Enhancing Bank Robustness through Dynamic Control of Leverage (DCL) in Contingent Convertible Bonds (CoCos): A Case Study Analysis

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List of Symbols

Symbol	Description
$\mathbb{E}_t[.]$	Expected Value
$\mathbb{1}(.)$	Indicator function
RQ_k	Residual value of DCL debt at time k
Q_k	Interest payment at time k
D_k	Total debt at time k
E_k	Total equity at time k
α_k	Proportion of DCL debt to total debt at time k
L_k	Leverage at time k
L_c	Critical (maximum) leverage threshold
$L_{\min}$	Minimum leverage threshold

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Abstract

Contingent Convertible (CoCo) bonds were introduced to strengthen bank stability by automatically converting debt into equity during financial distress. Recent and historical bank failures, such as the collapse of Credit Suisse, have highlighted critical weaknesses in their design, including vulnerability to regulatory discretion and market panic. This study analyses a novel framework, Dynamic Control of Leverage (DCL) CoCo bonds, that addresses these limitations through gradual and predictable conversions triggered by discrete leverage monitoring. Using historical market data from Refinitiv Eikon, this study simulates DCL performance in three case studies; Credit Suisse, Deutsche Bank, and Lehman Brothers, to evaluate its effectiveness across varied crisis scenarios.

Results indicate that in the Credit Suisse simulation, DCL significantly mitigated risk and delayed the bank's collapse. In the Deutsche Bank case, the framework provided proactive stabilization of capital levels, mitigating a potential failure. However, during Lehman Brothers' swift systemic collapse, DCL had limited impact, underscoring its constraints under extreme conditions. These results highlight DCL's strengths in bolstering bank resilience and its limitations in the face of rapid systemic failures.

Keywords: Contingent Convertible Bonds, Dynamic Control of Leverage, Banking stability

Aukið bolmagn banka með kvikri stýringu á gírun (e. Dynamic Control of Leverage) í skilyrtum breytanlegum (e. Contingent Convertible) skuldabréfum: Rannsókn með gögnum úr raunheiminum

Útdráttur

Skilyrt breytanleg (e. Contingent Convertable - CoCo) skuldabréf voru innleidd til að efla stöðugleika banka með því að breyta skuldum sjálfvirkt í eigið fé þegar fjárhagsstaða er slæm. Nýleg dæmi um gjaldþrot banka, svo sem hrun Credit Suisse, vörpuðu ljósi á alvarlega veikleika í hönnun slíkra bréfa, því þau reyndust háðari ákvörðunum eftirlitsaðila en upprunalega var spáð fyrir og verðmat þeirra er viðkvæmt fyrir ótta á fjármálamarkaði. Í þessari ritgerð er rannsakað nýtt fyrirhugað kerfi fyrir CoCo skuldabréf sem kallast "kvik stýring á gírun" (e. Dynamic Control of Leverage - DCL) sem vinnur gegn þessum veikleikum með fyrirsjáanlegum og tiltölulega smáum breytingum á skuldum yfir í hlutafé til að draga úr gírun þegar hún er há. Með sögulegulegum gögnum frá Refinitiv Eikon var gerð hermun til að spá fyrir um frammistöðu DCL bréfa fyrir söguleg ástönd hjá Credit Suisse, Deutsche Bank og Lehman Brothers, til að meta skilvirkni kerfisins í mismunandi aðstæðum.

Niðurstöðurnar benda til þess að í tilfelli Credit Suisse myndi DCL draga verulega úr áhættu og seinka hruni bankans töluvert. Í tilfelli Deutsche Bank lækkaði DCL kerfið gírun þegar hún var há sem leiddi til aukis virði fyrir fjárfesta. Hins vegar, fyrir skyndilegt hrun eins og í tilfelli Lehman Brothers þá hafði DCL takmörkuð áhrif þar sem það getur aðeins gripið inn í þegar gírun er há yfir tíma, sem var ekki staðan hjá Lehman fyrir hrun. Niðurstöðurnar draga fram getu DCL til að efla stöðugleika banka, en einnig takmarkanir fyrir hröð kerfilslæg hrun.

Lykilorð: Skilyrt breytanleg skuldabréf, kvik stýring á gírun, stöðugleiki banka

List of Abbreviations

Abbreviation	Description
AT1	Additional Tier 1
CET1	Core Equity Tier 1
CoCo	Contingent Convertible
DCL	Dynamic Control of Leverage
ERN	Equity Recourse Note
PONV	Point of non viability
FINMA	Swiss Financial Market Supervisory Authority (Ger.: Eidgenössische Finanzmarktaufsicht)
PWD	Principal Write Down
ECN	Enhanced Capital Note
GBM	Geometric Brownian Motion

Chapter 1

Introduction

The global financial crises of 2008 and the collapse of Credit Suisse in 2023 have underscored critical vulnerabilities in bank capital structures. In response to the 2008 crisis, regulators introduced contingent convertible bonds (CoCos) as a mechanism to bolster bank resilience by automatically converting debt into equity during distress, thereby aiming to avoid taxpayer-funded bailouts [1]. However, traditional CoCo bonds with fixed capital ratio triggers have shown significant limitations. They can fail to trigger conversions in time or create market uncertainty - as seen in Credit Suisse's 2023 failure, where $17 billion in CoCo (AT1) bonds were abruptly written down, highlighting a breakdown in the intended loss-absorbing mechanism. These events point to the need for more effective tools to enhance bank robustness and prevent such destabilizing outcomes [2], [3].

This thesis project analyses the novel Dynamic Control of Leverage (DCL) framework as an alternative approach to conventional CoCos designed to mitigate these shortcomings. DCL-based CoCo instruments monitor a bank's leverage and trigger debt-to-equity conversions dynamically, rather than relying on a single static threshold. By allowing proactive and gradual recapitalization to sensible leverage ratios, the DCL framework is expected to keep a bank's leverage within safe bounds and minimize the likelihood of default. In essence, DCL CoCos aim to provide the flexibility to shore up capital before a crisis point is reached, addressing problems of delay or inflexibility in traditional CoCo triggers [4].

The aims of this research are twofold. First, it seeks to evaluate whether DCL-driven CoCo bonds can more effectively maintain bank stability compared to traditional CoCos. Secondly, it investigates how applying DCL might alter outcomes in real-world scenarios. Specifically, the following research questions will be addressed:

- *How effective is the Dynamic Control of Leverage (DCL) framework in stabilizing banks during periods of financial distress compared to traditional CoCo* *bonds?*

- *To what extent can the implementation of DCL-based CoCo bonds mitigate financial distress and influence outcomes across different types of banking crises?*
- *What are the key parameters influencing the performance of DCL CoCo bonds, and how can they be optimized?*

To address these questions comprehensively, this thesis employs empirical simulations using historical financial data from three distinct banking crises; Credit Suisse, Deutsche Bank, and Lehman Brothers. These institutions represent varying degrees and types of financial distress, offering a testbed for assessing the Dynamic Control of Leverage (DCL) CoCo bonds under diverse crisis conditions.

The empirical simulations conducted in this research aim to verify the hypothesis that DCL-equipped CoCos can significantly improve a bank's ability to withstand financial shocks by enabling timely and controlled leverage adjustments. Specifically, the study explores whether such an approach would have mitigated the catastrophic outcomes observed in the Credit Suisse collapse in 2023, provided proactive stabilization under moderate distress scenarios, exemplified by Deutsche Bank, and how it would perform in the face of rapid systemic failures as exemplified by Lehman Brothers during the 2008 financial crisis.

This study offers several contributions. First, it advances the financial stability literature by exploring an innovative loss-absorbing instrument that could prevent bank failures more effectively than current tools. Second, it contributes to the CoCo bond literature by rigorously analyzing a dynamic trigger mechanism (DCL) through simulation and case study evidence. Third, it has strong policy implications and practical relevance: the findings can inform regulators and bank risk managers about improving capital regulation. If DCL CoCos prove effective, they could guide reforms in Additional Tier 1 capital requirements, helping policymakers strengthen the resilience of banks and reduce systemic risk.

Overall, by demonstrating the potential benefits of dynamically controlled leverage in CoCo bonds, this research is expected to show that DCL can enhance bank robustness and stability. Under the DCL framework, it is anticipated that a bank like Credit Suisse would experience a more timely, gradual and controlled capitalization process during distress, potentially averting the abrupt collapse witnessed in 2023. Such expected results would underscore DCL's value as a tool for financial stability, bridging a critical gap in current risk management practices.

Chapter 2

Literature Review

2.1 Overview of CoCo Bonds

Contingent Convertible (CoCo) bonds have gained prominence as financial instruments designed to stabilize banks during periods of financial distress. CoCo bonds were introduced after the 2008 financial crisis to provide banks with an automatic mechanism for strengthening their capital base during distress without needing a government bailout [1], [5]. These bonds automatically convert into equity or are written down when a bank's capital falls below a predetermined threshold. Prior to 2008, traditional bank capital structures included some hybrid debt (e.g. perpetual preferred or subordinated debt), but no widely adopted security had an explicit, rules-based conversion trigger akin to modern CoCo bonds [6]–[8]. Thus, the severe bank losses in the global financial crisis provided a reason to turn these theoretical contingent capital instruments into practice. Regulators and economists saw CoCos as a way to avoid future government bailouts by automatically converting debt to equity when a bank is under stress, thereby absorbing losses and recapitalizing the bank [9].

Early theoretical work by Flannery and the *Squam Lake Working Group on Financial Regulation* laid out the general framework: By credibly threatening dilution or losses to creditors when capital erodes, CoCos could incentivise preemptive risk management and help to control a bank's leverage during downturns [5], [10], [11].

In the aftermath of the 2008 crisis, CoCos moved from theory to reality. Banks and regulators began to rely more on CoCos as a tool to meet new, tougher capital requirements and to restore market confidence in bank solvency[1], [11], [12]. Notable early issuances were made by Lloyds (2009)[1] and Credit Suisse (2011). By

[1]In 2009, Lloyds offered bondholders an exchange into "Enhanced Capital Notes" (ECN), CoCos that would convert into equity if Lloyds core capital ratio fell below a trigger (around 5%)[13]–[15]

early 2011, Credit Suisse had executed a $6.2 billion issuance of high-trigger CoCo bonds (trigger at 7% CET1[2]), an amount which satisfied roughly half of the new contingent capital requirement imposed by Swiss regulators[16].

Regulatory frameworks, including Basel III, played a crucial role in shaping the issuance and structure of CoCo bonds by specifying minimum capital thresholds and loss-absorption mechanisms. The Basel III accords (2010–2011) recognized contingent convertibles as part of regulatory capital, setting the criteria for their inclusion in the balance sheets of the banks. In particular, Basel III stipulated that for a bond to count as Additional Tier 1 (AT1) capital, it must have a conversion trigger of at least 5.125% CET1/RWA (Common Equity Tier 1 ratio). This led many banks to issue *high-trigger* CoCos at that minimum level, since such instruments qualify as core going-concern capital. By contrast, CoCos with lower triggers (set closer to the point of non-viability) typically only qualify as Tier 2 capital. Regulators also imposed *point of non-viability* (PONV) clauses, requiring that any Tier 1 or 2 instrument (including CoCos) must absorb losses or convert if authorities declare the bank to be non-viable [11], [17].

The combined effect of these regulatory changes was a rapid growth in the CoCo market after 2009. Global banks embraced CoCos as a flexible capital management tool, issuing them in various currencies and formats. By 2013, banks worldwide had issued roughly $70 billion of CoCos since their inception [11].

2.1.1 Traditional Trigger Mechanisms and Pricing Models

The advent of CoCo bonds spurred academic literature to investigate how to model and price these instruments. CoCos are complex to value because their payoff depends on the evolution of the issuer's condition (generally the capital ratio or a market based trigger) and involves a nonlinear conversion option. Academics have approached this problem from multiple angles. Some have built structural credit risk models (using Merton-type models) for the bank's asset value. For instance, Pennacchi developed a structural model with stochastic asset dynamics and jump risk to value CoCos [18]. Notably, Pennacchi's model finds that the design features of CoCos materially affect credit spreads: for example, lower trigger levels lead to higher spreads, as do larger write-down fractions and conversion terms that favor shareholders (with a fixed-share conversion).

Another approach models CoCos using an equity derivatives pricing framework, viewing conversion as similar to hitting an option barrier. De Spiegeleer and Schoutens illustrate this by pricing CoCos using two alternative methods. One based on credit derivatives using default intensity, and one treating the CoCo bond

[2]CET1: Common Equity Tier 1

as an equity derivative with a stock price trigger [3][21].

The choice of trigger mechanism is of particular importance. Market-based triggers (e.g. stock price falling below a threshold) are appealing for their timeliness, but run the risk of potential multiple equilibria and could encourage market manipulation. For example, CoCo investors could attempt to short the stock as conversion looms, pushing the price down to ensure conversion at a more favorable rate. Existing shareholders, anticipating this, might also sell, therefore adding further downwards pressure on the stock price [22].

Book-value triggers, based on accounting ratios, can avoid direct market manipulation but may suffer from reporting delays. Sundaresan and Wang argued that purely market based triggers could be unstable, whereas Flannery countered that properly designed market triggers, such as using a long-term moving average or a dual-trigger system, could work and in fact encourage a more credible discipline in risk management [5], [23].

Lastly, the design characteristics of CoCos, such as the trigger level and loss-absorption method, will influence their risk and pricing. For example, CoCos with higher trigger levels or principal write-down (PWD) [4] features tend to offer higher yields at issuance than those with lower triggers or equity conversion features [11]. This reflects the increased risk to investors when conversion is more likely or more severe.

The yield (coupon spread) for CoCos is closely tied to their structural features and risk profile. In general, CoCo bonds are considered the riskiest class of bank debt, since they sit just above equity. As a result, they carry substantially higher coupons than conventional bonds [9], [11]. For example, Credit Suisse's inaugural 2011 CoCos carried a 9–9.5% coupon at a time when senior bank debt yields were much lower [16].

Over the past decade, CoCos have become an established part of the bank regulatory landscape, but their future trajectory continues to be shaped by evolving market conditions and regulatory perspectives. By 2023 the global CoCo/AT1 market had grown to roughly $275 billion [2], which indicates their acceptance by both issuers and investors. Regulators had for their part supported CoCo bonds as a key part of the post 2008 bail-in architecture. A recent example is the case of Credit Suisse in March 2023, where the Swiss authorities organized a takeover and wrote down CHF 16bn of Credit Suisse's AT1 CoCo bonds to zero as part of a rescue merger with UBS [2].

