Reverse Convertible Notes

Derivatives FIN-404

Andrea Cassotti (327919), Qais Humeid (323071),
Yann Eberhard (271804), Diego Lopez Codeso (325428)

May 5, 2021

Contents

1 Documentation

1.1 Definitions

A **reverse convertible note** is a derivative contract that pays a coupon at the end of every period, and pays a variable principal at maturity. If the price of the underlying asset at maturity is equal or higher than the strike price, the principal is equal to the nominal amount of the RCN. However, if the underlying price at maturity is lower than the strike price, the redemption is as follows (one of the following two outcomes) :

- The investor will receive in his account the number of shares corresponding to the ratio between the nominal amount and the strike price. The share fraction will be paid in cash. This in the case of physical delivery.
- The investor will receive a cash payment corresponding to $Denomination \cdot \frac{FinalLevel}{StrikeLevel}$ if the delivery is cash settled.

We can illustrate these terms by an example:
Let's take a Reverse Convertible Note with the following information
- Coupon : 5% p.a. (payable semi-annually)
- Maturity : 1 year
- Nominal Amount : CHF 1,000
- Issue Price : 100%
- Underlying : Nestlé
- Initial Fixing (price at the moment the product is launched) : CHF 107.96
- Strike Level : 90% (CHF 97,164)
- Delivery : Physical Settlement

Knowing these details, let's go over the different possibilities the investor will face, assuming he will invest in only one Note.
After 6 months and at the maturity of the product, the investor will receive a coupon of CHF $25 \cdot (0.05 \cdot 1,000/2)$.

Then, at maturity, the investor will be in one of the following two situations :

- The Nestlé Stock ends above the strike level at maturity. In this case, the investor will receive the nominal amount : CHF 1,000
- The Nestlé Stock ends below the strike level at maturity. Then, the investor will receive in his account 10 shares of Nestlé ($\frac{1,000}{97.164}$) and a payment in cash for the share fraction.

A **reverse convertible note with barrier** is a very similar product , with the difference that it includes a barrier level. This barrier can be of American type or European type. Let's now discuss the different payouts that may apply to the investor at maturity, because during the lifetime of the product the investor will simply receive the coupon payments as in the case of the reverse convertible note.

- European Barrier
  - If the underlying ends above the barrier level at maturity, then the investor will get 100% of the nominal amount.
  - If the underlying ends below the barrier level at maturity, then the investor will receive a physical delivery of a number of shares corresponding to the ratio between the nominal

amount and the strike price. The share fraction will be paid in cash. In the case of a cash settlement, he will receive a cash payment corresponding to $Denomination \cdot \frac{FinalLevel}{StrikePrice}$

- American Barrier
  - If the underlying has not crossed or touched the barrier level during the lifetime of the product, then the investor will be paid 100% of the nominal amount.
  - If the underlying has indeed crossed or touched the barrier level during the lifetime of the product, but its price at maturity is above the initial price, then the investor will also be paid 100% of the nominal amount.
  - Finally, in the case in which the underlying has crossed or touched the barrier level and ends at maturity below the initial price. The investor will receive a physical delivery of a number of shares or a cash settlements exactly as in the case of the European barrier.

Again, a practical case to illustrate the above words. To spot the difference between a reverse convertible note and a reverse convertible note with barrier, we are going to take the same example as before :
We then have the following **Reverse Convertible Note with barrier** with the following information
- Coupon : 5% p.a. (payable semi-annually)
- Maturity : 1 year
- Nominal Amount : CHF 1,000
- Issue Price : 100%
- Underlying : Nestlé
- Initial Fixing (price at the moment the product is launched) : CHF 107.96
- Strike Level : 100% (107.96)
- Barrier Level : 90% (CHF 97.164)
- Barrier Type : European
- Delivery : Physical Settlement

As before, after 6 months and at maturity, the holder of this note will receive a coupon of CHF $25 \cdot (0.05 \cdot 1,000/2)$.

