Fragmentation Is All You Need

Glowswap is a new type of blockchain based automated market maker that introduces a concept called liquidity borrowing, which allows traders to borrow liquidity from a public liquidity pool and use it to create private liquidity pools that only the borrower can exchange with. Assuming a competitive market of liquidity borrowers, Glowswap allows liquidity providers to passively capture nearly all of the LVR.

Surprisingly, the same primitives that allow Glowswap to passively capture LVR also enables an entirely new class of lending, allowing traders to execute strategies that resemble collateralized borrowing and leveraged perpetuals, except without any risk of being margin called. This unlocks a new class of long term, high leverage trading positions that were previously non-viable due to the risk of liquidation.

Background and Motivation

One of the fundamental primitives of blockchain finance is the automated market maker, or AMM. An AMM creates liquidity for an asset pair, acting as an always available counterparty for traders that wish to exchange one asset for the other.

The majority of AMMs today establish an asset price for traders based on the number of assets that are in the AMM, with no regard for the external market price of the assets. This means that the AMM is vulnerable to arbitrage transactions that profit from trading against the AMM when the assets are mispriced.

The generalized version of this problem is called loss versus rebalancing, or LVR, and essentially states that liquidity providers will always lose money by participating in the AMM rather than separately executing a rebalancing strategy with their assets. This means that it only makes sense to participate in an AMM if the fees collected by the AMM exceed the LVR.

Glowswap solves LVR by allowing anybody to borrow all of the liquidity in the AMM and obtain exclusive access to the LVR. A rational arbitrageur will be willing to pay a fee for this right, and in a competitive market the arbitrageur will have to pay a fee that is nearly equal to the value of the LVR.

The fees that arbitrageurs pay flow back to liquidity providers, giving them passive returns that are roughly equivalent to executing the best LVR strategies, without liquidity providers even needing to know who is capable of executing the best strategies.

Beyond just extracting LVR, arbitrageurs can expose their borrowed liquidity to the public, allowing anyone to trade against the liquidity for a fee that is chosen by the arbitrageur. The arbitrageur can ensure that they have priced their assets correctly before approving a transaction, meaning that they can extract all the value from noise traders while also retaining all of the LVR.

In an entirely different sphere of blockchain finance, lending protocols operate by requiring users to overcollateralize their loans. If the value of the collateral drops below a certain threshold, the user gets liquidated and loses all of their collateral.

The risk of liquidation forces users to limit their exposure to volatility. If users are taking a high leverage position, they can only reasonably keep their position open for a short period of time. Conversely, if users are taking a long lasting position, they have to limit their total leverage.

This problem can be solved using the same technique that allows liquidity providers to passively earn LVR. A trader can create a leveraged position for themselves with zero liquidation risk by borrowing liquidity into a private pool and then trading against that private pool.

For example, a potential borrower that has GLW tokens could take a leveraged position by borrowing liquidity into an exclusive pool. They can then sell their GLW tokens to their exclusive pool, extracting USDC. Because they are the only ones allowed to exchange with their exclusive pool, the GLW is safe and can be recovered at any time in the future by returning the USDC.

The borrower can then use the USDC to purchase more GLW tokens, increasing their exposure and creating a leveraged portfolio. The collateral in this case is the liquidity in the exclusive pool, which by definition cannot decrease. Because the borrower is required to return liquidity rather than a specific dollar value, the borrower remains solvent at all asset prices and will never be margin called.

By adding some simple primitives to a constant product market maker, Glowswap is able to solve LVR for liquidity providers while also enabling a lower risk platform for collateralized lending. Because the two use cases are in competition, the liquidity providers will passively earn interest based on whichever is more valuable.

The Basics: Automated Market Makers

An automated market maker, or AMM, is a digital marketplace where one asset can be exchanged for another. Traditionally, each AMM focuses on a single asset pair. For example, one AMM may create a marketplace between USDC tokens and GLW tokens.

AMMs require two different types of participants to function effectively. The first type of participant is a liquidity provider, or LP, and the second type of participant is a trader.

LPs participate in AMMs by depositing one or both assets of an asset pair into a liquidity pool, agreeing to buy or sell their assets according to a specified algorithm. Different types of AMMs use different algorithms.

LPs can decide to withdraw their liquidity at any time. Because the LP agreed to buy and sell assets according to an algorithm, the quantity of assets that the liquidity provider withdraws may not match the quantity of assets that the LP deposited.

This means that LPs are exposed to potential divergence loss, an outcome where the value of the assets that a liquidity provider can withdraw is lower than the current value of the assets that were originally deposited. To compensate for potential divergence loss, AMMs typically pay some sort of fee or yield to LPs.

All of the assets from LPs are combined together into a liquidity pool. Traders are then able to exchange assets with the liquidity pool according to the algorithm of the AMM.

Constant Product Market Makers

A constant product market maker, or CPMM, is a variant of AMM that uses the constant product rule as its algorithm for determining how assets in the liquidity pool can be bought and sold.

The constant product rule states that when a trader is exchanging assets with a CPMM, they can adjust the liquidity pool to have any quantity of each asset so long as the asset product remains the same both before and after the exchange.

The asset product is the product of the quantities of each asset in the liquidity pool. For example, a CPMM that has 100 USDC tokens and 100 GLW tokens will have an asset product of 10,000. A trader can therefore add and remove tokens in any quantity so long as after the exchange the asset product is still 10,000.

This means that if a trader adds 25 USDC tokens to the example CPMM, the total USDC tokens will increase to 125. The trader will then be required to remove exactly enough GLW tokens to keep the asset product at 10,000.

The exact number of tokens can be calculated with the equation `10,000 / 125`, which evaluates to 80 and says that the trader needs to leave 80 GLW tokens in the CPMM. Therefore, the trader must take 20 tokens for themselves. In other words, the trader has exchanged 25 USDC tokens for 20 GLW tokens.

The constant product rule is frequently expressed using the following equation:

`x * y = k`

In this equation, `x` and `y` are the quantities of each asset in the CPMM, and `k` is the asset product. You can see examples of the constant product rule in action in the table below:

Action	Result	USDC	GLW	Asset Product	GLW Price
init	init	100	100	10,000	1.00
swap 25 USDC	get 20 GLW	125	80	10,000	~1.56
swap 75 USDC	get 30 GLW	200	50	10,000	4.00
swap 50 GLW	get 100 USDC	100	100	10,000	1.00

The price of an asset in a CPMM can be determined using the Relative Price Formula, which divides the quantities of each asset in the CPMM. For example, price of GLW tokens in terms of USDC tokens can be determined by dividing the number of USDC tokens in the CPMM by the number of GLW tokens in the CPMM. The above table provides the GLW token price at each step as an example.

As tokens are exchanged, the price changes. You can see from the table that as more USDC tokens are added to the CPMM, fewer GLW tokens are received per USDC token that gets added. In the first exchange, a trader adds 25 USDC tokens and receives 20 GLW tokens. In the second exchange, a trader adds three times as many USDC tokens to receive just 50% more GLW tokens.

This effect is called "slippage", and it means that the final price of tokens for a trader is always worse than the initial price. The total amount of slippage experienced by a trader depends on the number of assets that get exchanged; as the size of the trade increases, the slippage gets worse.

All exchanges in a CPMM are reversible. In the final exchange, a trader adds 50 GLW tokens and receives 100 USDC tokens, effectively resetting the CPMM to its initial state.

Liquidity Mechanics of CPMMs

All of the assets in a CPMM come from liquidity providers, or LPs, who have deposited assets in to the CPMM. Once deposited, these assets are called "liquidity", and LPs are allowed to withdraw assets from the CPMM based on how much liquidity they have previously deposited.

The total amount of liquidity in a CPMM is measured by taking the square root of the asset product. When an LP deposits or withdraws assets, the amount of liquidity being added or removed can be tracked by measuring the change in the total amount of liquidity in the CPMM.

The square root of the asset product is used to track liquidity because it correctly tracks the value of the assets that have been provided as liquidity. As the value of assets change, the amount of liquidity that will be received per asset deposited will change accordingly.

