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Why Stablecoins Fail: An Economist's Post-Mortem on Terra

By Russell Wong

Why do some stablecoins, such as Terra's UST, fail but others do not? Was Terra just an unlucky victim of a classic bank run or speculative attack? Or was its high-yield deposit offering doomed to fail like a Ponzi scheme? What is the limit of the stablecoin's algorithm? What makes payment stable? In this article, we'll dive into potential answers to these questions about the failed stablecoin.

This article is the third in a series on central bank digital currencies.

At its peak, Terra's cryptocurrency UST was the third largest stablecoin in circulation, after Tether and USDC in terms of market cap. UST, however, collapsed in May.

Currently, there are about 200 stablecoins in circulation, primarily used to facilitate trading, lending or borrowing of other cryptocurrencies in online marketplaces. Terra's UST was different from other major stablecoins in a key way: It is backed by an algorithm rather than assets.

What Is Terra, and How Does an Algorithmic Stablecoin Work?

Terra is the blockchain that maintains the supply of two cryptocurrencies: LUNA and UST. They are traded and priced online in places like Binance, Curve and many others.

UST is an algorithmic stablecoin that maintains its price at $1 by the built-in algorithm (PDF) that promises one UST redeemable for $1 *worth* of LUNA, and vice versa.[1] For example, if the price of LUNA is $0.25, then a trader can "burn" (or destroy) one UST to "mint" (or create) four LUNA on the Terra Station. Conversely, if the price of LUNA is $3, a trader can mint one UST by burning 1/3 LUNA.

To see how the peg works, suppose UST is trading at $0.98 instead of at $1. An individual can buy one UST at $0.98, burn it at the Terra Station for $1 worth of LUNA, sell the LUNA immediately and make $0.02 profit. As long as UST is below $1, these profitable transactions result in continuing to burn UST in the market until the price of UST is pushed back to $1. Similarly, if UST is trading above $1 (say, $1.03), a trader could purchase $1 worth of LUNA, burn the LUNA to mint one UST and sell it in the market for a profit of $0.03.

How Did UST and LUNA Become Popular?

Part of Terra included a platform called Anchor, which allowed saving UST at a supposed risk-free deposit rate of 19.5 percent annually.[2] Think of the entity of Terra as consisting of two tranches:

- Short-term safe debt: UST via Anchor
- Equity: LUNA

With the peg, UST via Anchor is "safe" debt because its value is stable. Also, it is short-term debt because it is readily redeemable (in LUNA). Holding on UST is thus like rolling over the overnight debt. Equity is the residual value of an entity after it has paid off all its debt — in this case, the LUNA that would remain if all outstanding UST were redeemed. Thus, we can think of the equity value of Terra as the market cap of LUNA.[3]

This high-yield deposit attracted a lot of people to burn LUNA and deposit UST. For example, at Anchor's peak, the total circulating supply of UST was about $18 billion, with $16 billion locked in Anchor. In terms of corporate finance, it was like a company issuing short-term debt for stock buyback. As a result, the stock price (LUNA) went up, and the total debt (supply of UST) went up as well.

One distinctive design of the algorithmic stablecoin is that the equity (LUNA) is convertible to debt (UST) as well. With convertibility, the value of LUNA depends on the use value of UST. The rise of LUNA is ultimately related to the demand for stablecoins. Beyond this convertibility, LUNA is not different from other cryptocurrencies.

Are These Like Money Market Mutual Funds or Ponzi Schemes?

Some observers have compared UST to money market mutual funds (MMMFs). A money market is a decentralized market where participants can lend and borrow from each other via well-collateralized short-term loans. The issuers of MMMFs pool deposits and lend in the money market (among other similar investments). The returns are passed through to the depositors after deducting fees. Due to its nature, MMMFs are redeemable on short notice and are safe.

In this sense, UST is not an MMMF because the money paid is not invested in any asset. The money goes to the sellers of the UST or to the LUNA for minting UST. Depositing at Anchor, however, is closer to an MMMF in theory. Anchor allows borrowing UST at a floating loan rate after posting LUNA as collateral. (The collateral-loan ratio is 2:1.) Thus, the borrowing interest and the income from the collateralized LUNA generate cash inflow for Anchor.

