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Raviv, Alon and Hilscher, Jens and Peleg Lazar, Sharon

Bar-Ilan University, UC Davis, Bar-Ilan University

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Designing bankers' pay: Using contingent capital to reduce risk-shifting incentives

Jens Hilscher* jhilscher@ucdavis.edu

Sharon Peleg Lazar † pelegls@biu.ac.il

Alon Raviv‡ Alon.Raviv@biu.ac.il

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Abstract

Including contingent convertible bonds (coco) in the capital structure of a bank affects the sensitivity to risk of its equity-based compensation. Such risk-shifting incentives can be reduced if the coco bonds are well-designed. Similarly, we show that compensating executives instead with well-designed coco bonds can also reduce risk-shifting incentives. In practice, however, most coco bonds have characteristics that result in both stock and coco compensation having large sensitivities to changes in asset risk – equity-based compensation encourages executives to increase risk, coco compensation to reduce risk. We show that a pay package combining both stock and coco can practically eliminate risk-shifting incentives and that it can be implemented with a bank's preexisting coco bonds.

JEL classification: G21

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*University of California, Davis, Phone: +1-(530) 752-4081.

†Bar-Ilan University, Ramat Gan, Israel.

‡Corresponding author, Bar-Ilan University, Ramat Gan, Israel.

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1 Introduction

It is a common belief that the 2008-2009 financial crisis was in part the consequence of executive compensation formulas that gave top managers at banks incentives to choose a highly leveraged capital structure and take excessive risk (Bebchuk, Cohen, and Spamann, 2010; Bhagat and Bolton, 2014). Several proposals by both regulators and academics to address high leverage have come in the form of recommending or requiring the inclusion of contingent convertible bonds (coco hereafter) in the capital structure. Coco is a form of subordinated debt issued by banks that is automatically converted into equity when a certain stress-related trigger is breached. Issuing contingent capital reduces the likelihood that the financial institution will become distressed – if conversion occurs debt is reduced and equity capital is increased. The idea was adopted by global systemically important banks (G-SIB) starting in November 2009 with an issue by Lloyds (Berg and Kaserer, 2015). By the end of 2015 there were 731 coco issues with a combined notional value of $521 billion (Avdjiev, Bogdanova, Bolton, Jiang, and Kartasheva, 2020).

Including coco in the capital structure can, in addition to supplying additional capital in times of stress, affect and potentially reduce executives' incentives to increase risk to excessive levels (Glasserman and Nouri, 2012; Kaal, 2012; Squam Lake Group, 2013; Hilscher and Raviv, 2014; Berg and Kaserer, 2015; Martynova and Perotti, 2018). In the event of coco conversion, the bank's equity is divided up between previous shareholders and coco holders. Who gets what is critically important for risk-shifting incentives. For example, for write-down coco, in the event of conversion previous stockholders become the sole beneficiaries while previous coco holders receive nothing. In this case there is a clear incentive for equity holders to increase risk and thereby increase the likelihood of conversion. If, however, coco and stockholders receive a more similar share of the post-conversion equity, equity-based compensation can lose its risk-shifting incentives. Yet, in practice, the type of coco design that has been chosen by banks almost exclusively specified that equity holders are the sole or main beneficiaries of conversion (Berg and Kaserer, 2015; Goncharenko, Ongena, and Rauf, 2020). Thus, even though coco issuance has the potential to reduce risk-shifting incentives, this has not been achieved in practice.

An alternative approach to affect managements' incentives for risk-shifting is to use the coco bonds directly to compensate executives (Squam Lake Group, 2013). Such coco compensation has been adopted by several financial institutions. In 2011, Barclays was the first bank to announce a pay system that includes coco bonds as part of employees' performance based pay. UBS was the first bank to give its executives bonuses in the form of coco debt which is written-down if the bank's capital fails to meet capital requirements. Both UBS and Credit Suisse awarded their executives coco compensation in 2019.[1] We show that, if coco holders lose out in conversion, their incentives are to reduce risk and limit the probability of a conversion event. A more intermediate conversion ratio that results in a similar level of shares received by coco and stockholders in conversion can reduce the coco compensation incentives to decrease the bank's asset risk.

Our analysis in this paper considers the risk-shifting incentives resulting from *both* equity based and coco compensation. First, following previous work (Hilscher and Raviv, 2014; Chan and van Wijnbergen, 2017; Hesse, 2016; Himmelberg and Tsyplakov, 2014; Berg and Kaserer, 2015) we concentrate on the analysis of compensation in the form of equity. We show that effective choice of the conversion ratio, which determines the payoff to equity and coco holders in the event of conversion, can reduce and potentially eliminate the sensitivity of the manager's compensation to asset risk. We assume that the executive chooses or influences the bank's level of asset risk and that an optimal compensation contract avoids rewarding activities that change risk.[2]

We calculate the sensitivity of the compensation package to changes in asset risk, i.e., the vega of the executive's pay package. If the vega is large in absolute value, resulting in either strong incentives to increase or decrease risk, executive compensation may result in executives spending effort and resources changing risk instead of making the best possible lending decision. From a regulatory perspective, such incentives are therefore to be avoided, both because of deadweight costs of financial distress as well as negative effects due to potentially low-performing loans.

Second, we analyze the risk-shifting incentives resulting from a compensation package made up of coco bonds.[3] We show that effective choice of the coco terms, specifically the conversion ratio, directly affects these incentives. For low levels of the conversion ratio, for example write-down debt,

[1] "Barclays causes a stir with cocos plan," the Financial Times, January 25, 2011. "UBS leads way with bonuses shake-up," Financial Times, February 5, 2013. UBS Group AG, Compensation Report 2019; Credit Suisse Group AG, Annual report 2019.

