

# **THE *NEO* TWO-TOKEN BLOCKCHAIN.**

## **PART 1: ECONOMIC FUNDAMENTALS**

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### **Abstract**

In the paper we discuss some economic fundamentals concerning two token economies. In particular, we introduce some simple numerical indicators, based on prices, traded and circulating monetary quantities. Such indicators could be computed in real time and used as an economic evaluation of the two tokens, as well as the whole platform, to support policy making. We also present an intrinsic feature of two token economies, where one of the tokens can be obtained from the other without any out-of-pocket payment. Indeed, this may give rise to speculative trades that may potentially destabilize the blockchain.

## 1. Introduction

In recent years there has been a remarkable growth in the number of blockchain platforms providing a variety of services. Typically, platforms, are endowed with a native currency, token, which is used to perform a variety of functions: implement transactions and smart contracts, obtain voting rights for governance and others. In such blockchains, market demand for the unique token can be considered as an expression of the desirability of the platform. However, the market cannot distinguish, for example, between a request for implementing transactions from demand for voting rights.

Some platforms, such as NEO, have instead opted for a dual token economy, that is for introducing two different tokens performing different functions. Therefore, unlike the one-token blockchains, if traded on the market the two tokens can provide more detailed information on the attractiveness and desirability of the different functions, provided by the platform. Indeed, some users could be more interested in governance while others in the implementation of services on the blockchain.

In this paper, the first part of a two-articles project, we investigate some economic fundamentals of the two NEO tokens, while the second part of the project will focus on the dynamics of the platform.

In particular, we shall discuss how to define economic indicators to quantify the attractiveness, desirability, of the two tokens. These, we believe, may provide useful numerical representations on the degree of economic success of such tokens and, more in general, of the platform. The challenge

is to find indicators that are both sufficiently simple while, at the same time, effective in expressing the tokens' value. Indeed, if so, they could be both easy to compute and useful to support policy making of the platform.

Some *natural* variables to consider, for constructing such indicators, are the market prices and the exchanged quantities on the market. Yet, several other variables could also be informative and of interest such as the block size, the average transaction size, the average time that tokens are held in wallets and others.

In the work we shall mostly use market prices together with circulating and traded quantities, as privileged variables to construct indicators for the absolute/relative attractiveness of the two tokens. The paper is structured as follows. In Section 2 we discuss the *economic attractiveness* of the two tokens, and introduce some economic indicators, based on price and quantities taken separately. In Section 3 we present some indicators where price and quantities are combined. Section 4 is a short exposition of indicators for the economic value of the whole platform. Section 5 points out an intrinsic feature of two-token economies, that is the possibility of purely speculative financial flows. This may take place when one of the two tokens could be obtained, by holding the other token, without paying any out-of-pocket sum. Section 6 concludes the paper.

## **2. Two-Token Economies**

Two-token economies (TTE), as NEO, exhibit some resemblances with standard economies, and with other blockchain platforms, but also differences. We begin the paper discussing in this section some of the main economic features of TTE. With reference to NEO, we shall indicate the two tokens respectively by  $N(eo)$  and  $G(as)$ .

## 2.1 The nature of TTE

An interesting, preliminary, step in the analysis of TTE is to draw a quick comparison with standard economies. To do so we begin considering the following, simple, illustration. Suppose an individual living in country  $X$ , adopting fiat currency  $x$ , wishes to invest her wealth in country  $Y$ . Assume that in country  $Y$  the individual can only buy companies' assets  $a$  or the fiat currency  $y$ . With assets the individual can participate in the companies' governance, and enjoy part of the profits, while with  $y$  the individual can perform any economic transaction.

At a very high level, an individual investing her wealth in a TTE such as NEO, rather than in country  $Y$ , faces a similar situation, though with some differences. As for similarities, buying  $N$  is somewhat analogous to purchasing  $a$  while investing in  $x$  is analogous to investing in gas tokens  $G$ . Indeed, as in NEO, buying  $N$  allows the user to participate in NEO decision making while only with  $G$  the user can execute transactions on the platform. Additionally, holding  $N$  in one's wallet, and participating in voting sessions, generates rewards in  $G$  while in standard economies holding  $a$  generate rewards in  $y$ , however even without voting participation.

## 2.2 The economic meaning of $N$ and $G$

The standard economic interpretation, evaluation, of  $N$  and  $G$  hinges on their market price, where the price is typically computed in terms of fiat currencies, or of the main cryptocurrencies. Indeed, their price is supposed to embody the degree of *absolute desirability* of the two tokens by the market, that is desirability expressed in terms of a currency *external* to, outside, the platform.

Therefore, the price ratio can be interpreted to be the *relative desirability* of the two tokens, that is how much the market is valuing one token as compared to the other.

However, the price ratio neither contains explicit information on the exchanged volumes of tokens that induced that price, that is quantities, nor on the number of circulating quantities which may also represent informative indicators of the tokens' attractiveness. In what follows we introduce the above indicators and discuss their meaning.

### 2.3 The price ratio of $N$ and $G$

Let  $t = 0, 1, 2, \dots$  be the time index, indicating days, months etc. Furthermore, define  $p_{N\$}(t)$  and  $p_{G\$}(t)$  as the price of  $\$$  in terms of, respectively,  $N$  and  $G$ , with units of measurement given by, again respectively,  $\frac{\$}{N}$  and  $\frac{\$}{G}$ . That is, how many  $\$$  are exchanged against, respectively, one unit of  $N$  and one unit of  $G$ . In general, if  $C$  is a generic fiat currency/cryptocurrency traded in the market, then  $p_{NC}(t)$  and  $p_{GC}(t)$  indicate the prices of the two tokens with respect to such currency.

Thus we define the inverse prices as  $p_{\$N}(t) = \frac{1}{p_{N\$}(t)}$  and  $p_{\$G}(t) = \frac{1}{p_{G\$}(t)}$ . If  $p_{N\$}(t) = 0$  then, according to the standard definition, we call  $N$  a *free good*, since  $N$  tokens can be obtained against 0 units of  $\$$ . Alternatively, with any amount of  $\$$  it is possible to obtain  $\infty$  units of  $N$ . Similar considerations hold for  $p_{G\$}(t) = 0$ .

For the time being, we do not consider in the analysis the possibility of exchanging  $N$  *directly* with  $G$ , assuming that trades can only take place *indirectly*, through buying and selling  $\$$ . Moreover, we shall indicate the two relevant markets for trading the tokens as  $N\$$  and  $G\$$ , which are available

in one, or more, exchange node. Hence disregarding transaction fees the ratio, exchange rate, defined as

$$e_{NG}(t) = \begin{cases} \frac{p_{N\$}(t)}{p_{G\$}(t)} & \text{if } p_{N\$}(t) \neq 0, p_{G\$}(t) \neq 0 \text{ or both} \\ 1 & \text{if } p_{N\$}(t), p_{G\$}(t) = 0 \end{cases} \quad (1)$$

and expressed in terms of  $\frac{G}{N}$ , represents the number of  $G$  units that can be purchased with 1 unit of  $N$  in the market, by selling and buying  $\$$ . Notice that (1) is independent of the fiat currency with respect to which prices are computed. That is in a *well-functioning*, arbitrage-free, market the value of (1) should be the same regardless of the fiat currency/cryptocurrency used to compute the prices. Therefore, the number of  $G$  tokens than can be purchased with 1 unit of  $N$  tokens is the same if rather than buying and selling  $\$$  one would buy and sell a generic currency  $C \neq \$$ .

