [Memmel and Raupach, 2010] in several respects.

First, we consider a theoretical model that we calibrate for *each* bank using public data and we compare the observed decision with its predictions, i.e., we do not test a given statistical model.

Second, as opposed to e.g., [Berger et al., 2008], [De Jonghe and Öztekin, 2015], [Shimizu, 2015], we do not consider a partial adjustment model in which it may take several years for the bank, everything else equal, to reach the target capital ratio because the speed of adjustment is lower than one. For instance, in [De Jonghe and Öztekin, 2015] or in [Memmel and Raupach, 2010], they find a speed of adjustment[5] which is approximately equal to 30%. Within our framework, we consider a two-period model, say date 0 and date 1, and we assume that the target should be reached at time 1, that is, we make the implicit assumption that the speed of adjustment is equal to one. Since we consider a short period of time (few months), we exclude the possibility to increase retained earnings to reach the target.

Third, we also depart from the structural credit models literature, initiated by [Merton, 1974] and [Black and Cox, 1976] for the case of non financial corporations (and later on applied to banks in [Hugonnier and Morellec, 2017, Peura and Keppo, 2006]) in which the value of the assets is as-

[5] See also [Flannery and Rangan, 2006] for an early partial adjustment empirical model but in which financial firms are excluded.

sumed to follow a continuous-time stochastic process, possibly with jumps. This approach is perfectly sound when one considers the evolution of the market price of a *given* risky asset such as a stock. However, at a *consolidated level*, diversification effects *and* risk-management play a major role so that one can assume that the value of the consolidated assets is fairly stable over a short period of time. This assumption is (implicitly) made by supervisors when they perform the regulatory stress-tests in USA or in Europe (see e.g., [Braouezec and Wagalath, 2018, Flannery et al., 2017])). Otherwise, it would make no real sense to perform a stress test that takes several months. Following the recent literature on the subject, [Greenwood et al., 2015], [Cont and Schaanning, 2016], [Duarte and Eisenbach, 2015], we make the assumption that the various quantities of the balance sheet are stable over time.

From a technical point of view, within our framework , the choice of the channel(s) of adjustment is formulated as an optimization problem. In general, the optimization problem is non-linear and we provide necessary and sufficient conditions for the existence and uniqueness of a solution. In the particular case in which there is no price impact, it reduces to a linear-programming problem for which it is never optimal to mix the channel of adjustment. It is either optimal for the bank to issue new stocks or to sell the riskier assets but not both.

The rest of this paper is organized as follows. In the second section, we present and discuss the assumptions of our theoretical framework before stating the theoretical results. In section three, we present in detail the way we calibrate the parameters of the model and discuss the capital increase done by two European systemic banks in the first quarter of 2017. In section four, we briefly consider the case where the spread is a U-shaped function of the gross proceeds. The last section of the paper is devoted to a brief conclusion.

2 A simple model of systemic banking

We offer here a simple model for which the parameters are fairly easy to calibrate using public data. We consider the case of a systemic universal bank which is subject to the (evolving) Basel regulation and that holds three types of assets that differ by their riskiness and their liquidity.

1. A safe asset, cash, which is the value of the bank account of the bank at the central bank. Cash is not risky and is thus not subject to capital requirement.

2. A risky traded asset such a stock, an ETF, a bond, (possibly a derivative) for which some

capital is required because it is both subject to market risk and counterparty risk.

3. A set of non-traded loans for which capital is required because they are subject to credit risk.

Banks hold loans in their banking book for a non-negligible fraction (at least 30% of the total value of the assets) and also hold liquid traded assets in their trading book (stocks, bonds, ETF, derivatives). Due to the well-known adverse selection problem (e.g., [Diamond and Rajan, 2011]) loans are illiquid assets and thus are fairly difficult to resell in the short-term. Since we are interested to understand the conditions under which a bank optimally will issue new shares only, considering a model with more than one risky asset only contributes to complicate the analysis without new financial insights. For the sake of simplicity, we thus focus on the simplest model in which there is a unique risky traded asset subject to capital requirements. Of course, the bank can also invest in a risk-free asset which is thus not subject to capital requirement. In section 3 devoted to the empirical applications, we shall relax this assumption and we will explicitly consider the case of two risky assets, a liquid one and an illiquid one. We shall show that as long as the resale value of this illiquid asset is sufficiently small, nothing is fundamentally changed.

2.1 Bank's balance sheet and target capital ratio

Let $v > 0$ be the value of cash at time $t = 0$ and let P and q denote respectively the price (or the Mark-to-Market more generally) and the quantity of the risky asset held by the bank at date $t = 0$. The value of the risky asset at time $t = 0$ thus is equal to qP so that the total value of assets is equal to $A = v + qP$. On the liability side, let D be the sum of deposits and total face value of bonds that have been issued by the bank. Let E denotes the capital of the bank at time $t = 0$. From limited liability of shareholders, the value of total equity at date $t = 0$ is equal to $E = \max\{A - D; 0\} = \max\{v + qP - D; 0\}$ and we shall assume that this total capital is positive at time $t = 0$, that is

$$E = v + qP - D > 0 \tag{1}$$

The following balance-sheet represents the situation of the bank at time $t = 0$.

Balance sheet at time $t = 0$

Assets	Liabilities and Equity
Cash: v	Debt: D
Risky asset: qP	Equity : E
$A = v + qP$	$E + D$

Since there is only one risky asset, the risk-weighted asset (RWA) can thus be expressed as a percentage of the value of the risky asset qP (i.e., the trading book). As cash is considered as risk-free by regulators, its weight is equal to zero and thus is not subject to any capital requirement. The risk-weighted assets thus is equal to

$$\text{RWA} = \alpha qP \tag{2}$$

where $\alpha < 1$ is the *risk-weight* associated to the risky asset. Since all the quantities involved, i.e., cash, the value of the risky assets and the risk-weighted assets are disclosed in the annual report of banks, α is easy to calibrate and is equal to

$$\alpha = \frac{\text{RWA}}{qP} \tag{3}$$

Let

$$\theta = \frac{E}{\text{RWA}} = \frac{v + qP - D}{\alpha qP} \tag{4}$$

be the regulatory capital ratio of the bank at time $t = 0$ and let respectively θ_{min} and $\theta^* < \infty$ be the minimum capital ratio and the target capital ratio. For the sake of interest, we shall assume that

$$\theta_{min} < \theta < \theta^* \tag{5}$$

that is, the current capital ratio is lower than the target capital ratio but is higher than the minimum required.

2.2 Equity issuance versus asset sale: what are the costs?

There are essentially two channels of adjustment that can be used by a bank to increase its risk-based capital ratio in the short term ([Cohen and Scatigna, 2016]). It can issue new equity with a gross proceeds equal to $I > 0$ or it can reduce its risk-weighted assets (RWA) by selling a portion $s \in [0, q]$ of the risky asset (with positive weights) and then investing the proceeds in cash (with no weight). Of course, the bank can also mix the channels, i.e., it can issue new shares (i.e, choose $I > 0$) *and* sell a portion of the risky asset (i.e, choose $s > 0$).

Consider first the possibility to issue new shares. While there are several flotation methods, i.e., various to issue such new shares (see e.g., [Eckbo et al., 2007] for a comprehensive review), we only mention the three following ones.

- *Firm commitment*, in which the set of underwriter(s) contractually commit to buy the new shares at a fixed price.

- *Standby rights*, in which existing shareholders are offered the right but not the obligation to buy the new shares at a discount and the set of underwriters are committed to buy the unexercised new shares.

- *Direct public offering*, in which the issuer sells directly the equity without any underwriters.

The issuance cost obviously depends on the choice of the flotation method. The cheapest one is clearly the direct public offering because the issuer has no guarantee to receive the desired gross proceeds while the most expensive one is the firm commitment.

In [Eckbo et al., 2007], they make a distinction between direct costs (e.g., underwriter(s) fees, registration and listing fees) and indirect costs (e.g., stock price reaction to the offering announcement, cost of offering delay/cancellations...). It is also common (e.g., [Altınkılıç and Hansen, 2000]) to split the total direct cost of issuance into two types of costs; a fixed cost, related to various administrative costs (registration and listing fees) and a variable cost, related to the underwriter(s) compensation that critically depends upon the underwriting agreement and the gross proceeds. Since P denotes the asset price, we shall denote I the gross proceeds (I for investment) chosen by the bank. Following [Altınkılıç and Hansen, 2000], [Décamps et al., 2011] and [Gomes, 2001] among others, the total issuance cost function is assumed to be piece-wise linear:

$$\text{Cost of equity issuance} = K\mathbf{1}_{I>0} + cI \tag{6}$$

where $\mathbf{1}_{I>0} = 1$ if $I > 0$ (i.e., the bank issues new stocks) and $\mathbf{1}_{I>0} = 0$ if $I = 0$, K is the fixed (issuance) cost and $c \in (0, 1)$ is the (constant marginal) issuance cost. This means that when the bank decides to issue new equity for a gross proceeds equal to I, it has to pay K and cI, which means that the net amount of cash received by the bank, called the net proceeds, is equal to $(1-c)I - K$. For the net proceeds to be positive, I must be high enough. Dilution might also be an issue but as we shall see in the empirical application, the right issue is precisely designed to avoid dilution for those shareholders who choose to exercise their rights.

