Asian **B**itcoin Straddles **C**apital Guaranteed Note (ABC Note)

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1. Economic Motivation

1.1 Bitcoin frenzy

Over the year of 2020, Bitcoin has been increasingly accepted by the public. In Oct 2020, Paypal, the payment processing giant, announced the plan to accept cryptocurrency holdings and payments. Following Paypal's move, international banks such as Morgan Stanley started to offer Bitcoin funds to their clients. The acceptance of Bitcoin from the financial behemoths has made Bitcoin price skyrocketed and sparked another Bitcoin frenzy. Based on the growing number of active investors, Coinbase Research concluded that retail investors were steadily participating in the investment of Bitcoin.

1.2 Retail Investors' struggle between high return and high volatility

Witnessing a sevenfold surge in Bitcoin price since the beginning of 2020, it is conceivable that the general public is afraid of missing a great speculation opportunity. Güler (2021) supported the argument by attributing the speculative and irrational Bitcoin investment to the fear-of-missing-out (FOMO) psychology. Despite the fascination towards holding cryptocurrencies as an alternative asset, some retail investors are hesitated to invest in it due to the following reasons:

1. Limited understanding in cryptocurrencies
   Bitcoin is a nascent asset with only 13 years of price history. Henceforth, retail investors do not have sufficient understanding on Bitcoin risk and return profile. CNBC reported that only 16.9% of investors "fully understood" the value and potential of cryptocurrency. This lack of acquaintance made investors doubt if the currency was a sustainable and profitable investment.

2. Wild price fluctuation
   Bitcoin is extremely volatile by design owing to its inelastic supply. There are plenty of records that the currency moved for more than 30% overnight in both directions (CNBC, 2021). This feature deters investors as they could hardly bet on a certain direction and if they placed the wrong bet, the punishment would be painful.

In light of the above concerns, the financial product we propose aims to greatly mitigate the risk of Bitcoin, capture profit without making directional price predictions, as well as protect investors from huge loss.

2. Product Design

Name	**A**sian **B**itcoin Straddles **C**apital Guaranteed Note (ABC Note)
Underlying	Bitcoin-USD
Time to maturity	2 Years
Capital guarantee	80%
Unit price	USD1000

Capital Allocation	Management fee	1%
	Fixed Income Securities (US 2 Year treasury notes)	~80% (After management fee)
	Bitcoin Straddles	~20% (After management fee)

Payoff	Description
$Payoff = 0.8\,(1 - x\%) \cdot I + p \sum_{t=1}^{24} (\lvert S_t - \overline{K_t} \rvert)$ where - I is initial investment - $x\%$ is management fee - p is participation rate - $\bar{K}_t$ is mean price of Bitcoin in month t-1	<u>Before maturity</u> There are 24 monthly straddles. In each month, a straddle matures with payoff = $p\lvert S_t - K_t \rvert$. K_t is revised monthly and reset to the average Bitcoin price in the previous month. All monthly payoffs are accumulated. <u>At maturity</u> Investors receive 80% of the guaranteed capital and the cumulative payoff of the 24 straddles.

<u>2.2 Product Features</u>

1. Capital guarantee
   The majority of capital is allocated to risk-free bonds. Investors can receive the guaranteed portion regardless of option payoff.

2. Volatility trading
   Straddle payoff does not depend on the direction of price movements, but the magnitude instead. Investors who prefer not to bet on direction could benefit from price volatility.

3. Risk smoothing
   The payoff of the product does not solely depend on the Bitcoin price at maturity, but the average price movement throughout the 24-month holding period. The strike price reset setting raises the stability of the payoff stream.

3. Pricing Methodology

<u>3.1 Model Selection</u>

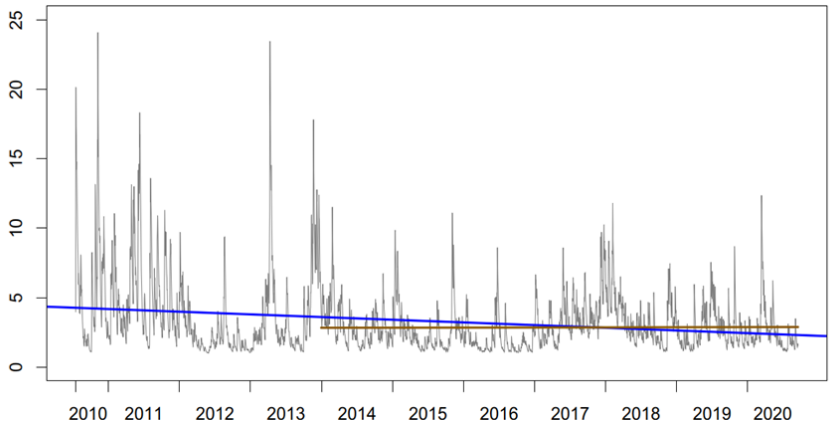
Bitcoin volatility exhibits large fluctuations, and thus it is more realistic to use a stochastic volatility model to price the product. The model chosen is the Heston model as it has two defining features - heavy tail distribution and mean-reverting volatility, which resonates with Bitcoin historical data.

Heston Model

$$dS_t = \mu S_t dt + \sqrt{v_t} S_t dW_t^S$$
$$dv_t = \kappa(\theta - v)dt + \xi\sqrt{v_t} dW_t^v$$

1. Heavy tails in Bitcoin return distribution
   From the R code, Bitcoin return is found to exhibit heavy tails on both ends, indicating that Bitcoin return is more likely to show extreme values.