Nevertheless, they are not enough to pay for the cash outflow of the deposit interest at 19.5 percent. (No MMMF could pay 19.5 percent, either.) As of the end of April, Anchor's cash inflow was about $0.7 billion, and its cash outflow for UST deposits was about $2.6 billion. The difference was actually made up by Terra's Yield Reserve, a pool of money raised from private investors.

In this sense, Anchor is not a rob-latecomer-to-pay-firstcomer Ponzi scheme. Anchor's deposit is more like an MMMF with a huge sign-up bonus, courtesy of its private investors. Also, as a decentralized finance (DeFi) platform, the cash flows of Anchor are executed automatically. An example of a Ponzi scheme-style cryptocurrency (confirmed by U.S. courts [PDF]) would be BitConnect, which appropriated the bitcoin in the users' BitConnect wallet to pay for its high-yield interest.

What Happened to UST, LUNA and Terra in May?

UST had been pegged at $1 quite successfully since its inception in 2019, even before Anchor was introduced in 2021. How did it collapse in May? Let me first document the collapse stage by stage, and then diagnose the causes.

Stage 1

On May 7, 2022, UST started experiencing selling pressure after people noticed an unusual amount of liquidity withdrawing from Curve, a DeFi exchange for trading cryptocurrencies. Liquidity on Curve is the amount of stablecoins such as Tether or USDC that someone is willing to sell for UST. The amount is public, like the number of candy bars visible in a vending machine. Thus, the withdrawal was like taking away some Snickers from the dispenser rack: Everyone could see they were gone. The withdrawal was not very big — amounting to about 6 percent of UST's market cap at the time — but it was the largest liquidity publicly visible.

This withdrawal caused UST's price to fall to as low as $0.985 on May 8. This first "depeg" was short lived, and UST bid back up to $0.995 on Binance in a few hours. However, confidence in UST was already shaken. Between May 7 and May 8, Anchor saw about 20 percent of its deposits exit, and the price of LUNA fell by about 17 percent. On the night of May 8, LFG (the organization behind Terra) announced it would deploy $1.5 billion of its reserves to defend UST.

Stage 2

On May 9, redemptions of UST ramped up, and the price of LUNA fell by another 48 percent over the course of the day. The price of UST dropped to as low as $0.60 on Binance. Although UST climbed back to as high as $0.93 on Binance at one point, it was the currency's final peak. UST became depegged shortly after, and the price of UST fluctuated wildly.

Stage 3

A *Minsky moment* — the start of a market collapse following prolonged speculation — happened when the market cap of LUNA fell below the market cap of UST. The price of UST then fell without much resistance to $0.22 on Binance. The liquidity for UST on Curve was mostly gone, and Anchor depositors fled en masse.

The redemption of UST meant that a lot more LUNA had been minted and was in circulation: The supply had been hyperinflated by about 80 times from 0.4 billion on May 10 to 32.0 billion on May 12. The price of LUNA tanked further from $31 to $0.01, and LUNA's peg was abandoned. Since then, UST and LUNA have been removed from major exchanges.

Was the Collapse Caused by a Speculative Attack?

Some people in the crypto community have suggested that UST's collapse was the result of a speculative attack. In economics, a speculative attack involves speculators borrowing an enormous amount of the pegged currency and dumping it on the open market. An example would be hedge funds (including George Soros' Quantum Fund) borrowing HK$30 billion to dump on the open market during the Asian Financial Crisis.

The success of a speculative attack relies on convincing the market to join the speculators' attack to corner the currency:

- If the currency depreciates, the speculators buy the depegged currency at a cheaper price, repay the currency loan and pocket the price difference.
- If the peg is maintained, then the speculators just buy and repay the currency at the same price.

The costs of the speculative attack are the interest costs and collateral costs of the currency loan.

