Sustainability of the Negatively Amortized Instant Loans

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Abstract

Blockchain evolution can be equally enabled by the new infrastructure, as well as, the new financial tools. This paper proposes a fast-slow token system called Satoshi Nakamoto Leverage (SNL), which can largely reduce overall volatility of purely virtual base assets like Ethereum (ETH). SNL smart contract is programmed as an artificially less liquid or slower crypto asset and provides a reasonable "storage of value" investment alternative. Further discussion covers SNL design, its implementation and market performance based on tests results and trading simulation analyzes.

1 Introduction

Proposal and development of the digital peer-to-peer cash systems like bitcoin[1] has been encouraged by novel applications of what is referred to as the distributed ledger technology (DLT)[1]. Consequently, a number of alternative coin "forks" like litecoin has helped to test engineering choices, as well as, enable wider adoption of crypto currencies. The technology spreading has also led to the development of the entirely de-novo projects triggering outbreak of blockchain-like systems. For example, development of the public state transfer system called ethereum[3, 4] that is simplifying prototyping of more generic behavior using smart contracts[5, 6]; or practical privacy motivated projects like monero[2] and zcash[3], etc.

[1] Lo demás es historia [2]

[2] As discussed in [7] but also consult other MRLs[8]

[3] Next to ZIPs and zcash protocol[9] one should be referenced to a paper on zk-SNARK proofs for secure multi-party computation (SMPC)[10], newest research like zk-STARK[11]

During the past decade popularization of the DLT has surpassed beyond its basic idea of immutable and trustless bookkeeping or electronic cash payments. This lead to the phenomenon of decentralized digital economy or crypto economy[12]. Multiple projects attributed to such phenomenon share a number of critical design similarities with their progenitor [1] requiring the underlying system to be *open*, *trustless* and *transparent*. **Open** system follows open source ideology with permissionless block update without restricting nodes that can freely join and part the network. **Trustless** system replaces the need for complex human regulations or any coercion[4] with the trust into a machine or an algorithm. **Transparent** system has mechanisms like cryptographical verification or mining lottery that are simple enough for comprehension, independent review and acceptance. Later, arguably being a major factor to acclaim DLT as the tool to create a more fair and simpler version of an alternative global financial system[5]. In the past decade crypto currencies like bitcoin[6] have already demonstrated their potential to become an early foundation of a new kind of economy powered by them and their various offspring.

Unfortunately, the emerged crypto economical space is currently still poorly supported by its yet unestablished ecosystem. It has a significant number of challenges to tackle - the most prominent few are (i) *privacy*[7], (ii) *governance* and (iii) *scalability*. One example of scalability issues includes limited transaction rate[8] as compared to the centrally governed and dominating alternatives. Other drawbacks like growing levels of electricity consumption may eventually be paid by our environment[9].

Probably the most acute category of the open problems to be added to the above "challenge list" is the lack of (iv) *financial sustainability*. Crypto ecosystem has been capable of remaining sustainable by periodically attracting highly-speculative and volatile investments. However, user community still lacks a complete implementation of *(iv)* which can help crypto economy to prevail as a technically or privately regulated phenomenon. Such

by Prof. Eli Ben-Sasson, as well as, work by others on $O(n)$ time zero-knowledge provers without trusted setup.

[4] similar to the illustration of Smith's invisible hand by M. Friedman in the intro to [13]

[5] "We are trying to create the world where transactions can move globally for free.." – Fred Wilson, public hearing of Jan 2014 at NYSDFS

[6] i.e. *open*, *trustless* and *transparent*

[7] "We must defend our own privacy if we expect to have any"

[8] partially addressed by micro payment channels as suggested by[14]

[9] Even though the potential ecological consequences of maintaining the increasing hashrate levels required by the SHA-256-based proof-of-work (PoW) consensus algorithm have arguably conservative projections e.g. currently estimated below 0.3% of worlds electricity consumption [15].

solution to the lack of *(iv)* can make crypto currency a viable alternative to the legal tender and banking services. Further continuation of the political and economical pressure coming from the authorities may lead to a financial crackdown for any related business and complete economical isolation. Such undesired scenario would mean the ultimate failure for the decentralized community[10] of users[11] to achieve all of its founding and primary objectives of constructing the crypto ecosystem that can resolve all important privacy[12], governance[13], scalability and financial sustainability issues.

There is an imminent need for a reliable, flexible and on-demand mechanism to create resilient money that can store and increase its value on a free market[14]. We propose yet another simple, self-contained, continuously-issuable and redeemable token in exchange for some base crypto currency but at self-adjustable rate. The objective of the created token is to reduce the inherited volatility of the underlying asset.

Outline The remainder of this article discusses motivation for current experimental work in section *Limitations of money*. Then we discuss the design of the experiment itself in section *Anti-volatility experiment* by detailing price calculation and the smart contract implementation. Next, we present some early data available from the tests and basic market simulations. Afterwards, we introduce topics of ongoing research on super-liquidity. We conclude with some open questions and remarks for the future work.

2 Limitations of money

The concept of money[15] has been around since a while as compared to bitcoin. Presumably modern economics took time and trial-error approach to evolve[16]. This may explain the excessive integration depth of the regulatory

[10]"The computer can be used as a tool to liberate and protect people, rather than to control them" – H. T. Finney

[11]both single users and cliques

[12]Arguably, DLT-forensics or money "tracing" is not the only efficient method of preventing or combating crime. Although such tracing is often justified by the "greater" cause for the many, in reality it is often abused by serving interests sought by the few

[13]"There is something exceedingly ridiculous in the composition of monarchy; it first excludes a man from the means of information, yet empowers him to act in cases where the highest judgment is required."