To better illustrate the relationship between the asset product and liquidity, Glowswap literature prefers to use an alternative to the constant product rule called the CPMM Invariant:

```
quantity_asset_a * quantity_asset_b = quantity_liquidity^2
```

This equation has the same basic form as the constant product rule, except that `x` and `y` have been given more meaningful names, and `k` has been disambiguated to be the square of the quantity of liquidity. The two forms of the equation are interchangeable, however the CPMM Invariant is often more useful when reasoning about CPMMs mathematically.

The CPMM Invariant enforces that the asset product cannot change when traders are making exchanges with the liquidity pool, therefore the asset product only changes when liquidity providers are depositing or withdrawing assets.

Liquidity providers are able to deposit assets in any ratio, as demonstrated in the following set of examples:

Action	Result	USDC	GLW	Product	Liquidity
init	init	100	100	10,000	100
deposit 44 USDC	+20 liquidity	144	100	14,400	120
deposit 52 USDC	+20 liquidity	196	100	19,600	140
deposit 44 GLW	+28 liquidity	196	144	28,224	168
deposit 52 GLW	+28 liquidity	196	196	38,416	196
deposit 27 USDC, 27 GLW	+27 liquidity	223	223	49,729	223
deposit 27 USDC, 27 GLW	+27 liquidity	250	250	62,500	250

You can see from the set of actions above that depositing the same number of tokens does not always result in receiving the same amount of liquidity. As one asset becomes a greater portion of the asset product, each additional unit of that asset will produce less liquidity. This means that liquidity providers experience slippage in the same way that traders experience slippage.

If assets are added in the same proportion as they already exist in the CPMM, then no slippage occurs. You can see the effect in the final two examples of the table above.

When an LP adds liquidity to a CPMM, they are allowed to withdraw up to the same amount of liquidity later. And just as liquidity can be deposited using any amount of either asset, liquidity can also be withdrawn using any amount of either asset.

Action	Result	USDC	GLW	Product	Liquidity
init	init	250	250	62,500	250
withdraw 90 USDC	-50 liquidity	160	250	40,000	200
withdraw 70 USDC	-50 liquidity	90	250	22,500	150
withdraw 90 GLW	-30 liquidity	90	160	14,400	120
withdraw 70 GLW	-30 liquidity	90	90	8,100	90
withdraw 30 USDC, 30 GLW	-30 liquidity	60	60	3,600	60
withdraw 30 USDC, 30 GLW	-30 liquidity	30	30	900	30

You can see from the table above that as one asset becomes a smaller portion of the CPMM, it costs more liquidity to withdraw that asset, and vice-versa, meaning that liquidity withdrawals experience slippage just like liquidity deposits. Similarly, slippage can be avoided by withdrawing assets in a ratio that matches the asset ratio of the CPMM.

Market Driven Price Discovery

If any member of the public is allowed to exchange freely with a CPMM, the CPMM will naturally converge to the external market price of its underlying assets. This is because any member of the public will be able to arbitrage a price mismatch between the CPMM and the external market, earning profit for themselves while also making the CPMM price more accurate.

For example, let's say the external market price of a GLW token is 1 USDC token per GLW token, but the CPMM has a price of 4 USDC tokens per GLW token. A trader will be able to make money by purchasing GLW tokens from the external market for 1 USDC token each and then selling them to the CPMM for 4 USDC tokens each. This process will decrease the price of GLW tokens on the CPMM while generating profit for the trader, and can be repeated until the price of GLW tokens on the CPMM matches the external market price of GLW tokens:

Action	Result	USDC	GLW	Price	Profit
init	init	400	100	4.00	-
exchange 25 GLW	receive 80 USDC	320	125	2.56	55 USDC
exchange 35 GLW	receive 70 USDC	250	160	~1.56	35 USDC
exchange 40 GLW	receive 50 USDC	200	200	1.00	10 USDC

The first traders to purchase GLW on the external market and exchange them with the CPMM make a lot of money; the first trade averages a profit of 2.2 USDC tokens per GLW token sold to the CPMM. As more traders participate in the arbitrage, the price of GLW tokens on the CPMM gets closer to the market price of GLW tokens, and the amount of profit per GLW token decreases. In total, the traders make 100 USDC tokens in profit before the arbitrage opportunity is fully consumed.

Because arbitrage opportunities generate profit for traders, traders are incentivized to ensure that the price of tokens on a CPMM matches the price of the tokens on external markets. Therefore, as long as traders can easily and cheaply arbitrage a delta between the CPMM price and the external market price, the CPMM price of any asset pair will closely track the external market price.

Exponentially Decayed Geometric Average Price

Because public CPMMs have strong incentives to follow the external market price of its assets, they are often used as on-chain price oracles. Done incorrectly, this can be dangerous because CPMM prices are easy to manipulate for short periods of time.

Exponentially Decayed Average

A common strategy for mitigating possible price manipulation is to use an average price across a range of time, applying an exponential weighted decay so that more recent prices have a higher weight in the average. Doing this ensures that any attempts at price manipulation have to sustain an incorrect price for a long period of time.

The exponential decay needs to have a half life that is long enough to ensure that price manipulation is difficult, but short enough to ensure that the presented price is not substantially out of date.

The minimum safe half life is going to be highly ecosystem dependent, however for any ecosystem with a large number of automated traders, a half life of four hours should be more than sufficient to filter out any price manipulation attempts.

Geometric Average

As of writing, most price oracles use an arithmetic mean to establish the average price. In the context of CPMMs, this is inaccurate, because the arithmetic mean changes depending on which asset is being used as the reference asset.

For example, a CPMM that spends 30 minutes at a price of 4 USDC tokens per GLW token and 30 minutes at a price of 0.5 USDC tokens per GLW token will have an arithmetic mean USDC price of 2.25 USDC tokens per GLW token, which says that, on average, one GLW token was more valuable than one USDC token.

However, if you take the exact same price history and use GLW tokens as the reference asset, you get an arithmetic mean of 1.125 GLW tokens per USDC token, which says that, on average, one USDC token was more valuable than one GLW token:

Title	Interval 1	Interval 2	Arithmetic Mean	Inverse
USDC per GLW	4.000	0.500	2.250	~0.444
GLW per USDC	0.250	2.000	1.125	~0.888

When taking a geometric mean instead, you get no such inconsistency. In both cases, the average says that the USDC token is roughly 41% more valuable than the GLW token:

Title	Interval 1	Interval 2	Geometric Mean	Inverse
USDC per GLW	4.000	0.500	~1.414	~0.707
GLW per USDC	0.250	2.000	~0.707	~1.414

Therefore, at least when using CPMMs, a geometric mean makes more sense than an arithmetic mean for determining the average price of two assets.

Simple Implementation: Dividing Average Assets Per Liquidity

You can get the geometric mean in a simple way by tracking the arithmetic average number of USDC tokens per liquidity, which we'll call `arithmetic_usdc_avg` as well as the arithmetic average number of GLW tokens per liquidity in the CPMM, which we'll call `arithmetic_glw_avg`. The geometric average price is `arithmetic_usdc_avg / arithmetic_glw_avg`.

As a bonus, you can get the instability of the asset pair using the equation `sqrt(arithmetic_usdc_avg * arithmetic_glw_avg)`. The lowest possible value of this equation is 1, which implies that there have been no price movements at all. As the price moves around, the instability increases.

USDC per GLW	Interval 1	Interval 2	Geometric Mean	Instability
example 1	4.000	4.000	4.000	1.000
example 2	4.000	0.500	1.414	~2.276
example 2	4.000	0.250	1.000	2.500

Putting Everything Together

Putting all of the above together, a strong methodology for creating an on-chain CPMM price oracle is to track the arithmetic average quantity of each asset per liquidity in the CPMM using an exponential decay. Users of the price oracle can then use each of the values to compute the geometric average price of each asset.

The optimal half life to use in the exponential decay is highly dependent on the ecosystem and market conditions. Therefore, a price oracle can maximize its potential utility by tracking multiple averages, each with a different half life.