Then, at maturity, the investor will be in one of the following two situations :

- The Nestlé Stock ends above the barrier level at maturity. In this case, the investor will receive 100% of the nominal amount : CHF 1,000
- The Nestlé Stock ends below the barrier level at maturity. Then, the investor will receive in his account 9 shares of Nestlé ($\frac{1,000}{107.96}$) and a payment in cash for the share fraction.

Regarding the autocallable and callable versions, the products' description above of the RCN and RCN with barrier still holds. The difference it that, under a callable version, the issuer of the note can redeem the product at his will prior to maturity. The issuer has the possibility to do that at specific dates planned in advance. If the issuer decides to early expire the product, the investor will receive a last coupon and be paid 100% of the nominal amount.

In the case of the autocallable version, at the issuance there is an autocallable level that is fixed. Then, if the underlying ends above this autocallable level during a specific date (autocallable dates planned at issuance), then the product automatically expires and the holder receives 100% of the nominal amount and a last coupon.

In general, the early redemption observation dates are the same as the coupon dates.

1.2 Why do they exist?

This kind of products can be interesting to investors that thinks that some underlying is going to be stable or slightly decrease during a certain period of time. It allows investors to be exposed to an underlying (or a basket or underlyings) they are interested in and earn some interest gain on it. In the worst case, they will receive in their account the underlying they were interested in at the beginning (in the case of a physical delivery).
Also, it offers the possibility to cash coupon payments in a flat market. And finally, it could offer some diversification for a portfolio.

Regarding the issuing banks, it allows them to offer an exposure to stocks to clients that are maybe risk-averse and do not want to hold directly a stock. This concerns the reverse convertible, because in the worst case the investor will receive the stock at the strike price which is lower than the initial price. And with a barrier-RCN, investors can benefit from some protection. These features may help the issuers to attract a broader class of investors.
Mostly, banks will earn fees and commissions on issuing this kind of products, then they will also earn money in the secondary market thanks to the bid-ask spread on market making. Finally, when reproducing the strategy of the product, usually banks will take a margin for them.

1.3 Some numbers

Between May 1998 and February 2007, a total of $ 45 billion US dollar-denominated reverse convertible notes were issued in the market. This figure is equivalent to 7,426 issues, 2,931 of which were issued in the Netherlands (for a total value of $11.3 billion) , 1,906 were issued in Great Britain (for a total of value of $17.9 billion), 1,117 were issued in the United States (for a total value of $5.6 billion), and 879 were issued in Germany (for a total value of $7.5 billion).

The median term to maturity is close to one year for all types except for zero-coupon RCNs that have a median term to maturity of 59 days.

The two industries in which the securities are most frequently used as underlying securities are Electronic and Other Electrical Equipment and Components (17% of the issues), and Industrial and Commercial Machinery and Computer Equipment (14% of the issues).

Regarding the Swiss Market, RCNs are frequently used and many Swiss financial institutions issue them. The SIX supervise the issuance and also quote them. In regards to the SVSP-Classification, the classification that does the SIX about the structured products, the RCNs are classified under the Yield enhancement category. As we can observe in the data provided by the SIX, Yield enhancement products represent between 18% to 27% of all the structured products traded in the SIX exchange. The major part being leveraged products as Mini-Futures or Warrants.

1.4 Investors

Regarding the investors' point of view, the benefits of holding a simple RCN is that they will receive a fixed coupon like a bond whatever happens. Then, regarding the redemption of the product various cases can happen :

- If the underlying ends at the final fixing date above the strike level, then the investor will receive 100% of his investment. This holds even if the underlying has lost some value.
- If the underlying ends at the final fixing date below the strike level, then the investor will receive the underlying in his account at the strike price (if the redemption is physical) or will

simply receive the cash difference corresponding to the loss if the redemption is in cash.

So, this product can be very interesting for an investor who thinks that the underlying will be flat or slightly positive during the period of investment. Even, if the underlying loses some value (but ends above the strike level), the investor would have been able to generate some gains. Which it would not have been the case if he held the underlying.

Comparing the RCN and RCN with barrier, the RCN with barrier is more interesting for a risk-averse investor. However, the RCN with barrier will pay a lower coupon.

