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Subspace x BlockScience: Parameter Selection Workshop

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May 16th, 2024

Today's Agenda

- Hello from BlockScience
- BlockScience x Subspace Collaboration
- Subspace cadCAD Model & Documentation walkthrough
- 'Parameter Selection Under Uncertainty' Deep Dive
- Q&A

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Hellos From BlockScience!

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BlockScience is an Engineering Firm

"The mission of BlockScience is to bridge the digital and physical worlds through innovative and sustainable engineering. We guide the development and governance of safe, ethical, and resilient socio-technical systems, leveraging emerging technologies to solve complex problems"

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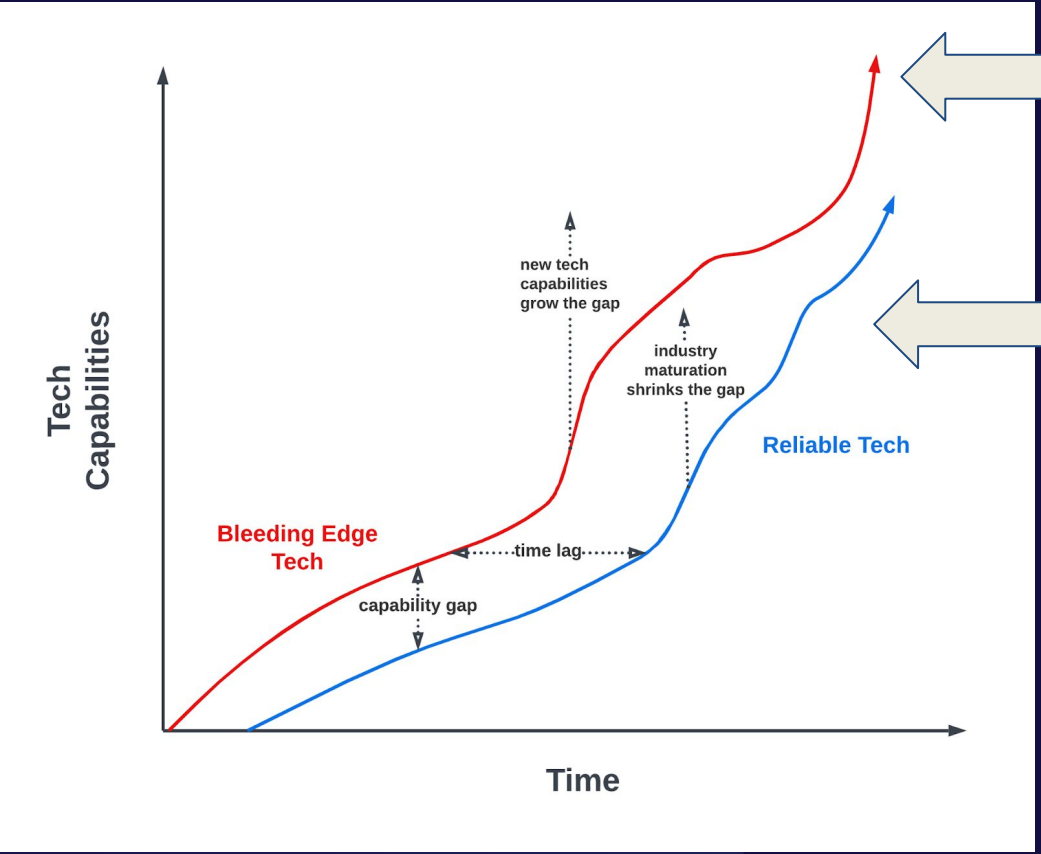
Source: https://blog.block.science/the-animating-purpose-of-blockscience/

BlockScience is an Engineering Firm



Advancing technical capabilities (eg Blockchains and AI)