It is usual (e.g., [Altınkılıç and Hansen, 2000]) to define the *spread* as the average cost of issuance per euro, i.e., it suffices to divide the rhs of equation (6) by the gross proceeds $I > 0$.

$$\text{Spread} = \frac{K}{I} + c \quad I > 0 \tag{7}$$

For systemic banks, as we shall see, the gross proceeds I is in billion while the fixed cost K is in (hundreds) thousands so that $\frac{K}{I}$ is negligible. We thus make the assumption that $\frac{K}{I} = 0$ so that c is the unique cost of issuance. It is actually well-known that the important source of issuance cost is the variable cost (e.g., [Altınkılıç and Hansen, 2000], [Calomiris and Tsoutsoura, 2010]).

Consider now the costs associated with replacing (i.e., selling) riskier assets with safe ones (cash or government securities) in order to decrease the risk-weighted assets. Let $s \in [0, q]$ be the quantity of the risky asset sold by the bank and $V(s)$ be the proceeds of the asset sale placed on the bank account of the bank (cash). Since the risk-weighted assets $\mathrm{RWA}(s) = \alpha P(q - s)$ is a decreasing function of s, everything else equal, the risk-based capital ratio of the bank will increase. For systemic banks, everything else is however not equal. Due to the existence of the price impact, the price of the risky asset will decrease with the quantity sold s and this will decrease the value of the assets and thus the total capital of the bank. Moreover, selling a portion of the risky asset will also reduce the (future) expected profit.

Price impact. For a large bank, called G-SIB or G-SII in Europe, selling an important volume of assets in a short period of time may generate a positive price impact. Following the seminal paper of [Greenwood et al., 2015], see [Duarte and Eisenbach, 2015], we consider the simplest case of a linear price impact. When the bank sells a quantity $s \leq q$ of the risky asset, the sale proceeds $V(s)$ is not equal to sP but is lower due to the existence of a positive price impact. For a given price P at time $t = 0$, the price at time $t = 1$ thus is equal to

$$P\left(1 - \frac{s}{\Phi}\right) \tag{8}$$

where $\Phi < \infty$ is called the market depth. The lower (higher) the market depth, the more (less) important the price impact. With a linear price impact given by equation (8), the proceeds $V(s)$ is equal to $sP(1 - \frac{s}{\Phi})$ and we shall make the realistic assumption that $V(s)$ increases with the quantity sold $s \in [0, q]$, i.e., $\frac{2q}{\Phi} < 1$. The cost due to the price impact of the bank is naturally measured as the difference between the proceeds without price impact and the proceeds with a positive price impact. This cost thus is equal to $sP(\frac{s}{\Phi})$ and increases with the quantity sold s. But this is not the only cost.

Reduction of the expected profit. Even without price impact, there is a cost associated to selling the risky asset, related to the fact that the expected profit will decrease with s. Assume that the expected profit is equal $\mathbb{E}\Pi(q) = \gamma q P$ (for some $\gamma < 1$ and some expectation operator $\mathbb{E}$) when the bank holds a quantity q of the risky asset, that is, the expected profit is a percentage of the total value of the position in the risky asset. When the bank resells a positive quantity s, it now holds a quantity $q-s$ and the resulting expected profit is equal to $\mathbb{E}\Pi(q-s) = \gamma P(q-s) = \mathbb{E}\Pi(q) - \gamma Ps$. Compared with the initial situation in which the bank held a quantity q, when it sells a quantity $s \leq q$, the reduction of its expected profit thus is equal to γsP, which constitutes the second opportunity cost of selling a portion of the risky asset. In the limiting case in which $s = q$, the bank only holds cash and the expected profit thus is equal to zero[6]. Overall, the cost of selling the risky asset is the cost related to the price impact plus the reduction of the expected profit.

$$\text{Cost of selling the risky asset} = sP\left(\gamma + \frac{s}{\Phi}\right) \tag{9}$$

We make the natural assumption that the aim of the bank is to choose the channel(s) of adjustment in order minimize the sum of the adjustment costs given by equation (6) plus equation (9).

2.3 The bank's optimization problem

For a given choice of channel(s) of adjustment $(s, I) \in [0, q] \times \mathbb{R}^+$, the bank's balance-sheet at date $t = 1$ is given as follows:

Balance sheet at time $t = 1$

Assets	Liabilities and Equity
Cash: $v + sP(1 - \frac{s}{\Phi}) + (1-c)I$	D
Risky asset: $(q-s)P(1 - \frac{s}{\Phi})$	$E(s, I)$
$A(s, I) = v + qP(1 - \frac{s}{\Phi}) + (1-c)I$	$E(s, I) + D$

and note that the total capital at time $t = 1$, $E(s, I) = \max\{A(s, I) - D; 0\}$, depends on (s, I) while the risk-weighted assets $\text{RWA}(s)$ depends only on s. Formally, the bank's optimization problem is

[6] In Europe, the profit would actually be negative since the rate of the deposit facility administered by the ECB is negative, equal to -0.4%. The rate of the deposit facility is the interest which is applied by the ECB when a given bank leaves its excess reserves on its bank account at the ECB.

as follows.

$$\min_{(s,I)\in[0,q]\times\mathbb{R}_+} C(s,I) = sP\left(\gamma + \frac{s}{\Phi}\right) + cI \tag{10}$$

s/c

$$\theta(s,I) := \frac{E(s,I)}{\text{RWA}(s)} = \frac{v - D + qP\left(1-\frac{s}{\Phi}\right) + (1-c)I}{\alpha(q-s)P(1-\frac{s}{\Phi})} = \theta^* \tag{11}$$

$$q - s \geq 0 \tag{12}$$

$$s \geq 0, I \geq 0 \tag{13}$$

Let $(s^*, I^*) \in [0,q] \times \mathbb{R}^+$ the optimal solution when it exists. When there is no price impact, since the total value of the assets as well as the total equity are *invariant* with respect to $s \in [0,q]$, a solution always exists in s (i.e., with $I = 0$) for each $\theta^* \in \mathbb{R}^+$. When the price impact is positive, the total value of the assets as well as the total capital of the bank are now *decreasing* functions of $s \in [0,q]$. As a result, a solution of the optimization problem in s only (i.e., with $I = 0$) may not always exist; reaching the target capital ratio may thus require from the bank to use the two channels of adjustment, i.e., asset sale and/or new issues.

Let $E(q,0) = v - D + qP(1 - \frac{q}{\Phi})$ be the total capital at time $t = 1$ when the bank sells 100% of its risky asset and do not issue new shares. It is easy to show that

$$E(q,0) > 0 \Longleftrightarrow \frac{q}{\Phi} < \frac{v + qP - D}{qP} \tag{14}$$

The condition $\frac{q}{\Phi} < \frac{v+qP-D}{qP}$ is also easy to check in practice since $\frac{v+qP-D}{qP}$ is just the ratio of the total capital at time $t = 0$ divided by the value of the risky asset at time $t = 0$. Let

$$\underline{\Phi} = \frac{q^2 P}{v + qP - D} \tag{15}$$

and note that $\Phi > \underline{\Phi}$ is equivalent to $E(q,0) > 0$.

Proposition 1 *(Existence of corner solutions)*

- *Assume that $s = 0$. If $c < 1$, then, for any $\theta^* \in \mathbb{R}^+$, there exists $\overline{I}(\theta^*)$ such that $(0, \overline{I}(\theta^*))$ is the unique solution of the optimization problem.*
- *Assume that $I = 0$. If $\Phi > \underline{\Phi}$, then, for any $\theta^* \in \mathbb{R}^+$, there exists $\overline{s}(\theta^*)$ such that $(\overline{s}(\theta^*), 0)$ is the unique solution of the optimization problem.*

Proof. See the appendix.