Regarding the drawnbacks, this financial product has limited upside. For example, if an investor enters in a RCN with maturity 6 months, coupon of 5% and which has Apple as underlying. If at the end of the 6 months Apple has increased by 20%, the investor will only get 5%. In that case, it would have been more interesting to directly invest in the stock instead of buying an RCN.

Another drawnback is the counterparty risk. Even if an investor holds a RCN on Apple issued by UBS, if UBS goes bankrupt the investor will loose his entire investment.

Also, if the holder of a RCN wants to get rid of it, it will be harder than a stock as the secondary market is not very liquid. Therefore, it also implies that the bid-ask spread is higher.

In regard to the (auto)callable versions, there is no real benefit for the investor. Because if the underlying is very likely to end above the strike level, then the holder will be fully paid and receive all the coupons. However, seeing that, the issuer will decide to terminate the contract early, or it will be expired automatically in the case of an autocallable version, depriving the holder from his future gains.

Investors can be interested in this kind of products to reduce the volatility of their portfolio and create fixed cash flows with a higher predictable outcome.

Another drawnback is that the holder of a RCN will not receive potential dividends and his product will may suffer because of the drop in the share price after the payment of a dividend.

Finally, reverse convertible face limited upside potential but are penalized by a disproportionate large downside risk. Then, the investor is not protected in the case of a market crash as during the covid crisis in March 2020.

1.5 Issuing banks

A benefit for the issuer regarding the barrier RCN is that it will be easier to sell to potential clients compared to simple RCN. The reason is that usually, the protection higher on the barrier RCNs. Therefore, the clients will think that they are well protected, but this protection is usually in the order of a drop in the share price of 30%-40%. But the client is not protected against bigger drops.

A benefit regarding the simple RCN is that it is easier to explain to a client rather than the barrier RCN.

From the point of view of issuing banks, the callable versions allow them to protect themselves from potential losses. For example, if a bank has issued a reverse convertible note, and the underlying is really out of the money. Then, there is a very low probability that the holder of the note will be exercised. Thus, the holder can wait until maturity for his full redemption of the nominal amount receiving all the coupons or sell it to the bank at a premium. To avoid that, the issuer bank can decide to early stop the product and protect itself because it may have been going out of refinancing on the money-market placement component. The banks can also call back a product for other many reasons.

On the other hand, the investors knowing that will maybe be less interested in this kind of products rather than the non callable versions.

1.6 RCNs and CoCo

A CoCo bond or Contingent Convertible bond is a fixed-income instrument. It allows the investor to benefit from a higher interest rate than straight bonds. The usual CoCo bond is a financial instrument that pays a fixed coupon to the holder and may be converted into equity if a certain trigger is breached. Usually, the trigger concerns a specific capital ratio like the Tier 1 capital for a bank. Knowing that, we can therefore make the analogy with the barrier Reverse Convertible.
As explained before, the holder of a barrier RCN receives a fixed coupon every period. At the term of the contract, he may receive a certain number of shares in his account instead of a redemption of the principal if the stock price has reached the barrier.
It is similar for the case of the CoCo, the investor receives each period a fixed coupon. Then, if the capital ratio (e.g. Tier 1) breaches the trigger level (similar to the barrier in the case of the RCN) the investor will also receive a certain number of shares in return.
So, we can observe that there are similarities between these two products. But there is also differences. For instance, the CoCos are not limited in the upside and the barrier level is not referred to an underlying like a stock.

2 Preliminary results

2.1

A RCN can be seen as a long position in a bond of principal I_0 with coupon payment of c at times $(T_j)_{j=1}^N$ and a short position in a European put option with strike $K = \alpha I_0$. The cash flows of such product are given by payments c at each T_j, payment of the principal equal to 1 at time T_N and the payoff of the short position $(-1/I_0)$ in the put option. Hence, at time t, it is given by

$$\mathbf{1}_{t\geq T} + \sum_{j=1}^{N}(T_j - T_{j-1})c\cdot\mathbf{1}_{t\geq T_j} - \frac{1}{I_0}\mathbf{1}_{t\geq T}(\alpha I_0 - I_T)^+ = \mathbf{1}_{t\geq T} + \sum_{j=1}^{N}(T_j - T_{j-1})c\cdot\mathbf{1}_{t\geq T_j} - \mathbf{1}_{t\geq T}\Big(\alpha - \frac{I_T}{I_0}\Big)^+$$

which is exactly the same expression.

