



MONETARY MODEL

November 2018

Abstract

In order to build a global digital currency – that truly functions as such – trust and credibility are essential.

Like money, trust doesn't grow on trees. It needs to be earned. Credibility must be established.

Saga's monetary model is designed to support the development of the currency from day one, when it is new and unproven, through its growth, until maturation into a standalone currency for widespread, everyday use.

This will be a long process, with multiple stages. In the life of a currency, some future events can be imagined and even predicted. There are also unknowns, which we acknowledge from the outset.

This document is a blueprint of measures that we believe support the Saga token, allowing it to gain trust. We outline core objectives for Saga's economy, and declare our guiding principles, before establishing how to meet them.

Over the last months, we have rigorously tested our assumptions with Saga's advisory board and team, and other prominent economists. Thanks to their input we've made several crucial improvements. We wish to further open our model to broader debate. Hoping to draw feedback and criticism, we now publish our monetary model.

To join the debate, we invite you to send comments and queries: economy@saga.org

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1. INTRODUCTION

The Need for a Monetary Model – Currency Governance

The basis of today's prevailing currency system is first and foremost trust.

Objects of intrinsic value – food, clothes, etc. – are traded every day in return for objects with no intrinsic value, such as banknotes, coins or electronic money. These forms of money are based on the trust that this same representation of worth will be able to purchase things of similar value in the future. This is the basis of the fiat currency system.

In this system, the responsibility to maintain the stability of a currency's purchasing power is taken by central authorities. Without such governance, currencies would be left completely exposed to the vagaries of market sentiment.

Until now, the administration of currency has mostly been the purview of governments. However, there is no reason why governments should be the only entities to issue a currency.

In fact, currency could benefit from responsible competition. Alternative models can be presented in order to motivate progress; currency should have the chance to evolve to better suit the changing needs of global citizens.

Saga offers an alternative model to state-managed fiat: a global currency, governed in monetary matters by code. The benefits of code are that it is transparent, predictable and impartial. Code does not favour any party, nor does it carry personal considerations. A global currency can be an appropriate means to serve our increasingly global society, in which economic activity is no longer restricted by national boundaries.

Saga's new system first has to prove itself in the eyes of the public. Therefore, while Saga is in the process of gaining acceptance, it draws trust from the existing monetary system. Saga's economy begins with complete backing by a reserve of major fiat currencies. Then, as the economy develops, our model reduces its anchoring to the existing system and starts to gain its own, independent value.

This paper contains a full account of Saga's monetary model; governed by an autonomous smart contract, responsible for guiding the Saga economy on a path of steady and appropriate growth. The Contract slowly and carefully shifts the source of trust from current dominant currencies to an eventual standalone value.

Modelling Trust

Saga tokens (SGA) are issued and sold by the Saga Smart Contract, which also offers to buy back and burn existing tokens.

Thus, the Contract adjusts the supply of Saga tokens to meet market demand, and to limit the impact of fluctuations in market confidence on SGA price. When the economy expands, the Contract increases the supply of SGA, moderating price appreciation. When the economy shrinks, the Contract reduces the token supply, curbing price depreciation.

The proceeds of issuing new SGA tokens are kept in a reserve, held in major banks, and stored in liquid assets that replicate the currency composition of the SDR — a basket of fiat currencies (USD, EUR, etc.) created by the International Monetary Fund.

The Reserve supports the Saga economy; it provides the Contract with the ability to buy back Saga tokens when demand falls. The Reserve only provides a fractional backing; it does not have the full means to buy back all SGA tokens at current market price. The backing ratio decreases as the economy expands.

Thus, *Saga is a variable fractional reserve economy*.

The fraction of Saga's economy backed by the Reserve represents the amount of trust drawn from the currencies that comprise the SDR currency basket. At the beginning of Saga's life, our model maintains a fully backed Reserve. One hundred percent of trust is obtained from the SDR currencies. Then, as the economy grows, the model begins to reduce its dependence on other currencies, and Saga acquires its own amassed trust.

2. SAGA CONTRACT AS SGA LIQUIDITY PROVIDER

A large part of this paper is devoted to describing Saga's pricing model, which sets a range for SGA value based on the strength of the SGA economy.

The Saga Contract ensures the value of SGA tokens is within the range given by the pricing model, by taking an active part in the SGA market, acting as a *liquidity provider*.

The Contract always offers to sell new SGA tokens, at a price — the **ask price** — given by Saga's model. Conversely, the Contract offers to buy back and burn SGA tokens at the model's **bid price**.

The bid and ask prices are not fixed — they increase when tokens are bought from the Contract, and decrease when tokens are sold back.

At any given moment the price of SGA tokens in the secondary market is constrained to lie¹ within the pricing model's bid/ask range. Whenever the market price of SGA leaves this range, the Contract intervenes and increases or decreases the supply of SGA, in order to restrain price fluctuations.

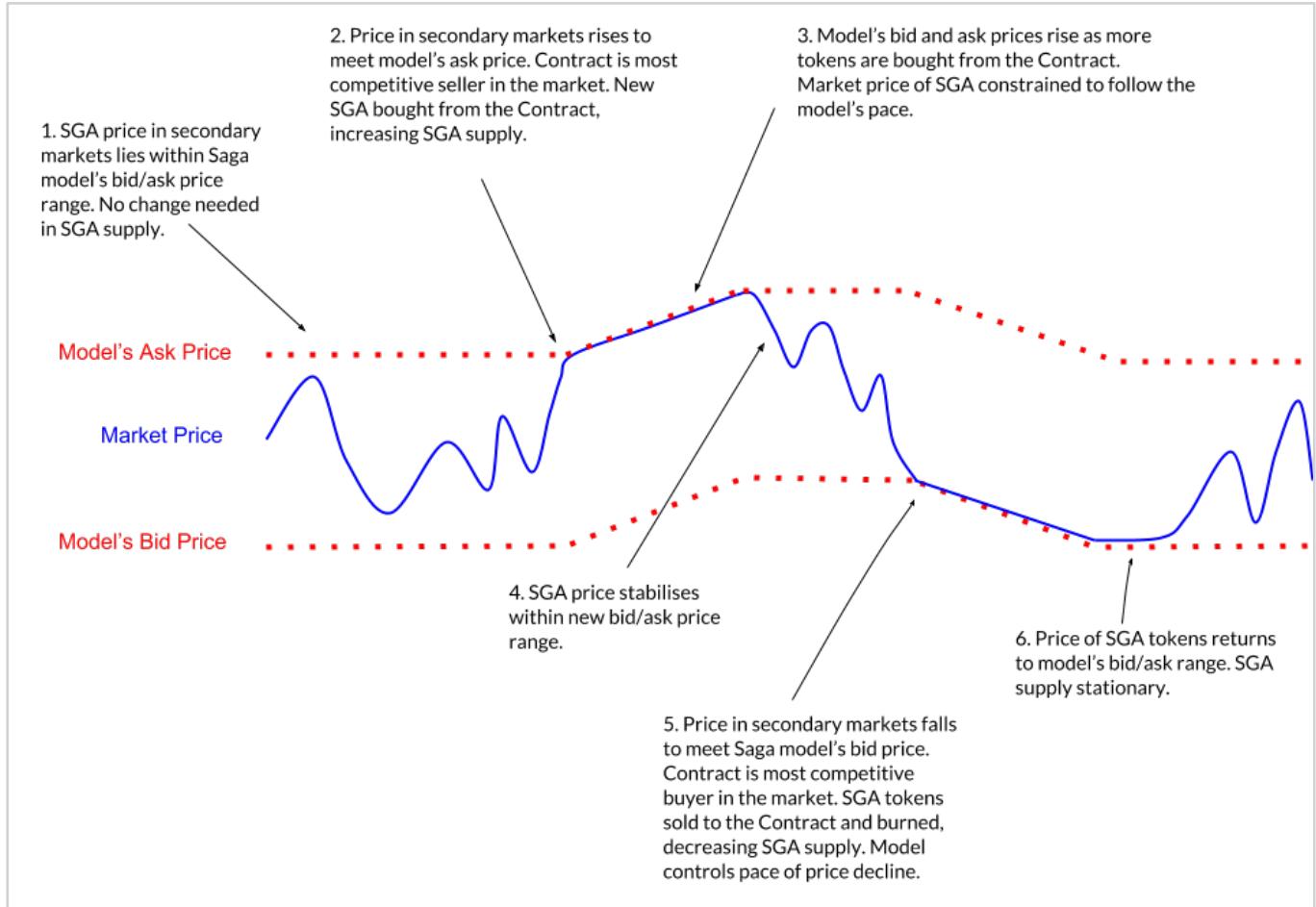
Consider an example in which demand for SGA rises and the price of SGA in the secondary market becomes higher than the model's ask price. The Saga Contract offers the cheapest price for buying SGA, so people (e.g. arbitrageurs) buy SGA directly from the Contract, not from the market. The supply of SGA rises in accordance with increased demand.

SGA will continue to be bought from the Contract for as long as the Contract offers the most competitive price; until the model's ask price has risen to meet the secondary market price.

Thus, at all times the Saga model either determines a range for SGA price, or controls the pace of movement when SGA price moves beyond this range. Saga's model enforces different rates of price movement at different stages of the economy's development.

¹ This relies on the existence of an efficient secondary market that includes market arbitrageurs. Until this is actually the case, the Saga Contract will employ a minimal bid-ask spread. It will control SGA price by virtue of the fact that it offers the most competitive price.

Figure 1: Saga Contract as SGA liquidity provider



For the sake of simplicity, the majority of this paper considers a pure pricing model, where the bid price is equal to the ask price (i.e. a bid/ask spread of zero). We can therefore refer to the 'price' of Saga tokens without ambiguity and assume the model completely dictates the price of SGA.

We designed Saga's pricing model using the same framework; it is more convenient to design the model to fulfil our aims if we assume it completely sets SGA price.

In Chapter 10 we describe the full framework, which includes a bid/ask price spread.

3. OBJECTIVES FOR SAGA'S MONETARY MODEL

Saga's monetary model has several objectives:

1. To prevent the possibility of malicious users manipulating the system and gaming the Reserve for unfair profit.
2. To ensure the pricing model is 'robust': if all SGA holders decide to sell their tokens back to the Contract, there must be enough money in the Reserve to pay them back at the model's prices.
3. The price of SGA should reflect the strength of the Saga currency. This could be measured by metrics such as: i) the amount of SGA in circulation; ii) the number of unique SGA holders; iii) the volume of SGA transactions.
4. The monetary model should aim to regulate volatility of SGA price, while also balancing the need for sufficient price appreciation.

Objectives 1 & 3 seem somewhat discordant. For example, imagine a pricing model that takes into account the daily volume of transactions between SGA participants. Two malicious participants could join forces and do the following: both buy SGA from the Contract, then trade large amounts of SGA between themselves, causing inflation in SGA price. Selling their SGA back to the Contract, they will realise an unfair profit.

Moreover, an effective way of ensuring the model is not susceptible to unfair gaming by participants is to make it path-independent. The behaviour of the model in a particular state should depend on that state alone, not how we got there. It is not possible to add more than one free variable to a pricing function and at the same time have a model which is both path-independent and robust.

Therefore, instead of designing a model that considers several metrics of Saga's health, we built a model that focuses on just one: the size of the economy.

Saga's pricing function is an increasing function of the SGA economy. Natural ways of measuring the size of the economy are: the total number of SGA in circulation; the amount of money in the Reserve; the market cap of SGA.

Saga's pricing model works as follows:

The price that the Contract charges to issue a new SGA token depends only on the number of existing tokens in circulation (i.e. discounting tokens sold back to the Contract and burned). The first SGA token is sold² at price $P(1)$. The second is sold at price $P(2)$, where $P(2) \geq P(1)$.

In general, the N^{th} token is sold for $P(N)$, where $P(N)$ is at least as large as the price of the previous token sold.

Proceeds from the sale of SGA tokens are kept in the Saga Reserve. When SGA is sold back to the Contract, the seller is reimbursed at the current price, regardless of when the token was originally

² We have simplified things here slightly for ease of understanding. In practice we consider SGA to be bought in infinitesimal pieces, thus the correct price to pay for a SGA token involves taking the integral of the pricing function. Exact details given in Chapter 5.

purchased. So if the token is sold when there are N tokens in circulation, the seller receives $P(N)$ from the Contract in return.

Taking this approach, objectives 1 and 2 are automatically fulfilled:

1. Path independence means the Reserve cannot be gamed. There is nothing to be gained from buying and immediately selling SGA tokens.
2. The Reserve remains solvent at all times. There are always enough funds to reimburse SGA tokens in the market. The Reserve simply withdraws money deposited into it at the point of the last token purchase.

Objective 3 – the accurate reflection of Saga's strength by SGA price – is fulfilled, as much as possible, by having Saga's pricing function determined by the size of Saga's economy.

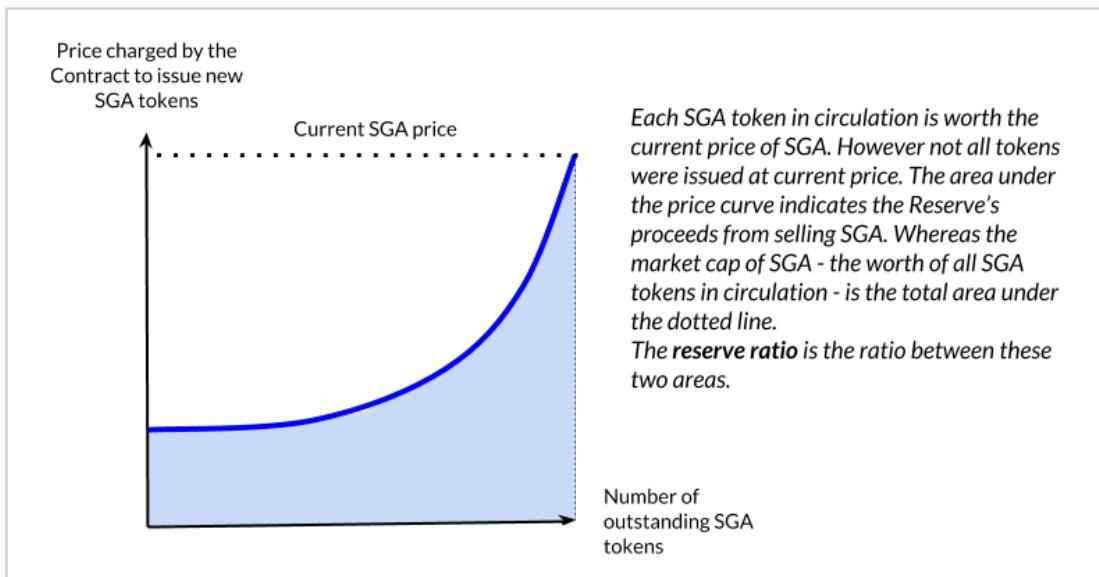
The remainder of this paper addresses the 4th, most intricate aspect of Saga's monetary model: the wish to tame volatility while supporting growth as Saga's economy develops.

4. THE RESERVE RATIO

Saga's pricing model increases the price of SGA as more tokens are bought from the Contract. However, SGA tokens are always *all* worth the current price of SGA, regardless of when the tokens were issued, or how much was paid for them. The result is that the Saga Reserve contains less money than the market cap of SGA.

We define the **reserve ratio** to be: *the amount of money in the Reserve as a percentage of Saga's market cap*. For example, a reserve ratio of 20% means the market cap is five times the value of the Reserve.

Figure 2: Visual description of the reserve ratio



The reserve ratio has several intuitive interpretations:

1. It is a measure of the ability of the Contract to buy back SGA tokens, without having to reduce the price of SGA.

Consider a case in which the reserve ratio is 20%. The Reserve only has 20% of the funds needed to buy back all SGA tokens at current price. If everyone begins selling their tokens back to the Contract, SGA price must drop for the Contract to pay everyone back.

If the reserve ratio is higher, say 80%, the Contract must still reduce the price of SGA as participants exit the economy, but the reduction in price need not be so drastic.

2. The reserve ratio represents the average price that buyers have so far paid for SGA, in relation to the current price. For example, a reserve ratio of 20% means the average buyer bought SGA from the Contract for 80% less than the current value.
3. Equally, the reserve ratio represents the average price that sellers of SGA receive, should they all sell SGA back to the Contract.
4. The reserve ratio is a measure of the rate of SGA price change. If SGA price grows rapidly with the number of SGA tokens, the reserve ratio will be low.

5. Perhaps most importantly, (one minus) the reserve ratio represents the trust and inherent value embedded in Saga.

Reserve Ratio & Market Trust

The value of an SGA token is derived from two distinct sources:

1. The Reserve backing.
2. ‘Market trust’ – determined by less tangible ingredients, such as market confidence and the general perception of SGA’s utility as a currency.

While the value derived from the Reserve is stable³, market trust is likely to be volatile, especially when Saga’s economy is small. On the other hand, market trust can grow against the SDR benchmark, whereas the Reserve – by definition – cannot.

