Building a Framework for Digital Currency Valuation

Sath Ganesarajah, September 2018.

The approach to digital currency valuation is not unlike that of traditional currency – they are both different forms of money. The objective of a valuation framework, in the context of money, is to understand the determinants of the exchange rate between two, or more, different currencies; what is the value of one money in terms of another. Valuation frameworks should not be designed to predict the future, but instead, help us understand the present fundamental drivers of value. By understanding the fundamentals, we can better assess any discrepancy between the current market price and trends that are developing in underlying supply and demand factors. These trends, which tend to be driven by economics, is what ultimately matters for investing.

This paper deals with digital currencies (popularised as cryptocurrency), which are native assets of a blockchain. Not all Cryptoassets or Digital Assets are digital currencies. The primary purpose of a digital currency is for use as money. Digital assets, on the other hand, can have a wide range of characteristics and uses, such as to represent physical assets digitally or for access to a particular platform or utility.

According to Jan Lansky in "Possible State Approaches to Cryptocurrencies" (Journal of Systems Integration), a cryptocurrency is a system that meets six conditions:

1. *The system does not require a central authority, its state is maintained through distributed consensus.*
2. *The system keeps an overview of cryptocurrency units and their ownership.*
3. *The system defines whether new cryptocurrency units can be created. If new cryptocurrency units can be created, the system defines the circumstances of their origin and how to determine the ownership of these new units.*
4. *Ownership of cryptocurrency units can be proved exclusively cryptographically.*
5. *The system allows transactions to be performed in which ownership of the cryptographic units is changed. A transaction statement can only be issued by an entity proving the current ownership of these units.*
6. *If two different instructions for changing the ownership of the same cryptographic units are simultaneously entered, the system performs at most one of them.*

Fundamental Models for Currency Valuation

There is no such thing as 'valuing money' – the value of one dollar is one dollar. We can, however, try to understand how the value of one type of money (currency) is determined in another currency. For example, the valuation of the US dollar against other foreign currencies is under the influence of an ever-changing number of factors which include:

- Purchasing Power Parity – The price of homogenous goods in different currencies
- Real Effective Exchange Rates – inflation adjusted price differentials
- Monetary Influences – the quantity and supply dynamics of money supply
- Balance of Payments Flow – trends in cross border transactions
- Portfolio Balances – trends in international foreign currency and securities holdings
- Technicals and Charting – price and exchange rate patterns used by traders

These factors, among others, are closely monitored and extensively modelled by market practitioners.

Figure 1 – Quantity Theory of Money, Relative Prices & Exchange Rates

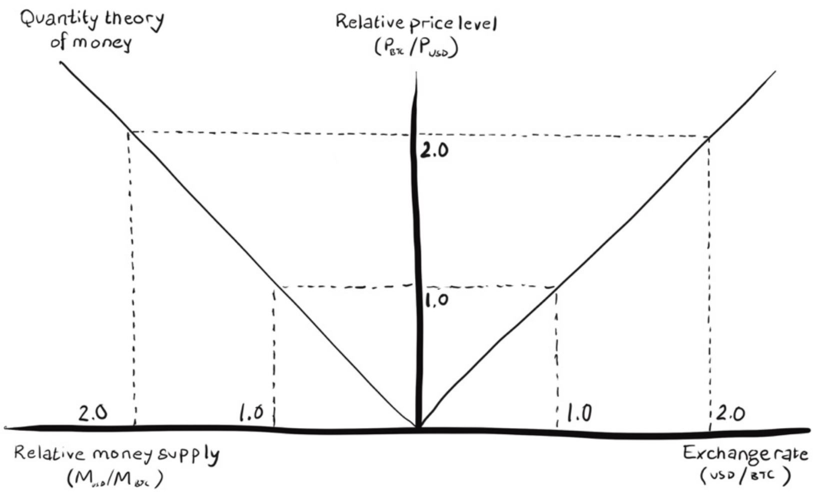
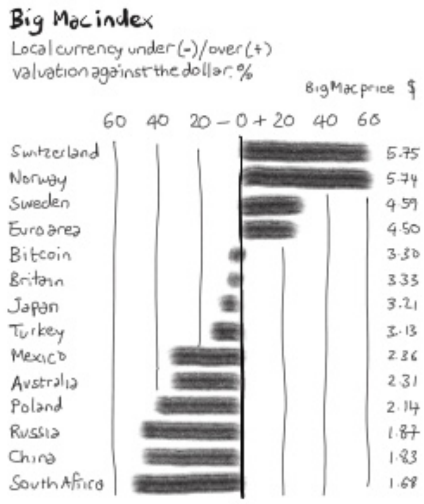


Figure 2 – The 'Big Mac Index' illustrating Purchasing Power Parity



Fiat Money has Embedded a Special Type of Credit Risk

Modern money (fiat money) is backed by nothing but the trust in the sovereign which governs it. For this reason, money has 'Sovereign Risk'. While today it may be unfathomable to think a currency in the developed world could fail, history is littered with examples of currency ‘failure’: the German Papiermark (1920s), the Greek Drachmai (1940s-1950s), the Argentine Peso (1975-1992), the Zimbabwe Dollar (mid-2000s), and many more. Currencies often fail through bankrupt policy, which leads to hyperinflation; the money supply might be exploited without restraint to finance a war, relieve debt burdens or support an ailing economy; resulting in the money becoming worthless. Since fiat money is not convertible to gold or any other commodity, it carries the risk that the sovereign will mismanage it. A long history of credible monetary policy can help hide the sovereign risk calculus, but it is never eliminated.