[2] This assumption follows the sentiment expressed in Jensen and Smith (1985), who point out that it is inefficient for management to choose negative net present value projects in an effort to change volatility.

[3] To the best of our knowledge, prior work has not used a coco pricing model to analyze the effect of the conversion ratio on the risk-shifting incentives resulting from coco compensation. Walther and Klein (2015), which we discuss in more detail below, consider the effect of adding write-down coco as part of a package.

equity holders are the sole or primary beneficiaries of conversion. Coco bonds are no longer part of the capital structure and stockholders, the residual claimholders, are no longer affected by payments at maturity to coco holders. Not surprisingly, equity holders are interested in increasing risk to make conversion more likely. In contrast, coco holders, who are better off if conversion becomes less likely, benefit from lower risk and therefore executives holding coco compensation want to reduce risk. As mentioned, in practice, the majority of coco bond terms have a low conversion ratio or one equal to zero (Berg and Kaserer, 2015; Goncharenko, Ongena, and Rauf, 2020). Thus neither equity-based nor coco-based compensation can mitigate the adverse effects of excessive risk taking brought on by these types of compensation packages.

In a third step, we propose a solution that allows for a reduction in risk-shifting incentives without having to change existing coco terms. If both forms of compensation are combined in the case of write-down debt, the risk-increasing incentives of equity based compensation cancel out with the risk-decreasing incentives of coco compensation. The resulting compensation package is able to substantially reduce and practically eliminate risk-taking incentives. We show that, choosing the right weights, allows for such a reduction in risk-shifting incentives not only for extreme levels of the conversion ratio but also for intermediate levels.

Our contribution is both positive and normative. Since coco compensation is usually awarded as part of a compensation that includes equity based compensation, we show that well-designed compensation can be achieved by combining the two parts in just the right way. Under such a compensation scheme, the executive has a minimal motivation to change the level of asset risk.

We contribute to the large and rich literature on contingent capital, starting with Flannery (2005) and including, among many others, Squam Lake Group (2010); Duffie (2013); Pennacchi (2010); Albul, Jaffee, and Tchistyi (2010); Glasserman and Nouri (2012); Pennacchi, Vermaelen, and Wolff (2014); Sundaresan and Wang (2015); Flannery (2016).[4] Most of these papers' primary focus is on pricing; our objective is instead to analyze the effect of coco design on risk-shifting incentives.

Walther and Klein (2015) consider risk-shifting incentives if write-down coco bonds are issued, executives are paid using stock options, and claims are priced using the Black and Scholes (1973) and Merton (1973, 1974) model, where conversion can only occur at maturity. In contrast, our setup assumes continuous conversion, we analyze the incentive effects of different conversions ratios, and

[4]For a recent comprehensive survey of the literature see Oster (2020).

analyze stock and coco compensation packages for the full range of coco conversion ratios.

The remainder of the paper is organized as follows. In section two we discuss the pricing model. Section three presents the analysis of the three compensation schemes: equity only, coco only, and both. Section four concludes.

2 Valuation of claims and incentives

In this section we present the pricing model for a bank with coco as part of its capital structure. The setup closely follows Hilscher and Raviv (2014) who use a contingent claim approach for pricing a bank's liabilities which is based on the Black and Cox (1976) model. The chosen pricing model has several advantages: conversion can occur prior to maturity; early default is possible; and the model allows for the possibility of deadweight costs of default. Conversion is triggered in the model if the value of the bank assets reaches a predetermined level. Goncharenko, Ongena, and Rauf (2020) point out that most issued coco bonds have accounting triggers, rather than a trigger based on the value of the bank's equity, an assumption common in many other models for pricing coco bonds. Our approach is thus consistent with current market practice.

2.1 Bank capital structure

We begin by describing the bank's capital structure. We consider a hypothetical bank with asset value denoted by V_t. To finance its assets, the bank issues three types of claims: zero-coupon secured deposits, coco bonds, and an equity claim. The secured deposits are the most senior claim in the capital structure with face value F^D. The second most senior debt security is the coco bond with face value F^C and market value C. The equity claim is the residual claim; it has market value E. All claims mature at time T.

Default occurs either at debt maturity, T, if the value of assets lies below the face value of the deposits, $V_T < F^D$, or at any time prior to maturity, $t < T$, if the value of bank assets touches the default threshold K^D. The default threshold is defined as $K^D = F^D\,(1-\gamma)$, where $0 \leqslant \gamma \leqslant 1$, meaning that the threshold is located below the face value of the deposits.[5] We can think of the

[5]This assumption, which follows Black and Cox (1976), captures the fact that the regulator has limited ability to seize the bank at the moment it becomes insolvent. The delay in seizure may be because of

size of γ as being related to the ability and willingness of the regulator to closely monitor and enforce bank solvency.[6]

Conversion of coco into equity occurs at any time prior to maturity if the value of the financial institution's assets drops below the conversion threshold, K^C. The threshold is defined as $K^C = (1+\beta)\left(F^C + F^D\right)$, where $\beta \geqslant 0$ measures the distance between the conversion threshold and the bank's face value of debt. The time of conversion is defined as $\tau_C = \inf\left\{t > 0 | V_t \leqslant K^C\right\}$. Note that $\beta \geqslant 0$ implies that the event of conversion will always occur before the event of default, i.e., $\tau_C \leqslant \tau_D$.