[14]and thus address (iv)

[15]..based on naturally constrained supply as in case with gold or sea shells[16, 17]

[16].., -2100, -1177, .., -660, -480, -441, -323, -300, -256, .., -107, -26, 33, 70, 208, 235, 313, .., 535, 538, 593, 632, 639, 654, .., 750, .., 875, 927, 1000, 1005, 1016, 1051, 1064, 1066, 1077, 1097, .., 1181, .., 1230, 1232, 1235, 1237, 1274, 1279, 1291, 1299, 1307, 1317, 1333,

"safe-guards" put into most of the money related processes. The reason why regulatory "firewall" remains selectively blind to some newest financial instruments[17] leaves room for doubt. Specifically, it is not clear whether financial "watchdog" always operates on completely fair terms or that its economical knowledge is scientifically sound. There is, of course, a known historical debate between "keynesian"[18] and "austrian"[19] schools of economics[20] on the subject of such topics as *how much intervention into national economy is too much?*

The keynesian theory is justifying state interventionism on an assumption that the economy is incapable of self-healing and restoring on its own by the natural order. By focusing on disputing Say's law from 1803[21] and offering an expansionary view for the national economy growth[22] keynesian theory redefines the supply-demand model and recommends governmental spending[23]. Due to the fact that keynesian theory advocates for invasive market manipulations by the governmental fiscal and monetary policies it has been embraced by state governments and central banks. Until today (neo)keynesian theory is the de facto theory of western economics[24].

Classical-keynesian[25] theory introduces a systematic view on the economy by defining and exploring the interplay on micro and macro levels. However

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1344, 1363, 1387, 1407, 1441, 1450, 1453, 1460, 1477, 1504, 1518, 1528, 1535, 1540, 1571, .., 1637, .., 1772, 1774, 1789, 1814, 1837, 1849, 1852, 1853, 1873, 1881, 1884, 1890, 1893, 1917, 1901, 1907, 1916, 1917, 1920, 1923, 1929, 1933, 1936, 1939, 1944, 1947, 1955, 1967, 1970, 1971, 1973, 1975, 1979, 1982, 1983, 1987, 1989, 1991, 1994, 1996, 1997, 1998, 1999, 2000, 2001, 2003, 2008, 2009, 2011, 2013, 2014, 2015, 2019, 2021, .., 2029, ..

[17]CDS[18]

[18]Keynesian *General Theory* dates back to the crisis of 1930s

[19]"I only took one economics course and was taught by someone from Austria..a different school.." – John Nash

[20]later has further evolved and largely coincides with "libertarian" purely economical views as opposite to the purely political ones: "One of the paradoxes of neoliberalism is that it is not new and it is not liberal" – N. Chomsky

[21]that simplistically explained money as barter exchange of products and commodities in which supply always generates demand and glut cannot occur. This eventually contradicted with the cause of the Great Depression of 1930s.

[22]in the time of crisis

[23] "Keynes in his General Theory (1936) resurrected a variant of Marx's exploitation theory. He argued that capitalists were unwilling to invest enough money to supply jobs to workers. These workers were unemployed. Marx had a phrase for them: the reserve army of the unemployed. Unlike Marx, Keynes did not want a bloody revolution. So, he proposed what a lot of other obscure non-economists had proposed in Marx's day: government spending. That would get the unemployed workers back on payrolls, either private or governmental." – Nouriel Roubini

[24]now merged into "neoclassical synthesis"

[25]and later post-keynesian

it is difficult to provide objective estimate of its value[26]. The reason for this is that through years most of the keynesian theoretical research remains mathematically and experimentally somewhat simplistic sticking to variations of original top-down models[27] to explain long- versus short-runs of business cycles[28]. The hidden risk of relying on pre-computational era expansionary theories[29] lies in the danger of missing the systematic complexity of money[30], while requiring government spending to be efficient[31].

To facilitate financing of the government expense (which is still paid by the people) the state can create money[32] issued as a legal tender (e.g. US dollar or Japanese Yen) or borrowed as a government loan[33]. Understanding endogenous vs. exogenous credit money creation is important not just for pragmatic bookkeeping of liabilities vs. assets[34]. Such difference in credit

[26]except for political

[27]incl. models of aggregated demand, multiplier, liquidity trap, IS-LM, etc

[28]One can not help but notice very little differentiation [whether that would be in style, quality or range of theoretical tools] except for wording and the scope of topics in works by keynesians like P. Krugman, N. Roubini, e.g. from works in minor theory revisions [19] dating 30-40 years back in time. In comparison, research like [20, 21] and many similar mathematically superior- or well-founded works developing and proposing more novel and theoretically advanced tools are tend to be decades long ignored by the mainstream science. These tools remain unemployed by keynesians for gaining better insights or deeper objective understandings by going beyond abstract assumptions and being based on real-world imperfect market data. Instead, the school's focus is on "holding the ground" by publishing in journals on political economy or even further directly coupling both politics and economy. If this is intentionally so, climbing up the social ladder becomes an academic exercise with moral issues and long-term consequences for the global economy.

[29]like keynesian macro-economics

[30]and monetary policies

[31]"[Keynesian macroeconomics] depends on government spending being efficient, lacking corruption, and being spent on the best possible economic uses while at the same time being able to collect enough taxes as to not run a massive deficit. That is an unrealistic expectation given any government throughout the extent of human history." – Ben Deneweth

[32]"In most modern economies, most of the money supply is in the form of bank deposits"[22]. Often only a small fraction e.g. less than few percent is circulating as cash and available to private individuals. The rest of the money supply is stored in the bank databases.

[33]"The critical feature of this model is that the economy's money supply is created by banks, through debt, rather than being created debt-free by the government. Our analytical and simulation results fully validate (all) Fisher's (1936) claims."[23]

[34]"In the context of fractional reserve banking, the traditional description of banking as 'acceptance of deposits for the purpose of lending' distorts the perspective in which economics of banking is understood and analyzed. In the real sector liabilities create assets, whereas in the monetary sector, assets create liabilities. The reserve requirements of central bank directly affect banks' deposit intermediation and checks bank leverage. In this context, the concept of asset based cash reserves appears more logically appealing

allocation poses open questions, which are essential for precise calculation of critical macro-economical characteristics. In particular, *how to account for how much money has been created?*[35] Clearly lack of such transparent reporting is not an issue for bitcoin-like systems.

Lack of transparency in reporting is not the only disadvantage of *fiat money, which are issued as a legal tender or borrowed as tokenized national debt. The main source of risks and limitations of the legal tender are imposed on it by its very issuer - the state, its fiscal policies and the executive central institutions. The legal tender shares political risks and economical liabilities of the respective nation.* In practice, none of these risks is safely isolated, insured or "fairly" distributed within the financial system of our planetary economy, which remains continuously volatile.