The Reserve, held in major currencies that make up the SDR basket, represents Saga’s anchoring to the established financial system. The reserve ratio therefore describes the extent to which Saga’s economy draws value from existing currencies, or rather has its own independent value, reflecting market trust.

Reserve Ratio & Volatility

One of our key objectives is to mitigate SGA price volatility. However, we also believe SGA price should vary to accurately reflect the strength of Saga’s economy.

Allowing the price of SGA to change opens the door to volatility. As market demand for SGA fluctuates, participants buy or sell SGA against the Contract, and the price of SGA – given by the pricing model – changes.

The steepness of Saga’s pricing curve dictates the exposure of SGA price to volatility. If the curve is shallow, the Contract provides a large amount of resistance to volatility – i.e. a large number of SGA must be traded before a significant effect on SGA price is seen. Conversely, if the price curve is steep, SGA price is more susceptible to volatility.

As mentioned above, the reserve ratio is precisely what determines the steepness of the pricing curve.

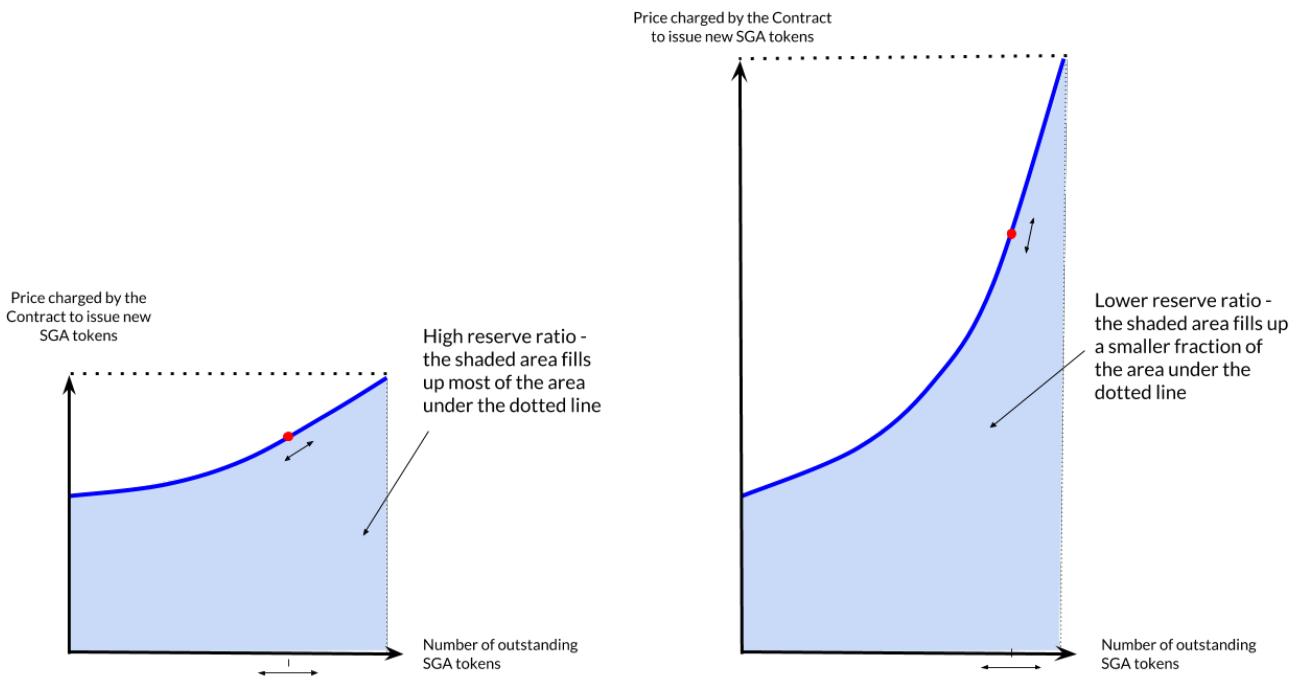
³ In terms of the unit of account, the SDR, at a given time.

Figure 3: Reserve ratio & Volatility

Market forces determine the number of outstanding SGA tokens. The model's pricing curve determines how changes in the number of SGA tokens affect SGA price.

1. The price of SGA grows slowly when the reserve ratio is high.
Fluctuations in market confidence and consequently in the number of SGA tokens, have little effect on SGA price, as the price curve is shallow.

2. If the reserve ratio is smaller, the price of SGA must adapt more quickly to changes in SGA supply.
Fluctuations in market confidence cause large changes in SGA price, as the price curve is steep.
SGA price is thus more likely to be volatile.



From Reserve Ratio Model to Pricing Model

When designing Saga's pricing curve we could, in theory, pick any arbitrary increasing function. However, it is difficult to choose a pricing function with any real meaning in an economic sense.

A better approach is to choose what the **reserve ratio** should be at various stages of Saga's growth. Indeed, the reserve ratio has an intuitive interpretation; it is a measure, amongst other things, of how much independent trust Saga's economy has. Furthermore, it is a measure of the power of Saga's Reserve to dampen SGA price movement and thus volatility.

Once we have designed how the reserve ratio should vary, a pricing function that creates this exact behaviour in the reserve ratio can be derived mathematically, as shown in the next chapter.

The pricing function is then not arbitrary; it is a derivative of the reserve ratio model, based upon economic considerations.

Saga's Reserve Ratio Model

Saga's monetary model is based on a variable reserve ratio. The reserve ratio starts at 100% and then gradually decreases as Saga's economy grows.

Reasons for this are as follows:

When Saga's economy is small, market trust is low, and therefore unstable. In order to limit SGA price exposure to fluctuations in market trust, a high reserve ratio is employed, favouring stability over growth at this stage.

As Saga's economy becomes stronger, market trust (and consequently SGA's independent value) increases and becomes more stable. At this point, a smaller portion of SGA's value should be based on the Reserve. In other words, a lower reserve ratio can be used, allowing greater exposure to market forces in favour of faster growth.

Saga's monetary model applies a reserve ratio of 100% until Saga's market cap reaches a certain threshold. Until this limit is reached, Saga is fully backed; the market cap is precisely the amount of money in the Reserve. The price of SGA is also constant; zero growth with zero volatility.

Benefits of this choice:

1. Everyone who buys SGA at this stage is on equal footing.
2. Deters a 'run on the contract'.

In our model, this stage lasts until Saga has a market cap of 20M SDR.

Thereafter, the reserve ratio decreases until it eventually reaches a minimum of 10%, then remains constant. A 10% reserve ratio is identical to the US Federal Reserve's current required reserve ratio on banks' Net Transaction Accounts.

5. THE MATHS BEHIND SAGA'S PRICING MODEL

We start by defining some notation:

R – the value of the Reserve

r – the reserve ratio

N – the number of outstanding SGA tokens

P – the price of SGA as given by Saga's pricing model

Deriving Price from Reserve Ratio

Recall that we designed Saga's pricing model by deciding how the reserve ratio should vary as the economy develops. Once we selected how the reserve ratio should behave, a pricing function that creates this behaviour can be derived as follows:

The reserve ratio, by definition, is the ratio between the amount of money in the Reserve and the market cap of Saga.

$$(1) \quad R = rNP$$

Thus $P = \frac{R}{rN}$. This is not yet enough, as we need to know R as a function of N .

Fortunately, our variables satisfy another equation:

$$(2) \quad R(N) = \int_0^N P$$

This equation says the amount of money in the Reserve – when there are N tokens in circulation – is precisely the proceeds from selling those tokens.

Combining the two equations, we get: $rNP = \int_0^N P$

Differentiating and rearranging gives:

$$(3) \quad \frac{1}{P} \cdot \frac{dP}{dN} = \frac{1}{rN} (1 - r - N \frac{dr}{dN})$$

We then solve this differential equation to get P as a function of N .

We consider SGA to be bought in infinitesimal pieces, so the cost of buying m new tokens when there are

already N tokens in circulation is given by $\int_N^{N+m} P(n) dn$.

Saga's Reserve Ratio Function

The reserve ratio in Saga's model decreases as a piecewise linear function of N – the number of SGA tokens in circulation. Under this choice differential equation (3) is easily solved. Furthermore, we do not lose anything by limiting ourselves to using a piecewise linear function for r , since piecewise linear functions can approximate any continuous function, to any degree of accuracy⁴.

In a given interval, i , the reserve ratio can be expressed as: $r(N) = \alpha_i - \beta_i N$ where α_i, β_i are non-negative constants. The solution to differential equation (3) is then:

$$P = \frac{\omega_i}{N \cdot r} \cdot \left(\frac{N}{r}\right)^{1/\alpha_i} \text{ where } \omega_i \text{ is a constant that ensures price continuity across intervals.}$$

And:

$$R = \omega_i \cdot \left(\frac{N}{r}\right)^{1/\alpha_i} \quad (\text{using equation 1})$$

The starting price of SGA (the initial condition of the differential equation) is free for us to choose – we chose it to be 1 SDR.

The full details of how we designed the shape of the reserve ratio function can be found in Appendix A.

Reserve Ratio & Volatility – Worked Examples

We give mathematical backing to our claim that the reserve ratio specifies the extent to which the Contract can restrain SGA price volatility. We do this by considering the cash flow needed to move SGA price.

Recall that the price of SGA changes when capital is injected into – or removed from – the Saga Reserve. If a substantial cash flow is needed to change SGA price significantly, then the Contract provides a high level of protection against market volatility. If a small net change in the Reserve results in a large price change, then SGA price will be more sensitive to volatility.

For simplicity in our calculations below, we consider a constant reserve ratio, though similar principles apply when working with a variable reserve ratio.

From equation (3) above we can derive that if the reserve ratio is kept at a constant value, r , then the relation between the price of SGA and the value of the Reserve is given by: $P \sim R^{1-r}$.

Differentiating gives that $\frac{dP}{dR} = (1-r) \cdot \frac{P}{R}$, which can also be written as $\frac{dP}{P} = (1-r) \cdot \frac{dR}{R}$.

⁴ In mathematical terminology, the fact that the set of piecewise linear functions is dense in the space of continuous functions on a closed, bounded interval under the uniform metric.

This states that a percentage change in the Reserve value causes a percentage change in SGA price reduced by a factor of $1 - r$. For example, if the model maintains a low reserve ratio of $r = 20\%$, then a 10% change in the Reserve would cause a price change in the order of 8%. If a higher reserve ratio is used, say $r = 80\%$, then the same 10% change in the Reserve only causes a 2% change in SGA price.

Further analysis can be found in Appendix B, where we use Monte Carlo simulations to gauge the sensitivity of SGA price to volatility, at various points of Saga's economy development.

6. SAGA GENESIS

The resources to build Saga's ecosystem derive from proceeds raised from early contributors, who support Saga before the SGA economy launches. They should receive commensurate compensation for that risk. On the other hand, compensation should not affect Saga's economy adversely.

Saga cannot just give out the first SGA tokens for free to early backers: the Saga Contract is committed to act as a liquidity provider for SGA tokens. It must ensure that there is always enough money in the Reserve to buy back SGA tokens at the price set by its pricing function. Therefore, the SGA Contract cannot mint SGA tokens before there is money in the Reserve. The same goes for selling SGA tokens at a discount – as other digital currencies have done.

Therefore, we devised a different way to recompense early backers, using a product called **Saga Genesis**.

When designing Saga Genesis, we had the following objectives:

1. The value of Saga Genesis should be tied to the success of Saga.
2. Saga Genesis should offer high prospect in return for the high risk taken by early backers.
3. The Saga Genesis model should not have an adverse effect on the main Saga economy model.
4. Saga Genesis holders should not hold too much power.
5. The lifetime of Saga Genesis should be limited – eventually the Saga Genesis economy should merge with the Saga economy.

We came up with a framework that recompenses early investors with SGA tokens, but not immediately. Instead, they receive their SGA tokens gradually, only if and when Saga's economy grows through various milestones.

The exact mechanism for Saga Genesis is as follows:

A Saga Genesis (SGN) is a digital token that represents a *potential* to receive up to 15 SGA tokens. The Saga model defines several market-cap milestones, which we call '**Genesis Minting Points**'. When the Saga economy reaches a Minting Point for the first time, new SGA tokens are generated on behalf of each SGN token. Overall, across all the Minting Points, 15 SGA tokens are minted for each SGN token.

A Saga Genesis token holder can at any time send their SGN token to the Saga Genesis Contract and receive the SGA tokens that have been minted for the SGN token. We call this 'converting SGN to SGA'. However, in doing so, the SGN token is burned. So if the SGN token was converted before all 15 SGA tokens were minted, the holder loses the potential to receive the remaining SGA tokens.

This framework for Saga Genesis fulfilled our objectives:

1. **The value of SGN is tied to the success of SGA:** The SGA-SGN conversion ratio – the number of SGA received when one SGN token is converted – depends on the number of market-cap milestones the SGA economy has grown through i.e. SGN investors' return only increases if the Saga economy itself flourishes. The value of the SGA tokens received depends on the price of SGA, which is also dependent on the strength of the Saga economy.

2. **SGN represents a high-risk, high-prospect investment:** If the Saga economy fails to pass many (or any) of the market cap milestones, SGN will have a low (or no) return. On the other hand, if the economy succeeds, an SGN token can be worth up to 15 SGAs, yielding a significant return.
3. **Saga Genesis does not adversely affect the main SGA economy:** Generating SGA tokens for SGN holders, without adding extra money into the Reserve, must impact on Saga's pricing model. The size of the impact depends on the ratio between the number of SGA tokens generated and the total number of SGA tokens.

Since we mint SGA tokens for SGN holders at *market cap* milestones rather than at *time* milestones, we can ensure that we only generate SGA tokens for SGN holders when the Saga economy can handle it. We designed the location of each Genesis milestone, and the number of SGA generated, to contain the effect on the SGA economy.⁵

An additional benefit of minting at market cap milestones is that the model is deterministic; if we generated SGA tokens at fixed points in time, we would have no way of knowing in advance the effect this would have on the Saga economy.

4. **Saga Genesis holders do not have too much power:** There are a limited number of Saga Genesis tokens, 107 million overall. Consequently, the number of SGA tokens minted for early investors is limited.

Moreover, these SGA tokens are minted in stages – only if and when the Saga economy has grown through a market cap milestone. This means the number of SGA tokens owned by early investors can only increase once the number of SGA tokens bought by regular participants has also increased. So early investors never swamp the main SGA economy.

This is a significant benefit of Saga's model. Usually, when a new company or digital currency is created, early backers start by owning 100% of all the equity or tokens. This percentage decreases when equity is sold or more tokens are generated. However the decrease is often gradual, so early backers retain significant control.

Take Ethereum. Approximately 70 million ETH were generated for early backers and participants of the pre-sale. Since then, to date, fewer than 30 million new ETH have been generated, meaning that the original tokens still account for over 70% of the ETH economy.

By contrast, in Saga's model, early backers start out owning no SGA tokens; and at their maximum, SGN holders together own less than 30% of all SGA tokens.

5. **The influence of Saga Genesis on Saga's main economy is limited:** Once all the Minting Points have been reached, and 15 SGA tokens have been minted for each SGN token, Saga Genesis ceases to impact Saga's pricing model. Saga Genesis becomes synonymous with Saga – an SGN token is just like a 15 SGA bill.

⁵ Exact details of how we designed Genesis Minting Points can be found in Appendix A of this paper.

Remarks

- Those who convert SGN to SGA before all 15 SGA tokens have been minted lose their rights to the remaining SGA tokens. This protects the Saga economy; it encourages SGN holders to stay in the Saga economy, not just take their SGA tokens and ‘run’.

Indeed, we do not expect *anyone* to convert SGN to SGA before all 15 tokens have been minted. Rather, we assume they will get a better price selling SGN in the secondary market. This is because the market value will no doubt take into account the possibility that more SGA tokens will be minted for the SGN token; whereas converting SGN negates this possibility.

- Secondly, when SGN is converted to SGA the rights to SGA tokens not yet minted are lost – but the SGA tokens are still generated at Minting Points. This ensures Saga’s pricing model is deterministic. The alternative would be that each time the Saga economy reaches a Genesis Minting Point, the number of SGA tokens minted – and consequently the effect on the pricing model – would depend on the number of remaining SGN tokens. We rejected this option; we do not want the actions of SGN token holders to impact Saga’s pricing model, since this could open the door to manipulation.
- One final point to note is that the conversion ratio of SGN-SGA depends on the number of Genesis Minting Points the Saga economy has passed. In other words, the conversion ratio depends on the *high-water mark* of Saga’s economy.

This raises one potential problem: the possibility that SGN holders may attempt to artificially increase Saga’s high-water mark by buying and immediately selling SGA tokens against the Saga Contract. To protect against this, the Contract only mints new SGA tokens tokens for SGN holders if Saga’s market cap remains above a Genesis Minting Point for a period of seven days.