[3]De Spiegeleer and Schoutens develop the derivatives-based framework further, applying it to early issues by Lloyds (2009) and Credit Suisse (2011) [13], [14], [19], [20]. Their analysis quantifies the risks for different CoCo structures and show how trigger conditions and conversion terms would affect a CoCo's valuation [21].

[4]CoCos that include a principal write-down (PWD) feature do not convert the bond to equity on breach of the trigger, instead PWD writes off the bond. Bondholders, therefore, do not recoup any of the bond's value on PWD conversion.

The collapse of Credit Suisse in 2023 and the subsequent write-down of CHF 16 billion worth of Additional Tier 1 (AT1) CoCo bonds by the Swiss Financial Market Supervisory Authority (FINMA) sent shockwaves through financial markets. Unlike traditional cases where equity holders bear losses first, Credit Suisse bondholders were wiped out while shareholders retained some value. This inversion of the creditor hierarchy led to significant backlash and uncertainty surrounding CoCo bonds as a bail-in tool [2]. Regulators such as the European Central Bank (ECB) and the Bank of England responded by reaffirming their commitment to the conventional priority order in financial resolutions. However, the incident underscored the inherent risks and ambiguities in CoCo bond contracts, particularly those with discretionary triggers allowing regulators to make case-by-case determinations. Market reactions were immediate, with a sharp decline in AT1 bond prices globally and increased scrutiny of CoCo bonds and regulatory decision-making.

Beyond these considerations, scholars have identified several structural weaknesses in conventional CoCo bond design. One major concern is that many CoCos now carry low capital-ratio triggers (e.g. a Common Equity Tier 1 ratio around 5.125% to qualify as AT1), meaning conversion or write-down occurs only when the bank is already near failure. If the trigger threshold is set too low, the bank could slide into default before the CoCo ever converts, a scenario described as a *debt-induced collapse* where the instrument fails to recapitalize the firm in time [24], [25]. Compounding this issue, most AT1 CoCos include a discretionary point of non-viability (PONV) trigger (following Basel III) that allows regulators to force a conversion, adding further uncertainty for investors.

Additionally, the common use of accounting-based triggers (like regulatory CET1 ratios) has been criticized for their lack of transparency and responsiveness. The CET1 ratio is updated infrequently and can be influenced by accounting decisions, so relying on it makes the conversion decision backward-looking. This opacity and delay complicates the investors ability to assess conversion risk, potentially leading to mispricing or complacency in good times and an abrupt loss of confidence when conditions deteriorate [2].

To address such problems, researchers have proposed using market-based triggers (e.g. a threshold based on the bank's stock price), since market prices are forward-looking, objective, and continuously observable. A share-price trigger could in theory provide a timelier signal of distress, as it "encompasses all information known about the company" in real time [4]. However, pure market triggers carry their own challenges (such as the risk of self-fulfilling price spirals), so the optimal trigger design for CoCos remains an area of ongoing debate. Overall, the literature suggests that traditional CoCo bonds, as currently designed, may not always perform their intended role of smooth loss absorption and bank stabilization, a concern vividly illustrated by the Credit Suisse case and related studies [26]–[28]. This thesis will further analyse a particularly promising proposal for a nopvel trigger by Segal and Ólafsson which aims to mitigate the downsides of traditional CoCo bonds, as described in the next section.

2.2 Introduction to DCL (Dynamic Control of Leverage) CoCo Bonds

In a recently published paper by Segal and Ólafsson, the authors present a novel framework for a contingent convertible bond called *Dynamic Control of Leverage* (DCL) *CoCo bond* [4]. The primary motivation behind this work is to address fundamental weaknesses in traditional CoCo bonds by introducing a mechanism that adapts dynamically to a firm's leverage levels. The DCL model regulates a company's leverage by converting the traditional coupon payments of the bond to equity while a critical leverage threshold is breached. This process aims to enhance stability, prevent sudden large capital dilution (which has proven to be an issue for traditional CoCo bonds [2], and mitigate market panic compared to conventional CoCo bonds. The methodology integrates the leverage ratio as a transparent control variable, making the conversion process more predictable and reducing reliance on external regulatory intervention.

The contribution of the paper is significant as it presents an innovative alternative to existing CoCo bond structures, which have been criticized for their reliance on regulators as stated before. The DCL model provides an automated, self-regulating approach to leverage control, reducing risks associated with conventional CoCo conversions. This research is particularly relevant given recent banking crises (such as Credit Suisse, Silicon Valley Bank and First Republic Bank) and regulatory concerns over capital adequacy in financial institutions [29]–[31].

2.2.1 Leverage adjustments under DCL

The DCL framework employs two complementary mechanisms to keep a bank's leverage within a desired range. First are equity conversions at high leverage. If the bank's leverage rises above the maximum threshold, DCL triggers a conversion of that period's interest payments on the CoCo bonds into equity. This effectively injects a small amount of new equity (instead of paying interest in cash) to bring leverage down. Conversely, if the bank's leverage falls below the minimum threshold, DCL mandates an issuance of additional DCL debt (a "top-up loan") to raise the leverage back up to the minimum level. This adds debt to the balance sheet, pushing the leverage ratio upward.

The general formula for the debt-to-assets ratio (leverage) at time k is given by Equation 2.1:

$$L_k = \frac{D_k}{D_k + E_k} \tag{2.1}$$

where D_k is the total debt and E_k the total equity at time k. A high value of L_k (close to 1) means the firm is predominantly debt-financed (highly levered), whereas a lower L_k indicates a more equity-funded firm. In the DCL framework, the market value of equity is used as a proxy to the total equity value and the total debt is affected by DCL top-up loan issuances and adjustments, which allows for a dynamic market-based trigger. The framework expresses leverage in bond-specific terms so if a company has multiple different types of debt (not only DCL based debt), then the company's overall debt-to-asset ratio is scaled by the proportion of DCL debt to the total debt (represented by α_k). Accordingly, for a firm with several classes of debt, the leverage applicable to the DCL bond can be written as:

$$L_k = \frac{D_k}{D_k + E_k} \approx \frac{RQ_k}{RQ_k + \alpha_k \times NS_{k-1} \times S_k} \tag{2.2}$$

Where RQ_k is the residual value of DCL debt at k interval time, α_k is the proportion of the residual value to the total debt of the company, NS_{k-1} is the total number of shares outstanding and S_k is the share price of the company. These values are used to proxy the "real" book-value debt-to-asset leverage for the company and are used to provide a real-time market based measure to the bond.

The residual value of the bond, RQ_k, is defined by Equation 2.3:

$$RQ_k = Q\left((1+r)^k + \frac{1-(1+r)^k}{1-(1+r)^{-N_n}} \right) \tag{2.3}$$

Where Q is the nominal of the bond, r is the interest rate, and $N_n = N \cdot n$ is the number of payments to maturity (where N is the time to maturity in years and n is the frequency of payments).

If leverage is maintained above the minimum threshold $L_{\min}$ through the lifetime of the bond, then RQ_k is deterministically drawn down according to Equation 2.3. If, however, the leverage is below the threshold at any interval time k, then additional *top-up* DCL bonds are issued with the same maturity to raise the leverage back above the minimum threshold, as described by Equation 2.4.

$$\begin{aligned} L_{\min} \stackrel{!}{=} L_{k,adjusted} &= \frac{D_k + \Delta_{D,k}}{(D_k + \Delta_{D,k}) + E_k} \\ &= \frac{RQ_k + \Delta_{D,k}}{(RQ_k + \Delta_{D,k}) + \alpha_k \times NS_{k-1} \times S_k} \end{aligned} \tag{2.4}$$

Where $\Delta_{D,k}$ is the size of the top-up loan at interval time k required to raise the leverage L_k up to $L_{\min}$. The only other case where RQ_k deviates from being deterministic is if the regulator determines (and if it has the ability to determine) that the bank has reached a point of non-viability (PONV) and chooses to extraordinarily force a write-down of the bond.

Conversely, if the leverage ratio is above the critical (maximum) leverage trigger at interval time k, the interest payment is not paid out to bondholders. Instead, the payment is converted to equity in the form of additional stock issuance according to Equation 2.5, using the predetermined conversion price S_p. This leads to a gradual dilution of bondholders through interest payment conversions when leverage is too high, instead of sudden and large drawdowns that characterize traditional CoCo bonds. As such, DCL aims to prevent a sudden collapse by correcting the leverage preemptively over time.

$$NS_k = NS_{k-1} + \frac{P_N(T_k)}{S_p} \cdot \mathbb{1}_{\{S_k \leq S_{c,k}\}} \tag{2.5}$$

$P_N(T_k)$ is the payment due at T_k time, NS_k is the number of shares outstanding at interval time k and $\mathbb{1}_{\{S_k \leq S_{c,k}\}}$ is the indicator function (equals one if $S_k \leq S_{c,k}$, and zero otherwise). This conversion of interest into shares effectively lowers the leverage by adding to the equity, as can described by Equation 2.6.

$$L_{k,\text{adjusted}} = \frac{D_k}{D_k + E_k + P_N(T_k)} \tag{2.6}$$

2.2.2 DCL modelling and Empirical Gaps

The authors of the original paper defined a stochastic model for DCL simulations, assuming that equity follows geometric Brownian motion (GBM). They simulate several theoretical scenarios to demonstrate the model's effectiveness and compare DCL with traditional CoCo bonds and other leverage-based financial instruments, establishing a clear advantage in terms of risk mitigation and predictability. The technical standards align with established frameworks like Basel III, and the conversion mechanism limits dilution to interest payments rather than full principal amounts. Leverage is used as a trigger metric as opposed to conventional models relying on accounting-based or static triggers that could be subject to delays and regulatory discretion.

One potential limitation of the model in the paper is its reliance on simplified capital structure assumptions. While these assumptions help isolate the effects of DCL, real-world financial structures may introduce complexities not accounted for in the study. Furthermore, while the simulations suggest a reduction in default probability, additional empirical validation using real market data would strengthen the findings. That is particularly regarding potential risks associated with DCL implementation in different market environments.

This thesis aims to address these concerns by expanding the model to incorporate more complex capital structures and conducting empirical testing with real-world data to validate the simulations, and addressing potential risks related to investor perception and regulatory acceptance of the DCL model. It also aims to clarify the reduction in likelihood of market panic and dilution risk, and how predictable their behaviour is compared to traditional CoCos. Despite the substantial contributions of existing research, several empirical gaps persist. While previous theoretical models and limited simulations exist[5], comprehensive empirical validations using historical datasets from real-world financial institutions are non-existent. Second, studies examining responses of market participants, including that of investors and regulators, to the introduction and use of DCL CoCos are lacking. Addressing these empirical gaps could significantly enhance understanding and aid in the practical implementation of the DCL mechanism.

In summary, the paper by Segal and Ólafsson represents a valuable advancement in financial instruments for managing leverage and risk. With further empirical validation and refinements, the DCL framework has strong potential for practical application in financial markets in the current regulatory environment.

2.3 Key Takeaways

The literature on CoCo bonds shows both their benefits and limitations, particularly their unpredictable conversion mechanisms and regulatory uncertainty. The Credit Suisse CoCo wipeout highlighted the risks associated with discretionary regulatory decisions, revealing weaknesses in traditional CoCo frameworks. The DCL framework offers a promising improvement by dynamically managing leverage through interest payment conversions, mitigating sudden capital dilution and reducing market panic. Its leverage-based trigger mechanism enhances predictability compared to traditional CoCo structures. While theoretical models and simulations demonstrate its advantages, further empirical validation using real-world data is necessary to confirm its effectiveness in different market conditions.

Future research should focus on integrating DCL into existing regulatory frameworks and exploring its viability across diverse financial institutions. Additionally, addressing potential challenges such as investor perception and regulatory acceptance will be crucial in assessing its practical implementation. As financial markets evolve, the DCL approach represents a significant step toward enhancing financial stability and risk management in banking institutions.

[5] See introducing paper on DCL by Seagal and Ólafsson, and extension for continuous monitoring published in *Finance Research Letters* [4], [32]

Chapter 3

Methodology

3.1 Research Design

This study employs a quantitative and empirical research design, using historical data for simulations to assess the potential performance of the DCL framework. The research replicates and expands upon the theoretical framework established by Segal and Ólafsson [4], applying it specifically to the real-world scenarios of the Credit Suisse collapse, Deutsche Bank stress period of 2018 to 2021, and Lehman Brothers leading up to the 2008 collapse. A comparative analysis is included to contrast outcomes from the simulated DCL bonds against the non-DCL baseline scenarios, analysing the resulting indicators such as the leverage, dilution rates, and the frequency of conversions.

The aim of the study was to examine whether a Dynamic Control of Leverage (DCL) CoCo bond framework could effectively stabilize a bank's capital structure.

The analysis utilized comprehensive historical financial data sourced from Refinitiv Eikon and the banks financial reports. To answer the hypotheses, the focus was placed on examining how varying key parameters such as leverage thresholds, conversion frequencies, and coupon-to-equity conversion prices influence the bank's financial stability, market volatility, and equity dilution under different distress conditions. Additionally, an analysis was conducted to assess the robustness and reliability of the DCL approach across diverse market stress scenarios with different case studies.

Both daily and yearly time-series data were collected from the Refinitiv Eikon Python API, which included data for daily closing prices, shares outstanding and the total debt. Data for the historical Additional Tier 1 (AT1) debt was not available in Refinitiv Eikon so it was manually compiled from the bank's yearly 20-F reports

[1].

The model parameters chosen for the simulations included the bond's nominal amount (usually set to equal historical AT1 debt), the leverage trigger thresholds (L_c and $L_{\min}$), conversion prices, and frequency. The DCL mechanism was then simulated using a Jupyter notebook and Python to define and simulate bonds for the historical periods using the input data, tracking at interval times when the leverage breaches trigger thresholds, leading to an interest-to-equity conversion (for a critical *maximum* leverage breach) or additional DCL issuance (for a minimum leverage breach).

Finally, a sensitivity analysis was conducted to explore how varying the key parameters such as the trigger level (e.g. 88% to 94% debt-to-assets), interest conversion frequency (annual vs. quarterly vs. monthly), conversion price, and initial nominal of the bond, and how they would impact the outcomes for the bank's leverage trajectory and total equity dilution.