Indeed, since  $p_{NC}(t) = p_{N\$}(t)p_{\$C}(t)$  and  $p_{GC}(t) = p_{G\$}(t)p_{\$C}(t)$  it would immediately follow that  $\frac{p_{NC}(t)}{p_{GC}(t)} = \frac{p_{N\$}(t)}{p_{G\$}(t)}$ .

However, it is worth anticipating that informative as it may be, below we shall discuss that  $e_{NG}(t)$  could be an incomplete, partial, indicator since it does not take explicitly into account the volumes of tokens exchanged in the market.

Hence the following basic, and intuitive, interpretations of (1) can be made. Broadly speaking, the larger  $e_{NG}(t)$  the *stronger*, the more desirable is  $N$  compared to  $G$ , while the contrary holds the smaller is  $e_{NG}(t)$ . Moreover, if  $e_{NG}(t) < 1$  then one could claim that  $G$  is *more powerful* than  $N$ , if  $e_{NG}(t) > 1$  that  $N$  is *more powerful* than  $G$  while in the limiting case of  $e_{NG}(t) = 1$  that they are *equally powerful*.

It is appropriate to point out that such interpretation certainly makes sense when the circulating number of both tokens is sufficiently large, and the markets (in principle) *thick*, that is

exhibiting some meaningful volumes of trades. In that case, market prices and traded quantities can be appropriate signals of tokens desirability. Instead, when the circulating quantity of a token is low, in the extreme case just one unit, then care may be required when interpreting the price ratio. Later we shall come back to the issue when introducing quantities.

Intuitively, one would expect  $e_{NG}(t) > 1$  because of the intrinsic *asymmetric* relationship between the two tokens. Indeed, as in NEO,  $G$  is distributed to  $N$ 's holders for voting participation, without any *out-of-pocket* payment, while the contrary is not true. That is,  $G$  holders cannot obtain  $N$  unless they pay for them while  $N$  holders can obtain  $G$  also without explicitly paying for them. It is true that voting participation requires attention, is time consuming and for this reason it bears an *opportunity cost*. However, this is not an *out-of-pocket*, explicit, disbursement of money.

A similar, simple, indicator to (1), still based only on prices, could be the following

$$d_{NG}(t) = p_{N\$}(t) - p_{G\$}(t)$$

that is the difference between the amount of dollars, fiat currency that, respectively, a single unit of  $N$  and a single unit of  $G$  can buy. As compared to (1) the interpretation of  $d_{NG}(t)$  requires some attention, since  $p_{N\$}(t)$  is expressed in terms of  $\frac{\$}{N}$  and  $p_{G\$}(t)$  in terms of  $\frac{\$}{G}$ . Hence, to make sense of  $d_{NG}(t)$  we could assume that  $p_{N\$}(t)$  is multiplied by one unit of  $N$  and  $p_{G\$}(t)$  by unit of  $G$ , so that  $d_{NG}(t)$  is simply expressed in \$. In case prices are the same it is  $d_{NG}(t) = 0$ , which corresponds to  $e_{NG}(t) = 1$  in (1), while  $d_{NG}(t) > 0$  corresponds to  $e_{NG}(t) > 1$  and  $d_{NG}(t) < 0$  to  $e_{NG}(t) < 1$ . Since we find  $e_{NG}(t)$  a more intuitive index to discuss the economics of the two tokens, in the rest of the paper we shall focus on it.

Following the above considerations, in general we expect  $N$  to be somehow more *attractive* than  $G$  hence  $e_{NG}(t) > 1$ . Yet, the level of  $e_{NG}(t)$  can be affected by several factors, some of which we discuss later.

As an example of the above considerations, data from Coinmarketcap indicate that on 31 October 2021 it was  $p_{N\$}(t) = 44.7$  and  $p_{G\$}(t) = 9.1$ , while on 31 October 2022 it was  $p_{N\$}(t) = 8.51$  and  $p_{G\$}(t) = 2.62$ . Therefore,  $e_{NG}(t) = 4.91$  on 31 October 2021 while  $e_{NG}(t) = 3.24$  on 31 October 2022. Hence, these empirical observations are consistent with the intuition that  $e_{NG}(t) > 1$ . Moreover,  $e_{NG}(t)$  was larger in 2021. Therefore, we may interpret this as  $N$  having become less attractive, in absolute value and relatively to  $G$ , between 2021 and 2022. In what follows we shall discuss how the indications provided by the prices can be complemented with quantities, to extract additional information from the data on the economics of  $N$  and  $G$ .

#### 2.4 The absolute supply-demand ratio of $N$ and $G$

To gain further insights on the interpretation of  $e_{NG}(t)$ , and discuss how quantities could be informative on the attractiveness of the two tokens, consider the limiting case  $e_{NG}(t) = 1$ , that is  $p_{N\$}(t) = p_{G\$}(t)$ , which means that with 1\$ it is possible to buy the same number of  $N$  and  $G$  units. Suppose, for example, that  $p_{N\$}(t) = 2 = p_{G\$}(t)$  and assume that both prices are equilibrium prices, that is they equalize supply and demand in the  $N\$$  and  $G\$$  markets. Before proceeding a note on terminology is in order, to point out that, for example, *at the equilibrium price* the supply  $S_{N(\$)}(t)$  of  $N$  in the  $N\$$  market coincides with the demand of  $N$  in the same market, that is with the supply  $S_{\$(N)}(t)$  of  $\$$  in that market. That is, the exchange of those two quantities effectively takes place at the prevailing price. The same holds for the  $G\$$  market.

Consider first the  $N\$$  market, where  $p_{N\$}(t) = \frac{S_{\$(N)}(t)}{S_{N(\$)}(t)}$ . As above, if  $p_{N\$}(t) = 0$  it follows that  $S_{\$(N)}(t) = 0$  while  $S_{N(\$)}(t)$  could be any non-negative number.