The incentives of either equity-based[7] or coco compensation depend critically on what happens at conversion. Specifically, what matters is whether or not conversion is an event that benefits shareholders or coco holders, or both. If a conversion event occurs, the coco is converted into equity and the coco holder receives a share α $(0 \leqslant \alpha \leqslant 1)$ of the equity while the original shareholders receive the remaining $(1-\alpha)$. If there is no default, coco holders' payoff at maturity is $\alpha\left(V_T - F^D\right)$ and original stockholders receive $(1-\alpha)\left(V_T - F^D\right)$. Therefore as α increases, more of the residual value at maturity is paid to coco holders, while equity holders receive less. If there is no conversion event or default prior to maturity the coco bonds pay F^C at maturity while the stock, as the residual claim, pays $\left(V_T - F^C - F^D\right)$.

A very common form of coco bonds is write-down debt, for which $\alpha = 0$, meaning that the original shareholders receive everything and coco holders receive nothing. Thus equity holders benefit at the expense of coco holders if conversion occurs. Indeed, when analyzing incentives in Section 3 we find that if coco comes in the form of write down debt, equity-based compensation results in risk-shifting incentives. Higher volatility means a higher conversion probability, which is good news for stockholders. In contrast, coco compensation with that type of conversion ratio results in a desire to decrease risk.

imperfect information due to a discrete audit frequency (Duffie and Lando, 2001), or because the regulator chose a policy where banks are not immediately seized (Cetin, Jarrow, Protter, and Yıldırım, 2004) perhaps since close monitoring may be costly and difficult in the case of complicated bank balance sheets.

[6] In the Black and Cox (1976) model the event of default leads immediately to bankruptcy. Galai, Raviv, and Wiener (2007), François and Morellec (2004) and Moraux (2019) consider a model where bankruptcy does not occur automatically in the event of default and depends on the time spent in distress.

[7] We refer to stock compensation as equity-based. Edmans, Gabaix, and Jenter (2017) find that between 2000 and 2014, options declined from 49% to 16% of pay, while restricted stock increased from 7% to 44%.

2.2 Valuation and the effect of the conversion ratio α

We next discuss the pricing of the different claims. The pricing equations are the basis for studying the sensitivity of coco and stock values to changes in asset risk.

We price each claim by replicating its payoff using a combination of barrier options. To price the options we follow standard option pricing theory developed by Black and Scholes (1973) and Merton (1973, 1974) in which the dynamics of the bank's assets follow a standard Geometric Brownian Motion and the Black and Cox (1976) model in which exercise can happen at any time before maturity. We obtain closed-form solutions for the option values developed by Merton (1973) and Rubinstein and Reiner (1991).

Coco The coco generates a payoff in two mutually exclusive events: no conversion before maturity, T, which generates a fixed payoff of F^C, and conversion but no default, which generates the payoff $\alpha\left(V_T - F^D\right)$. Therefore:

$$C_T = F^C \cdot 1_{\{\tau_C > T\}} + \alpha \cdot \left(V_T - F^D\right) 1_{\{\tau_C < T < \tau_D, V_T > F^D\}}, \tag{1}$$

where 1_ψ is an indicator function of the event ψ.

To price the coco we replicate each of the payoffs with barrier options. The first payoff can be replicated by F^C units of a *down-and-out* digital barrier option with a barrier of K^C, which we denote $DB^{dout}\left(K^C\right)$. The second payoff can be replicated by a spread position in two *down-and-in* barrier call options with the same strike, but with different barriers. The coco holder has a long position in α units of a *down-and-in* call option on the value of assets with a strike price equal to the face value of deposits F^D and a threshold level of K^C which we denote $CB^{din}\left(K^C, F^D\right)$. However, if asset value falls further and touches the default threshold the equity becomes worthless and the coco holder receives nothing. To capture this payoff structure we add a similar but short position in a *down-and-in* call option $CB^{din}\left(K^D, F^D\right)$ with the same terms except having a barrier at the default threshold. This means that if asset value touches K^D the two option payoffs cancel each other. We can write the coco value as:

$$C = F^C \cdot DB^{dout}\left(K^C\right) + \alpha \cdot \left(CB^{din}\left(K^C, F^D\right) - CB^{din}\left(K^D, F^D\right)\right). \tag{2}$$

The first term, which captures value from the state where neither conversion nor default occurs, decreases with volatility. The second term increases with volatility; it will reach its maximum value at a high level of volatility, where value from a high conversion probability is captured while not losing too much value from a high default probability. Therefore, as long as there is a sufficient amount of value from the conversion but no default state, it is possible to eliminate risk-shifting incentives by appropriate choice of the conversion ratio.[8]

Stock The stock generates a payoff in the same two events as the coco. If a conversion event does not occur (nor default) the stock pays $V_T - F^C - F^D$. If a conversion event does occur, but not a default, the payoff is $(1-\alpha) \cdot (V_T - F^D)$. Therefore, the payoff at maturity is:

$$E_T = \left(V_T - F^C - F^D\right) \cdot 1_{\{\tau^C > T\}} + (1-\alpha) \cdot \left(V_T - F^D\right) \cdot 1_{\{\tau^C < T < \tau^D, V_T > F^D\}}. \tag{3}$$

The first payoff can be replicated by a *down-and-out* call option, $CB^{dout}\left(K^C, F^D + F^C\right)$. This option is a European call option on the underlying bank asset value that pays off at maturity only if the asset value does not touch the conversion threshold K^C before maturity. In case of conversion, equity value is divided between the original stockholders, who receive $(1-\alpha)$, and the coco holders, who receive a fraction α. Therefore, as in the case of the coco we use a position in a *down-and-in* call option to take into account the stream of cash flows in the event of early conversion; the number of option units is equal to $(1-\alpha)$. The value of the stock is equal to:

$$E = CB^{dout}\left(K^C, F^D + F^C\right) + (1-\alpha) \cdot \left(CB^{din}\left(K^C, F^D\right) - CB^{din}\left(K^D, F^D\right)\right). \tag{4}$$

The first term captures value in the event of no conversion. If the bank is somewhat close to the conversion threshold and volatility rises, its value will decline. The second term is the same as the second term of the coco value; if volatility rises, its value increases. This means that, once again, it is possible to completely eliminate risk-shifting incentives by appropriate choice of the conversion ratio, so long as the vega of the second term is sufficiently high and the vega of the first term is negative.

