A Potential Solution for Bittensor Alpha Emission Issues

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With the launch of dTao in February 2025, the tokenomics of Bittensor were fundamentally changed. Every subnet, in addition to receiving tao emission every block, also receives alpha emission in two different forms:

alpha_in: emitted into the liquidity pool.	Maximum initial emission = 1α/block
alpha_out: emitted to holders: owners/miners/validators.	Maximum initial emission = 1α/block

The tokenomics of each alpha token is similar to that of tao: max of 21M tokens, and a similar halvening schedule. It is important to note that because alpha can potentially emit tokens at 2x the rate of tao, the halvening schedule of alpha is much faster compared to that of tao, and the last alpha will be emitted long before the last tao.

tao_in is emitted into each subnet's liquidity pool at a rate proportional to the price of the subnet:

$$tao_{in} = \frac{price_i}{\sum price}$$

This ensures that the sum of all tao_in across all subnets sums to one.

It is also critical to note that alpha_in must be emitted at a rate that keeps the price of the subnet constant.

$$alpha_{in} = \frac{tao_{in}}{price_i}$$

(N.B. There are scenarios where this formula might raise the value of alpha_in to a value greater than 1, but this is accounted for on chain through subsidy. While an important mechanism on the chain, we will omit this for simplicity and clarity).

alpha_out is the alpha token awarded to the participants of the subnet. Before halvenings are considered, 1 alpha_out is created every block.

With the fundamentals of tao_in, alpha_in and alpha_out, let's move to the first issue - what happens when there are tao halvenings and alpha halvenings.

Issue 1: The halvening

When tao and alpha halve, the tao and alpha emitted to each subnet also halve. The schedules for tao and alpha halvenings will be different (and each subnet will have different alpha halvening schedules.) Further:

- tao_in and alpha_in halve in accordance with tao halvenings.
- alpha_out halves in accordance with alpha halvenings.

Let's look at why:

Tao halvening

The tao_in equation can be modified to account for the tao halvening *k* as follows:

$$tao_{in} = \frac{price_i}{\sum price}\left(\frac{1}{2}\right)^k$$

At each tao halvening, the tao_in will drop by a factor of 2.

Alpha halvening

Subnet price is defined as the ratio of tao and alpha present in the liquidity pool (referred to as tao_in and alpha_in):

$$price_i = \frac{tao_{in}}{alpha_{in}}$$

Since the emission of tao_in and alpha_in cannot affect the alpha price of the subnet, the emission of alpha_in is also affected by the tao halvening:

$$alpha_{in} = \frac{tao_{in}}{price_i}\left(\frac{1}{2}\right)^k$$

To state in words: at the tao halvening, the tao_in to each subnet is reduced by 50%. In order for the price to remain constant, the amount of tao_in and alpha_in emitted to the liquidity pool must remain constant. Since tao_in drops by 50%, alpha_in must also drop by 50% at the tao halvening.

Here's another way of looking at it:

price	0.1
tao_in	0.1
alpha in	1
alpha out	1

At the first tao halvening:

price	0.1
tao_in	0.05
alpha in	0.5
alpha out	1

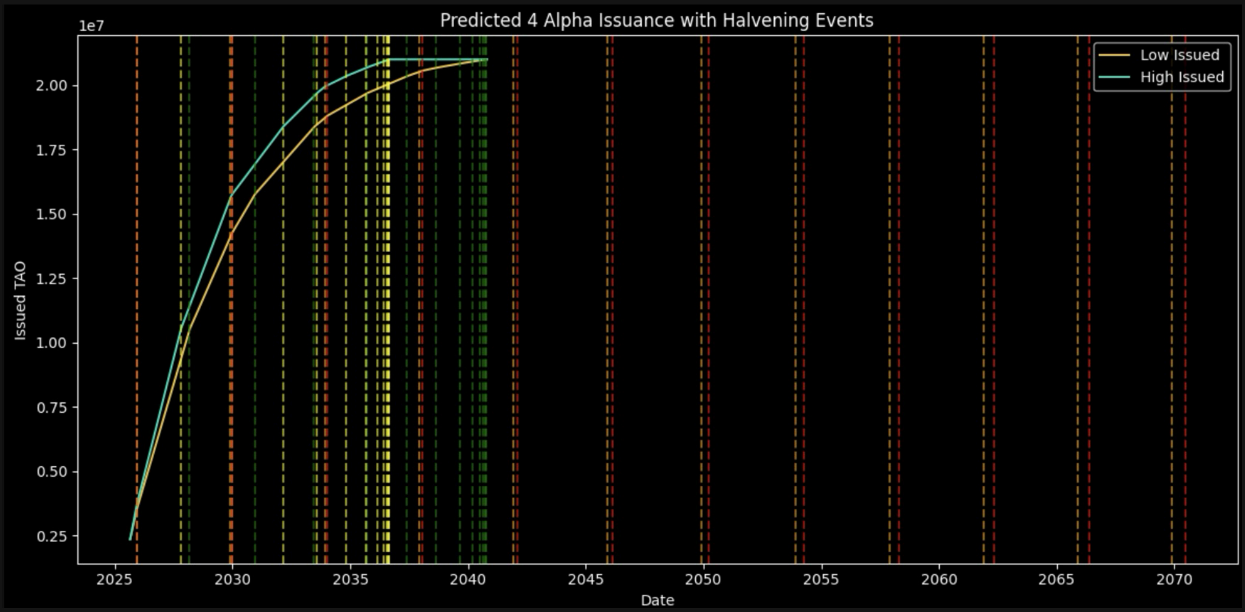
Both tao_in and alpha_ in drop by half. This ensures that that price is not changed by emission of tao and alpha into the liquidity pool., and the amount of tao_in across all subnets equals the total amount of tao emitted.