Then, of course,  $p_{N\$}(t) = 2$  can obtain if  $S_{N(\$)}(t) = 10$  and  $S_{\$(N)}(t) = 20$ , so that  $p_{N\$}(t) = \frac{S_{\$(N)}(t)}{S_{N(\$)}(t)} = \frac{20}{10} = 2$  or, alternatively, it could be  $p_{N\$}(t) = \frac{S_{\$(N)}(t)}{S_{N(\$)}(t)} = \frac{400}{200} = 2$  etc. Namely, the value  $p_{N\$}(t) = 2$  can be generated by, possibly, very different supply and demand levels in the  $N\$$  market, having the same proportion. Indeed, in general, any pair  $S_{\$(N)}(t)$  and  $S_{N(\$)}(t)$  satisfying the equality

$$S_{\$(N)}(t) = 2S_{N(\$)}(t)$$

would generate the same price  $p_{N\$}(t) = 2$ .

Likewise, also the value  $p_{G\$}(t) = 2$  may in principle be generated by any suitable supply-demand pair, in the  $G\$$  market. Suppose now, for instance, that  $p_{N\$}(t) = \frac{400}{200} = \frac{4}{2} = p_{G\$}(t)$ ; can we really claim that, in general,  $N$  and  $G$  are *equally strong*, or *equally desirable*, in the market? Based on the demand-supply *quantities* generating the two prices the answer may be *dubious*. This is because the prices are simple effectively exchanged demand-supply *ratios* and, therefore, do not embody information on the *size* of the transactions executed.

In what follows we introduce some simple quantity indicators which, however, as we shall discuss, they are also not free from interpretational ambiguities.

To see why consider for example, *basic* indicators such as the quantity ratios

$$Q_{\$}(t) = \frac{S_{\$(N)}(t)}{S_{\$(G)}(t)} = \frac{400}{4} = 100 = \frac{200}{2} = \frac{S_{N(\$)}(t)}{S_{G(\$)}(t)} = Q_{NG}(t) \quad (2)$$

that is the ratio of the supplied  $\$, N$  and  $G$  volumes, which could be used to argue about the *desirability* of  $N$  as compared to  $G$ . That is, quite simply, also the absolute volume of transacted currencies may be informative on the two tokens' attractiveness, hence their strength. By considering the ratio  $\frac{400}{4}$  in (2) we can observe that, in equilibrium, the traded volume of  $\$$  against

$N$  is hundred times the traded volume of \$ against  $G$ , which may be interpreted as a much larger market *willingness to buy*, desirability for,  $N$ .

However, at the same time, in (2) the ratio  $\frac{200}{2}$  may also be interpreted as a higher *willingness to sell*  $N$ , instead of  $G$ , against \$, and so of a stronger preference, by the platform users, for keeping  $G$  instead of  $N$ .

This suggests that the interpretation of quantity ratios may be approached from *two perspectives*: the point of view of the *buyers* and that of the *sellers*, for  $N$  and  $G$ . Indeed, in the above example, the buyers seem to be more interested in  $N$  while the sellers in  $G$ . Moreover, since  $p_{N\$}(t) = p_{G\$}(t)$  one may also claim that the preferences,  $N$  for the buyers and  $G$  for the sellers, are of the same extent, degree.

To further develop the above discussion, based on quantities, consider now the case of  $p_{N\$}(t) \neq p_{G\$}(t)$ . As an example, suppose again  $p_{N\$}(t) = \frac{400}{200} = 2$  but  $p_{G\$}(t) = \frac{10}{2} = 5$  so that, according to the price ratio  $e_{NG}(t) = \frac{2}{5} < 1$ , we would argue that  $G$  is stronger, relatively more desirable, than  $N$ .

The interpretation based on the quantity ratios

$$Q_{\$}(t) = \frac{400}{10} = 40 < 100 = \frac{200}{2} = Q_{NG}(t)$$

would be analogous, but not identical, to the previous one. While  $Q_{\$}(t) = 40$  suggests that the volume of exchanged \$ against  $N$  is 40 times the one exchanged against  $G$ , the number of  $N$  supplied against \$ is 100 times the number of  $G$  supplied against \$. Therefore, one may observe that  $N$  is preferred by the *buyers*,  $G$  by the *sellers*, however with the latter preference being stronger than the former. That is, the quantity ratios may complement (1) with interesting information on which side of the market can explain the value of  $e_{NG}(t)$ .

Finally, notice that the left-hand side of (2) is a pure number, since is the ratio of  $\frac{\$}{\$}$ , while the right-hand side is expressed in terms of  $\frac{N}{G}$ .

### 2.5 Arbitrage: direct vs indirect markets for $N$ and $G$

Before proceeding it is worth reminding that the price ratio (1), expressed in terms of  $\frac{G}{N}$ , *cannot* be interpreted as the quantity of  $N$  traded against  $G$ , since we assumed no *direct* exchange market for that. It only represents the ratio between the two quantities traded in the market against  $\$$ . Likewise, in the above example, the ratio  $\frac{N}{G} = \frac{200}{2} = 100$  *could not* be considered as the number of  $N$  tokens exchanged against  $G$  tokens. However, if a direct ( $NG$ ) exchange market exists, then due to arbitrage activity the price  $p_{NG}(t)$  could not differ from  $e_{NG}(t)$  and so  $p_{NG}(t) = e_{NG}(t)$ .

Indeed, suppose  $p_{NG}(t) = \frac{1}{100} = \frac{G}{N}$  while  $e_{NG}(t) = 1$ , with  $p_{N\$}(t) = \frac{400}{200} = 2 = \frac{4}{2} = p_{G\$}(t)$ .

Then a user owning  $1G$  could sell it in the  $NG$  market to obtain 100 units of  $N$  tokens. Subsequently, by selling these  $100N$  units against  $\$$  she would obtain  $200\$$  which, in turn, when sold against  $G$  tokens would generate  $100G$ . Therefore, by doing this the user could obtain a very large number of  $G$  tokens with an initial single  $G$  token. But of course, by replicating the same procedure more than once the supply of  $G$  tokens in the  $NG$  direct market will increase, possibly also the supply of  $N$  will decrease, and the price  $p_{NG}(t)$  will tend to increase. Analogous considerations apply for the other two markets, until the equality  $p_{NG}(t) = e_{NG}(t)$  would tend to prevail.

In case a direct market is introduced, with the arbitrage activity inducing

$$p_{NG}(t) = e_{NG}(t)$$

then this *non-arbitrage* equation poses some condition on the traded relevant quantities.