Understanding Digital Currency

Digital currencies belong to no sovereign, yet the protocol on which they operate is like a border-less country that exists only in cyberspace. As a new infrastructural, decentralised layer of the internet, digital currencies substitute the sovereign risk associated with a traditional currency with 'Network Risk'. In the same way a traditional currency can fail from policy mismanagement by its governing body, digital currency is also trusting of its governing authority – the network protocol.

The primary risk for a network protocol is that it is no longer used, since network protocols rely on 'network effects' for their power. The market is very good at measuring the risk of users no longer using the network – it does this in almost real time. If no one uses a digital currency protocol, it will soon be worthless as measured in terms of hard currency (i.e. dollars). Certain types of network risks are harder to ascertain from the market price because digital currencies are a two-sided system, made up of 'users' and 'miners' and only users interact with the market. The market price is only indirectly affected by vulnerabilities of the mining network, including the risk of the mining network folding or an attack on the blockchain. Blockchains can fail from either 'bad' agents who attack the network or from mining economics that do not incentivise the maintenance of the infrastructure.

Network Risk

Network Risk cannot be readily quantified and is dependent on subjective analysis. The strength of a network will depend on a variety of factors, many of which can be specific to the blockchain protocol on which the digital currency operates. The core principles behind measuring network risk is to determine the factors that support:

1. Strength and Quality of Network Architecture
2. Strength and Quality of Network Ecosystem

The network architecture determines how the protocol functions and how the embedded incentives maintain the infrastructure and provides protection from attack. The consensus mechanism is a crucial aspect of blockchain security, however other blockchain design choices such as currency supply schedule, cryptographic hash function and block creation time can also affect the confluence of factors that determine network strength (risk). Metrics that measure these factors include:

- Network Hash Rate
- Hash Rate Distribution
- Estimated Value of Hardware Assets Associated with the Network
- Difficulty Level
- Miner Economics & Break-evens

Understanding the strength of the network architecture is a technical undertaking, with mostly quantifiable metrics, however, the strength of the network ecosystem is equally important. Technology and mathematics underpin the fabric of blockchain but at the most fundamental level, blockchains remain a social construct. Without people behind the computers, there is no network. Protocol governance is codified but the code itself is governed by people. The ecosystem which determines network support, growth and functionality can be influenced by blockchain design choices such as programming language used, open or closed source code and overarching philosophy. Metrics that can measure the strength of the ecosystem include:

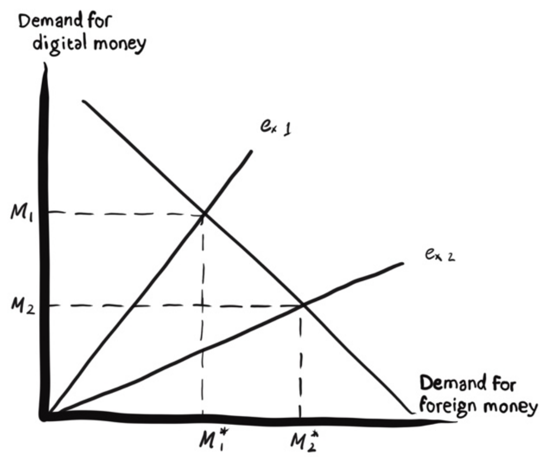
- Wallet Growth
- Node Growth
- Node Topology
- Node Decentralisation
- Social Media Analysis: Google Search Trends, Reddit, Twitter
- Developer Support (Github analysis: lag commit, change commit)
- Regulatory Risk Measures

<u>Network Risk is much like Sovereign Risk or Credit Risk because it measures existential failure and default.</u>

Exchange Rate Determination

The demand for holding digital currency balances come from the unique monetary services that traditional money may be incapable of performing or because they might provide similar services at a lower opportunity cost. We must augment tools used to understand traditional currencies for digital currencies by evaluating their use cases and measuring the volume of goods and services exclusively priced in the digital currency. For example, on the Bitcoin Network, digital transactions are required to have fees paid in bitcoin for processing. On the Filecoin Blockchain, hard-disk space can be rented with fees and payments denominated in 'filecoins'. Digital currencies have their own internal economies and associated 'Gross Domestic Product' (GDP).