Alpha_out is controlled by the alpha halvening n:

$$alpha_{out} = \left(\frac{1}{2}\right)^n$$

The halvening issue:

This works well…for a few halvenings. But alpha, with its larger emission, begins to halve more and more frequently:



The red/orange dotted lines show predicted ranges of tao halvenings.
The green/yellow dotted lines show predicted ranges of alpha halvenings.

The last alpha halvening could be as soon as 2037.

For one of the original 64 dTao subnets (assuming no de-registrations) the halvening events could occur in the following order (yellow lines in the above figure):

List 1:

1. t1
2. a1
3. a2
4. t2

5. a3
6. a4
7. t3
8. a5
9. a6
10. a7
11. a8
12. a9
13. a10
14. a11
15. a12
16. t4

So why this acceleration of alpha halvenings? The problem is the rate of alpha_in emission. With alpha_in tied to the tao halvening, the emission of alpha is heavily weighted into the liquidity pool (with less alpha to stakeholders) as the halvenings accelerate.

To better notate multiple halvenings, I will use the notation (tk, an) where k is an integer denoting the tao halvening, and n is an integer for the alpha halvening..

Consider (t2, a2) - both halvenings are at 2. The subnet described above (price 0.1) has the following emissions:

price	0.1
tao_in	0.025
alpha in	0.25
alpha out	0.25

The next halvening is alpha halvening 3 (t2, a3):

price	0.1
tao_in	0.025
alpha in	0.25
alpha out	0.125

Then alpha halvening 4(t2, a4):

price	0.1
tao_in	0.025
alpha in	0.25
alpha out	0.0625

Since alpha_in is unaffected by the alpha halvening, the block emission of alpha is weighted more and more heavily towards alpha_in with each subsequent alpha halvening. Since alpha_in remains large, and the alpha emission between halvenings gets smaller and smaller, the alpha halvenings occur at a rapid cadence.

Further - alpha will hit 21M issued alpha towards the end of List 1. At (t4, a14):

price	0.1
tao_in	0.0062500
alpha in	0.0625000
alpha out	0.0000610

Every block - there is 0.06 alpha injected, exceeding the maximum alpha emitted. This is currently a bug on the chain.

Issue 2: Future Subnets have limited liquidity

Imagine a new subnet registering in the 2nd tao halvening (t2, a0):