For completeness, in what follows we illustrate the point. Consider the three markets 1)  $N\$$ , 2)  $G\$$  and 3)  $NG$ , and indicate with  $\$, G_i, N_i$ , with  $i = 1,2,3$ , the quantities of the three currencies exchanged in the three markets, where  $G_1 = N_2 = \$_3 = 0$ . Finally, suppose  $\$_T = \$_1 + \$_2$ ;  $G_T = G_2 + G_3$ ;  $N_T = N_1 + N_3$  are the total quantities of the three currencies exchanged in the three markets. Then  $p_{NG}(t) = e_{NG}(t)$  implies

$$p_{NG}(t) = \frac{(G_T - G_2)}{(N_T - N_1)} = \frac{G_3}{N_3} = \frac{\frac{\$1}{N_1}}{\frac{\$2}{G_2}} = \frac{\$1}{N_1} \frac{G_2}{\$2} = e_{NG}(t) \quad (3)$$

Equation (3) includes many variables so that none of them, alone, could be fully determined unless we fix all the others. Therefore, there could be several, in fact unlimited, combinations of the relevant quantities which can satisfy (3). To gain some insights, below we take as given  $r = \frac{\$1}{\$2}$ ,  $N_T$  and  $G_T$  to investigate the relationship between  $N_1$  and  $G_2$ . Indeed, after appropriate rearrangement (3) can be written as

$$N_1 = \frac{rG_2N_T}{(G_T - G_2(1 - r))} \quad (4)$$

In absence of arbitrage possibilities, the above expression (4) provides some interesting indications on  $N_1$ . First, for any  $r > 0$ , it is increasing in  $G_2$ . Moreover, as  $G_2 \rightarrow G_T$  then  $N_1 \rightarrow N_T$  while as  $G_2 \rightarrow 0$  then also  $N_1 \rightarrow 0$ . Additionally, it is increasing in  $r$ , converging to  $N_T$  as  $r$  goes to infinity, and  $N_T$  but decreasing in  $G_T$ .

Notice that in (4) the value of  $r$  is the same, regardless of the third currency. Indeed, since  $N_1, N_T, G_2$  and  $G_T$  are uniquely determined quantities in the market, independently of the third currency, it follows that the ratio  $r$  must be the same whichever is the third currency. For instance,

if rather than \$ we would consider € then the ratio  $r' = \frac{\epsilon_1}{\epsilon_2}$  will be such that  $r' = \frac{p_{\$€(t)\$1}}{p_{\$€(t)\$2}} = r$ , where  $p_{\$€(t)}$ , expressed in terms of  $\frac{\epsilon}{\$}$ , is the price, exchange rate, of € in terms of \$.

As a simple numerical illustration, suppose  $r = 1$ ,  $N_T = 1000$  and  $G_T = 100$ ; then (4) would lead to  $N_1 = 10G_2$ , regardless of the absolute size of  $\$1$  and  $\$2$ , since what it counts for (3) is their ratio only. Hence, in this case

$$p_{NG}(t) = \frac{(100 - G_2)}{(1000 - 10G_2)} = \frac{1}{10} \quad (5)$$

Expression (5) is of course an identity which endows  $G_2 > 0$  with the freedom to take any value in the relevant domain, leaving indeterminate also the absolute levels of  $p_{N\$}(t)$  and  $p_{G\$}(t)$ . If  $G_2 = 1$  then  $G_3 = 99$ ,  $N_1 = 10$  and  $N_3 = 990$ . Since  $r = 1$  then  $\$1 = \$2$ , so that if  $\$1 = \$2 = 100$  it follows that  $p_{N\$}(t) = 10$  and  $p_{G\$}(t) = 100$  while if  $\$1 = \$2 = 1000$  then  $p_{N\$}(t) = 100$  and  $p_{G\$}(t) = 1000$ . Therefore, the amount of \$ determines the absolute level of the two prices while the arbitrage activity their ratio, which indeed could now inform on the number of  $G$  tokens exchanged against  $N$  tokens, in the *direct* market.

## 2.6 The relative supply-demand ratio of $N$ and $G$

The tokens' market price, being defined as the ratio between the absolute levels of supply and demand, does not consider the number of circulating tokens. For example, suppose again  $p_{N\$}(t) = \frac{400}{200} = 2 = \frac{4}{2} = p_{G\$}(t)$ . Of course, the number of traded  $N$  tokens, that is 200, is much larger than the number of traded  $G$  tokens. However, as for the two tokens' market attractiveness is concerned, such direct comparison between absolute quantities may be deceiving. Indeed, what

may be more interesting/informative to consider is the proportion between traded and circulating tokens. Therefore if at time  $t$ , for instance, the number of  $N$  circulating tokens is  $N_c(t) = 400000$  and the number of circulating  $G$  tokens is  $G_c(t) = 200$  then

$$s_{N(\$)}(t) = \frac{S_{N(\$)}(t)}{N_c(t)} = \frac{200}{400000} = \frac{1}{2000} < \frac{2}{200} = \frac{1}{100} = \frac{S_{G(\$)}(t)}{G_c(t)} = s_{G(\$)}(t) \quad (6)$$

That is, the relative number of supplied  $G$  tokens  $s_{G(\$)}(t)$  would be higher than the relative number of supplied  $N$  tokens  $s_{N(\$)}(t)$ , and the ratio of these two relative quantities equal to

$$q_{NG}(t) = \frac{s_{G(\$)}(t)}{s_{N(\$)}(t)} = \frac{0.01}{0.002} = 5 \quad (7)$$

Notice that such ratio would be a pure number, that is independent of the measurement units, as well as the ratio  $Q_{\$}(t) = q_{\$}(t) = \frac{400}{4} = 100$  between the traded dollars. Therefore, comparing now the two relative-quantity ratios we observe that  $q_{\$}(t) = 100 > 5 = q_{NG}(t)$  and so that, despite the price ratio being equal, it seems to suggest that in fact  $N$  is more desirable, for both the *buyers* and the *sellers*, than  $N$  since it is *relatively* less traded.

### 2.7 The “virtual” price of $G$ and $N$

In the above discussion we took as reference for the economic value of the two tokens their prices against  $\$$ , when considering indirect exchanges with respect to a generic currency, or the price of  $N$  against  $G$  in a direct market. Then, the arbitrage activity led to

$$p_{NG}(t) = \frac{p_{N\$}(t)}{p_{G\$}(t)} = e_{NG}(t)$$

The relevant prices  $p_{NG}(t), p_{N\$}(t), p_{G\$}(t)$  are all computed in the three *bilateral* markets  $NG, N\$, G\$$  on the basis of the demand and supply, hence quantities exchanged, in those markets.

However, whether or not a direct  $GN$  market exists, it is always possible to compute a ratio between the total number of  $N$ ,  $S_N(t)$ , exchanged against all currencies and the total number of  $G$ ,  $S_G(t)$ , traded against all currencies. That is, the ratio  $v_{NG}(t)$  defined as

$$v_{NG}(t) = \frac{S_G(t)}{S_N(t)}$$

which we call a *virtual price* since, typically, it is not explicitly computed and yet it may also be a useful indicator to evaluate the relative desirability of the two tokens.