Figure 3 – The relative demand for holding particular currencies will affect equilibrium Exchange Rates



Measuring GDP, modelling monetary systems and understanding currency flows between different economies are ideas familiar with economists. We can build fundamental models using a monetary approach (demand for money) and extend with flow approaches that measure 'external balances' of an economy; abstracting a 'current account balance' as well as 'capital and financial account'. While there is no government or regulatory sources for the data, there is the blockchain itself (the block explorer), which can be combined with forensic analysis to infer the data needed. Blockchain data includes:

- Transaction Fees
- Transaction Volume
- Transaction Value
- Block Analysis (Transactions per Block, Confirmation Time, Average Block Size, Memory Pool Size)
- Exchange Volume Analysis (Breakdown by regions, currency pairs)

Figure 4 – Relative changes in Economic activity will impact the Exchange Rate

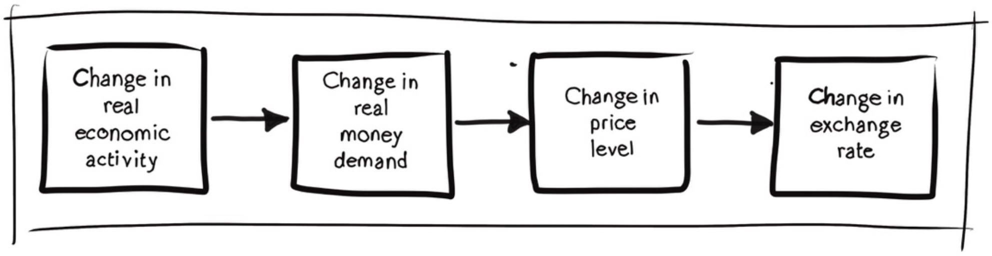
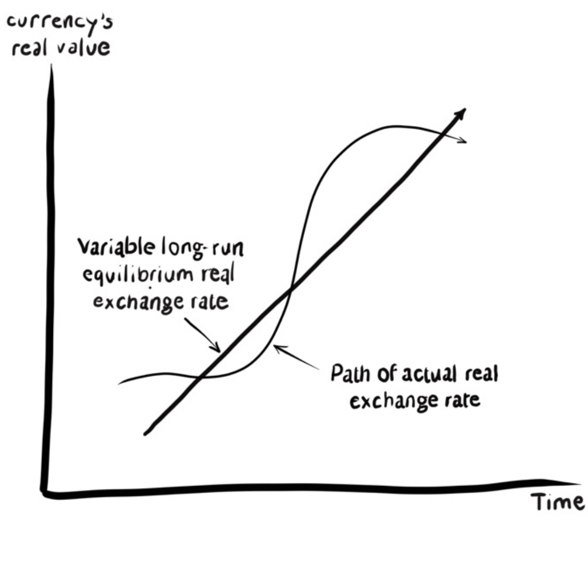


Figure 5 – Market forces create disturbances in the Long-Run Equilibrium Exchange Rate



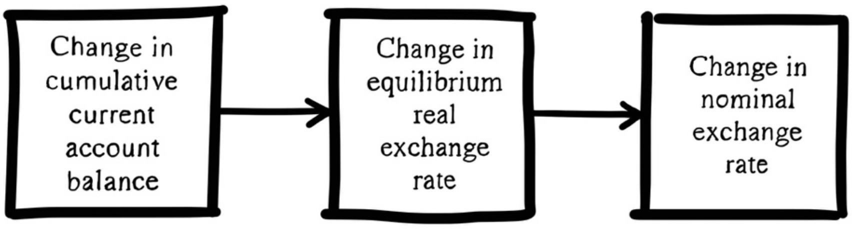
Exchange Rate Risk and Network Risk cannot be Disentangled

When a currency is at risk of failure, this risk will manifest itself in the exchange rate. The 'default' risk cannot be disentangled from the exchange rate risk. This is the same with digital currencies. The network risk cannot be appropriated from the exchange rate – it will just 'turn up' in the market price. The very nature of exchange rates is to measure the price of one currency in another, while remembering that both currencies are not assets that have a different price in their own money. We can show this by considering that one dollar cannot 'go to zero'. One dollar is always one dollar. It is the exchange rate that we refer to when we say the currency has failed. Likewise, for bitcoin, it cannot go to zero. If the network is attacked, the blockchain has ways to recover. It may not be possible to recover in a way such that long-term credibility is restored (i.e. Zimbabwe), but it can recover. It is worth remembering the blockchain is immutable, so one bitcoin will always be one bitcoin, and it will always belong to the same private key – even if the network 'implodes' from a mining boycott, if the miners were to return, bitcoin balances would be preserved.

Constructing the 'Balance of Payments' for Digital Currency

The Balance of Payments (BOP) is a statistical statement designed to provide, for a specific period of time, a systematic record of an economy's transactions with the 'rest of the world'. The BOP has great significance on exchange rate determination since it records the trade flows between external economies and the internal economy, which in turn determines the supply and demand for currency.