Saga Genesis & the Reserve Ratio

When Saga’s economy reaches a market cap at which a Genesis Minting Point occurs, the Contract generates SGA tokens for SGN holders. This is done without any increase to the Reserve.

Recall that the reserve ratio is defined as $r = \frac{R}{NP}$

At a Minting Point, N increases with R remaining the same. The price, P , of SGA should also remain the same, so SGA holders are not immediately disadvantaged by the minting of new tokens. Therefore the reserve ratio drops. If there are N SGA tokens in circulation before the Genesis Minting Point, and n new tokens are minted, the new reserve ratio will be: $r_{post-minting} = \frac{N}{N + n} \cdot r_{pre-minting}$

Once SGA tokens have been minted for SGN holders (after a week has passed), it cannot be undone: if the Saga economy begins to shrink, we do not un-mint the tokens. Therefore we need a new model for when the economy shrinks backwards through a Minting Point milestone.

We defer the discussion of a ‘Shrinking Economy’ to a later chapter of this document.

The Saga Foundation

The Saga Foundation is a non-profit organisation dedicated to creating and maintaining the Saga economy. The Foundation owns 36% of SGN tokens. These will be used to fund the Foundation's activities once proceeds from the original SGN sale have run out. As the Foundation is the most dominant SGN holder, a vesting mechanism has been included in Saga's model to prevent the Foundation selling its SGN tokens during early stages of Saga's development.

The SGA tokens generated on behalf of the Foundation's SGN are not all minted at regular Genesis Minting Points. Some are minted at delayed points, which we call Vesting Points. There are three Vesting Points in Saga's model, and at each, a portion of the Foundation's SGN tokens are 'unlocked' meaning SGA tokens that should have already been minted on their behalf are minted. Delaying the minting of the Foundation's SGA tokens to a later stage minimises the impact on the economy.

7. SAGA'S MODEL IN FIGURES AND TABLES

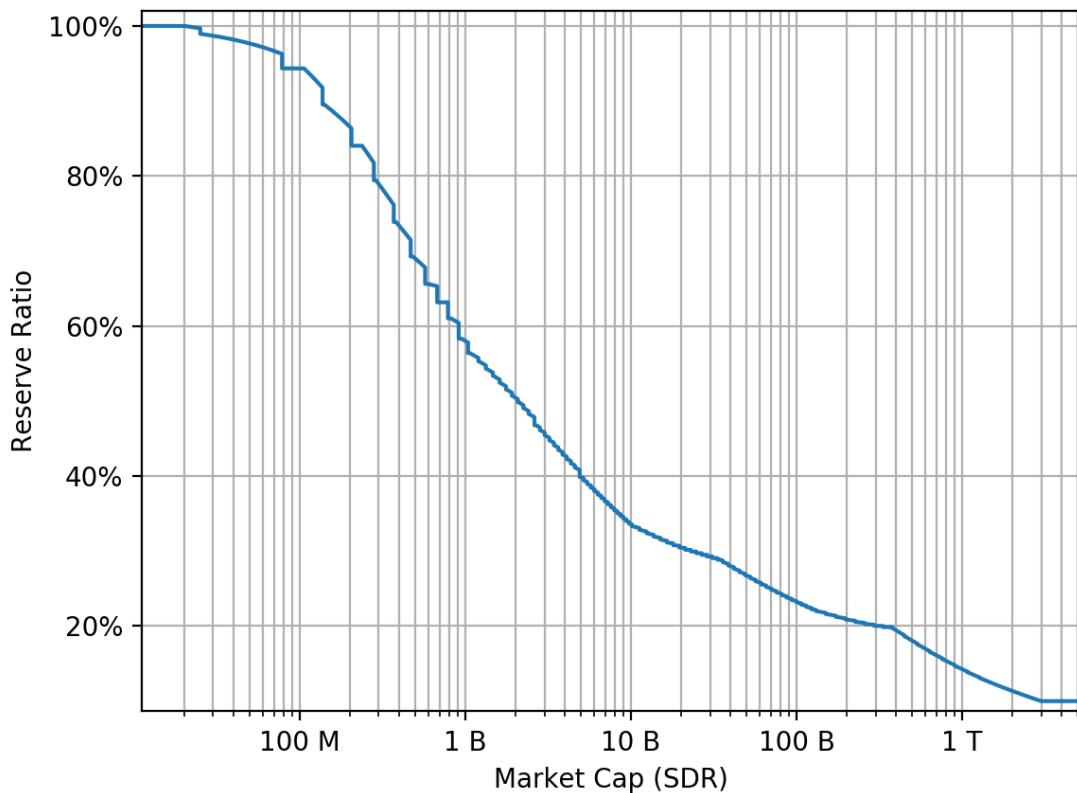
We built Saga's monetary model based on the principles detailed above. Here we show the main features of the model. Appendix A lists the exact parameters used to build the model.

Reserve Ratio Function

The reserve ratio decreases as Saga's economy increases in market cap. The decrease is linear in the number of SGA tokens in circulation. Drops to the reserve ratio also occur each time the economy reaches a Genesis Minting Point.

Figure 4: Reserve ratio as a function of Saga's market cap

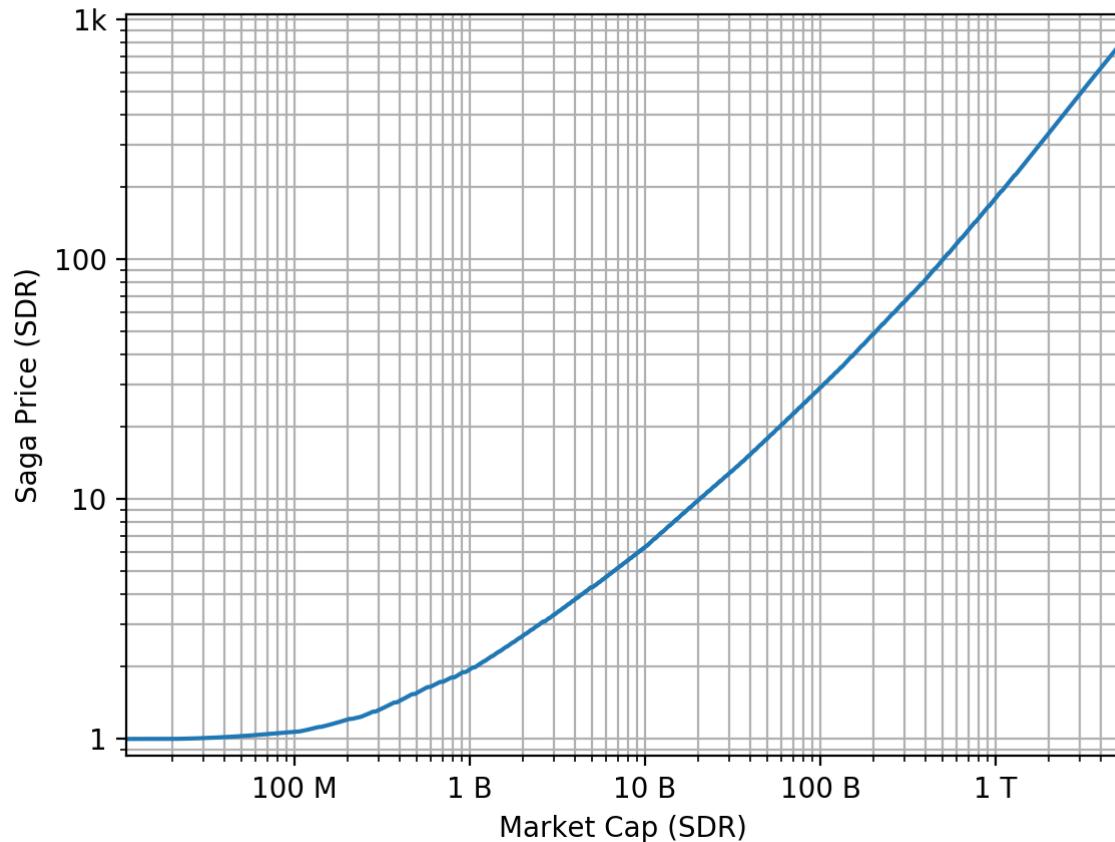
Market cap is shown on a logarithmic scale



Pricing Function

We now show how the price of SGA increases as Saga's economy grows. The pricing function was calculated to create the exact behaviour in the reserve ratio shown in Figure 4.

Figure 5: SGA price as a function of SGA market cap



The following table contains an overview of Saga's model.

Table 1: Key features of Saga's economy at various market cap milestone.

Market Cap	SGA Price	Reserve Ratio	Total Funds in Reserve
(SDR)	(SDR)	%	(SDR)
100 M	1.1	94%	94 M
200 M	1.2	87%	173 M
300 M	1.3	79%	237 M
400 M	1.4	73%	293 M
500 M	1.6	69%	345 M
700 M	1.7	63%	442 M
1 B	2.0	58%	580 M
1.5 B	2.3	53%	799 M
2 B	2.7	50%	1.0 B
3 B	3.3	45%	1.4 B
4 B	3.8	42%	1.7 B
5 B	4.3	40%	2.0 B
10 B	6.3	34%	3.4 B
50 B	18.0	27%	13.4 B
100 B	29.3	23%	23.3 B
200 B	48.7	21%	41.7 B
500 B	99.9	18%	90.2 B
1 T	180.4	14%	142.5 B
2 T	334.6	11%	227.4 B
3 T	487.3	10%	300.0 B
5 T	771.8	10%	500.0 B

Reserve Ratio, Volatility & Growth

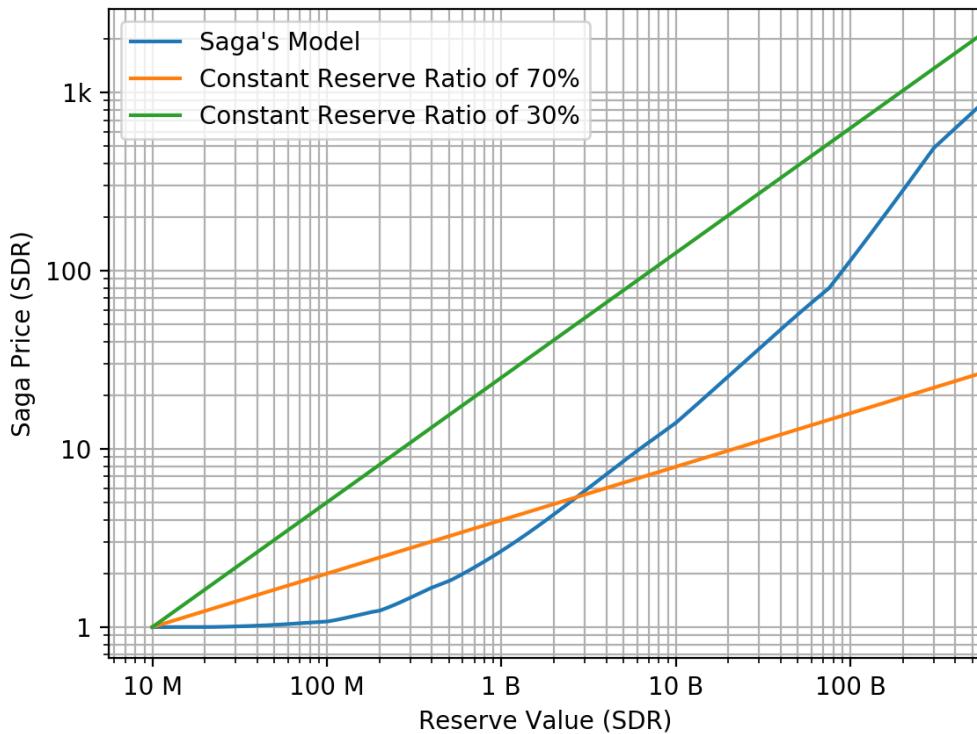
The Saga Contract moderates the growth of SGA price. We claimed above that the reserve ratio gives a heuristic of the extent to which the Contract provides resistance to price change. When the model maintains a high reserve ratio, volatility and growth are discouraged; when the model maintains a low reserve ratio, SGA price is more open to volatility and growth.

Saga's model keeps a high reserve ratio during the early stages of the economy, in order to aid price stability. As Saga's economy progresses, a lower reserve ratio is maintained, to allow faster growth.

The following figure compares SGA price growth of Saga's model, to price growth of alternative models that employ constant reserve ratios.

Figure 6: Price growth of Saga's model & two models that employ a constant reserve ratio

The model that keeps a constant 'low' reserve ratio exhibits the fastest price growth. The model with a 'high' reserve ratio exhibits slower growth. In Saga's model, price growth is variable: at the beginning, growth is slow in order to encourage stability; as Saga's economy grows our model reduces its resistance to price movement.



A good way of measuring sensitivity of SGA price to market volatility is to measure how much money must be injected into – or removed from – the Reserve in order for SGA price to move. Table 2 gives the sensitivity of SGA price at a selection of different market caps.

Note that as Saga's economy grows and the model employs a lower reserve ratio, SGA price becomes more sensitive to change in *relative* terms – a smaller percentage change in the Reserve value gives rise to the same percentage price change.

However, since the Reserve becomes larger as the economy grows, it actually becomes harder to move SGA price in terms of the *absolute* amount of capital needed.

In other words, when the economy is large, the sheer size of the Reserve protects SGA price from volatility. We can allow the model to employ a smaller reserve ratio in order to give market forces a greater role in determining SGA price.

Table 2: Changes in Reserve needed to change SGA price by 1% & 10%

Market Cap	Reserve Value	SGA price	Reserve ratio	Relative Change in Reserve needed to increase SGA price by:		Amount of capital needed to increase SGA price by:	
				1%	10%	1%	10%
(SDR)	(SDR)	(SDR)	(%)	(%)	(%)	(SDR)	(SDR)
100 M	94.3 M	1.07	94%	10.3%	67.2%	10 M	63 M
500 M	345 M	1.56	69%	2.2%	25.3%	8 M	87 M
1 B	580 M	1.95	58%	1.9%	19.1%	11 M	111 M
5 B	2.00 B	4.30	41%	1.4%	13.8%	27 M	276 M
10 B	3.36 B	6.32	34%	1.3%	13.5%	45 M	455 M
50 B	13.4 B	17.96	27%	1.2%	11.6%	154 M	1.55 B
100 B	23.3 B	29.28	23%	1.1%	11.4%	266 M	2.67 B
500 B	90.2 B	99.91	18%	0.79%	7.8%	711 M	7.02 B
1 T	143 B	180.34	14%	0.76%	7.5%	1.09 B	10.7 B

8. SHRINKING ECONOMY

Every time Saga's economy reaches a new 'Genesis Minting Point' (hereafter GMP), the Contract mints SGA tokens for SGN holders. The process is not reversible – if Saga's economy subsequently shrinks back through the GMP, the SGA tokens are not burned. Consequently, a new pricing model must be used – the economy cannot shrink in the exact same manner it grew.

The new model must satisfy the basic mathematical constraints that we presented in Chapter 5. An additional constraint also applies here: the new model must be consistent with the old. The amount of money in the Reserve when the economy reaches the GMP should be precisely the correct amount required to buy back all SGA tokens under the new model.

Mathematically, this constraint can be expressed as follows. If the previous pricing function was $P(N)$, and our new pricing function is $P'(N)$, then the following relation must hold:

$$\int_0^N P(m) dm = \int_0^{N+n} P'(m) dm$$

where N is the number of SGA tokens in circulation at the GMP, and n is the number of SGA tokens minted.

As long as we respect these constraints, in theory, we may design the new pricing function in any manner we choose.

Shrinking Economy Framework

Recall we designed the 'base pricing model' – the model that dictates how Saga's economy grows – by focusing on the behaviour of the reserve ratio function. Recall also that the reserve ratio function fully determines the entire pricing model.

When designing models for a shrinking Saga economy, we again focused on determining the reserve ratio function. We did so with reference to the original, 'base' function.

Our approach: the reserve ratio function for a shrinking economy should be higher than in the base model. Indeed, the reserve ratio is a measure of how much market trust Saga's economy has earned; an economy going through a recession enjoys less trust than a growing economy of the exact same size. In addition, a higher reserve backing provides extra support to Saga's shrinking economy – this should alleviate panic and help stimulate a recovery.

The approach we took is as follows:

Consider a GMP.

- Let r_{min} denote the value of the reserve ratio immediately after the GMP.
- Let $r_{base}(R)$ be the value of the reserve ratio in the base model when the Reserve value was R SDR.
- Let $r_{shrinking}(R)$ be the value of the reserve ratio in the new model, at this same point.

Saga's model employs the following formula for $r_{shrinking}(R)$:

$$r_{shrinking}(R) = r_{base}(R) + (1 - r_{base}(R)) \cdot \frac{r_{base}(R) - r_{min}}{1 - r_{min}}$$

Notes:

1. The rightmost term is always positive, so $r_{shrinking}(R) \geq r_{base}(R)$ – i.e. the reserve ratio when the economy shrinks is always at least as large as when the economy grew.
2. The term $(1 - r_{base}(R)) \cdot \frac{r_{base}(R) - r_{min}}{1 - r_{min}}$ can be thought of as the amount of trust lost in Saga's economy. It is proportional to how far the economy has shrunk since its high-water mark.