To see how informative it could be, with respect to the previous indicators, consider the following very simple example. Suppose there are only two currencies to trade the two tokens with:

\$ and €. Moreover, assume  $p_{N\$}(t) = \frac{S_{\$(N)}(t)}{S_{N(\$)}(t)} = \frac{400}{200} = 2$ ,  $p_{G\$}(t) = \frac{S_{\$(G)}(t)}{S_{G(\$)}(t)} = \frac{4}{2} = 2$  so that  $e_{NG}(t) =$

$\frac{p_{N\$}(t)}{p_{G\$}(t)} = \frac{2}{2} = 1 = p_{NG}(t)$ . Furthermore, suppose that  $p_{N\text{€}}(t) = \frac{S_{\text{€}(N)}(t)}{S_{N(\text{€})}(t)} = \frac{100}{20} = 5$ ,  $p_{G\text{€}}(t) =$

$\frac{S_{\text{€}(G)}(t)}{S_{G(\text{€})}(t)} = \frac{20}{4} = 5$  so that  $e_{NG}(t) = \frac{p_{N\text{€}}(t)}{p_{G\text{€}}(t)} = \frac{5}{5} = 1 = p_{NG}(t)$ . So according to (1), and considering

arbitrage activity, the two tokens are equally desirable by the market.

However, computing the *virtual price* we obtain  $v_{NG}(t) = \frac{S_G(t)}{S_N(t)} = \frac{2+4}{200+20} = \frac{6}{220} \sim 0.03$

suggesting that  $G$  is a stronger token than  $N$ , because the total number of traded  $G$ s is much lower.

Again,  $v_{NG}(t)$  is not a *proper price*, since quantities are supplied and demanded in separate markets and not in a single, global, market. Hence it can only be interpreted as an *hypothetical price* in the

following way: if the total traded quantities were exchanged as a whole, rather than on bilateral

markets, then  $v_{NG}(t)$  would be the equilibrium price. Though not computed in practice,  $v_{NG}(t)$  may

be informative as a ratio of total quantities exchanged on the market. The example shows a major

difference between the indicators based on bilateral markets and the virtual price. Again, this may

be because in  $v_{NG}(t)$  we considered absolute instead of relative, to the circulating quantities,

exchanged volumes. With relative quantities we may expect a reduction of the difference, as compared to bilateral markets, yet there is no *a-priori* reason to expect that such difference would be eliminated.

### 3. The economic meaning of $N$ and $G$ as a combination of prices and quantities

In the previous sections we discussed some alternative criteria to evaluate the attractiveness of the two tokens, based on price and quantity market data, on a separate basis. We have also seen that the suggestions emerging from different criteria may sometimes be consistent, while on other circumstances they could differ. Based on this, in the section we propose some composite indicators, that would embody the above considerations, to compare to  $e_{NG}(t)$ .

Because tokens' desirability through quantities can be interpreted from two sides, *sellers* and *buyers*, below we proceed considering both perspectives.

- i) (*Relatively Weighted Price Ratio,  $RW_{NG\alpha}(t)$ ; the sellers' perspective*) A first, simple, indicator to consider  $RW_{NG\alpha}(t)$  can be defined as follows

$$RW_{NG\alpha}(t) = \begin{cases} \frac{[p_{N\$}(t)]^{(1-\pi_{N\$})}}{[p_{G\$}(t)]^{(1-\pi_{G\$})}} & \text{if } p_{N\$}(t) \neq 0, p_{G\$}(t) \neq 0 \text{ or both} \\ 1 & \text{if } p_{N\$}(t), p_{G\$}(t) = 0 \end{cases} \quad (8)$$

where

$$\pi_{N\$} = \begin{cases} \frac{s_{N(\$)}(t)}{s_{N(\$)}(t) + s_{G(\$)}(t)} & \text{if } s_{N(\$)}(t) \neq 0, s_{G(\$)}(t) \neq 0 \text{ or both} \\ 1 & \text{if } s_{N(\$)}(t), s_{G(\$)}(t) = 0 \end{cases} \quad (9)$$

and

$$\pi_{G\$} = \begin{cases} \frac{s_{G(\$)}(t)}{s_{N(\$)}(t) + s_{G(\$)}(t)} & \text{if } s_{N(\$)}(t) \neq 0, s_{G(\$)}(t) \neq 0 \text{ or both} \\ 1 & \text{if } s_{N(\$)}(t), s_{G(\$)}(t) = 0 \end{cases} \quad (10)$$

Notice that, for completeness, we should have written  $\pi_{N\$}$  as  $\pi_{N\$}(t)$  and  $\pi_{G\$}$  as  $\pi_{G\$}(t)$ , since both of them are time dependent. However, to save on notation we omitted the time index, although we should keep in mind that (9) and (10), as well as the quantities, vary with time.

From (9) and (10) it follows that  $s_{N(\$)} = 0 = s_{G(\$)}$  is a possibility, when neither  $N$  nor  $G$  are exchanged on the market, in which case we assume  $\pi_{N\$} = 1 = \pi_{G\$}$ ; as a consequence,  $\pi_{N\$} = 1 - \pi_{G\$}$  only when either  $\pi_{N\$} \neq 0$ , or  $\pi_{G\$} \neq 0$  or both. Therefore if, for example,  $\pi_{N\$} = 0$  then for any  $s_{G(\$)} > 0$ , however small, it will be  $\pi_{G\$} = 1$ , that is (9) would assign full value to  $\pi_{N\$}$ , even with a minimum exchange of  $G$  units. A similar reasoning holds for (10). Finally, notice that both (9) and (10) are pure numbers, which implies that also  $RW_{NGa}(t)$  will have as unit of measurement the ratio  $\frac{G}{N}$ .

It is immediate to observe that (8) is a simple extension of  $e_{NG}(t)$ , where the market prices are weighted by the shares of trades. Notice however that  $p_{N\$}(t)$  is weighted by  $1 - \pi_{N\$}$ , while  $p_{G\$}(t)$  is weighted by  $1 - \pi_{G\$}$ . Indeed, based on previous discussion, the desirability of  $N$  not only is *positively* related to  $p_{N\$}(t)$  but also *negatively related* to  $\pi_{N\$}$  since, from the *seller's* perspective, the smaller is  $\pi_{N\$}$  the more  $N$  is desirable as compared to  $G$ .

In case  $p_{N\$}(t), p_{G\$}(t) > 0$  and  $\pi_{N\$}, \pi_{G\$} > 0$  expression (8) becomes

$$RW_{NGa}(t) = \frac{[p_{N\$}(t)]^{\pi_{G\$}}}{[p_{G\$}(t)]^{\pi_{N\$}}} \quad (11)$$

which, in practice, is the most common formulation taken by  $RW_{NGa}(t)$ . Indeed, henceforth we shall refer to (11)

Some comments are in order. First notice that when  $p_{N\$}(t) = p_{G\$}(t) > 0$  then  $RW_{NGa}(t) = 1$  if and only if  $\pi_{N\$} = \frac{1}{2} = \pi_{G\$}$ . Therefore, since when prices and traded shares are positive and equal it is  $RW_{NGa}(t) = 1$ , it would be intuitive to consider also for  $RW_{NGa}(t)$  the unit value as the one expressing the same market attractiveness for the two tokens. However, unlike  $e_{NG}(t)$ , it may be  $RW_{NGa}(t) = 1$  also for  $p_{N\$}(t) \neq p_{G\$}(t)$ , as long as the value of  $\pi_{N\$}$  appropriately compensates for the price difference.