At first look, modern day international monetary system (IMS) resembles an almost "monolithic" and well-functioning organism[36]. At a closer look however, despite its **central** role in our global economy, IMS is embedded into economical processes through archaic layers of a number of rules, international agreements and precedent-based regulations. In addition to a network of national central banks (each being put in charge of the wealth management task for the respective nation[37]), it involves multiple other institutional players[38]. As a result, the continuity and well-functioning of global economy and its money requires constant human supervision. For instance, with the correction of Bretton Woods System in 1970[39] many countries have adopted flexible exchange rates, which created a trend of high Foreign Exchange (FX) reserves maintained by central banks. Today implementation of certain monetary policy by supporting desired fixed exchange rate can be costly[40]. Meanwhile, such topics like a call for *New Bretton Woods* agreement to review International Monetary Fund (IMF) reserve policy are ac-

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than liability based reserve [as in fractional reserve theory]."[24]. Also see the neo-chartism debate in [25].

[35]by central and commercial banks[26]

[36]designed by its principal architects J. M. Keynes and H. D. White in Bretton Woods in 1944

[37]"Concentration of wealth yields concentration of political power. And concentration of political power gives rise to legislation that increases and accelerates the cycle." – N. Chomsky

[38]Like International Monetary Fund (primarily responsible for monitoring and managing international country debt), World bank, and FATF-like regulatory bodies (for overseeing the respective policy for the cross-border capital transactions i.e. by combating tax evasion and money-laundry).

[39]It was corrected by several Accord agreements with the demise of fixed exchange rates and de-dollarization.

[40]E.g. the Swiss central bank resisted appreciation during 2008-2010; the loss due to devaluation of purchased reserves amounted to 5% GDP [27]

tively rehashed. Interestingly, the partial fallback to Gold Standard can be reconsidered as a viable option[41] e.g. for US. Although politically hard, that would mean a certain regression to 1970[42] and 1944[43].

On the negative side, in the passed two decades we have observed another trend of economical interventionism[44] called neomercantilism[45]. Economic globalization naturally leads to the increased market entropy[46] with the tendency for the real sector of the undeveloped countries to become less different from the developed once and overall market trends less predictable[47]. Due to dominating role of the keynesian theory in the western economy and, as the result, absence of enough alternative economic data - one can only speculate how such accumulated stagnation in thought has been affecting households' welfare of those states and the world[29–31].

We believe there is a need for financial practices that are alternative to the costly keynesian-like monetary policies and highly regulated markets[48]. This can be perhaps addressed by a new school[49] of economical ideas: (a) motivated or based on bitcoin-like systems[1] with a clear focus on solving privacy, governance, scalability, financial sustainability and independence of decentralized crypto economy; (b) combined with the learnings and critical reflections of [32] aimed on applying new smart continuously relaxing market optimization[50] to manage the state welfare; (c) dedicated to the reduction of the global debt, gradual liberation and off-load of the global economy from

[41] Next to other reserve assets such as reserve currencies (USD, EUR, CNY), currency basket, SDRs

[42] Nixon shock

[43] From the discussions before IMS agreement was reached the international banking mood was skeptical of fixed exchange rates having USD as the FX reserve. "The recipient of gold does not have to trust the government stamp upon it..No act of faith is called when gold is used in payments"..[28]. Notably the concept of trustless system is designed to improve this.

[44] despite the efforts of World Trade Organization (WTO)

[45] Chimerica trade wars

[46] A contradicting signal from globally consolidating security markets can be misread but is rather an outlier than an economy trend of a traditional industry as e.g. series of M&A deals of companies and capital around NYSE.

[47] e.g. without global access and control of the massive amounts of personal data, which is beyond the scale of the "Five Eyes" surveillance programs.

[48] Including selective unfair stimulation of individual economies, which are sometimes more efficient but often at the costs of others

[49] Such *neo-tokyo consensus* school of economics can humbly preoccupy itself with the needs of sustainable as opposite to the expansionary growing planetary economy

[50] outside of the cultural reality of the Tokyo Consensus zone, e.g. much more pragmatic than concepts of quantum-easing or without modern and corrupt institutional banking at all

the regulatory "financial" chores of the individual states[51].

Further we will discuss how some of these tasks can be solved by designing and conducting an experiment in the existing virtual crypto-economical space.

3 Anti-volatility experiment

The future of our welfare lies in the ubiquitous digital economy[52]. At the moment its crypto-economical foundation increasingly deviates into a dangerous direction of becoming highly over-regulated on terms and conditions of the existing institutional system[53]. It is a challenge for the crypto economy: (i) to remain financially independent from the existing system and (ii) to offer a financial sustainability in a fully decentralized manner, alone due to the designed properties of the algorithm. It is unclear whether or not it is possible to achieve such a state of complete self-sustainability for any token traded and bounded inside an enclosed virtual economy. However, we will propose and review an approach of how an additional mediating token, constructed around any base crypto currency, can reduce the inherited volatility of the base.

The idea is to program a controlled liquidity crypto asset in a way that would have restricted or more predictable (de/in)flation rates. Token becomes more inert and shows a "slower" market behavior by design. As a result of such sensitivity it responds with higher resilience to the significant volume movements which are typical for large scale speculations or "pump and dump" manipulations. Hence such token can be a reasonable investment choice purposed for the more long-term "storage of value".

SNL (non-exclusively) stands for *Satoshi Nakamoto Leverage* or the SNaiL token. For the simplicity of the experiment it is sufficient to rely on the well-developed blockchain infrastructure like the Ethereum network. Hence SNL implements ERC20. Most importantly ETH as the underlying or base currency can exhibit high volatility levels with similar co-movements to [1]. The latter is enough for the purpose of the experiment. Next, we explain how exactly both assets jointly form a double token (or a fast-slow) system[54] with

[51] while those states continue to act as private property and civil rights guarding agents, rather than expensive debt-leveraging corporations

[52] As its virtual component being continuously augmented by digitalization of the rest of the real world.

[53] Contrary to the vision of [1] "..electronic cash would allow online payments to be sent directly from one party to another without going through a financial institution".

[54] Certain initial similarity to [33] may be found, but fast-slow system is focused on sustainability task.

SNL being a slow token and ETH being the fast one.