The Price of Liquidity

A CPMM is equivalent to a portfolio of assets that is continuously rebalancing itself. The Equal Value Theorem states that at all times, the CPMM maintains an equal relative value of both assets in its liquidity pool. You can see some examples in the following table:

Action	Result	USDC	GLW	Price	GLW Value in USDC
init	init	400	100	4.00	400
swap 25 GLW	get 80 USDC	320	125	2.56	320
swap 35 GLW	get 70 USDC	250	160	~1.56	250
swap 40 GLW	get 50 USDC	200	200	1.00	200

If the price of a GLW token increases, the CPMM effectively sells some of its GLW tokens to acquire more USDC tokens, rebalancing itself to maintain an equal value of each asset. Similarly, if the price of a GLW token decreases, the CPMM effectively buys more GLW tokens using its USDC, once again maintaining an equal value of each asset.

Because a CPMM is always shuffling assets around to maintain value equality, the price of 1 liquidity is dependent on both the price of the underlying assets as well as the equation that CPMMs use to maintain an equal value of each asset. The price of 1 liquidity in a CPMM can therefore be calculated using the Liquidity Price Equation:

```
price_liquidity = 2*sqrt(price_asset_a*price_asset_b)
```

When one of the assets is a stablecoin such as USDC, the equation can be simplified because the price of the stablecoin is always 1. Therefore, for the USDC and GLW asset pair, the price of 1 liquidity is:

```
2*sqrt(price_glw)
```

This means that the price of one liquidity increases as the price of a GLW token increases, and vice-versa.

CPMMs have a mathematical property called guaranteed loss, which means that in all cases where the relative asset prices change, the value of holding liquidity is strictly lower than the value of holding the underlying assets that originally composed the liquidity.

For example, at a price of 100 USDC tokens per GLW token, a CPMM will have 10 USDC tokens and 0.1 GLW tokens for each liquidity in the CPMM. A potential liquidity provider could therefore choose to hold 1 liquidity, or they could choose to hold 10 USDC tokens and 0.1 GLW tokens.

Guaranteed loss establishes that in the above example, holding 10 USDC tokens and 0.1 GLW tokens will always outperform holding 1 liquidity in the CPMM. You can see that in action in the following table:

GLW Price	Liquidity Value	Original Asset Value	Guaranteed Loss
100	20.0	20.0	0.0
400	40.0	50.0	-10.0
25	10.0	12.5	-2.5

If the GLW price quadruples, the value of holding one liquidity will increase from \$20 to \$40, however the value of holding 10 USDC tokens and 0.1 GLW tokens will increase from \$20 to \$50. Similarly, if the GLW price decreases to 1/4th, the value of holding one liquidity will decrease from \$20 to \$10, however the value of holding 10 USDC tokens and 0.1 GLW tokens will only decrease from \$20 to \$12.5.

This means that if LPs are not earning some type of yield or fee, they are strictly losing money by being LPs versus simply holding the underlying assets. Therefore, a CPMM will struggle to attract LPs unless it has a way to compensate for guaranteed loss.

Path Independence

The basic CPMM has a property called "path independence", which means that the value of an LP's assets can be determined by looking only at the current asset prices of CPMM, and it doesn't matter if the price has previously been significantly higher or significantly lower.

This means that if an LP experiences a large amount of guaranteed loss, they can potentially recover their funds by continuing to hold their liquidity until the price returns to its original value. The path independence of CPMMs ensures that if the asset prices recover, the value of the liquidity will also recover.

For this reason, guaranteed loss has historically been called "impermanent loss", because the loss would reverse if the price reversed. However, impermanent loss is a misleading term because - excluding yield - an LP will always strictly benefit by converting their liquidity to the underlying assets instead of holding liquidity.

The guaranteed loss of CPMMs is impermanent in the same way that losing money to a scammer is impermanent under the logic you will get another paycheck soon anyway. This paper therefore urges that the term "impermanent loss" should be retired and replaced with the term "guaranteed loss".

Adding Liquidity Borrowing to CPMMs

Traditional AMMs require two types of participants to function effectively: the liquidity provider and the trader. Glowswap extends this by adding a third type of participant: the liquidity borrower.

The Basic Borrowing Mechanic

Glowswap is a CPMM that allows anyone to borrow its liquidity. This means that the liquidity gets migrated from the public CPMM into a private CPMM that can only be used by the borrower. In Glowswap, the public CPMM is called the source CPMM and private CPMMs are called exclusive CPMMs.

A borrower is allowed to perform all of the standard actions on their exclusive CPMM. This includes exchanging assets, depositing liquidity, and withdrawing liquidity, but only as long as the borrower follows one unbreakable rule: the exclusive CPMM must always have at least as much liquidity in it as was originally borrowed.

Let's explore an example Glowswap instance where no borrowers have borrowed liquidity yet, and the source CPMM has 100 USDC tokens as well as 100 GLW tokens:

Name	USDC	GLW	Liquidity
source CPMM	100	100	100

The source CPMM supports all of the standard operations of a CPMM. That means anyone can become a liquidity provider by depositing liquidity, any existing liquidity providers can withdraw their liquidity, and any traders can exchange assets with the CPMM according to the CPMM Invariant.

The source CPMM also supports borrowing, which means anyone can migrate some amount of liquidity from the source CPMM to an exclusive CPMM. Here is an example where an exclusive CPMM is created by borrowing 10 liquidity:

Name	USDC	GLW	Liquidity
source CPMM	90	90	90
exclusive CPMM	10	10	10

The borrower is now able exchange assets with the exclusive CPMM, as well as deposit liquidity into the exclusive CPMM. At this point, the borrower is not able to withdraw any liquidity because doing so would bring the total liquidity below 10, and the exclusive CPMM is required to stay above 10 liquidity at all times.

The safety of Glowswap CPMMs depends on a property called the law of accumulating liquidity, which states that when any number of CPMMs of the same asset pair are combined, the resulting CPMM will have at least as much liquidity as the cumulative liquidity of the individual CPMMs. This means that as long as the exclusive CPMM maintains 10 liquidity, it will always be able to return at least 10 liquidity to the source CPMM, regardless of how asset prices change in either the source CPMM or the exclusive CPMM.

Turning Exclusive Liquidity into Guaranteed Gains

CPMMs have a property called guaranteed loss, which means that - in the absence of fees or yield - liquidity providers will always lose money by providing liquidity to a CPMM rather than keeping the underlying assets.

Exclusive CPMMs benefit from the opposite effect, which is called guaranteed gains. This is because, in contrast to the source CPMM, the exclusive CPMMs always retain the underlying assets until the borrower makes an exchange. Therefore, as the asset prices change in the source CPMM, the exclusive CPMMs maintain their original asset ratio and acquires arbitrage opportunities.

Let's explore an example using the exclusive CPMM that we created previously. If the GLW token price in the source CPMM quadruples, an arbitrage opportunity is created for the borrower:

Name	USDC	GLW	Liquidity	Price
source CPMM	180	45	90	4
exclusive CPMM	10	10	10	1
borrower	0	0	-	-

The source CPMM has a relative price of 4 USDC tokens per GLW token, and the exclusive CPMM has its original price of 1. The borrower can therefore buy GLW tokens from their exclusive CPMM for 1 USDC token each, and sell them for 4 USDC tokens each. In total, the borrower is able to trade roughly 3.4 GLW tokens from their exclusive CPMM for roughly 12.7 USDC tokens from the source CPMM, creating the following outcome:

Name	USDC	GLW	Liquidity	Price
source CPMM	~167.3	~48.4	90	~3.4
exclusive CPMM	~18.6	~5.4	10	~3.4
borrower gains	~2.1	~1.2	-	-

After the exchange, the borrower has managed to extract ~2.1 USDC tokens and ~1.2 GLW tokens for themselves, thus turning the guaranteed loss of the liquidity providers into guaranteed gains for the borrower.

Competition for Liquidity

Anyone can be a borrower, and dynamic of guaranteed gains and guaranteed loss ensures that borrowers always make money at the expense of LPs. Therefore, in the absence of any fees, all available liquidity would always be consumed by borrowers and no liquidity would ever be provided by LPs.

To balance things out, Glowswap sets an interest rate on liquidity. This gives LPs a yield and therefore a reason to provide liquidity, and it also creates an expense for borrowers. The interest rate is continually adjusted according to supply and demand.