Putting those technical capabilities into practice in stable and productive ways

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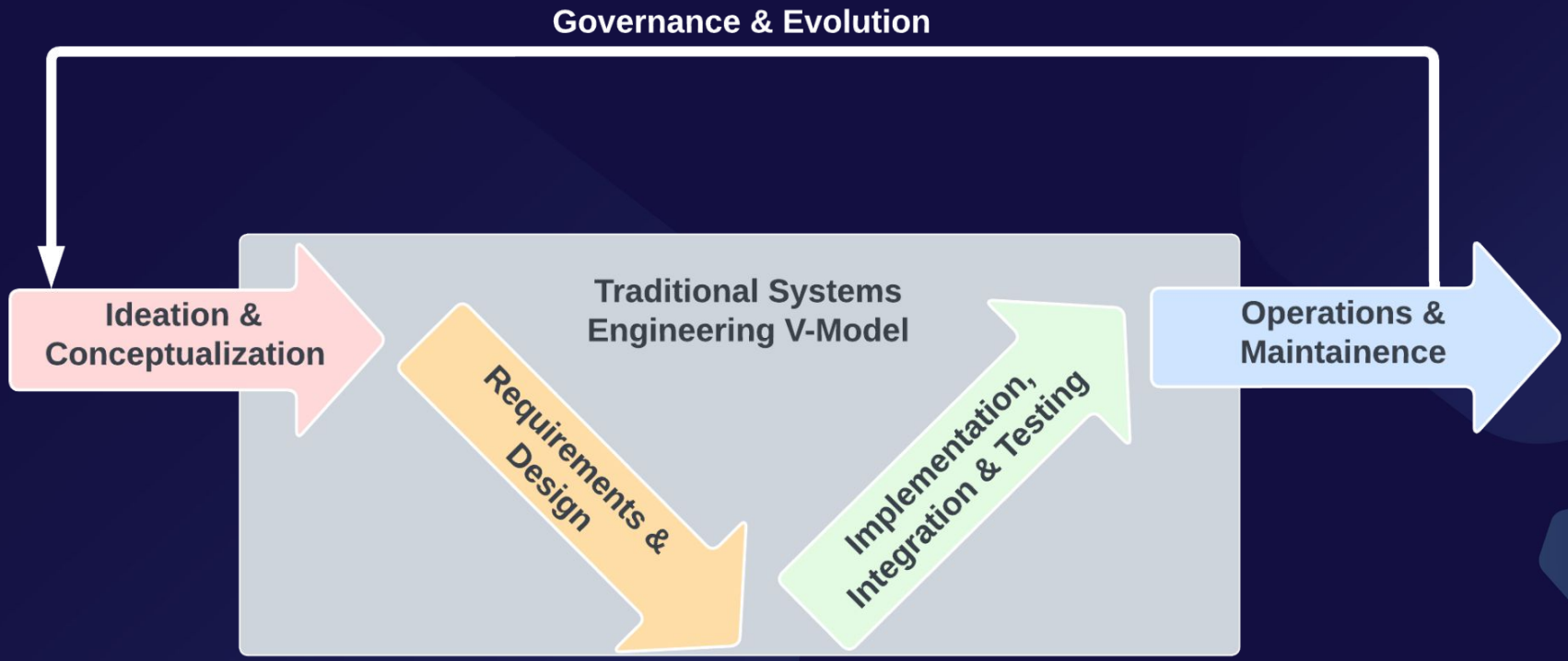
Engineering Lifecycle helps manage complexity over time



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Source: https://blog.block.science/block-by-block-managing-complexity-with-model-based-systems-engineering/

BlockScience x Subspace Collaboration

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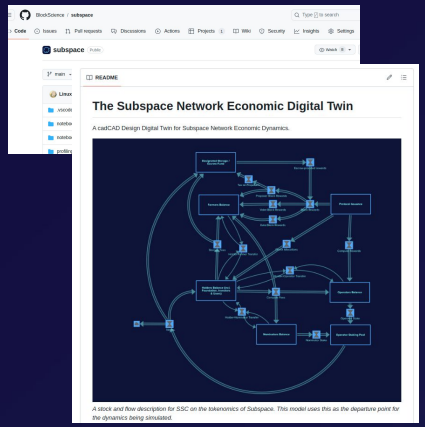
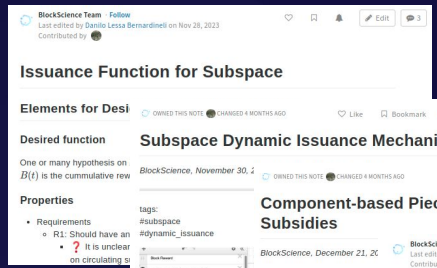
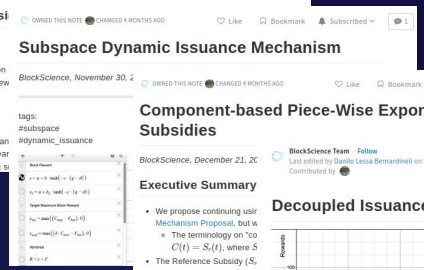
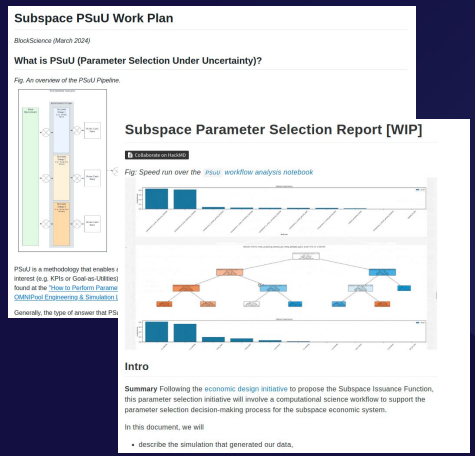
BlockScience x Subspace: Collaboration Timeline & Artifacts