[8] In our analysis of risk-shifting incentives we focus attention on the effect of the conversion ratio, α, and, in the next section, on the weight of coco, ω, in a compensation package which includes coco and stock. What this does is to change the vega of the compensation – stock, coco, or a package. Changing other input parameters, such as the conversion threshold or the leverage ratio of the bank, will affect the vegas of the individual pricing components in equations (2) and (4). However, these effects are secondary to the conversion ratio, which changes the relative weight of the two components from which security holders derive value. Hilscher and Raviv (2014) analyze different factors affecting risk-shifting incentives.

The valuation equations point the way towards a strategy to minimize risk-shifting incentives. For the case of write down debt, coco value will decrease with volatility while stock value will increase. This means that it is possible to combine both, using just the right weights, to eliminate risk-shifting incentives. We now examine these incentives more closely using realistic inputs for the model.

3 Risk-taking incentives of different compensation packages

We assume that the optimal compensation contract is one that avoids rewarding activities that change risk.[9] That is, incentives to either increase or decrease risk are inefficient and should be avoided. We therefore next search for compensation packages that are relatively insensitive to the level of risk for a large range. In such cases the executive has little motivation to change the level of asset risk since the benefit from doing so is small.

Our view is motivated by the perspective of a policymaker whose goal it is to maximize surplus in the economy. Investments in negative net present value activities for the purposes of risk targeting are undesirable. The same goes for inefficient bailouts in times of distress, which may have resulted from excessive levels of risk taking. Thus incentives in either direction may be undesirable – high risk may result in instability (an important reason for the financial crisis), while low risk may result in a credit freeze and a lack of lending by financial institutions. A compensation package which is insensitive to asset risk is beneficial to other claimholders, not only to the regulator, as there are dead-weight costs of risk-shifting. For example, reducing or increasing risk can lead to fire sales of assets. Such view is consistent with Jensen and Smith (1985), who note that it is inefficient for management to choose negative net present value projects in an effort to change volatility.

The level of asset risk is chosen to maximize the value of the bank manager's compensation. We measure the effect of the compensation package risk-shifting motivation by the percent change in

[9] The potential for inefficient asset substitution due to conflicts of interest between stockholder and creditors is particularly high for banks (Jensen and Meckling, 1976; Galai and Masulis, 1976). A bank can choose what type of lending it engages in and may therefore be more able to change its risk profile than, for example, a mature manufacturing firm. In addition, the main debtholders are dispersed and insured (the depositors) and therefore have little incentive to monitor the bank's activities (John, Mehran, and Qian, 2010).

value of the package in response to a one percent increase in asset volatility (vega). We calculate the vega for different compensation packages, starting with equity-based and coco compensation. As discussed in Section 2, for a specific bank, it is in general possible to eliminate risk-shifting incentives entirely and reach a vega equal to zero by appropriate choice of the conversion ratio. However, asset risk may vary across banks and for a bank over time, either because of executives actively seeking to increase risk or because of changes to the bank's loan portfolio over time. We therefore now consider whether or not it is possible to design compensation packages that minimize risk-shifting incentive for a large range of risk levels.

We consider asset risk levels from zero to 12%. This range is consistent with the recent findings of Goncharenko, Ongena, and Rauf (2020), who analyze the volatility of European banks. They show that more than 95% of them have asset volatility below 12% and the majority of banks have asset risk below 5%. We assume a large range in order to show that our proposed compensation packages result in low levels of vega for different levels of asset risk. If vega is small, and specifically if it lies below a certain threshold, we assume that it is not worth it for management to actively engage in risk-shifting activities. The loan portfolio would need to be changed in order to risk-shift, and such changes involve transaction costs and costly effort.[10]

In order to quantify the manager's risk taking incentives in a bank that has issued coco bonds we use the following base case parameters. The regulatory seizing policy parameter is $\gamma = 3\%$ and the conversion threshold parameter is $\beta = 1\%$. The bank's leverage ratio is $LR = 0.93$, face value of the secured debt is $F^D = 100$ and the face value of coco debt is $F^C = 3$. The time to maturity is one year, $T = 1$, while the barrier frequency is $dt = 0$ and the risk-free interest rate is $r = 1\%$. We assume that the level of asset risk is in the range 0% to 12%. Appendix A provides details about the choices of base case parameters.

3.1 Stock compensation

From the pricing equation for the different claims in Section 2 we know that, in the case of equity-based compensation, incentives to increase risk are present if the conversion ratio α is small. This

[10] We assume that at the bank has chosen the project with the highest NPV under a constraint on the level of its asset risk made by the regulator and that changing risk away from this level is inefficient. Therefore an executive pay package that encourages market discipline is a package which does not encourage risk-shifting from the initial level of risk.

is the case, for example, for write-down debt; in that case conversion is beneficial for stockholders.

Figure 1a shows how the conversion ratio affects the dependence of the equity value on asset risk. If the conversion ratio is low, stock value increases substantially with asset risk, especially for intermediate and higher levels of risk. If the conversion ratio is high, stock value decreases with asset risk. In this case stockholders lose out in the event of conversion.[11]

We calculate the absolute value of the percent change in compensation in response to a one percent increase in asset risk (vega). If the conversion ratio is equal to zero, stock value is monotonically increasing in asset risk. At low levels of risk, the vega is zero; it then increases and reaches its maximum at 4.16% for an asset risk level of 4.7%. After that vega declines to a level of 1.85% for an asset risk level of 12%.