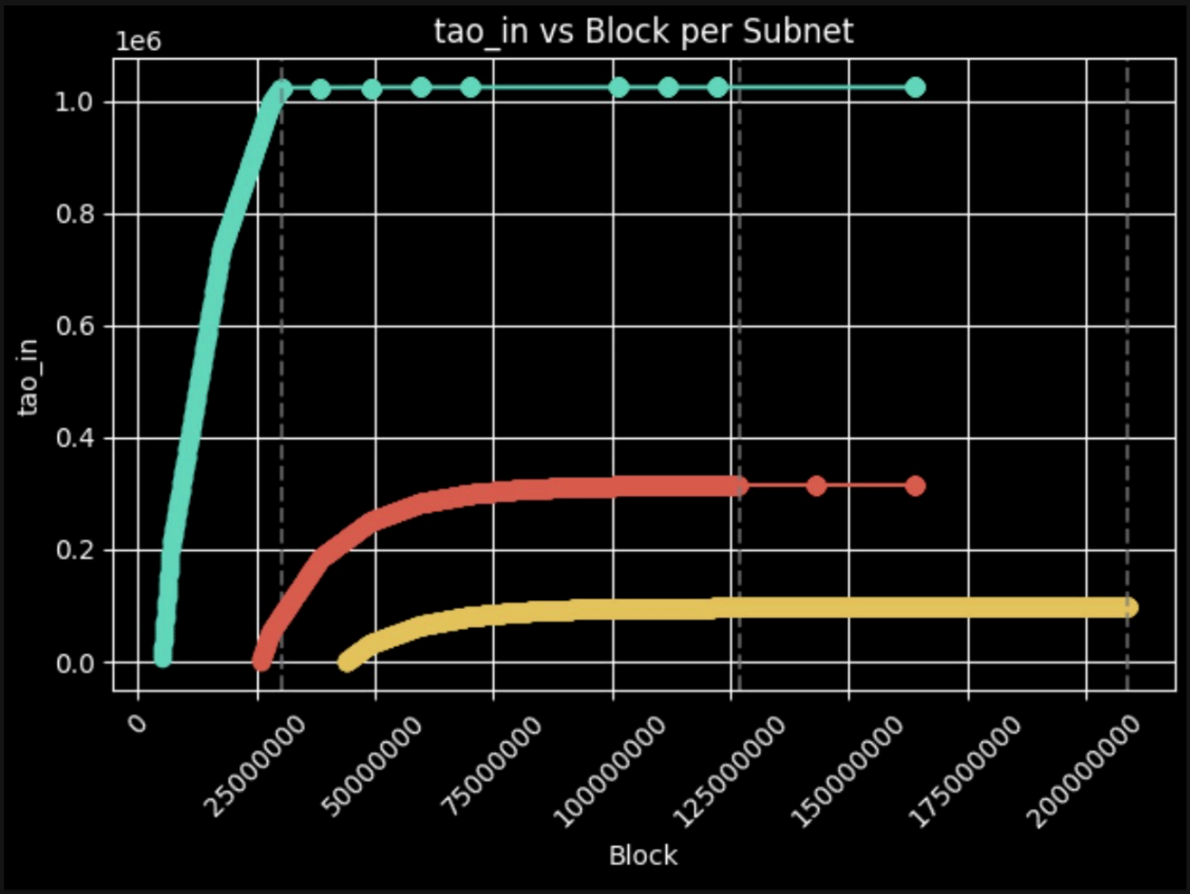
price	0.1
tao_in	0.025
alpha in	0.25
alpha out	1

This subnet will have VERY low liquidity in the subnet pool, making it very difficult for miners, validators and the SN owner to exchange alpha for tao (and eventually other tokens or currencies).

Visualising the issues:

The following chart shows 3 subnets:

- OG_subnet: subnet that existed at dTao launch (teal)
- 2nd_halvening: a subnet started in the 2nd tao halvening (red)
- 4th halvening: a subnet started in te 4th tao halvening (yellow)



The OG subnet suffers from the chain reaction issue (Issue 1), and the last alpha is emitted in just 9 years (approximate date is October 4, 2034).

The later subnets display the issue with lower volume liquidity pools. The liquidity in the pools are 75% to 90% lower than that of an OG subnet.