Figure 3 – How the Current Account Balance will interact with drivers of the Exchange Rate

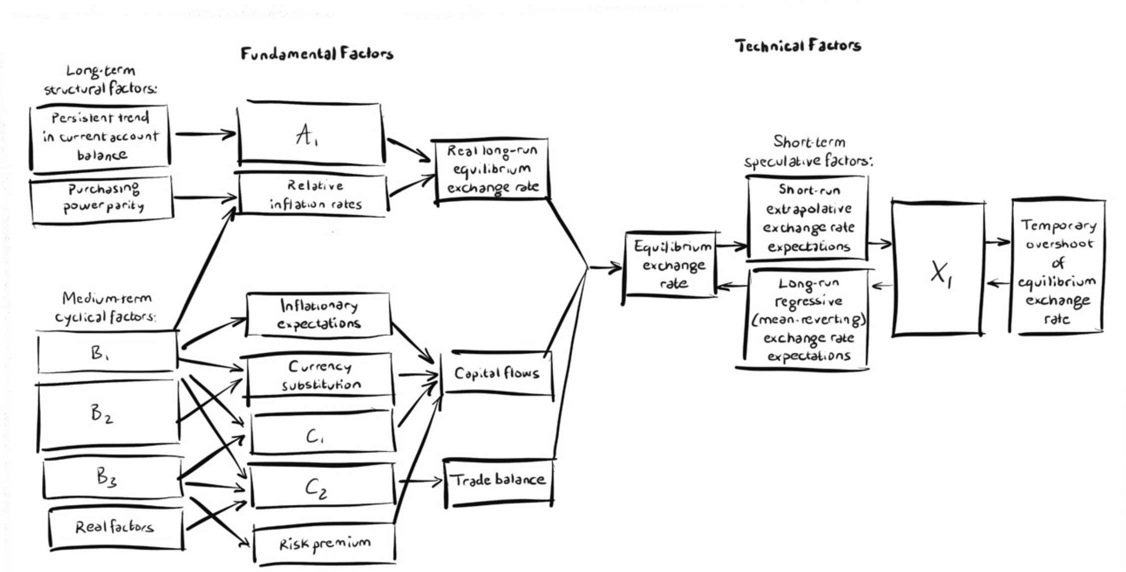


For economies governed by a sovereign, the data compilation process can be coordinated using centralised and official agencies. For digital currency, an economy with no central authority, the process needs to be re-designed.

Every transaction for a particular digital currency is recorded in its respective blockchain, however, the data will require 'cleaning' due to the existence of change outputs, self-churn, privacy enhancements, mixers and spam. Then the task of isolating 'foreign exchange' transactions, required for compiling the BOP, needs additional investigative work. The transaction recorded 'on-chain' can be assumed to only represent one side of the transaction. If we assume the transfer of funds from one party to another is payment for a good or service, the blockchain does not record the goods or services exchanged. Therefore, it is difficult to know which transactions represent an exchange of funds for goods and services and which relate to an exchange of another (foreign) currency. Only by isolating the transactions relating to the exchange of currency can we determine the money flows in and out of an economy. In the appendix, we provide further detail of this idea by explaining the balance of payments construct; highlighting why the accounting model is crucial in understanding exchange rates between currencies. Blockchain forensics will require the availability of data sources that may be difficult to acquire. For example, since most foreign exchange transactions happen through exchanges, exchange data (which will have to include in-house transaction data) will need cross-checking with the block explorer. Additional considerations include 'higher-layer' foreign exchange transactions, where currency flows could occur off-chain. The feasibility of turning BOP theory into BOP statistical tables may sound increasingly far-fetched, however a number of firms exist to undertake precisely this type of work.

In this paper we have introduced the BOP construct as applied to digital currencies. Understanding currency flow requires understanding the industries that support the digital currency and how to draw borders around a border-less economy. Once we are able to systematically record and analyse the economic activity, applying traditional, time-tested methods of currency forecasting and valuation becomes straight forward.

Figure 4 – Building a Framework for Digital Currency Valuation



APPENDIX

Monetary Theory, The Balance of Payments, and Exchange Rate Determination

First Principles

The Franklin Dollar

In an imaginary town, Franklin, the currency used for all trade and commerce is the Franklin Dollar ($). We want to measure the demand for money in Franklin. To do this, we choose a time frame of one year and then measure the total amount of money and record all transactions that have occurred in this period.