We measure risk-shifting incentives of compensation using *maximum vega*, which is the highest level of vega over the full range of asset risk levels. Using our base case parameters we find that when the coco's conversion ratio is in the range $0.36 < \alpha < 0.96$ the stock's maximum vega is lower than 2% suggesting that the bank's manager has little incentives to change risk. When the coco's conversion ratio is in the range $0.53 < \alpha < 0.82$ the stock's maximum vega is lower than 1%, and substantially lower than the maximum vega for the case of write-down coco, 4.16%.

In a final step, we identify the conversion ratio for which maximum vega is minimized. Thus for each possible conversion ratio between zero and one, we find the maximum vega and then choose the conversion ratio that minimizes risk-shifting incentives (smallest maximum vega).

Including well-designed coco can substantially reduce and virtually eliminate any dependence of stock value on asset risk. The smallest maximum vega is reached at a conversion ratio of $\alpha = 0.7$ (Figure 1a). For low levels of risk there is a very slight decline in equity value as risk increases, while equity value increases slightly when risk is higher. The maximum vega is equal to 0.16% and is reached at asset risk levels of 4.3% and 10.2%. Therefore, a manager of a bank that has issued coco with a conversation ratio of 70%, whose compensation consists of just stock, has no clear incentive to engage in activities that will change the risk of bank's assets. It is therefore possible to design coco so that, when issued, equity based compensation results in little incentive to change the level of asset risk.

[11] A similar graph and corresponding results, based on the same pricing model, are presented in Hilscher and Raviv (2014).

3.2 Coco compensation

In the last few years several leading global banks such as UBS and Credit Suisse have started to compensate their executives with coco. We now consider the effect of coco compensation on executives' risk taking motivation. As we point out in Section 2, it is again possible to minimize and in most cases entirely eliminate the sensitivity of coco to asset risk by appropriately choosing the conversion ratio α. Next we show that it is also possible to design coco compensation that has a very low level of sensitivity over a wide range of asset risk levels.

Figure 1b plots the value of coco compensation as a function of asset risk. Coco value is almost a mirror image to stock value (Figure 1a). If the conversion ratio is low, for example in the case of write down debt, there is a strong incentive to reduce risk, the counterpart to the strong incentive to increase risk if there is equity compensation. Maximum absolute vega for a conversion ratio equal to zero is 13.4% and it is reached at an asset risk level of 5.3%. In contrast, if the conversion ratio is high, value increases significantly if asset risk is increased from medium and high initial levels. We note that, using write down coco bonds directly for compensation results in a vega that is quite a bit larger than the case of equity compensation.

However, as in the case of equity, it is possible to design coco so that incentives are minimized. Using the base case parameters we find that for low conversion ratios, $\alpha < 0.3$, the value of coco is decreasing with the level of asset risk while for high conversion ratios $\alpha > 0.71$ the value of coco is increasing with the level of asset risk. For intermediate conversion ratios the value of coco is decreasing in risk for low levels of risk and increasing for high levels. The coco's smallest maximum vega is achieved when the conversion ratio is $\alpha = 0.54$. It is equal to 1.76% and is reached at asset risk levels of 3.6% and 9.6%. Even though this sensitivity is quite a bit larger than the sensitivity in the case of well-designed stock compensation, we nevertheless see a large decline relative to the case of, for example, write-down debt.

When the coco's conversion ratio is in the range $0.53 < \alpha < 0.57$ the stock's maximum vega is lower than 2%. Assuming that there is a cost to changing the level of asset risk, the above results suggests that it may not be beneficial for the manager to change the level of asset risk in this case and therefore that a coco compensation can be designed so that it does not affect the manager's risk taking incentives.

Coco bonds issued by large banks mostly have a low conversion ratio or are write-down debt.[12] Goncharenko, Ongena, and Rauf (2020) find that more than 70% of the issued coco in Europe are "write down" coco. As shown, this means that coco holders are generally motivated to decrease risk and therefore, coco debt does not make a good compensation for the bank's managers if the objective is to reduce incentives to change risk. However, as we will show next, the bank can use its existing coco as part of a compensation package consisting of both stock and coco in a way that minimizes the manager's motivation to change the level of asset risk.

3.3 A compensation package with stock and coco

We now analyze the case where the compensation package consists of both stock and coco. If a bank issues coco with a low conversion ratio, both stock and coco compensation have strong risk-shifting incentives. But a combination of both can substantially reduce those incentives. The idea is that adding coco compensation to existing stock compensation can offset the strong motivation to increase risk that is present when using stock compensation on its own.

Figure 2 demonstrates the idea. In this example the coco's conversion ratio is $\alpha = 0.1$ meaning that at conversion wealth transfers from the coco holders to stock holders. From the figure it is clear that the value of stock is increasing with risk while the value of coco is decreasing with risk. Both the value of the stock and the coco are highly sensitive to changes in the level of asset risk; the stock's maximum absolute value of vega is equal to 3.6% while the coco's is equal to 10.6% and they are reached at asset risk level of 4.7% and 4.8%, respectively.

In contrast, the value of a compensation package consisting of 35% coco and 65% stock is relatively insensitive to the level of asset risk – the two components' values change in opposite directions – and the maximum vega is 0.7% which is reached at asset risk levels of 3.7% and 9.9%. The weights in this example are chosen to minimizes the manager's incentives to change the level of asset risk when the coco's conversion ratio is $\alpha = 0.1$, and the combination indeed results in a substantial decline in vega.

