VIGOR*

Chester Hedron[1]

***Abstract*— VIGOR is a crypto-backed decentralized stablecoin on the EOS blockchain that tracks the US dollar.**

I. INTRODUCTION

The VIGOR stablecoin is a financial engineering innovation with regards to a decentralized stable unit of account. This project creates a crypto-backed stablecoin without a central counterparty by enabling participants to separate and transfer both **volatility risk** and price **event risk** through open source escrow smart contracts. Stablecoins are created and loaned out when EOS native crypto tokens are put into escrow as collateral and backed by insurers. This project introduces a decentralized system of borrowing & insuring; a crypto credit facility with only two distinct independent participants:

- **Borrowers**
  - escrow EOS native tokens as collateral
  - take stablecoin loans, maintaining collateral level
  - pay premiums over time to insure their collateral
- **Insurers**
  - escrow EOS native tokens as insurance assets
  - earn premiums based on contribution to solvency
  - bailout: take-over & recap undercollateralized loans

A. The Problem

Currently there is no decentralized stablecoin on EOS. Many use cases involving time value of money require this kind of basic functionality. Other projects suffer the following problems that this project will attempt avoid or improve upon:

- **Intractable Governance**
  - governance token concentrated to a few whales leading to manipulation
  - voter apathy, voters expected to vote on complex topics for which they have no interest nor specialty
  - making bug fixes and software upgrades especially on ethereum require odd workarounds requiring central control or bloat
- **Weak financial engineering**
  - arbitrary loan pricing with no financial model nor market price discovery
  - complete lack of risk modeling
  - participants having no way to know if risk/return is attractive
  - no stress testing is done nor considered
  - underestimating frictions of bailing out impaired financial products
- **Not scalable**
  - arbitrarily restricting users to use only low leverage
  - poor user experience such as transaction fees and slow block times

B. The Solution

VIGOR stablecoin system allows users to borrow stablecoin against their EOS crypto. It facilitates the transfer of volatility and price event risk embedded in token prices. No mechanism yet exists on EOS mainnet for seperating and transfering these risks. Users can do the following:

- **Income**
  - earn income on EOS native tokens by escrowing them for use as insurance assets that back stablecoin loans
- **Leverage**
  - get up to 10x leveraged exposure to token prices by taking secured stablecoin loans followed by selling it for EOS
- **Hedge**
  - token holders can reduce exposure to prices by taking secured stablecoin loans followed by hodling stablecoin, effectively overlaying a put option on the crypto

VIGOR is structured as a decentralized autonomous community (DAC) for the advantages this governance structure provides. Elected custodians manage multisig access to update

*VIGOR stablecoin project originates from the many not the few.

[1] Special thanks to genesis custodians.

the contract code. The custodians will make critical operating decisions and will hopefully be experts in their respective fields. The governance token is called VIG. It's utility is to provide access to the system, to be used as a fee token, and to be used as a final reserve (see subsection II-F). Custodian elections will be facilitated by randomly selecting users and requiring them to cast a vote when transacting on the system. Both borrower and insurer will have a voice in the elections. VIG tokens are paid-in by borrowers to purchase loan insurance and a cut is held by the system to be used as final reserve. The VIG token distribution methodology will try to discourage whale-sized holders, by distributing equally to all DAC genesis custodians, and by airdrop. The bailout mechanism is low friction and does not require auctions but rather the insurers simply take possession of the remaining collateral and debt of failed loans thus the illiquidity risk is offloaded to insurers who are compensated to take this risk. VIGOR is built on EOS to take advantage of no user transaction fees and fast blocktimes. Some unique requirements of the VIGOR system can perhaps be met using the new liquidapps.io DAPP network powered by DSP's with vRAM and forthcoming vCPU. Specifically this will enable the VIGOR project to benefit from the ability to generate free escrow accounts for users, store large datasets of historical prices for risk and stress testing calculation, use oracles for obtaining the price datasets (though at first we are considering Delphi Oracle or Oraclize), obtain random deviates required for risk simulation, and execute cpu intensive algorithms for pricing and stress testing. We are aware that Block.one may build stablecoin tech into the base layer eos.io but to date there is no evidence, and it may be a good thing to have competing systems. Users will be able to stake their tokens (both collateral and insurance asset tokens) even when locked in escrow to utilize their ram and net resources however the system will automatically begin unstaking if collateral levels fall too low relative to user debt. VIGOR was designed from day one to have solid financial engineering specification using structured products and derivatives along with standards in regulatory risk management. For example our smart contract implementation focuses heavily on the duality:

- **Pricing**: valuation model & price discovery
- **Risk**: risk framework, stress model, & capital adequacy

The result is a self-sustaining ecosystem balanced by borrowers and insurers which is robust to extreme price events. VIGOR is a crypto-backed stablecoin system with relatively tractable governance, higher leverage capability for borrowers, and higher adoption/scalability than has ever been possible.