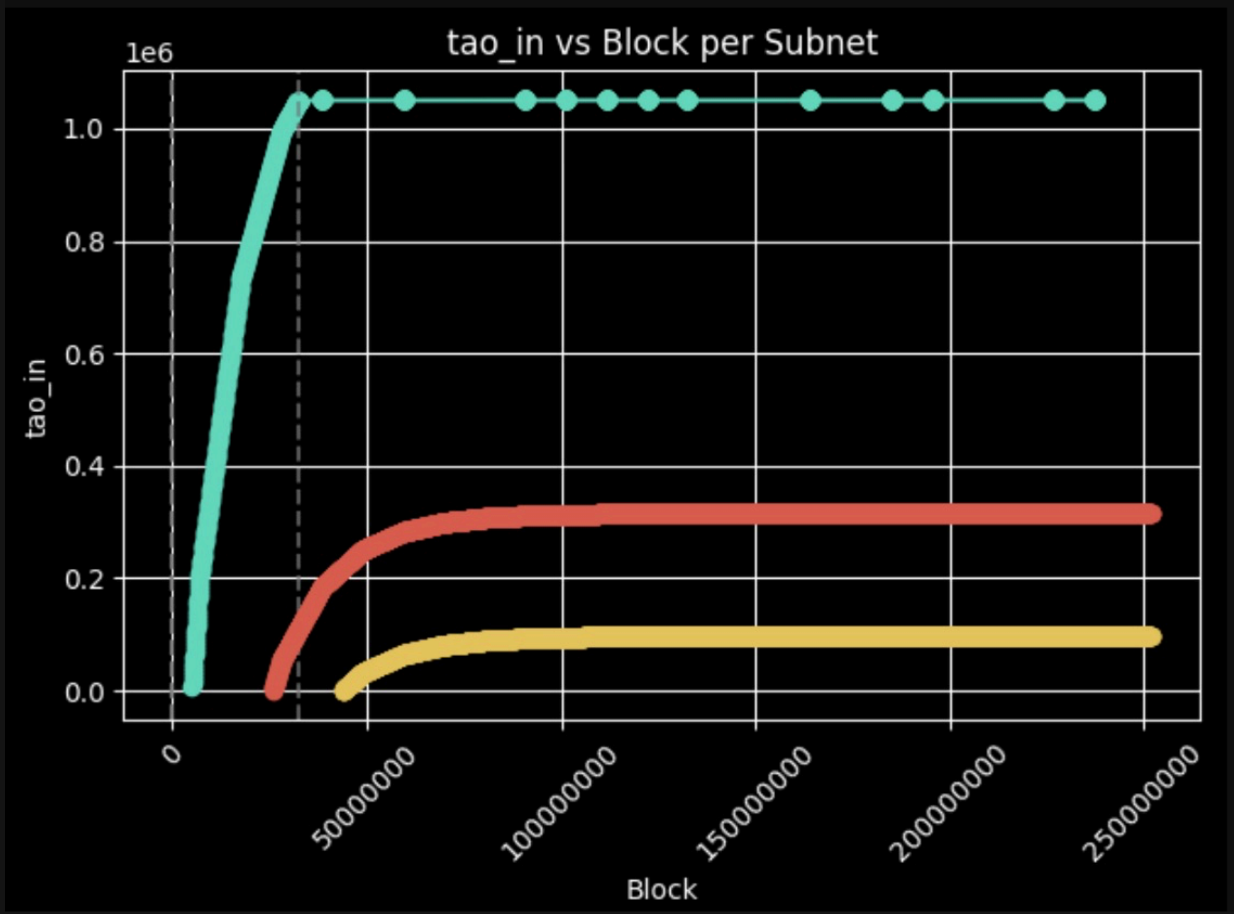
Proposed solution: Sync alpha halvenings with tao halvenings

Maciej Kula has proposed to eliminate the alpha halvening schedule, and have alpha halve with tao. By reducing alpha_out at the tao halvening, the emission of alpha_out is reduced - slowing the emission of alpha overall.

There are a few issues that arise:

- The first tao halvening is in December 2025. Halving alpha_out in ~2 months (rather than ~2 years) from the time of this writing will have a profound impact on profitability for miners and validators.
    - Loss of miners may lead to loss of competitiveness inside subnets, slowing innovation.
    - Validator teams will lose a large percentage of income.
- The issue of alpha acceleration is not solved.

Let's look at point 2. As described in Issue 1 above, the acceleration of alpha emission is fueled by alpha_in. Lowering alpha_out slows alpha emission, but not at the source of the issue.



The charts are not fundamentally changed. The OG subnet gains about 9 additional months of emission (last alpha on July 21, 2035).

Our Proposed Solution:

Attacking the problem: alpha_in

As noted above, the rapid acceleration of alpha halvenings is driven by alpha_in remaining high. Any solution to the issue must address the rate at which alpha_in is emitted into liquidity pools.

With that in mind, I propose changes to the way that alpha_in and tao_in are emitted. The changes will take place alpha halvening:tao_halvening ratio for s subnet changes.

I propose three possible scenarios for this ratio:

alpha halvening > tao_halvening

This scenario will only happen with “old subnets” that have survived through multiple tao halvenings. As shown in List 1, this begins after a subnet has survived 2 or more tao_halvenings. Let’s call these OG subnets.

As List 1 describes, the alpha halvening acceleration occurs in the 2nd and 3rd tao halvening for the OG subnets. For subnets that have survived 2-3 tao halvenings (5-8 years), the emissions into the subnet pool will change.

Here’s an example for an OG subnet at (t2, a3) and (t2,a4) with the current emission schedule:

price	0.1
tao_in	0.025
alpha in	0.25
alpha out	0.125

price	0.1
tao_in	0.025
alpha in	0.25
alpha out	0.0625

Alpha_out - the rewards for participants of the network continues to plummet, potentially causing profitability issues for miners, validators and the subnet owner.