3.2 Limitations of the Methodology

Several limitations of this methodology should be noted. First, the model makes simplified assumptions that do not fully capture the complexity of a real bank's capital structure (for example, we assume a single class of DCL CoCo debt and do not model other contingent liabilities or interactions with other capital instruments). This simplification was necessary to isolate the effect of the mechanism, but it means that potential secondary effects are not considered. Second, the analysis relies on historical data and a back-testing approach, which may limit the generalizability of the findings (future crises or market conditions could deviate from the historical patterns). Third, the simulations do not explicitly incorporate potential dynamic responses from investors or changes in regulatory behavior. In a real-world setting, the introduction of DCL CoCo bonds could itself influence investor confidence or regulatory actions in ways that are not captured in the simulations.

[1]Since UBS took over Credit Suisse in 2023, the archive of 20-F reports for Credit Suisse is hosted by UBS at `https://www.ubs.com/global/en/investor-relations/complementary-financial-information/disclosure-legal-entities/archive-credit-suisse.html`

Chapter 4

Empirical Analysis and Results

4.1 Introduction

This chapter conducts an empirical evaluation of the DCL framework across three representative bank crisis scenarios. The selected case studies include the severe idiosyncratic collapse of Credit Suisse, a moderate contained stress event at Deutsche Bank, and the systemic failure of Lehman Brothers. By investigating crises of varying magnitude and origin, the analysis tests the robustness of the DCL mechanism under diverse market conditions and identifies where its effects are most pronounced.

The methodology leverages real-world historical data and simulation modeling. Actual financial and market data from each case are used to faithfully recreate the crisis conditions, while a simulation model projects the impact of dynamically adjusted leverage triggers on key risk and capital metrics. By calibrating the DCL framework to each scenario, the analysis evaluates how such contingent convertible instruments would have performed if deployed in practice. This approach ensures that the evaluation reflects realistic stress dynamics and institutional details of each crisis scenario.

By comparing outcomes across the three cases, the chapter identifies where the DCL framework provides the greatest benefits and where its impact is more limited. Contrasting the systemic market-wide collapse (Lehman Brothers) with the firm-specific crisis (Credit Suisse) and the contained stress scenario (Deutsche Bank) clarifies the contexts in which dynamic leverage control most effectively bolsters bank resilience. Ultimately, this comparative perspective highlights the conditions under which the DCL CoCo framework yields the largest improvements in financial stability and resilience, and those in which its advantages are attenuated.

Case Study: Credit Suisse

4.2 Overview of the Credit Suisse Collapse

Credit Suisse's collapse in March 2023 marked a significant event in global financial markets, revealing vulnerabilities within existing regulatory frameworks and highlighting systemic risks associated with traditional contingent convertible (CoCo) bonds. Over several years preceding the collapse, Credit Suisse faced repeated challenges, including substantial financial losses linked to high-profile scandals and investment mishaps, deteriorating investor confidence, and declining stock prices[33]–[35].

The critical moment occurred when Swiss regulators, specifically FINMA, intervened, fully writing down approximately CHF 16 billion of Additional Tier 1 (AT1) CoCo bonds while partially preserving shareholder value. This unconventional regulatory decision led to considerable backlash among bondholders and triggered widespread market panic and uncertainty about the viability and predictability of traditional CoCo instruments. Patrick Bolton emphasized how this regulatory discretion not only inverted conventional loss hierarchies but also severely undermined investor trust in CoCos, casting doubts on their effectiveness as reliable capital buffers [2].

Furthermore, traditional CoCo bonds, initially proposed by Flannery and others [5], were intended to automatically bolster bank capital during financial stress through predefined conversion triggers based primarily on accounting capital ratios. However, Credit Suisse's experience demonstrated fundamental flaws in this design. The delayed responsiveness of accounting-based triggers and the opaque nature of discretionary regulatory interventions resulted in abrupt, large-scale equity dilution and exacerbated market volatility.

The collapse underscored the urgency to revisit CoCo bond structures, prompting examination into alternative frameworks such as DCL. By studying the specific dynamics of the Credit Suisse crisis, this thesis aims to investigate whether the proactive, gradual conversion mechanics of DCL CoCos could have effectively mitigated the severity of the collapse, providing a clearer, more predictable response to financial distress scenarios.

4.3 Application of DCL CoCo Bonds to the Credit Suisse Case

This section presents a detailed empirical analysis investigating the effectiveness of the DCL framework for contingent convertible (CoCo) bonds, specifically through the lens of the Credit Suisse collapse. The analysis explores how a DCL-based CoCo structure might have performed differently compared to traditional CoCo bonds during the financial turmoil experienced by Credit Suisse.

4.3.1 Historical data

Figure 4.1 shows data for Credit Suisse gathered from Reuters Refinitiv Eikon API. The timeframe was deliberately chosen to be from 2018 to 2023 to capture the state of the stock during normal times and to contrast with the 2023 crisis. By June 2025, after substantial dilutions and regulatory interventions, the share price had fallen over 95% from 2018 highs, and the stock was finally delisted from the NYSE (New York Stock Exchange).

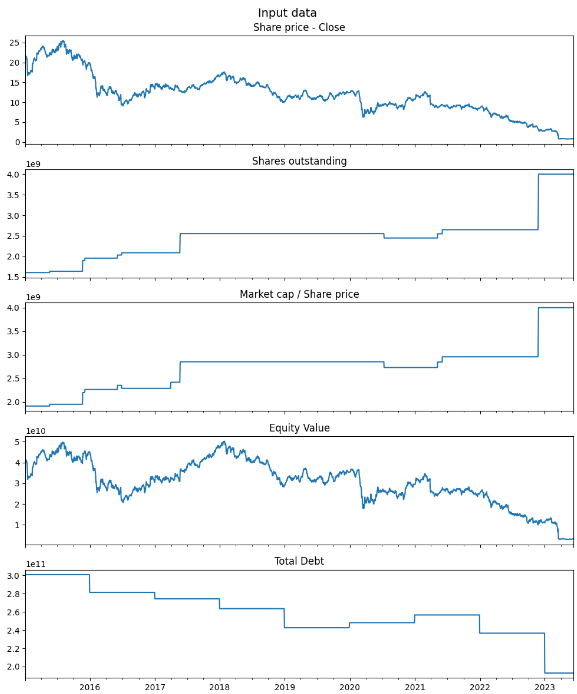


Figure 4.1: Historical data for Credit Suisse

4.3.2 Simulating DCL Contingent Convertible bonds

The original thesis introducing the DCL framework simulated a stock using geometric Brownian motion (GBM) choosing sensible parameters. Many of these parameters could be translated without much change for real-world scenarios, with on exception. Banks are generally much more leveraged than non-financial companies. As a result, it is not uncommon to see debt-to-asset ratios for banks in the range of roughly 85% to 95%[36]. To account for the higher leverage in the banking sector, the minimum leverage threshold was set at 85% and the maximum at 95% (where the originial paper set them at 50% and 80% respectively). The price of conversion was in every case set at the initial closing price of the shares at issuance.

The initial nominal value of the DCL bond was set to match the size of total AT1 debt at issuance in 2018, to test the case if all traditional CoCo bonds were DCLs instead. This resulted in the initial nominal, Q, to be set at CHF 10.216 billion to match the reported total value of AT1 debt in the 20-F filings. Notably, the total debt of the company does not equal the total amount of DCL bonds, which is why the derivations had to adjust using α_k to be proportional to the total debt of the company.

Similarly, the number of shares outstanding was set at the initial real value in 2018 and allowed to float with the DCL, since it can issue new shares conditional on breach of the lower trigger. The annual cost of debt was set to match Credit Suisse AT1 debt issuances and set at 7.5%[1].

Otherwise, the parameters in the model were set to match those of the simulations from the proposing paper, which resulted in the inputs shown in table 4.1.

Inputs	**Values**
Nominal debt value, Q	10,216,000,000 CHF
Maturity of loan in years, N	10
frequency of payments per year, n	2
Annual cost of debt, R	7.5%
Initial number of shares NS_0	1,607,168,947
Conversion price, S_p	21,69 CHF
Triggering leverage, L_c	0.90
Lower leverage level, L_{min}	0.85

Table 4.1: Input parameters for modelling a DCL bond on Credit Suisse

Figure 4.2 shows the results of simulating a DCL bond on the input parameters in table 4.1, and it shows how the leverage would change the capital structure of the company over time. Notable for Credit Suisse is the high operating leverage

[1]See *SEC Form 6-K/A: Revised Financial Report for Fourth Quarter 2013*

which results in a prevalence and immediacy of additional share issuance (starting in mid-2016) which continued for every subsequent interval date. This is a much earlier intervention than other metrics at the time would permit, since the model set the maximum leverage trigger conservatively at 90% with the aim to adjust for increased stability and preempt or mitigate a potential future crisis.

Comparing the leverage ratios with and without the DCL bond shows that by 2021 the bond had made enough conversions to significantly draw down the leverage ratio, at least to a more sensible level than if the bond had not been in place. This came at the cost of bondholders who only received direct interest on the bonds on the first three payment dates, every later payment being converted into equity. For the shareholders, the resulting dilutions amounted to a total of CHF 5.5bn worth of new shares being issued.

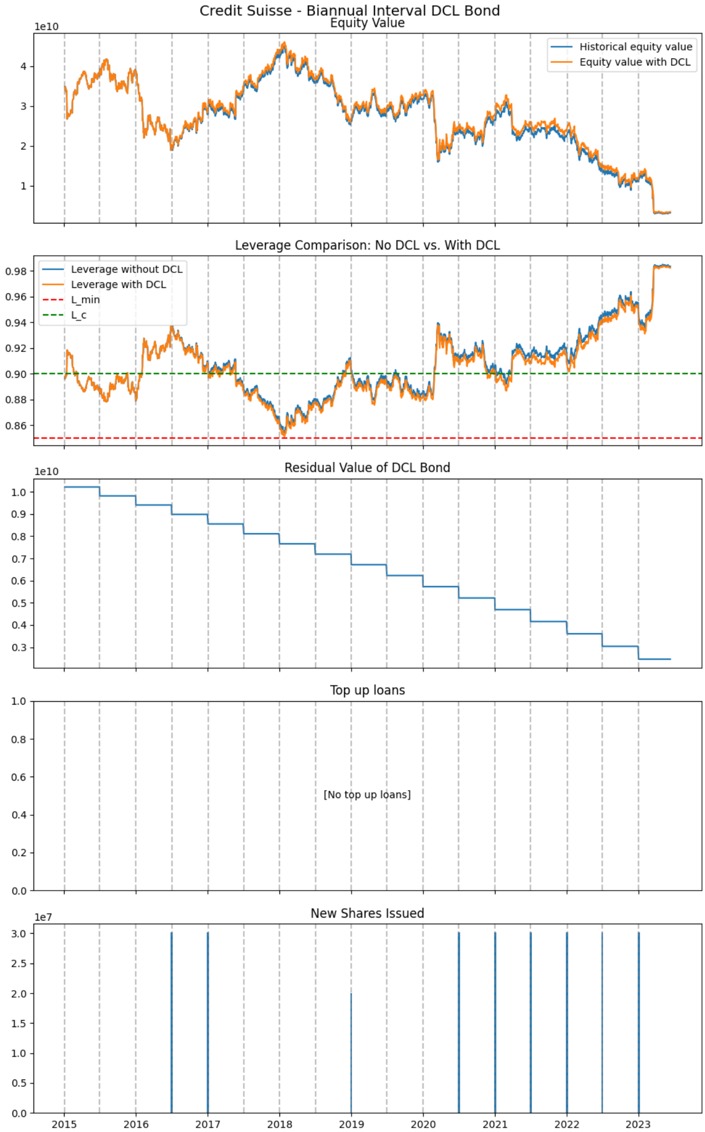


Figure 4.2: Effect of applying a DCL mechanism on AT1 debt for Credit Suisse

4.4 Sensitivity Analysis

Configuring the bond parameters will be important to balance the interests of bondholders and shareholders, since different parameters can greatly affect the resulting outcomes. The following sensitivity analysis aims to aid management in this decision-making by thoroughly comparing different model parameters and analysing their effect on the bond, and finally deliver some recommendations based on the results.

To compare conversions for shareholders and bondholders, the total dilution for shareholders is calculated as the sum value of additional shares issued during the lifetime of the DCL bond. That is, the sum value of those interest payments that were converted into equity, using the conversion price S_p and market price S_k:

$$\sum_{k=1}^{N} \frac{P_N}{S_p} \cdot \mathbb{1}_{\{L_k > L_c\}} S_k \tag{4.1}$$

4.4.1 Frequency of interest payments and leverage adjustments

The DCL base contingency mechanism only adjusts at set intervals. Increasing the frequency of checks leads to an increase in the probability of conversion of interest payments and of gradual bondholder dilution. However, it also leads to a more timely and effective adjustment of leverage and decreases the probability of default for the company.

In the Credit Suisse case, the share price and the leverage were highly volatile throughout the period. The leverage frequently crossed the upper threshold, causing the bond to be diluted at interval times. Increasing the frequency of checks also increases the frequency of conversions. Since the frequency of payments also affects the size of each payment, the resulting leverage adjustments were not greatly affected, as can be seen in figure 4.3.

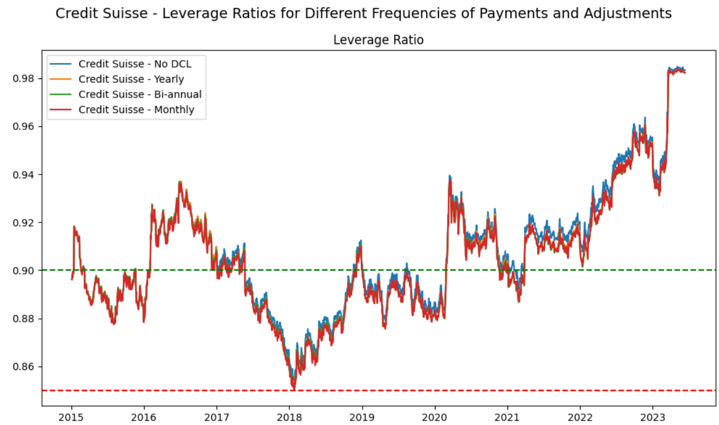


Figure 4.3: Leverage over time for different frequencies of payments (and leverage adjustments)

The effects of the frequency had little effect on the resulting equity dilutions (value of interest conversions into equity), as can be seen in table 4.2.

Frequency of payments and adjustments, n	**Total dilution [CHF]**
Monthly	2,561,445,587
Bi-annual	2,445,032,848
Yearly	2,555,453,474

Table 4.2: Dilution to Credit Suisse stock for different conversion prices.