Sep ’23 — Nov ’23 — Feb ’24 — April ’24

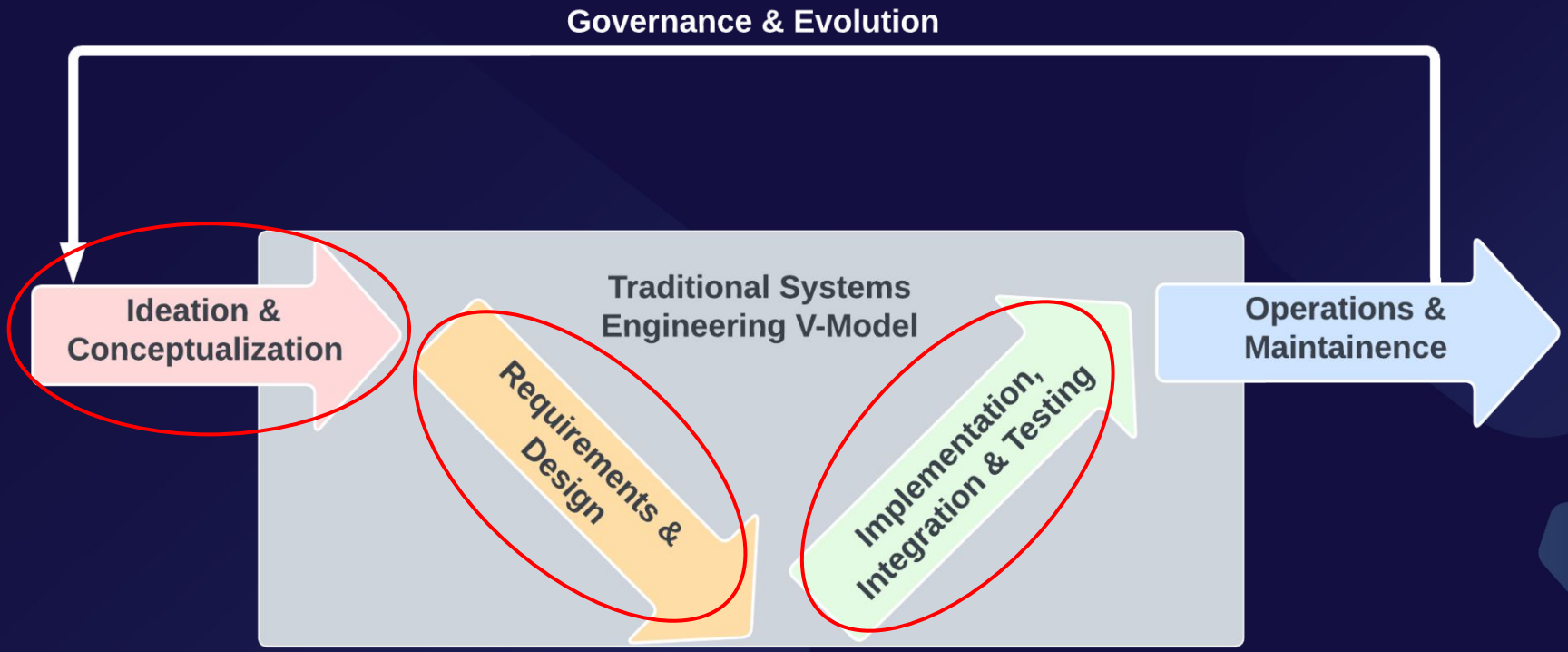








Engineering Lifecycle with Subspace Protocol



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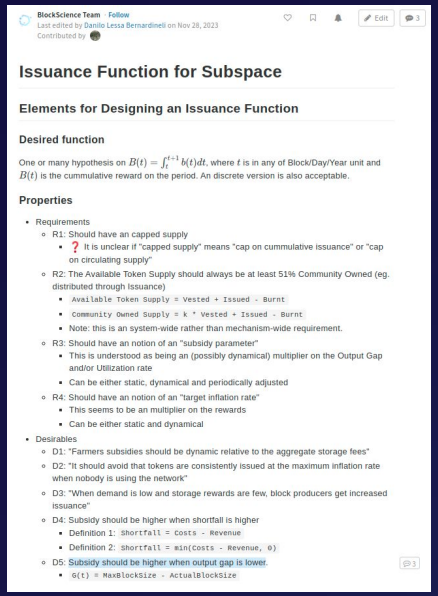
Source: https://blog.block.science/block-by-block-managing-complexity-with-model-based-systems-engineering/

Economic Design Initiative - The Subspace Issuance Function

Objective: Recommend the functional form of a mechanism that satisfies requirements and desirables related to token issuance in the Subspace protocol



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Issuance Function for Subspace

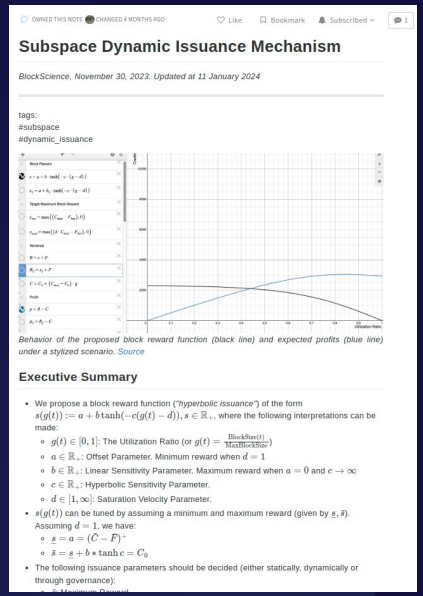
Elements for Designing an Issuance Function

Desired function

One or many hypothesis on $B(t) = \int_t^{t+1} b(t)dt$, where t is in any of Block/Day/Year unit and $B(t)$ is the cummulative reward on the period. An discrete version is also acceptable.

Properties

- Requirements
  - R1: Should have an capped supply
    - ❓ It is unclear if "capped supply" means "cap on cummulative issuance" or "cap on circulating supply"
  - R2: The Available Token Supply should always be at least 51% Community Owned (eg. distributed through issuance)
    - `Available Token Supply = Vested + Issued - Burnt`
    - `Community Owned Supply = k * Vested + Issued - Burnt`
