Automated Market Making

A novel design by Chintai

Overview

An Automated Market Maker (AMM) is a trading mechanism where trades are executed instantly using market orders. The trade price of an asset is calculated based on available liquidity and order size. Two essential features of an AMM include:

The system's design ensures it never fully depletes its liquidity. As an asset's liquidity nears zero, its price should trend towards infinity.
There must be a compelling incentive system in place for liquidity provision.

AMM User Roles

Within the AMM ecosystem, different participants play vital roles:

Trader: Engages in asset swaps through the AMM, with the exchange rate determined by asset price, order size and current liquidity.

Liquidity Provider (LP): Contributes assets to the AMM, enabling trades. In return, LPs earn a portion of the trading fees generated and any incentive schemes that the AMM is participating in.

Issuer: Introduces an asset on the Chintai platform, making it available for trading within the AMM.

Benefits of the AMM

Automated Market Makers (AMMs) have revolutionized the trading landscape by offering several distinct advantages. Firstly, they provide continuous liquidity, ensuring that traders can execute their orders without the need for a matching counterpart. This is particularly valuable in less liquid markets. Secondly, they operate on predefined algorithms, eliminating the reliance on traditional order books and offering more predictable and transparent trading conditions. Additionally, by allowing users to earn fees as liquidity providers, AMMs democratize the trading ecosystem, fostering broader participation. Their decentralized nature also reduces the risks associated with central points of failure, bolstering the resilience of the market.

How it works

Providing Liquidity

For an AMM system to function efficiently, it necessitates sufficient liquidity for assets being traded. Investors who possess an asset and are seeking passive income from its trading fees step in to offer this liquidity.

Upon providing liquidity for a specific asset (let's call it asset X), the investor is issued a distinct token (denoted as LPX). This LPX token represents the investor's share in the liquidity pool. The quantity of LPX tokens received is contingent on its current price relative to asset X, which is determined by the existing asset ratios within the AMM.

Example

- Asset X gets introduced in the AMM with zero initial liquidity.
- User A offers the initial liquidity, depositing 15 units of X. As a record of this contribution, they're issued 15 units of LPX. The total LPX supply effectively indicates the ownership fractions of the pool for asset X.
- User B later deposits 5 units of X and obtains 5 LPX units in return.
- After some trades, the liquidity pool of X now holds 24 units. Ownership is determined by LPX holdings: User A owns 15 LPX (or ¾ of the total) and User B holds 5 LPX (or ¼ of the total).
- If User A decides to withdraw liquidity, the 15 LPX tokens are burned, and User A receives 18 units of asset X (¾ of the pool), resulting in a increase of 3 units.

Example

- Asset X is introduced with no liquidity.
- User A steps in first, depositing 15 units of X, receiving 15 LPX tokens.
- After some trades, the pool's size grows to 20 units of X; the amount of LPX tokens has not increased..
- Now the ratio of LPX to LP is 15/20, so when User B adds 5 units of X, they receive 5 * 15/20 (3.75) LPX tokens. .

In essence, these LPX tokens offer an elegant way to monitor and claim proportional ownership and rewards within the AMM's liquidity pool.

Trading

In the AMM system, trading is seamlessly executed by depositing one asset and specifying another asset you wish to receive in return. The quantity of the asset you acquire from a trade is precisely determined by four factors: the price of each asset involved in the trade, the size of your order, the current liquidity in the system, and the underlying mathematical principles governing the AMM. This process is transparent and deterministic, allowing anyone to compute the expected outcome. For a deep dive into the specific mathematical formulations, please consult the Appendix: Mathematics of Trading.

Fee Distributions

Trading on the AMM incurs fees, which are levied proportionally based on the trade size for both assets involved in the exchange. Each token in the system may have an independent fee structure. Upon collection of these fees, a portion is allocated to Chintai, while the remaining is funneled back into the liquidity pool of the respective asset. This reinvestment in the liquidity pool serves as a motivating factor for liquidity providers, ensuring they're rewarded for their contributions to the ecosystem.

Unique Features of the Chintai AMM

Pairing to an unobtainable relay token

In the AMM system, every token is associated with a unique intermediary known as the RELAY token. When a fresh token is introduced to the AMM, it's paired with the RELAY, establishing a reference point for all trades.