The smart contract has the following straightforward implementation (see *Listing 1 - SnailToken.sol*). SNL tokens are minted and burned on-demand[55] by deposit and withdraw operations directly on the contract. All three operations such as *deposit*, *withdraw* and *transfer* can equally contribute to the transfer rates that are tracked totally and individually (as per holder) by the smart contract for the period of the last *25 days*. The token price is determined dynamically (and individually for each holder) based on the information stored or updated in the smart contract during previous transactions:

$$P_{t+1}(h,a) := \sqrt{\frac{D_t}{S_t}} + I'_{t+1}(h,a) \tag{1}$$

The above equation will compute the price for a holder h to purchase[56] certain amount a of SNL tokens in exchange for a base deposit in fast tokens (ETH) at the given discrete time-point $t+1$ (or equivalently a transaction number), where D_t stands for the deposit of ETH in the smart contract at previous time-point and S_t stands for the total supply of SNL tokens so far[57]. The first component with the token-base ratio $\frac{D_t}{S_t}$ under the square root is also called the *indicative price* and does not depend on the purchased (or transfered) amount a. On the contrary, the last component $I'_{t+1}(h,a)$ is called the *discounted interest* and it can grow proportionally to a within a range of $[0, 0.24]$ of a. Higher interest "payouts" can slow down the price movement[58]. Like this interest determines how fast such price (1) can change depending on the market demand-supply pressure for the slow token.

Interest[59] is computed individually for each SNL holder. An ERC20 smart contract already holds information about the balance of every holder $B(h)$ s.t. $B_{t+1}(h,a) := B_t(h) + a$. In addition to the individual balances, SnailToken contract keeps track about how much each holder has transfered in the last 25 days $avg(R_{t+1}(h,a)) := avg(R_t(h)) + a$ and also the total average daily transfer rate for all holders $avg(\bar{R}_{t+1}(h,a)) := avg(\bar{R}_t(h)) + a$. More formally calculation of the individual interest rate as well as the applied ownership

[55]"..the creation of money as bank credit is limited by the demand for credit, not by the reserve requirement" – R. Werner

[56]The reverse is trivial

[57]Smart contract has an implemented restriction such that the price of one SNL token is always greater or equal to one ETH token.

[58]All interest payments are also contributed to the same common deposit D_t on the smart contract, which is supporting the indicative price. This means that interest is shared by all holders that choose not to trade their tokens at the moment.

[59]as it follows from (1)

discount can be described in following steps[60]:

if $l := 4$ and $m := 26$ are the respective low and highest rate constants, $\beta = \frac{avg(B_{t+1}(h,a))}{S_{t+1}}$ is the future balance ratio, $\tau = \frac{avg(\bar{R}_{t+1}(h,a))}{avg(\bar{R}_{t+1}(h,a))}$ is the future transfer ratio and $\theta = \frac{B_t(h)}{S_t}$ is the ownership ratio by holder at previous time-point, then interest rate is

$$I_{t+1}(h,a) := \frac{a \times min(avg(\beta,\tau),m)}{100} \tag{2}$$

and ownership ratio can be applied for a discount

$$l'_{t+1}(h,a) := \frac{a \times \sqrt{l * max(min(\theta,l^2),1)}}{100} \tag{3}$$

where l' is a discount or a normalized low interest[61]. Finally discounted interest will be computed as

$$I'_{t+1}(h,a) := max(I_{t+1}(h,a), l'_{t+1}(h,a)) - l'_{t+1}(h,a) \tag{4}$$

So indeed, $I'_{t+1}(h,a) \in [0, 0.24]$ of the amount a as restricted by the constants and the formula construct.

Price dynamics of equation (1) depends on the transactions volume conducted by all of the involved market participants and bounded by $O(sqrt(n))$. We expect that the demand for slow tokens like SNL will be able to represent the demand for the value storage. Such demand will begin to approximate the token's price much more accurately as the number of participants, the total volume of transactions and the amount of funds committed to the contract will gradually increase over time.

4 Results

In this section we describe observations and market simulations results in order to provide better insights into designed SNL performance through data and illustrations. Instead of using existing tools[62], simulation results were obtain by running own small framework developed specifically for SNL.

[60] Always consult the SnailToken.sol code for the exact implementation[34].

[61] Observe that $l'_{t+1}(h,a) \in [0.02, 0.08]$ of a

[62] Although such external tools can support simulation of complex trading strategies and take into account great variety of external and real-time signals e.g. [35], a simpler modelling technique using own implementation of crypto trading as a multi-agent system is sufficient for the SNL simulation purposes.

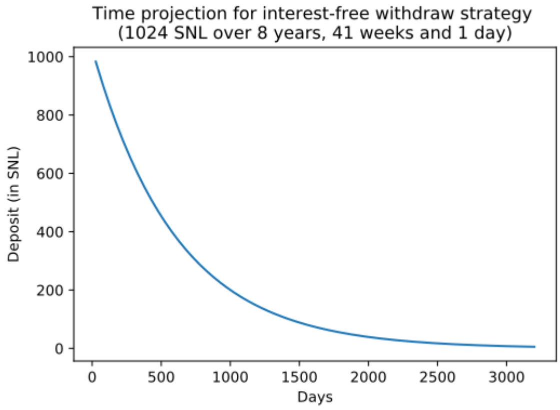


Figure 1: Zero-interest withdraw strategy

The illustration in previous fig.1 helps to consider a zero-interest approach of the most cost efficient withdraw of the base currency (ETH) in exchange for initially purchased tokens. This is a theoretical computation with similar results obtained from the test on the smart contract. It serves as a useful demonstration of the resistance property of the SNL token. An important consequence of such property would be a protection mechanism from the rapid market dump. Indeed, if we assume a situation when all of market agents except one decide to sell their SNL tokens almost at the same time, by doing so they will have to pay almost the highest interest into the shared deposit D_t. Later means that the last holder[63] will be able to exchange[64] her/his slow tokens at the remaining deposit value[65]. Meaning that all the SNL balance of the last holder will be proportional to 18-24% of the total base deposit[66] before such market dump.

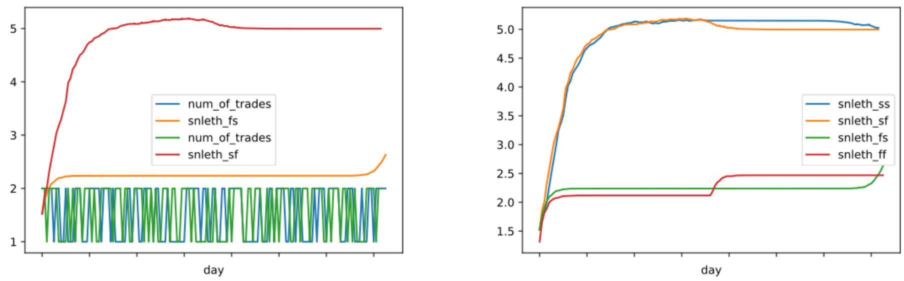
Next fig.2 (a) shows simulation results when several agents are trading varying volumes in different order. The orange line corresponds to trades of bigger volume chunks coming first, so *snleth_fs* price means *fast* start with bigger buys and *slow* continuation with the smaller ones. The red line *snleth_sf* means the opposite - small volumes are bought first and then market is continued with bigger purchases.