Guaranteed gains is one strategy among many that borrowers can employ to make money from exclusive liquidity. Borrowers that are effective at turning exclusive liquidity into profit will be willing to pay an interest rate to gain access to that profit.

More skilled borrowers will be able to make more money, and therefore will be able to pay a higher interest rate. In a competitive market, the interest rate will be set by the most skilled borrowers, and that interest rate will price out all other borrowers.

In an efficient market, LPs will passively earn interest that is roughly equal in value to the amount of value that can be extracted by the most skilled borrowers, effectively allowing LPs to outsource the intelligence of portfolio management without needing to take any risks themselves, as a borrower that loses money will only lose their own money.

Interest Rate Mechanics

Borrowers pay interest continually as interest is accrued. This means that interest is not compounding, and therefore the interest rate for borrowers is measured using APR rather than APY. This also means that borrowers need to keep extra assets available to pay interest. If a borrower does not have enough assets available to pay interest, all borrowed liquidity is immediately returned to the source CPMM.

Interest is tracked and paid in terms of liquidity. For example, an exclusive CPMM that has borrowed 100 liquidity at an interest rate of 20% APR will need to pay 20 liquidity per year in interest.

Importantly, this value does not change as asset prices fluctuate. This means that even if the value of the assets decreases, the borrower will remain solvent because the value of the borrowed liquidity will decrease in tandem.

Borrowers maintain a reserve to pay interest by depositing extra assets into their exclusive CPMMs. For example, a borrower that has borrowed 100 liquidity might deposit an extra 5 USDC tokens and 5 GLW tokens, bringing the total liquidity up to 105. Glowswap can then extract interest for a while without pushing the exclusive CPMM below its minimum requirement of 100 liquidity.

The initially borrowed liquidity in an exclusive CPMM is referred to as borrowed liquidity, and the extra liquidity that is added to pay interest is referred to as interest liquidity.

Borrowers can deposit more assets into their exclusive CPMMs at any time, which means that a borrower can arbitrarily extend the lifetime of any borrowed liquidity, potentially keeping an exclusive CPMM alive for years while only ever keeping a few days worth of liquidity interest in the exclusive CPMM at any given time.

The interest rate adjusts dynamically based on supply and demand, which means that borrowers need to be somewhat attentive even if their exclusive CPMM has a large amount of interest liquidity.

Interest Payment Settings

When Glowswap collects interest from exclusive CPMMs, it extracts just enough assets to increase the total amount of liquidity in the source CPMM by the amount of interest that is owed. This often means that the exclusive CPMM is giving up less than 1 of its own liquidity per liquidity that is sent to the source CPMM.

For example, let's say the source CPMM has 100 USDC tokens and 100 GLW tokens, and the exclusive CPMM has 200 USDC tokens and 50 GLW tokens, and the source CPMM collects 1 liquidity of interest:

Name	USDC	GLW	Liquidity
source before	100.0	100.0	100.0
exclusive before	200.0	50.0	100.0
source after	~101.6	~100.4	101.0
exclusive after	~198.4	~49.6	~99.2

The exclusive CPMM paid interest in the form of 1.6 USDC tokens and 0.4 GLW tokens, which increased the source CPMM liquidity by 1, but only decreased the exclusive CPMM liquidity by 0.8. This is because the interest payment is taking advantage of price arbitrage between the two CPMMs.

Glowswap gives borrowers control over how interest is collected from their exclusive CPMMs. In the above example, Glowswap collected interest using the asset ratio of the exclusive CPMM, but borrowers can request that assets be paid to the source CPMM using any asset ratio.

Recommended Interest Settings

Glowswap operates in a byzantine environment, which means that asset prices are subject to manipulation. A potential malicious actor could manipulate the asset prices on the source CPMM to force the borrower to pay unfair quantities of interest if the borrower sets an exploitable asset ratio for their interest payments.

The two most exploitable asset ratios are 1:0 and 0:1, meaning that the borrower is electing to either always pay interest using entirely USDC tokens or they are electing to always pay interest using entirely GLW tokens. In both cases, the total amount of interest that the borrower has to pay approaches infinity as an attacker manipulates the price of the source CPMM.

The least exploitable asset ratio is the ratio that represents the fair market price of the assets. It is therefore strongly encouraged that borrowers select this ratio to pay their interest. Borrowers can update their interest ratio at any time to track the external market price, and borrowers can also configure their exclusive CPMM to pay interest using the EDGAP of the source CPMM.

Liquidation Protection

When the amount of liquidity in an exclusive CPMM falls below the amount of liquidity that was borrowed, the exclusive CPMM is immediately liquidated. However, Glowswap will make one final effort to preserve the exclusive CPMM by performing an arbitrage transaction.

If the relative asset price in the exclusive CPMM is different than the relative asset price of the source CPMM, the exclusive CPMM can increase its own liquidity by performing an arbitrage transaction with the source CPMM.

If an exclusive CPMM is about to be liquidated, Glowswap will automatically perform this transaction in an attempt to save the exclusive CPMM. Glowswap will perform the smallest possible arbitrage transaction that allows the exclusive CPMM to remain solvent.

This transaction will change the asset ratio of the exclusive CPMM, and potentially disrupt any strategy that the borrower is attempting to execute with their borrowed liquidity. This harm is still better than a full liquidation, but borrowers should strive to avoid needing liquidation protection.

The liquidation protection mechanic is not resistant to byzantine market manipulation, therefore it should be seen as a last resort rather than a standard practice.

Setting the Interest Rate

Glowswap adjusts the interest rate for borrowing liquidity based on supply and demand. Specifically, Glowswap sets a target of having 80% of the total liquidity borrowed at any point in time. If less than 80% of the liquidity has been borrowed, the interest rate will decrease, and if more than 80% of the liquidity has been borrowed, the interest rate will increase, allowing market forces to determine the optimal interest rate for liquidity.

Glowswap allows up to 99% of all provided liquidity to be borrowed at any given time. If a full 99% of liquidity has been borrowed, borrowers will not be able to create new exclusive CPMMs nor will they be able to borrow more liquidity into their existing CPMMs. Instead, they have to wait until more liquidity is available in the source CPMM.

The interest rate is adjusted on a continuous basis and it can be adjusted by up to 20% per day. For example, if the current interest rate is 10% APR and one day has passed since the previous update, the interest rate could be adjusted to any value between 8.3% and 12%. The maximum interest rate is 10,000% APR.

If the interest rate is below 0.5%, it will be adjusted by an absolute value of up to 0.1% per day. This allows the interest rate to recover quickly if it spends a long time at near-zero values. The minimum interest rate is 0.1% APR.

APR Attacks

An attacker can increase the interest rate by borrowing large amounts of liquidity for a short period of time. If any exclusive CPMMs are close to liquidation, this could potentially catch borrowers off guard and force an early liquidation.

Unless the interest rate is below 0.5%, it takes roughly 4 days to double the interest rate. This gives attentive borrowers a large amount of time to respond to APY attacks. It also gives liquidity providers time to add more liquidity to the source CPMM so they can benefit from the increased interest rates.

A long term APR attack is difficult to sustain, because more liquidity providers will show up to collect the interest while the interest rate rises, meaning the attacker has to pay higher and higher interest rates while borrowing larger and larger amounts of liquidity. The attack is nonetheless viable for a sufficiently motivated attacker, and therefore borrowers need to be aware the potential risk.

Limiting Exclusive CPMMs

When collecting interest, Glowswap needs to iterate over every exclusive CPMM each time that someone transacts with the source CPMM. To keep transaction costs under control, Glowswap targets having 20 exclusive CPMMs, only allows up to 40 total.

All exclusive CPMMs are required to pay a flat amount of interest to exist, independent of how much liquidity they have borrowed. This flat rate is called the slot fee, and it ensures that larger borrowers get priority access to exclusive CPMMs, as they will be able to amortize the slot fee better.

The slot fee is set according to supply and demand, increasing when there are more than 20 exclusive CPMMs, and decreasing when there are less than 20 exclusive CPMMs. Like the interest rate, the slot fee can adjust by up to 20% per day. The minimum slot fee is equal to the cost of borrowing 0.2% of all liquidity in the source CPMM, and there is no maximum.