Indeed, for example, suppose  $p_{N\$}(t) = 10$  and  $p_{G\$}(t) = 2$ ; then if  $\pi_{N\$} = \frac{\ln p_{N\$}}{\ln p_{G\$} + \ln p_{N\$}} \sim 0.77$  it is  $RW_{NGa}(t) = 1$ , that is if tokens  $N$  are relatively more traded than  $G$ . So, with the above values,  $e_{NG}(t) = 5$  would suggest that  $N$  is more desirable than  $G$  while  $RW_{NGa}(t) = 1$  that they are equally desirable, from the sellers' perspective. To summarise, according to  $RW_{NGa}(t)$ , for the two tokens to be considered equally desirable by the market a lower price for  $G$  must be compensated by a lower relative sale.

Therefore, in analogy with  $e_{NG}(t)$ , we interpret  $RW_{NGa}(t) > 1$  as  $N$  being more attractive than  $G$  and, similarly, for  $RW_{NGa}(t) = 1$  and  $RW_{NGa}(t) < 1$ .

Additionally observe that  $RW_{NGa}(t) = e_{NG}(t)$  for  $\pi_{N\$} = \frac{1}{2}$ ; that is, when the relative trades of  $N$  and  $G$  are the same then  $RW_{NGa}(t)$  returns the same indications as  $e_{NG}(t)$ , as (11) will depend only on prices.

More in general,  $RW_{NGa}(t) \geq e_{NG}(t)$  when

$$\frac{[p_{N\$}(t)]^{\pi_{G\$}}}{[p_{G\$}(t)]^{\pi_{N\$}}} \geq \frac{p_{N\$}(t)}{p_{G\$}(t)}$$

hence when

$$p_{N\$}(t) \leq [p_{G\$}(t)]^{\left(\frac{\pi_{G\$}}{\pi_{N\$}}\right)} \quad (12)$$

that is if  $p_{N\$}(t)$  is sufficiently low. Thus, for given  $p_{G\$}(t)$  and  $\pi_{N\$}$ ,  $RW_{NGa}(t)$  would be larger than  $e_{GN}(t)$  when  $p_{N\$}(t)$  is low enough and the contrary when it is large. Such difference is of course due to the presence of the relative quantity weights.

Furthermore,  $RW_{NGa}(t) \geq 1$  if

$$p_{N\$}(t) \geq [p_{G\$}(t)]^{\left(\frac{\pi_{N\$}}{\pi_{G\$}}\right)} \quad (13)$$

Additionally, observe that in (12) the expression  $[p_{G\$}(t)]^{\left(\frac{\pi_{G\$}}{\pi_{N\$}}\right)}$  is linear in  $p_{G\$}(t)$  for  $\pi_{G\$} = \frac{1}{2}$ , convex if  $\pi_{G\$} > \frac{1}{2}$  and concave if  $\pi_{G\$} < \frac{1}{2}$ . Likewise, in (3) the expression  $[p_{G\$}(t)]^{\left(\frac{\pi_{N\$}}{\pi_{G\$}}\right)}$  is linear in  $p_{G\$}(t)$  for  $\pi_{G\$} = \frac{1}{2}$ , concave if  $\pi_{G\$} > \frac{1}{2}$  and convex if  $\pi_{G\$} < \frac{1}{2}$ . Thus, taken together (12) and (13) establish a *dual relationship* between the conditions for  $RW_{NGa}(t) \geq e_{NG}(t)$  and for  $RW_{NGa}(t) \geq 1$ . Indeed, the following simple conclusion immediately obtains

**Proposition** Suppose  $\pi_{G\$} > \frac{1}{2}$ ; then (12) and (13) can both be true only if  $p_{G\$}(t) > 1$ . If  $\pi_{G\$} < \frac{1}{2}$ ; then (12) and (13) can both be true only if  $p_{G\$}(t) < 1$ .

Finally, it is worth pointing out that  $RW_{NGa}(t)$ , in (8) and (11), has been defined considering  $p_{N\$}(t)$  and  $p_{G\$}(t)$ , that is referring to the indirect markets  $N\$$  and  $G\$$ , rather than to the direct market  $NG$ , hence the price  $p_{NG}(t)$ . However, in principle it would make perfect sense to consider  $p_{NG}(t)$  as a reference for the combined price-quantity indicator for the values of  $N$  and  $G$ . In what follows we briefly discuss how  $RW_{NGa}(t)$  relates to  $p_{NG}(t)$ , under the  $p_{NG}(t) = e_{NG}(t)$  non-arbitrage condition.. Indeed,

$$RW_{NGa}(t) = \frac{[p_{N\$}(t)]^{\pi_{G\$} - \pi_{N\$} + \pi_{N\$}}}{[p_{G\$}(t)]^{\pi_{N\$}}} = \frac{[p_{N\$}(t)]^{\pi_{N\$}}}{[p_{G\$}(t)]^{\pi_{N\$}}} [p_{N\$}(t)]^{\pi_{G\$} - \pi_{N\$}} = [p_{NG}(t)]^{\pi_{N\$}} [p_{N\$}(t)]^{\pi_{G\$} - \pi_{N\$}}$$

Namely,  $RW_{NGa}(t)$  is positively related to  $p_{NG}(t)$ , according to the function  $[p_{NG}(t)]^{\pi_{N\$}}$ , scaled by the quantity  $[p_{N\$}(t)]^{\pi_{G\$}-\pi_{N\$}}$ . It follows that it is also  $RW_{NGa}(t) = [e_{NG}(t)]^{\pi_{N\$}}[p_{N\$}(t)]^{\pi_{G\$}-\pi_{N\$}}$ .

Therefore, by construction,  $RW_{NGa}(t)$  cannot be expressed as a function of  $p_{NG}(t)$  only, but it depends also on  $p_{N\$}(t)$ , except for when  $\pi_{G\$} = \frac{1}{2} = \pi_{N\$}$ , in which case

$$RW_{NGa}(t) = \sqrt{p_{NG}(t)} = \sqrt{e_{NG}(t)}$$

ii) (*Relatively Weighted Price Ratio,  $RW_{NGb}(t)$ ; the buyers' perspective*) A complementary indicator to  $RW_{NGa}(t)$ , considering the buyers' perspective could then be defined as follows

$$RW_{NGb}(t) = \begin{cases} \frac{[p_{N\$}(t)]^{\pi_{N\$}}}{[p_{G\$}(t)]^{\pi_{G\$}}} & \text{if } p_{N\$}(t) \neq 0, p_{G\$}(t) \neq 0 \text{ or both} \\ 1 & \text{if } p_{N\$}(t), p_{G\$}(t) = 0 \end{cases} \quad (14)$$