But alpha_in keeps on trucking at a high value - pushing the total alpha emitted higher, and accelerating the alpha halvenings, while providing minimal benefit for the subnet (after 2 halvenings, there will be a large quantity of tao and alpha in the liquidity pool)

When the alpha halvening is larger than the tao halvening, we can re-adjust the emission of tao_in and alpha_in to use the alpha_halvening k instead of the tao_halvening n:

$$tao_{in} = \frac{price_i}{\sum price}\left(\frac{1}{2}\right)^k$$

$$alpha_{in} = \frac{tao_{in}}{price_i}\left(\frac{1}{2}\right)^k$$

Let's try the proposed equations at the same timeframe (t2, a3) and (t2,a4):

price	0.1
tao_in	0.0125
alpha in	0.125
alpha out	0.125

price	0.1
tao_in	0.00625
alpha in	0.0625
alpha out	0.0625

Alpha_in is drastically reduced in both scenarios, slowing the chain-reaction push of alpha emission to accelerate the alpha halvenings.

Comparing the two scenarios, it is important to note that tao_in is also greatly reduced in the new scenario.

- These are OG subnets. For a subnet launched at dtao, by the time they reach their 3rd or 4th alpha halvening, they will already have a significant amount of tao in their pool. Liquidity is not a *huge* concern for a subnet in this situation.

- A subnet with a price of 0.1 **could** have 0.025 tao emitted (using today's emission rules). But the examples above show 0.0125 and 0.00625.
- **This difference in tao_emission is stored as *excess_tao*, and distributed to other, newer, subnets. There is no change to tao emission - and no change to the tao halvening schedule.**

This can be used to resolve the issue on chain where alpha_in continues to be emitted after the 21M max supply of alpha has already been emitted.

alpha halvening == tao_halvening

There is no change in emission for subnets that have equal halvenings. These subnets may have been around a while, but not long enough to remove *excess_tao* from their liquidity pools.

alpha halvening < tao_halvening

As Bittensor continues past the first tao halvening later this year, new subnets will continue to be registered. As noted earlier, these subnets will have issues with low liquidity in the subnet pools due to very low tao_in and alpha_in emission rates. This issue increases with each subsequent tao halvening.

Here we propose to distribute the *excess_tao* described above (collected from OG subnets) to these subnets with critically low liquidity.

In this paper, we will discuss 3 distribution methods:

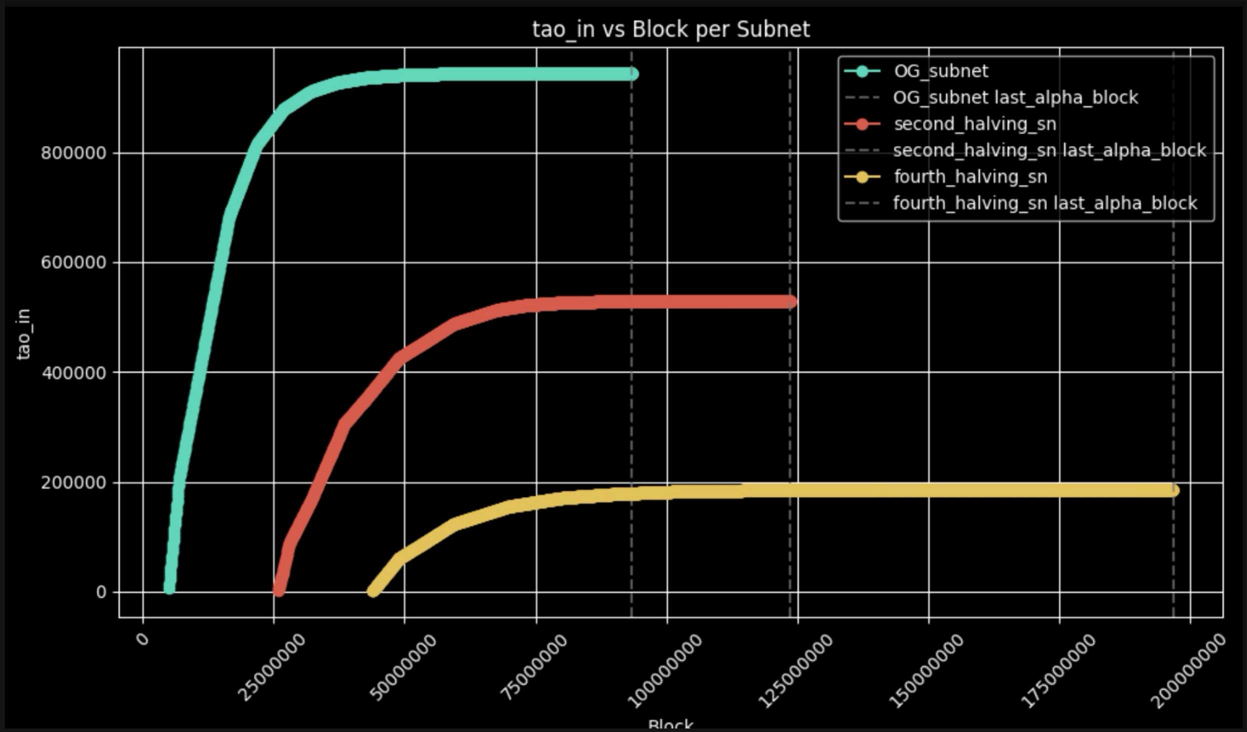
Excess_tao scenario 1:

Equal distribution to all subnets in this where the tao halvening count > alpha halvening count.