4.4.2 Converison price and bond conversions

The conversion price plays a crucial role in determining the extent of bond conversions into equity. If set too low, it can cause excessive dilution for existing shareholders. If set too high, it may not effectively recapitalize the bank during financial distress. Figure 4.4 illustrates how different conversion prices affect the leverage over the observed period.

At higher conversion prices (set above the initial market price), fewer shares are issued per interest payment converted, resulting in less immediate dilution but potentially insufficient leverage adjustments during periods of distress. Conversely, lower conversion prices result in a higher number of shares issued per converted interest payment, facilitating faster leverage corrections at the cost of greater dilution.

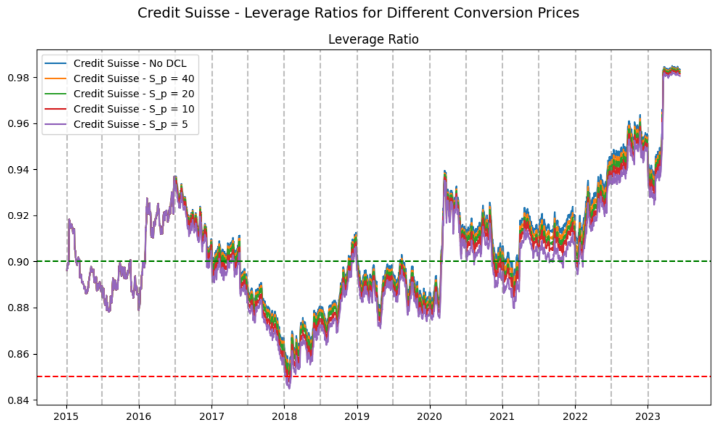


Figure 4.4: Leverage over time for different conversion prices

For Credit Suisse, setting the conversion price near or slightly below the initial share price (around CHF 20) balances recapitalization effectiveness and dilution management. Lowering the conversion price below 10 CHF resulted in significantly decreased shareholder dilution (at the cost of smaller leverage adjustments) as can be seen in table 4.3.

Conversion price, S_p	**Total dilution [CHF]**
40	1,440,862,600
20	2,582,021,019
10	4,227,971,795
5	5,379,393,217

Table 4.3: Dilution to Credit Suisse stock for different conversion prices.

4.4.3 Leverage triggers

The choice of leverage trigger thresholds significantly impacts the responsiveness and effectiveness of the DCL mechanism. Setting the leverage trigger higher delays conversions, potentially allowing risks to escalate, while a trigger set too low (below 85%) can lead to overly frequent conversions,

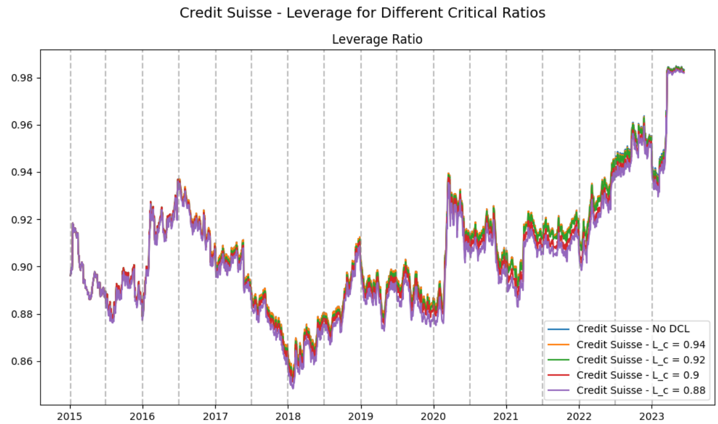


Figure 4.5: Leverage over time for different critical trigger values

Figure 4.5 depicts the impact of varying critical leverage trigger values on Credit Suisse's leverage ratio over time. At a lower trigger, the DCL mechanism responds early to increasing leverage, providing timely but frequent interventions that keep leverage tightly controlled. Conversely, a higher trigger results in fewer adjustments as leverage accumulates closer to critical points.

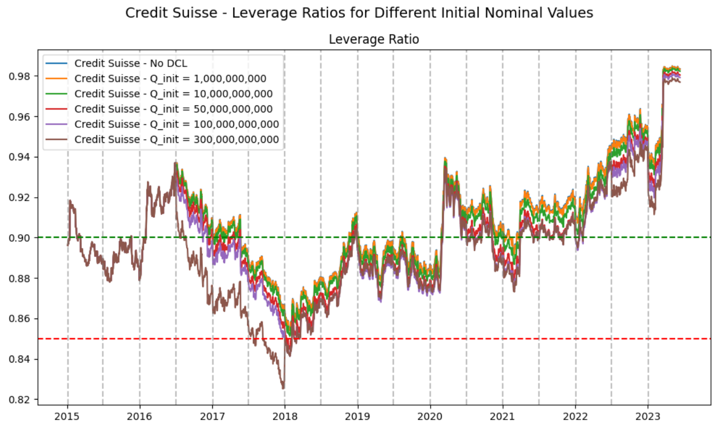
For Credit Suisse, a sensible leverage trigger around 90% provided a balanced approach, enabling manageable equity dilution while ensuring sufficient leverage corrections to mitigate severe distress scenarios more effectively.

Conversion trigger, L_c	**Total dilution [CHF]**
0.94	266,117,457
0.92	590,169,920
0.9	2,445,032,848
0.88	4,284,133,873

Table 4.4: Dilution to Credit Suisse stock for different critical triggers.

4.4.4 Initial nominal

The initial nominal value of the DCL determines how much of the capital structure of the company is affected by the mechanism. The simulations in this paper generally equate the initial nominal values to historical AT1 debt which has historically only been a relatively small proportion of the total debt. Increasing this value has a great effect on the resulting dilutions, as can be seen in Figure **??**.



Of particular note was the largest simulation where the initial nominal was set to equal approximately the historical initial total debt (CHF 300bn). The result was a greatly increased speed of leverage drawdown since interest payments are also larger, and the total dilution is greatly increased (though seemingly not enough to avoid the eventual collapse, according to the figure). However, one must keep in mind that bank managers would probably not allow for this large of a ratio of relatively high interest-paying debt.

Initial nominal, Q_{init} [CHF]	**Total dilution [CHF]**
1,000,000,000	260,139,632
10,000,000,000	2,410,690,779
50,000,000,000	5,455,826,836
100,000,000,000	7,740,773,567
300,000,000,000	21,713,380,713

Table 4.5: Dilution to Credit Suisse stock for different initial nominal values.

4.4.5 Conclusions and Comparisons to Traditional CoCo Bonds

Compared to traditional CoCo bonds, DCL CoCos offer distinct advantages by addressing critical shortcomings highlighted during the Credit Suisse collapse. Traditional CoCo bonds typically rely on fixed capital ratio triggers or regulatory discretion, which can lead to delayed conversions or abrupt, substantial write-downs. In contrast, the dynamic leverage monitoring and incremental equity conversions inherent in DCL bonds provide a more controlled, predictable approach to recapitalization.

The literature demonstrates that, under the traditional CoCo bond structure, leverage adjustments can be significantly delayed, only occurring once severe distress thresholds were breached. This delay is likely to amplify market panic and cause excessive investor losses, as seen in the 2023 crisis [2], [11], [37]. Conversely, the DCL framework proactively adjusted leverage with frequent, smaller conversions of interest payments into equity, significantly reducing abrupt equity dilution and mitigating investor uncertainty.

The sensitivity analysis underscores the importance of carefully calibrating DCL parameters to ensure optimal performance. Setting appropriate conversion prices and leverage triggers can significantly mitigate systemic risks, prevent abrupt dilutions, and enhance stability. Specifically, the analysis recommends a conversion price around the initial market price to balance dilution and effective recapitalization. Leverage triggers set to around 90% to ensure timely yet controlled adjustments to leverage, and mitigating the effect of market disruptions.

Implementing these recommendations might have provided Credit Suisse with a more gradual and predictable recapitalization path, potentially preventing the market panic and bondholder wipeout which occurred during the 2023 collapse.

Case Study: Application of DCL to other banks

4.5 Introduction

Building on the insights from the Credit Suisse case study, this chapter examines the application of the DCL framework to two additional banking institutions: Deutsche Bank and Lehman Brothers. These two cases are chosen to illustrate the performance of DCL under different crisis scenarios. Deutsche Bank represents a bank that underwent periods of financial stress yet ultimately avoided collapse, providing a test of DCL in a moderate distress scenario. In contrast, Lehman Brothers suffered a catastrophic failure during the 2008 global financial crisis; a worst-case scenario that allows us to evaluate the limitations of DCL in the face of systemic collapse.

Similar to the Credit Suisse analysis, historical data and simulations are employed to assess how a DCL-based contingent convertible bond might have operated for each institution. We discuss the frequency and magnitude of DCL-triggered conversions (such as interest-to-equity swaps or contingent debt issuances) and their effect on each bank's leverage trajectory. By comparing these outcomes, we aim to understand how DCL can bolster a bank's resilience or fall short, depending on the severity and nature of a crisis. The following sections detail the findings for Deutsche Bank and Lehman Brothers, respectively, followed by a comparative discussion of all three case studies (Credit Suisse, Deutsche Bank, and Lehman Brothers).

4.6 Deutcshe Bank

Deutsche Bank's financial health in the post-2008 era was characterized by bouts of instability, though it never experienced a complete failure. The bank struggled with high leverage and legal troubles throughout the 2010s, and its stock price and creditworthiness periodically came under severe pressure (for example, during 2016 and 2018)[38], [39]. However, unlike Credit Suisse in 2023, Deutsche

Bank managed to weather these storms without triggering a crisis or resorting to an external bailout. This makes it an insightful case to apply the DCL framework as a preventive measure in a contained stress scenario.

For the DCL simulation, we consider Deutsche Bank's balance sheet and market data over a multi-year period encompassing its known stress episodes (e.g. the 2015–2018 timeframe). Using this data, we calibrate a DCL-based CoCo instrument with parameters similar to those used in the Credit Suisse case (e.g. with the same critical thresholds, but with a different conversion price, set to equal the initial share price). The DCL mechanism is applied to monitor Deutsche Bank's leverage ratio as shown in Figure 4.6. During periods of rising leverage or deteriorating equity, the DCL trigger automatically converts a portion of interest obligations into equity for the CoCo bondholders, thereby boosting equity capital and reducing debt. In periods of stability, no conversion is triggered and the CoCo behaves like normal debt. This dynamic adjustment aims to keep Deutsche Bank's leverage within a safe band, avoiding breaching any regulatory capital triggers or the point of non-viability (PONV).

The results for Deutsche Bank indicate that the DCL framework would have activated only modestly, in sharp contrast to the more frequent interventions observed in the Credit Suisse scenario. Fewer interest-to-equity conversion events are triggered under DCL, each corresponding to moments of notable stress. For instance, during early 2016 when fears of a possible AT1 coupon suspension caused Deutsche Bank's contingent capital bond prices to plunge [4], the DCL mechanism would likely have kicked in preemptively. Instead of allowing panic to fester, DCL would convert that period's coupon payments into equity, shoring up Deutsche Bank's Tier 1 capital. This incremental recapitalization could have reassured investors by demonstrating automatic loss absorption, and indeed in reality Deutsche Bank did manage to continue paying its AT1 coupons after reaffirming its capital strength.

Figure 4.6 illustrates Deutsche Bank's leverage ratio over time with the DCL CoCo in place. The plot shows that leverage stays relatively stable, with upticks during stress periods that triggered DCL conversions. These modest interventions had a cumulative effect of gradually lowering the leverage, without significantly affecting the equity value of the bank. In summary, the Deutsche Bank case demonstrates the DCL mechanism in a scenario of contained distress: the framework adds an automatic stabilizer that converts interest to equity sparingly, ensuring the bank never strays into dangerously high leverage. This contrasts with the Credit Suisse experience, where much larger and more frequent interventions would have been necessary to counteract a far more severe decline in asset value. By avoiding a crisis altogether, Deutsche Bank under DCL highlights how proactive leverage control can maintain bondholder value, rather than having to manage a full-blown collapse.

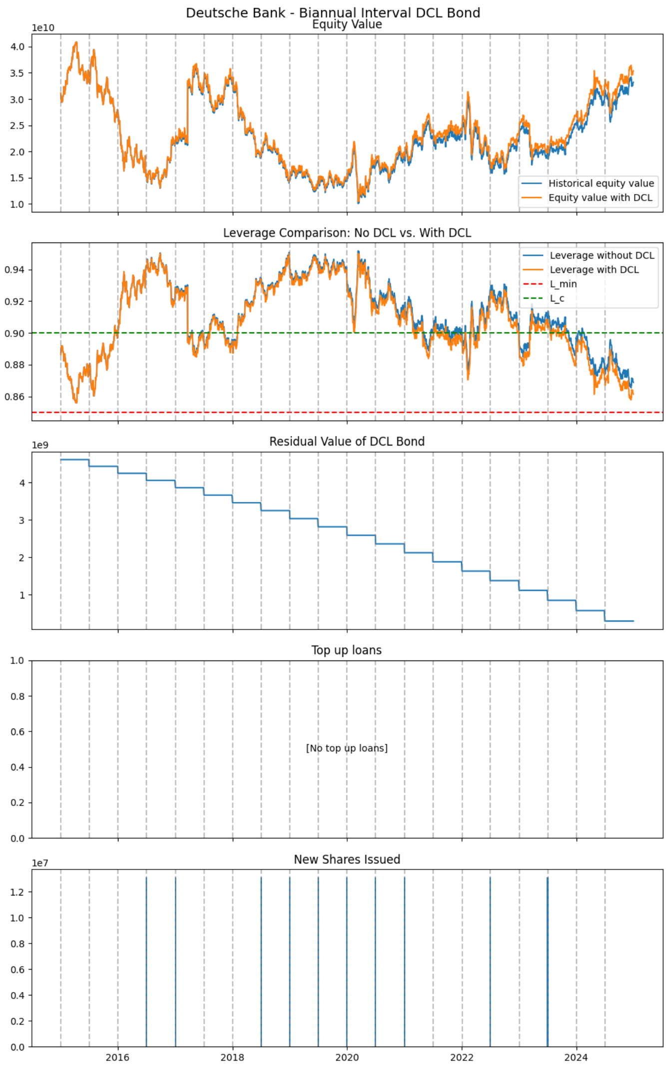


Figure 4.6: Results of simulating DCL for Deutsche Bank show a limited and gradual conversion into equity during times of distress.