    - Note: this is an system-wide rather than mechanism-wide requirement.
  - R3: Should have an notion of an "subsidy parameter"
    - This is understood as being an (possibly dynamical) multiplier on the Output Gap and/or Utilization rate
    - Can be either static, dynamical and periodically adjusted
  - R4: Should have an notion of an "target inflation rate"
    - This seems to be an multiplier on the rewards
    - Can be either static and dynamical
- Desirables
  - D1: "Farmers subsidies should be dynamic relative to the aggregate storage fees"
  - D2: "It should avoid that tokens are consistently issued at the maximum inflation rate when nobody is using the network"
  - D3: "When demand is low and storage rewards are few, block producers get increased issuance"
  - D4: Subsidy should be higher when shortfall is higher
    - Definition 1: `Shortfall = Costs - Revenue`
    - Definition 2: `Shortfall = min(Costs - Revenue, 0)`
  - D5: Subsidy should be higher when output gap is lower.
    - `G(t) = MaxBlockSize - ActualBlockSize`



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Subspace Dynamic Issuance Mechanism

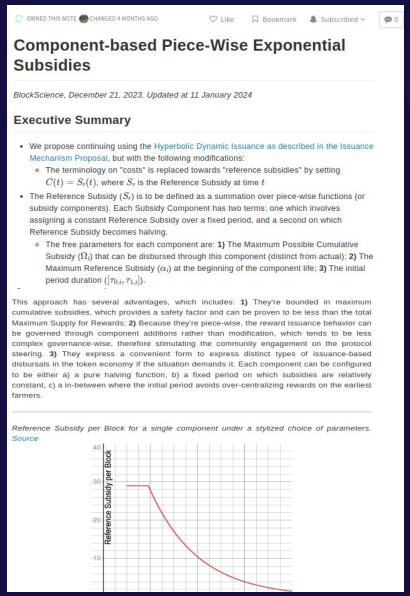
BlockScience, November 30, 2023. Updated at 11 January 2024

tags:
#subspace
#dynamic_issuance

Behavior of the proposed block reward function (black line) and expected profits (blue line) under a stylized scenario. Source