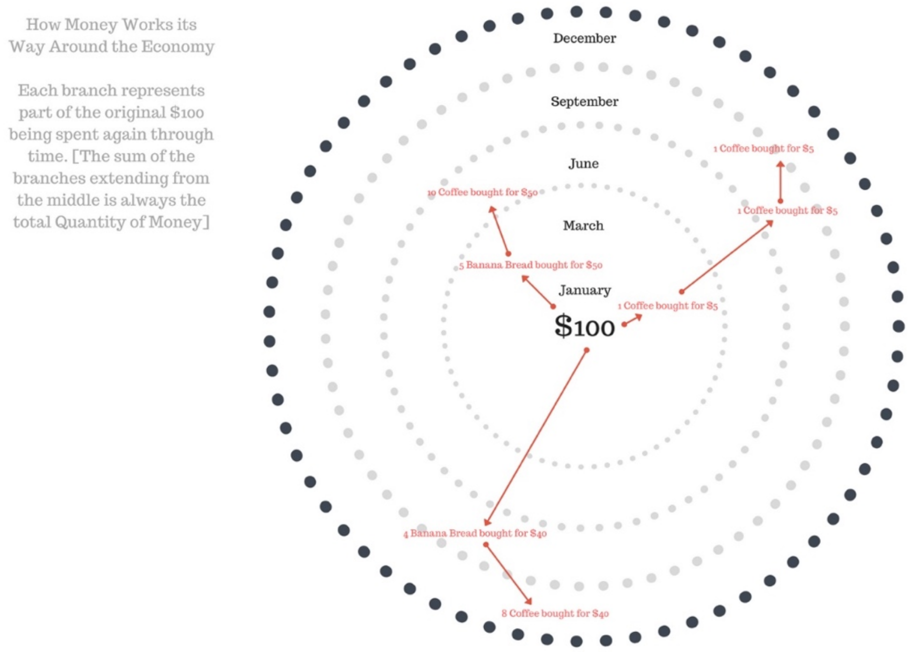
The Town of Franklin

Currency Franklin Dollar ($)

Total Quantity of Money, in Given Year = $100

All Economic Transactions, in Given Year:

15th January, 1 Coffee bought/sold for $5
22nd February, 5 Banana Bread bought/sold for $50 ($10 each)
16th April, 10 Coffee bought/sold for $50 ($5 each)
10th July, 1 Coffee bought/sold for $5
18th August, 4 Banana Bread bought/sold for $40 ($10 each)
1st September, 1 Coffee bought/sold for $5
15th November, 8 Coffee bought/sold for $40 ($5 each)



The 'Equation of Exchange', an identity first popularized by Irving Fisher in "The Purchasing Power of Money" (1911), states that the 'Demand for Money' must equal the 'Money Supplied in exchange for Goods and Services'.

The Equation of Exchange

$$M * V = P * Q$$

Money Demand = Money Supply

M = Quantity of Money
V = Velocity
P = Price Level
Q = Quantity of Goods

P * Q = Nominal GDP

V, Velocity, is a scalar which measures the number of times money circulates around the economy. We calculate the Demand for Money, for the given year, in Franklin to be $195. Or, put another way, the $100 in the economy circulated 1.95 times.

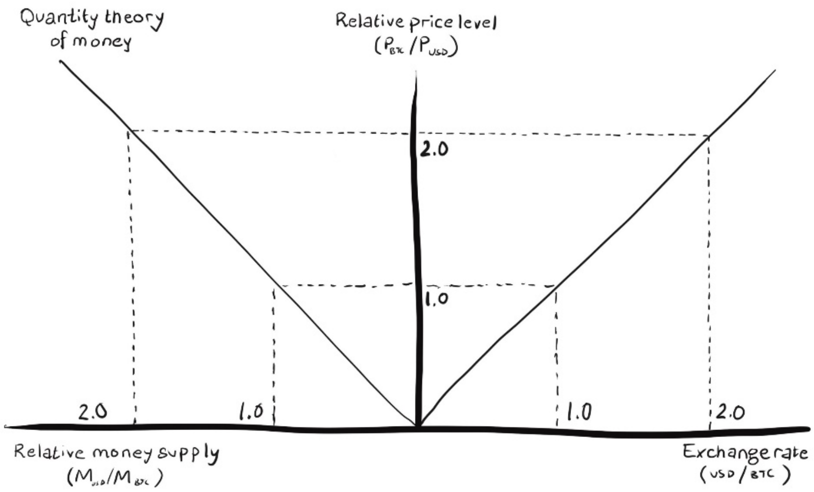
V = P * Q / M

M : $100
Calculating P * Q :
15th January, 1 Coffee * $5 = $5
22nd February, 5 Banana Bread * $10 = $50
16th April, 10 Coffee * $5 = $50
10th July, 1 Coffee * $5 = $5
18th August, 4 Banana Bread * $10 = $40
1st September, 1 Coffee * $5 = $5
15th November, 8 Coffee * $5 = $40
Sum of all transactions = $195 = Money Supplied = Nominal GDP

V = $195 / $100 = 1.95

Particularly for a fixed money supply, the velocity of money is an important measure of how robust an economy is. The right-hand side of the equation (PQ) is nominal GDP, so increasing velocity with stable prices (inflation) has the effect of increasing GDP.