The above proposition shows that under rather mild assumptions, the bank is able to reach its target capital ratio by issuing new shares only or by selling a portion of the risky asset only. When $\Phi > \underline{\Phi}$ (equivalently, when $E(q,0) > 0$), as shown in proposition 1, there always exists a solution to the optimization problem in s (with $I = 0$) but the risk-based capital ratio $\theta(s,0)$ needs not be an increasing function of s for each $s \in [0,q]$. For $\theta'_s(s,0) > 0$ for each s, the market depth must be high enough. We show in appendix the existence of a smallest market depth $\overline{\Phi}$ (with $\overline{\Phi} > \underline{\Phi}$) such that, when $\Phi > \overline{\Phi}$, the risk-based capital ratio $\theta(s,0)$ is an increasing function of s for each $s \in (0,q)$. In lemma A 3, we show that an upper bound for $\overline{\Phi}$ is $q\left(1+\frac{qP}{E(0,q)}\right)$, and it is easy to check that $\underline{\Phi}$ is lower than $q\left(1+\frac{qP}{E(0,q)}\right)$. On the contrary, when $\Phi \in (\underline{\Phi}, \overline{\Phi})$, as shown in Fig. 1, the risk-based capital ratio is not a monotonic function of s and this somehow "pathological" behavior (due to the fact that $\theta'_s(s,0)$ is a quadratic equation in s) can complicate the analysis of the optimization problem. One way to avoid this problem consists in assuming that $\Phi > \overline{\Phi}$. We shall make a weaker assumption, which is satisfied for banks under consideration in the empirical analysis. We allow Φ to be in $(\underline{\Phi}, \overline{\Phi})$ but we shall assume that, for a given target θ^*,

$$\overline{s}(\theta^*) < \widetilde{s}_1 \tag{16}$$

where $\widetilde{s}_1$ is the smallest s such that $\theta'_s(\widetilde{s}_1,0) = 0$, see Fig. 1. When this assumption does not hold, from Fig. 1, it can be seen that $\overline{s}(\theta^*)$ is not a continuous function of θ^* in a neighborhood of θ_{max}; for all positive ϵ, when $\theta^* \leq \theta_{max}$, $\overline{s}(\theta^*) \leq \widetilde{s}_1$ while when $\theta^* > \theta_{max}$, $\overline{s}(\theta^*) > s_{max}$. In such a case, the analysis of the optimization problem is more difficult since it can be shown that the iso-target function (see the discussion below) is not continuous. When condition (16) is satisfied, such a discontinuity does not occur and the optimization problem can easily be solved since all the functions involved are continuous and differentiable.

Consider now Fig.2 and let us the call iso-target curve the subset of points defined as follows

$$\Theta^* = \{(s,I) \in [0,\overline{s}(\theta^*)] \times [0,\overline{I}(\theta^*)] : \theta(s,I) = \theta^*\} \tag{17}$$

From proposition 1, when $s = 0$, the target can be reached by choosing $\overline{I}(\theta^*)$ while when $I = 0$, the target can be reached by choosing $\overline{s}(\theta^*)$. As both s and I can be positive, Θ^* provides the set of choices of s and I such that the target is reached. As one may expect, the marginal rate of substitution between the gross proceeds and the quantity of risky asset sold is negative. Starting from a given point $(s,I) \in \Theta^*$, if the bank decides to slightly increase the quantity sold from s to $s+\delta s$, it can thus decrease the gross proceeds from I to $I-\delta I$ for some positive δI. The optimal

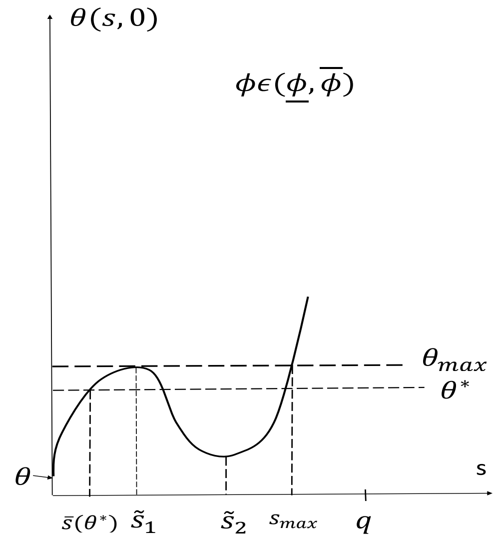

Figure 1: The risk-based capital is not an increasing function of s

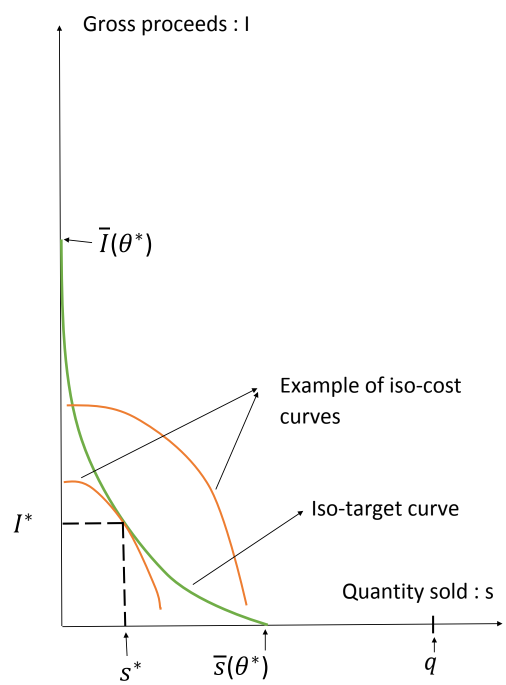

Figure 2: Optimal solution: $s^* > 0$ and $I^* > 0$

choice $(s^*, I^*) \in \Theta^*$ obviously depends upon the cost associated to each channel of adjustment. In appendix, we show that the iso-target curve (i.e., the constraint) is a decreasing and strictly convex function of s while an iso-cost curve is a decreasing and strictly concave function of s. The optimization problem thus is "well-behaved" in that when it is optimal to mix the channel of adjustment, this solution is found by using a classical tangency condition, see Fig. 2. Depending upon the parameters of the model $\alpha, \gamma, c, \theta^*$, with $\frac{1}{\Phi} > 0$, the optimal solution belongs to one (and only one) type of the three types of solutions below.

$$\underbrace{s^* = 0 \text{ and } I^* > 0}_{\text{Issue only}} \quad \text{or} \quad \underbrace{s^* > 0 \text{ and } I^* > 0}_{\text{Mix}} \quad \text{or} \quad \underbrace{s^* > 0 \text{ and } I^* = 0}_{\text{Sell only}} \tag{18}$$

On Fig. 2, the unique solution of the optimization is a "mix", that is, $s^* > 0$ and $I^* > 0$ which can be found using a classical tangency condition.

2.4 Optimal channel(s) of adjustment

We shall formulate the solution of the optimization problem in terms of *critical spreads*. For pedagogical purpose, we first present the case without price impact. In such a case, the optimization program (10) subject to the constraints given by equations (11), (12) and (13) actually reduces to a *linear programming problem* so that the optimal strategy is a "corner solution", i.e., of the form $(0, I^*)$ or $(s^*, 0)$, it is never optimal to mix the channel of adjustment.

Proposition 2 *Assume that* $\frac{1}{\Phi} = 0$ *(i.e., no price impact) and let*

$$\widetilde{c} = \frac{\gamma}{\gamma + \alpha\theta^*} \tag{19}$$

be a critical spread. The optimal channel of adjustment is as follows.

- *When* $c < \widetilde{c}$*, the bank will issue equity only.*
- *When* $c > \widetilde{c}$*, the bank will sell the risky asset only.*

Proof. See the appendix.

From the above proposition, when γ tends to zero, the cost of selling the risky asset also tends to zero since there is no price impact. As a result, the critical spread $\widetilde{c}$ tends to zero and it becomes highly likely that selling the risky asset will constitute the optimal channel of adjustment. From equation (19), when α tends to zero, the critical spread tends to one so that it becomes optimal to issue new equity only. This property comes from the fact that $\frac{\partial s^*}{\partial \alpha} > 0$, that is, the optimal quantity of the risky asset to sell is an increasing function of α. Since s^* is negative when α is small enough, there exists $\overline{\alpha} > 0$ such that $s^* = 0$ for each α lower than $\overline{\alpha}$ since s^* must be non-negative (because of the non-negativity constraints, see equation 13). From an empirical point of view, this property suggests that banks with a low α are more likely, everything else equal, to issue new equity when there is no price impact. In the same vein, when the target θ^* decreases (increases), everything else equal, banks are more (less) likely to issue new shares since the critical spread increases (decreases) and tends to one.

Proposition 3 *Assume that $\frac{1}{\Phi} > 0$ and that condition (16) is satisfied. Let $(\widetilde{c}_l, \widetilde{c}_h)$ be a couple of critical spreads, where*

$$\widetilde{c}_l = \frac{\gamma}{\gamma + \alpha\theta^* - \frac{q}{\Phi}(1 - \alpha\theta^*)} \tag{20}$$

with $\widetilde{c}_l < \widetilde{c}_h$. The optimal channel(s) of adjustment is (are) as follows.

- *When $c < \widetilde{c}_l$, the bank will issue equity only.*
- *When $c \in (\widetilde{c}_l, \widetilde{c}_h)$, the bank will both issue new equity and sell a portion of the risky asset.*
- *When $c > \widetilde{c}_h$, the bank will sell the risky asset only.*

Proof. See the appendix.

Note that since the critical spread $\widetilde{c}_h$ is not used in the rest of this paper, we only prove its existence and uniqueness in the appendix but we do not explicitly compute it. It is easy to see that as long as there is a positive price impact, the following inequality is true.

$$\widetilde{c}_l > \widetilde{c} \tag{21}$$

Compared to the no-price impact case, it is now costlier to make use of the asset sale channel. As a result, everything else equal, the bank will more likely issue new shares, which is captured by the fact that the critical spread increases, i.e., $\widetilde{c}_l$ is higher than $\widetilde{c}$. Without price impact, i.e., $\frac{1}{\Phi} = 0$, the two critical spread coincide. Note that the critical spread $\widetilde{c}_l$ depends upon the various parameters. As in the no price impact case, the following properties are true.

$$\frac{\partial \widetilde{c}_l(\alpha, \theta^*, \gamma)}{\partial \alpha} < 0 \qquad \frac{\partial \widetilde{c}_l(\alpha, \theta^*, \gamma)}{\partial \theta^*} < 0 \qquad \frac{\partial \widetilde{c}_l(\alpha, \theta^*, \gamma)}{\partial \gamma} > 0 \tag{22}$$

As already discussed, when α (or θ^*) increases, the critical spread decreases and this decreases the likelihood that the bank will issue new shares. On the contrary, when γ increases, this increases the critical spread $\widetilde{c}_l$ since the asset sale solution is now costlier.