Executive Summary

- We propose a block reward function (*"hyperbolic issuance"*) of the form $s(g(t)) := a + b\tanh(-c(g(t) - d)), s \in \mathbb{R}_+$, where the following interpretations can be made:
  - $g(t) \in [0, 1]$: The Utilization Ratio (or $g(t) = \frac{\text{BlockSize}(t)}{\text{MaxBlockSize}}$)
  - $a \in \mathbb{R}_+$: Offset Parameter. Minimum reward when $d = 1$
  - $b \in \mathbb{R}_+$: Linear Sensitivity Parameter. Maximum reward when $a = 0$ and $c \to \infty$
  - $c \in \mathbb{R}_+$: Hyperbolic Sensitivity Parameter.
  - $d \in [1, \infty]$: Saturation Velocity Parameter.
- $s(g(t))$ can be tuned by assuming a minimum and maximum reward (given by $\underline{s}, \bar{s}$). Assuming $d = 1$, we have:
  - $\underline{s} = a = (\bar{C} - \bar{F})^+$
  - $\bar{s} = \underline{s} + b * \tanh c = C_0$
- The following issuance parameters should be decided (either statically, dynamically or through governance):



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Component-based Piece-Wise Exponential Subsidies

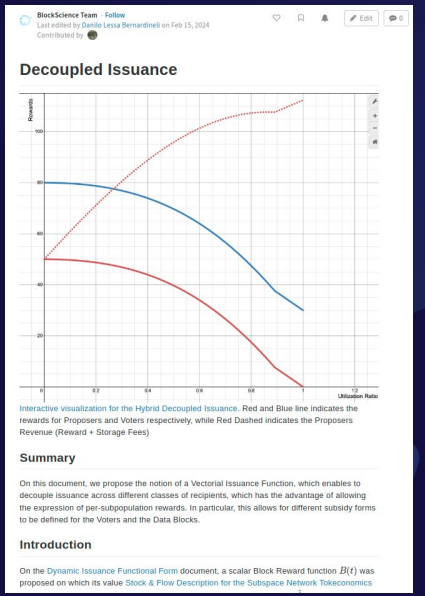
BlockScience, December 21, 2023. Updated at 11 January 2024

Executive Summary

- We propose continuing using the Hyperbolic Dynamic Issuance as described in the Issuance Mechanism Proposal, but with the following modifications:
  - The terminology on "costs" is replaced towards "reference subsidies" by setting $C(t) = S_r(t)$, where S_r is the Reference Subsidy at time t
- The Reference Subsidy (S_r) is to be defined as a summation over piece-wise functions (or subsidy components). Each Subsidy Component has two terms: one which involves assigning a constant Reference Subsidy over a fixed period, and a second on which Reference Subsidy becomes halving.
  - The free parameters for each component are: **1)** The Maximum Possible Cumulative Subsidy (Ω_i) that can be disbursed through this component (distinct from actual); **2)** The Maximum Reference Subsidy (α_i) at the beginning of the component life; **3)** The initial period duration ($\lceil \tau_{0,i}, \tau_{1,i} \rfloor$).

This approach has several advantages, which includes: **1)** They're bounded in maximum cumulative subsidies, which provides a safety factor and can be proven to be less than the total Maximum Supply for Rewards; **2)** Because they're piece-wise, the reward issuance behavior can be governed through component additions rather than modification, which tends to be less complex governance-wise, therefore stimulating the community engagement on the protocol steering. **3)** They express a convenient form to express distinct types of issuance-based disbursals in the token economy if the stimulation demands it. Each component can be configured to be either a) a pure halving function, b) a fixed period on which subsidies are relatively constant, c) a in-between where the initial period avoids over-centralizing rewards on the earliest farmers.