In one approach to Exchange Rate Determination we can compare Purchasing Power Parity between the two economies, the differences in money supply and velocities and arrive at an understanding of which money is in more demand, and therefore should have upward pressure on the exchange rate between the two currencies.



The Nakamoto Bitcoin

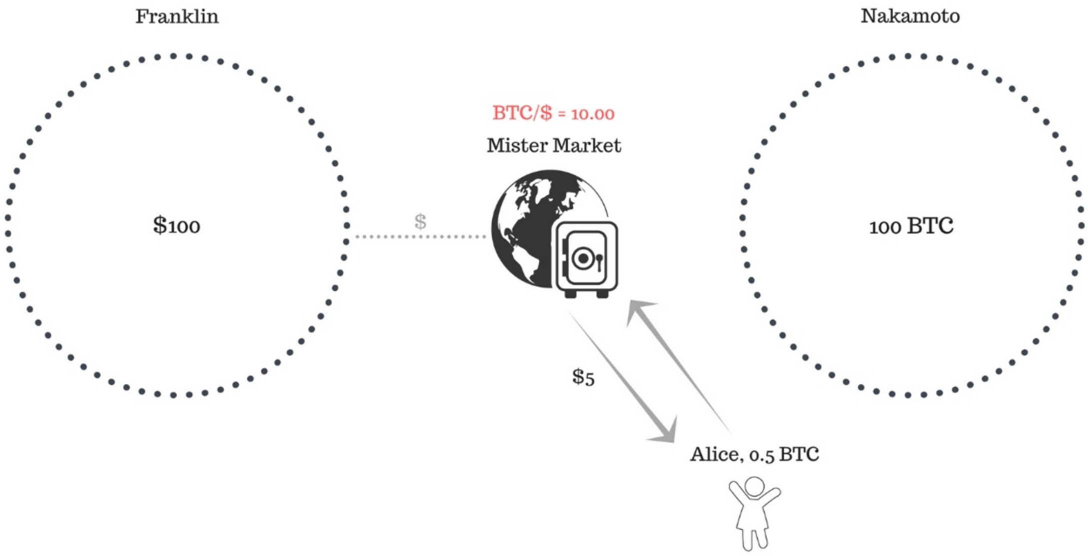
Nakamoto is another fictional town, which uses another currency, the Nakamoto Bitcoin (BTC). Let us consider a new time period (and so, ignoring the transactions from the previous example), where the quantity of money in Nakamoto is 100BTC and the quantity of money in Franklin is $100.

Mister Market

Alice lives in Nakamoto, where all her daily transactions are in Bitcoins. One day she decides she wants to buy a coffee from the town of Franklin, however, Franklin coffee shops do not accept Bitcoin. To buy the coffee, Alice needs to convert some of her Bitcoins into Dollars.

'Mister Market' is a company that helps its customers with foreign exchange (FX) transactions. Alice needs $5 to buy a coffee from Franklin, therefore asks Mister Market how many Bitcoins they need in exchange for the $5 Dollars required in return.

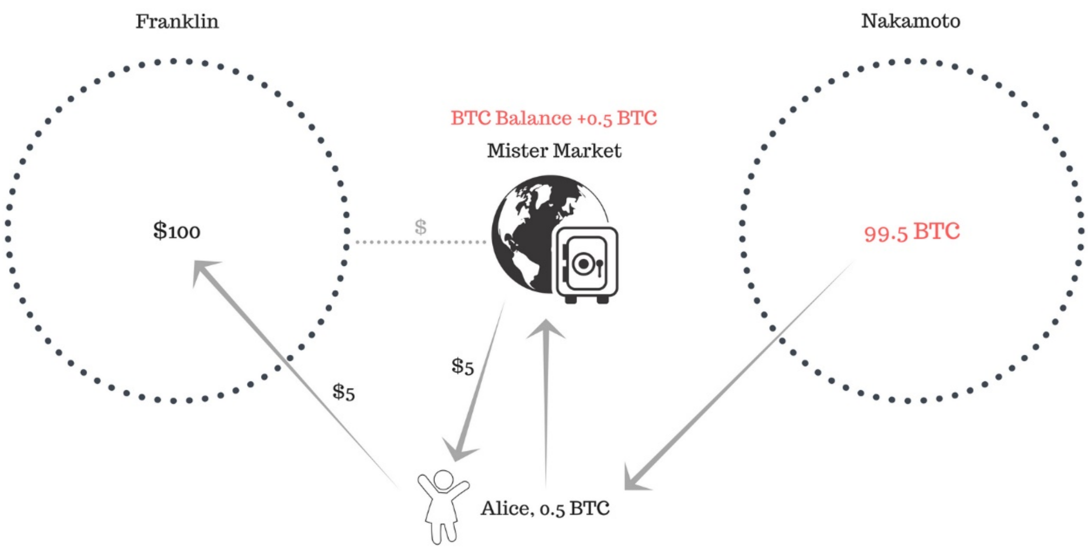
Mister Market tells Alice the Bitcoin/Dollar exchange rate is 10.00 (one Bitcoin buys ten Dollars). Alice makes a transaction to convert 0.5 Bitcoin to $5 at this exchange rate.