We next find the optimal weights so that the manager's compensation package has the smallest maximum vega. We do so for any coco conversion ratio, including the commonly used write-down coco with a conversion ratio $\alpha = 0$. We define ω as the percent of the manager's compensation that

[12] Berg and Kaserer (2015) write "the large majority of the contingent capital instruments issued so far entail a wealth transfer from contingent capital holders to equity holders at conversion."

consists of coco and $(1-\omega)$ as the percent of the manager's compensation that consists of stock.[13]

Figure 3 reports maximum vega as a function of the fraction paid out using coco, ω, for different coco conversion ratios, α. For write-down coco there is a noticeable decline in maximum vega as coco is added to the compensation package. When 33% of compensation is paid in coco, maximum absolute value of vega is minimized at a level of 0.69%. As the conversion ratio increases to $\alpha = 0.2$ and $\alpha = 0.4$, the optimal fraction paid in coco increases and the maximum vega also increases, though only very slightly, to 0.73% and 0.88%.

We can find the optimal fraction ω^* paid in coco for every conversion ratio, α, so that the maximum vega over the range of asset risk levels is minimized. Figure 4a presents ω^* for each conversion ratio, α. For any conversion ratio below $\alpha = 0.55$ and above $\alpha = 0.7$ it is possible to find a compensation package consisting of both stock and coco which decreases the bank manager's incentives to change risk as measured by the maximum vega. When the conversion ratio is in the range $0.55 < \alpha < 0.7$ the compensation package minimizing the manager's risk-shifting incentives consists of just stock.

Figure 4b shows the maximum vega resulting from the package compensation. When employing the optimal compensation package, maximum vega is equal to 0.69% for write-down coco, 1.09% for a conversion ratio of 49%, and 0.48% for a conversion ratio of $\alpha = 1$. For most of the range of conversion ratio, these numbers are substantially lower than using stock compensation on its own, and they are everywhere lower than employing coco compensation. Importantly, there is a very large reduction in maximum vega for write-down coco and low conversion ratios as they have been used for cocos issued in the market. We thus show that, using existing coco debt as part of a compensation package, it is possible to significantly reduce risk-shifting incentives relative to existing compensation based on either on stock or coco.

[13]The fraction ω denotes the percent of compensation value paid in coco at a baseline level of asset risk equal to zero. (We choose this baseline for simplicity and results are robust to choosing other levels.) Starting from the baseline level, and using the relative weights in coco and stock, we calculate vega for the full range of asset risk levels to find maximum vega.

4 Conclusion

Once a bank has issued coco debt this affects the risk taking incentives of a manager whose compensation consists of stock. Consistent with previous work, we find that the conversion ratio – the fraction of proceeds going to stock and coco holders in the event of conversion – is critically important in determining incentives. Write-down coco, where stockholders gain in the event of conversion, results in stock compensation incentivizing risk-shifting. We show that, if the compensation is made up of coco, there are risk-reducing incentives in this case.

It is possible to design coco debt in such a way that stock or coco compensation has very low risk-shifting incentives. However, this would require conversion ratios that are much higher than what is observed in practice – banks that issue coco bonds prefer to choose low conversion ratio, in many cases write-down debt.

Fortunately, it is possible to substantially reduce risk-shifting incentives using the available securities. If compensation packages can be a combination of coco and stock, the terms of the coco become much less important, as long as the relative weight of the two compensation components can be chosen freely. This means that banks that have already issued coco can put in place packages that eliminate risk and that banks that plan to issue coco in the future can choose coco terms that may satisfy investors and market demand with no or little concern regarding incentives. Those can be minimized later when designing compensation packages.

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Appendix A: Base case parameters

- **Maturity** (T): We choose a 1-year maturity following Marcus and Shaked (1984) and Ronn and Verma (1986). This maturity is also reasonable given that major audits are scheduled once a year. At such a time the regulator may ask the financial institution to change its capital structure.

- **Principal amounts**: We assume that the bank has a capital structure composed of deposits with face value $F^D = 100$, and contingent capital debt with a face value $F^C = 3$. The coco face value of 3% of deposits is similar to the ratio in the case of Lloyds' contingent capital.

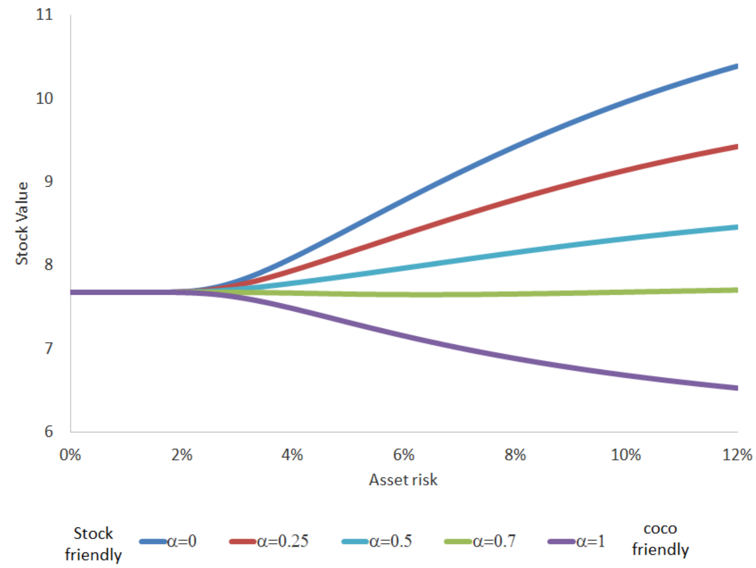
- **Conversion threshold** (β): We choose a conversion threshold, $K^C = \left(F^D + F^C\right)(1+\beta)$ that is located $\beta = 1\%$ above the total face value of the two debt instruments. Thus conversion occurs before debt maturity the first time that the value of the bank's assets is equal to $(1+\beta)$ times the total face value of the debt. In our model, β is positive to ensure that the event of conversion is prior to the event of default.