Figures 7-10 below give an illustration of what happens at a Minting Point, and what happens if the economy begins to shrink afterwards.

Figure 7: Illustration of SGA price around a GMP

The economy grows along the blue line until it reaches a GMP. At this point, new SGA tokens are minted. If the economy now begins to shrink it cannot shrink backwards along the blue line – the SGA tokens minted at the GMP cannot be un-minted. Instead, the economy shrinks along the green line.

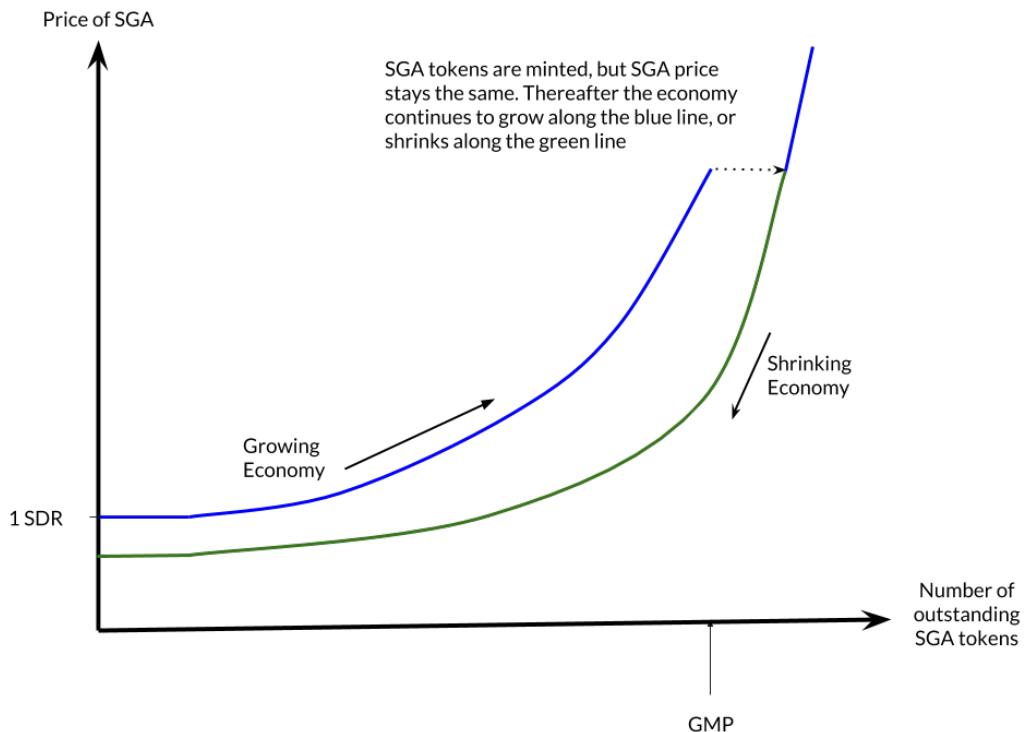


Figure 8: Price of SGA in several shrinking economy models,
at various high-water marks (HWM) of Saga's economy

The blue line indicates how the price of SGA increases when the economy grows. The orange line shows how the price of SGA drops if the economy begins to shrink having reached a high-water mark market cap of 1 billion SDR. And so on.

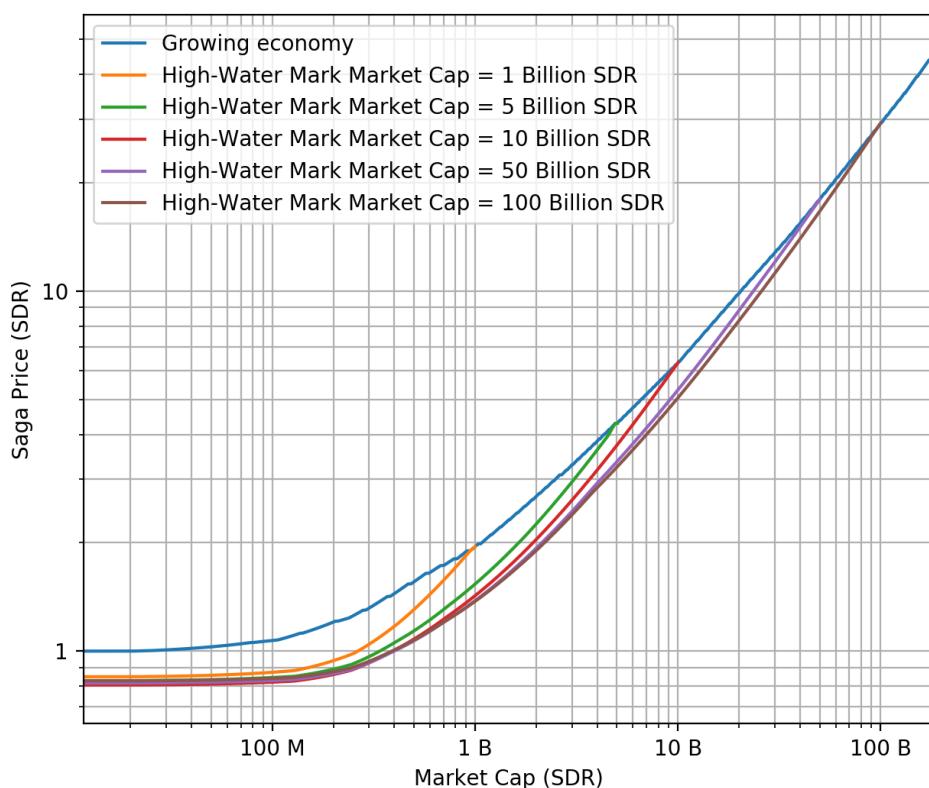


Figure 9: Illustration of Reserve Ratio around a GMP
 When the economy shrinks, the reserve ratio is higher than it was when the economy grew. This counter-cyclical factor acts to stabilise the Saga economy, discouraging any herding behaviour or a run on the bank scenario.

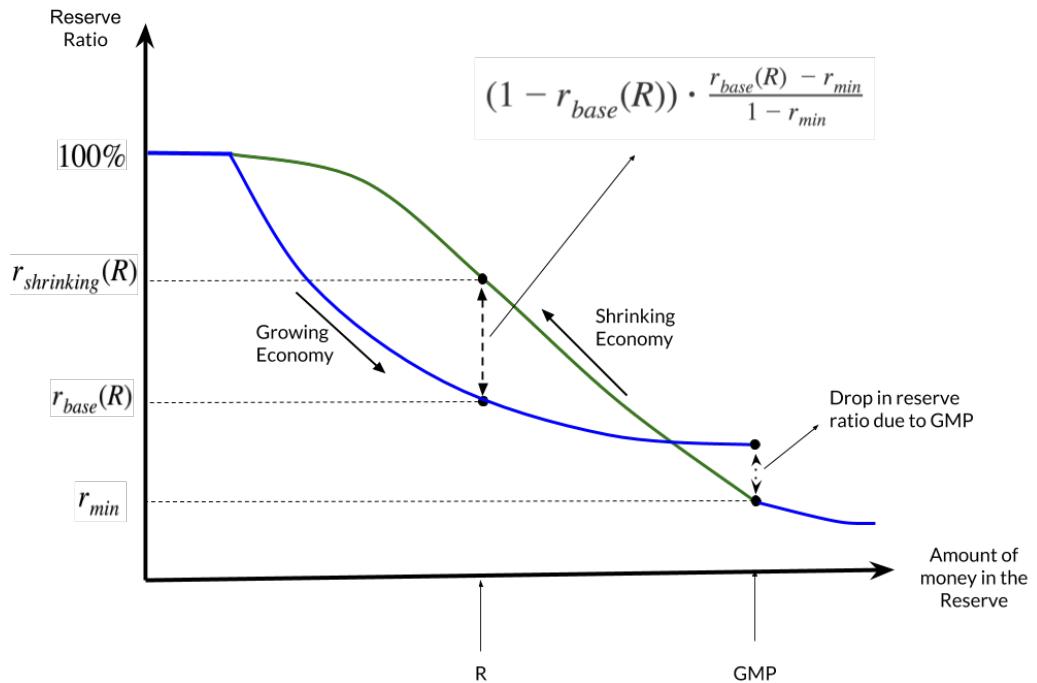
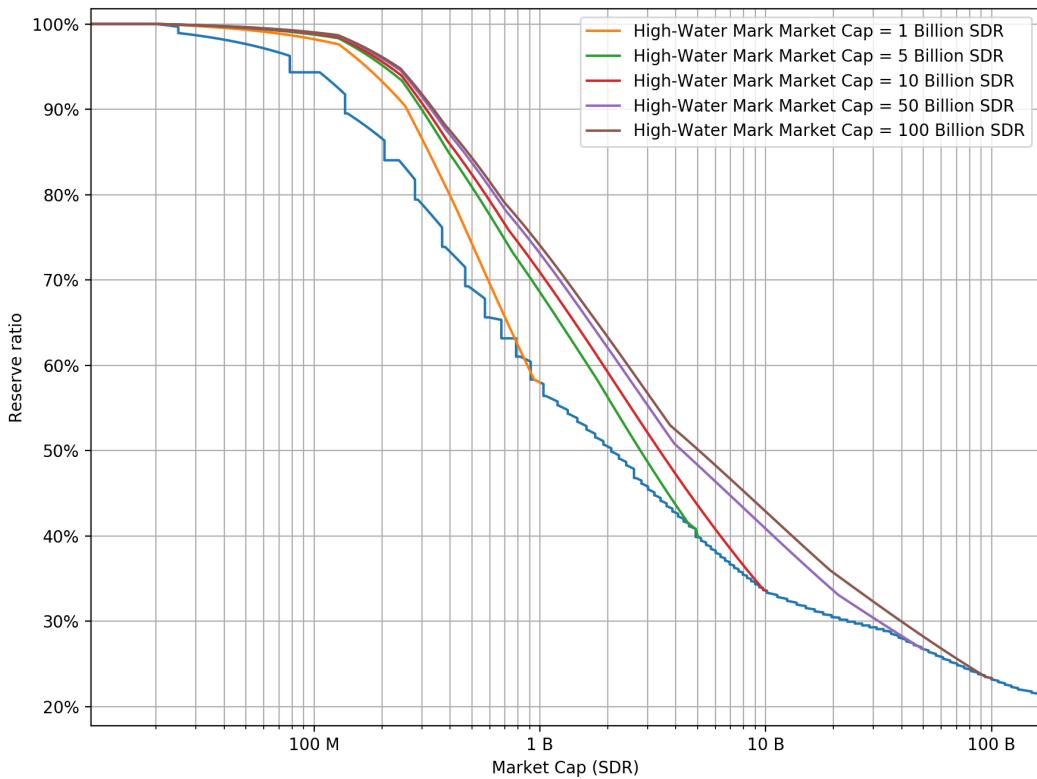


Figure 10: Reserve Ratio function of various shrinking economy models



9. PRICE ADJUSTMENT

Until now, we have described Saga's model in its pure, theoretical setting, with little reference to how it is actually implemented. In the following chapters we describe our approach to translating the pure model into a framework that operates in the real world.

The issue we address here is the deviation of the Reserve value from the model's assumption. Saga's model assumes the Reserve is strictly composed of the net proceeds from selling SGA. In practice, however, the Reserve would have other sources of income and expenses, not taken into account by the model.

Primarily, these include:

1. Accrued interest. The Reserve fund will be held in major regulated banks in liquid, low-risk assets that pay interest. The accrued interest is added to the Reserve fund.
2. Reserve management costs. Direct costs of holding the Reserve – e.g. bank commissions and blockchain transaction costs – are paid for by the Reserve fund itself.
3. Revenue from the bid/ask price band. See next Chapter.

Therefore, at any given moment, there is a likely to be a divergence between what our model thinks the value of the Reserve is, and what the value of the Reserve actually is. We denote these two values as R_{model} and R_{actual} respectively.

Pricing Saga should be based on the *actual* value of the Reserve. For example, if the Reserve accrues interest, the price of SGA should rise accordingly so owners of SGA benefit from the 'time value of money' – otherwise Saga's usefulness as a store of value would be compromised.

Therefore, when implementing the Saga model, the price employed by the Contract is the price given by the model, multiplied by the ratio between R_{model} and R_{actual}

$$\text{In other words, } P_{actual} = \frac{R_{actual}}{R_{model}} \cdot P_{model}$$

Note the reserve ratio remains constant, since both SGA price and the Reserve have changed by the same factor.

10. PRICE BAND

Introduction & Motivation

We have described how we built a model where the Contract completely determines SGA value by offering to buy and sell SGA at the same price.

However there are substantial advantages to allowing SGA price to fluctuate without the Contract always intervening.

In practice therefore, Saga's Contract does not fully determine a single price for SGA, but rather determines a price band. The Contract offers to buy and sell SGA at different prices: it sells SGA at a price, P_{ask} , and buys back SGA at a lower price, P_{bid} .

There are several benefits to this mechanism:

1. Opening SGA to the free market:

If the Saga Contract bought and sold SGA at the same price, most trading activity would happen with the Contract. As market demand for SGA rises or falls, participants would approach the Contract to buy or sell SGA, causing a rise or fall in the supply of SGA.

However, it makes no sense that the supply of SGA should rise and fall with every whim of the market.

Applying the price band framework, the supply of SGA does not change with every change in SGA holdings. Instead, Saga's model defines a range in which it is deemed acceptable for SGA price to vary. SGA is free to rise and fall within this band according to market forces. Only when SGA price moves significantly, deviating from the band, will the Saga Contract step in and take measures to slow down price movements.

2. Reducing operational costs:

In a model without a price band, most buying and selling of SGA occurs with the Contract.

However, in order to change the supply of SGA, the Contract must perform a currency conversion – since Saga keeps its Reserves denominated in SDR while payments are received in other forms.

Performing currency conversions each time there is a fluctuation in market demand for SGA is expensive and cumbersome. These costs must be borne by someone; either by market participants, or by the Reserve fund – in which case it is borne by all SGA holders via the price adjustment mechanism described in the previous chapter.

On the other hand, with a price band framework, most trading activity will not involve the Contract, as commercial exchanges are likely to offer smaller bid/ask spread. In preference, the secondary market provides the majority of SGA liquidity, drastically reducing the number of currency conversions.

3. The Reserve accrues income from the price band:

Consider a scenario in which the market price of SGA rises to the top of the price band, before falling to the bottom. When the market price was at the top of the band, market participants bought SGA from the Contract at price P_{ask} . When market price was at the bottom of the band, market participants sold SGA back to the Contract at the lower price P_{bid} . The Saga Reserve thus gained the difference, $P_{ask} - P_{bid}$, on every SGA token bought and then sold.

Why is this positive?

Recall that all profits of the Reserve fund are returned to SGA holders through an increase in the value of their SGA, as described in the previous chapter.

This is consistent with our general approach. Throughout this paper we stressed the wish to protect SGA holders against volatility in SGA price. The price band mechanism means that – if volatility does develop – market players pay the cost of the bid/ask spread, and long-term SGA holders are compensated for the volatility through an increase in the value of their SGA.

4. Finally, the price band gives an added layer of protection against market manipulations, such as front-running by blockchain miners:

Indeed, any strategy that attempts to make money buying and selling SGA tokens through the Contract is immediately weakened by the bid/ask spread.

Consequences of the Price Band

We have explained our motivations for including two separate prices in Saga's model – the ask price and the bid price.

The material presented in previous chapters still applies; the pricing model from previous chapters determines the mid price of SGA – the average of the Contract's ask and bid prices.

In reality, SGA price in secondary markets can fluctuate within a price band around this value. The extent to which price can fluctuate before the Contract steps in to limit price movement is determined by the width of the price band.

Price Band Width

We define the width, w , of the Contract's price band to be the distance between the ask price and the mid price, given as a percentage of the mid price.

Under this definition, the Contract's ask price is $P_{ask} = P_{mid} \cdot (1 + w)$; and the bid price is $P_{bid} = P_{mid} \cdot (1 - w)$

For example, if the model's mid price is 100 SDR and the width of the price band is $\pm 7\%$, then the Contract's ask price is 107 SDR and the bid price is 93 SDR.

The width of the price band is a measure of how much SGA price is allowed to fluctuate in the market before the Contract intervenes.