[63]e.g assuming his balance is $B_t(h) := 1$

[64]For example, by adopting the zero-interest withdraw strategy described on fig.1.

[65]or $\sqrt{\frac{(m-max(l'))*D_t}{100}}$, where $m := 26, l := 8$ and $S_t = B_t(h) = 1$ and as follows from the price equation (1) minus "time" spent on optimal withdraw strategy

[66]Note that discounted interest and specified percentage range is computed in SNL



(a) Slow vs. fast buying (b) Buying and selling

Figure 2: Price development for different speed in buying and selling

Comparing orange and red lines[67] of fig.2 (a) we can observe that fast-slow purchases (in orange) will stabilize the price much faster. Indeed, if trading starts with immediate growth or higher demand for SNL tokens[68], then the consequent trades of smaller volumes[69] have lesser effect on a quickly formed price plateau.

Also note the auto-correction of price in form of an early drop of the red line in case of slow buys. A sequence of discrete events of similar volume purchases has grown the price too fast. This over-appreciation of SNL gets auto-corrected to a lower price (if compared to fast-slow scenario in orange). This is the desired behavior of the smart contract.

Similar auto-correction happens in the second half of the plot with slow and fast sells on fig.2 (b)[70]. Selling trades produce almost identical plots since such dynamics is equally captured by the *discounted interest* in the price formula (1), programmed in the smart contract for all three operations[71] - *deposit*, *withdraw* and *transfer*.

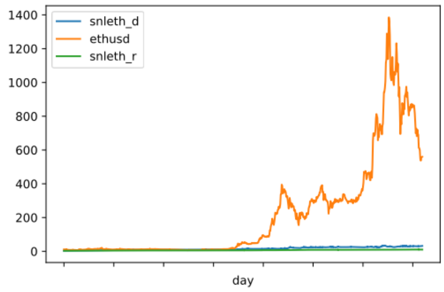
[67] See *snl-trade/playbook.py - scenarios 1 and 2*

[68] which can be interpreted as purchases in bigger volumes

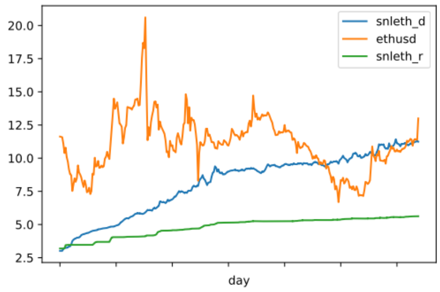
[69] "slower" trades

[70] Figure contains two more trading combinations: *snleth_ff* standing for fast buy and fast sell; *snleth_ss* standing for slow buy and slow sell. More details in *snl-trade/playbook.py - scenarios 3, 4, 5 and 6*

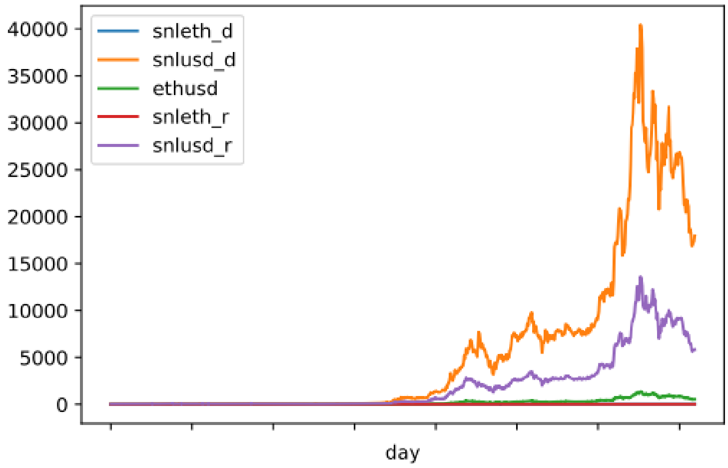
[71] see previous section again for explanation



(a) Backtracking price for 720 days



(b) Zoom into the first 320 days



(c) Backtracking with full legend

Figure 3: Ethereum price back tracking

Finally, we want to discuss simulation results based on the tracking of historical ethereum prices[72]. Simulation was run with 25 agents buying and selling SNL tokens[73]. Agents are monitoring the price change of *ethusd* and decide whether they want to take profit from the price difference, prevent loss or continue to hodl[74]. By changing the settings of the hodling period for the agents in the simulation, we have fixed two main trading scenarios of

[72]Tracking of *ethusd* prices starts back from 4/1/2016 and continues for the next 720 days.

[73]by calling *depositEth()* and *widthrawEth()* methods - see SnailToken.sol

[74]In particular, parameters like *min_trading_time_in_days* and *max_trading_time_in_days* determine the hodling period. For more details - see *snl-trade/config.py*

interest:[75] *relaxed* - a more careful (sparse) trading with max hodling for 40 days; *dense* - a more frequent trading with max hodling for 7 days.

By comparing dense trading (in blue) with much more sparse or relaxed trading (in green) on fig.3 (a) and (b), the difference between dense *snleth_d* and relaxed *snleth_r* lines becomes prominent. Relaxed trading turned out very stable, but more profitable for the agents with more opportunities to wait for better price difference. However in order to test SNL resistance and to simulate occasional demand shocks of the crypto market, dense scenario has been included as well, exhibiting much more random trading by agents[76].

After zooming into the trading dynamics of the first 320 days as shown on fig.3 (b), one can observe that due to the active trade of different volumes the SNL price in base tokens grows steadily. Then the blue line starts to vertically reflect or flip price dynamics of *ethusd* (but on much smaller scale), while the green line persists with its slow but steady growth. We expect that such vertical flipping of prices, as taking place between *ethusd* and *snleth_d*, will be even more significant in the real market context, outside of the simulation[77].