- **Leverage ratio** (LR): We define the quasi leverage ratio as the present discounted value of book liabilities divided by current asset value, $LR = \frac{\left(F^D+F^C\right)e^{-rT}}{V_t}$. We choose a quasi leverage ratio of 0.93 which is typical for commercial and investment banks (John, Mehran, and Qian, 2010).

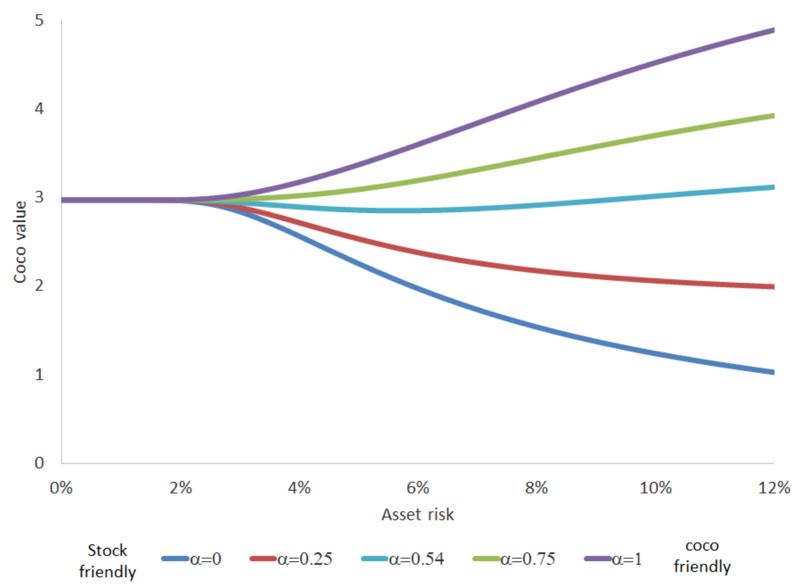
- **Interest rate** (r): We choose a continuously compounded constant rate of 1%.

- **Regulatory seizing policy** (γ): We assume that the regulator seizes the bank the first time that the value of assets is 3% below the face value of the deposits.

- **Minimum and maximum asset risk** (σ): We assume that asset risk lies between 0% and 12%. These levels are consistent with Mehran and Rosenberg (2008), who find that the average asset risk of banks in a large sample is equal to 5.3% and that the size of the cross-sectional standard deviation around this average is equal to 2.2%. Recently, Goncharenko, Ongena, and Rauf (2020) show that almost all banks which have issued coco have asset volatility in the range between 0% and 12%.



(a) Stock



(b) Coco

Figure 1: **The value of stock and coco for different conversion ratios.** We assume the level of asset risk is in the range 0% to 12% and report values for different levels of the conversion ration α. Levels of $\alpha = 0.70$ and $\alpha = 0.54$ for stock and coco respectively are chosen to minimize risk-taking incentives.

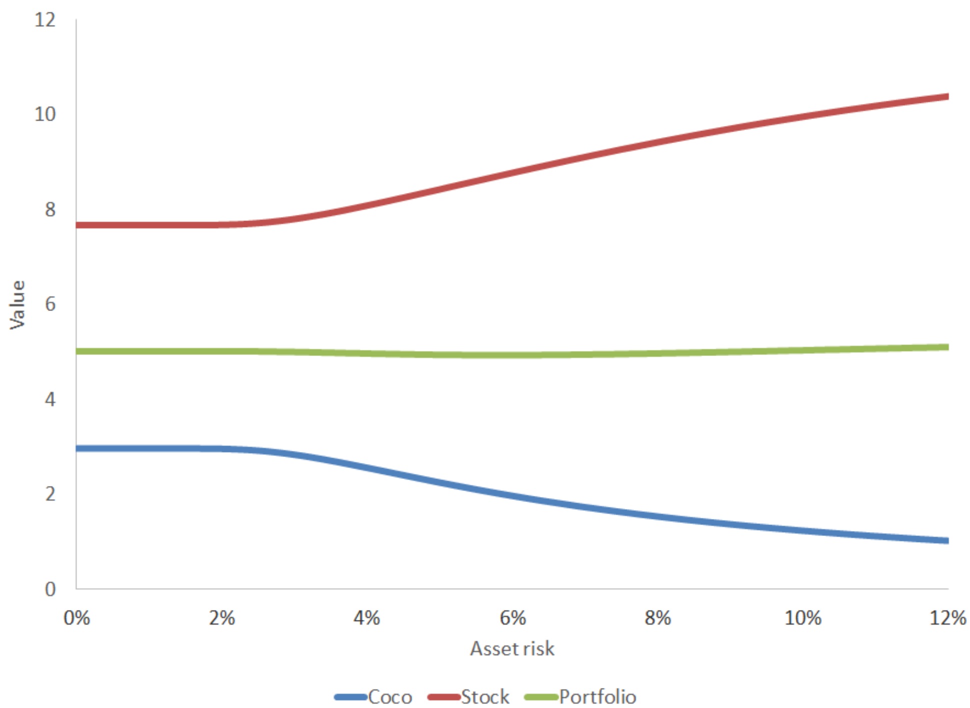


Figure 2: **The value of coco, stock, and a compensation package that minimizes risk-shifting incentives.** The coco's conversion ratio is $\alpha = 0.1$. The weight of coco in the executive's compensation is chosen to minimize the maximum compensation vega over the range of asset risk levels; it is $\omega^* = 0.35$. All other parameters are the same as in the base case analysis (see Figure 1a and Appendix A).