4.7 Lehman Brothers

Lehman Brothers presents a starkly different scenario, a case of systemic collapse where the DCL framework's limitations become apparent. Prior to its bankruptcy in September 2008, Lehman Brothers had aggressively expanded its balance sheet, accumulating high leverage during the mid-2000s housing boom. In fact, by 2007 the firm's leverage ratio had climbed to extraordinary levels (over 30:1, meaning over $30 in assets for every $1 in equity)[40]. This made Lehman highly vulnerable to any downturn in asset values. Yet during those boom years, a DCL-based CoCo instrument might not have triggered any conversions at all. Lehman's reported capital ratios remained adequate, and the absence of stress signals would mean no automatic interest-to-equity swaps. In other words, through 2006–2007 the DCL mechanism would likely have stayed dormant while Lehman continued to issue debt and grow, inadvertently allowing leverage to remain elevated. The very strength of the pre-crisis market (and Lehman's record profits in 2005-2007) meant that DCL had little reason to intervene early on.

When the situation began to deteriorate in 2007 and especially in 2008, the DCL trigger for Lehman Brothers would belatedly start activating. As mortgage defaults surged and Lehman's asset values plummeted, the bank's leverage would rapidly breach the trigger threshold, forcing the DCL CoCo to respond. In theory, this response would involve converting interest (and possibly portions of principal, if structured to do so) into equity to recapitalize Lehman. Such conversions, however, would have been fighting a losing battle against the swift erosion of Lehman's asset base. Lehman's share price collapsed and its losses mounted dramatically in 2008 as the firm lost $2.8 billion in Q2 2008 and announced an additional $6 billion capital raise in June 2008[40], alongside asset sales to reduce leverage. Despite these efforts (which mirror what DCL conversions aim to achieve, i.e. raising equity and cutting debt), market confidence in Lehman did not recover. The DCL mechanism, similarly, would have added equity incrementally, possibly buying some extra time, but it is unlikely to have reversed the terminal decline. At best, continuous DCL conversions might have slowed the descent into insolvency, delaying the point of non-viability by a matter of weeks or months.

Crucially, Lehman Brothers' collapse was driven by systemic factors that DCL could not address: a fundamental collapse in asset quality and liquidity. Even if DCL had been in place providing automatic recapitalization, the magnitude of Lehman's losses would have overwhelmed those conversions. Scholars such as Andrew G. Haldane provide evidence that conventional CoCo bonds (with static triggers) would not have prevented Lehman's bankruptcy because the triggers would have been tripped too late or not at all [12]. DCL's continuous monitoring could trigger earlier than static ratios, but in Lehman's case the crisis dynamics were so fast and severe that earlier intervention might still not suffice. Eventually, Lehman would run out of time and capital, a fate that DCL is more likely to delay, not avoid, when underlying insolvency is imminent. Indeed, the analysis underscores that DCL is designed to "buy time, not magically cure insolvency". In Lehman's scenario, even if DCL had stretched the timeline, the end result would almost certainly remain a collapse in the absence of an external rescue or broader market stabilization.

Figure 4.7 illustrates a hypothetical trajectory of Lehman Brothers' leverage under a DCL regime versus the actual collapse. Due to the rising equity value through 2007, the DCL framework issued additional top-up debt, raising the leverage above the no DCL scenario, potentially exacerbating the following crisis. Then during 2008 we see a series of conversion-driven equity infusions as the crisis unfolds for both scenarios. Ultimately, the DCL-triggered interventions fail to stabilize the firm, reflecting the reality that Lehman declared bankruptcy despite last-minute capital injections. In sum, the Lehman Brothers case highlights a key limitation of the framework similarly to the Credit Suisse case: in an extreme systemic crisis where asset quality collapses across the board, DCL cannot by itself save the bank. It may delay the failure and reduce the chaos of an abrupt collapse, but it cannot compensate for a fundamentally unsustainable balance sheet. This outcome stands in contrast to Deutsche Bank's case (where DCL could gradually stabilize leverage levels) and even to Credit Suisse's case (where DCL could significantly delay the collapse). Lehman's failure emphasizes that DCL, while powerful, is not a panacea for all crises.

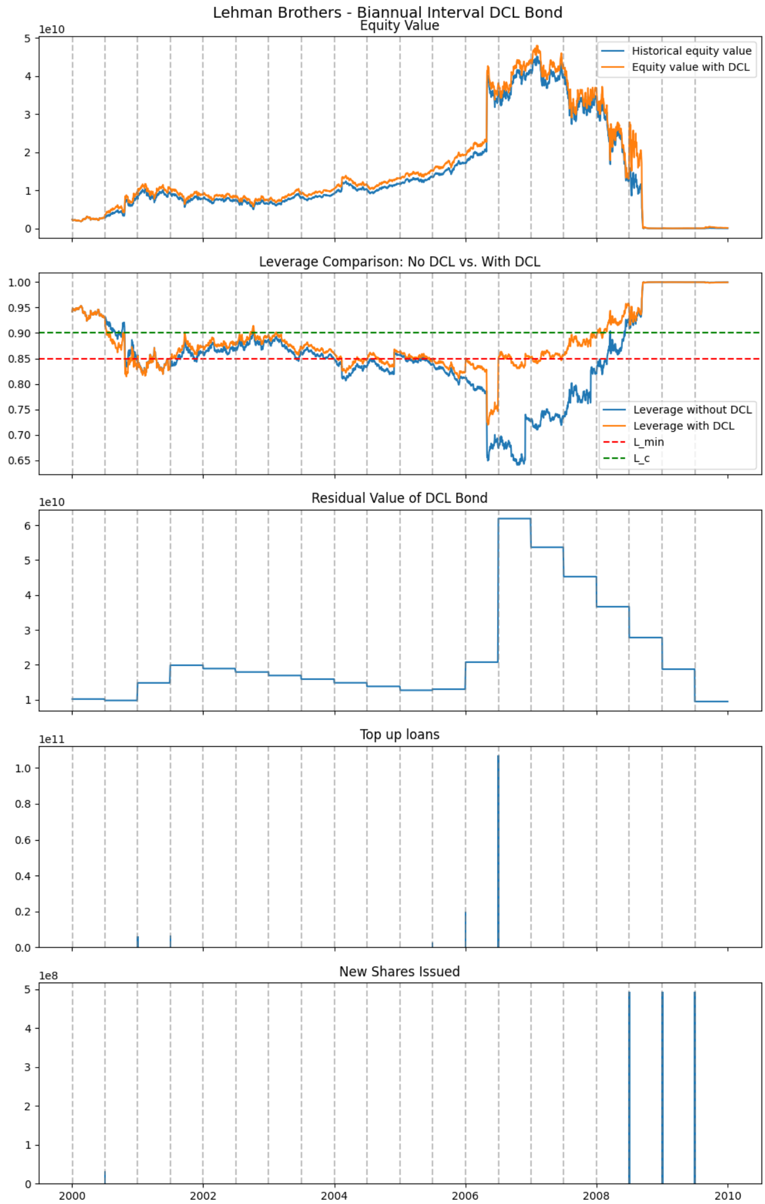


Figure 4.7: The results from simulating DCL on Lehman brothers shows large additional DCL issuances leading to the Great Financial Crisis, therefore raising the leverage at an inappropriate time, considering the need for large capital injections during the crisis.

Chapter 5

Discussion

The analysis underscores several critical implications regarding the efficacy of the DCL framework compared to traditional Contingent Convertible (CoCo) bonds. Primarily, this research contributes significantly to the existing body of literature by empirically validating the theoretical advantages of DCL mechanisms through real-world simulation, particularly in the context of the Credit Suisse collapse.

The most important insight from this thesis is that the DCL approach could substantially enhance bank stability by providing proactive, incremental equity adjustments rather than relying on abrupt, large-scale interventions. The findings demonstrate that, had Credit Suisse implemented DCL-based CoCo bonds, the effect of dramatic market disruptions and the following bondholder wipeout may have been mitigated. These results also show that DCL addresses some of the criticisms highlighted in the literature concerning traditional CoCo mechanisms, namely, their reliance on static triggers and the opacity associated with regulatory discretion [2], [37].

The sensitivity analysis revealed that selecting appropriate parameters, particularly conversion prices and leverage thresholds, is crucial to balancing recapitalization efficiency and market impact. The parameters identified through simulation suggest a conversion price close to or just under the initial market price and a leverage trigger around 90%, providing a compromise between immediate leverage correction and gradual shareholder dilution. The sensitivity results should aid issuers and regulators in understanding the effectiveness of choosing appropriate parameters.

Moreover, this research illustrates how the limitations of traditional CoCo bonds can be addressed. Traditional mechanisms often trigger conversions only after severe financial distress (or leave the decision to regulators at PONV), which tends to exacerbate market instability and investor panic, demonstrated by the abrupt AT1 bond wipeout for Credit Suisse. In contrast, the DCL framework, with its gradual conversions, would significantly reduce the likelihood of sudden large-scale losses and systemic disruptions. Essentially, a single drastic drawdown will not occur under DCL, unless regulators force it. Instead, the loss to bondholders is distributed in smaller doses, which may be more manageable for markets and stakeholders (hence, “no pain, no gain”, small pains to avoid a big one, following Flannery’s original concept for reverse convertible debentures [41].

However, several limitations warrant consideration when interpreting the results. First, the study relies on historical simulation data, inherently carrying assumptions that may oversimplify real-world complexities. Second, investor perception and regulatory acceptance of DCL instruments were not directly modeled, potentially impacting market dynamics differently than predicted since persistent conversions could negatively affect shareholder perceptions of the health of the company. Future research could address these gaps by conducting more extensive empirical studies across diverse banking environments and assessing investor behavior through surveys or market studies.

Despite these caveats, the evidence presented is robust in showing the theoretical and simulated benefits of DCL over traditional CoCo structures. Importantly, the analysis is grounded in a real-world case study, giving the results practical relevance. The proactive leverage control of DCL appears to address the core weakness identified in traditional CoCos: the delay in response. The results align with views that well designed CoCos (with high triggers and strong incentives) can motivate banks to strengthen capital well before insolvency [24]. In the DCL model, conversions can happen early and often enough to keep the bank out of the danger zone, embodying that sentiment.

From a regulatory and policy perspective, these findings are significant. They suggest that incorporating the DCL mechanism could enhance the resilience of banks and reduce systemic risk. A DCL framework could be seen as an automated stabilizer for bank capital. By embedding market-based triggers, they lessen the need for discretion from regulators (which, as seen, can be a double-edged sword) and provides more transparency to investors about how a bank will recapitalize under stress. This could, in theory, reduce ”moral hazard” and increase market discipline, as bank management would know that any excessive leverage will promptly dilute shareholders, aligning incentives more with prudent risk management [41].

Naturally, implementing such a framework would require careful design of the trigger and conversion terms (as we have analyzed) and clear communication to the market. There may also be legal and operational hurdles to issuing DCL CoCos, and it would be important to ensure that these instruments qualify as regulatory capital (just as AT1 CoCos do under Basel III [11]).

In summary, the DCL approach addresses many of the shortcomings observed in the Credit Suisse collapse and in the literature on traditional CoCos. It provides a market-aligned mechanism for recapitalization that could prevent the kind of sudden collapse witnessed in 2023. The potential downsides (dilution and possibly investor wariness of frequent conversions) seem manageable with proper calibration and are arguably a necessary trade-off for greater stability.

5.1 Comparison of DCL Outcomes

Across the three case studies; Credit Suisse, Deutsche Bank, and Lehman Brothers, we observed that the Dynamic Control of Leverage framework exhibits both significant strengths and clear limitations, depending on the crisis context. Here, we discuss the qualitative differences:

5.1.1 Deutsche Bank (Moderate Stress):

DCL kept Deutsche Bank's leverage under control with only minimal intervention. The bank never reached a critical failure point under the DCL scheme. This demonstrates DCL's efficacy in a moderate, idiosyncratic stress scenario, acting as a protective buffer that prevents a downturn from snowballing into a crisis. In Deutsche Bank's case, the DCL mechanism essentially averted any collapse by stabilizing leverage preemptively.

5.1.2 Credit Suisse (Severe Idiosyncratic Crisis):

The Credit Suisse analysis from the previous chapter showed that DCL would have significantly delayed the bank's collapse, although not completely preventing it. Frequent conversions of interest to equity would have provided vital breathing room (on the order of months of delay in reaching PONV). Thus, for a major bank experiencing a rapid loss of confidence and capital (as Credit Suisse did in 2023), DCL can meaningfully mitigate the severity of the crisis. It buys time for management or regulators to intervene, potentially avoiding the need for an outright bailout or the kind of abrupt AT1 wipeout that occurred [2].

5.1.3 Lehman Brothers (Rapid Systemic Collapse):

In the Lehman scenario, even an optimally designed DCL could not have prevented failure. A conservatively designed DCL might have delayed collapse to some extent but ultimately would not realistically save Lehman without external rescue, due to the sheer scale of losses and system-wide loss of liquidity. This underlines that DCL is not a cure-all; in worst-case systemic crises, its benefit is largely in softening the blow (perhaps enabling a more orderly resolution) rather than fully averting bankruptcy.

5.1.4 Summary

Comparing the outcomes highlights a few crucial points. First, DCL is highly effective at maintaining stability in contained or moderate crises, as evidenced by the Deutsche Bank case. The automatic incremental recapitalizations can keep a bank from ever hitting a danger zone, thereby preventing panic from escalating. Second, in intermediate crises like Credit Suisse's, DCL cannot outright stop failure if a bank's fundamentals are irreparably damaged, but it can significantly delay collapse and reduce its chaos, providing a critical window for corrective action. Third, in extreme systemic crises like Lehman's, DCL's impact is marginal as it serves only to increase the probability of delaying the inevitable, reinforcing the understanding that no contingent convertible mechanism can substitute for broader solutions (such as market-wide support or timely intervention) when a firm's asset base is crumbling.

Overall, the case studies confirm that the Dynamic Control of Leverage framework offers a valuable improvement over traditional CoCos in many scenarios, but it must be viewed as part of a spectrum of tools. In a best-case application (like the Deutsche Bank scenario), DCL can mitigate a crisis by continuously policing leverage. In a mid-case (Credit Suisse), it can absorb shocks and buy crucial time to fix problems or arrange rescues, even if it cannot ultimately save the bank on its own. And in the worst case (Lehman Brothers), DCL's continuous conversion mechanism would still fail to protect the bank from collapse, illustrating the boundary of its effectiveness. This comparative analysis underscores that while DCL can significantly enhance resilience and reaction speed for banks, it is not infallible as extreme scenarios may still require additional measures beyond the scope of contingent capital instruments.