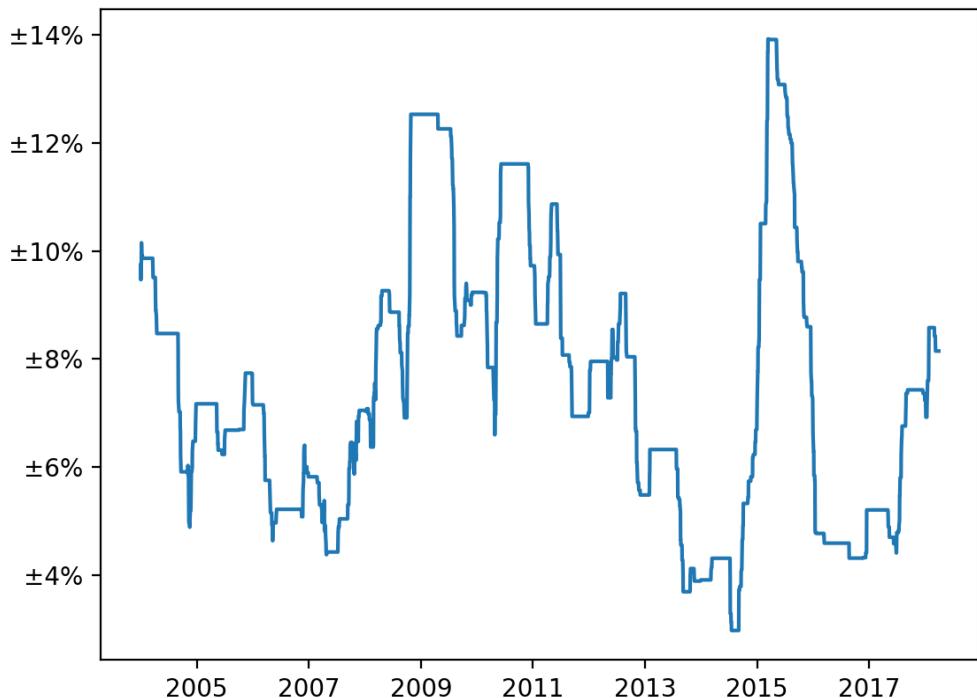
We had several considerations for determining the width of the price band.

- When Saga's economy is small the width should be minimal: just enough to cover operational costs for trading with the Contract.

When Saga's economy is in the earliest stages of its development we want the Contract to fully control the price of SGA. Moreover, secondary market liquidity is likely to be limited. We determined the Contract should employ a price band of width $\pm 0.15\%$ at this stage, on par with fees charged by major exchanges.

- The width of the price band should increase as Saga's economy grows. As the market cap of SGA grows we wish to give the secondary market a greater role in determining price.
- The maximum value of the price band width, when Saga's economy has reached first-rank prominence, should allow SGA price fluctuations similar to those of major fiat currencies. We chose a value of $\pm 15\%$. This is supported by two observations:
 - A criterion for countries to join the Eurozone is that their currency remains within a 15% band around a targeted Euro exchange rate value for at least two years.⁶
 - Having studied exchange rates of several major currencies, we found that 1-year price fluctuations lay within a 15% band even in times of exceptional crisis (e.g. 2008 financial crisis).

Figure 11: Width of fluctuations in EUR-USD Exchange Rate over a rolling 250 market day period



Price Band Width Framework

⁶ https://ec.europa.eu/info/business-economy-euro/euro-area/enlargement-euro-area/introducing-euro-adoption-fixed-euro-conversion-rate/erm-ii-eus-exchange-rate-mechanism_en

We modelled the width of the price band to grow inversely to the reserve ratio; the more the market gives trust to Saga's economy (i.e. reserve ratio is lower), the greater the market role in determining SGA price (i.e. price band is wider).

Opening up SGA price discovery to secondary markets requires these markets be both active and liquid. The model maintains a minimal bid-ask spread, until this is the case.

When an active secondary market is established, the width of the price band can begin to increase, allowing the Saga economy to enjoy the benefits outlined above.

Commensurate with other existing cryptocurrencies, we (conservatively) assume a well-established secondary market for SGA will develop by the time SGA market capitalisation reaches 1 Billion SDR (1.4 Billion USD). If a secondary market has not yet been established by that point, the Saga Foundation can delay the widening of the price band.

The width of the price band in Saga's model is defined as follows:

$$w = 0.15\% \quad \text{when market cap of SGA is smaller than 1 billion SDR}$$

$$w = \frac{c_1}{r} + c_2 \quad \text{when market cap of SGA is greater than 1 billion SDR}$$

Where r refers to the value of the reserve ratio and c_1 and c_2 are constants that ensure the width of the price band is $\pm 0.15\%$ when the market cap of Saga is 1 billion SDR, and that the width reaches its maximum value of $\pm 15\%$ when the reserve ratio reaches its minimum value of 10%.

Table 3: Price-Band Width at various points in Saga's model

Market Cap (SDR)	Price-Band Width (%)	Reserve Ratio %
< 1 B	$\pm 0.15\%$	100 - 58.0%
3 B	$\pm 0.97\%$	45.8%
10 B	$\pm 2.4\%$	33.6%
30 B	$\pm 3.2\%$	29.3%
100 B	$\pm 4.7\%$	23.3%
300 B	$\pm 6.0\%$	20.0%
1 T	$\pm 9.6\%$	14.3%
> 3 T	$\pm 15.0\%$	10%

Figure 12: Width of Price Band in Saga's model

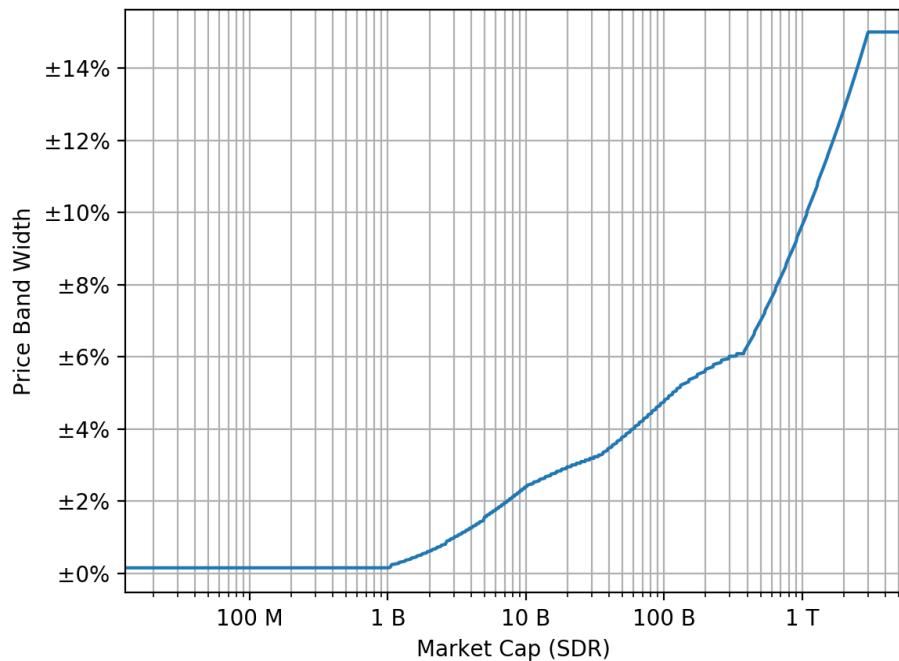


Figure 13: Bid and Ask Prices of Saga's model

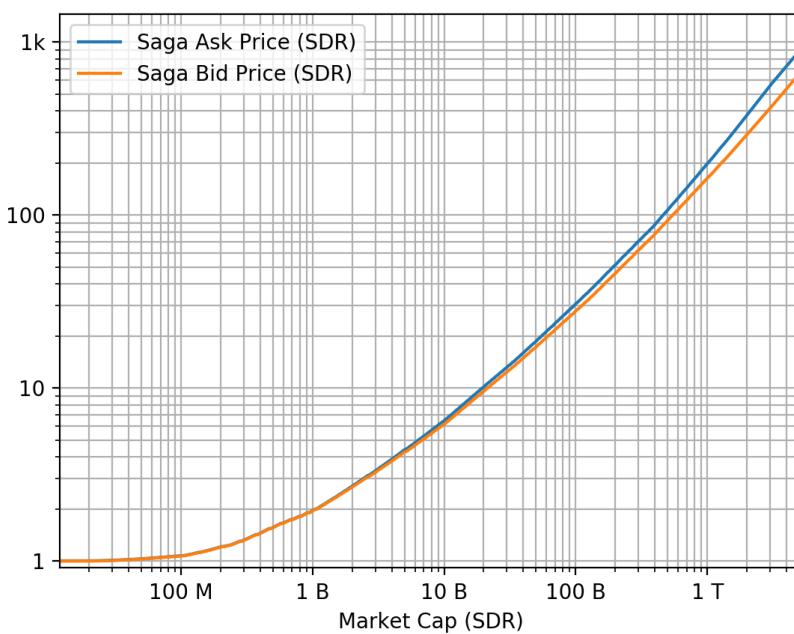
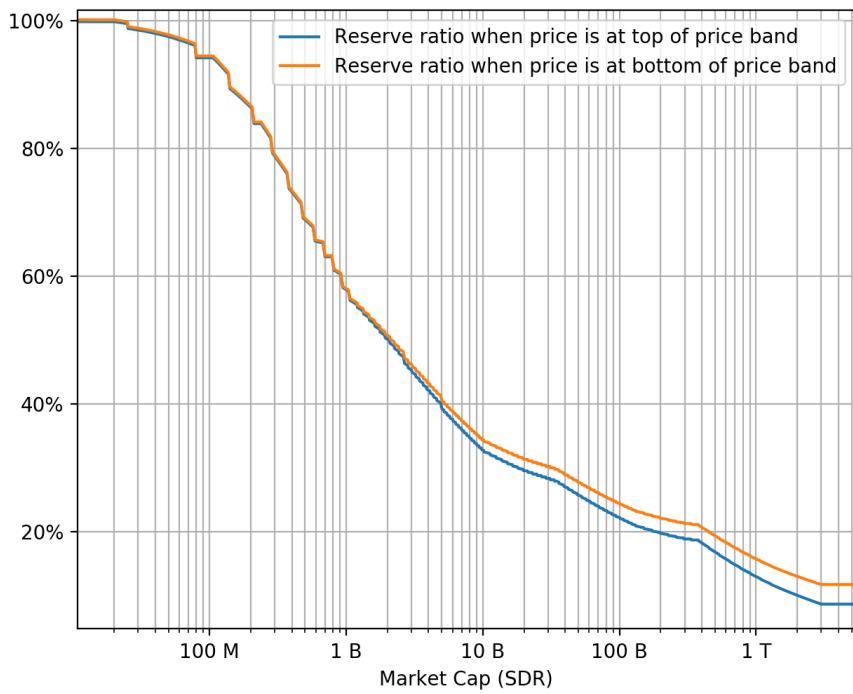


Figure 14: Reserve ratio band



11. OPERATING ON THE BLOCKCHAIN

Working with ETH

We implement code-based elements of our monetary model as a smart contract on the Ethereum blockchain network, as opposed to running on private servers. The crucial and sensitive nature of the topics involved – the ability for the market to control SGA supply, and the relation between SGA supply and SGA price – calls for a decentralised implementation. Decentralisation guarantees complete transparency, assuring holders of SGA that our model is actually carried out as described, and that there is no private body that has the ability to manipulate or change the model.

Our model uses the IMF's SDR as its unit of account, but there is no way of sending SDR over the Ethereum blockchain at this time. Indeed, there is no way of sending any fiat currency over any blockchain.

Consequently, when implementing Saga's liquidity provision model, money is transferred to and from the Contract in the form of ETH, Ethereum's native currency. Participants that wish to buy SGA send ETH to the Contract; and participants that sell SGA back to the Contract are reimbursed in ETH.

The model still operates based on the SDR: when participants send ETH to the Contract to buy SGA, the Contract calculates the value of the ETH in SDR⁷ and generates SGA accordingly; when participants sell SGA, the Contract calculates how much SDR the seller should receive and sends the equivalent amount⁸ in ETH.

Balancing Liquidity & Risk

In order to provide immediate liquidity to sellers of SGA, the Contract keeps an amount of ETH on hand in a *liquidity buffer*. All other ETH received by the Contract is converted into fiat, and deposited in Saga's Reserve.

When participants sell SGA to the Contract, ETH is withdrawn from the liquidity buffer to reimburse the seller. If ETH levels in the liquidity buffer fall below a defined threshold, fiat is withdrawn from the Reserve, converted into ETH, and sent to replenish the liquidity buffer.

There is an inherent tradeoff here: in order to provide immediate liquidity, ETH must be kept in the liquidity buffer. On the other hand, keeping part of the Reserve in ETH exposes the Reserve – and thus SGA price – to fluctuations in ETH price.

We intend to keep Saga's liquidity buffer at a level sufficient for the Contract to provide liquidity under 'normal' market conditions, while the majority of the Reserve will be kept in SDR.

During times of high volume of selling SGA, the liquidity buffer may be depleted faster than we can top it up. The Ethereum network, and consequently Saga's smart contract, works 24-7, while withdrawals from bank accounts are limited to banks' business hours.

⁷ According to the ETH/SDR exchange rate offered to Saga by its currency exchange providers

⁸ According to the SDR/ETH exchange rate offered to Saga by its currency exchange providers

To mitigate some of this gap, we work with a number of liquidity providers that will allow us to acquire ETH even during off-hours. However, the amount these providers can supply without further deposits from banks is limited.

Under exceptional market conditions, it is possible that participants will want to sell SGA to the Contract and the liquidity buffer will not have enough ETH to reimburse them immediately. In such cases, participants may still sell SGA back to the Contract, and will enter a queue to be reimbursed once the liquidity buffer has been topped up. Reimbursement of ETH is done on a first-in-first-out basis.

The queue stores obligations in terms of SDR, not ETH. When the liquidity buffer is topped up, ETH is sent to participants in the reimbursement queue according to the current SDR-ETH exchange rate. Thus, whilst waiting for reimbursement, participants are not exposed to the value of ETH nor to the value of SGA, but only to our unit of account, the SDR.

The introduction of an ETH redemption queue clearly impairs the ability of SGA holders to sell SGA immediately, and therefore diminishes Saga's promise of liquidity. However, we consider this mechanism to be best-possible under the circumstances, as it mitigates the other risk of exposure to ETH value fluctuations.

Protection Against Front-Running

A consequence of operating on a public blockchain is that requests to trade SGA with the Contract are publicly visible, even before they are executed. Moreover, orders are not necessarily executed in the order they are made. This exposes Saga to the problem of *front-running*.

Since our model sets the price of SGA according to the number of SGAs in circulation, buy transactions result in an increase in SGA price, while sell transactions result in a decrease in SGA price. If a large transaction request is made, other players could capitalise on the knowledge about future price changes by submitting a similar request that they hope will be carried out before. If they are successful, after the original order transaction is executed, attackers can close their position with an assured gain.

The result is that the original participant receives a less favourable price than otherwise.

Front-running can be done by blockchain miners or non-miners alike, and is a problem that affects many blockchain-based projects.

Our price band provides some protection against front-running. Given that participants buy SGA at the model's ask price and sell SGA at the lower, bid price, a front-run will only be profitable against orders that are large enough to cause a change in SGA price wider than the price band.

For example, an order to buy SGA will only be susceptible to a front-running attack if it is large enough to cause the Contract's bid price to rise above the previous ask price.

The fact that we designed the width of Saga's price band inversely to the reserve ratio means that SGA participants are always protected to some extent from front-running: either by a high reserve ratio or by a wide price band:

When the SGA economy is small, the price band is narrow. But the reserve ratio is high. So SGA price is resistant to change, and large transactions are needed to move price through the price band.

When the economy is larger, the reserve is low and SGA price is more susceptible to change. But this is precisely the stage when the price band is wide, so large transactions are still needed to create a price change larger than the width of the price band.

The following table gives the sizes of transaction that make front-running attacks profitable at various stages in Saga's economy.

Table 4: Susceptibility to Front-Running at various points in Saga's model⁹

Market Cap (SDR)	Price-Band Width (%)	Reserve Ratio (%)	Size of Order Susceptible to Gaming	
			(SDR)	(% of Reserve)
100M	±0.15%	94.3%	4.9 M	5.15%
300M	±0.15%	79.0%	1.8 M	0.74%
1 B	±0.15%	58.0%	3.3 M	0.57%
3 B	±0.97%	45.8%	39 M	2.83%
10 B	±2.4%	33.6%	198 M	5.91%
30 B	±3.2%	29.3%	729 M	8.30%
100 B	±4.7%	23.3%	2.3 B	9.66%

⁹ When SGA market cap is below 1B SDR, the price band remains constant though the reserve ratio decreases. Price is more amenable to change: a smaller percentage of the overall reserve is required to move SGA price across the price band.

12. STANDALONE ECONOMY

Saga's reserve-based model sets the price of SGA in terms of our Reserve currency – the SDR. This means SGA's purchasing power is related to the purchasing power of SDR: if SDR weakens or strengthens relative to some other unit of account, then the Reserve-backed value of SGA weakens or strengthens in a similar manner.

While Saga's economy is developing, basing its value on a Reserve denominated in SDR is beneficial; the currencies that make up the SDR are established and widely trusted units of account on which to base our nascent currency.