Designed exclusively for internal operations within the AMM, the RELAY token isn't available for direct purchase or storage in traders' portfolios. During a trade, a user must stipulate the token they're trading in relation to the RELAY and subsequently indicate which token they intend to procure using the temporary RELAY balance. This process is atomic, ensuring that RELAY tokens never appear outside the AMM framework.

All asset valuations within the system are gauged against the RELAY token.

Example:

Suppose a user aims to swap USD for the X token, where the price of 1 X token is 2.5 USD. Note: The following example ignores fees and slippage for simplicity.

- The prevalent exchange rate for USD vis-à-vis RELAY is 2:1 (1 USD fetches 2 RELAY tokens).

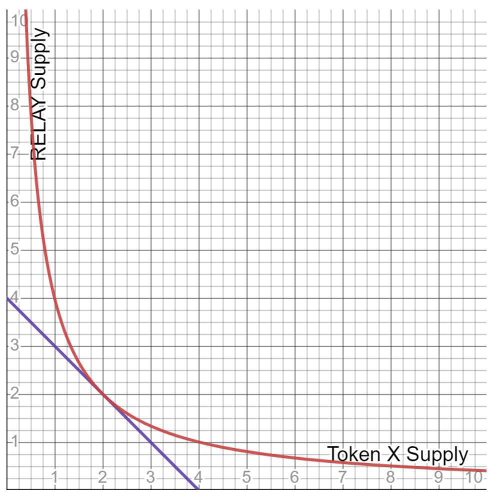
- Concurrently, the X token's rate relative to RELAY stands at 5:1 (1 X is equivalent to 5 RELAY).
- The trader sells 100 USD, momentarily acquiring 200 RELAY tokens. These are instantly exchanged for X tokens.
- The user secures 40 X tokens.

Liquidity curve

In order to provide single sided liquidity linked to the RELAY token, the mathematics has to allow asymmetric values of liquidity for each asset, whilst not creating arbitrage opportunities.
The standard formula for the liquidity curve of an AMM is the constant product formula:

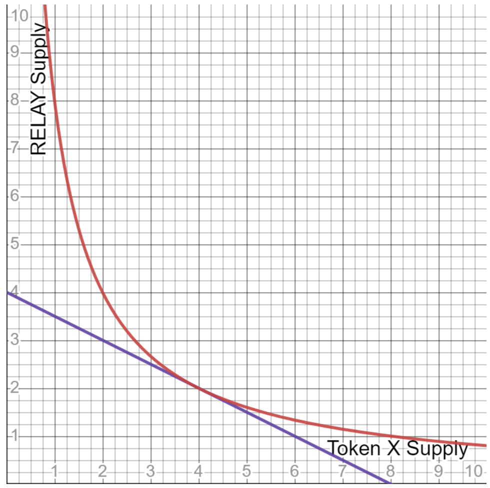
$$y = \frac{a}{x}$$

Where *y* is the supply of the RELAY token, *x* is the supply of the X token, and *a* is a constant when trading.
Whenever trading occurs, the supply of either *x* or *y* is increased from the trader selling the token, and because *a* is constant, the value of *y* or *x* respectively must decrease, so that the equation remains valid.
This can be shown as a graph as follows:

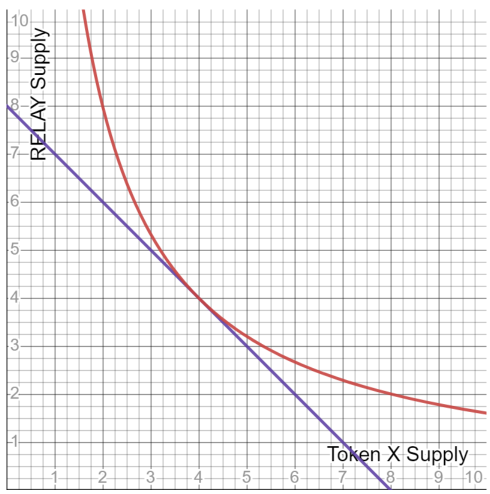


Where the red line represents the possible values of the system when trading occurs, and the blue line represents the gradient at the point (2,2), which is -1. This means that if there were 2 of token X and 2 relay tokens in the system, the price of the assets would be 1:1.