Reference Subsidy per Block for a single component under a stylized choice of parameters. Source



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Decoupled Issuance

Interactive visualization for the Hybrid Decoupled Issuance. Red and Blue line indicates the rewards for Proposers and Voters respectively, while Red Dashed indicates the Proposers Revenue (Reward + Storage Fees)

Summary

On this document, we propose the notion of a Vectorial Issuance Function, which enables to decouple issuance across different classes of recipients, which has the advantage of allowing the expression of per-subpopulation rewards. In particular, this allows for different subsidy forms to be defined for the Voters and the Data Blocks.

Introduction

On the Dynamic Issuance Functional Form document, a scalar Block Reward function $B(t)$ was proposed on which its value Stock & Flow Description for the Subspace Network Tokeconomics

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Source: https://github.com/BlockScience/subspace/blob/main/resources/subspace-issuance-function-economic-report.md

Economic Design Initiative - The Subspace Issuance Function

Subspace Dynamic issuance Functional Form:

$$B(t) = a + b\tanh -c(g(t) - d)$$

Where:

$$a = C_p(t) - b\tanh\left(c \cdot d\right)$$
$$b = \frac{C_p(t) - (C_p(t) - \bar{F}(t))^+}{\tanh c}$$

and both C_p, C_v and C_d are defined as per the Component-based Halving Subsidies:

$$C_j(t) = \sum_i \alpha_{i,j}(1 \cdot [\tau_{0,i,j} < t < \tau_{1,i,j}] + e^{-\frac{\alpha_{i,j}}{K_{i,j}}(t-\tau_{1,i,j})} \cdot [\tau_{1,i,j} < t])$$

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Source:

Implementation of the Issuance Function

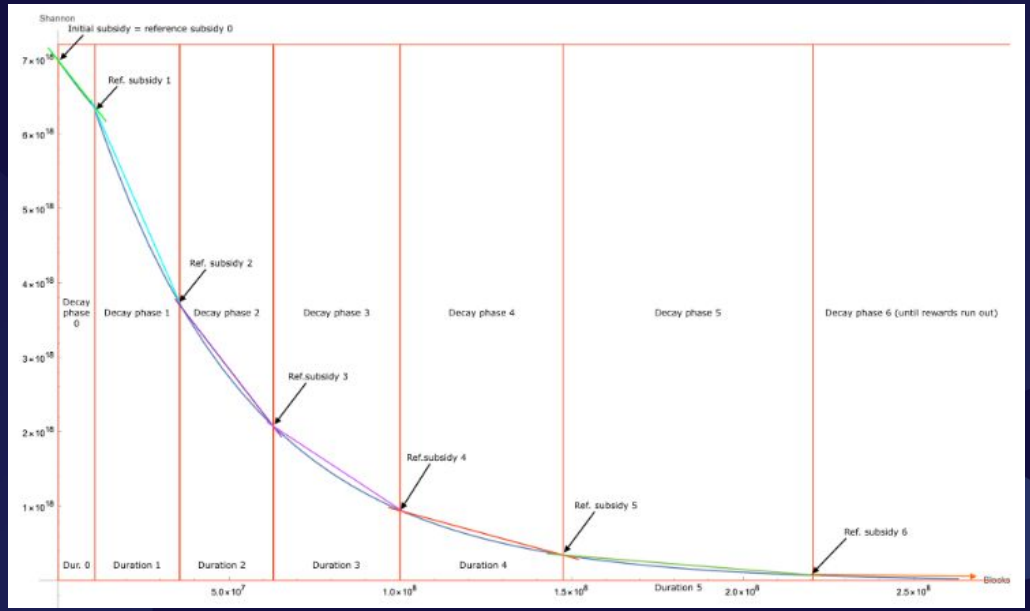
$$a + b\tanh(-c(\text{blockspace\_utilization} - d))$$

where

- $a = S_r - b * \tanh(c * d)$ the offset parameter (sets the amount of reward issued at 0 utilization to S_r).
- S_r is `reference_subsidy = reference_subsidy_for_block(ProposerSubsidyParams, block_height)`, a maximum amount of SSC issued at 0 utilization.
- $b = \frac{S_r - \max(S_r - \bar{F}, 0)}{\text{const } \tanh(c*d)} = \frac{\min(S_r, \bar{F})}{\text{const } \tanh(c*d)}$ is a linear sensitivity parameter.
- $\bar{F}$ is `max_block_fee = MAX_NORMAL_BLOCK_LENGTH * transaction_byte_fee`, maximum possible amount of storage fees in this block. 5
- (const) c is hyperbolic sensitivity parameter (determines the shape of the reward function) (currently, 0.99)
  - ▶ Note
- blockspace_utilization = `AvgBlockspaceUsage/MAX_NORMAL_BLOCK_LENGTH`
- (const) $d = 1$, utilization rate at which reward issued is 0