which is like (11) except for  $\pi_{N\$}$  and  $\pi_{G\$}$  that are now swapped. Indeed, from the buyer's point of view the desirability of  $N$  is positively related not only to  $p_{N\$}(t)$  but also to  $\pi_{N\$}$ , since the larger is  $\pi_{N\$}$  the more attractive is  $N$  for the buyers. Considerations analogous to those that we made for  $RW_{NGa}(t)$  are now holding for  $RW_{NGb}(t)$ , when switching  $\pi_{N\$}$  and  $\pi_{G\$}$ . In analogy with  $RW_{NGa}(t)$  we can see that

$$RW_{NGb}(t) = \frac{[p_{N\$}(t)]^{\pi_{N\$}-\pi_{G\$}+\pi_{G\$}}}{[p_{G\$}(t)]^{\pi_{G\$}}} = \frac{[p_{N\$}(t)]^{\pi_{G\$}}}{[p_{G\$}(t)]^{\pi_{G\$}}} [p_{N\$}(t)]^{\pi_{N\$}-\pi_{G\$}} = [p_{NG}(t)]^{\pi_{G\$}} [p_{N\$}(t)]^{\pi_{N\$}-\pi_{G\$}}$$

and so that  $RW_{NGb}(t)$  depends on  $[p_{NG}(t)]^{\pi_{G\$}}$ , unless  $\pi_{G\$} = \frac{1}{2} = \pi_{N\$}$ .

Finally, it may be interesting to point out that  $RW_{NGa}(t) \geq RW_{NGb}(t)$  if and only if  $\pi_{G\$} \geq \pi_{N\$}$  which, with  $\pi_{N\$}, \pi_{G\$} > 0$ , implies  $\pi_{G\$} \geq \frac{1}{2}$ .

iii) (*Absolutely Weighted Price Ratio,  $AW_{NGa}(t)$ ; the sellers' perspective* ) An alternative indicator, though similar to  $RW_{NGa}(t)$ , can be a price ratio weighted with absolute quantities,  $AW_{NGa}(t)$ , defined as follows

$$AW_{NGa}(t) = \begin{cases} \frac{[p_{N\$}(t)]^{(1-\lambda_{N\$})}}{[p_{G\$}(t)]^{(1-\lambda_{G\$})}} & \text{if } p_{N\$}(t) \neq 0, p_{G\$}(t) \neq 0 \text{ or both} \\ 1 & \text{if } p_{N\$}(t), p_{G\$}(t) = 0 \end{cases} \quad (15)$$

where

$$\lambda_{N\$} = \begin{cases} \frac{S_{N(\$)}(t)}{S_{N(\$)}(t) + S_{G(\$)}(t)} & \text{if } S_{N(\$)}(t) \neq 0, S_{G(\$)}(t) \neq 0 \text{ or both} \\ 1 & \text{if } S_{N(\$)}(t), S_{G(\$)}(t) = 0 \end{cases} \quad (16)$$

and

$$\lambda_{G\$} = \begin{cases} \frac{S_{G(\$)}(t)}{S_{N(\$)}(t) + S_{G(\$)}(t)} & \text{if } S_{N(\$)}(t) \neq 0, S_{G(\$)}(t) \neq 0 \text{ or both} \\ 1 & \text{if } S_{N(\$)}(t), S_{G(\$)}(t) = 0 \end{cases} \quad (17)$$

The above indicator is analogous to (8) except for the weights  $\lambda_{N\$}$ ,  $\lambda_{G\$}$ , which now contain absolute quantities  $S_{N(\$)}(t)$ ,  $S_{G(\$)}(t)$  rather than relative ones. As well as for  $RW_{NGa}(t)$ , because the value  $AW_{NGa}(t) = 1$  obtains when  $p_{N\$}(t) = p_{G\$}(t)$  and  $S_{N(\$)} = S_{G(\$)}$ , we shall interpret  $AW_{NGa}(t) = 1$  as equally desirable tokens, and analogously for  $AW_{NGa}(t) > 1$  and  $AW_{NGa}(t) < 1$ .

Since  $S_{N(\$)}(t) = N_c(t)s_{N(\$)}(t)$  and  $S_{G(\$)}(t) = G_c(t)s_{G(\$)}(t)$  it follows that

$$\lambda_{N\$} = \frac{s_{N(\$)}(t)}{s_{N(\$)}(t) + \frac{G_c(t)}{N_c(t)}s_{G(\$)}(t)} \quad (18)$$

and  $\lambda_{N\$} \geq \pi_{N\$}$  if and only if  $N_c(t) \geq G_c(t)$ , that is if the number of circulating  $N$  is larger than the number of circulating  $G$ . Unsurprisingly, according to (18)  $AW_{NGa}(t)$  turns out to be more sensitive

than  $RW_{NGa}(t)$  to the number of circulating tokens, rather than to the absolute number of traded tokens. Indeed, from (18) it follows that the two ratios differ only by the multiplying factor  $\frac{G_c(t)}{N_c(t)}$  appearing at its denominator.

Finally, to complete, in analogy to (14) it is possible to define the following

iv) (*Absolutely Weighted Price Ratio,  $AW_{NGb}(t)$ ; the buyers' perspective*)

$$AW_{NGb}(t) = \begin{cases} \frac{[p_{N\$}(t)]^{\lambda_{N\$}}}{[p_{G\$}(t)]^{\lambda_{G\$}}} & \text{if } p_{N\$}(t) \neq 0, p_{G\$}(t) \neq 0 \text{ or both} \\ 1 & \text{if } p_{N\$}(t), p_{G\$}(t) = 0 \end{cases} \quad (19)$$

#### 4. The economic meaning of the NEO platform

It may also be interesting to consider economic indicators of the platform desirability, as a whole, still based on prices and quantities. A first, rather intuitive, indicator to consider could be the following

(v) (*Relatively Weighted Price Average,  $RWA_{NGa}(t)$ ; the sellers' perspective*) A simple indicator that might be considered,  $RWA_{NGa}(t)$ , can be defined as follows

$$RWA_{NGa}(t) = \begin{cases} p_{N\$}(t)\pi_{G\$} + p_{G\$}(t)\pi_{N\$} & \text{if } \pi_{N\$} \neq 0, \pi_{G\$} \neq 0 \text{ or both} \\ \frac{(p_{N\$}(t)+p_{G\$}(t))}{2} & \text{if } \pi_{N\$}(t), \pi_{G\$}(t) = 0 \end{cases} \quad (20)$$

The above definition is simply a convex combination, a standard average, of the two token prices. As well as in (11) in expression (20)  $p_{N\$}(t)$  is weighted by  $\pi_{G\$}$ , since for the sellers the importance of  $N$  is positively related to both  $p_{N\$}(t)$  and  $\pi_{G\$}$ . Hence, the larger  $\pi_{G\$}$  the more representative is  $p_{N\$}(t)$  of the whole platform value for the sellers.