However, at some point, if Saga's economy continues to grow, it will no longer make sense to value SGA in terms of SDR. If Saga's market cap reaches into the trillions, Saga itself would be highly established and no longer require support from the SDR. At this stage, Saga can take a 'life of its own' where it is not directly affected by rises and falls in the value of the Reserve.

Hence, at some stage, the reserve-based pricing model should be dropped in favour of a different model.

Setting the behaviour of a global digital currency of first rank prominence, when we are so far from this, is an impossible task. We do not presume to describe a world so different from today. Instead, we present a 'default' behaviour for how Saga's currency will behave should it reach this stage. The default behaviour can be revised by the community¹⁰ if it turns out to be sub-optimal.

This default behaviour is to set a hard cap on the supply of SGA tokens.

Above this cap, the Contract does not mint new SGA tokens. However SGA tokens can always be sold back to the Contract under the original pricing model. If this occurs, the Contract will continue to re-issue SGA tokens until the hard cap is once again reached.

Effectively, the Saga Contract ceases to be a liquidity provider for both buying and selling SGA tokens and only offers to buy SGA from the market. Thus, the Contract sets a floor for the price of SGA in terms of the SDR, but not a ceiling.

We chose the hard cap to occur when Saga's market cap reaches 5 trillion SDR (~7 trillion USD). At this stage the model's bid price is 656 SDR.

From this point onwards, SGA price can increase freely in the secondary market, effectively detaching SGA value from the Reserve.

The Contract still provides a floor for the price of SGA. If the price of SGA in secondary markets ever falls below 656 SDR, participants will sell SGA back to the Contract. The original pricing model will then kick back into action.

Thus, once the hard cap has been reached, SGA price is still supported by its Reserve but is no longer constrained by it.

¹⁰ The Saga foundation has established a research institute with the goal of laying the framework for such future decision making.

APPENDIX A: THE PARAMETERS USED TO BUILD SAGA'S MODEL

In this paper, we detailed our aims and motivations in designing Saga's monetary model, and the conclusions we reached. There were four main frameworks we had to design:

1. The behaviour of the reserve ratio function, for a growing economy
2. Saga Genesis Minting Points
3. The reserve ratio in a shrinking economy
4. The width of the price band

Details of the last two frameworks – the shrinking economy and the price band width – were already given in full in the paper above.

Below, we provide the full details of exactly how we built the first two frameworks – the reserve ratio function for a growing economy, and Genesis Minting points – and the parameters used.

Note the model we describe here determines the mid price of the Contract's ask and bid prices – the ask and bid prices themselves are determined by the mid price and the width of the price band.

1. The Reserve Ratio Function

The general framework for Saga's reserve ratio model is:

- The reserve ratio should remain at 100% until a certain threshold in market cap is reached.
- Until this threshold, SGA price remains fixed at 1 SDR.
- Afterwards, the reserve ratio decreases piecewise linearly in accordance with the number of SGA in circulation.
- The reserve ratio decreases to a minimum of 10%, then stays at 10% thereafter.

We consider the amount of money in the Reserve as the best measure of Saga's success, so we designed the model using that as the main independent variable.

We built the reserve ratio function as follows:

There were several points we wished the function to go through. We call these points 'target points'. More precisely, a target point is a target of the form: "We would like the reserve ratio to be $x\%$ when the Reserve reaches a value of $y \text{ SDR}$ ".

For example, the first target point was: "The reserve ratio should stay at 100% until 20M SDR has been put in the Reserve."

The next target was: "The reserve ratio should reach 95% when the Reserve value reaches 100M SDR."

In the interval between these two target points, the reserve ratio decreases linearly from 100% to 95%. We calculate exactly what the rate of decline should be so that, if nothing changes, the value of the Reserve will be 100M SDR when the reserve ratio reaches 95%. In other words, we calculate exactly what the slope of the reserve ratio function should be, so that we hit our second target exactly.

The only complication: when a Genesis Minting Point occurs, the reserve ratio drops artificially due to the minting of new SGA tokens – i.e. the reserve ratio function is momentarily knocked off course. Therefore, we re-calibrate the slope of the reserve ratio function to continue to aim for the next target point.

Target points used for our model:

Target Point No.	0	1	2	3	4	5	6	7
Reserve Size (SDR)	0	20 M	100 M	200 M	500 M	10 B	75 B	300 B
Reserve Ratio	100%	100%	95%	85%	65%	30%	20%	10%
Market Cap (SDR)	0	20 M	105 M	230 M	770 M	33 B	375 B	3 T

The calculation to find the slope of the reserve ratio in a particular interval, i , is as follows:

Let us denote the number of SGA in circulation, the reserve ratio, and the value of the Reserve at the beginning of the interval as N_0 , r_0 and R_0 respectively.

Let the next target be that the reserve ratio should equal r_1 when the Reserve value equals R_1 .

Let N_1 be the number of SGA tokens in circulation when the target point is achieved at the end of the interval.

Let α_i , β_i be the parameters that determine the shape of the reserve ratio function in interval i – so the reserve ratio during the interval is given by $r = \alpha_i - \beta_i N$

Note that N_1 , α_i , and β_i are not yet known. We can find their values by solving the following three equations:

$$1. \ r_0 = \alpha_i - \beta_i N_0 \quad (\text{reserve ratio is } r_0 \text{ at the beginning of the interval})$$

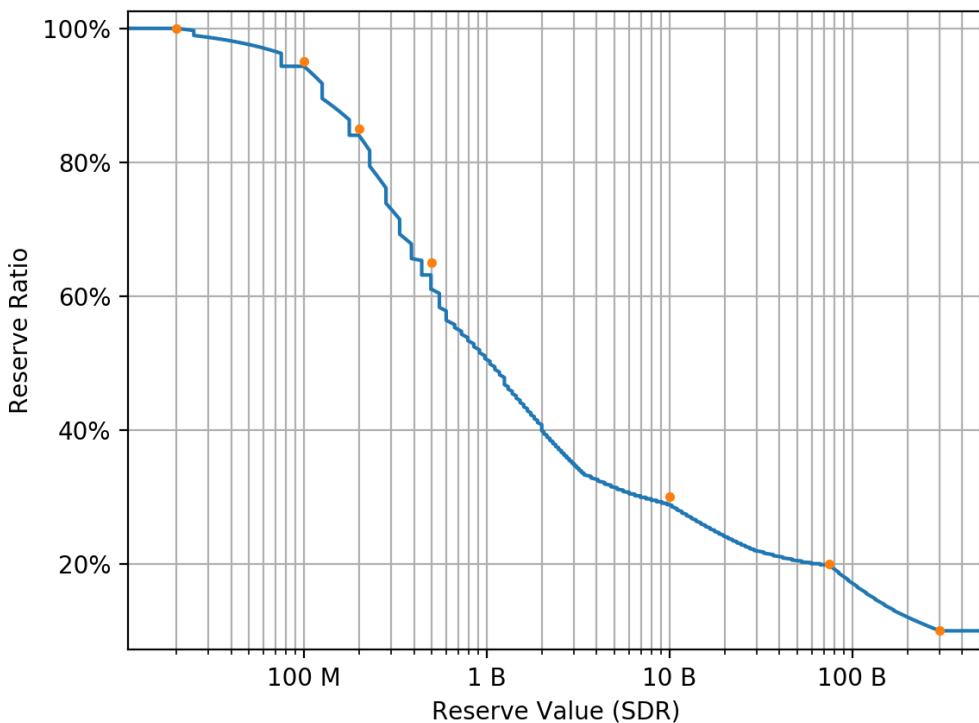
$$2. \ r_1 = \alpha_i - \beta_i N_1 \quad (\text{reserve ratio is } r_1 \text{ at the end of the interval})$$

$$3. \ R_1 = R_0 \cdot \left(\frac{N_1 \cdot r_0}{r_1 \cdot N_0} \right)^{1/\alpha_i} \quad (\text{Reserve amount is } R_1 \text{ at the end of the interval}^{11})$$

It is possible – due to drops in the reserve ratio that occur at Genesis Minting Points – that the value of the reserve ratio could be slightly *below* the next target value. In other words, it is possible for the reserve ratio to decrease below the target value r_1 before the Reserve value reaches R_1 . In this case we keep the reserve ratio constant until the Reserve value reaches R_1 .

¹¹ Using the equation for R as a function of N that was derived in the Paper (note that in the Paper, the constants R0, N0 and r0 were all subsumed into the constant omega).

Figure A.1: Reserve ratio as a function of the Reserve value,
with the model's target points superimposed in orange



2. Saga Genesis Minting Points

Saga Genesis Minting Points are where the Contract mints SGA tokens for SGN holders, with no increase to the Reserve.

The general framework and aims that we detailed above were:

- Overall, 15 SGA tokens should be minted for each SGN token.¹²
- The minting of these tokens should be done step-by-step as the economy grows.
- The number of tokens minted at each Minting Point should be ‘reasonable’; it should balance the aims of providing sufficient return for SGN holders, with the requirement that impact to Saga’s pricing model be minimised.
- We should ensure that SGA tokens minted for SGN holders do not represent a significant proportion of the total SGA economy.

There were two aspects we needed to design:

- A. The location of each Genesis Minting Point
- B. The number of SGA tokens generated at each Minting Point

A. Location of each Genesis Minting Point

¹² Note: there are 107 million SGN tokens in total.

Recall that if a Minting Point occurs when there are N SGA tokens in circulation, and if n new tokens are minted, then the reserve ratio decreases by a factor of $(1 - \frac{n}{N+n})$

The fraction $\frac{n}{N+n}$ is a measure of the extent to which a Minting Point impacts Saga's economy.

In general, the later we can put off Minting Points the better – since if N is larger, the effect to the economy will be smaller. Therefore, we aimed to have as few minting points as possible, while also acknowledging the need to provide an adequate rate of return for SGN holders.

We set the first Genesis Minting Point to occur when the Reserve value reaches 25M SDR.

When designing the location of the other Genesis Minting Points we used two parameters: *abs_step* and *rel_step*.

If the previous Genesis Minting Point occurred when the Reserve value was R_0 SDR, then the next minting point occurs once the Reserve has increased by $abs_step + R_0 \cdot rel_step$ SDR.

We used these parameters to ensure that, in order to reach the next Minting Point, Saga's economy must grow significantly – both in relative and in absolute terms.

B. Number of SGA tokens generated at each Minting Point

Once we have decided the location of a Minting Point, we need to decide how many SGA to mint.

In addition to our aim of having a balanced rate of return for SGN holders, we want to make sure that SGN holders do not control a significant proportion of the SGA economy. Therefore, we mint SGA tokens in reference to the number of SGA tokens already in circulation.

For this we used a parameter, *minting_factor*.

If there are M SGA tokens in circulation at a Minting Point - not counting SGA tokens that were themselves minted for SGN holders – then we mint a further $M \cdot minting_factor$ tokens.

The *minting_factor* parameter helps control the percentage of Saga's economy that SGN holders own – so that early backers do not swamp Saga's economy. In Saga's model, at their maximum, SGN holders own less than 30% of all SGA tokens.

Parameters

We built our model so that the minting of SGA tokens for SGN holders happens at different rates.

In the first stage we aim to get the conversion ratio of SGN-SGA to equal 1 by the time that the Reserve value is 500 million SDR. For this stage we do not use the `minting_factor` parameter. Instead the amount of tokens minted depends on the Minting Point's distance to the target. In subsequent stages, the rate of minting SGA tokens is steadily reduced.

The parameters we used for each stage are:

#	Up to conversion ratio	abs_step	rel_step	minting_factor
1	1	50M SDR	1%	n/a
2	4	50M SDR	1.5%	1%
3	10	150M SDR	5%	1%
4	15	250M SDR	12%	1%

A table of all Genesis Minting Points is given in Appendix D.

Vesting Points

70% of all SGN token are created before the launch of the Saga economy. The rest of the SGN tokens (that belongs to Saga Foundation) are minted, in three 10% steps, only when the economy reaches certain thresholds (vesting condition). This allows to mint fewer SGA tokens when the economy is still small and more effected by minting.

When a vesting condition is met, the relevant SGN tokens and the SGA needed to cover already passed minting point are minted. These vesting points are like other regular minting points, but here the minted SGA are used to cover the new SGN and to increase the conversion ratio.

The three vesting points and their vesting condition are:

Vesting Point Number	1	2	3
Reserve Value at Vesting Point (SDR)	600 M	1.25 B	2 B
Market Cap at Vesting Point (SDR)	1.04 B	2.61 B	4.9 B
Percentage of total SGN minted at Vesting Point	10%	10%	10%

APPENDIX B: MONTE CARLO SIMULATIONS – SENSITIVITY TO VOLATILITY

In this paper we described our efforts to build a pricing model that *curtails* SGA price volatility.

We designed the reserve ratio to be high when Saga's economy is small in order to reduce volatility: a large number of new SGA tokens must be purchased before SGA price moves significantly. Moreover, the price band is narrow, meaning the Contract steps in frequently to change SGA supply and temper SGA price volatility.

When Saga's economy is larger, the reserve ratio is lower: a smaller relative change in Saga's Reserve is needed for SGA price to move¹³. In addition, the price band is wider. Thus, as the SGA economy becomes more established, the Contract plays a smaller role in regulating SGA price, and increasingly allows market forces to determine SGA price.

Here we present the results of Monte Carlo simulations on Saga's pricing model, that aim to gauge the sensitivity of SGA price to volatility at various stages in Saga's development.

In our experiments, we simulated daily percentage changes in SGA market cap and then looked at how the price of SGA would be affected. We generated the percentage changes from a normal distribution with mean zero.¹⁴ Each simulation had two input parameters: the starting value of the market cap of SGA, and a value for the standard deviation of the daily percentage changes in the market cap.

We generated market cap time series, consisting of 365 periods. The time series begin with Saga at the given initial market cap, and SGA price lying in the middle of the Contract's bid/ask price range.

At each step, a percentage increase or decrease to the market cap is generated at random from the normal distribution. The corresponding change in SGA price is then calculated as follows:

We assume SGA price moves in tandem with the market cap with no change in the supply of SGA, for as long as SGA price remains within the Contract's bid/ask range. If price does leave this range, then we assume people buy or sell SGA tokens with the Contract until the market cap given by Saga's model matches the new market cap.

Below are figures showing results from ten Monte Carlo simulations. We generated percentage changes in market cap randomly from a $\text{Normal}(0, 1\%)$ distribution and considered the effects of these changes at different points in Saga's economy.

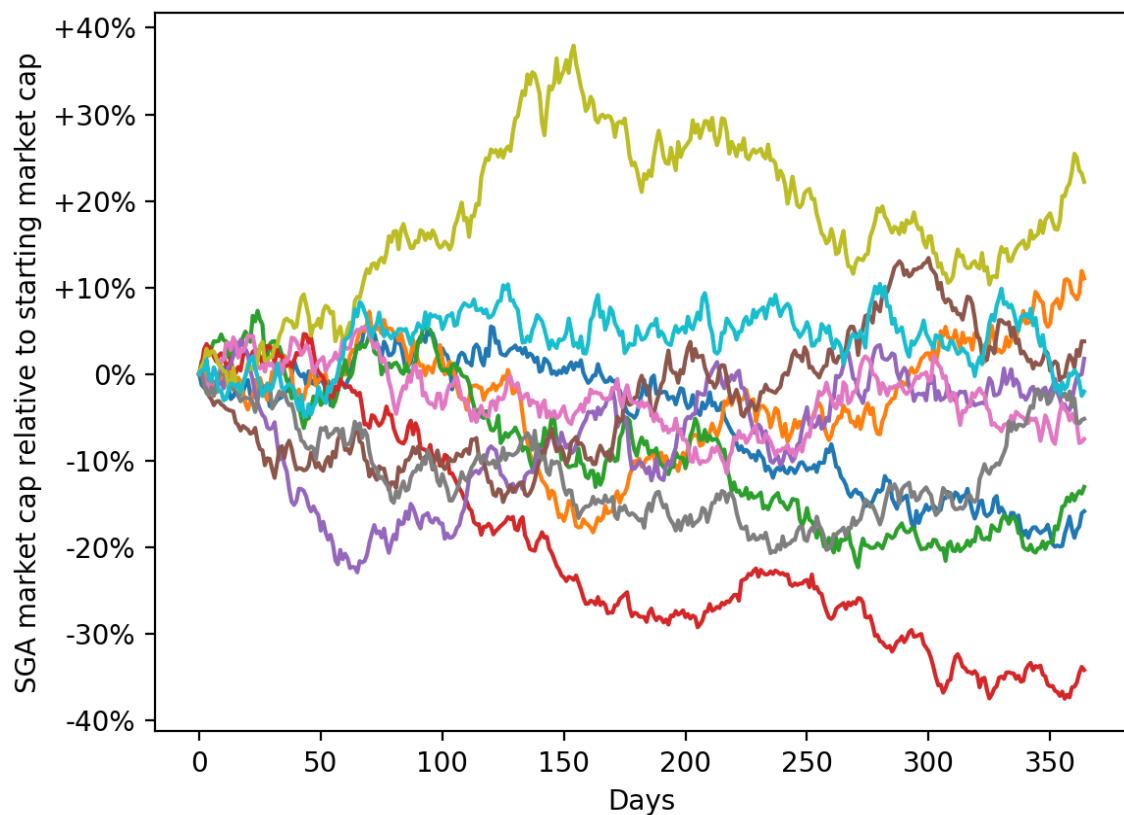
The results are consistent with our theoretical results from Chapter 5; the lower the reserve ratio, the more magnified the corresponding price changes were.