In my view, it is unlikely that UST's decline was the result of a large-scale speculative attack for several reasons. First, it is unprofitable ex ante to borrow to dump UST. As mentioned above, before borrowing $1 UST via Anchor, it was necessary to first obtain $2 worth of LUNA as collateral. Also, the borrowing interest rate of UST on Anchor was floating, so it could easily have been pushed upward when speculators borrowed an enormous amount. The speculators can short sell in other online marketplaces too, but the funding rates of UST were as high as 500 percent during the period, and we did not see significant

borrowing activities.[4] In the typical scenario of a speculative attack, once the funding rate of a currency loan rises dramatically, the demand for the currency increases, helping to defend it.

In sum, a large-scale currency attack appears to have been unprofitable ex ante. It is possible, as some claim, that the initial withdrawals were orchestrated actions of speculators, but that does not equate to a speculative attack in the economic sense.

Were These Stablecoin Failures Like Bank Runs?

A bank run happens when depositors withdraw en masse and the bank runs out of cash to meet all withdrawal demand even after a fire sale of its long-term assets. When this occurs, depositors who are late to withdraw suffer losses. This is what motivates running the bank in the first place: Everyone wants to be the first to get their money out. Bank runs are avoidable if banks are just illiquid rather than insolvent.

The collapse of UST does have some features of classic bank runs, such as heavy deposit withdrawals from Anchor and redemptions on UST. Unlike in classic bank runs, though, Anchor was actually *solvent* at the eve of collapse. Even under the assumption of the 19.5 percent deposit rate, Terra's Yield Reserve at the end of April was expected to be large enough to make Anchor's cash outflow for 44 days. Also, a path of diminishing deposit rates had been announced on March 24, well before the collapse in May. Furthermore, unlike a bank that can run out of cash, Terra never runs out of LUNA as it can always mint LUNA from thin air.

One possibility is that the prices of UST and LUNA could fall simultaneously fall to exactly zero. In this equilibrium, Terra can't mint infinite amounts of LUNA for $1 worth, and the peg of UST collapses. But as mentioned above, the collapse of UST and LUNA happened over days rather than instantly. The price of the depegged UST was eventually $0.22, while LUNA was close to zero but still positive.

Why the Algorithm Did Not Work

In theory, as long as the price of LUNA is positive, the price of UST should never fall below $1 as people will arbitrage by burning the cheap UST and minting $1 worth of LUNA. According to the theory, the algorithm should always maintain the peg, regardless of whether the liquidity on Curve was withdrawn.

In practice, the arbitrage was limited by two things: the spread and redemption capacity. These are somewhat similar to the liquidity fees and redemption gates of MMMFs. The spread is the percentage loss when minting LUNA from burning UST, which is typically 2 percent but increases exponentially when minting becomes larger than the redemption capacity (initially about 20 million LUNA).

The idea behind the spread and redemption capacity is to encourage trading LUNA in secondary markets such as Binance and Curve instead of minting and burning LUNA on the Terra Station. Without these features, if liquidity in the secondary markets was too low, one could easily manipulate the price of LUNA, then exchange LUNA on the Terra Station (where the price of LUNA used to calculate the number of mint arrives with some delay) to pocket the price difference.[5] The redemption capacity limits the scale of this manipulation.

This means, for example, that a trader who wants to burn UST, mint LUNA and sell for USDC should find it more efficient to sell UST for USDC in the market. In normal times, these two methods (minting versus market) result in the same price of LUNA, and the price of UST in the market is pegged to $1.

But the market method relies heavily on the liquidity in markets like Curve, which should have grown at the pace of UST's rise. When liquidity started draining in stage 1, some people turned to minting. They also became willing to sell UST below $1 in the market as the spread started applying. The $1.5 billion from LFG to defend UST was insufficient compared to the $18 billion worth of UST in circulation. Compare that with when Hong Kong successfully defended the peg. Hong Kong's reserves was more than three times greater than the outstanding stock of currency.