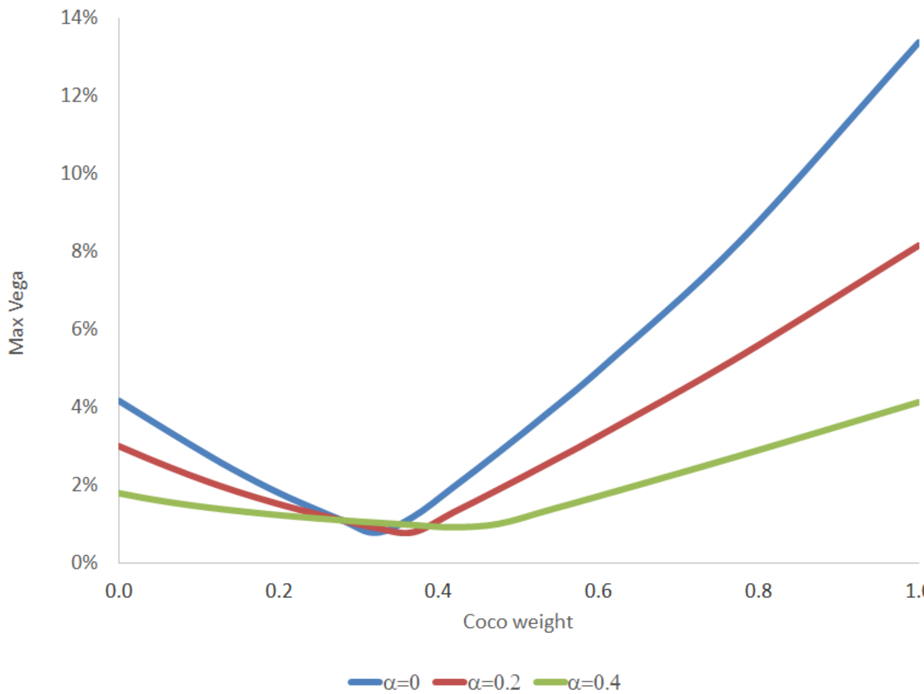
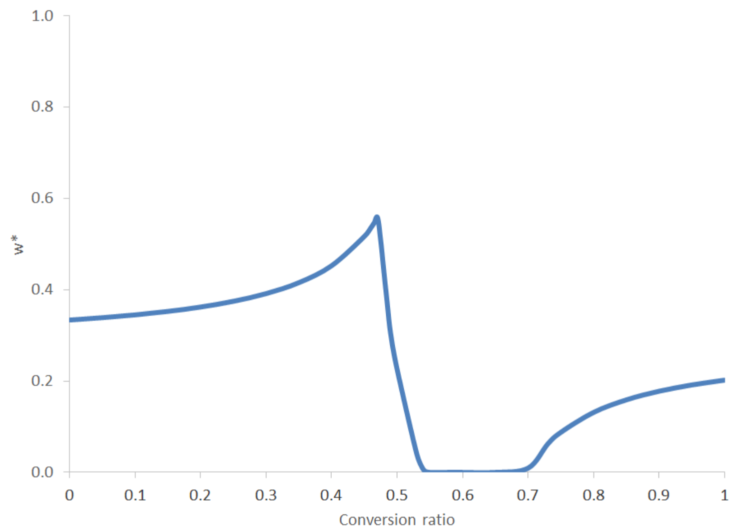
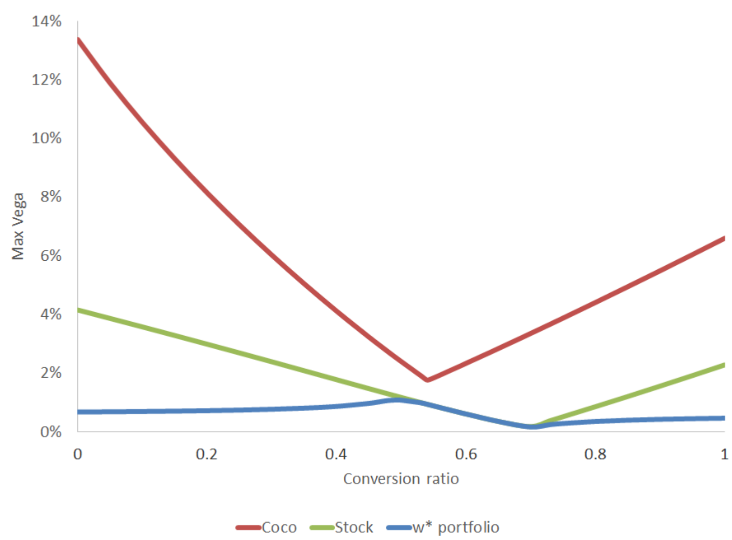


Figure 3: **The vega of a compensation package as a function of the weight in coco and stock.** We report maximum vega for portfolios of stock and coco as a function of the weight in coco ω. The figure shows results for low levesl of the conversion ratio α. Asset risk is in the range 0% to 12% and all other parameters are the same as in the base case analysis (see Figure 1a and Appendix A).



(a) The weight that minimizes the manager's motivation to shift risk.



(b) Maximum vega of stock, coco and the compensation package with the smallest vega.

Figure 4: **Designing compensation packages with the smallest maximum vega.** Panel A reports the optimal fraction ω of the compensation package made up of coco. Panel B reports maximum vega for stock, coco, and the package. We assume the level of asset risk is in the range 0% to 12%. The other parameters are the same as in the base case analysis (see Figure 1a and Appendix A).