To prevent attackers from monopolizing the exclusive CPMMs, even for a short time, an initialization fee is required to create an exclusive CPMM. The fee increases exponentially in the number of exclusive CPMMs that have been created.

If there are no exclusive CPMMs, a new exclusive CPMM will need to pay roughly 2 days worth of slot fees to be initialized. When there are 20 exclusive CPMMs, the 21st will need to pay exactly 30 days worth of slot fees to be initialized. And when there are already 39 exclusive CPMMs, the 40th and final exclusive CPMM will need to pay roughly 13 months worth of slot fees to be initialized.

All of the slot fees and initialization fees are distributed to the liquidity providers of the source CPMM, driving up their effective APY.

Liquidity Providers

Liquidity providers earn all of the interest that is paid by borrowers. The yield is continuously compounding, which means that it should be measured using APY. Furthermore, typically only 80% of the liquidity is being borrowed, therefore LPs often earn a materially different interest rate than what borrowers pay. Here's a quick table with some examples:

Borrower APR	LP APY
6.00%	4.92%
10.00%	8.33%
50.00%	49.18%
100.00%	122.55%

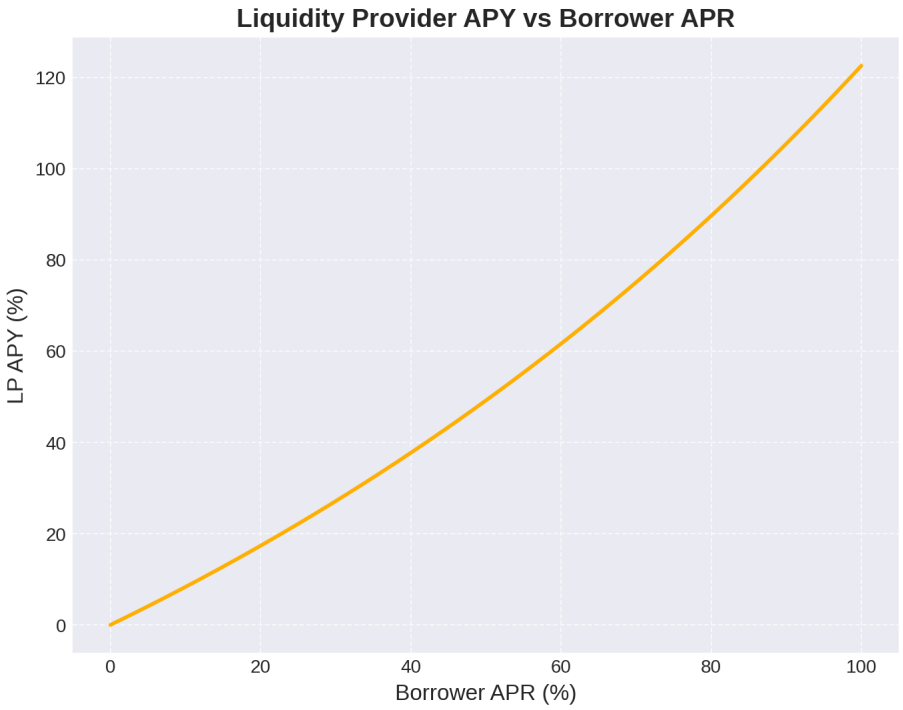

Figure 1: Borrower APR vs LP APY

Withdrawing Liquidity

One of the key advantages of Glowswap over traditional collateralized positions is that Glowswap never needs to liquidate borrowers due to price volatility. This makes it much safer for borrowers to take long term, high leverage positions. Glowswap also allows borrowers to extend their exclusive CPMMs at any time by adding more interest liquidity. This means that liquidity providers are not always able to withdraw their liquidity - existing borrowers get priority over withdrawal requests from LPs.

Despite these constraints, LPs will be able to withdraw liquidity without delay under most circumstances. This is because Glowswap targets having 80% of the liquidity borrowed, meaning 19% of the liquidity is available to be withdrawn immediately. However, if 99% of the deposited liquidity has been borrowed, then liquidity withdrawals will be put into a queue that gets processed as more liquidty becomes available.

Existing borrowers get priority over liquidity withdrawal requests, but liquidity withdrawal requests get priority over new borrowing requests. Therefore, as long there is a withdrawal queue, no borrowers will be able to create new exclusive CPMMs nor borrow more liquidity into existing CPMMs as all of the new liquidity will be used to process the withdrawal queue.

New liquidity can come from a handful of sources. It can come from new liquidity providers that are depositing assets into the source CPMM, it can come from borrowers that are returning liquidity or otherwise being liquidated, and it can come from interest payments that are being made by borrowers.

LPs do not earn interest while they wait in the withdrawal queue, which increases the APY of all other LPs, therefore also increasing the incentives to deposit liquidity. The interest rate itself will also be rising by 20% per day, even further increasing incentives for new liquidity to come in and help clear the withdrawal queue.

If there is any withdrawal queue at all, LPs earn >25% more APY versus when Glowswap is at equilbrium. If the withdrawal queue consists of more than half of all the liquidity, LPs earn >150% more APY versus when Glowswap is at equilibrium:

Borrower APR	LP APY	LP APY (small queue)	LP APY (>50% queue)
6.00%	4.92%	6.13%	>12%
10.00%	8.33%	10.45%	>21%
50.00%	49.18%	60.63%	>192%
100.00%	122.55%	169.15%	>624%

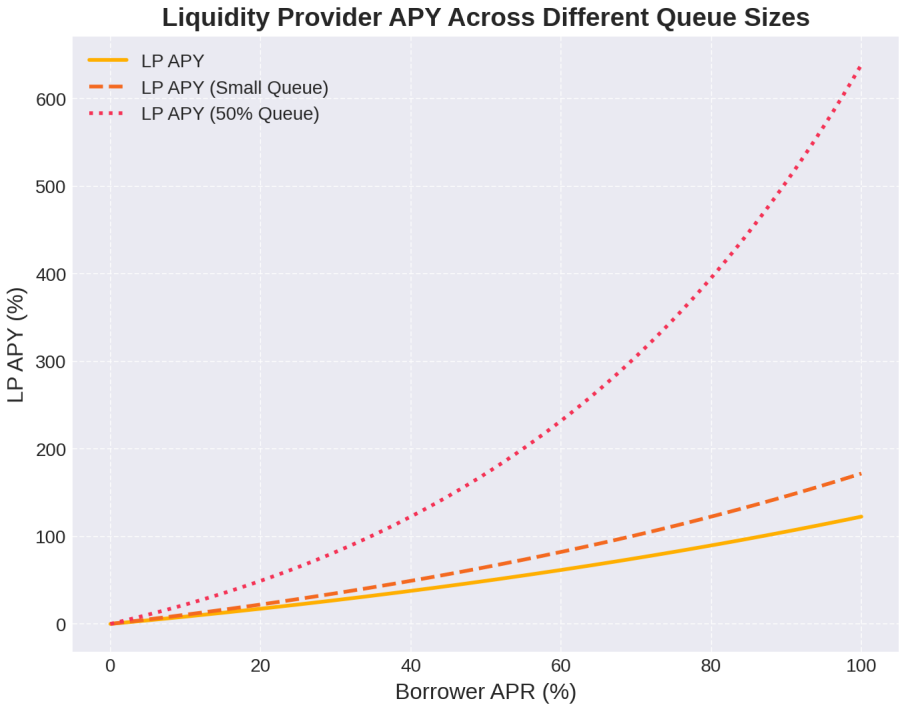

Figure 2: Borrower APR vs LP APY with Queues

Worst Case Liquidity Withdrawal

In the worst case, an LP will be trying to withdraw liquidity when the interest rate is 0.1%, all other liquidity providers have already submitted withdrawal transactions, borrowers are refusing to return liquidity, and no new liquidity providers are joining the source CPMM even though the APY is astronomical.

Even in this scenario, the LP will be able to withdraw their liquidity after no more than 57 days, because the interest rate will be high enough that the borrower's total interest paid will mathematically have to exceed the total liquidity that they borrowed.

If the interest rate starts at 5% APR instead of 0.1% APR, the LP will receive their liquidity within 40 days.