Notice in fig.3 (c) that slower or less liquid SNL token (in orange and in purple) has higher, often amplified, price volatility of its faster counterpart ETH (in green). This desired multiplying effect can be compared to the long period volatility cycles of highly illiquid assets like real-estate, frequently caused by demand shock waves[37]. The difference in pricing mechanism of SNL is that it is designed. The mechanism is programmed as predictable and open virtual asset to adjust in a much shorter cycles.

Despite being insightful, the above simulation results can not fully capture a missing feedback link of *snlusd* pair fully affecting pricing of *ethusd*. In order to fully learn how the SNL trading can reduce the volatility of ETH, we need to continue our tests in a real-world environment by deploying developed smart contract and making it available to the public trade. From the point of few of behavioral trading, bidirectional interaction between SNL and ETH is a key requirement for the complete fast-slow system performance. New data could allow better understanding of the simulated above price movements.

[75] See *snl-trade/playbook.py - scenarios 7 and 8*

[76] "Our main result, which is independent of the market considered, is that standard trading strategies and their algorithms, based on the past history of the time series, although have occasionally the chance to be successful inside small temporal windows, on a large temporal scale perform on average not better than the purely random strategy, which, on the other hand, is also much less volatile."[36]

[77] According to behavioral trading, we expect SNL and ETH movements to "cancel out" each other. In particular, when the price for ETH drops, market agents start purchasing SNL tokens as form of value storage. And vise-versa, if ETH/USD grows too high, agents would prefer to profit by withdrawing ETH from the contract and selling it at a higher price.

5 Super-liquidity

Super-liquidity trading (SLT) system is a mathematical construct, defined below to describe an efficient digital market model. Assets that are traded on such market[78] may benefit from the trade option against at least one *super-liquid* exchange medium.

Consider an abstract liquid trading (ALT) system as a weighted directed graph $G := (V, E, w)$, where set of vertices $V, |V| \leq |\mathbb{N}|$ contains digital representation of all tradeable assets in G, set of edges $E = \{e \in V \times V : w(e) > 0\}$ represents all possible atomic[79] asymmetric[80] trades, which are weighted by the function $w : E \to \mathbb{R}^+$ corresponding to the price of some trade $e \in E$.

Definition 1 - half-liquid asset.

Vertex $v \in V$ represents half-liquid asset[81] iff either $deg^-(v) = 0$ (source) or $deg^+(v) = 0$ (sink), where $deg^{(-|+)} : V \to \mathbb{N}$ is respectively a number of tail ends (indegree) and a number of head ends (outdegree) from vertices adjacent to v.

Corollary 1.1 - liquid vertex.

Any *liquid vertex* $v \in V$ has both $deg^-(v) \geq 1$ and $deg^+(v) \geq 1$.

Corollary 1.2 - liquid graph.

If there exists a strongly connected subgraph $G' \subseteq G$ s.t. all of its vertices are liquid, then G' is called *liquid graph.*

Corollary 1.3 - k-liquid graph.

If $G' \subseteq G$ is a k-connected liquid graph, then G' is called *k-liquid.*

Trade paths can have different liquidity preferences. For example, if a path $(s, v) : s, v \in V$ on graph G has preferable liquidity when compared to any other path $(s', v) : s', v \in V$, then (s, v) is a shorter or equally weighted

[78] **almost surely** in efficient way

[79] no double-spending

[80] costs for buying and selling operations are not necessarily equal

[81] Fully illiquid assets are disconnected from G, since they are not digitally traded and unpractical to consider. We assume that no such asset will exists in the future.

path than (s', v) iff $\sum_{e \in (s,v)} w(e) \leq \sum_{e \in (s',v)} w(e)$ and both paths end with betweenness center v.

Definition 2 - preferable liquidity path.

Let $S \subset V \times V$ contain all shortest paths from vertex s to vertex t: $\forall s, t \in V$. Also let vertex $v \in V$ have the maximal[82] betweenness centrality measure $C_B(v) := \sum_{s \neq t \neq v \in V} \frac{\sigma_{st}(v)}{\sigma_{st}} : \forall (s,t) \in S$, where $\sigma_{st} := \sum_{(s,t) \in S} \sum_{e \in (s,t)} w(e)$ and $\sigma_{st}(v)$ is a sum of only those shortest paths in S which contain v. We say that $(s,t) \in S$ is a *path with preferable liquidity* if it ends with v, i.e. $t = v$.

In order to capture a desired super-liquidity property of an always preferable asset in an ALT-system G, we need to identify such asset not only as a preferable "exit" (sink) vertex, but also as the one that can be consequently traded for any other liquid asset in G at the most attractive price.

Definition 3 - super-liquidity.

A liquid vertex $v \in V(G')$ of a complete liquid subgraph $G' \subseteq G$ is called a *super-liquid vertex* iff any preferable liquidity path $p = (s, v)$ can be **almost surely** continued with an efficient trade for any other liquid $u \in V(G'), u \neq v$ in such a way that $\sum_{e \in (s,u)} w(e) \leq \sum_{e \in (s,v)} w(e) + \sum_{e \in (v,u)} w(e)$ and (s, u) is a shortest path.

Corollary 3.1 - super-liquid graph.

A complete liquid subgraph $G' \subseteq G$ is called a *super-liquid graph* iff G' contains a super-liquid vertex.

Last definition of a super-liquid graph provides us with a starting point for the future framework of the super-liquidity trading (SLT) system that can in theory allow efficient price trading. However there is no practical duality between super-liquid and illiquid assets. Instead, we can choose to link super-liquid vertex with a controlled liquidity asset, that has a programmable dynamic pricing model[83]. Such subgraph is called a super slow and super fast (S3F) liquidity system with at least two liquid tokens (vertices).

[82] In general, unless $C_B(v)$ has a maximum value on G, there could be a group of vertices with the maximal betweenness centrality score $M = \{v \in V : C_B(v) = max(C_B(V))\}$. In that case definitions are adopted to consider $\forall v \in M$.

[83] similar to SNL

Another open problem is to try to implement SLT-system in practice e.g. as an almost perfect decentralized crypto exchange (DEX). In that case such DEX needs to resolve practical aspects like: (1) *free-market requirement* - trading operations can not be regulated or rely exclusively on fiat; (2) *market soundness* - provide enough information to choose which trade is more desirable[84] or optimal out of any two options; (3) *market completeness* - conduct deep trade operations[85] on a graph G with as many tradeable assets as possible.