It is important to point out that the interpretation of (20) requires some attention, since  $p_{N\$}(t)$  is expressed in terms of  $\frac{\$}{N}$  and  $p_{G\$}(t)$  in terms of  $\frac{\$}{G}$ . Therefore, to make sense of  $RWA_{NGa}(t)$  we assume that  $p_{N\$}(t)$  is multiplied by one unit of  $N$  and  $p_{G\$}(t)$  by unit of  $G$ , so that  $RWA_{NGa}(t)$  is simply expressed in \$.

(vi) (*Relatively Weighted Price Average,  $RWA_{NGb}(t)$ ; the buyers' perspective*) Analogously the indicator  $RWA_{NGb}(t)$  is defined as follows

$$RWA_{NGb}(t) = \begin{cases} p_{N\$}(t)\pi_{N\$} + p_{G\$}(t)\pi_{G\$} & \text{if } \pi_{N\$} \neq 0, \pi_{G\$} \neq 0 \text{ or both} \\ \frac{(p_{N\$}(t) + p_{G\$}(t))}{2} & \text{if } \pi_{N\$}(t), \pi_{G\$}(t) = 0 \end{cases} \quad (21)$$

which instead focuses on  $p_{N\$}(t)$  being more representative of the platform economic value when  $\pi_{N\$}$  is large.

It follows immediately that  $RWA_{NGa}(t) > RWA_{NGb}(t)$  if and only if

$$[p_{N\$}(t) - p_{G\$}(t)][\pi_{G\$}(t) - \pi_{N\$}(t)] > 0 \quad (22)$$

that is if either  $p_{N\$}(t) > p_{G\$}(t)$  and  $\pi_{G\$}(t) > \pi_{N\$}(t)$  or the opposite. Hence

$$RWA_{NGa}(t) = RWA_{NGb}(t) \quad (23)$$

if either  $[p_{N\$}(t) - p_{G\$}(t)] = 0$  or  $[\pi_{G\$}(t) - \pi_{N\$}(t)] = 0$  or both, and

$$RWA_{NGa}(t) < RWA_{NGb}(t) \quad (24)$$

that is if either  $p_{N\$}(t) < p_{G\$}(t)$  and  $\pi_{G\$}(t) > \pi_{N\$}(t)$  or the opposite.

## 5. Two-Token based speculation activity

Two token platforms, such as NEO, exhibit a distinguishing feature that might give rise to a, potentially, destabilizing speculation activity. In practice it may be unlikely: however, it is important to make the point for the platform to be aware of it, to prevent its possible occurrence. As we shall see, such feature is intrinsic to TTE, whenever one of the two tokens can be obtained from the other, without *any out-of-pocket* payment. In the NEO platform tokens  $G$  are obtained for free by holders of token  $N$ , provided they perform governance, voting and transfer activities. For each validated block the system distributes 5 units of  $G$ , which are assigned after every *epoch*, which is composed of 21 blocks. So, the units of gas that a node can obtain in an epoch varies between 0 and 105.

Suppose  $0 \leq ng \leq 105$  is the number of  $G$  units that a node holding  $n$  units of  $N$  tokens expects to obtain at the end of an epoch, where  $g$  is the number of gas units obtainable during an epoch with 1 unit of  $N$ . Now suppose, with no major loss of generality, that at the beginning of an epoch a node owns just 1\$, no  $N$  and no  $G$  tokens. Then, assuming prices to be constant over an epoch, the node can sell on the market 1\$ to obtain  $p_{\$N}(t)$  units of  $N$  tokens, expecting to receive at the end of the epoch  $p_{\$N}(t)g$  units of  $G$  tokens with no out-of-pocket payment, for its activities on the platform.

Then, for example, she could convert the  $G$  tokens to obtain  $p_{\$N}(t)gp_{GN}(t)$  units of  $N$  tokens, which together with the initially owned units of tokens would make a total of  $p_{\$N}(t)gp_{GN}(t) + p_{\$N}(t)$  units of  $N$  tokens, owned by the node at the end of the epoch.

Finally, converting back those tokens to \$ the node would obtain

$$[p_{\$N}(t)gp_{GN}(t) + p_{\$N}(t)]p_{N\$}(t) = 1 + gp_{GN}(t) > 1 \quad (25)$$

units of \$. Namely, starting with 1\$ the node would expect to obtain more than 1\$ after the trades described above. Therefore, from a purely financial point of view, the expected return rate of 1\$ invested in  $N$  tokens would be given by

$$\frac{[(1 + gp_{GN}(t)) - 1]}{1} = gp_{GN}(t) \quad (26)$$

As an example, assuming non-arbitrage and  $p_{GN}(t) = e_{GN}(t) = 3.24$  at 31 October 2022, and considering the market average interest rate given by 5%, then to prevent speculative activities it will have to be

$$g3.24 \leq 0.05$$

hence

$$g \leq 0.015$$

Therefore, during an epoch, to avoid speculative monetary flows for each single  $N$  token the expected number of  $G$  tokens obtained, with no out-of-pocket payment, should be less than about 1.5% of 105, that is less than  $(0.015)105 \sim 1.62$ . In reality, the upper bound 0.015 for  $g$  could probably be higher since trading currencies is costly, as well as because there may be opportunity costs in holding  $N$  tokens in one's wallet for an epoch.

To summarise, from a policy making point of view, as long as  $g$  is sufficiently low potential, purely speculative, monetary flows that may destabilize the platform should not take place. Therefore it is important for the platform to monitor, and keep under control, the above conditions to prevent speculation. Indeed, for instance, if the market interest rate would decrease then, everything else being the same, speculation may become more likely. Alternatively, if  $p_{GN}(t)$  increases then  $g$  could become larger.

## 6. Conclusions

In the paper, to our knowledge, for the first time we have proposed a discussion on the economic fundamentals of a TTE. In particular, we have introduced a number of economic indicators that might be considered to define absolute and relative economic values for the tokens, as well as for the whole platform. To construct such indicators we used market prices, traded and circulating quantities of the tokens. These are only a subset of the possible metrics that one could consider, and for this reason our proposed indicators are by no means the only ones. Indeed, we mentioned the number of transactions and their average monetary size, the block size and others, could also be informative variables to consider.

The analysis on traded quantities suggested the introduction of two different perspectives, the *buyers'* and the *sellers'*, for the combined price-quantity indicators. We conceive the proposed indicators, computed in real time, as composing a *dashboard* for the blockchain policy makers, that can enjoy the continuous observation of the absolute and relative economic values of the tokens, as well as of the platform. As simple as they may be, we believe that the indicators can convey interesting, and effective, information to decision makers.

Finally, we pointed out an intrinsic feature of a TTE, such as NEO, which, depending on the relevant variables, may in principle induce purely speculative monetary flows that could destabilize the platform. We observed that in reality such flows may be unlikely, but we also argued that it is appropriate for policy makers to be aware of it. The relevant indicators to prevent destabilizing speculation could also be part of the decision makers' *dashboard*.