As a result:

Liquidity improves drastically for all three subnets:
OG subnet's tao_in drops from over 1M tao to less than 1M tao.
2nd halvening subnet: tao_in liquidity jumps from ~300k to ~500k.
4th halvening subnet: tao_in liquidity from ~100k to ~200k.

Alpha emission DRASTICALLy slows:
OG subnet: last alpha emits in 2058 (extending alpha emission by 24 years)
2nd halvening subnet: last alpha emits in 2070
4th halvening subnet: last alpha emits in 2098



This very simple reduction of tao_in and alpha_in for OG subnets with high alpha_halvenings successfully slows the alpha halvening schedule. By reducing alpha_in at the same rate as alpha_out, subnet participants are not penalized for participating in a late stage subnet.

A simple redistribution of the *excess_tao* from older subnets to newer subnets successfully solves two flows in the dTao mechanism: slowing the chain reaction of alpha_halvenings and increasing liquidity for subnets that are formed after multiple tao halvenings.

Excess_tao scenario 2:

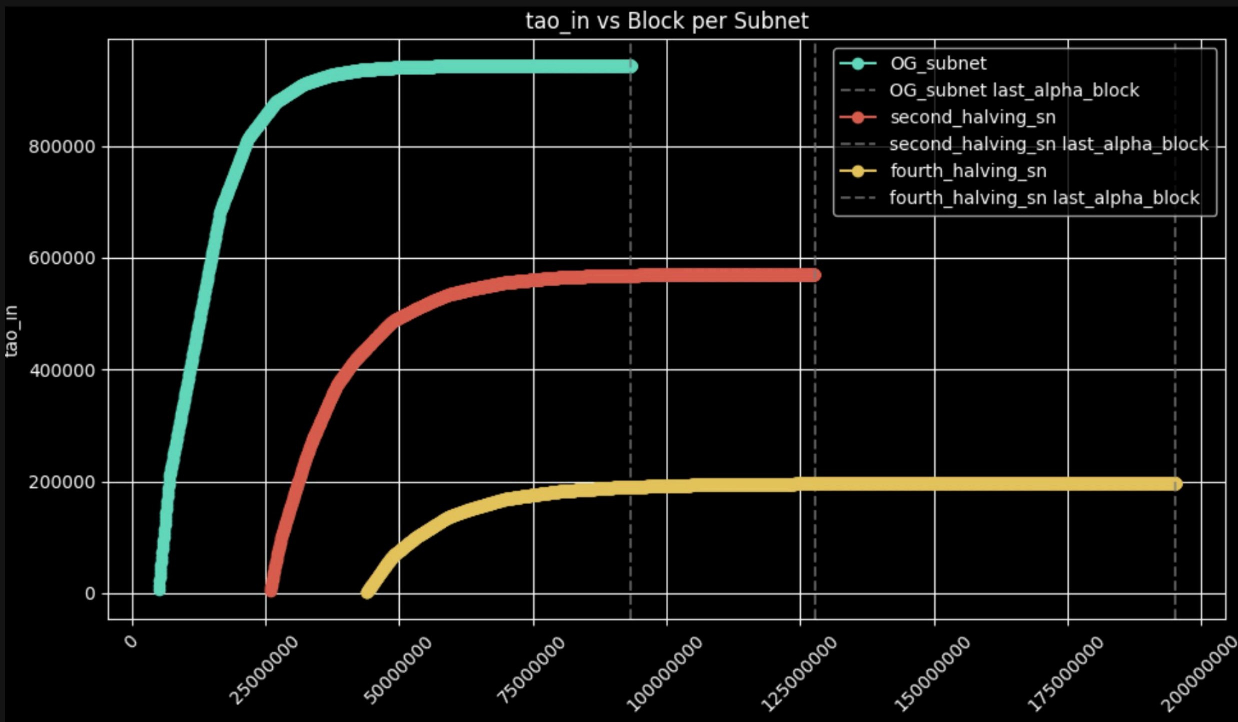
Based on the success of scenario 1, a simple 1:1 distribution to all subnets that "fit the bill," let's attempt to better shape the distribution of excess tao.