3 Empirical applications to two European systemic banks

In 2017, two European G-SIIs, the German Deutsche Bank and the Italian bank UniCredit, decided to issue new shares via an underwritten rights offering (standby rights). In such a right offer[7], existing shareholders are given the right but not the obligation during the subscription period (typically a couple of weeks) to buy new the shares on a pro rata basis and a at pre-specified price (the subscription price) which is below the current market price. Moreover, the set of underwriter(s) have committed (in general under some conditions) to acquire all the new shares that would remained unsubscribed. Since these capital increase decisions have been taken in 2016, for the sake of interest, we shall apply the predictions of our model as if we were on December, 31, 2016 and we consider the following question: can we rationally explain the decision of Deutsche Bank and UniCredit to issue new stocks in the first quarter of 2017 ?

3.1 The case of Deusche Bank

We shall explain in detail the methodology followed to calibrate the various parameters for the case of Deusche Bank. All the information regarding the capital increase 2017 can be found on the website of Deutsche Bank (https://www.db.com/ir/en/capital-increase-2017.htm). Since the methodology is similar for UniCredit, we will be more brief.

Basic facts. In the beginning of April 2017, Deutsche Bank successfuly issued 687.5 million new shares stocks for a total value of €8 billion. In a Media Release as of 5 March, 2017, Deutsche Bank announced a target Common Equity Tier 1 ratio, i.e., CET 1 divided by the risk-weighted assets (RWA), equal to 14.1%. The subscription period of the rights offer was from March 21, 2017 to April, 6, 2017, and the subscription price was €11.65 per new share (with no par value) while the market price was around €15 during this period, that is, the discount was approximately equal to 25%. Moreover, each new share carried the same dividend rights as all other outstanding shares of Deutsche Bank. The capital increase has been underwritten by thirty banks but Credit Suisse, Barclays, Goldman Sachs, BNP Paribas, Commerzbank, HSBC, Morgan Stanley and UniCredit are the main underwriters as each of them committed to subscribe from 6.09% to 8.28% of the new shares underwritten. The number of shares increased from 1.3793 billion to 2.066 billion and Deutsche Bank reports (in the media release as of 7, April, 2017) that 98.9% of the subscription

[7]See for instance the comprehensive review of [Eckbo et al., 2007], see also [Holderness and Pontiff, 2016] for a recent overview of rights offerings in USA.

rights were exercised. According to Deutsche Bank (see the media release as of 7 April 2017).

> *Had the capital increase been completed on 31 December 2016, Deutsche Bank's Common Equity Tier 1 (CET1) ratio on that date would have been 14.1% on a pro forma CRD4 fully loaded basis rather than 11.8%.*

It is explicitly stated in the prospectus (see p. 113) that existing shareholders that exercise their subscription rights will continue to see their percentage share in the share capital of the Company nearly unchanged. However, for those who decided not to exercised their rights, their percentage ownership in the company's share and their voting rights will be diluted by 33%.

Estimation of the parameters. We need to estimate all the parameters of the model, that is, v, qP, $\frac{q}{\Phi}$, α, c, γ and θ^*.

From the interim report as of June 2017 (page 32), it is reported that the gross proceeds amount to €8 billion while the net proceeds amount to €7.9 billion. As a result, since the cost of issuance is equal to the difference between the gross proceeds and the net proceeds, i.e., it is equal to €0.1 billion[8], so that

$$c = \frac{0.1}{8} \approx 1.25\% \tag{23}$$

From the annual report as of December 2016 (see the balance sheet), the total value of the assets, A, is equal to €1591 billion while the value of the cash, v, is equal to €181 billion. As a result, the value of the risky asset $qP = A - v$ is equal to €1410 billion. From the liabilities side, since total equity is equal to €64.81 billion, it thus follows that $D = 1591 - 64.81 =$ €1526.2 billion. The balance sheet of Deutsche Bank at the end of December 2016 with only the two items of interest is provided below.

Deutsche Bank's Balance sheet as of December 2016 (in billion)

Assets	Liabilities and Equity
Cash: $v = 181$	Debt: $D = 1526.2$
Risky asset: $qP = 1410$	Equity : $E = 64.81$
$A = 1591$	$E + D = 1591$

[8]In the prospectus, it is explicitly stated that the maximal amount that Deutsche Bank will pay is €141 million. Due to the success of the right offer, this amount has been less than €141 million.

Since the risk-weighted assets (fully loaded) is equal to €357.5 billion, it thus follows from equation (3) that

$$\alpha = \frac{357.5}{1410} \approx 25.3\% \tag{24}$$

To apply proposition 3, we need an estimation $\frac{q}{\Phi}$. In [Greenwood et al., 2015], see also the related paper of [Duarte and Eisenbach, 2015] they make the assumption that $\frac{1}{\Phi}$ is of the order of 10^{-13}. Given equation (8), this means that selling for 10 billion (i.e., $s = 10^{10}$) of the risky asset leads to a price change of 10 bps (i.e., $\frac{s}{\Phi} = 10^{-3} = 0.1\%$). In this paper, since proposition 3 explicitly depends on $\frac{q}{\Phi}$, we shall proxy this quantity $\frac{q}{\Phi}$ by the total exposure of Deutsche Bank denoted V_{DB} divided by the sum of total exposure denoted V_{Sum}, that is $\frac{V_{DB}}{V_{Sum}}$. The ratio $\frac{V_{DB}}{V_{Sum}}$ is used by supervisors to compute the score of banks considered as G-SIBs (such as Deutsche Bank) for the size indicator. The greater the ratio $\frac{V_{DB}}{V_{Sum}}$, everything else equal, the higher the loss absorbency requirements (capital surcharge) for the bank. The total exposure of Deutsche Bank V_{DB} is available in the annual report but can also be found on the website of the European Banking Authority (EBA) while the sum of the total exposure V_{Sum} can be found on the website of the Bank for International Settlements (BIS). As of December 2016, V_{Sum}= €75900 billion[9] while V_{DB}=€1363 billion[10]. It thus follows that

$$\frac{q}{\Phi} = \frac{qP}{\Phi P} \approx \frac{V_{DB}}{V_{Sum}} = \frac{1363}{75900} = 1.8\% \tag{25}$$

The parameter γ is by definition equal to $\frac{\mathbb{E}\Pi(q)}{qP}$ and is more delicate to estimate as it depends upon the expected future profits. In 2015 and in 2016, (in part) due to litigation costs, Deutsche Bank made a *loss* equal respectively to €6.7 billion and to €1.35 billion. If we estimate statistically γ using years 2015 and 2016 only, γ will be negative and this might not correctly reflect the future expected profits. Moreover, since the capital increase has been successful, i.e., 98.9% of the rights were exercised, the new shares have been bought (by existing shareholders) in the expectation of positive future profit. We thus discard the years 2015 ad 2016 and we estimate γ using the average of the years 2012, 2013 and 2014, that is, we consider the net income attributable to shareholders divided by the value of the risky assets (i.e., total assets minus cash). The three values found are equal to 0.013%, 0.04%, 0.098% respectively so that

$$\gamma \approx 0.05\% \tag{26}$$

[9]https://www.bis.org/bcbs/gsib/denominators.htm

[10]http://www.eba.europa.eu/documents/10180/1922794/Deutsche+Bank+-+2016.pdf/169f26cb-283a-4519-849e-dec3dff067ad and note that one considers the date of the reporting date, December 2016.

Note that if one estimates this parameter γ by using years 2009 to 2016, i.e., including the two years where the bank makes losses, the prediction of our model remains unchanged.