2.2

A RCN with barrier can be seen as a long position in a bond of principal I_0 with coupon payment of c at times $(T_j)_{j=1}^N$ and a short position in a European put option with strike $K = \alpha I_0$ with the following additional clause: if the price remains above a certain floor βI_0 the option becomes void. In other words, it is a short position in a down-and-in put option with barrier level at βI_0.

2.3

Suppose $\beta \in [\alpha, 1]$, when $\mathbf{1}_{\{\tau_\beta \leq T\}} = 1$ the Barrier-RCN has the exact same cumulative cash flows as the simple RCN.

When $\mathbf{1}_{\{\tau_\beta \leq T\}} = 0$, we have

$$\tau_\beta > T \quad \Rightarrow \quad I_T > \beta I_0 \geq \alpha I_0 \quad \Rightarrow \quad \Big(\alpha - \frac{I_T}{I_0}\Big)^+ = 0$$

Here, we used the fact that $\beta \geq \alpha$. This shows that the term $\mathbf{1}_{\{\tau_\beta \leq T\}} = 1$ doesn't change the expression and thus it equals a simple RCN.

2.4

The holder of the note has the same position in the bond and the European down-and-in put as in part 2.2. He also holds a short position in a Bermudean derivative with exercise dates at the same

time as when coupons are paid and same maturity $T = T_N$. If this derivative isn't exercised by the issuer before maturity, it pays nothing. If it is exercised at time $T_j < T_N$, it will induce the following cash flows : -1 at T_j and c for all $T_i > T_j$. Furthermore, it will also have a cash flow of $1 - \mathbf{1}_{\tau_\beta \leq T} \cdot (\alpha - \frac{I_T}{I_0})^+$.

We can see that if the Bermudean derivative is exercised, the payments of the European down-and-in put and the bond after the date of exercise are cancelled out with those of the RCN and it will pay 1 at the date of exercise. Hence, it is exactly equivalent to the cash flows of a callable Barrier-RCN.

2.5

We want to find the formula for the price of a callable Barrier-RCN under the unique EMM $\mathbb{Q}$. The exercise dates are $(T_j)_{j=1}^{N-1}$. Furthermore, in this case, the callable right is given to the issuer, hence he will exercise to lose the less amount of money possible (a minimum, not a maximum as in the usual American options). The price of the derivative at time T_i is given by

$$P_{T_i} = \min \left\{ 1 + c,\ \mathbb{E}^{\mathbb{Q}}_{T_i}[P_{T_{i+1}}] + c \right\}$$

Here, the c isn't inside the expectation since the coupon is paid at time T_i and it has a fixed value.

The optimal stopping time is given by

$$\tau^\star = \inf \left\{ i \in \{1, \dots, N-1\} \ :\ P_{T_i} = 1 + c \right\}$$

In this case, $\inf \emptyset = T$ meaning that it isn't optimal for the issuer to exercise the derivative before maturity.

3 Valuation code

See Code

4 Model calibration

See Code

5 Analysis

5.1

See Code

5.2

First of all, what can be observed is that the level of β does not have any effect on the simple RCN as this could be expected. Also, when $\beta = 1$, the simple RCN and the Barrier-RCN have exactly the same behaviour and same cumulative cash flows as derived and explained in point 2.3 (both lines overlap in the Figure 1).

Then, regarding the simple RCN, the higher is α the higher the coupon rate will be. This result is not surprising at all since α is considered to be the exercise price. Then, if α is high, it means that the option is ATM or really close to be. So, it is more likely to be exercised and not be redeemed at par. This implies more risk and therefore must be rewarded with more interest.