In the scenario where there are new subnets that require liquidity, each will have different (t,a) halvenings, and the liquidity problem is greater for "newer" subnets over older ones. In these cases the

Halving_difference = tao_halvening - alpha_halvening

For example (t3, a0) has a larger difference than (t3,a1).

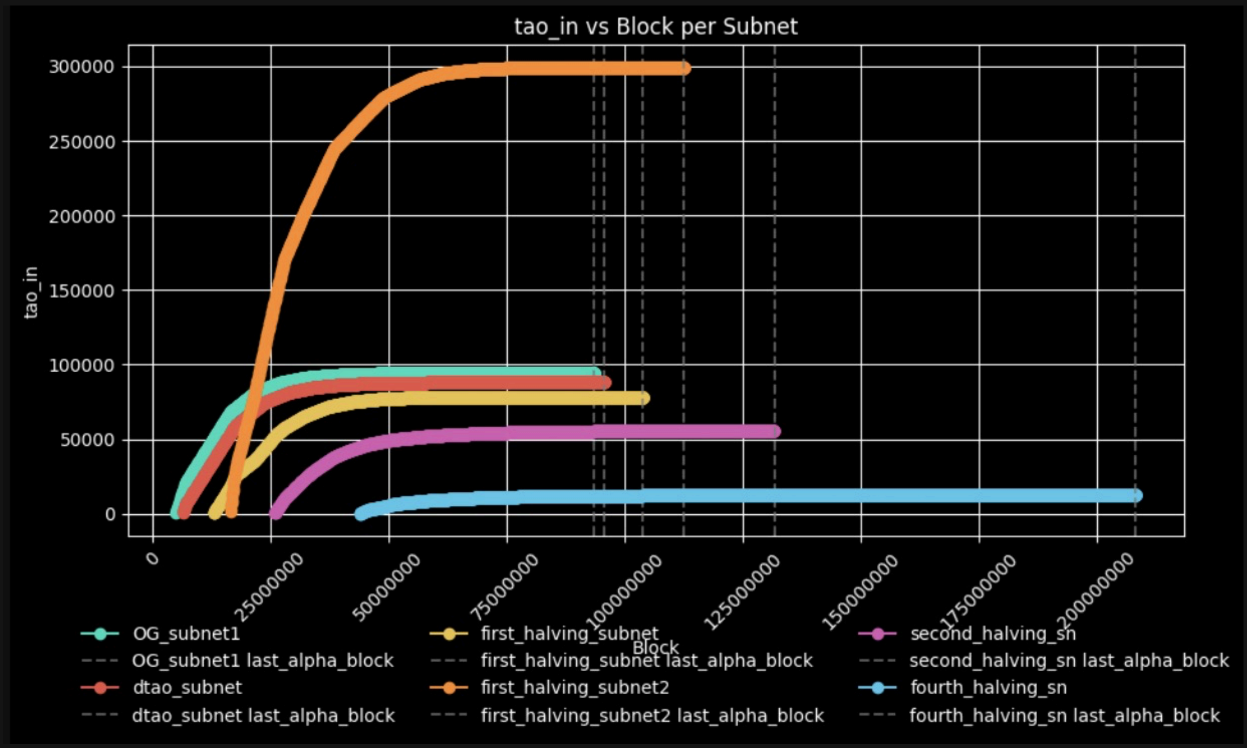
In our simplified example with 3 subnets, the needle does not move a lot (shown with all prices at 0.01 instead of 0.1 - the chart appearance is the same):



I would expect this to fit better with more subnets and greater/varied amounts of excess.

Different prices

When all prices are similar, the described approach works. Here is the chart for scenario 2 where all the prices are ~0.01, but a subnet started in halvening 1 has a price of 0.05 (the orange line).