Adding liquidity changes the value of *a*, so lets imagine you want to add 2 more tokens to the X supply. the graph if you did this, *a* would change from 4 to 8 and the graph would look like this:



The gradient has changed from -1 to -0.5, essentially changing the price of the pair to a ratio of 1:2, and creating an arbitrage opportunity. The only way in a traditional AMM to avoid this is to provide equal value of liquidity on both sides, in this case, adding 2 X tokens and 2 RELAY tokens:

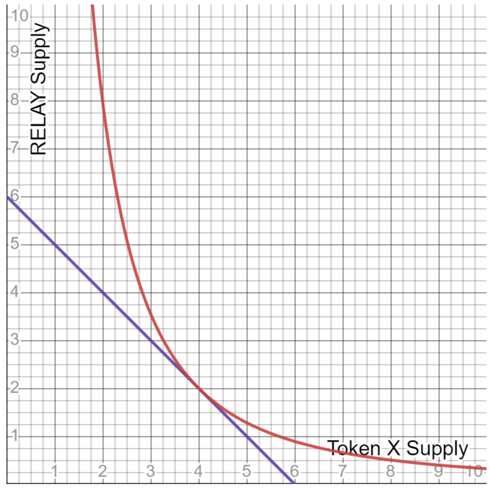


This gives you the same gradient you started with, and therefore does not create an arbitrage opportunity.

In our system, the liquidity curve looks like this:

$$y = \frac{a}{x^b}$$

and the values of *a* and *b* are constant for trading, but variable for adding liquidity. This means that you can provide more liquidity in the X token without providing more in the RELAY, and the curve changes shape then asymmetrically:



In this example, *a* is set to 32, and *b* is set to 2, giving a curve that goes through the point (4,2) whilst still having a gradient of -1.
For more details on this, please see the appendix.

Absolute slippage tolerance

Most AMMs have some system of tolerance against slippage. Usually expressed as a percentage. For example, if a user wants to make an order that should cause slippage of 1%, they may set the tolerance to 2%, meaning that if the slippage were suddenly to jump to 2% just before the user executed their trade then it would still be acceptable, however if it were above 2% then the transaction would rollback.

Our system takes instead a minimum expected payment in the receiving asset. If you want to trade asset A for B and you expect to sell 10 A to get 20 B, you can say that you want the tolerance to be 15 B, and if the trade would get you less than this amount of B, it will rollback.

This has the advantage of functioning as you expect regardless of whether someone changes the amount of liquidity in the system just before your trade goes through, or if someone makes a large trade just before you do. The second case is not covered typically by slippage percent tolerance mechanisms.

Expected Economic Impact

The pairing mechanism and slippage

In our AMM setup, token-to-token trades are facilitated via a unique intermediary step using the RELAY token. If an individual wishes to trade token A for token B, the AMM orchestrates the transaction in two phases:

1. Token A is exchanged for RELAY.
2. The acquired RELAY is then traded for token B.

Slippage, or the variance between the expected price of a trade and the price at which the trade is executed, varies based on the order's size and the available liquidity of the paired tokens. In a conventional double-sided AMM, each leg of the trade (A -> RELAY and RELAY -> B) would introduce slippage. However, our AMM's distinct design ensures the RELAY token boasts a significantly large liquidity pool, making it resistant to slippage. As a result, when trading between tokens A and B, the only slippage encountered stems from the inherent liquidity of A and B, leaving the RELAY token's liquidity impact out of the equation.

Order book exchange synergy

By integrating the inherent liquidity of an AMM with a conventional orderbook, the trading ecosystem is enriched, offering an enhanced depth of liquidity. The AMM's liquidity is represented as distinct orders within the orderbook. When a trader initiates an order, the system can precisely gauge how much of that order should be addressed by the AMM versus the orders already present in the orderbook. This precision ensures the best possible execution price.