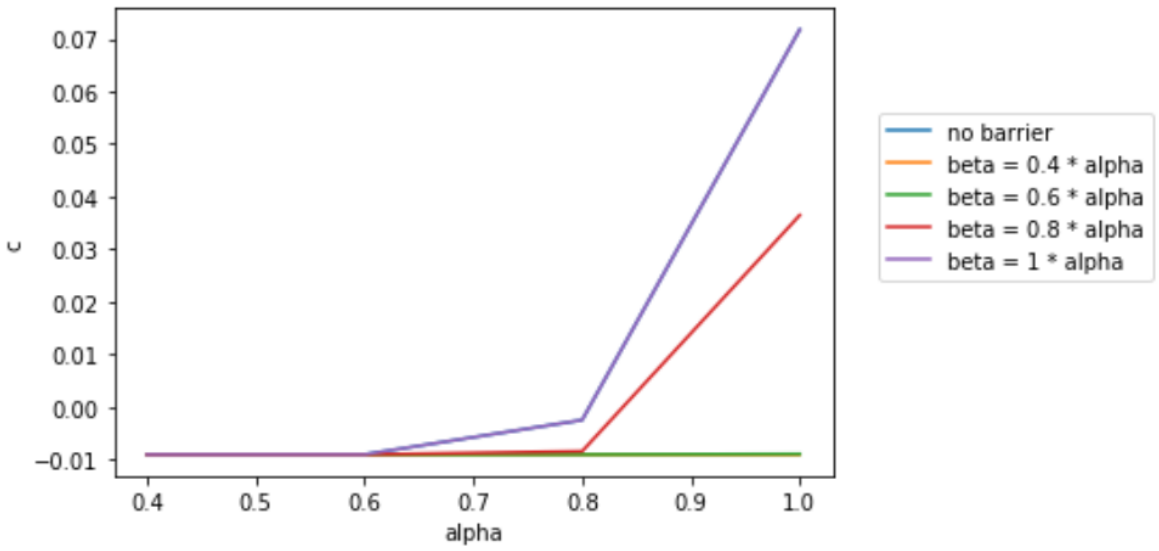

Figure 1: Par coupon rates in function of α

Regarding the Barrier-RCN, the higher is α the higher is the coupon rate as in the case of the simple RCN. We can also observe that the higher is β the higher the coupon rates will be. Again, this result is totally consistent because β behaves like a protection for the investor. So, if β is very low, the investor is protected against a big drop of the underlying and therefore has a low probability to be exercised. On the other side, if β is high, the investor has low protection and then has higher probability to be exercised. Thus, the more the investor is protected, the lower his coupon rate will be. This is consistent with the risk-reward theory.

5.3

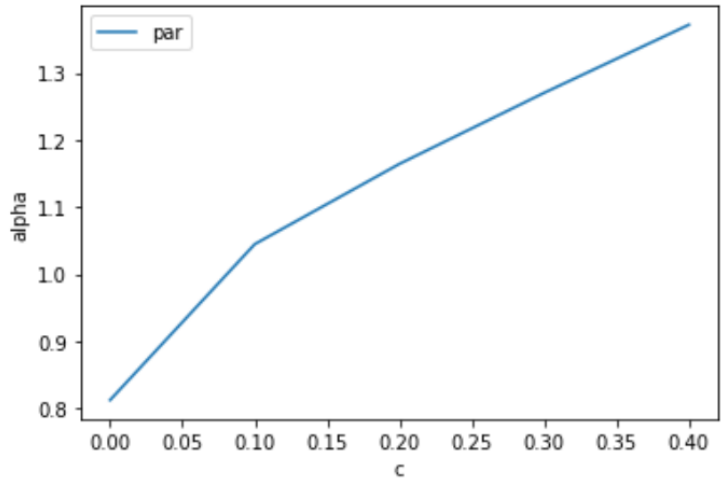

Figure 2: Par-α in function of the coupon rate for the simple RCN

As explained before, the α depends positively on the coupon rate. So, the higher the coupon rate, the higher the α must be. As we can observe in Figure 2, for a very high coupon, α must be higher than 1. This means, that the option on the underlying is already in-the-money at the start of the product. In this case, the investor is very likely to be exercised, because of the high risk of this product it must reward a high coupon rate.