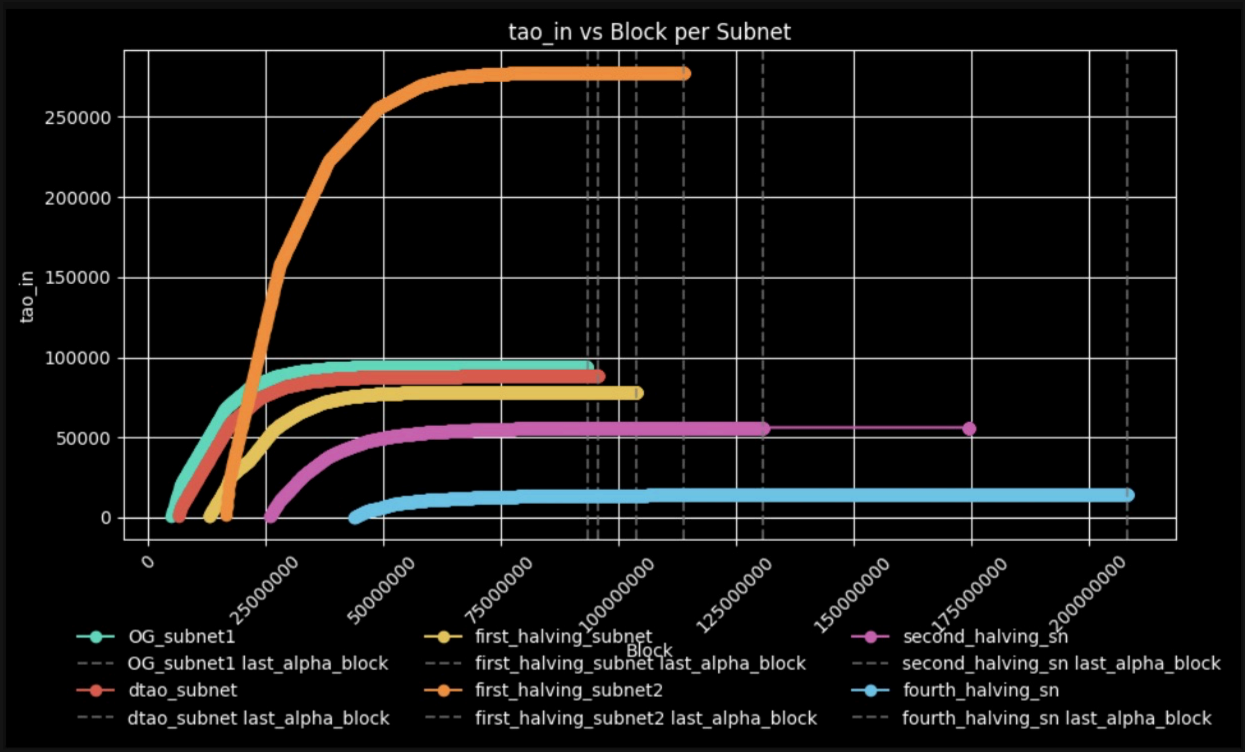


The orange line subnet has reached success on its own, yet is still receiving the excess from the proposed mechanism.

The orange subnet has occasion where its alpha halvening < tao halvening, and is eligible for a subsidy. But, seeing as the subnet is more successful than several of its OG subnet counterparts, it does not **require** such subsidy.

Adding a price cap for subsidy removes the subsidy on the orange subnet.

In the example below, the price cap is the average price of subnets providing the subsidy. This lowers that tao_in of the orange subnet by ~20,000 tao (~300k to ~280k):



The excess distribution has great potential for redistributing tao_in away from OG subnets (that are facing runaway alpha halvenings due to a high value of alpha in) to newer subnets with low liquidity.

Clearly there are optimizations and tests to be performed to optimize the redistribution of excess_tao, but this paper has outlined the potential of this procedure to alleviate two critical alpha emission issues.

Excess tao scenario 3:

If redistributing liquidity is a “no go” on chain, the excess toa could be subsidized. The current tao subsidy uses the tao to buy alpha, and then the alpha is burned. This would lead to a very small increase in alpha price for the subnet - which has not been studied in this article.

Next steps

The proposed solution to decelerate alpha emission has been proposed for OG subnets. By changing the emission into the pool of both alpha_in and tao_in when the alpha_halvening count is greater than the tao_halvening count, we have shown that we can successfully slow the emission of alpha, and actually extend the emission lifetime of the oldest subnets in the

Bittensor network. This process of alleviating alpha_in emission generates excess tao, which is redistributed to newer subnets.

The generation of excess_tao allows us to solve an issue that arises on late forming subnets (where alpha_halvening << tao_halvening). excess_tao that collected from the older subnets due to the alpha_in/tao_in limiting can be distributed to the newer subnets - thereby increasing liquidity in the subnet pools for these subnets.

We have shown a few possible mechanisms for the tao redistribution to the newer subnets:

- straight ratio
- ratio based on the tao_halvening-alpha_halvening difference
- Modifiers to reduce excess_tao distribution to new subnets that have found success.

Another advantage of this method is time.

The proposed syncing of tao and alpha halvenings would need to be in place before the first tao halvening (December 2025). The solution proposed in this paper must be in place on chain prior to ~July 2029 - the approximate time when the first excess_tao payment will be made. This gives the teams involved time to work through the exact rules around redistribution of excess_tao to newer subnets without the feeling of being rushed by looming events on chain - and potentially making changes that create further issues down the line.

In conclusion - adapting emission into the pool for subnets with alpha_halvening > tao_halvening appears to solve two critical issues: the chain reaction alpha halvening of older subnets, and the low subnet liquidity that will occur in newer (post 2nd tao halvening) subnets.