Putting everything together:

$$\begin{gathered}
a + b\tanh(-c(\text{blockspace_utilization} - d)) = \\
S_r - b * \tanh(c * d) + b\tanh(-c(\text{blockspace_utilization} - d)) = \\
S_r - b(\tanh(c * d) - \tanh(-c(\text{blockspace_utilization} - d))) \approx \\
|c = 0.99, d = 1| \approx \\
S_r - b(\tanh(c * d) - \tanh(c * d)(1 - \text{blockspace_utilization})) = \\
S_r - b\tanh(c * d)\text{blockspace_utilization} = \\
|b = \frac{\min(S_r, \bar{F})}{\tanh(c * d)}| = \\
S_r - \text{blockspace_utilization} * \min(S_r, \bar{F})
\end{gathered}$$



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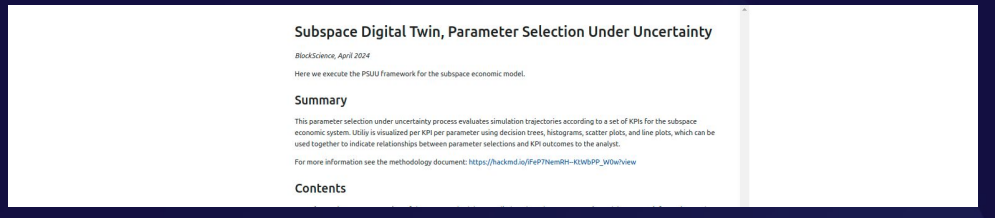
Source: https://subspacelabs.notion.site/Dynamic-Issuance-Specification-3bdf63955cb9434893478897775d71c24

Parameter Selection Initiative - The Subspace Economic System

Objective: Determine the “best” overall parameters for the Subspace Issuance function & other economic system parameters to support decision making ahead of mainnet launch



Subspace Digital Twin, Parameter Selection Under Uncertainty

BlockScience, April 2024

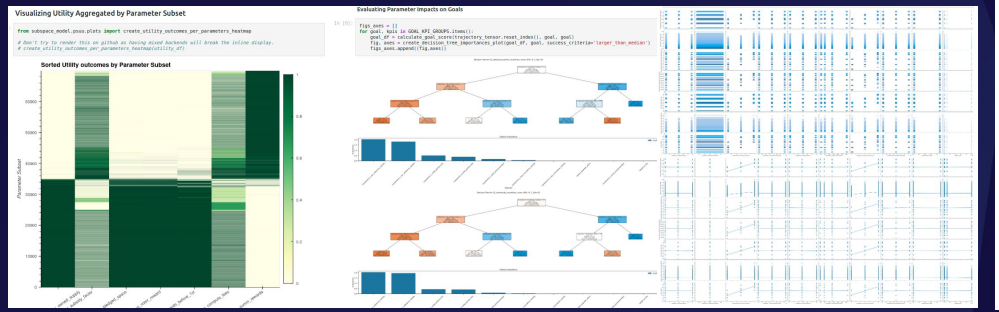
Here we execute the PSUU framework for the subspace economic model.

Summary

This parameter selection under uncertainty process evaluates simulation trajectories according to a set of KPIs for the subspace economic system. Utility is visualized per KPI per parameter using decision trees, histograms, scatter plots, and line plots, which can be used together to indicate relationships between parameter selections and KPI outcomes to the analyst.

For more information see the methodology document: https://hackmd.io/iFeP7NemRH-KtWbPP_W0w?view

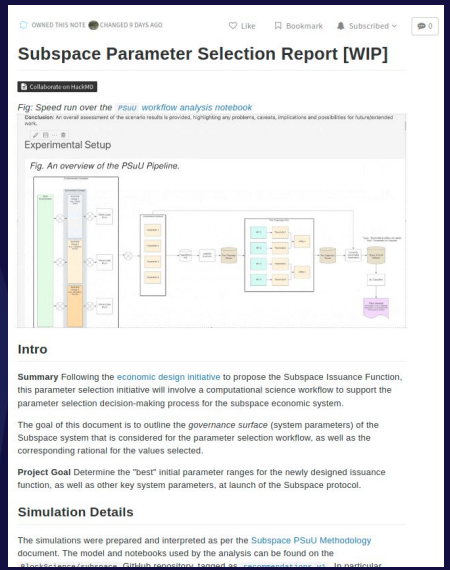
Contents



Visualizing Utility Aggregated by Parameter Subset

Sorted Utility outcomes by Parameter Subset

Evaluating Parameter Impacts on Goals



Subspace Parameter Selection Report [WIP]