5.2 Leverage Breaches in DCL Bonds With High Leverage Thresholds

The simulation results reveal a notable divergence when applying the DCL framework to highly levered banks, compared to the original DCL proposal. In particular, breaches of the minimum leverage threshold under DCL lead to alarmingly large "top-up" debt issuances (i.e. new debt that must be issued to restore leverage to the minimum). This outcome was not as pronounced in the original paper's simulations, largely because that study assumed lower leverage levels and thresholds. Banks and similar financial institutions typically operate with much higher leverage ratios (on the order of 85–90%[36]) than firms in other sectors, so their DCL thresholds (both minimum and maximum) must be set higher. As a result, when a bank breaches its leverage thresholds, the size of the required adjustment (debt or equity issuance) is significantly larger than in the original lower-leverage scenarios (see *Top-up loans* in Figure 5.1). This difference is mainly attributed to the compounding effect of high baseline leverage on the DCL adjustment formulas, leading to much bigger corrections in a banking context.

For a typical non-financial company with moderate leverage, these DCL adjustments (adding equity or debt) would be relatively manageable. In a highly levered bank, however, two issues arise: *1)* a breach of the minimum leverage threshold necessitates a very large debt issuance to compensate, and *2)* by contrast, a breach of the maximum threshold is corrected with a relatively small equity conversion (since only an interest payment's worth of equity is added). In other words, when leverage thresholds are set very high, as they would be for banks, the DCL mechanism becomes asymmetric. The downside case (leverage too low) requires a far bigger intervention than the upside case (leverage too high). The following analysis and example illustrate why this is the case and quantify the magnitude of these adjustments.

5.2.1 Adjustments triggered by leverage breaches

Banks generally operate with leverage ratios around 85–90%, which is substantially higher than the leverage assumptions in the original DCL study. Implementing DCL with such high leverage thresholds leads to markedly different adjustment dynamics. In essence, the higher the baseline leverage, the larger the absolute changes in debt or equity needed to correct any deviation. This section uses the DCL formulas to demonstrate how raising the leverage thresholds into the 85–90% range can make the required adjustments much larger when breaches occur.

To begin, recall the definition of leverage. The leverage at time k is given by Equation 2.1 as the ratio of debt to total assets (debt plus equity) at that time, determined using market values with Equation 2.2. If the leverage at time k exceeds the critical maximum leverage threshold L_c (i.e. $L_k > L_c$), the DCL framework responds by converting the CoCo bond's interest payment at time k into equity. In practice, this means the interest that would have been paid to bondholders is instead turned into an equivalent value of new shares, which increases equity by an amount ΔE_k. Because debt remains the same while equity rises, the leverage ratio is reduced. The adjusted leverage after this interest-to-equity conversion is given by Equation 2.6:

This gradual equity injection brings the leverage down closer to the acceptable range. Notably, ΔE_k (the forgone interest payment) is typically a small fraction of D_k, so this mechanism corrects leverage incrementally. By this framework, frequent small conversions can prevent leverage from straying too far above L_c without dramatically diluting shareholders at any single point in time.

Conversely, if the leverage at time k drops below the minimum leverage threshold $L_{\min}$ (i.e. $L_k < L_{\min}$), the DCL framework issues additional debt to raise leverage back up. Specifically, an amount of new debt ΔD_k is issued such that the lever-

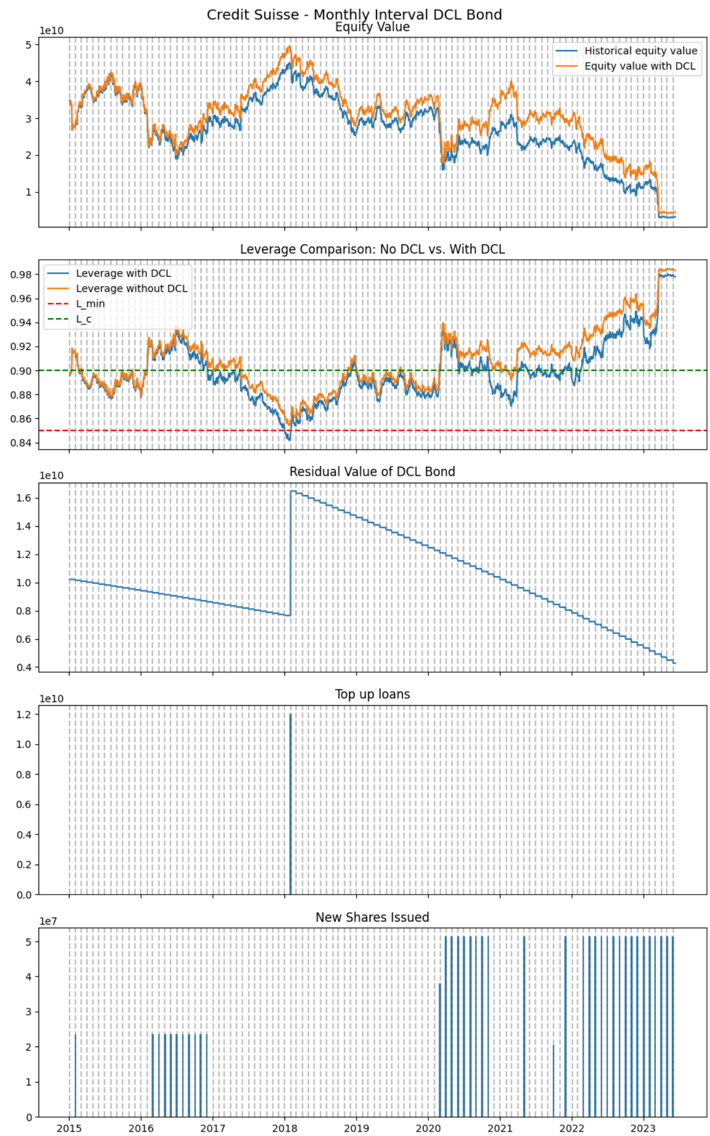


Figure 5.1: For highly levered instituitons, minimum leverage breaches can result in very large top-up loan corrections, which are required to raise the levereage back up to the minimum leverage threshold.

age returns to exactly L_{min}. The new adjusted leverage after this "top-up" debt issuance is given by Equation 2.4:

This mechanism effectively forces the bank to take on more debt whenever its leverage has become too low (i.e. equity has become too high relative to debt).

It is important to observe the asymmetry between these two adjustments at high leverage levels. Adding a given amount of equity ΔE_k when leverage is high has a noticeable effect in reducing L_k (because it increases the denominator of the ratio), but the amount ΔE_k is inherently limited by the size of an interest payment. On the other hand, adding debt ΔD_k when the company is already highly levered has a diminishing effect on L_k as L_k approaches 1, since each additional unit of debt yields a smaller increase in the leverage ratio (because debt and total assets increase in tandem). Therefore, to achieve even a minor increase in L_k (back up to L_{min}), the required ΔD_k can be very large if L_k is initially close to the threshold. The following example quantifies this effect for a real case.

Example: Credit Suisse Leverage Breach

To illustrate the scale of minimum leverage adjustments required under DCL for a highly levered institution, we examine a scenario using Credit Suisse's balance sheet data. Table 5.1 summarizes the relevant parameters for Credit Suisse at a point in early 2023 when its leverage was approximately $L_k = 0.8489$. This corresponds to a total debt (D_k) of approximately CHF 274.28 billion and total equity (E_k) around CHF 48.81 billion. Now, consider a DCL scheme in which the minimum leverage threshold L_{min} is set to 0.85. At this moment, the bank's actual leverage (84.89%) has just fallen slightly below the required 85% minimum. According to the DCL rules, this breach would trigger an immediate debt issuance to bring the leverage back up to 0.85.

Parameter	**Value**
Company	Credit Suisse
Total Debt, D_k	274,280,000,000
Total Equity (Market Value), E_k	48,813,335,162
Leverage (L_k)	0.8489

Table 5.1: Parameters for minimum leverage distance modelling.

Using sample numbers from Credit Suisse, the leverage shortfall is $L_{\text{min}} - L_k = 0.8500 - 0.8489 = 0.0011$. Table 5.2 shows the size of the "top-up" loan, ΔD_k, required to restore L_k to various possible threshold levels at or above 85%, given the bank's current D_k and E_k. To reach a leverage of 85%, the framework must issue approximately CHF 2.32 billion in new debt. This relatively modest amount of debt raises the leverage from 84.89% to 85.0%. However, if the minimum threshold were set even higher, the required capital infusion grows dramatically. For instance, to achieve a leverage of 86% under the same conditions, the bank would need about CHF 25.6 billion in additional debt. Pushing to a 90% leverage threshold would require roughly CHF 165 billion, and for 94% leverage (not far from the upper end of banks' operating range) the necessary top-up debt soars to an astounding CHF 490 billion. These figures underline an exponential growth in required intervention as the threshold rises further from the actual leverage. In fact, the size of the needed top-up loan increases nonlinearly (almost exponentially) as the gap $(L_{\text{min}} - L_k)$ widens (this relationship is visualized in Figure 5.2). Even a 1–2 percentage point increase in the leverage requirement can translate into tens of billions of CHF in extra debt needed.

L_{min}	Distance $(L_{\text{min}} - L_k)$	Top-up loan $\Delta_{D,k}$ $[10^9 CHF]$
0.85	0.001081	2.32
0.86	0.011081	25.57
0.87	0.021081	52.39
0.88	0.031081	83.68
0.89	0.041081	120.66
0.90	0.051081	165.04
0.91	0.061081	219.27
0.92	0.071081	287.07
0.93	0.081081	374.24
0.94	0.091081	490.46

Table 5.2: The size of top-up loans required to increase the current leverage up to a minimum leverage threshold increases (almost) exponentially faster as the distance from the current leverage increases

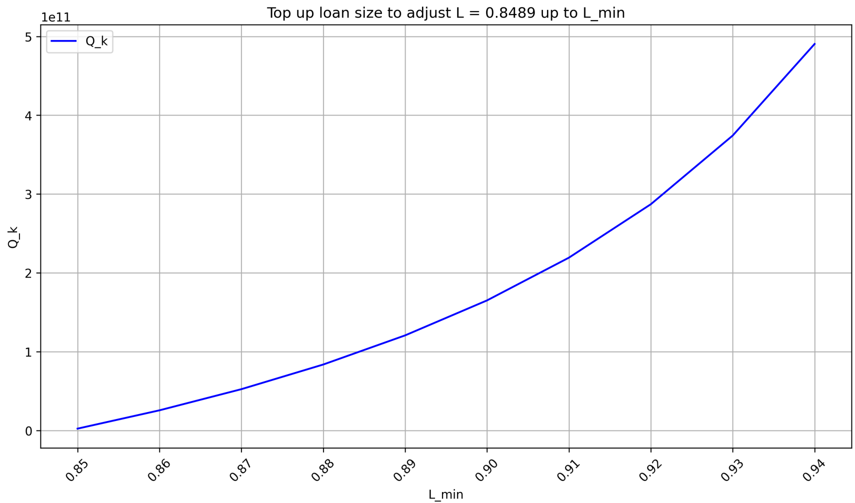


Figure 5.2: The top up loan size to adjust L_k up to L_{min} inccreases in size quickly as the distance of the current leverage from the minimum leverage threshold increases.

This example highlights the practical implications of setting very high leverage thresholds in a DCL framework for banks. When a bank is already highly levered, even a minor shortfall below the minimum leverage ratio can necessitate a prohibitively large recapitalization through debt issuance. Such large interventions could be difficult to implement in reality and might introduce their own risks (for example, straining the bank's borrowing capacity or spooking investors).

Solving Leverage Asymmetry at the Minimum Threshold

The core of the asymmetry problem is that adding debt becomes less effective at raising the leverage ratio when the institution is already highly levered. Each additional unit of debt both increases the numerator (D) and the denominator ($D+E$) in the leverage ratio, so the leverage rises at a slowing rate. To counteract this, a more effective solution could be to reduce the equity component in tandem with the debt injection. In practice, this could be achieved by using the new "top-up" debt proceeds to repurchase shares or pay dividends. By returning the injected funds to shareholders (either by buying back stock or distributing cash), the bank's equity value E is drawn down, which amplifies the increase in leverage for a given amount of new debt. This approach essentially swaps equity for debt, maintaining total assets nearly constant, rather than simply adding assets via new debt.

For the share buyback case, the number of shares to be drawn down would be equal in value to the top-up loan that is issued for the adjustment, so the change in equity value is $\Delta_{E,k} = -\Delta_{D,k}$. Also, since the DCL framework uses the market value as a proxy for the value of total equity then $\Delta_{E,k} = \Delta_{NS,k} \cdot S_k$, where $\Delta_{NS,k}$ is the change in shares outstanding.

When applying an equity drawdown using the top-up loan the equation for adjusted leverage (Equation 2.4) changes, the derivation of which can be seen in Equation 5.1.

$$\begin{aligned} L_{\min} \overset{!}{=} L_{k,adjusted} &= \frac{D + \Delta D_k}{(D + \Delta D_k) + (E + \Delta_E)} \\ &= \frac{D + \Delta D_k}{(D + \Delta D_k) + (E + \Delta_S S_k)} \\ &= \frac{D + \Delta D_k}{(D + \Delta D_k) + (E - \frac{\Delta D_k}{S_k} S_k)} \\ &= \frac{D + \Delta D_k}{D + E} \end{aligned} \tag{5.1}$$

A key observation is that the leverage function becomes simply a linear function of ΔD_k. Comparing this result to the original (Equation 2.4), we see an important difference. In Equation 2.4, ΔD_k appeared in both the numerator and denominator, whereas in Equation 5.1 the ΔD_k cancels out of the denominator. This means that under the buyback (equity drawdown) strategy, each unit of debt issued has a direct, one-for-one effect on increasing leverage, unencumbered by a growing asset base. In effect, the leverage increase is now linear in the size of the top-up loan, instead of diminishing. As a result, the size of the required top-up loan can be dramatically smaller. Solving Equation 5.4 for the required ΔD_k to reach a given $L_{\min}$ yields:

$$\Delta D_k = L_{\min}(D + E) - D \tag{5.2}$$

which is significantly lower than the debt required in the earlier no-buyback scenario. (For comparison, without an equity reduction the required debt adjustment was $\Delta D_k = \frac{L_{\min}(D_k+E_k)-D_k}{1-L_{\min}}$, which for high $L_{\min}$ is much larger due to the division by $(1 - L_{\min})$.