This integration offers several notable benefits:

- Optimal Pricing: Ensures users receive the most favorable rate for their trades.
- Arbitrage Opportunity Minimization: By syncing prices between the AMM and the order book, potential price discrepancies, ripe for arbitrage, are eliminated.
- Enhanced Token Pairing: With this approach, tokens on the orderbook can be matched against any other token, dramatically expanding the variety of trading pair options.

Furthermore, this method introduces a vast expansion in the range of available trading pairs. If there are N assets available for trading, the system can facilitate up to N(N-1) pairs. While many of these pairs might appear unrelated, they present new avenues for detailed technical analysis, potentially unveiling unique market insights.

Instant Liquidity for Issuers

In traditional markets, when new tokens or assets are launched, they often struggle to find initial liquidity. This can lead to wide spreads, high slippage, and a lack of price discovery. The AMM's innovative design tackles this challenge head-on by allowing issuers to tap into immediate liquidity. This not only facilitates smoother transactions but also ensures more accurate and efficient price determination for newly introduced assets. When issuers can provide their tokens in an AMM and instantly create a market for them, it accelerates adoption and fosters a more conducive environment for growth and investor confidence.

Attractive Onboarding

For traders and investors, entering a new platform can be daunting, especially with concerns about liquidity, spreads, and the general user experience. The AMM addresses these concerns by ensuring a liquid market for a wide array of assets. The confidence that one can enter or exit positions without facing massive slippage or encountering thin order books makes the onboarding experience far more appealing. This attractiveness not only retains existing users but also draws new participants, thereby expanding the ecosystem's user base.

Passive Income for Liquidity Providers

Liquidity providers play a pivotal role in the AMM ecosystem. By staking their assets in the liquidity pool, they facilitate trades and ensure market efficiency. As a reward for this service, they earn a fraction of the trading fees. This creates an attractive passive income stream. As the AMM witnesses more trading volume, these returns can be significant. This passive income model encourages more users to stake their assets, ensuring the system remains liquid and robust.

Arbitrage Opportunities

AMMs, by design, operate on algorithms that can sometimes result in price deviations from other markets or platforms. These discrepancies create arbitrage opportunities for traders. Arbitrageurs can capitalize on these price differences to lock in risk-free profits, buying an asset where it's cheaper and selling it where it's priced higher. While this might seem like an inefficiency, it's beneficial for the AMM system. Arbitrage actions help in price correction and bring the AMM's prices in line with the broader market, ensuring that the platform's asset prices remain competitive and reflective of real-world values.

Potential Risks

Managing Incorrect Initial Pricing in AMM

When introducing a new asset to an AMM, its initial pricing is manually determined. If inaccurately overpriced, there's a risk where asset holders might exploit this by selling their assets at this overvalued rate, adversely affecting liquidity providers.

To mitigate such risks, it's imperative to have a deep understanding of the asset's price before it's integrated into the AMM.

Risk Mitigation

The incorrect pricing of assets could be managed by only allowing a centralized entity to set the price and add an asset to the ecosystem.

A viable alternative emphasizes dual-sided liquidity provisioning. This not only permits anyone to incorporate any asset, enhancing system decentralization, but also necessitates users to pair their newly introduced asset with a well-established, highly liquid one. Such recognized assets—like USD, BTC, or ETH—have undergone exhaustive price discovery phases. When users back their tokens by pairing with such high-value assets, it signals their commitment. Essentially, they vouch for their asset's worth by aligning it with a recognized asset's value, fostering trust and reducing initial pricing errors. Note that even if dual-sided liquidity provisioning is enforced, all the benefits of single sided liquidity are still valid in our system.

Issuance of more tokens than expected

A potential risk in our AMM system is the unexpected issuance of an overwhelming number of tokens via a smart contract. If unchecked, malicious entities could potentially use these surplus tokens to purchase all other assets in the AMM without genuine cost. While standard AMMs diminish a token's leverage when its paired asset's liquidity runs low—forming a natural protective barrier—our AMM system lacks such constraints due to its unique equal pairing mechanism.

Risk mitigation

Selective Onboarding: Limiting our AMM system to only trustworthy tokens and enterprises can reduce such risks. To ensure the credibility of the entities, we would conduct rigorous KYC checks on token issuers, making them liable for any unscrupulous activities.