Figure B.1: Ten random time series of fluctuations in SGA Market cap.

¹³ In absolute terms this still amounts to a significant amount of cash flow, as the Reserve is much larger.

¹⁴ Zero mean so that market cap is equally likely to increase or decrease. We note that considering a non-zero mean (drift) would not provide more insight.

Standard deviation of the daily percentage changes is 1%



Figures B.2-7: The effect on SGA Price of these market cap fluctuations, at different stages in Saga's economy. The original market cap fluctuations are shown in faded lines.

In Figure 2, the reserve ratio is 100% and fluctuations in the market cap have no effect on SGA price – except for within the Contract's narrow price band. In later figures, the reserve ratio is lower and the impact on SGA price is larger.

Figure B.2: Starting Market Cap 10M SDR. Reserve ratio 100%.
Width of Price Band $\pm 0.15\%$

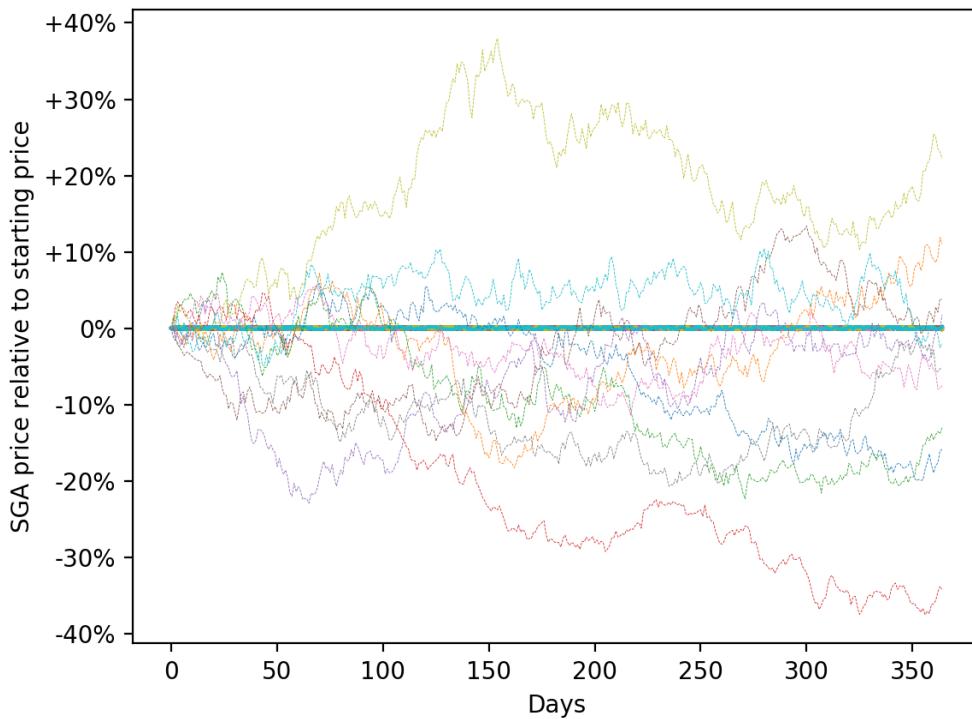


Figure B.3: Starting Market Cap 100M SDR. Reserve ratio 94%.
Width of Price Band $\pm 0.15\%$

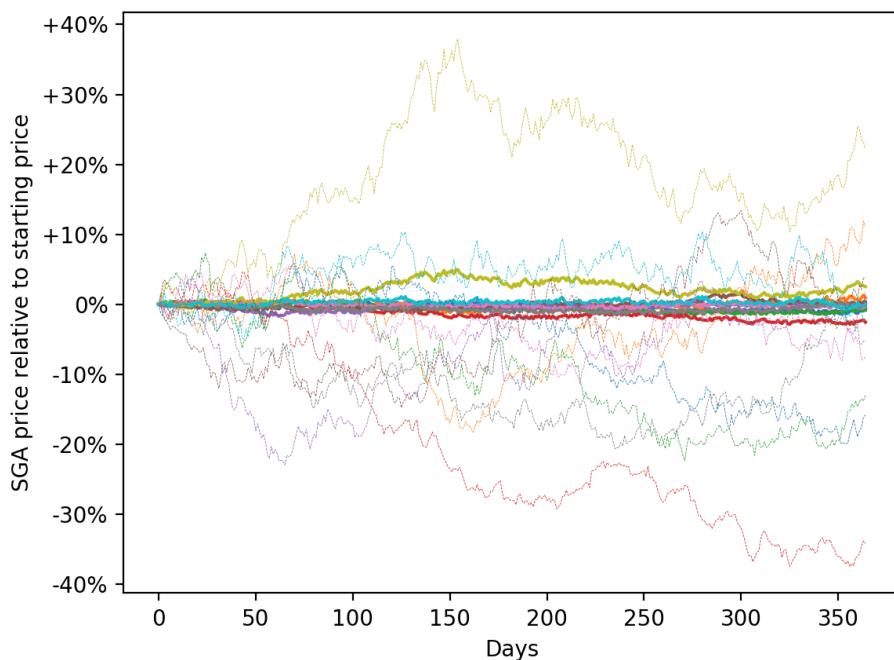


Figure B.4: Starting Market Cap 1B SDR. Reserve ratio 58%.
Width of Price Band $\pm 0.15\%$

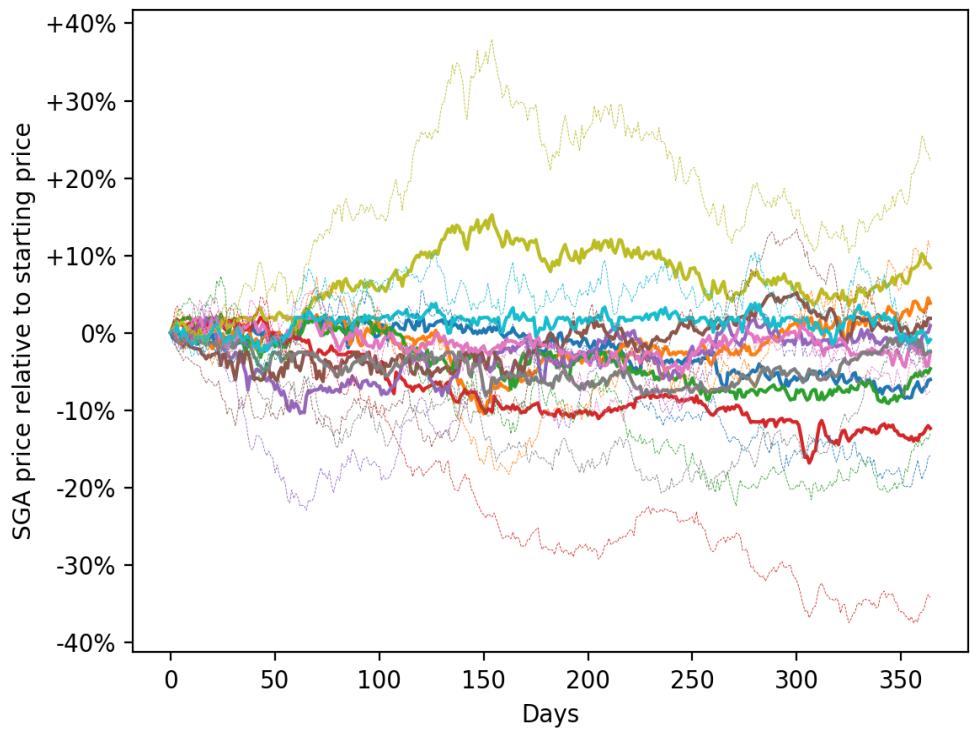


Figure B.5: Starting Market Cap 10B SDR. Reserve ratio 34%.
Width of Price Band $\pm 2.4\%$

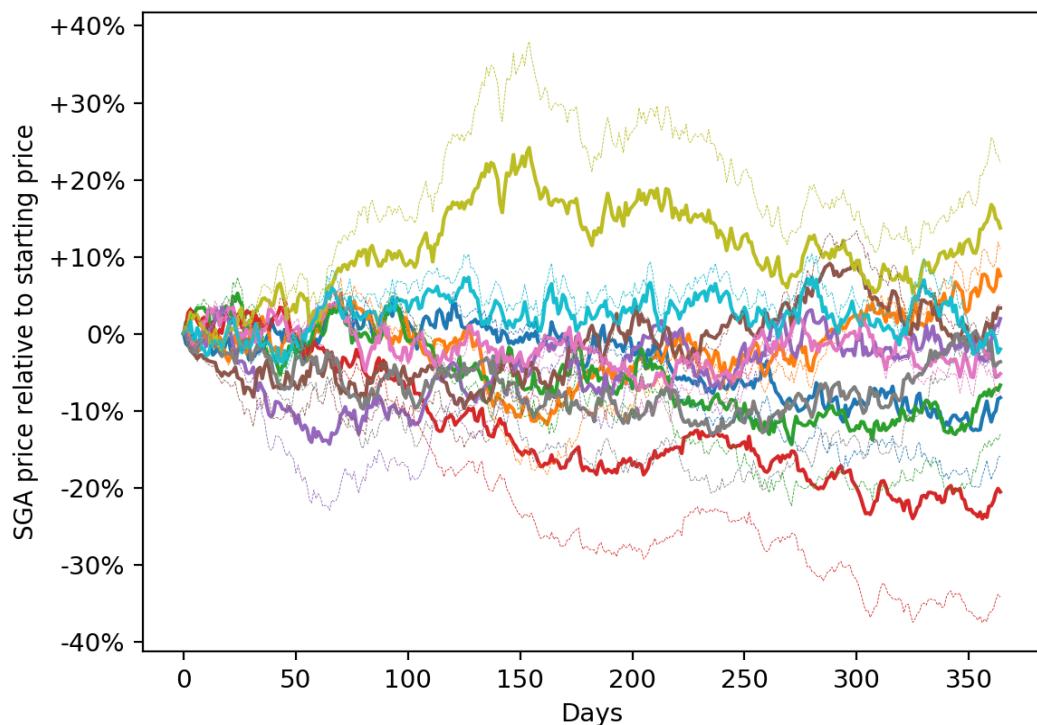


Figure B.6: Starting Market Cap 100B SDR. Reserve ratio 23%.
Width of Price Band $\pm 4.7\%$

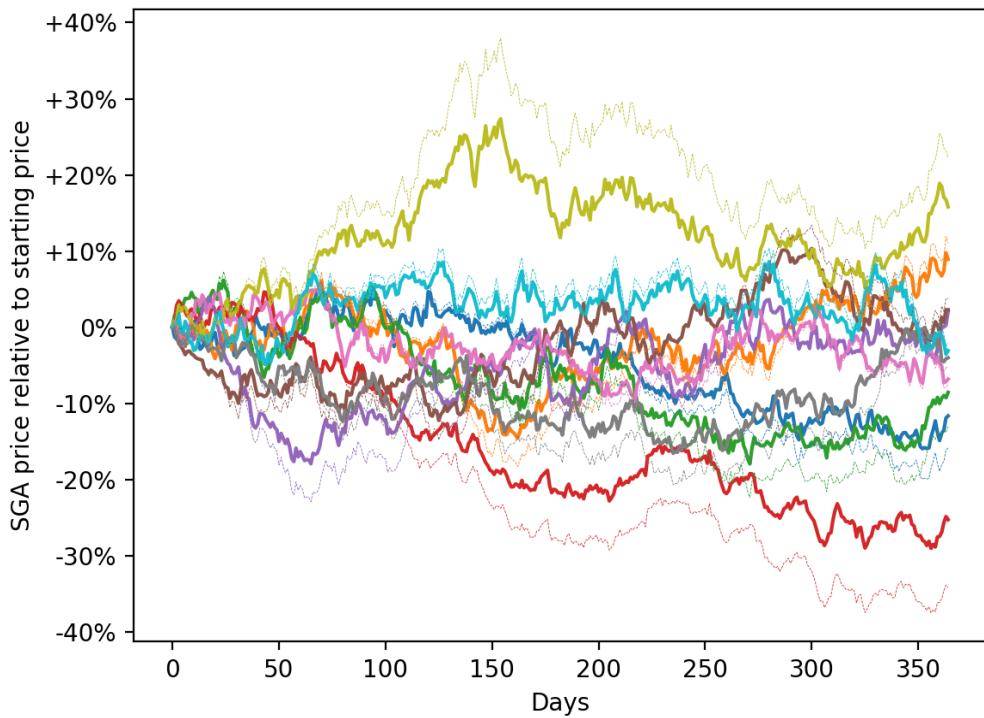
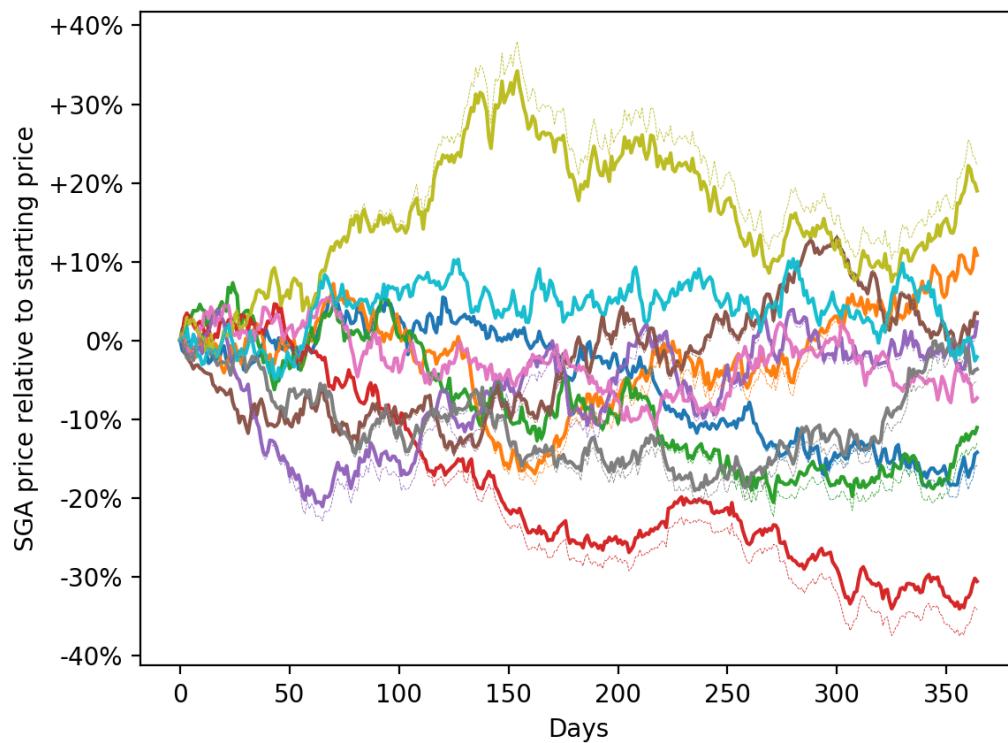


Figure B.7: Starting Market Cap 1T SDR. Reserve ratio 14%.
Width of Price Band $\pm 9.6\%$



We now present quantitative results for further illustration.

For a given time series, we define its relative volatility to be its standard deviation divided by its mean. For example, if the average price of SGA across a time series is 5 SDR, and the standard deviation is 0.1 SDR, then the relative volatility is $0.1 / 5 = 0.02$ (2%).

For a given pair of simulation parameters, we performed 20,000 Monte Carlo simulations and calculated the relative volatilities of the market cap time series and the SGA price time series. We then took the average of the volatilities across all 20,000 simulations.¹⁵ These values give an indication of how sensitive SGA price is to volatility in its market cap at the given starting points.

Simulation Results - We present results for six different starting market cap values. For each market cap value, we considered standard deviations of 0.5% and 1% in the daily market cap percentage changes.