From the annual report as of December 2016, p. 257, Common Equity Tier 1 (fully loaded) is equal to €42.28 billion, Additional Tier 1 is equal to €4.7 billion and Tier 2 is equal to €12.67 billion. The total capital *fully loaded* is equal to €59.6 billion and is thus lower than the €64.81 billion reported in the balance sheet because of few regulatory deductions. It thus follows that the Common Equity Tier 1 ratio is equal to $\frac{42.28}{357.5} \approx 11.8\%$ and the total capital ratio is equal to $\frac{59.6}{357.5} \approx 16.6\%$. If one adds the €8 billion of new shares to Common equity Tier 1, we obtain a Common Equity Tier 1 ratio equal to 14.1%, as predicted by Deutsche Bank in the media release as of 7 April 2017. Since the target θ^* is expressed in our model as Tier 1 plus Tier 2 divided by the risk-weighted assets, we now have to compute θ^* from the target CET 1 (fully loaded) announced by Deutsche Bank. From the target ratio CET 1 (fully loaded) equal to 14.1%, the target capital ratio θ^* thus is equal to

$$\theta^* = 14.1\% + \left(\frac{4.7 + 12.67}{357.5}\right) \approx 18.9\% \tag{27}$$

To sum-up, the value of the parameters are given below.

$$c = 1.25\%, \alpha = 25.3\%, \;\; \gamma = 0.05\%, \;\; \frac{q}{\Phi} = 1.8\%, \;\; \theta^* = 18.9\% \tag{28}$$

Before computing the critical spread, let us check whether or not the condition given by equation (14) is satisfied. Since $v + qP - D = 59.6$, $qP = 1410$, it thus follows that $\frac{59.6}{1410} \approx 4.2\% > \frac{q}{\Phi} = 1.8\%$ so that the condition thus is satisfied[11]

We are now in a position to compute the critical spread provided by the rhs of equation (20). By inserting the numerical values found in equation (28), we find that a critical spread equal to

$$\widetilde{c}_l = \frac{0.05\%}{0.05\% + 25.3\% \times 18.9\% - 1.8\%(1 - 25.3\% \times 18.9\%)} \approx 1.6\% \tag{29}$$

Since $c = 1.25\%$, it thus follows that $c < \widetilde{c}_l$ so that our model correctly predicts the decision of Deutsche Bank to issue new shares only. Note interestingly that without price impact, the critical spread is equal to 1.03% and it is thus optimal to (only) sell assets. For Deutsche bank, the price impact thus seems an important factor to consider in the decision.

A balance sheet with liquid and illiquid assets. With two risky assets, a liquid and a illiquid one, the balance sheet of Deutsche bank is now as follows.

[11] The condition (16) is also satisfied.

Deutsche Bank's Balance sheet as of December 2016 (in billion)

Assets	Liabilities and Equity
Cash: $v = 181$	Debt: $D = 1526.2$
Liquid assets: $qP = 1001$	Equity : $E = 64.81$
Illiquid assets : 409	
$A = 1591$	$E + D = 1591$

The illiquid assets, subject to credit risk, are loans accounted at fair value but it is important to note that this fair value is *not* equal to their resale value. As is well-known, due to the adverse selection problem, loans are difficult to resell in the short term even with a discount. The liquid assets, mainly subject to market risk and counterparty risk, include the financial assets through profit or loss (€743.8 billion), the financial assets available for sale (€56.22 billion) and various heterogeneous assets. In such a type of risky assets framework, to imply the weight of each risky asset, one must consider the RWA related to the risk of the asset and not the (total) RWA.

The RWA for each risk is disclosed in the annual report of each bank. The RWA for credit risk is equal to €220.3 billion, the RWA for counterparty risk is equal to €9.5 billion, the RWA for market risk for €33.8 billion and the RWA for operational risk for €92.6 billion. Of course, it remains unclear whether the operational risk should be related to the banking book (illiquid assets) or to the trading book (liquid assets). To imply the weight α of the liquid asset, we shall thus consider the two polar cases. One in which this operational risk is 100% related to the banking and the other one in which it is 100% related to the trading book. As a result, we obtain a lower and an upper bound for α.

- Assume that operational risk is 100% related to the banking book. As a result, for the numerator, we only consider the RWA for market risk and counterparty risk. The minimum value of α thus is equal to $\underline{\alpha} = \frac{33.8+9.5}{1001} = 4.3\%$.

- Assume now that operational risk is 100% related to the trading book. As a result, we now add the RWA for operational risk. The maximum value of α thus is equal to $\overline{\alpha} = \frac{33.8+9.5+92.6}{1001} = 13.5\%$.

One can thus conclude that $\alpha \in [4.3\%, 13.5\%]$ so that it is always lower than 25.3%. From equation (22), we know that when α decreases, everything else equal, this increases the likelihood that the bank will issue new shares. As a result, abstracting the illiquid asset, it is still optimal to issue new shares and not to sell the liquid assets. Assuming now that the operational risk is 100% related to the trading book, the (implied) weight of the illiquid asset is equal to $\underline{\nu} = \frac{220.3}{409} \approx 54\%$, which means that it might be optimal to sell these illiquid assets rather than to issue new shares. However, if one assumes that the resale value of the loans is small enough, it won't be optimal to resell them. In such a case, the optimal liquidation strategy is equivalent to the one postulated in [Cifuentes et al., 2005]; the bank should first sell the liquid assets, and, if needed, the illiquid asset. For the case of Deutsche Bank, if it had to sell assets, liquidating a fraction of the liquid asset would be enough to reach the target. As a result, the illiquid asset plays no role, and we are back to the one risky asset model.

3.2 The case of Uni credit

On March 2, 2017, UniCredit[12] completed its capital increase for an overall amount of €13 billion and it is stated in a media release that their aim is bring their fully loaded CET 1 capital ratio above 12.9% at the end of December 2019. The subscription period of the rights issue was (in Italy) from February, 6, 2017 to February, 23, 2017 and the subscription price was equal to €8.09 while the market price was around €12.5 during this period. From the public (interim) report as of June 2017 p. 32, the cost of the capital increase is equal to €0.33 billion, the difference between the gross proceeds, equal to €13 billion and the net proceeds equal to €12.67 billion[13], so that $c = \frac{0.33}{13} = 2.53\%$. From page 42 of the annual report as of December 2016, the risk-weighted assets is equal to €387.15 billion, CET 1 is equal to €31.53 billion, Tier 1 is equal to €35 billion and the total capital, that includes Tier 2, is equal to €45.15 billion. The CET 1 capital ratio thus is equal to 8.15% while the total capital ratio is equal to 11.66%. Since the total value of the assets as of 2016 is equal to €859.5 billion while the cash is equal to €13.5 billion., the balance sheet is as follows.

[12] All the information regarding the capital increase 2017 can be found on the web site of UniCredit, see https://www.unicreditgroup.eu/en/governance/capital-strengthening.html

[13] In a securities note as of February, 2017, the total amount of expenses have been estimated up to about €500 million, "including consulting expenses, out-of pocket expenses and underwriting fees calculated at the highest level". The real cost thus has been lower, equal to €330 million.

UniCredit's Balance sheet (December 2016)

Assets	Liabilities and Equity
Cash: $v = 13.5$	Debt: $D = 814.35$
Risky asset: $qP = 846$	Equity : $E = 45.15$
$A = 859.5$	$E + D = 859.5$

The implied weight is equal to $\alpha = \frac{387.15}{846} = 45.7\%$ and note that it is almost two times the one of Deutsche Bank. Using years 2014 and 2015 yields $\gamma \approx 0.21\%$. From the website of the EBA, the total exposure is equal to €974.4 billion, so that $\frac{q}{\Phi} \approx \frac{974.4}{75900} = 1.3\%$. If one ads €13 billion to CET1, the CET 1 capital ratio is equal to 11.5% (and remains lower than the target of 12.9%, the target in 2019), then the risk-based capital ratio is equal to 15%, i.e., $\theta^* = 15\%$. By inserting the numerical values found in equation (28), we find that a critical spread equal to

$$\widetilde{c}_l = \frac{0.21\%}{0.21\% + (45.7\% \times 15\%) - 1.28\%(1 - (45.7\% \times 15\%))} \approx 3.57\% \tag{30}$$

Since $c = 2.53\%$, it thus follows that $c < \widetilde{c}_l$ so that our model correctly predicts the decision of Uni Credit to issue new shares only. Note finally that, as for the case of Deutsche Bank, there were no dilution for existing shareholders who decided to "fully subscribe the Offering to the extent to which they are entitled", see the document called the securities note as of February, 2017 (see p 89).

4 The spread as a U-shaped function of the gross proceeds

Up to now, we made the assumption that the spread is equal to $\frac{K}{I} + c$, where c is a constant, which means that the spread is a decreasing function of the gross proceeds I. However, in their paper, [Altınkılıç and Hansen, 2000] argue that, from the underwriting theories, the issuer's spread should be a U-shaped function. It should first decrease with I because of a fixed cost effect (i.e., because $\frac{K}{I}$ is decreasing with I) and should then increase due to a rising placement cost effect (i.e., finding more buyers become more difficult and thus riskier for the underlying set of underwriters). They find empirical results that are consistent with a family of U-shaped (spectrum theory). More recently, in [De Jonghe and Öztekin, 2015], the authors find empirically that, to reach a target capital ratio, smaller banks tend to sell assets while large banks tend to issue new stocks. They note that this is a good news for financial stability as smaller banks have by definition a total value of their assets (much) lower than systemic banks and are less inter connected. We shall now suggest that if one

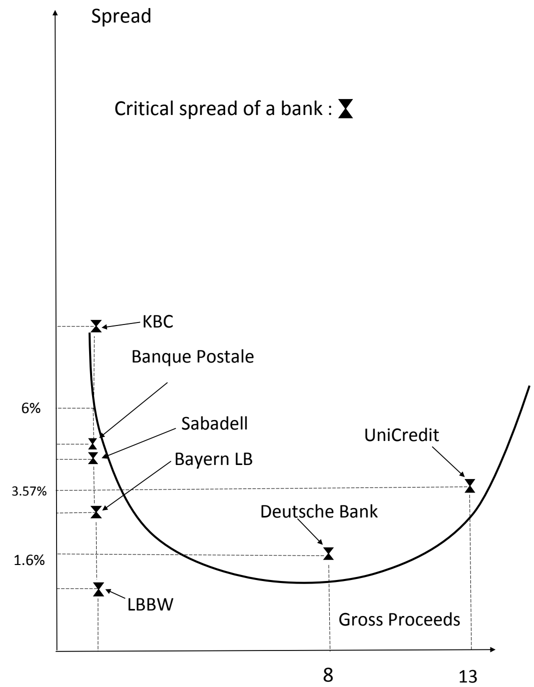

Figure 3: Spread as a U-shaped function and critical spread

assumes that the spread function is a U-shaped function of the gross proceeds, then, our model might provide a theoretical explanation to the empirical findings of [De Jonghe and Öztekin, 2015].