Supply Monitoring: By vigilantly observing the supply of assets issued on our platform, we can put preemptive measures in place. For instance, if an asset's supply expands beyond an established threshold, the system can automatically freeze it. Though this may inadvertently affect some inflationary tokens, it's a calculated trade-off for enhanced system security.

Circuit Breakers: Another protective mechanism could be the introduction of circuit breakers. These would suspend a token's trading activity if its price undergoes drastic fluctuations within a short period. Such rapid price changes would likely indicate an abuse of the system, thus activating the circuit breaker would be a swift responsive action.

Impermanent loss (or gain)

In the realm of Automated Market Makers (AMMs), impermanent loss is a potential risk faced by liquidity providers. It refers to the discrepancy in value between holding an asset and providing it as liquidity in an AMM due to price fluctuations.

Traditional AMM Scenario

Imagine you're a liquidity provider in a traditional AMM. You decide to supply liquidity to a BTC-USD pool, depositing 1 BTC (valued at $10,000) and an equivalent $10,000 USD. If BTC's external market price rockets to $20,000, traders spot an arbitrage opportunity. They buy BTC from the AMM, causing its proportion in the pool to decrease. Later, if you decide to withdraw your share, you might find the pool's composition has shifted to 0.5 BTC and $15,000 USD. Although the total value you receive seems significant, it's less than the $20,000 you'd have if you had merely held onto the 1 BTC. This difference in value is the impermanent loss.

Our AMM System Scenario

Now, consider our unique AMM system, where you're not required to pair with another asset. You deposit just 1 BTC (valued at $10,000). With BTC's market price doubling to $20,000, traders flock to buy BTC by selling other assets like ETH and USD. On withdrawing, you might find you have only 0.6 BTC, a decrease from your original deposit, despite BTC's price surge. This too is impermanent loss, but it arises in a different dynamic.

Risk Mitigation

One approach to temper this risk is through diversification. Let's say instead of supplying just 1 BTC, you diversify by depositing 0.33 BTC ($3,333), $3,333 USD, and an equivalent value in ETH. When BTC's price surges, traders still buy BTC, but because of your diversified liquidity provision, the impermanent loss is cushioned.

Counterparty exit liquidity risk

A distinct risk arises from the possibility of having an extremely asymmetric distribution of assets. Consider that asset A constitutes 90% of the total value of liquidity in our AMM. Unlike standard AMMs, our setup allows for such high concentration of a single asset. Now, if asset A's value experiences a slight decline, it can have disproportionate consequences. Traders might scramble to exchange other assets for asset A to take advantage of this dip. This buying frenzy could swiftly exhaust the AMM's reserves of other assets.

Risk mitigation

The recommended strategy to mitigate this risk is to mandate users to supply liquidity using two different tokens of equivalent value.

For example, if someone wishes to introduce asset A into the AMM, they must simultaneously provide an equal value of another asset, say asset B. This approach ensures a more balanced distribution of assets within the system, thus reducing the potential harm from any drastic shifts in a dominant asset's value. It's a mechanism designed to maintain stability in our unique AMM environment.

Innovation Gateway

Combination with order book exchange

It is possible to combine the orders from the AMM with orders from an order book exchange. Before executing an order, a calculation can be done to determine the best execution price across the two systems, ensuring that all users get the optimal deal when trading.
Additionally, the creation of new pairs on the order book exchange can be done on-the-fly, as the AMM allows any-to-any pairings, the equivalent can be set up for the order book exchange. This allows for very exotic trading strategies, such as “Sell A for B when the price of C reaches D”, where A, B, C, and D are all different assets. It also helps to decouple the power of the most liquid assets from the ecosystem, so that when BTC goes up or down in price, it does not have to drag every other asset with it.

Automated ETFs

It is possible to create an ETF in an automated way whose price will exactly match the expected underlying asset’s prices. The ETF can be minted in exchange for providing enough of the underlying asset, or by paying in one asset and having the AMM automatically convert the provided asset into the appropriate underlying assets. Burning the ETF will reward the token holder with the underlying assets directly. The ETF can be marked to market easily within the AMM system, meaning that the ETF will very accurately match the index it represents.