In stage 2, trading against a redemption capacity with falling LUNA prices meant that the exit window was shrinking. Terra responded by raising the redemption capacity. But once confidence was shaken by the first depeg, the sudden widening of the exit window only made people to stampede rather than hodl. The liquidity problem further worsened, and more people started redemption with spreads increasing on the Terra Station, the supply of LUNA inflating greatly and the price of UST fluctuating wildly.

In stage 3, the redemption capacity was so binding that the arbitrage mechanism of algorithmic stablecoin was no longer working. At the Minsky moment when the market cap of LUNA was below the market cap of UST, the value of LUNA clearly was not enough to redeem all the UST in circulation. In this case, UST was no longer a stablecoin, and the price of UST (as well as LUNA) collapsed.

How Did Security Features Make the Collapse Worse?

One factor that has not been much discussed is that Terra's proof of stake (POS) mechanism accelerated its failure. Maintaining a blockchain requires validators' synchronizing and confirming the transaction data continuously. There are two main mechanisms to compensate the validators:

- A proof of work (POW) mechanism compensates validators according to their computation power (which requires energy).
- A POS mechanism compensates according to validators' stake of the cryptocurrency.

POS makes Terra more energy efficient than other POW cryptocurrencies like bitcoin. However, as the price of LUNA started collapsing, the stake of validators' LUNA fell to almost zero, which meant malign actors could become the dominant validators by acquiring a large amount of LUNA to stake at almost no cost. As a result, Terra had to halt its blockchain to reduce the risk of governance attacks, which further curtailed its pegging mechanism.

Conclusion

UST was backed by LUNA, but the price of LUNA was backed by its option value of converting to UST. When the confidence of this circular backing is shaken, the liquidity of algorithmic stablecoin becomes flighty. In this case, the algorithm does not fully function because Terra needs to (but can't always) defend both UST and LUNA. When market liquidity evaporated, UST and LUNA ultimately relied on the issuer's equity to support the prices, similar to the backing of a more traditional currency as seen in the Asian Financial Crisis. It is the part of economics cannot be replaced by technology.

Other stablecoins indeed try to maintain their pegs by more traditional ways. For example, Tether and USDC are backed by low-yield cash-equivalent assets like narrow banks. DAI are backed by Ether (another cryptocurrency) but overcollateralized at 150 percent. These stablecoins are more stable than algorithmic stablecoins, although less collateral efficient.

On the other hand, the modern banking system is designed to solve the liquidity issue through various means. Banks are insured by the Federal Deposit Insurance Corp., which mitigates the risk of bank runs and flighty liquidity. At the time of liquidity needs, banks can borrow and lend from each other in the Fed funds market. If the funding market proves insufficient, banks can always borrow liquidity at the Fed's discount window. Banks' liquidity is enforced and monitored under the Fed's supervision.

In sum, a sound payment ecosystem is not just about currencies. It includes a solid user base, associated funding markets, policy, regulation and the support of central banks.

Russell Wong is a senior economist in the Research Department at the Federal Reserve Bank of Richmond. He writes about cryptocurrencies and recently wrote about SWIFT and the Fed as the borrower of the last resort. He also co-organizes a monthly webinar series on CB&DC.

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[1] *Some algorithmic stablecoins like IRON (which also failed eventually) can be burned to mint a portfolio of a dollar worth of the native floating coin (TTAN) and another stablecoin (USDC), and vice versa.*

[2] *To be precise, depositing UST into Anchor essentially buys aUST with UST. The exchange rate of aUST in UST is controlled such that it grows at an annual rate of 19.5 percent. Thus, the deposit interest is paid via the appreciation of aUST.*

[3] *I am grateful to Doug Diamond who shared with me his idea of LUNA as equity, which comes from his MBA class materials at the University of Chicago.*

[4] *Indeed, during the course of attacking the Hong Kong dollar, the interest rate had been pushed up to 280 percent in the interbank market and Soros eventually gave in.*

[5] *This price delay was the main reason why the IRON stablecoin failed. The introduction of spread and redemption capacity was part of the response to the post-mortem of IRON.*

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