From the 2017-list of 35 banks reported on the website of the EBA[14], 12 are considered as G-SIIs. By definition, a bank which is listed on the 2017-list has an overall exposure measure of more than €200 billion. When one inspects the 23 banks that are not considered as G-SIIs, some of them have a total value of their assets between €200 billion and €250 billion. Compared with many G-SIIs for which the total value of the assets typically exceed €1500 billion, for these smaller banks, a capital increase in million (i.e., less than one billion) might be enough to increase (significantly) their CET1 capital ratio. For instance, on June, 2016, Erste Group Bank decided to issue additional Tier 1 capital, more precisely non-cumulative bonds with an annual coupon rate equal of 8.875% and with a total nominal value of €500 billion. They also disclose in their annual report as of 2016 that their minimum target capital ratio is a CET1 capital ratio fully loaded at least equal to 12.75% for 2019 and they observe that the target has been reached since the CET1 capital ratio fully loaded is equal to 12.8% in 2016. To be able to derive the critical spread of these smaller European banks, i.e., to

[14] http://www.eba.europa.eu/risk-analysis-and-data/global-systemically-important-institutions/2017

predict the optimal decision of those non-systemic banks, we shall make the assumptions that

$$I(\theta^*) = 500 \text{ million} \tag{31}$$

that is, we assume that given the target capital ratio which is not observed in general, the gross proceeds is equal €500 million. For these banks with a total value of the assets typically lower than €250 billion, the price impact is very low, i.e., close to $\frac{250}{75900} \approx 0.33\%$ as of 2016. To facilitate the exercise, we consider as negligible this price impact and we assume that $\frac{1}{\Phi} = 0$. In such a situation, as we have already seen, the optimization problem reduces to a linear programming problem for which it is never optimal to mix the channel of adjustment. We shall focus on banks that belong to countries of the Euro zone and that have a total assets lower than €250 billion. Since Erste Group Bank reaches its target capital ratio in 2016, we have decided not to include this bank in our exercise. Overall, five banks are considered, Bayern LB (German), Banque Postale (French), Sabadell (Spanish), LBBW (German), and KBC (Belgium). The (unique) critical spread of each bank is given below (details related to the computation can be found in the appendix)

$$\widetilde{c}_{Bayern} = 3.38\% \quad \widetilde{c}_{BPost} = 5.6\% \quad \widetilde{c}_{Sabadell} = 5.4\% \quad \widetilde{c}_{LBBW} = 1.23\% \quad \widetilde{c}_{KBC} = 11.48\% \tag{32}$$

In our (small) sample of banks, the average spread is equal to 5.5%, which is a result consistent with the finding of [Boyson et al., 2016] since found a spread (for issuing common stocks) equal to 5.02%. Let

$$\text{Spread}(I) = \frac{K}{I} + c(I) \tag{33}$$

be the spread as a function of I, where $c(I)$ is the non constant marginal cost (of issuance) function. Assume now, as in Fig. 3, that the spread is a U-shaped function of I. We already know that for Deutsche Bank and UniCredit, it was optimal to issue new shares only because the observed spread was higher than their critical spread, something that we reproduce on Fig. 3. If one now assumes that the spread that must be paid by the bank is equal to 6% for a gross proceeds of €0.5 billion, i.e., $c(0.5) = 6\%$, then, except for the Belgium bank BKC, it is optimal to sell assets only for the other banks. We do not claim that this approach in terms of U-shaped function constitutes the definitive answer to the empirical finding of [De Jonghe and Öztekin, 2015] but it provides a simple and credible explanation since the price impact should not be an issue for small banks.

5 Conclusion

We presented in this paper a simple model of optimal choice of channel(s) of adjustment when the aim of the bank is to reach a target capital ratio. We considered the case of two European systemic banks, Deutsche Bank and UniCredit, for which the optimal target is explicitly disclosed and we have shown that our model is able to predict the observed decision of these two banks to issue new shares only. We then considered a model in which the spread is U-shaped, and this simple approach might explain the empirical finding of [De Jonghe and Öztekin, 2015] in which large banks tend to issue new shares while small banks tend to sell assets.

6 Mathematical appendix

6.1 Preliminary results

From equation (11) when $I = 0$, the risk-based capital ratio is equal to

$$\theta(s,0) := \frac{E(s,0)}{\mathrm{RWA}(s)} = \frac{v - D + qP\left(1 - \frac{s}{\Phi}\right)}{\alpha(q-s)P(1-\frac{s}{\Phi})} \tag{34}$$

which is a *non-linear function* of the quantity sold s. We want to study the evolution of $\theta(s,0)$ as a function of s assuming that $\Phi \in (2q, \infty)$. Throughout this appendix, $E'(s,0)$ and $\mathrm{RWA}'(s)$ will respectively denote the partial derivative with respect to s. Let $\theta'_s(s,0) := \frac{\partial\theta(s,0)}{\partial s}$. By definition of the derivative

$$\theta'_s(s,0) = \frac{E'(s,0)\ \mathrm{RWA}(s) - E(s,0)\ \mathrm{RWA}'(s)}{(\mathrm{RWA}(s))^2} \tag{35}$$

and note that the sign of $\theta'_s(s,0)$, denoted $\mathrm{Sgn}(\theta'_s(s,0))$, is simply the sign of the numerator of equation (35), that is

$$\mathrm{Sgn}(\theta'_s(s,0)) = \mathrm{Sgn}[E'(s,0)\ \mathrm{RWA}(s) - E(s,0)\ \mathrm{RWA}'(s)] \tag{36}$$

From equation (34), it is not difficult to show that

$$\mathrm{Sgn}(\theta'_s(s,0)) = \mathrm{Sgn}\left(-\frac{qP}{\Phi}\ \alpha(q-s)P\left(1-\frac{s}{\Phi}\right) + \alpha P\left[1 - \left(\frac{2s-q}{\Phi}\right)\right]\left[v - D + qP\left(1-\frac{s}{\Phi}\right)\right]\right) \tag{37}$$

Note importantly that the sign of $\theta'_s(s,0)$ is the sign of a *quadratic equation* in s. As a result, $\theta'_s(s,0)$ needs not be a monotonic function of s.

Lemma A 1 *If $\Phi > \underline{\Phi}$ (or equivalently if $E(q,0) > 0$), then, $\theta'_s(0,0) > 0$*

Proof. Letting $s = 0$ in equation (37) leads to $\mathrm{Sgn}(\theta'_s(0,0)) = v - D + qP + (v-D)\frac{q}{\Phi}$. Since $v - D + qP > 0$, if $(v - D) > 0$, then, it follows immediately that $\theta'_s(0,0) > 0$. However, in general, $(v - D) < 0$. Since $E(q,0) = v - D + qP(1 - \frac{q}{\Phi}) > 0$ by assumption, it is easy to show that $v - D + qP + (v - D)\frac{q}{\Phi} > v - D + qP(1 - \frac{q}{\Phi})$ is equivalent to $\frac{q}{\Phi}(v - D + qP)$, which is a positive quantity. As a result, $\theta'_s(0,0) > 0\square$

Lemma A 2 *There exists a smallest $\overline{\Phi} > 0$ such that for all $\Phi > \overline{\Phi}$ and all $s \in (0,q)$, $\theta'_s(s,0) > 0$.*

Proof. From equation (37), when Φ tends to infinity, for all $s \in (0,q)$, the rhs of equation (37) tends to $\alpha P(v + qP - D) > 0$. Since the rhs of equation (37) is a continuous function of Φ, there thus exists a smallest market depth denoted $\overline{\Phi}$ such that for all $\Phi > \overline{\Phi}$ and all $s \in (0,q)$, $\theta'_s(s,0) > 0$ $\square$

Remark. *It is actually not difficult to show that a necessary but not sufficient condition for $\theta'_s(s,0) > 0$ is $E(s,0) > 0$.*

We now provide an upper bound for $\overline{\Phi}$.