Table 5.3 illustrates the impact of this combined approach using the same example as before. For each threshold $L_{\min}$, we list the original required ΔD_k (from Table 5.2) alongside the new required ΔD_k if the debt is used for share buybacks (Equation 5.2). The contrast is stark. At $L_{\min} = 0.90$, the necessary recapitalization drops from 165.0 to just 16.5 billion CHF (only about 10% of the original amount). At $L_{\text{min}} = 0.94$, the required debt falls from 490.5 billion to about 29.4 billion CHF. In fact, across the board the buyback strategy reduces the needed debt by a factor of roughly $1/(1-L_{\text{min}})$ (for example, a factor of around 10 at 90% leverage, around 16.7 at 94% leverage), completely eliminating the non-linear blow-up seen earlier.

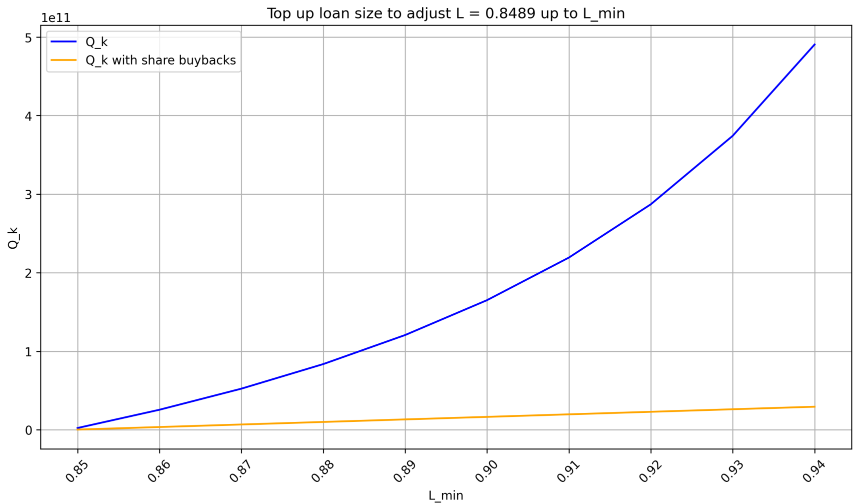


Figure 5.3: Top up loan size to adjust L_k up to L_{min} scales much slower (linearly) if the company draws down equity (using a top-up DCL loan) to raise leverage.

$L_{\mathbf{min}}$	Distance ($L_{\min} - L_k$)	Top-up loan $\Delta_{D,k}$ $[10^9 CHF]$	Top-up loan with buybacks $\Delta_{D,k}$ $[10^9 CHF]$
0.85	0.001081	2.32	0.35
0.86	0.011081	25.57	3.58
0.87	0.021081	52.39	6.81
0.88	0.031081	83.68	10.04
0.89	0.041081	120.66	13.27
0.90	0.051081	165.04	16.50
0.91	0.061081	219.27	19.73
0.92	0.071081	287.07	22.96
0.93	0.081081	374.24	26.19
0.94	0.091081	490.46	29.42

Table 5.3: The effect of pairing debt issuance with equity reduction (share buybacks) on required top-up loan size shows how the top-up loans scale with the two different methods. The scenario assumes initial $L_k \approx 0.849$ as in Table 5.2. For each minimum leverage target, the table compares the debt needed under the standard DCL approach vs. the debt needed if the same amount is used to repurchase equity. The buyback strategy yields a much smaller required ΔD_k, mitigating the leverage asymmetry problem.

By drawing down equity, the leverage asymmetry is effectively resolved. The size of the required intervention becomes linear in the shortfall, and the magnitudes are much more reasonable for practical recapitalization. In summary, using the DCL bond's debt issuance to retire equity (through buybacks or dividends) can keep a highly levered bank's leverage ratio within the prescribed band without the need for extreme debt issuance. This modification to the DCL mechanism could thus greatly enhance its practicality and effectiveness for banks operating with very high leverage thresholds, ensuring stability is maintained with manageable adjustments rather than outsized, destabilizing ones.

5.3 Time Delta of Collapse

As observed in the case studies, the Dynamic Control of Leverage mechanism did not ultimately prevent a collapse for Lehman or Credit Suisse. However, it did delay the collapse. In other words, even though DCL could not save the bank from reaching the point of non-viability, it provided an additional buffer of time before that point was reached. This additional survival period is a critical benefit since it gives management and regulators a grace period to react to the crisis (for instance, to raise new capital) that would not exist under a traditional CoCo bond with no ongoing conversions. This time gained under DCL can denoted as $\Delta T_{\text{Collapse}}$.

Mathematically, we can define the time to collapse T_{collapse} as the time at which the bank's leverage reaches a terminal threshold corresponding to regulatory failure. For the purposes of calculating T_{collapse} we assume $L = 0.96$ as the PONV.

$$T_{\text{Collapse}} = \inf\{t \geq 0 \mid L(t) \geq 0.96\} \tag{5.3}$$

We can calculate this time for two scenarios: one with the DCL bond in place, which converts interest to equity when leverage is too high at interval times, and one with only traditional debt (no conversions). Let $T_{\text{Collapse}}^{(\text{DCL})}$ be the collapse time under the DCL framework, and $T_{\text{Collapse}}^{(\text{No DCL})}$ be the collapse time with an equivalent bond that does not convert (the status quo case). The time gained until collapse due to DCL is then defined as the difference:

$$\Delta T_{\text{Collapse}} = T_{\text{Collapse},i}^{(\text{DCL})} - T_{\text{Collapse},i}^{(\text{No DCL})} \tag{5.4}$$

Assuming both scenarios start from the same initial conditions and are subjected to the same stress scenario. By construction, $\Delta T_{\text{Collapse}}$ will be positive (or zero in trivial cases) whenever DCL successfully delays the failure relative to the no-DCL case. A larger $\Delta T_{\text{Collapse}}$ means DCL provided a longer breathing space before collapse. On the other hand, $\Delta T_{\text{Collapse}} = 0$ would indicate that DCL made no difference in the collapse timing.

5.3.1 Time as a Design Objective

Given the importance of this additional survival time, one can envision time gained until collapse as an explicit design objective for DCL instruments. Bank management and regulators might ask: How many extra months or years of viability can this DCL bond assure us under extreme conditions? If DCL can be calibrated to reliably provide, say, an additional two years of survival under a crisis scenario, that is extremely valuable. It could mean the difference between a disorderly failure and a managed recovery. Thus, when structuring a DCL-based CoCo, one could set a target $\Delta T_{\text{Collapse}}$ (for a given stress scenario or probability level) and then choose the bond's parameters, such as the conversion trigger level and conversion price, to achieve that target.

In practical terms, however, $\Delta T_{\text{Collapse}}$ cannot be known in advance with certainty. It will depend on the path that the bank's leverage actually takes during the lifetime of the bond, which is inherently stochastic. The actual realized time gained in a real crisis will vary. If the crisis is mild, the bank might not collapse at all (so $\Delta T_{\text{Collapse}}$ is essentially the full horizon). If the crisis is extremely severe, DCL might only postpone failure by a short period. Therefore, a sensible way to optimize the delay would be to estimate $\Delta T_{\text{Collapse}}$ under a range of plausible scenarios and use the expected time gained as a guide for setting the DCL parameters. In other words, the goal could be to maximize $E[\Delta T_{\text{collapse}}]$ or to ensure with high confidence that $\Delta T_{\text{Collapse}}$ exceeds a certain minimum.

To estimate this, we can use a Monte Carlo simulation approach. By simulating many possible crisis scenarios for the bank's balance sheet, we can observe the distribution of collapse times with and without DCL, and thereby quantify the distribution of $\Delta T_{\text{Collapse}}$. The expected additional survival time $E[\Delta T_{\text{Collapse}}]$ can be calculated as:

$$\mathbb{E}[\Delta T_{\text{Collapse}}] \approx \frac{1}{N} \sum_{i=1}^{N} \left(T^{(\text{DCL})}_{\text{Collapse},i} - T^{(\text{No DCL})}_{\text{Collapse},i} \right) \tag{5.5}$$

where i indexes each simulated scenario (out of N total simulations). This provides a quantitative measure of how much extra time, on average, DCL is likely to buy the bank in a crisis. In addition, the spread of the $\Delta T_{\text{Collapse}}$ distribution across simulations would tell us the risk (variance) in that time benefit (e.g., whether DCL almost always provides a small but consistent time gain, or sometimes provides a huge gain and other times none at all).

5.3.2 Monte Carlo Framework for Delta Collapse Time Estimation

Monte Carlo simulations were conducted to quantitatively estimate the additional time gained before collapse under a DCL CoCo mechanism. This simulation generated 2000 hypothetical equity trajectory scenarios (approximately based on 2018–2023 Credit Suisse financial data and observed volatility), under both a DCL-based CoCo framework and a no-DCL scenario. The parameters for the Monte Carlo simulations are shown in table 5.4.

For each simulated path, the time of collapse (defined as the time when leverage breaches the PONV threshold, leading to non-viability) was recorded for both DCL and no-DCL, and the difference $\Delta T_{\text{Collapse}} = T^{\text{DCL}}_{\text{Collapse}} - T^{\text{No DCL}}_{\text{Collapse}}$ computed. The resulting distribution of $\Delta T_{\text{Collapse}}$, as seen in Figure 5.4 reflects how much longer the bank could survive with DCL in place, compared to without it. The Monte Carlo results confirm that DCL provides a significant buffer since in vir-

Parameter	**Value**
Initial DCL nominal	CHF 10,216,000,000
Initial equity	CHF 60,000,000,000
Initial total debt	CHF 275,000,000,000
Minimum leverage ratio, $L_{\min}$	0.85
Critical (maximum) leverage ratio, L_c	0.90
Conversion price, S_p	CHF 21.69
Initial share price, S_0	CHF 21.69
Share price drift, μ	-0.15
Share price standard deviation, σ	0.25
Interest, r	0.075
Time to maturity, T	10 years
Frequency, n	2

Table 5.4: The input paramters for the Monte Carlo simulations aimed to simulate a bank whose equity value moves toward a point of non-viability. The initial values (nominal, equity, debt and share price) are based on the Credit Suisse simulations and are made for a 10 year bond with a biannual frequency of interest payments (and potential leverage adjustments). The initial number of shares is derived as the initial equity value divided by the initial share price.

tually all simulation runs, the collapse is delayed (i.e. $\Delta T_{\text{collapse}} > 0$), sometimes substantially so.

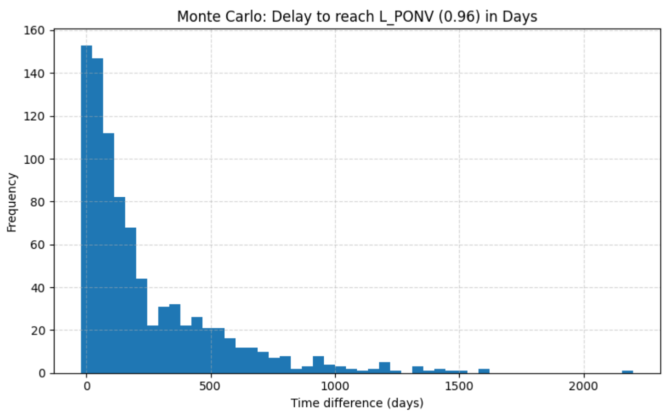


Figure 5.4: The results of the Monte Carlo Simulations show a significant but varied delay for when leverage reaches the *point of non-viability* under the DCL framework compared to non-DCL.

The simulations yielded an expected (mean) additional time to collapse of 238.7 days, with a median $\Delta T_{\text{collapse}}$ of 132.5 days. This indicates that, on average, the DCL mechanism could have extended Credit Suisse's life by roughly three quarters beyond the point at which it would have failed under a traditional CoCo structure. The distribution of outcomes was varied as the standard deviation of $\Delta T_{\text{collapse}}$ was 285.9 days. 99.85% of the simulated paths resulted in $\Delta T_{\text{collapse}} > 0$, meaning that in all but 0.15% of cases, the DCL framework delayed the collapse compared to the no-DCL baseline. These key statistics are summarized in Table 5.5.

Measure	**Result**
Mean delay	238.7 days
Median delay	132.5 days
Std. dev.	285.9 days
Range	-20 to 2197 days
Negative delays	3

Table 5.5: The results of the Monte Carlo Simulations show a significant delay in reaching the point of non-viability (PONV), though with notably large variance. In only 3 cases did the DCL framework accelerate a collapse.

The results in table 5.5 also show a large range for the delay. The longest delay, the results of which are shown in Figure 5.5, can be interpreted as the result of a distress period from which the bank partially recovered using DCL, only to continue to experience downwards pressure on the equity which results in eventually reaching a PONV. The figure is particularly interesting as it clearly shows how DCL lowered the leverage over time.

Figure 5.6 showcases one of the three cases where the result was a negative delay (effectively accelerating the collapse). This can be interpreted as the result of additional debt issuance from early minimum leverage breaches (which raised the leverage above the non-DCL case), followed by a swift enough decline in equity value to not allow for the DCL mechanism to convert the principal to equity quickly enough to lower the leverage below the non-DCL case before reaching the PONV.