Alice then buys her coffee from the Franklin coffee shop for $5.

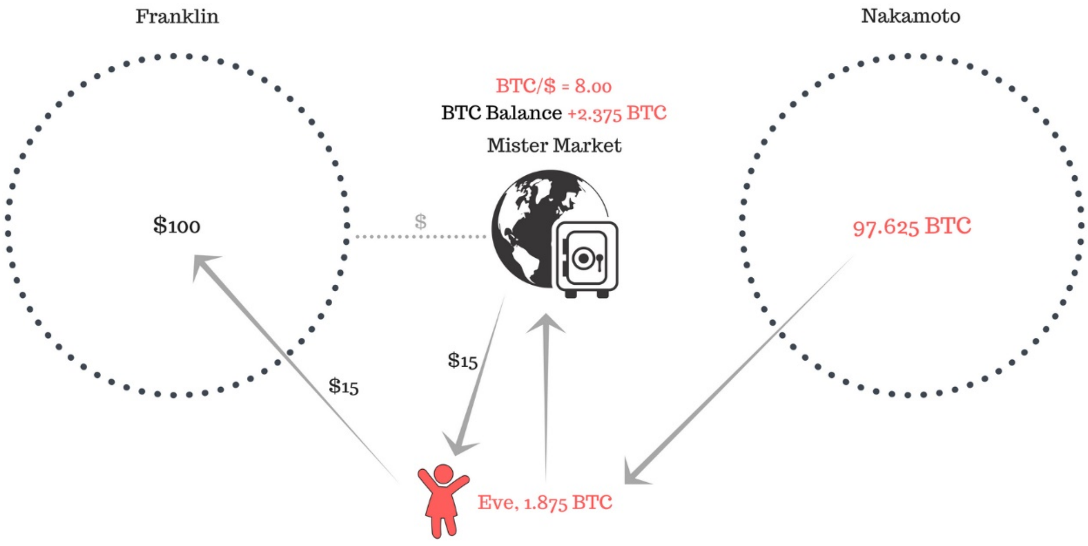
External Accounts & The Balance of Payments

After Alice's FX transaction, something has happened to the effective money supply of the Nakamoto economy. 0.5 Bitcoins has left the Nakamoto economy and is now with Mister Market. Nothing has happened to the Dollar economy - Mister Market must have had the $5 Dollars in possession before the FX transaction, to be able to give to Alice, who then spends the Dollars in the Dollar economy (Franklin).



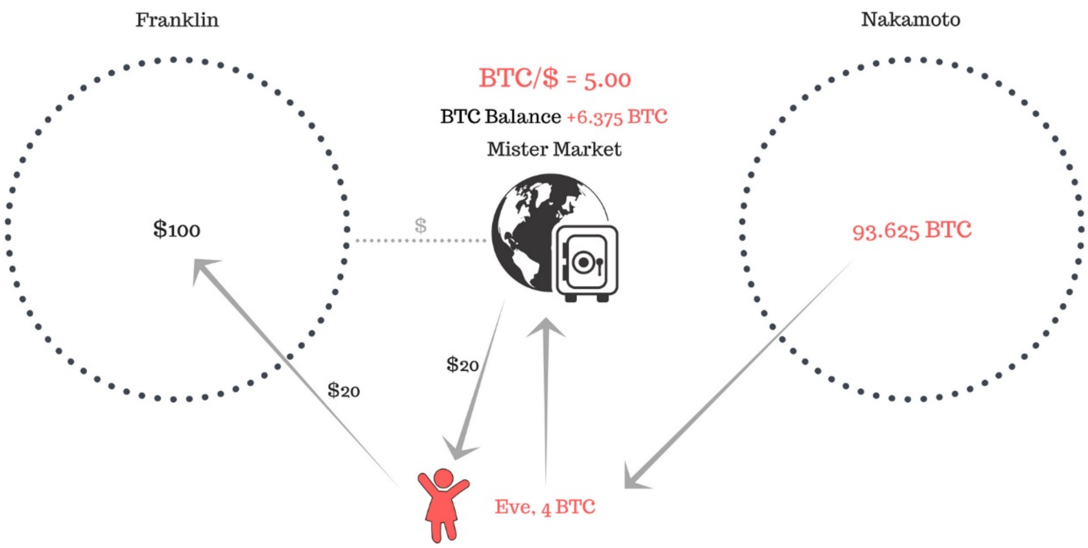
Mister Market's foreign exchange balances represents the 'Balance of Payments' between the two economies. From Franklin's point of view, the economy has accumulated 0.5 Bitcoins on its 'external account' (another way to think about this is that they have 0.5 BTC for sale if anyone wanted to buy it with Dollars). From Nakamoto's point of view, the economy owes Franklin $5, at current exchange rates, to get back the 0.5 Bitcoins that has escaped their economy.