Lemma A 3 $\overline{\Phi} \leq q\left(1 + \frac{qP}{E(0,q)}\right)$

Proof. From equation (37) to the sign of $\theta'_s(s,0)$ is equal to

$$\underbrace{\left(-\frac{qP}{\Phi}\ \alpha(q-s)P\left(1-\frac{s}{\Phi}\right)\right.}_{A(s)} + \underbrace{\alpha P\left[1-\left(\frac{2s-q}{\Phi}\right)\right]\left[v-D+qP\left(1-\frac{s}{\Phi}\right)\right]}_{B(s)} \tag{38}$$

We want to find a sufficient condition such that equation (38) is positive for all s and note that $A(s) < 0$ while $B(s) > 0$ for each s since $E(0,q) = v - D + qP\left(1-\frac{q}{\Phi}\right) > 0$. Note that $B(s) > \alpha P\left[1-\left(\frac{2s-q}{\Phi}\right)\right]E(0,q)$ for each s. In the same vein, $A(s) < -\frac{qP}{\Phi}\alpha qP\left(1-\frac{s}{\Phi}\right)$ for each s. Simplifying by αP, this leads to $\left[1-\left(\frac{2s-q}{\Phi}\right)\right]E(0,q) > \frac{qP}{\Phi}q\left(1-\frac{s}{\Phi}\right)$ which in turn is always true if $\left[1-\frac{q}{\Phi}\right]E(0,q) > \frac{q^2P}{\Phi}$ and is in turn equivalent to $\Phi > q\left(1+\frac{qP}{E(0,q)}\right)$. We thus have shown that for each s, $\alpha P\left[1-\left(\frac{2s-q}{\Phi}\right)\right]E(0,q) > \frac{qP}{\Phi}\alpha qP\left(1-\frac{s}{\Phi}\right)$, so that for each s $B(s) > A(s)$. Since we found a sufficient condition for which $\theta'_s(s,0)$ for each s, it may be the case that $\overline{\Phi} < q\left(1+\frac{qP}{E(0,q)}\right)$ $\square$

Lemma A 4 *If $\Phi \in (\underline{\Phi}, \overline{\Phi})$, then, there exists two roots $\widehat{s}_1$ and $\widehat{s}_2$ (with $\widehat{s}_1 < \widehat{s}_2$) such that $\theta'_s(\widehat{s}_i, 0) = 0$ for $i = 1, 2$.*

Proof. When $\Phi \in (\underline{\Phi}, \overline{\Phi})$, by definition of $\overline{\Phi}$, the risk-based capital ratio $\theta(s,0)$ cannot be an increasing function of s for each $s \in (0,q)$. From lemma 1, we know that when $\Phi > \underline{\Phi}$ (or equivalently when $E(q,0) > 0$), $\theta'_s(0,0) > 0$. Since $E(q,0) > 0$ and $\lim_{s\to q} \mathrm{RWA}(s) \to 0$ so that $\lim_{s\to q}\theta(s,0) \to \infty$, there thus exists two roots $\widehat{s}_1$ and $\widehat{s}_2$, with $0 < \widehat{s}_1 < \widehat{s}_2 < q$, such that $\theta'_s(\widehat{s}_i, 0) = 0$ for $i = 1,2$ and such that $\theta'_s(s,0) > 0$ for $s \in (0, \widehat{s}_1)$, $\theta'_s(s,0) < 0$ for $s \in (\widehat{s}_1, \widehat{s}_2)$ and $\theta'_s(s,0) > 0$ for $s \in (\widehat{s}_2, q)$ $\square$

6.2 Proofs

Proof of proposition 1. When $c < 1$ and $s = 0$, the risk-based capital ratio $\theta(0, I)$ is an increasing function of I. As a result, for each $\theta^* \in \mathbb{R}^+$, there exists a unique $\overline{I}(\theta^*)$ such that $\theta(0, \overline{I}(\theta^*)) = \theta^*$.

Since $\overline{I}(\theta^*)$ is the smallest value of I such that $\theta(0,\overline{I}(\theta^*)) = \theta^*$, when $s = 0$, $\overline{I}(\theta^*)$ thus solves the optimization problem. This concludes the first part of the proof. For the second part of the proof, note first that $\lim_{s\to q} \mathrm{RWA}(s) \to 0$. Since $\Phi > \underline{\Phi} \iff E(q,0) > 0$, it thus follows that $\lim_{s\to q} \theta(s,0) := \frac{E(s,0)}{\mathrm{RWA}(s)} \to \infty$. Since $\theta(s,0) = \frac{E(s,0)}{\mathrm{RWA}(s)}$ is a continuous function of $s \in [0,q)$, for each $\theta^* \in \mathbb{R}^+$ there exists a unique $\overline{s}(\theta^*) < q$ such that $\theta(\overline{s}(\theta^*),0) = \theta^*$. When $\theta(s,0)$ is an increasing function of s for each $s \in (0,q)$, there is a unique $s_1 < q$ such that $\theta(s_1,0) = \theta^*$. In such a case, for all θ^*, $s_1 = \overline{s}(\theta^*)$. When $\theta(s_j,0) = \theta^*$ for $j \in J$ and when J is not a singleton, in such a case, only the smallest one solves the optimization problem. Let s_1 be the smallest value and we are back to the previous case $\square$

We have defined $\overline{s}(\theta^*)$ such that $\theta(\overline{s}(\theta^*),0) = \theta^*$. Let us now define the function $I(s,\theta^*) \in [0,\overline{I}(\theta^*)]$ such that $\theta(s,I(s,\theta^*)) = \theta^*$ for each $s \in [0,\overline{s}(\theta^*)]$. Let $C(s,I) = sP(\gamma + \frac{s}{\Phi}) + cI = k$, where $k > 0$ be a level curve of the cost function and let $I(s,k)$ be such that $C(s,I(s,k)) = k$ for each s.

Proposition A 1 *Assume that condition (16) holds. The function $I(s,\theta^*)$ is a decreasing and strictly convex function of s while the function $I(s,k)$ is a decreasing and strictly concave function of s.*

The proof will consist in few simple results.

Claim A 1 *Assume that $I_2 > I_1$. Then, for all $s \in [0,q)$, $\theta(s,I_2) > \theta(s,I_1)$.*

Proof. Since by definition $\theta(s,I) = \frac{v-D+qP\left(1-\frac{s}{\Phi}\right)+(1-c)I}{\alpha(q-s)P(1-\frac{s}{\Phi})}$, it is elementary to show that if $I_2 > I_1$, then, for all $\Phi > \underline{\Phi}$ (but this is true for all $\Phi > 0$) and all $s \in [0,q)$, $\theta(s,I_2) > \theta(s,I_1)$. $\square$

From equation (11), it is easy to show that the iso-target curve $I(s,\theta^*)$ is equal to

$$I(s,\theta^*) := I(s) = \frac{\theta^*\alpha(q-s)P(1-\frac{s}{\Phi}) - \left[v - D + qP\left(1-\frac{s}{\Phi}\right)\right]}{1-c} \tag{39}$$

and note that from claim A 1, if $I(s,\theta^*) > 0$, then $s < \overline{s}(\theta^*)$. When $\Phi \in (\underline{\Phi},\overline{\Phi})$, conditions (16) ensures that $I(s,\theta^*)$ is a continuously differentiable[15].

Claim A 2 *For each $s \in (0,\overline{s}(\theta^*))$, $\theta'_s(s,0) > 0$ is equivalent to $I'(s,\theta^*) < 0$*

[15]It can be shown upon demand that when $\Phi \in (\underline{\Phi},\overline{\Phi})$ and when $\theta^* > \theta_{max}$, then, the function $I(s,\theta^*)$ is not anymore continuously differentiable, which complicates the analysis of the optimization problem.

Proof. Along the iso target curve, i.e., as long as s is such that $\theta(s, I(s,\theta^*)) = \theta^*$, $d\theta(s,I) = 0$, which is equivalent to $d\theta(s,I) = \frac{\partial\theta(s,I)}{\partial s}ds + \frac{\partial\theta(s,I)}{\partial I}dI = 0$ and finally yields $\frac{dI}{ds} := I'(s) = -\frac{\frac{\partial\theta(s,I)}{\partial s}}{\frac{\partial\theta(s,I)}{\partial I}}$ where $\frac{\partial\theta(s,I)}{\partial I} > 0$. Since $\frac{\partial\theta(s,I)}{\partial I} > 0$, for each $s \in (0,q)$, $I'(s) < 0$ is equivalent to $\frac{\partial\theta(s,I)}{\partial s} > 0$ for any $I \geq 0$ $\square$

It is easy to show that $C(s, I(s,k)) = k$ is equivalent to

$$I(s,k) = \frac{k}{c} - \left(\frac{sP(\gamma + \frac{s}{\Phi})}{c}\right) \tag{40}$$

We are now in a position to complete the proof. From claim A 2, we already know that $I'(s) < 0$ and it is easy to see that $I''(s) = (\frac{1}{c})\frac{\alpha\theta^* 2P}{\Phi} > 0$ for each $s \in (0, \overline{s}(\theta^*))$, which shows that $I(s)$ is a decreasing and strictly convex function of s. From equation (40), it is easy to show that $I'(s,k) = -\frac{1}{c}\left(\gamma P + \frac{2sP}{\Phi}\right) < 0$ while $I''(s,k) = -(\frac{1}{c})\frac{2P}{\Phi} < 0$. As a result, the function $I(s,k)$ is a decreasing and strictly concave function of s for any $k > 0$ $\square$