Simulation parameters:				Simulation results:	
Starting Market Cap	Starting Reserve Ratio	Starting Width of Price Band	Std of Daily Market Cap Percentage Changes	Market Cap Volatility	Price Volatility
(SDR)	(%)	(%)	(%)	(%)	(%)
10 M	100%	$\pm 0.15\%$	0.5%	3.61%	0.14%
			1%	7.24%	0.14%
100 M	94.3%	$\pm 0.15\%$	0.5%	3.61%	0.32%
			1%	7.24%	0.67%
1 B	58.0%	$\pm 0.15\%$	0.5%	3.61%	1.47%
			1%	7.24%	2.86%
10 B	33.6%	$\pm 2.40\%$	0.5%	3.61%	2.47%
			1%	7.24%	4.57%
100 B	23.3%	$\pm 4.75\%$	0.5%	3.61%	3.06%
			1%	7.24%	5.58%
1 T	14.3%	$\pm 9.65\%$	0.5%	3.61%	3.51%
			1%	7.24%	6.72%

APPENDIX C: MONTE CARLO SIMULATIONS – IMPLICATIONS OF THE PRICE BAND

¹⁵ 20,000 simulations was enough for the results to converge to at least 2 significant figures.

Recall that the Saga Contract sells SGA tokens at a price – the ask price – and buys them back at a lower price – the bid price.

Market price of SGA is free to fluctuate in between the two prices, and only when market price leaves this range does the Contract step in to change the supply of SGA tokens and thereby slow down price movement.

The width of the price band – the percentage distance between the Contract’s two prices – gets larger as the SGA economy grows.

The Reserve fund profits the difference between the ask and the bid price every time a token is bought from the Contract and subsequently sold back.

In this Appendix we aim to gauge the amount the Reserve can profit from volatility in SGA price.

Recall the Reserve is used solely to underwrite SGA tokens, and profit in the Reserve is reflected in an equivalent increase in SGA price.

We produced Monte Carlo simulations of fluctuations in SGA market price. The daily returns (the percentage change in SGA price), were drawn from a normal distribution with zero mean and a given standard deviation.

Each Monte Carlo simulation consists of 365 such days. On every simulated day, we check if the new market price is within the Contract’s price band. If not, we assume people buy or sell SGA until the Contract’s ask or bid price respectively matches the new SGA market price. The supply of SGA is thus adjusted in accordance with the price change.

For each simulation we calculate the amount of money that the Reserve gains from the Contract’s buying and selling SGA tokens. Table C.1 below shows the average income – both in absolute and in relative terms – obtained by averaging 20,000 such simulations.

Figure C.1: Example of a Monte Carlo simulation. Simulation starts with SGA market cap at 10B SDR; daily price returns are drawn from a normal distribution with standard deviation 1%

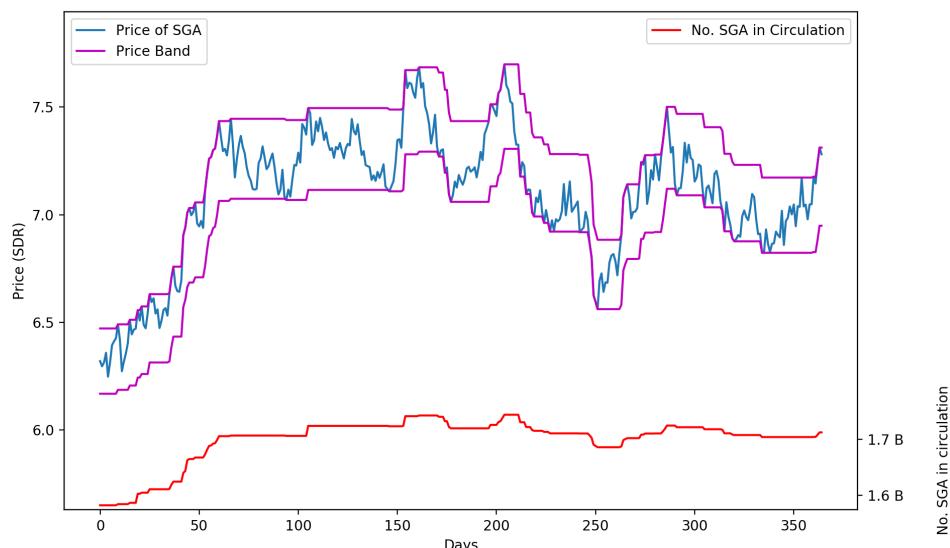


Table C.1: Average gross & net income from 20,000 Monte Carlo simulations of price fluctuations.

Net income is calculated under the assumption that the Reserve undergoes operational costs of 0.15% every time SGA tokens are traded with the Contract. The net income as a percentage of the starting Reserve value gives an indication of how much SGA price would be inflated due to the price adjustment mechanism of Chapter 9.

Simulation parameters:				Simulation results:			
Starting Market Cap	Starting Reserve Value	Starting Width of Price Band	Std of Daily Returns	Price Volatility	Gross Income from Price Band	Net Income from Price Band	Net Income as percentage of starting Reserve
(SDR)	(SDR)	(%)	(%)	(%)	(SDR)	(SDR)	(%)
100 M	94.3 M	$\pm 0.15\%$	0.5%	3.2%	1.09 M	0	0%
			1%	6.05%	2.37 M	0	0%
			5%	27%	38.2 M	22.5 M	23.9%
1 B	580 M	$\pm 0.15\%$	0.5%	3.6%	1.52 M	0.41 M	0.07%
			1%	7.3%	4.11 M	1.59 M	0.27%
			5%	30%	90.4 M	7.02 M	12.1%
10 B	6.3 B	$\pm 2.4\%$	0.5%	3.6%	14.1 M	13.2 M	0.39%
			1%	7.3%	50.4 M	47.2 M	1.40%
			5%	37%	854 M	799 M	23.8 %
100 B	23 B	$\pm 4.7\%$	0.5%	3.6%	95.1 M	92.1 M	0.39%
			1%	7.3%	374 M	36.2 M	1.55%
			5%	37%	6.65 B	6.44 B	27.6%
1 T	142 B	$\pm 9.6\%$	0.5%	3.6%	294 M	289 M	0.20%
			1%	7.2%	1.61 B	1.58 B	1.11%
			5%	37%	35.8 B	35.3 B	24.8%

APPENDIX D: SAGA MODEL POINTS

Details of all Model Points of Saga's monetary model. The majority of points are Genesis Minting Points, where SGA tokens are generated on behalf of SGN holders.

Note:

1. Points 16, 26 & 36 are Vesting Points. Recall these are points where some of Saga Foundation's SGN tokens are minted together with SGA tokens needed for these SGN tokens to catch up with the rest of the SGN tokens. The SGN-SGA conversion ratio does not change at these points.
2. Points 1, 4, 7, 14, 67, 95 & 104 are Target Points. These are points where the parameters of Saga's reserve ratio function change, without any SGA minted for SGN holders. The SGN-SGA conversion ratio does not change at these points. See Appendix A.
3. There are 107 million SGN tokens in total.

	Market cap	Number of SGA (before)	Minting Amount	Inflation	SGN-SGA Conversion ratio (after)	Reserve ratio (before)	Reserve ratio (after)
#	(SDR)	-	-	%	-	%	%
0	0	0	N/A	N/A	0	N/A	100%
1	20 M	20 M	N/A	N/A	0	100%	100%
2	25 M	24.99 M	0.19 M	0.75%	0.003	99.7%	98.9%
3	78 M	74.0 M	1.51 M	2.04%	0.02	96.3%	94.3%
4	106 M	98.7 M	N/A	N/A	0.02	94.3%	94.3%
5	137 M	122 M	3.06 M	2.50%	0.06	91.8%	89.5%
6	205 M	169 M	4.66 M	2.75%	0.13	86.3%	84.0%
7	238 M	193 M	N/A	N/A	0.13	84.0%	84.0%
8	280 M	216 M	6.30 M	2.92%	0.21	81.7%	79.4%
9	369 M	260 M	8.00 M	3.07%	0.32	76.1%	73.9%
10	467 M	304 M	9.74 M	3.20%	0.45	71.5%	69.3%
11	572 M	347 M	11.5 M	3.32%	0.60	67.8%	65.6%
12	676 M	391 M	13.4 M	3.42%	0.78	65.3%	63.2%
13	785 M	435 M	15.3 M	3.51%	0.98	63.2%	61.0%
14	820 M	453 M	N/A	N/A	0.98	61.0%	61.0%
15	912 M	480 M	17.2 M	3.59%	1.21	60.4%	58.3%
16	1.04 B	523 M	13.0 M	2.48%	1.21	57.8%	56.4%
17	1.20 B	569 M	4.65 M	0.82%	1.27	55.7%	55.3%
18	1.33 B	601 M	4.92 M	0.82%	1.32	54.7%	54.3%
19	1.47 B	633 M	5.20 M	0.82%	1.39	53.8%	53.4%

	Market cap	Number of SGA (before)	Minting Amount	Inflation	SGN-SGA Conversion ratio (after)	Reserve ratio (before)	Reserve ratio (after)
#	(SDR)	-	-	%	-	%	%
20	1.61 B	665 M	5.45 M	0.82%	1.45	52.9%	52.4%
21	1.76 B	695 M	5.71 M	0.82%	1.52	52.0%	51.5%
22	1.91 B	726 M	5.96 M	0.82%	1.59	51.1%	50.7%
23	2.07 B	756 M	6.20 M	0.82%	1.66	50.3%	49.9%
24	2.24 B	785 M	6.43 M	0.82%	1.73	49.4%	49.0%
25	2.41 B	815 M	6.66 M	0.82%	1.81	48.7%	48.3%
26	2.61 B	846 M	19.4 M	2.29%	1.81	47.8%	46.8%
27	2.82 B	885 M	7.10 M	0.80%	1.88	46.5%	46.1%
28	3.01 B	914 M	7.32 M	0.80%	1.96	45.8%	45.4%
29	3.22 B	942 M	7.53 M	0.80%	2.04	45.1%	44.7%
30	3.42 B	970 M	7.73 M	0.80%	2.12	44.4%	44.1%
31	3.64 B	998 M	7.94 M	0.79%	2.20	43.8%	43.5%
32	3.86 B	1.03 B	8.14 M	0.79%	2.29	43.2%	42.8%
33	4.09 B	1.05 B	8.33 M	0.79%	2.37	42.6%	42.3%
34	4.33 B	1.08 B	8.52 M	0.79%	2.46	42.0%	41.7%
35	4.58 B	1.11 B	8.72 M	0.79%	2.55	41.4%	41.1%
36	4.90 B	1.14 B	27.3 M	2.39%	2.55	40.8%	39.9%
37	5.17 B	1.18 B	9.08 M	0.77%	2.64	39.7%	39.4%
38	5.45 B	1.21 B	9.27 M	0.77%	2.72	39.2%	38.9%
39	5.73 B	1.24 B	9.45 M	0.76%	2.81	38.7%	38.4%
40	6.01 B	1.26 B	9.62 M	0.76%	2.90	38.3%	38.0%
41	6.31 B	1.29 B	9.80 M	0.76%	2.99	37.8%	37.5%
42	6.61 B	1.32 B	9.97 M	0.76%	3.09	37.4%	37.1%
43	6.93 B	1.35 B	10.1 M	0.75%	3.18	36.9%	36.7%
44	7.25 B	1.37 B	10.3 M	0.75%	3.28	36.5%	36.2%
45	7.58 B	1.40 B	10.5 M	0.75%	3.38	36.1%	35.8%
46	7.92 B	1.43 B	10.6 M	0.75%	3.47	35.7%	35.4%
47	8.27 B	1.45 B	10.8 M	0.74%	3.58	35.3%	35.1%
48	8.62 B	1.48 B	11.0 M	0.74%	3.68	34.9%	34.7%
49	8.99 B	1.51 B	11.1 M	0.74%	3.78	34.6%	34.3%
50	9.36 B	1.53 B	11.3 M	0.74%	3.89	34.2%	34.0%

	Market cap	Number of SGA (before)	Minting Amount	Inflation	SGN-SGA Conversion ratio (after)	Reserve ratio (before)	Reserve ratio (after)
#	(SDR)	-	-	%	-	%	%
51	9.75 B	1.56 B	11.4 M	0.73%	3.99	33.9%	33.6%
52	10.1 B	1.59 B	11.6 M	0.73%	4.10	33.6%	33.3%
53	11.3 B	1.65 B	12.1 M	0.73%	4.22	33.1%	32.8%
54	12.5 B	1.71 B	12.6 M	0.74%	4.33	32.6%	32.4%
55	13.7 B	1.77 B	13.0 M	0.74%	4.46	32.2%	31.9%
56	15.1 B	1.83 B	13.5 M	0.74%	4.58	31.8%	31.5%
57	16.5 B	1.89 B	14.0 M	0.74%	4.71	31.4%	31.1
58	18.0 B	1.95 B	14.4 M	0.74%	4.85	31.0%	30.8%
59	19.6 B	2.01 B	14.9 M	0.74%	4.99	30.7%	30.5%
60	21.2 B	2.07 B	15.3 M	0.74%	5.13	30.4%	30.2%
61	23.0 B	2.13 B	15.8 M	0.74%	5.28	30.2%	29.9%
62	24.8 B	2.19 B	16.2 M	0.74%	5.43	29.0%	29.7%
63	26.8 B	2.25 B	16.7 M	0.74%	5.58	29.7%	29.5%
64	28.8 B	2.31 B	17.1 M	0.74%	5.74	29.5%	29.3%
65	31.0 B	2.37 B	17.6 M	0.74%	5.91	29.3%	29.1%
66	33.3 B	2.43 B	18.0 M	0.74%	6.08	29.1%	28.9%
67	34.7 B	2.48 B	N/A	N/A	6.08	28.9%	28.9%
68	35.9 B	2.50 B	18.5 M	0.74%	6.25	28.7%	28.5%
69	38.8 B	2.56 B	18.9 M	0.74%	6.43	28.3%	28.1%
70	41.9 B	2.62 B	19.4 M	0.74%	6.61	27.8%	27.6%
71	45.3 B	2.69 B	19.8 M	0.74%	6.79	27.4%	27.2%
72	48.9 B	2.75 B	20.3 M	0.74%	6.98	27.0%	26.8%
73	52.6 B	2.82 B	20.7 M	0.73%	7.18	26.6%	26.4%
74	56.7 B	2.88 B	21.1 M	0.73%	7.37	26.2%	26.0%
75	61.0 B	2.95 B	21.6 M	0.73%	7.57	25.8%	25.6%
76	65.6 B	3.01 B	22.0 M	0.73%	7.78	25.4%	25.2%
77	70.5 B	3.08 B	22.5 M	0.73%	7.99	25.0%	24.8%
78	75.7 B	3.15 B	22.9 M	0.73%	8.20	24.7%	24.5%
79	81.3 B	3.21 B	23.3 M	0.73%	8.42	24.3%	24.1%
80	87.2 B	3.28 B	23.8 M	0.73%	8.65	24.0%	23.8%
81	93.4 B	3.35 B	24.2 M	0.72%	8.87	23.6%	23.5%

	Market cap	Number of SGA (before)	Minting Amount	Inflation	SGN-SGA Conversion ratio (after)	Reserve ratio (before)	Reserve ratio (after)
#	(SDR)	-	-	%	-	%	%
82	100 B	3.42 B	24.7 M	0.72%	9.10	23.3%	23.2%
83	107 B	3.48 B	25.1 M	0.72%	9.34	23.0%	22.9%
84	115 B	3.55 B	25.5 M	0.72%	9.58	22.7%	22.6%
85	123 B	3.62 B	26.0 M	0.72%	9.82	22.4%	22.3%
86	131 B	3.69 B	26.3 M	0.71%	10.1	22.2%	22.0%
87	151 B	3.82 B	27.4 M	0.72%	10.3	21.8%	21.6%
88	173 B	3.95 B	28.4 M	0.72%	10.6	21.4%	21.2%
89	198 B	4.08 B	29.4 M	0.72%	10.9	21.0%	20.9%
90	226 B	4.21 B	30.4 M	0.72%	11.1	20.7%	20.6%
91	258 B	4.34 B	31.5 M	0.72%	11.4	20.4%	20.3%
92	294 B	4.48 B	32.5 M	0.73%	11.7	20.2%	20.0%
93	333 B	4.62 B	33.6 M	0.73%	12.1	20.0%	19.9%
94	377 B	4.76 B	34.7 M	0.73%	12.4	19.9%	19.7%
95	380 B	4.80 B	N/A	N/A	12.4	19.7%	19.7%
96	449 B	4.91 B	35.7 M	0.73%	12.7	18.7%	18.6%
97	535 B	5.05 B	36.8 M	0.73%	13.1	17.7%	17.5%
98	637 B	5.18 B	37.8 M	0.73%	13.4	16.7%	16.5%
99	759 B	5.32 B	38.8 M	0.73%	13.8	15.7%	15.6%
100	904 B	5.45 B	39.7 M	0.73%	14.1	14.8%	14.7%
101	1.08 T	5.58 B	40.7 M	0.73%	14.5	13.9%	13.8%
102	1.28 T	5.71 B	41.5 M	0.73%	14.9	13.1%	13.0%
103	1.52 T	5.84 B	9.31 M	0.16%	15.0	12.4%	12.4%
104	3.00 T	6.16 B	N/A	N/A	15.0	10.0%	10.0%