Example Borrower Strategies

Glowswap is closer to a platform than it is to a simple AMM, and many interesting use cases can be developed using exclusive CPMMs as a primitive. Individuals can use borrowed liquidity to execute rebalancing strategies, take leveraged positions in an asset, and perform collateralized borrowing.

Borrowers can also use Glowswap to create shared liquidity apps that take advantage of synergies between multiple users with different goals. Example apps include rebalanced AMMs and leverage aggregators.

High Leverage Rebalancing

If a borrower anticipates high volatility in the relative asset prices of the source CPMM, the borrower can profit by borrowing a large amount of liquidity and executing a rebalancing strategy.

For example, a borrower that is anticipating high volatility within the next 175 hours will want to borrow as much liquidity as possible. 175 hours is roughly 2% of a year, which means at 20% APR the borrower is going to need to provide about 0.4% of the borrowed assets as interest liquidity.

In other words, if the borrower has 10 USDC tokens and 10 GLW tokens, they can borrow 2500 liquidity and expect their interest collateral to last roughly 175 hours. The full setup looks like this:

Action	USDC	GLW	Liquidity
source init	50,000	50,000	50,000
borrow	2,500	2,500	2,500
source final	47,500	47,500	47,500
interest	10	10	10
exclusive	2,510	2,510	2,510

At a cost of just 10 USDC tokens and 10 GLW tokens, the borrower has acquired the ability to volatility trade using 2500 USDC tokens and 2500 GLW tokens for the next ~175 hours.

As the price of GLW changes, the borrower can choose to collect arbitrage by rebalancing their exclusive CPMM against the updated source CPMM. As the borrower collects arbitrage, the profits go into their exclusive CPMM, which effectively increases the amount of interest liquidity.

The borrower can choose between withdrawing the interest liquidity as profits, using the interest liquidity to extend the lifetime of their exclusive CPMM, or even choosing to keep the same lifetime by borrowing a larger amount of liquidity.

High Leverage Rebalancing Portfolio Analysis

If the borrower is using the above setup to execute a single arbitrage transaction immediately prior to liquidation, the value of the borrower's portfolio can be modeled with a simple equation. The portfolio is made up of these five components:

- 2500 USDC Tokens (in the exclusive CPMM)
- 2500 GLW Tokens (in the exclusive CPMM)
- 2500 Liquidity (borrowed from the source CPMM)
- 10 USDC Tokens (used to pay interest)
- 10 GLW Tokens (used to pay interest)

If we assume that USDC tokens are worth 1, then the value of liquidity is `2*sqrt(glw_price)`. If we assume that the source CPMM has infinite liquidity, the value of above portfolio matches the following equation:

```
2500 + 2500*glw_price - 2500*2*sqrt(glw_price) - 10 - 10*glw_price
```

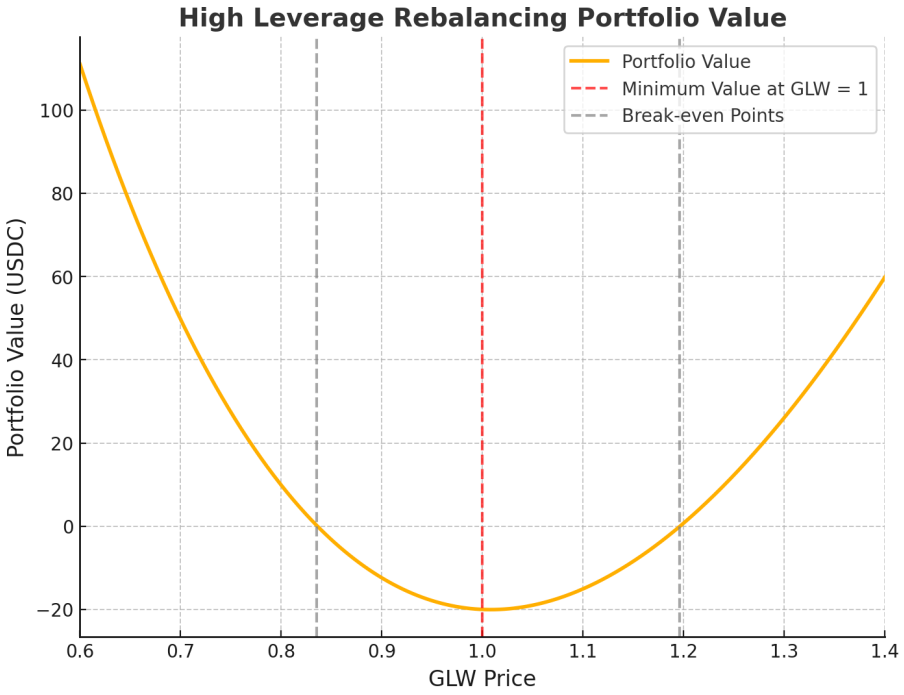

Figure 3: High Leverage Rebalancing Portfolio Value

The minimum value of this equation is -20 and occurs at a GLW price of 1. This means that the borrower, who is trying to make money on volatility, loses the most money if there is no change in price.

The portfolio has a negative value between the GLW prices of ~0.835 and ~1.196, which means that the price needs to swing about 20% total for the borrower to make money if they are only going to execute a single arbitrage transaction. The price swing will need to be larger if the borrower has enough size that they would experience meaningful slippage or cause meaningful price impact.

In most cases, a borrower will make more money by executing multiple arbitrage transactions rather than waiting to execute one transaction at the end, however those are more difficult to model.

High Leverage Asset Exposure

Interestingly, as the GLW price goes to infinity, the value of the portfolio above approaches `2490*glw_price`, which is equal to the trader taking a leveraged position with 124.5x leverage versus using the initial interest liquidity to buy 20 GLW tokens.

Even more interesting, this portfolio benefits from the property of path independence, which means that highly leveraged positions don't have to fear margin calls or other price based liquidations. Unlike traditional leverage, the borrower's position remains active even if the GLW price falls close to zero. This makes Glowswap based leverage significantly less risky than traditional leverage in many scenarios, especially scenarios where the borrower wants to make a long term, high leverage bet.

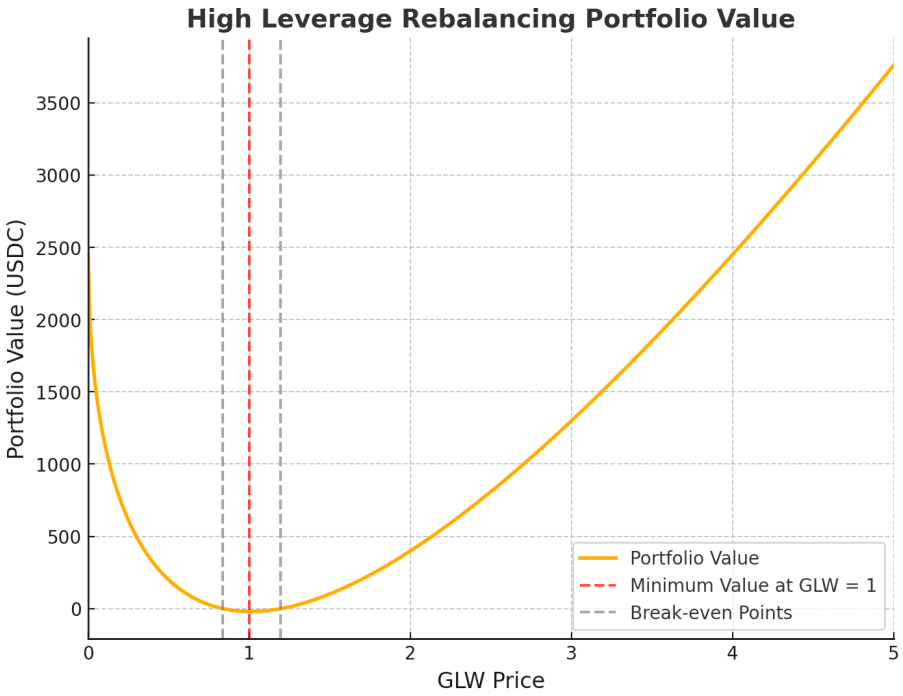

Figure 4: High Leverage Rebalancing Portfolio Value

Efficient Leveraged Asset Exposure

If the borrower is looking to take a highly leveraged bet like in the previous scenario, then simply borrowing a massive amount of liquidity and sitting on it will be roughly as capital efficient as the best currently known strategy.