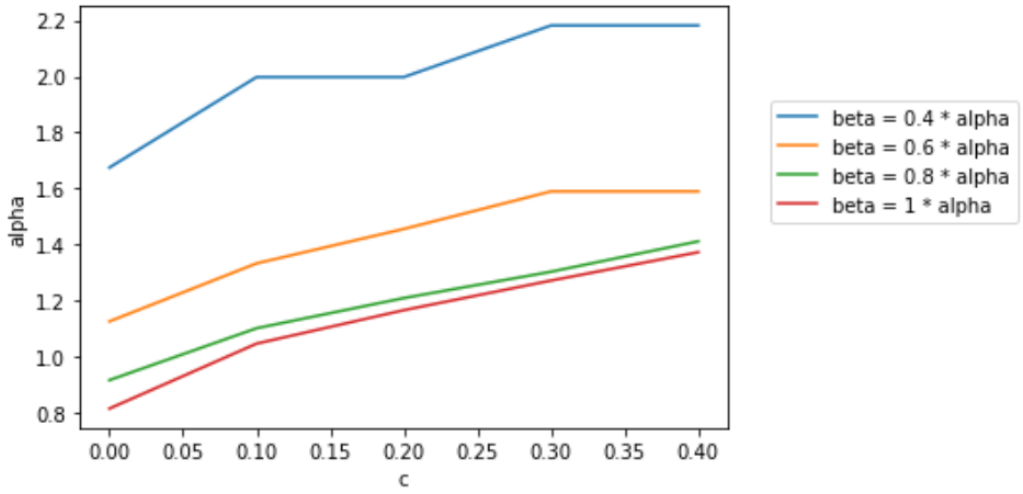

Figure 3: Par-α in function of the coupon rate for the Barrier-RCN

5.4

As discussed before, the α also depends positively on the coupon rate for the Barrier-RCN as in the case of the simple RCN. The higher the coupon rate, the higher the α will be. Another distinction in the case of the Barrier-RCN is the barrier level (β). As we can observe in Figure 3, if $\beta < 1$ it will shift up the level of the α to attain the same level of coupon than in the case without barrier. This is due to the risk-reward payoff, if $\beta < 1$ the investor is protected and the product is less risky. Therefore, to have the same coupon than in the case without barrier, the α should be higher than in the case without barrier.

5.5

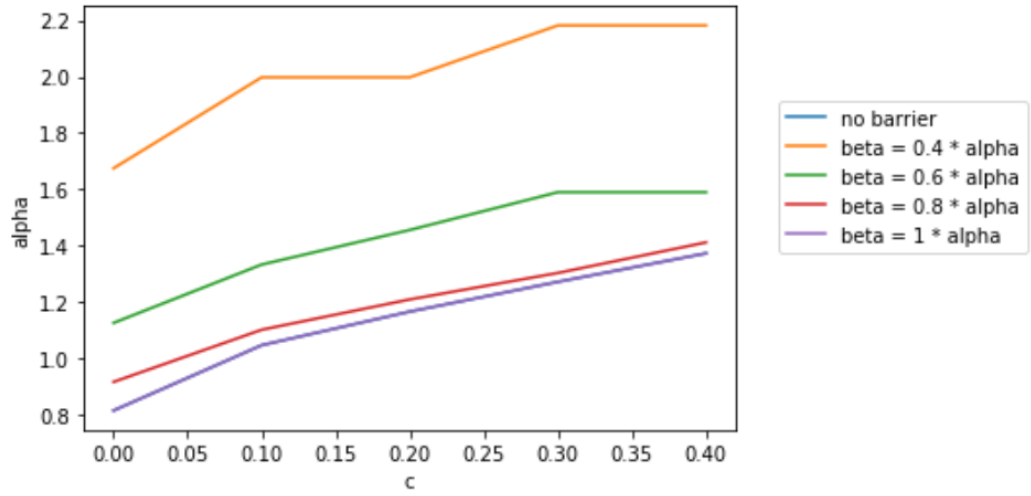

Figure 4: Same as Figure 3 but adding the simple RCN

When $\beta = 1$ the simple RCN and the Barrier-RCN behave in the same way, then there is no difference between both products as we can see in Figure 4 (both lines overlap). When $\beta < 1$, the α of the Barrier-RCN is higher than the α of the simple RCN. Because, when there is a barrier with a level lower than one, the product is less risky. So, to attain the same level of coupon than in the case without barrier (more risky) the α should be higher. This is because the coupon-rate depends positively on the α as explained before.