With work on the above considerations continued, SLT model can be found applicable in fintech system design. If one takes probability into account next to using more sophisticated simulation tools over the above basic graph-theoretical definitions, it should be possible to model trade efficiency of digital assets with in-depth understanding. Although at the moment super-liquidity is still only a concept, it can be used to conceive fintech applications already today. We believe that in the near future such abstraction can be approximated by a real-world crypto trading system with sufficient ability to support seamless interoperability between multiple blockchains and their hosted digital assets.

6 Conclusions

We have proposed the fast-slow token system, where the slow token can significantly decrease volatility of the fast one by lowering potential demand shocks and resisting to the price dumps[86]. By doing trade simulations, we have observed a "canceling out" behavior in SNL and ETH movements in fig.3 (b). Next stage of our experiment is to make the developed smart contract available for the public trade, by which we hope to get new data to support that working hypothesis on cross-cancellation behavior. Our bigger vision is to contribute to the strong financial sustainability of the existing crypto economy as a whole[87].

After invention of bitcoin-like systems, continuous dependency and inability to discard fiat in daily use is, at least, alarming[88]. It is our strong believe that any further strong deviation from the concept of free-market

[84] when pricing function $w(e)$ is difficult to define

[85] both in depth and in breadth

[86] The details of the **anti-volatility experiment** and presented simulation results are discussed in sections 3 and 4.

[87] which is still in its fragile embryo state

[88] However as more people learn how to use crypto currency, we believe that in the future one does not need to be a bitcoin-maximalist to label fiat money, respective fiscal policies or any lack of free-market economy as the ultimate ponzi scheme.

and border-less economy is a highly undesired financial scenario, which we intend to avoid. Principles of the free-market foundation for open crypto trading systems require a much greater level of financial resistance, which the conducted research and work on SNL can help with.

Introduced topics of super-liquidity in previous section are still part of an ongoing and future research. Discussion of further results is still premature, but the hope is that learning more about SLT-systems among other applications can help to: (i) get better liquidity access, assuming more advanced infrastructural interoperability; (ii) refine proposed fast-slow tokens behavior, specifically by better price control; (iii) program more sophisticated resistance scenarios.

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Appendix

```
/**
 * Interface of the Satoshi Nakamoto Leverage (SNL) contract.
 *
 * Complete source code can be found in
 * `https://gitlab.com/takeshikodo/snl-wallet/contracts/SnailToken.sol`
 */
contract SnailToken is ERC20, ERC20Detailed {

    event InterestOnSnl(address sender, uint256 snlAmount, uint256 interest);
    event SoldSnl(address buyer, uint256 snlAmount, uint256 ethAmount);
    event BoughtSnl(address seller, uint256 snlAmount, uint256 ethAmount);

    /**
     * Describe token: name, symbol, decimals.. and mint initial supply.
     */
    constructor() ERC20Detailed("SnailToken", "SNL", 18)
        public {
    }

    /**
     * Learn total ETH deposit supporting the token supply.
     */
    function getEthDeposit()
        public view returns (uint256) {
    }

    /**
     * Learn total rate.
     */
    function getTotalRate(uint256 day)
        public view returns (uint256) {
    }

    /**
     * Learn holder's rate.
     */
    function getHolderRate(address holder, uint256 day)
        public view returns (uint256) {
    }

    /**
```

```
     * Return the SNL/ETH ratio for price calculation.
     *
     * Note that 1 SNL >= 1 ETH.
     *
     * @param baseAmount  unsigned 256-bit integer number
     * @param tokenAmount unsigned 256-bit integer number
     * @return signed 64.64 fixed point number (@see f64.sol)
     */
    function getTokenRatio(uint256 baseAmount, uint256
tokenAmount)
        internal pure returns (int128) {
    }

    /**
     * Convert SNL to ETH at the inner exchange rate (price), w/
o applied interest.
     */
    function convSnl2Eth(uint256 amountSnl)
        public view returns (uint256) {
    }

    /**
     * Convert ETH to SNL at the inner exchange rate (price), w/
o applied interest.
     */
    function convEth2Snl(uint256 amountEth)
        public view returns (uint256) {
    }

    /**
     * Track total (global) rates as a sum of all rates.
     */
    function _trackTotalRates(uint256 _value, uint256 currentDay
)
        internal returns (bool)  {
    }

    /**
     * Very similar to the global tracking, however applied to
individual holder.
     */
    function _trackHolderRates(uint256 _value, uint256
currentDay)
        internal returns (bool) {
    }

    /**
     * Track transfer rates (volumes).
     */
```

```
    function trackSnlRates(uint256 _value, uint256 _timestamp)
        internal returns (bool) {
    }

    /**
     * Get transfer rates: total and individual (holder's).
     *
     * Ignore outdated data since last tracking. Return trivial
     * moving average over the array of rates.
     */
    function _getRates(address holder, uint256 currentDay)
        internal view returns (uint256, uint256) {
    }
    function getRates(address holder, uint256 _timestamp)
        public view returns (uint256, uint256) {
    }

    /**
     * Get interest rate based on the rate of the recent
   transaction volume.
     *
     * Note that any form of transfer including deposits,
   withdraws or p2p
     * transfer do contribute to the tracked rates equally.
     */
    function _getSnlInterest(address holder, uint256 amountSnl,
   uint256 _timestamp)
        internal view returns (int128) {
    }
    function getSnlInterestPct(address holder, uint256 amountSnl
   , uint256 _timestamp)
        public view returns (uint256) {
    }
    function getSnlInterestPct(address holder, uint256 amountSnl
   )
        public view returns (uint256) {
    }
    function getSnlInterest(address holder, uint256 amountSnl,
   uint256 _timestamp)
        public view returns (uint256) {
    }
    function getSnlInterest(address holder, uint256 amountSnl)
        public view returns (uint256) {
    }

    /**
     * Same as buying token at market price plus interest.
     */
    function depositEth()
```

```
        public payable returns (bool)  {
    }

    /**
     * Same as selling token at market price minus interest.
     */
    function withdrawEth(uint256 amountSnl)
        public returns (bool)  {
    }

    /**
     * Extend to track transfers.
     */
    function transfer(address _to, uint256 _value)
        public returns (bool) {
    }

    /**
     * Extend to track transfers.
     */
    function transferFrom(address _from, address _to, uint256
    _value)
        public returns (bool) {
    }
}
```