II. Risk Framework

A. Credit Enhancement

Two types of credit enhancement are used which enables prudent lending:

- **Overcollateralization** (margin or haircut) refers to holding an amount of collateral that exceeds the value of the loan and can provide a buffer against fluctuating collateral prices.
- **Insurance** is used to protect collateral value against catastrophic price events.
  - Stablecoin borrowers insure their collateral by paying premium protection payments over time on a Token Event Swap (TES) an innovative smart contract which triggers bail-out if a price event occurs in exchange for premium payments.
  - Insurers take on risk to earn the premium and provide loan backing by escrowing crypto tokens into an insurance asset pool.

B. Solvency

The stablecoin will have stable value to the extent that loans either have excess collateral or that the insurance is sufficiently capitalized. Therefore our smart contract models the capitalization of the insurance with critical importance. The system applies the Solvency II risk framework used by insurance regulators in the EU.

- **Solvency Ratio** measures insurers ability to bail-out undercollateralized loans, see Figure 1.
  - **Own Funds** is the amount of crypto collateral insurers have escrowed (assets) above the market value of TES insurance that borrowers have purchased (liabilities).
  - **Solvency Capital Requirement (SCR)**. A natural question is how much "Own Funds" is sufficient? SCR is defined as this required amount, for a given tolerance of certainty.
  - **Solvency Ratio $>$ 100%** is an example of a desirable limit set by VIG custodians.

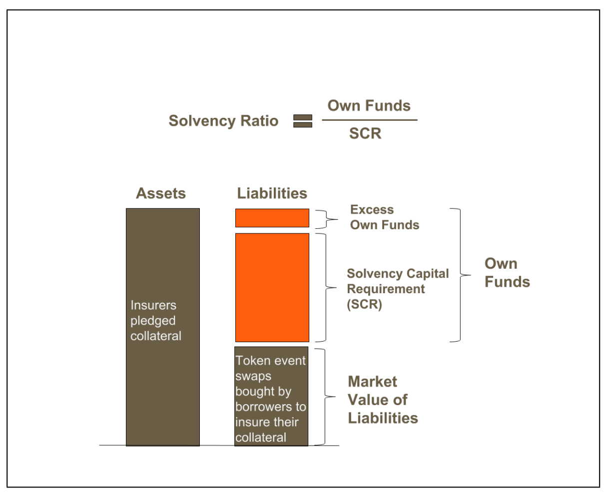

Fig. 1. Economic Balance Sheet

SCR is obtained as shown in Figure 2 as the change in Own Funds between normal and stressed markets. To arrive at SCR the core operation is to conduct a stress test per Solvency II which provides information about the required quantity of crypto collateral that should be escrowed by insurers to maintain solvency. For this stress test the project implements a TES pricing model to provide a best estimate for market value of the TES liabilities in normal conditions and a stress model for what their shocked value might be (given varying levels of certainty). Own Funds equals the amount of crypto collateral pledged by insurers minus our best estimate **normal** market value of the TES contracts. Stressed Own Funds equals the **stressed** value of crypto collateral pledged by insurers minus our best estimate **stressed** value of the TES contracts. Finally, SCR is the change in Own funds due to stressed markets and **Solvency Ratio** is the ratio of Own Funds to SCR.

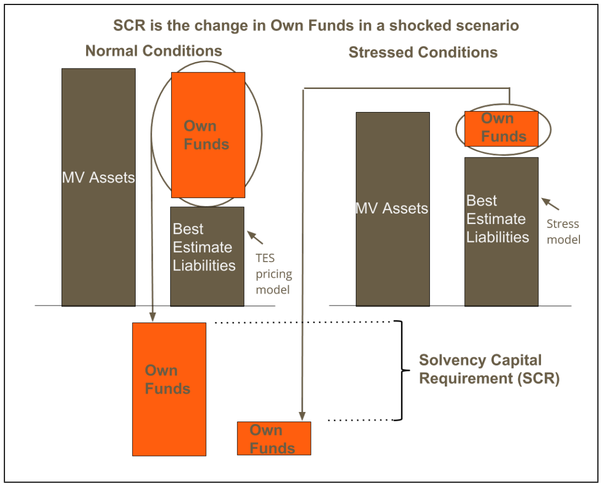

Fig. 2. Solvency Capital Requirement (SCR)