5.6

The issuer will optimally call back the product when the continuous value is higher than the principal + coupon. The issuer will apply the following rule :

$$\text{Exercise if : Continuous Value} > \text{Principal} + \text{Coupon Payment}$$

5.7

As we can observe in Figure 5, the shape of the lines are very similar to the case in Figure 1 where there was no callable feature. However, we can see here that with the callable feature, for a same α the coupon rate is higher. This is due to the fact that with a callable RCN, the investor faces a call risk. The issuer of the note can call back the product at its sole discretion. Therefore, because with a callable feature the investor faces a disadvantage in comparison with the case without a callable feature, he must be rewarded with a higher coupon.

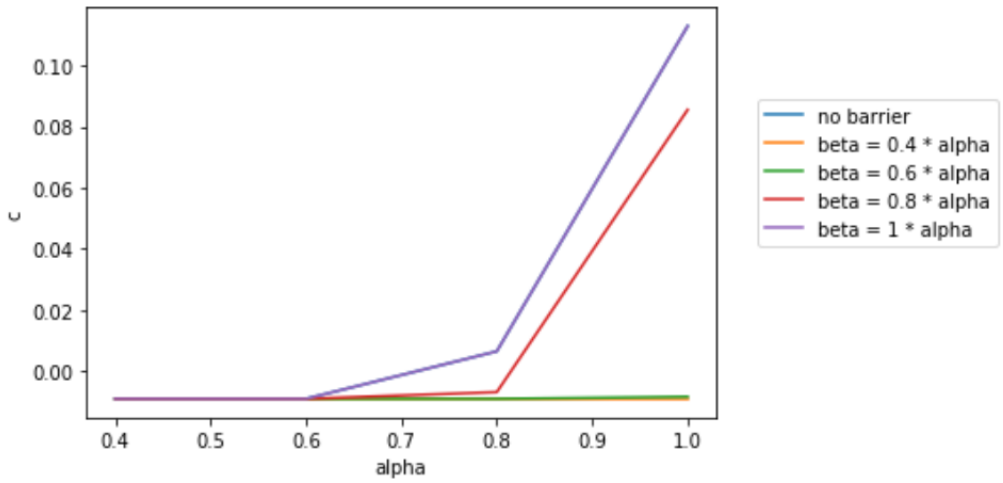

Figure 5: Par-coupon in function of α for different callable RCN

5.8

As observed in Figure 6, the plot is almost the same than Figure 5 but with interchanged axes. The interpretation stays the same than before. The lower the α, the lower the coupon. If we add a barrier level to the note, it will decrease the coupon rate because the risk will be lower. In consequence, to attain a higher coupon, we have to increase the α. Again, in this case, the coupon is higher than in the case without a callable feature because the investor must be rewarded in compensation to this right given to the issuer.