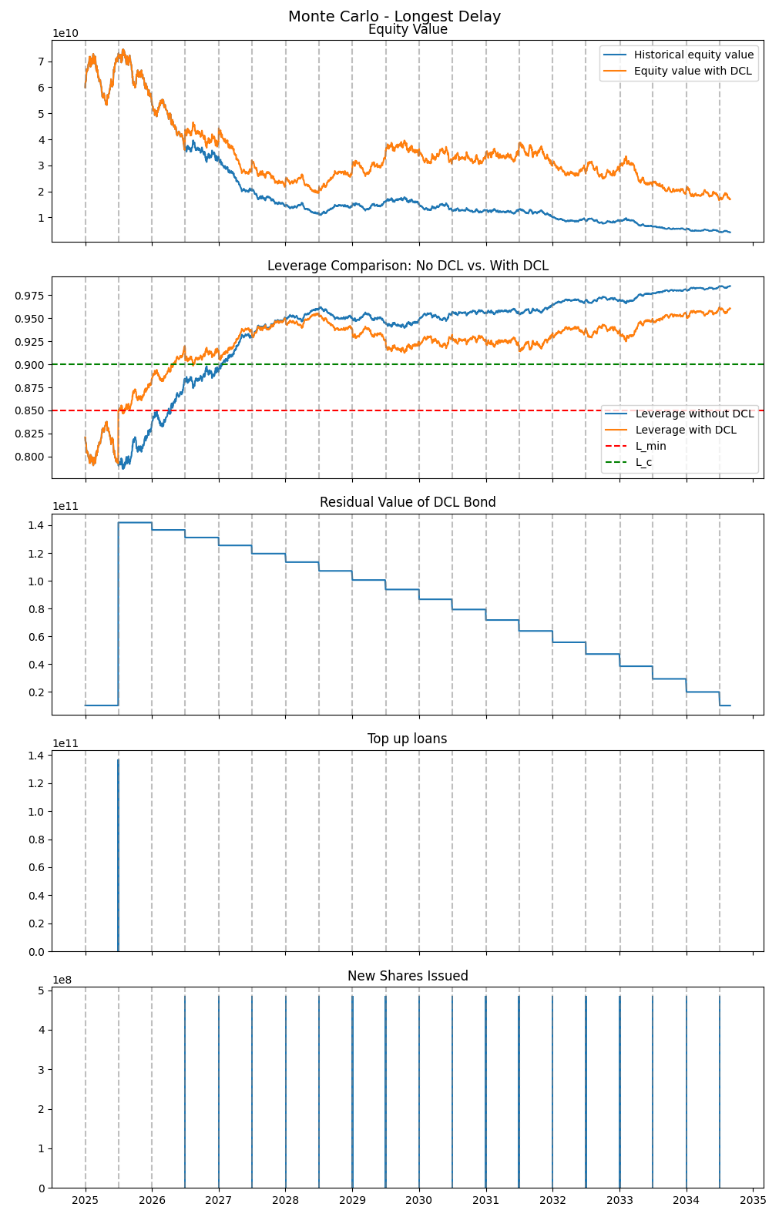


Figure 5.5: Leverage path for the run with the greatest extension of survival time (from those with paths reaching PONV, of 2000 total runs). This example illustrates how repeated, incremental equity injections can effectively lower leverage over time. The No-DCL scenario crossed L_{PONV} 2028-06-21 but the DCL scenario crossed on 2034-06-27, a 6.02 year difference.

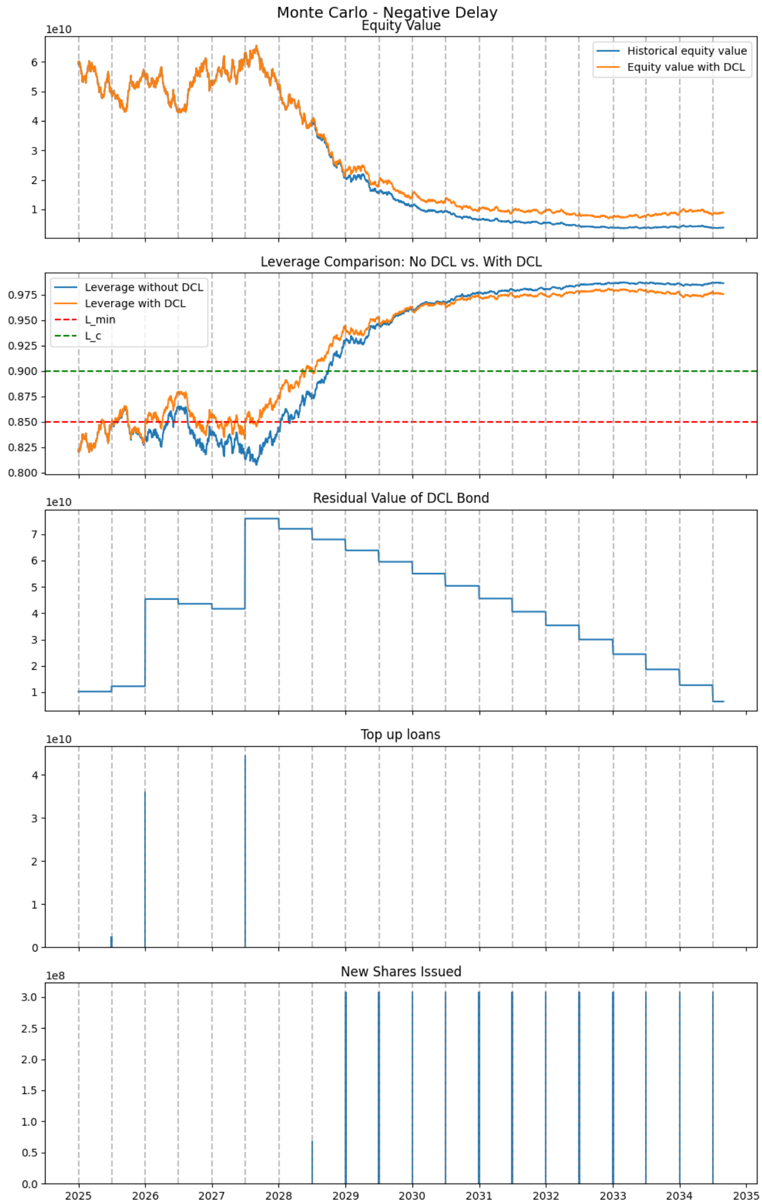


Figure 5.6: One of only three Monte Carlo scenarios, of 2000 runs, where DCL accelerated failure ($\Delta T_{\text{Collapse}} = -8$ days). Early breaches of the minimum leverage threshold triggered top-up debt issues, temporarily lifting DCL leverage above the baseline. A rapid equity decline then left too little time for interest conversions to offset the added debt, so the DCL path reached PONV marginally before the no-DCL. This example shows that in extremely fast collapses it can (though rarely) shorten rather than lengthen the time to non-viability.

In summary, the Monte Carlo analysis provides strong evidence that implementing DCL-based CoCo bonds would have substantially delayed the failure of Credit Suisse relative to a traditional CoCo bond framework. The time gained before reaching the point of non-viability can be non-trivial and importantly represents a critical window in which management and regulators could intervene with corrective actions, asset sales, or capital injections to rescue the bank. This finding quantitatively validates the earlier qualitative observation that *the DCL bond gives the bank an additional buffer during a crisis*, and it aligns with the notion of using time gained as a key objective for DCL design (as proposed in Section 5.3.1). The clear implication is that time is a valuable asset in crisis management, and the DCL mechanism's ability to buy additional time can be decisive in averting collapse.

It is worth emphasizing the value for DCL to "buy time," not to magically cure insolvency. The simulation framework is a way to quantify how much time is bought. If the underlying condition of the bank is terminal (e.g. asset quality keeps deteriorating badly), DCL will not save the bank indefinitely. The case studies confirmed that eventually the leverage will reach L_{PONV} if they historically occured. However, the extra time afforded by DCL can be critical. In a crisis, time is one of the most precious commodities: time for asset values to possibly recover, time to restructure or raise new equity, or time for regulators to arrange an orderly resolution or merger. To conclude, the Dynamic Control of Leverage framework cannot completely avert collapse in a worst-case scenario, but it can significantly delay the collapse, and this delay, encapsulated by a positive $\Delta T_{\text{Collapse}}$, is a key advantage of DCL. With the Monte Carlo analysis outlined above, one can rigorously estimate this advantage and potentially use it to optimize the DCL instrument's design (for example, setting the maximum trigger might be decided based on which yields a larger expected $\Delta T_{\text{Collapse}}$ without undue side effects).

Chapter 6

Conclusion

In this thesis, we examined the Dynamic Control of Leverage (DCL) framework applied to contingent convertible (CoCo) bonds across three pivotal case studies: Deutsche Bank, Credit Suisse, and Lehman Brothers. The comparative analysis of these cases demonstrates that DCL can significantly bolster bank stability, though its effectiveness varies with the severity of financial distress. Deutsche Bank's scenario (a case of moderate, firm-specific stress) illustrated that DCL CoCo bonds could effectively stabilize leverage, preventing dangerous debt spirals and maintaining capital ratios within safe bounds. The Credit Suisse 2023 crisis, a more severe but contained collapse, showed that DCL would have mitigated the bank's failure by converting interest to equity incrementally, avoiding the abrupt historical $17 billion write-downs of capital instruments and reducing market panic [2]. In stark contrast, Lehman Brothers' 2008 collapse (an extreme systemic failure) revealed DCL's limits: while the mechanism might only marginally delay Lehman's failure, buying a critical window of extra time, it could not ultimately prevent collapse given the overwhelming scale of losses. These outcomes underscore that DCL is most effective in moderate or contained crises, where it can proactively reinforce capital, whereas in a full-blown systemic meltdown its benefit is largely in gaining time rather than averting insolvency.

Effectiveness and Regulatory Integration

The case study findings highlight where and how DCL adds value. Notably, the strength of DCL lies in its proactive, adaptive recapitalization during distress. By enabling frequent, incremental equity injections, it could effectively lower leverage in the Deutsche Bank case and could have prevented the risk of a sudden loss of investor confidence that static triggers can have. In Credit Suisse's case, the DCL approach would provide a transparent, rule-based path to recapitalization, helping to preserve confidence and financial stability during the bank's resolution. These successes point to a clear policy implication: DCL CoCos could be integrated into regulatory frameworks as a forward-looking tool to preempt crises. Regulators could require or encourage banks to issue DCL-based contingent capital, thereby introducing an automatic stabilizer that kicks in before a bank breaches critical capital thresholds. Such integration would enhance transparency and predictability in bank capital regulation. In essence, DCL offers a practical mechanism for keeping banks' leverage in check in real-time, which could guide reforms in Additional Tier 1 capital requirements and strengthen overall financial system resilience. Embracing DCL within the regulatory toolkit can help buy time and buffer for troubled banks, giving management and authorities a chance to intervene early with less disruption.

Limitations

Overall, the findings paint an optimistic outlook for DCL as a next-generation contingent capital solution. Across the case studies, DCL proved its ability to dynamically absorb losses and stabilize banks during distress, validating its theoretical promise as an improvement over traditional CoCo bonds. By avoiding the pitfalls of fixed capital triggers, DCL provides a more effective and transparent loss-absorbing capacity that can bolster market confidence during bank stress. This forward-looking framework exemplifies how gradual, rules-based conversions can mitigate systemic risk and prevent panic, aligning with calls for more flexible crisis management tools in banking [42]. Crucially, DCL delivers what conventional CoCos could not: time. Even if it cannot single-handedly save a bank facing catastrophic losses, DCL buys precious time in a crisis, time for asset values to recover or for corrective actions to take effect. This additional breathing room can mean the difference between a contained episode and a disorderly collapse. That said, it is important to acknowledge DCL's limitations. In a worst-case systemic crisis (as Lehman's case showed), DCL is not a cure-all if a bank's fundamentals are irreparably damaged, continuous conversions will reach a point of non-viability without much upside. The Lehman scenario reminds us that DCL cannot completely avert failure when underlying insolvency is too deep, underscoring the need to use DCL in tandem with broader systemic safeguards. Despite these caveats, the promise of DCL remains strong: it represents a substantial step forward in bank capital design, offering a more resilient and responsive buffer that can greatly reduce the likelihood and severity of bank failures in most scenarios.

Future works

Future research directions include further empirical investigations across different financial institutions and market conditions, as well as studies on investor perception and regulatory adoption challenges for DCL instruments. For example, it would be worthwhile to test DCL CoCos in a broader set of scenarios or with other banks to see if the benefits hold generally. Additionally, exploring how markets would price DCL CoCos (compared to traditional CoCos) could provide insight into the feasibility of issuing such instruments.

In conclusion, Dynamic Control of Leverage emerges from this research as a highly promising contingent capital tool that can fill critical gaps in the current financial safety net. Its performance in the case studies, stabilizing or salvaging banks in distress demonstrates that with the right design, CoCo bonds can be made to be more effective at crisis prevention. By pursuing the outlined future research and gradually addressing implementation challenges, scholars and policymakers can refine DCL further and solidify its role in banking regulation. The optimistic outlook is that DCL, as a next-generation capital instrument, could become a cornerstone of a more resilient banking system, where regulators and banks dynamically contain leverage and avert disaster before it spirals out of control, while also being prepared for the limits of such tools in reacting to short-term events. With continued innovation, DCL CoCo bonds have the potential to significantly strengthen financial stability and reduce the frequency and severity of banking crises in the years ahead.

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Appendix A

Additional Tables and Figures

Figure A.1 shows the results of an additional simulation that is not used for this thesis. It shows a daily interval (near continuous) bond for Credit Suisse which is particularily noteable since it could be used as an approximation for an *American* (continuous) DCL bond.

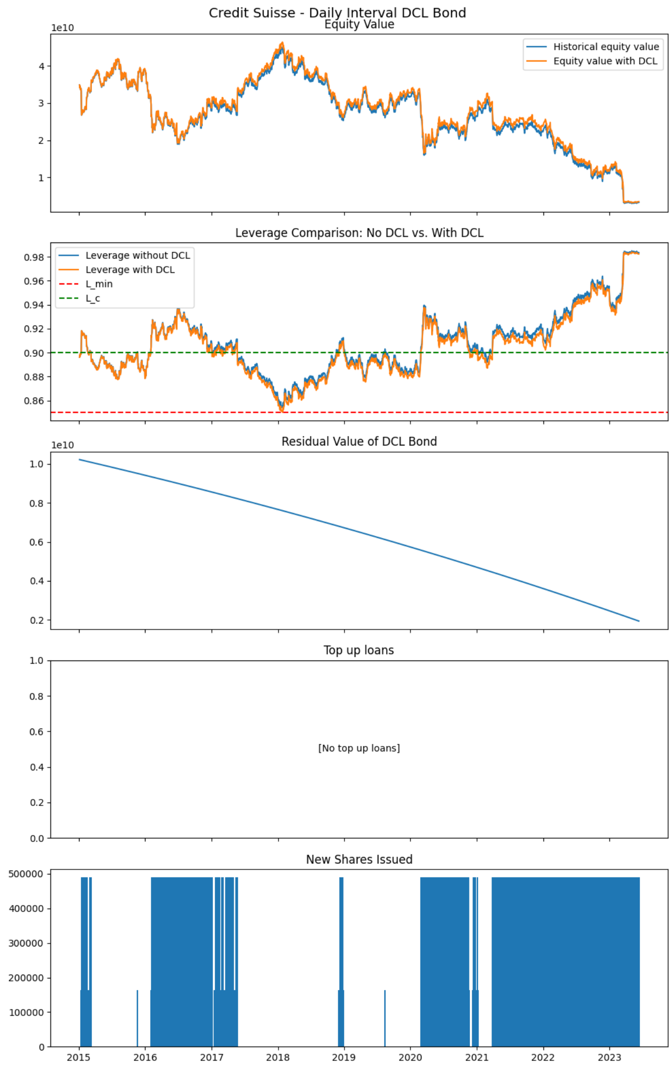

Figure A.1: Results of simulating a daily interval DCL bond for Credit Suisse