C. Stress Model

The stress model is a copula based Monte Carlo simulation of correlated extreme price events. The simulation generates the portfolio loss distribution as in Figure 3. Results of the stress model has three categories of loss, expected loss which is backed by overcollateralization, unexpected loss which is backed by insurers, and stress loss which is backed by VIG final reserves (see subsection II-F). Three key inputs to this model are probability of each collateral token having an extreme price event, their correlation, and the amount lost (1-recovery) due to an event. Probability (derived from hazard rate) and recovery are obtained from TES market prices, see subsection III-B Price Discovery. Correlations will be modeled from token returns through common latent factors and a stressed scenario of the correlation structure will be used. This stress model is used primarily to simulate unexpected loss to obtain SCR and Solvency Ratio but will also provide a measure of capital efficiency and risk concentration (Risk Adjusted Return on Capital and contribution to RAROC) to indicate system health.

D. Structured Product

All TES loan insurance contracts written to insure collateral are taken together as a basket of TES to form an aggregated insurance premium. Insurers take the other side by selling protection on notional amounts of a basket TES (a single TES written on a basket of collateral), see Figure 4. The basket TES may be tranched in later releases.

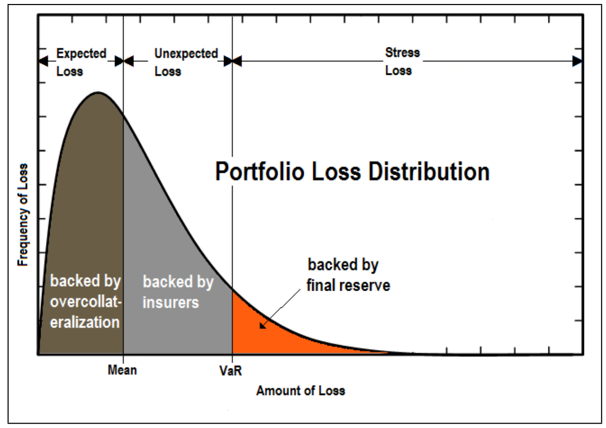

Fig. 3. Stress Model: Portfolio Loss Distribution

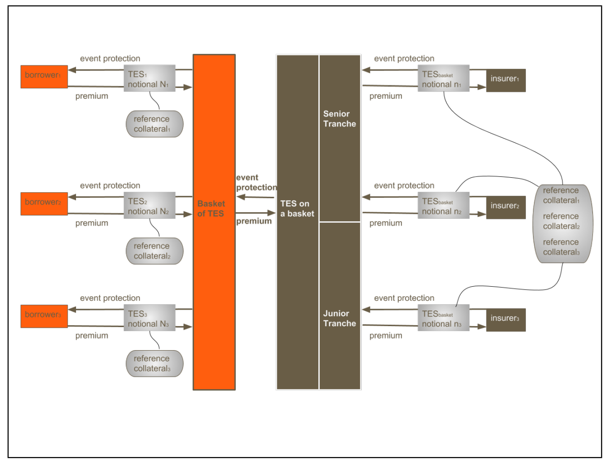

Fig. 4. Structured Product: transferring risk with a basket of token event swaps (TES) and a single TES written on a basket of collateral

E. Bail Outs

A TES is triggered for bail-out if collateral value falls below the value of debt for a given loan. If a TES is triggered then the basket TES protection sellers would immediately take-over (take ownership of) and recap the undercollateralized loan realizing a loss. Gains and losses of the insurance asset pool is shared accross sellers. Participation is commensurate with **contribution to solvency** defined as the change in Solvency Ratio resulting from a given TES seller escrowing tokens into the insurance pool. Handling bail-outs does not require auctioning collateral into distressed markets; the basket TES is both funded and physically settled.

F. Final Reserve

Premiums paid-in by borrowers is required to be denominated in VIG tokens and must be posted prior to drawing loans; insufficient maintenance of VIG balance triggers bail-out of the loan with borrower retaining any excess collateral. Insurers are paid denominated in VIG.

The system stores a cut of VIG premiums as final reserves after making VIG payment to insurers. VIG **final reserves** is used recap the system if at any time the insurance asset pool is depleted, covering the so-called stress losses as depicted in Figure 3.

III. Pricing Framework

A. Pricing Model

The **token event swap TES** contract delivers a protection payment (the cost to bail-out an undercollateralized loan) at the time of the triggering event, defined as the token price declining below a pre-specified triggering barrier level (value of collateral falling below the value of debt). In exchange the TES protection buyer makes periodic premium payments at the TES rate up to the triggering event.