Proof of proposition 2. Since the optimization program is a linear programming problem, the solution is either $(0, \overline{I})$ or $(\overline{s}, 0)$ and note that $\theta < \theta^*$ is equivalent to $-v + D + qP(\theta^*\alpha - 1) > 0$. Consider the pure equity solution. It is easy to show that $\overline{I} = \frac{qP(\alpha\theta^*-1)-(v-D)}{1-c} > 0$ so that $C(0,\overline{I}) = \frac{c}{1-c}(qP(\alpha\theta^* - 1) - (v-D)) > 0$. Consider now the pure asset sale solution. It is easy to show that $\overline{s} = \frac{qP(\alpha\theta^*-1)-(v-D))}{\alpha P\theta^*} > 0$ so that $C(\overline{s}, 0) = \frac{\gamma[qP(\alpha\theta^*-1)-(v-D)]}{\alpha\theta^*} > 0$. Let $\widetilde{c}$ be the critical spread for which $C(\overline{s}, 0) = C(0, \overline{I})$. Since $C(\overline{s}, 0) = C(0, \overline{I}) \iff \frac{\widetilde{c}}{1-\widetilde{c}} = \frac{\gamma}{\alpha\theta^*}$, this yields the desired critical spread $\widetilde{c} = \frac{\gamma}{\gamma+\alpha\theta^*}$. It is easy to show that $c < \widetilde{c}$ is equivalent to $C(\overline{s}, 0) > C(0, \overline{I})$ so that it is optimal to issue new equity only, i.e., $(s^*, I^*) = (0, \overline{I})$. Reverse the inequality to obtain the second part of the proposition $\square$

Proof of proposition 3. Instead of solving the optimization problem using Kuhn and Tucker, we make use of the specific problem under consideration and we use the fact that we have only two variables s and I. By inserting equation (39) into the cost function $C(s, I)$, we thus obtain a cost function $C(s, I(s,\theta^*)) \equiv C(s)$ that only depends on s. The optimization problem thus reduces to a uni-dimensional minimization problem. Since $C''(s) > 0$ for each $s \in (0, q)$, i.e., the cost function is convex in s, it thus follows that s^* such that $C'(s^*) = 0$ is a global minimum. Computations of $C'(s^*) = 0$ is equivalent to

$$s^* = \frac{\frac{\alpha\theta^* c}{1-c}(1 + \frac{q}{\Phi}) - \left(\gamma + \frac{cq}{(1-c)\Phi}\right)}{\frac{2}{\Phi}(1 + \frac{\alpha\theta^* c}{1-c})} \tag{41}$$

and it suffices now to solve $s^*(\widetilde{c}_l) = 0$, i.e., to solve $\frac{\alpha\theta^*\widetilde{c}_l}{1-\widetilde{c}_l}(1 + \frac{q}{\Phi}) - \left(\gamma + \frac{\widetilde{c}_l q}{(1-\widetilde{c}_l)\Phi}\right) = 0$ to obtain the desired critical spread $\widetilde{c}_l$. When $c < \widetilde{c}_l$, since s^* is non-negative, $s^* = 0$ and it is thus optimal to only issue new equity, this concludes the first part of the proof. Consider now the highest critical spread $\widetilde{c}_h$. To prove the existence and uniqueness of $\widetilde{c}_h$, assume that $c = 1$. In such a case, $\frac{\partial \theta(s,I)}{\partial I} = 0$ while $\frac{\partial C(s,I)}{\partial I} > 0$ for each $\in [0, q)$ and each $I \geq 0$ so that $I^* = 0$. Since the optimization problem defined by equations (10) to (13) is continuous and monotonic in c, there exists a unique critical spread $\widetilde{c}_h > \widetilde{c}_l$ such that for each $c > \widetilde{c}_h$, the optimal solution is $(s^* = \overline{s}; I^* = 0)$ while when $c \in (\widetilde{c}_l, \widetilde{c}_h)$, the optimal solution is $(s^* > 0; I^* = 0)$ $\square$

Remark. When $\Phi \to \infty$, everything else equal, the optimization problem tends to a linear programming problem for which mixing the channels of adjustment is never optimal. As a result, when $\Phi \to \infty$, it must also be the case that $\widetilde{c}_h \to \widetilde{c}$.

6.3 Critical spread for European banks with total assets between €200 billion and €300 billion

Bayern LB (Germany). As of December 2016, the RWA is equal to €65.20 billion, CET1 is equal to €9.54 billion while the total capital is equal to €11.05 billion. The total capital ratio thus is equal to 17%. The total value of the assets is equal to €212.15 billion and the value of cash is equal to €2.1 billion so that $qP = 210.05$. From these data, $\alpha = 31\%$. Since CET1 is equal to 14.7%, when the bank raises €0.5 billion, the CET1 capital ratio moves to 15.45%, i.e., it increases by 75 bps. As a result, the total capital ratio, which becomes the target, is now is equal to $\theta^* = 17.7\%$. By estimating γ using the years 2015, 2016, we find respectively a value equal to 0.20% and 0.184% so that the average is equal to $\gamma = 0.192\%$. It thus follows from equation (19) that

$$\widetilde{c}_{Bayern} = 3.38\%. \tag{42}$$

Banque Postale (France). As of December 2016, the RWA is equal to €59.53 billion, CET1 is equal to €8.17 billion while the total capital is equal to €11.55 billion. The total capital ratio thus is equal to 19.4%. The total value of the assets is equal to €229.6 billion and the value of cash is equal to €2.7 billion so that $qP = 226.9$. From these data, $\alpha = 26.2\%$. Since CET1 is equal to 13.7%, when the bank raises €0.5 billion, the CET1 capital ratio moves to 14.5%, i.e., it increases by almost 80 bps. As a result, the total capital ratio, which becomes the target, is now is equal to $\theta^* = 20.24\%$. By estimating γ using the years 2015, 2016, we find respectively a value equal to 0.325% and 0.3% so that the average is equal to $\gamma = 0.3125\%$. It thus follows from equation (19) that

$$\widetilde{c}_{BP} = 5.6\% \tag{43}$$

SABADELL (Spain). As of December[16] 2016, the RWA is equal to €86.07 billion, CET1 is equal to €10.33 billion while the total capital is equal to €11.851 billion. The total capital ratio thus is equal to %. The total value of the assets is equal to €212.5 billion and the value of cash is equal to €11.68 billion so that $qP = 200.82$. From these data, $\alpha = 42.8\%$. Since CET1 is equal to 12 %, when the bank raises €0.5 billion, the CET1 capital ratio moves to 12.6%, i.e., it increases by 60 bps. As a result, the total capital ratio, which becomes the target, is now is equal to $\theta^* = 14.35\%$. By estimating γ using the years 2015, 2016, we find respectively a value equal to 0.351% and 0.353%

[16] They placed 500 billion of Tier 2 capital in 2016.

so that the average is equal to $\gamma = 0.352\%$. It thus follows from equation (19) that

$$\widetilde{c}_{Sabadell} = 5.4\%. \tag{44}$$

LBBW (Germany). As of December 2016, the RWA is equal to €77.4 billion, CET1 (fully loaded) is equal to €11.76 billion while the total capital is equal to €16.64 billion. The total capital ratio thus is equal to 21.5%. The total value of the assets is equal to €243.6 billion and the value of cash is equal to €13.53 billion so that $qP = 230.07$. From these data, $\alpha = 33.6\%$. Since CET1 is equal to 15.2 %, when the bank raises €0.5 billion, the CET1 capital ratio moves to 15.83 %, i.e., it increases by 63 bps. As a result, the total capital ratio, which becomes the target, is now is equal to $\theta^* = 22.15\%$. By estimating γ using the years 2015, 2016, we find respectively a value equal to 0.18% and 0.0043% so that the average[17] is equal to $\gamma = 0.093\%$. It thus follows from equation (19) that

$$\widetilde{c}_{LBBW} = 1.23\% \tag{45}$$

KBC (Belgium). As of December 2016, the RWA is equal to €78.48 billion, CET1 is equal to €12.65 billion while the total capital is equal to 16.24 €billion. The total capital ratio thus is equal to 20.7%. The total value of the assets is equal to €239.33 billion and the value of cash is equal to €20.14 billion so that $qP = 219.2$. From these data, $\alpha = 35.8\%$. Since CET1 is equal to 14.3%, when the bank raises €0.5 billion, the CET1 capital ratio moves to 14.95%, i.e., it increases by 43 bps. As a result, the total capital ratio, which becomes the target, is now is equal to $\theta^* = 21.33\%$. By estimating γ using the years 2015, 2016, we find respectively a value equal to 1.06% and 0.924% so that the average is equal to $\gamma = 0.99\%$. It thus follows from equation (19) that

$$\widetilde{c}_{KBC} = 11.48\% \tag{46}$$

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[17] The net consolidated profit is equal to 0.142 billion in 2016 while it was equal to 0.531 billion in 2015. This explains why the value of γ is very low for the year 2016.

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