However, if the borrower is looking for a more moderate amount of leverage, they can gain significant capital efficiency by using a different strategy. As a tradeoff, the borrower will have more downside exposure.

Let's explore an example with a borrower that has 100 GLW tokens, and wishes to get 3x leverage for six weeks. At 20% APR, the borrower can accomplish this by borrowing 130 liquidity and then setting aside ~3 liquidity to pay interest. Since the borrower only has GLW tokens, the borrower is going to need to sell ~3 GLW tokens to get ~3 USDC tokens for interest liquidity. The full set of required steps is outlined below:

Action	USDC	GLW	Liquidity
source init	50,000	50,000	50,000
borrower init	0	100	-
borrow	130	130	130
source 2	49,870	49,870	49,870
exchange GLW	~3	~3	0
source final	~49,867	~49,873	49,870
borrower 2	~3	~97	-
interest	~3	~3	~3
exclusive	~133	~133	~133
borrower	0	~94	-

After all of these actions, the borrower ends up with an exclusive CPMM that has 133 USDC tokens, 133 GLW tokens, and enough interest liquidity to last six weeks at 20% APR. The borrower also still has roughly 94 GLW tokens.

In the next step, the borrower takes their 94 GLW tokens and exchanges them with their exclusive CPMM. This will give the borrower ~78 USDC tokens, which the borrower will use to buy GLW tokens from the source CPMM. The borrower can then repeat the cycle, exchanging the GLW tokens with their exclusive CPMM to get more USDC tokens, and so on. After enough iterations, the Glowswap state will look something like this:

State	USDC	GLW	Liquidity
source	~49,941	~49,800	49,870
exclusive	~59	~300	~133
borrower	0	~0	-

In total, the borrower has put 300 GLW tokens into their portfolio, effectively obtaining 3x leverage while only needing to borrow 130 liquidity. The full portfolio for the borrower can be modeled with the following equation:

```
59 + 300*glw_price - 130*2*sqrt(glw_price) - 6*glw_price
```

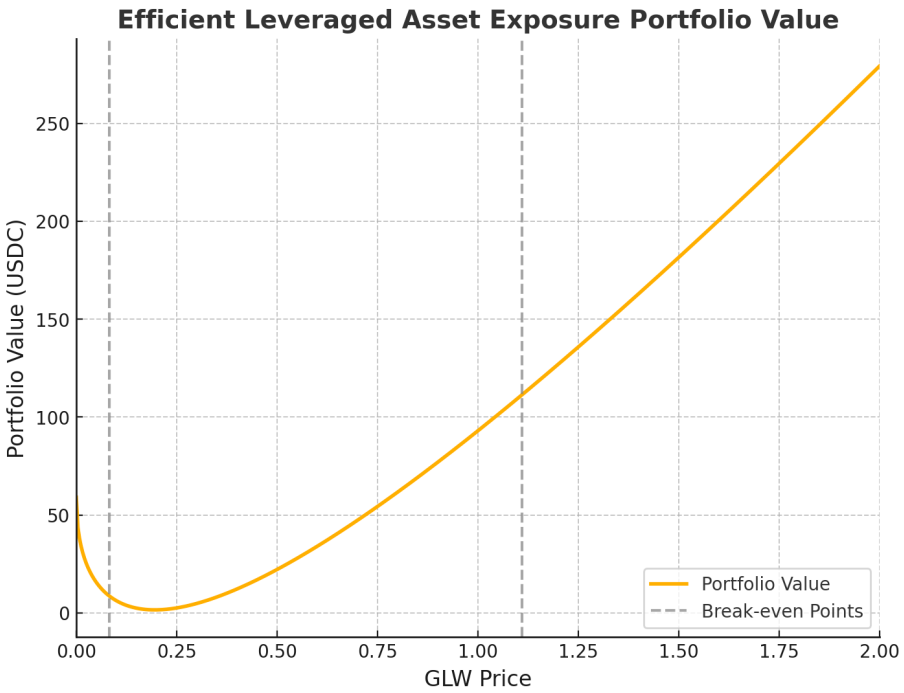

Figure 5: Efficient Leverage Portfolio Value

As the GLW price goes to infinity, this portfolio grows to a value of roughly `294*glw_price`, which means that the borrower has roughly 2.94x leverage versus just holding 100 GLW tokens.

This portfolio outperforms holding 100 GLW tokens for all GLW prices below ~0.083 and above ~1.11. This means that as long as the GLW price increases by more than 11% in the six weeks that the exclusive CPMM is open, the borrower will be able to withdraw more than 100 GLW tokens from their exclusive CPMM.

This portfolio asymptotically approaches 3x leverage, however for smaller price movements it will underperform a traditional 3x leverage trading strategy. Unlike traditional leverage however, there are no margin calls, which makes the strategy significantly safer for longer exposure periods. It also means the Glowswap version of leverage is immune to major events such as squeezes.

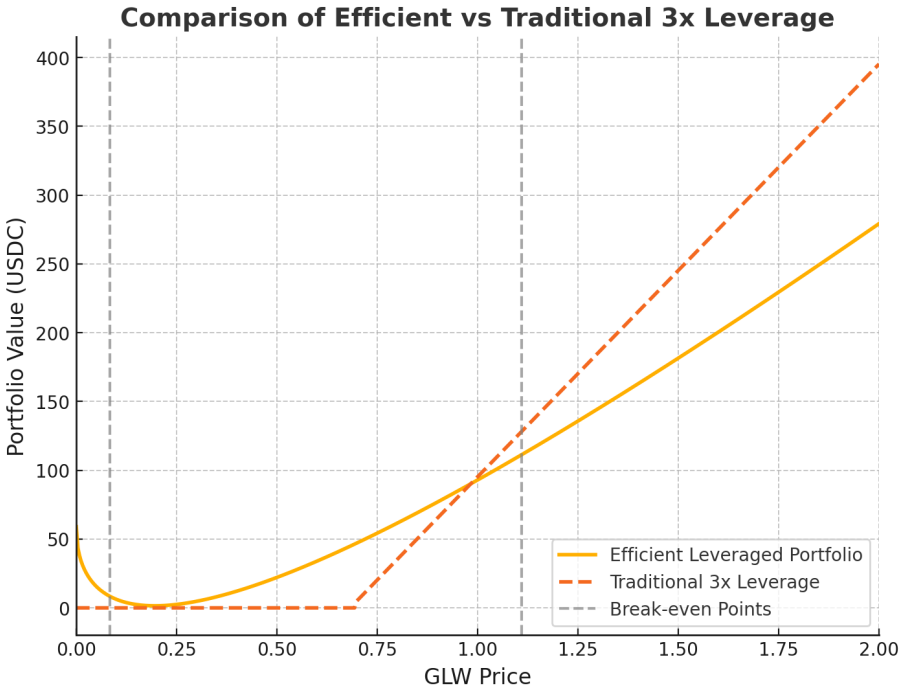

Figure 6: Efficient Leverage Portfolio Value

Similarity to Perpetuals

Leveraged asset positions on Glowswap closely resemble perpetual swaps without price based liquidation risk. The interest liquidity of Glowswap leverage is similar to the funding rate of perpetuals, and borrowers can arbitrarily extend the duration of their position by adding more interest liquidity.

In exchange for the elimination of price based liquidation risk and other downside protections, borrowers sacrifice some upside exposure, especially for more moderate price increases. Individual borrowers also need to borrow anywhere between 25% and 100% more assets to get the same leverage.

Both the reduced upside exposure and increased borrowing requirements can be mitigated or even eliminated by shared liquidity applications that pair the borrower with counterparties who are taking opposing positions.

Glowswap Collateralized Lending

A more complex use of borrowed liquidity is collateralized lending. This use case is particularly relevant to the Glow protocol, because Glow has a large number of solar installers that collect rewards in GLW tokens. These solar installers want to keep their GLW tokens, but they also require lots of cash to build more solar farms.

In traditional finance, the solar installers could make use of collateralized lending. This would allow them to give their GLW tokens to a lender as collateral and receive US dollars in exchange. They can get their GLW tokens back later by returning the US dollars with interest.