The TES pricing model is based on the jump-to-default extended constant elasticity variance model by P. Carr & V. Linetsky [1] known as JDCEV where the token price is modeled as a diffusion, punctuated by a possible jump to zero:

$$dX_t = [r + h(X_t)] X_t dt + \sigma(X_t) X_t dB_t \tag{1}$$

where r, $\sigma(X_t)$, and $h(X_t)$ are risk free rate, instantaneous token volatility, and the state dependent jump-to-default intensity (hazard rate).

To capture the negative link between volatility and token price, we assume a constant elasticity of variance (CEV) specification for the instantaneous token volatility prior to extreme price events:

$$\sigma(x) = ax^{\beta} \tag{2}$$

where β is the volatility elasticity parameter and a is the volatility scale parameter.

To capture the positive link between extreme price events and volatility, the hazard rate is an increasing affine function of the instantaneous variance of returns on the underlying token:

$$h(x) = b + c\sigma^2(x) = b + ca^2x^{2\beta} \tag{3}$$

where b is a constant parameter governing the state-independent part of the jump-to-default intensity and c is a constant parameter governing the sensitivity of the intensity to the local volatility σ^2.

The TES price (aka premium rate) is obtained following Mendoza-Arriaga & Linetsky [2] as the rate ϱ that equates the present value of the protection payoff to the present value of the premium payments.

The protection payment is the specified percentage $(1-\boldsymbol{r})$ of the TES notional amount that the TES pays out to take-over the undercollateralized loan ($\boldsymbol{r}$ is the "recovery rate" and $1-\boldsymbol{r}$ is the "loss-given-the-triggering barrier crossing event"):

$$\begin{aligned} &PV\,(protection) = \\ &(1-\boldsymbol{r})\left(\int_0^T e^{-r\cdot u}\,\mathbb{E}_x\left[e^{-\int_0^u h(X_v)dv} h(X_u)\,\mathbb{1}_{\{T_L>u\}}\right]du \right.\\ &\left. + \,\mathbb{E}_x\left[e^{-r\cdot T_L-\int_0^{T_L} h(X_u)du}\mathbb{1}_{\{T_L\le T\}}\right]\right) \end{aligned} \tag{4}$$

The first term in parenthesis is the payoff triggered by a jump and the second term is the payoff if the token price hits the barrier by diffusion.

The present value of all premium payments made by the TES protection buyer is:

$$\begin{aligned} &PV\,(premium) = \\ &\varrho\cdot\Delta\cdot\sum_{i=1}^{N} e^{-r\cdot t_i}\,\mathbb{E}_x\left[e^{-\int_0^{t_i} h(X_u)du}\mathbb{1}_{\{T_L\ge t_i\}}\right] \end{aligned} \tag{5}$$

where L is the barrier, T is the horizon, N is the number of premium payments, $\Delta = T/N$ is the time between premium payments, $t_i = \Delta\cdot i, i = 1, 2, ..., N$ is the i^{th} periodic premium time, T_L is first hitting time.

As collateral price and volatility change over time the premium charged to the borrowers (pricing) is adjusted using the TES pricing model; borrowers actually pay a floating premium rate. Premiums adjust inversely proportional to collateralization levels and proportional to level of collateral token volatility.

The basket TES is priced as a DV01 weighted average basket of TES spreads and the tranche pricing uses a Gaussian copula factor model as in Wang et al. [3].

B. Price Discovery

This section describes how market based price discovery is achieved. TES model prices offered to borrowers are scaled higher or lower to drive Solvency Ratio to a target set by custodians (such as 100%). The "right" price should lead to a balance between loan collateral and insurance assets. The concept is similar to option market makers updating implied volatility based on order book imbalances. Three parameters in the pricing and risk models are scaled in an effort to drive Solvency Ratio closer to its target: hazard rate function parameters, b and c as in Eq. 3 as well as recovery $\boldsymbol{r}$ as in Eq. 4.

C. Stability

The stablecoin is designed to be price stable to USD using the following four pillars of stability:

1) **Crypto-overcollateralized**
   Stability depends firstly on the level of overcollateralization which covers expected losses. The system prices the collateral in USD, and overcollateralization is defined as USD value of collateral minus number of stablecoins of debt. This system is extendable to create stablecoins that track anything with a price including other fiat currencies, baskets of fiat, low vol baskets of crypto etc.
2) **Collateral is insured**
   Event risk and volatility of the collateral is transferred to insurers. Stability then also depends on the level of capital adequacy or solvency of the insurance. The system scales insurance pricing through implied hazard rates and recovery rates to drive Solvency Ratio to the target set by manager vote.
3) **Final Reserve**
   The insurance asset pool represents capitalization to cover unexpected losses estimated by the stress model to a degree of certainty specified by VIG custodians.