2. Mean-reversion feature of volatility
   Baur, Dimpfl (2021) discovered that starting from 2014, Bitcoin volatility trend has not been significantly different from zero (i.e. the trend is flat), which resembles mean reversion.



The red line represents the volatility trend starting from 2014 (Baur & Dimpfl, 2021).

3.2 Calibration

For most of the parameters in the Heston model, we could estimate by observing the historical data. Yet, the mean-reverting rate κ and "vol of vol" ξ could not be observed from historical data and thus optimization was used to estimate them. We proposed two methods of optimization: we chose the combination of κ and ξ that

1. minimized the gap between actual option price and Monte Carlo simulated option price
2. minimized the actual 30-day rolling volatility and Monte Carlo simulated volatility

The above two methods yielded simulated option prices that had similar correlation (~70%) with the actual option prices. Nonetheless, the first method returned a price distribution that better resembled the actual Bitcoin price. Hence, the κ (~1) and ξ (~10) were calibrated by using method 1.

3.3 Pricing the Straddles

In each month, daily changes of volatility and Bitcoin price is modelled by the Heston model. At the end of each month, monthly straddle payoff was calculated as $|S_t - K_t|$ where S_t was the last price in month t and K_t was the mean price in month t-1. The 24 monthly payoffs were summed up as the final payoff. This process was repeated for 10,000 trials and the mean of all 10,000 final payoffs were deemed as the fair price of the 24 straddles (~150,000USD) .

4. Participation Rate, Hedging and Issuer's Profit

4.1 Participation Rate

The fair price of the 24 straddles were calculated with 1 unit of Bitcoin and its price is deemed to be too pricey for retail investors. Therefore, a participation rate of the Straddles was added to lower the price. Moreover, some investments were put in risk-free bonds to protect investors' capital.

$$(1\ -x\%)\ I = 0.8\ (1-x\%)\ I\ e^{-2r} + p\ \cdot Fair\ Price\ of\ Straddle,$$
$$where\ x\%\ represents\ management\ fee, p\ represents\ participation\ rate$$

The left hand side denotes the after-fee initial investment. The right hand side describes the allocation of capital into bond and straddle respectively. Using the fair price calculated from Monte Carlo simulation, the participation rate p is then determined.

4.2 Hedging Strategy

Given that the product structure is similar to a series of Bitcoin vanilla options, except that the strike prices are periodically reset, an almost-perfect hedge is possible without using complicated strategies.

At the beginning of each month, the issuer should determine the average Bitcoin price over the last month as the option strike price. Next, the issuer purchases p units of European call option and p unit of put option with the predetermined strike and one month maturity. The only hedging requirement is to monitor the Bitcoin price each month.

4.3 Issuer's Profit

The issuer profit consists of 3 parts :

$$Profit = x\% \cdot I + 0.8\ (1-x\%) \cdot I \cdot \sum_{s=1}^{3} \frac{c}{2} \cdot\ e^{r\left(T-\frac{s}{2}\right)} + p \sum_{t=1}^{24} \left(\left|\ S_t - \overline{K_t}\right|\right) \left(e^{r\left(T-\frac{t}{12}\right)} - 1\right),$$
$$where\ I\ represents\ initial\ investment, x\%\ represents\ fee, c\ represents\ coupon\ rate$$

1. 1% management fee

2. Coupon payments of treasury note
   79.2% (i.e. 80% x 99%) of the initial investment is invested in US Treasury bonds. The issuer collects the semi-annual coupons on behalf of investors.

3. The present-value-future-value differential of straddle payoffs.
   As the issuer longs call and put options in the portfolio, it receives option payoff each month. However, the investors are paid with the non-compounding cumulative straddle payoffs. The time value of money is instead realized by the issuer.

The reason why only 1% fee is charged is that the issuer does not solely rely on the fee but also the coupons and time value of money. The low fee structure can be regarded as an attractive marketing point to retail investors. It is also noteworthy that the issuer's profit increases with the risk-free rate, implying that the potential profit can be larger when the Federal Reserve increases the interest rate back to the pre-Covid level.

5. Product Backtesting

Investment Period	Annualized Return
2019-11 to 2021-11	52%
2018-11 to 2020-11	15%
2017-11 to 2019-11	16%

The backtesting result is illustrated in the table above. If the product was invested in late 2019, the annualized return on investment would have achieved 52%. On the other hand, if it was purchased at the time right before the 2018 cryptocurrency crash, the ABC Note would have still yielded a considerable 16% return. From the perspective of retail investors, the return is significantly higher than fixed income instruments and they enjoy a 80% safety margin.

6. Further Issues

Transaction costs

The issuer bears the risk of fluctuating transaction costs and hence reducing profit. The costs could stem from the commission fee charged by option exchanges, and widening bid-ask spread when the trading volume is low.

Potential Product Variants

1. Use strangles instead of straddles
   A straddle strategy is costly as at-the-money options are more expensive. An alternative is strangle, which involves cheaper out-of-the-money options. A larger quantity of options can be purchased given the limited capital and hence the return under high volatility scenario may be enhanced.

2. Revise call-put ratio in straddles
   The current call-put ratio is 1:1 such that investors benefit equally from any price direction. Observing the success of Bitcoin over the last decade, investors may have a bullish view. To cater for their preference on the long side, call-put ratio can be greater than 1 so that investors realize higher payoff from Bitcoin appreciation.

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