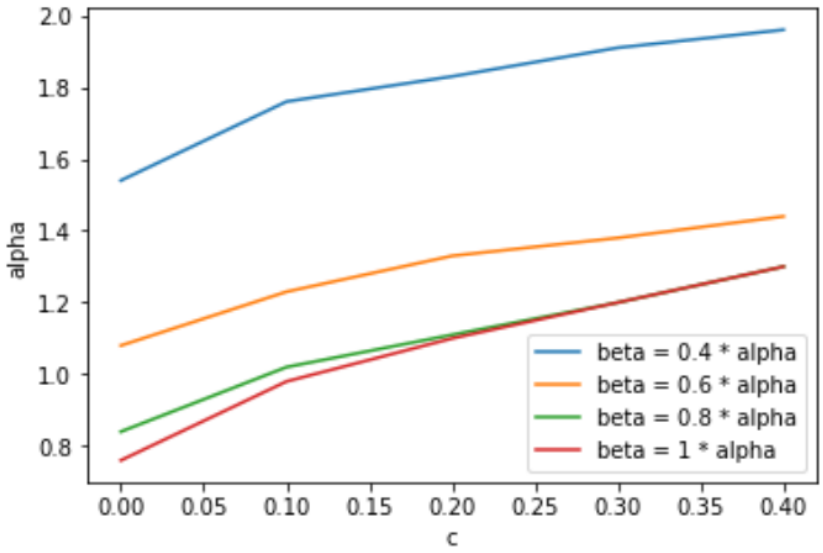

Figure 6: Par-α in function of the coupon rate for callable Barrier-RCN

5.9

TERMSHEET

Reverse Convertible on the SMI

Specifications of the product

Nominal Amount :	CHF 1000
Issue Price :	100%
Initial Fixing Date :	5 May 2021
Final Fixing Date :	5 May 2022
SVSP-Classification :	Yield enhancement - Reverse Convertible (1220), according to the Swiss Derivative Map available at www.svsp-verband.ch

Underlying :

Name	ISIN Code	Reference Exchange	Initial Fixing	Strike Price
SMI Index	CH000998089	SIX Swiss Exchange	11'118	11'118

Terms and Conditions

Coupon Rate :	7.17%
	The coupons are paid monthly
Calculation method :	30/360

Payout :

1. If at the final fixing date, the level of the SMI is above the Strike Price (11'118), the amount redeemed per note will be 100% of the nominal value.
2. If at the final fixing date, the level of the SMI is equal or below to the Strike Price, the amount redeemed per note will be $\frac{FinalPrice}{StrikePrice} \cdot NominalAmount$

Profit and Loss Expectations

Performance of the SMI	Nominal Reimbursement in Cash
25%	1000
10%	1000
5%	1000
-5%	950
-10%	900
-25%	750

Other Pricings

Our desk can offer other types of products with different risk-reward perspectives as listed below :

Product	Coupon Rate	Strike Level	Barrier Level	Callable Feature
Barrier RCN	6.12%	100%	90%	None
Callable RCN	11.28%	100%	None	Yes
Callable Barrier RCN	11.20%	100%	90%	Yes

For risks and explanations of the other products priced, please refer to the presentation at the beginning.

References

[1] FINRA : National Association of Securities Dealers, https://www.finra.org/investors/alerts/reverse-convertibles-complex-investment-vehicles

[2] Investopedia : An Introduction to Reverse Convertible Notes (RCNs), https://www.investopedia.com/articles/bonds/08/reverse-convertible-note.asp

[3] Investopedia : Convertible vs Reverse Convertible Bonds, https://www.investopedia.com/ask/answers/05/reverseconvertiblebond.asp

[4] SIX : Market Report Express, https://www.six-structured-products.com/en/latest-news/market-report

[5] Le Temps : Les Cocos sont comparables aux barrier reverse convertibles, https://www.letemps.ch/economie/cocos-comparables-aux-barrier-reverse-convertibles

[6] CoCos: a primer by Stefan Avdjiev, Anastasia Kartasheva, Bilyana Bogdanova, https://www.bis.org/publ/qtrpdf/r_qt1309f.pdf

[7] Investopedia : Contingent Convertibles (CoCos), https://www.investopedia.com/terms/c/contingentconvertible.asp

[8] Structured Products easy explained, https://www.my-structured-products.com/index.php/know-how/yield-enhancement/54-barrier-reverse-convertible

[9] Swissquote : Derivative Finder, https://www.swissquote.ch/index/index_quote_f.html

[10] SIX : Product-Know-How, https://www.six-structured-products.com/en/know-how/product-know-how/introduction

[11] Rodrigo Hernández, Wayne Y. Lee, Pu Liu-An. Economic Analysis of Reverse Exchangeable Securities - An Option-Pricing Approach. June 2010, Review of Futures Markets 19(1): 67-98