Much like traditional perpetuals, traditional collateralized lending has sharp edges. Borrowers are expected to provide collateral that has significantly higher value than the money they borrow, and if the value of the collateral drops at any point, the lender may choose to liquidate the borrower.

Glowswap offers a path independent alternative that allows borrowers to extract cash without needing to worry about getting liquidated if the GLW price drops. The setup works a lot like efficient leverage, except that instead of extracting USDC from the exclusive CPMM and using it to buy GLW tokens, the borrower extracts USDC from the exclusive CPMM and uses it to build solar farms.

Let's explore an example with a borrower that wants to take 100 GLW tokens and turn them into 60 USDC tokens via collateralized lending, keeping the exclusive CPMM open for six months. The setup has a few tricks:

Action	USDC	GLW	Liquidity
source init	50,000	50,000	50,000
borrower init	0	100	-
borrowed	~80	0	40
source final	~49,920	50,000	~49,960
interest	0	~24	4
exclusive	~80	~24	44
borrower	0	~76	-

When the borrower opens the exclusive CPMM, they only borrow USDC from the source CPMM. This is allowed as long as the borrower then adds enough of their own GLW tokens to bring the exclusive CPMM up to the minimum required liquidity. The borrower adds roughly 24 GLW tokens of their own, which brings the exclusive CPMM up to 44 liquidity. That's 40 liquidity to cover what was borrowed, plus 4 liquidity to cover 6 months of interest at 20% APR.

This leaves the borrower with 76 remaining GLW tokens that can be exchanged with the exclusive CPMM to extract USDC tokens. After the exchange, the Glowswap state looks like:

Action	USDC	GLW	Liquidity
source	~49,920	50,000	~49,960
exclusive	~20	100	44
borrower	~60	0	-

All 100 of the borrower's GLW tokens are tucked safely into the exclusive CPMM, and the borrower has been able to extract ~60 USDC tokens that they can now use to build solar farms. In six months, when the borrower has finished their solar project and recovered their $60, they can use that money to recover their GLW tokens.

Assuming that the borrower gets their full $60 back and 4 liquidity is collected as interest, the borrower's end state portfolio can be modeled with the following equation:

```
60+16+96*glw_price-40*2*sqrt(glw_price)
```

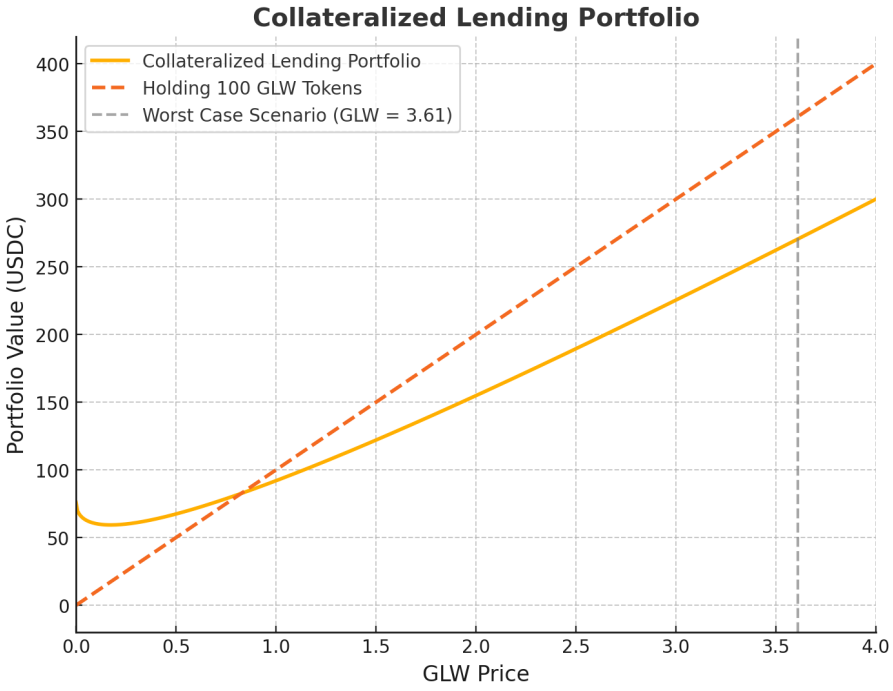

Figure 7: Collateralized Lending Portfolio Value

In the worst case, this collateralized lending portfolio has ~75% of the value of holding 100 GLW tokens, which happens at a GLW price of 3.61. This means that at worst, the borrower is giving up ~25% of their upside in exchange for receiving 60% of the value of their tokens in cash immediately.

Rebalanced AMMs

A classic problem with CPMMs is the problem of adverse selection. The price of assets is set by the previous trader, and the CPMM does not respond to changes in the external market price until someone executes an arbitrage transaction. This arbitrage transaction corrects the price of the AMM, but does so at the cost of extracting value from the AMM.

Glowswap enables a shared liquidity application called a rebalanced AMM, which automatically rebalances itself before every single exchange with a trader, ensuring that the AMM captures all of the arbitrage instead of the trader.

To build a rebalanced AMM, a borrower can borrow liquidity from the source CPMM and put it into their own exclusive CPMM. They can then wrap that exclusive CPMM with an API that can be called by the public. The API allows the public to transact with the exclusive CPMM.

The implementation of the API will always rebalance the exclusive CPMM with the source CPMM both immediately before and immediately after each transaction, ensuring that all arbitrage value accrues to the borrower. The borrower also has the full freedom to charge fees to the users of the API.

A more complex variation of rebalanced AMM can rebalance itself against an external market such as a centralized exchange before and after each transaction. The on-chain implementation is relatively simple: the API requires a signature from the borrower before it will accept a transaction from the public.

This forces the public to use an off-chain API provided by the borrower which will perform all of the transactions with centralized exchanges prior to authorizing any transactions on the rebalanced AMM.

Leverage Aggregators

The first high efficiency leverage example obtained 6 weeks of 3x leverage on 100 GLW tokens at 20% by borrowing roughly 130 liquidity. In other words, it was necessary to borrow 1.3 liquidity per initial GLW token.

If another borrower wanted to create a similar portfolio but with 1.5x leverage, they would have needed to borrow roughly 28 liquidity. If each borrower is acting fully independently, they need to borrow a combined ~157 liquidity.

However, if the borrowers had been working together, they would have been looking for a total exposure of 450 GLW tokens from a starting balance of 200 GLW tokens. To make this aggregated position work, they would have only needed to borrow ~152 liquidity, which would reduce interest payments and boost the overall returns for each portfolio. The savings are more significant if some of the counterparities are looking to take a leveraged short position on GLW tokens.

Leverage aggregators can also allow traders to create more nuanced portfolios. When building a solo portfolio, the portfolio value always has 3 terms: some amount of positive USDC exposure, some amount of positive GLW exposure, and some amount of negative liquidity exposure.

If the leverage aggregator can find counterparties that are willing to take exposure from the individual components of the borrowed portfolio, more pure positions can be created for traders.

The design space for leverage aggregators is quite large. If multiple positions are being merged together to save on interest, some algorithm has to determine how the savings will be divided. If portfolios are being split into multiple components, some algorithm has to determine the interest rate for each component.

Most importantly, if multiple positions are being merged together, some strategy needs to be in place to ensure safety in situations where one party wishes to exit their position and another party wishes to maintain their position. In the simplest scenario, the leverage aggregator can fix things by borrowing more liquidity and increasing interest rates for the remaining parties, however the source CPMM is not guaranteed to have liquidity available.

Conclusion

Glowswap is a new type of blockchain based AMM that improves upon predecessors by allowing borrowers to move liquidity into exclusive CPMMs, effectively fragmenting the liquidity.

This fragmentation allows borrowers to compete with each other by building creative products using their exclusive liquidity, while still keeping the bulk of the liquidity on one platform. The borrowers that can create the most value with their liquidity will be able to tolerate higher interest rates, which will allow them to take a larger percentage of the overall liquidity without having to convince any liquidity providers to migrate between platforms.

Much of the historic research on blockchain based exchanges has been focused on eliminating fragmentation. As it turns out however...

Fragmentation is all you need.