Eve, another Nakamoto inhabitant, hears about the wonderful coffee being served in Franklin and decides to follow Alice's lead. Eve wants to buy 3 cups of coffee for herself and friends. She asks Mister Market to exchange her Bitcoins for the $15 she needs to buy the coffees. Mister Market already has 0.5 Bitcoins and is worried about stock-piling Bitcoins while seeing no demand from anyone to buy them from him. Mister Market agrees to change Eve's money but for a new Bitcoin/Dollar exchange rate of 8.00. Eve gives Mister Market 1.875 Bitcoins to receive $15.



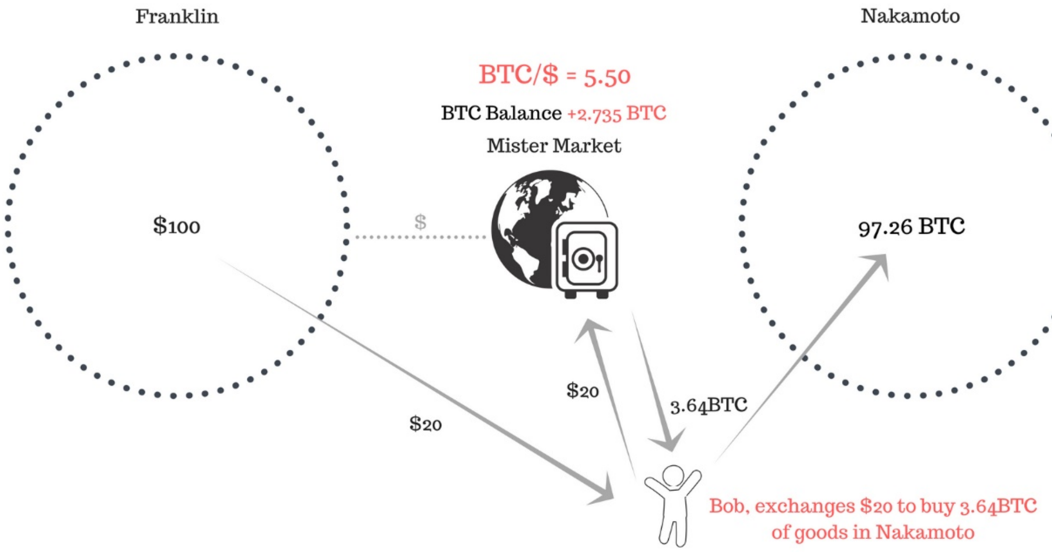
Eve's friends loved the coffee. Eve decides to buy more Franklin coffee. Eve asks Mister Market for $20 in exchange for Bitcoin.

Mister Market becomes uncomfortable stock piling even more Bitcoin. Mister Market make a less attractive exchange rate to Eve than the last transaction, showing Bitcoin/Dollar as 5.00. Eve completes the transaction anyway.



Exchange Rate Determination

We can already see how the Balance of Payments has a direct impact on the exchange rate between the two currencies. The only way for the Balance of Payments to 're-balance', is if the inhabitants of Franklin start to demand goods and services from Nakamoto. The demand for Nakamoto goods and services will create the demand for its money, Bitcoin, thereby relieving the downward pressure on the exchange rate. Luckily, because Mister Market is adjusting his exchange rate in accordance to the supply and demand of currency, Nakamoto goods and service will look more and more attractive as the exchange rate moves lower.



In traditional currency markets, Mister Market is represented by exchanges, international corporations, banks, financial institutions and governments. Since traditional currencies are governed by their sovereign, governments can collect information on foreign exchange transactions from all the relevant agents that operate in their jurisdiction. Government agencies regularly compile comprehensive statistical statements that represent the Balance of Payments (officially called 'The Current Account Statement' and 'The Capital and Financial Accounts').

The Balance of Payments cannot predict the future path of exchange rates. The statements only serve as a snapshot of the current flow and trends in foreign exchange transactions. For currency investors, this information provides insight into the strength of a particular monetary system, which is inextricably intertwined with its economy. This information is crucial to understanding exchange rates, since it directly measures the relative demand of currencies.

Digital currency markets have no governing sovereign. Digital currencies are decentralised, operate only on the internet, and transcend borders and jurisdictions. However, this does not mean abstracting 'the Balance of Payments' is impossible – it is just more difficult. One of the virtues of a Blockchain is the transparency of transaction data – every 'on-chain' transaction is recorded and available for all to see. The challenge is to isolate which transactions relate to 'foreign exchange'.

Understanding exchange rate determination of a digital currency requires analysis of the goods and services priced in its specific currency – this is how to determine the nominal GDP of a borderless economy. Bitcoin is like a borderless country that exists only in Cyberspace, but its internal economy is bordered by the transactions that are denominated in Bitcoin.

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