Listing 1: SnailToken.sol

```
-----BEGIN PGP PUBLIC KEY BLOCK-----

mQINBFz+GNcBEACzMQStVcbLa68gE7sH7SsP1frBBkrJNY11mlyMdXJ8AyuRcLVs
HSU+dwDJupmEFKJaYau5vigtUzW5EFJQWj6dxki+A2JGM1UdKz6lCfgZrLmT1GkO
LIboUAyQcSMUIHM7rW1mMaH4Z+XqUjgjMVGAjO7WhM37tm23FJm2ym6p+zPVbs0D
UIoROCvmoiVjVLPDUYAlSIcowfC3W2xx9n201CNLqI5sAXplxvtP88YIZpBHUBOr
8SqR9f/bAVrDIEYCd9MXYw5y0kcDYdykOqZLPFIgE1aznv5J9yNYLhyCT5XOyIUu
NQEByEHwtjSWkybdt1527HEmzdMGKF/g2zNFhRq2cOWv0ZbNKASk5EGOQBXBOtIw
3Z8nyngshkmJiig8TZKqObC/P3H9UX7r5Lcni0hD9CzrZg6LQDp9rcKwo6hYd8li
bTq9Aw1iUID814am5VQbzCZEg6EgsEfITyDaPxT8Yo19geo3CvPgUqpo2C7ALDIc
L+6YWaJt6/XQhLtPOKE8MMZz1uOoMrd3CUlThAYCjTvKYwO/2cdjT9R5uJDZp7Mp
vv9mmWhvaYz6SFAJaILHsGTgok8rCaV7WTT6Y+Hlkd2747qwVhrW94HD5Ipdw9Pu
u5SnzzD7LNALKbAcknsPx5dvWybev8GhgqMftUqqA2jH9NQorUpvIJIYNwARAQAB
tClUYWtlc2hpIEtvZG8gPHQ0azNzaDFrMGQwQHByb3Rvbm1haWwuY29tPokCTgQT
AQoAOBYhBOgzIZkQMombsfOYxWR3+uOvw0UYBQJc/hjXAhsDBQsJCAcDBRUKCQgL
BRYCAwEAAh4BAheAAAoJEGR3+uOvw0UYJpAP/1EKBxyHQi+fSvMc/3UtcWaPyWvF
47V7WBaAq7fOg12jnEQ8xZQxsGd56XZ2bAHufMGP4Box2gfeV3BRtjZ+JnENSAof
fhNO4Ki8G4ZiAFX1xxTjgyjXT/np8p2JL13QYJXJTuEJ4zkUfAJMgMFZITQ86rG8
z6kLGSWGZHGrvMW/lxBEh6BWQdELc6Tf3XjnjSXAlLxrLywC85ihqztRrih4KwIq
oHbqW2tvQiIXDT9Sr2MGV8B46qzPZiP9dQzcGZgSbzZpoNLBg7VVdbw0WjCR7Pvy
EffpeEEU9JpfNPFWRFe4oR1ZMZLFqvTDfSTbUMYPCiTjDtjgrfAvFRyWIrbaF8lO
GDR/dlTaE0NzaWqY5svL/JN1FwUbclpOr3Mt3jIo8O0yAdOhF+kKVe51iF2xjWEj
8NFuOMQcLlSIQj8/iCDpDlR7CqrXTtc8VoKTGuONE6bXfbErUPqyDJDSd0E8oMtY
4NUG9pzddQy7A3D/LmO1wfHHoBj5MD6Xs6VZ3P4EYwzqppmP2AxT66E0qaQjzSfd
9gph8MIdWfaESr5Tr/BTZWdzDkBZk6U4Tn4jpbW1t0tzACKwY21mII8Q+ks7cXcy
RlNjMFwSomBi/3tFWukI+LAPe9L1296Zd1euN2TptvQ38emtN48MUhcjLy0HPyK3
4GFQ5P8wPROcYRXXuQINBFz+GNcBEAC6Ab1vqKZofIr8PuX9HmqG+5vMu5keyDXi
aN8rXKsgnNnPJkySbOMr7xwjZPR+F762C4tXQroKIEJrwsXTGE2qxJ/i/b6Oz4D0
LfqDZjah7p2n5GS3/jKzYJcSpBw9mTvju9XDx6dddc/n1M5yfdYxy5mytdusFlVu
Dgz7QInwPRhty5dpBHgwRCuzB6R9dQZvFroipkfxJnkiNtct0oeGMfl5hZW2v9LM
RoAikvNzWP8ecg+QMBuvAQMoksbEEq+5jDqGKv4u5x0BZAT5HCp+65j7/wVkiICd
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1nLJ25ZttOueJLSoBBdqnrvRoU5ZDXo0lOvu1+DhYDsK3aQxCtt/oWOoWdFLFSij
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V+xXcw3i01CfHQ3rk6UCRtMgW0hJ9Cfx1IUBwDd5xsDH0r2bvfoFgXRXJqIUfYzr
TUM8ES+Dbl0i7qwYGo4sT0FgZKXvuzhEd7xTs8VWlg1c+OYEFXJHbsWTkWteJuwL
w3XZwDxIzP2SQRfFEPHamkVqfdhpHjvwbcx6n8+YOg/pEPbGt78GNiLWUqawD1nu
neP5YbIBjQARAQABiQI2BBgBCgAgFiEE6DMhmRAyiZux85jFZHf646/DRRgFAlz+
GNcCGwwACgkQZHf646/DRRiF/A//f5E6bRVxwtrzR1R9gWiYzTa25tv1972JdRe7
zOW63yNpVeC4SmfbgL+uSJP1HxiVEYl50Sw6gPtAXNHaBqWYZxSuivVHrX91USKv
xGG+cKlbi7TQhoxq/s64y9i7RsuBHzru5h5rBiX6WewhXlzlgyp2ZN663oqqWR1O
hA8nk+Zmjg4NyFfXKFhhLOfME9jF/ZvTbdTebEp6eq1skjeBp2b6V1P/zRFI9N8w
aHSq1dZfC/CAv8OZv6zAc5WGijmqkwENDEbhIx57qNEdPpAvpmmr1XupJqRIoAh7
1pyNheOnUlCLAlyNlHA68PRILr9pqFm3EtKLhpCmjX/KhjCIAGVRj7cMZDx3BECj
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