Conclusion

The AMM system is a novel and unique way to create liquidity and allow markets to form that are optimal and very efficient. The liquidity of assets is not fractionalized between different pairs, allowing for higher general liquidity, and a series of unique improvements and innovations to the way transactions are processed.

There are various risks associated with the AMM system, most of which can be mitigated by requiring that two assets are provided when adding liquidity.

Whilst this AMM is currently in the experimental phase, we hope to see it perform well in live environments in the near future, and will adjust the system according to the feedback received from the community.

Appendix

Mathematics of Liquidity Provision

The liquidity formula for the AMM is dependent on a couple of variables:

- *x* is the amount of liquidity in token X
- *y* is the amount of liquidity in the RELAY token
- *a* and *b* are constants for a Token X and the RELAY token during trading, and variables when adding or removing liquidity.

When liquidity is added to a token, the values of *x* and *y* should remain constant, and the price should also remain constant. The price is represented by the derivative of the liquidity formula:

$$y = \frac{a}{x^{b}}$$

$$\frac{dy}{dx} = \frac{-ab}{x^{b+1}}$$

New values for *a* and *b* can now be calculated as follows:

$$b = -\frac{x\frac{dy}{dx}}{y}$$

$$a = yx^{b}$$

Mathematics of Trading

If the user wants to buy some of token *y* using token *x*, then they can do so by transferring token *x* to the smart contract, indicating with the memo that this is a trade, and not adding liquidity.
So lets assume that the value of *a* and *b* are set to 10000 and 1.4 respectively. There are currently 10 of token *x* in the system and 398 of token *y* in the system. We are going to add 1 of token *x* to the system, thus increasing the *x* supply to 11.

<u>Original calculation</u>

$$y = \frac{a}{x^{b}}$$

$$398 = \frac{10000}{10^{1.4}}$$

<u>New calculation after trade</u>

$$y = \frac{a}{x^{b}}$$

$$y = \frac{10000}{11^{1.4}}$$

$$y = 348$$

The new supply of the *y* token has to be 348, which means that the amount of tokens received in the trade by the user is 398 - 348 = 50 *y* tokens.

As a single equation for switching between any token (x_1) and any other token (x_2) that isn't the relay token

$$x_{2,bought} = x_{2,supply} - \left(\frac{a_2}{2y_{supply} - \frac{a_1}{(x_{1,supply} + x_{1,sold})^{b_1}}} \right)^{1/b_2}$$

Mathematics of Slippage

When selling a token, there may be a difference between the expected amount of tokens received at the current price, and the actual amount of tokens received. This is because as you withdraw tokens from a pool, the supply of that token goes down, which increases the price. Therefore as tokens are withdrawn, the price goes up, which increases the average price a user pays for the tokens. Slippage is much higher in cases where a high percentage of the pool is being withdrawn.

The formula for slippage can be thought of as follows: the slippage (expressed as a percentage) is equal to the expected amount of tokens received (according to the current price) divided by the actual amount of tokens received. First we must calculate the current price:

$$y = \frac{a}{x^b}$$

$$\frac{dy}{dx} = \frac{-ab}{x^{b+1}}$$

Once we have the current price, we can use that to calculate the expected tokens received, and we can also calculate the amount of actual tokens received. We can then use these two variables to calculate the slippage as a percentage:

$$slippage = \left(\frac{expected\ tokens\ received}{actual\ tokens\ received} - 1\right) * 100$$

$$expected\ tokens\ received = current\ price * tokens\ sold$$

$$expected\ tokens\ received \ = \ \frac{-ab}{x^{b+1}} * tokens\ sold$$

$$actual\ tokens\ received \ = \ current\ y\ liquidity \ - \ liquidity\ of\ y\ after\ trade$$

$$actual\ tokens\ received \ = \frac{a}{x^{b}} \ - \ \frac{a}{(x+ts)^{b}}$$

$$slippage \ = \ \left(\frac{\frac{-ab}{x^{b+1}} * ts}{\frac{a}{x^{b}} - \frac{a}{(x+ts)^{b}}} \ - \ 1\right) \ * \ 100$$