Fig: Speed run over the PSuU workflow analysis notebook

Experimental Setup

Fig. An overview of the PSuU Pipeline.

Intro

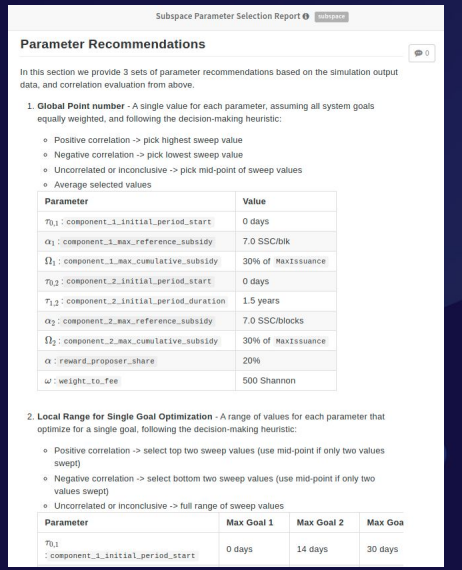
Summary Following the economic design initiative to propose the Subspace Issuance Function, this parameter selection initiative will involve a computational science workflow to support the parameter selection decision-making process for the subspace economic system.

The goal of this document is to outline the *governance surface* (system parameters) of the Subspace system that is considered for the parameter selection workflow, as well as the corresponding rational for the values selected.

Project Goal Determine the "best" initial parameter ranges for the newly designed issuance function, as well as other key system parameters, at launch of the Subspace protocol.

Simulation Details

The simulations were prepared and interpreted as per the Subspace PSuU Methodology document. The model and notebooks used by the analysis can be found on the



Subspace Parameter Selection Report

Parameter Recommendations

In this section we provide 3 sets of parameter recommendations based on the simulation output data, and correlation evaluation from above.

1. **Global Point number** - A single value for each parameter, assuming all system goals equally weighted, and following the decision-making heuristic:
   - Positive correlation -> pick highest sweep value
   - Negative correlation -> pick lowest sweep value
   - Uncorrelated or inconclusive -> pick mid-point of sweep values
   - Average selected values

Parameter	Value
$\tau_{0,1}$: component_1_initial_period_start	0 days
α_1 : component_1_max_reference_subsidy	7.0 SSC/blk
Ω_1 : component_1_max_cumulative_subsidy	30% of MaxIssuance
$\tau_{0,2}$: component_2_initial_period_start	0 days
$\tau_{1,2}$: component_2_initial_period_duration	1.5 years
α_2 : component_2_max_reference_subsidy	7.0 SSC/blocks
Ω_2 : component_2_max_cumulative_subsidy	30% of MaxIssuance
α : reward_proposer_share	20%
ω : weight_to_fee	500 Shannon

2. **Local Range for Single Goal Optimization** - A range of values for each parameter that optimize for a single goal, following the decision-making heuristic:
   - Positive correlation -> select top two sweep values (use mid-point if only two values swept)
   - Negative correlation -> select bottom two sweep values (use mid-point if only two values swept)
   - Uncorrelated or inconclusive -> full range of sweep values

Parameter	Max Goal 1	Max Goal 2	Max Goa
$\tau_{0,1}$: component_1_initial_period_start	0 days	14 days	30 days

Sources:

- *https://github.com/BlockScience/subspace/blob/main/notebooks/workflows/psuu.ipynb*
- *https://github.com/BlockScience/subspace/blob/main/resources/subspace-parameter-selection-report.md*

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BlockScience x Subspace: Artifacts Summary

Canonical Resources:

- GitHub Repository: BlockScience/Subspace
- Economic Design Report
- Parameter Selection Report

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Subspace cadCAD Model & Documentation walkthrough

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‘Parameter Selection Under Uncertainty’ Deep Dive

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Q&A

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Thank You!