Actual losses may prove worse than estimated due to model risk. So the VIG final reserve backs the insurance pool as a lender of last resort covering these so-called stress losses.

4) **Solvency target**
Custodians set the target solvency giving them the power to run the insurance business from conservative to aggressive.

IV. Governance

The VIGOR project is a decentralized autonomous community run by custodians voted in by users. Custodians vote on all issues concerning the running of the DAC. Tools and dapps will be developed through community worker proposals. Initially the DAC is run by a core team called genesis custodians as the platform is being created and implemented. We plan to adopt the same or similar DAC framework as eosDAC.

V. Token Lending Facility

This paper has mainly addressed borrowing of stablecoin through a crypto *credit* facility. Here we introduce future capabilities for a crypto *lending* facility which allows borrowing and lending of crypto tokens through the use of an upside TES and an implied zero cost collar. A lender will be able to escrow crypto tokens for lending and earn insurance premium for taking exposure to bail out risk of upside price events. A crypto token borrower would post stablecoin as collateral and pay upside TES insurance premiums as they borrow crypto tokens and take the other side of the collar. This creates another insurance pool and structured product for a basket of upside TES. This is distinctly different than REX and Chintai as they only deal with *resource lending*, whereas the VIGOR project deals with lending the entire token asset so includes price volatility and price event risk (in other words capital gains/losses). The final reserve for this insurance pool may also serve as a source of liquidity to facilitate new lenders entering and current lenders wanting to exit.

VI. Options

In a later release this project seeks to implement options trading. This is a direct use case for our multisig escrow contracts and stablecoin. We plan to enable long call options, long put options, selling covered calls, and selling cash secured put options. It will enable decentralized derivative trading between users without central custody or clearing.

VII. Token Allocation

The utility token VIG has three main utilities in the system:

- **fee token** stablecoin borrowers must buy loan insurance which is paid over time and denominated in VIG tokens
- **final reserve** for backing of stress losses
- **access/credit score** users need VIG to access the system and their credit score is a function of total VIG paid in over time (and number of late payments/collections)

The VIG token will have an initial supply of 1b tokens with 0% annual inflation rate and will be allocated as follows:

- **20% community**: via free airdrop for wide distribution
- **50% developer fund**: for research, engineering, deployment, business development, marketing, distribution, staking resources etc.
- **30% DAC long term fund**: for long-term network governance, partner support, academic grants, public works, community building, etc.

VIII. CONCLUSIONS

The VIGOR stablecoin system innovates the crypto-backed decentralized stable unit of account. The system creates a decentralized credit facility that enables trustless crypto-secured financing. It creates the first decentralized market where borrowers and insurers interact to separate and transfer both volatility risk and event risk embedded in token prices. Thus the system creates the stablecoin utilizing token event swaps TES's and financial product structuring in a standard regulatory risk-based capital framework. Market based price discovery is a key feature which minimizes price inefficiencies to the benefit of users. The system focuses on financial engineering specification of risk, on-chain stress testing, price modeling and price discovery to ensure sufficient backing of the stablecoin and should provide for transparent and concise voting agendas. The bail-out mechanism is low friction; designed to avoid auctioning of collateral into distressed markets. We unlock scalability with a system that can handle more leverage e.g. users increase loan insurance if they have low collateral levels. The system can be viewed as necessary protocol layer for a robust crypto-backed stablecoin system that scales, has tractable governance, and on top of which we can deploy an interface with automated features that users care about. This platform has potential for users to build a crypto credit score a natural application of identity on the blockchain.

The VIGOR DAC is a decentralized autonomous community owned and run by its members to build stablecoin technology.

References

[1] Carr, P., and Linetsky, V. A Jump to Default Extended CEV Model: An Application of Bessel Processes. Finance and Stochastics 10, 3 (2006), 303330.

[2] Mendoza-Arriaga, Vadim Linetsky, Pricing Equity Default Swaps under the Jump to Default Extended CEV Model, Finance and Stochastics, September 2011, Volume 15, Issue 3, pp 513540.

[3] Wang D., Rachev S.T., Fabozzi F.J. (2009) Pricing Tranches of a CDO and a CDS Index: Recent Advances and Future Research. In: Bol G., Rachev S.T., Wrth R. (eds) Risk Assessment. Contributions to Economics. Physica-Verlag HD