Overcoming economic stagnation in low-income communities with programmable money

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Abstract. A multidisciplinary analysis of local currencies as a means to drive growth in traditionally economically stagnant communities. This paper evaluates the factors leading to a cycle of low incomes and quality of life, focusing on the Brazilian *favelas* as an introductory case study. The research draws from macroeconomic concepts applied at the community-level and utilizes former research of local currencies to formulate a model which is replicable across different geographical locations. An implementation is proposed using the Ethereum protocol, providing features which would facilitate both the onboarding and continued performance of the system. The shortcomings of public blockchain networks are addressed and it is concluded that in the medium-term, blockchain-based systems should become the norm for successful local currency projects.

1. Introduction

For most countries, economic growth has been a large focus of public policy throughout the past century. The aggregated Gross Domestic Product of all countries has risen continually through time with few exceptions, and totals over US$80 trillion as of writing (World Bank, 2017). However, as the world becomes wealthier as a whole, the number of people living with a low income grows alongside it (World Bank, 2017), creating unbalanced societies in which the products of wealth generation are not reaped by its entire population. This unequal distribution of wealth forces the creation of communities that face subpar quality of living, composed of households that often cannot afford the cost of living elsewhere. This phenomenon is especially noticeable in Brazil, a country with one of the highest Gini coefficients in the world (World Bank, 2017). In Brazil, low-income households often populate urban areas denominated *favelas*, which are communities characterized by low income, high crime rates and a geographical isolation from the key areas of cities, as they take up peripheral land, often on hillsides.

Low-income communities such as *favelas* can often be trapped in an economic cycle of poverty, experiencing a level of stagnation which prevents the development of the community as a whole. In order to mitigate this issue, charities, NGOs and other social responsibility programmes aim to develop new strategies to help improve the standard of living for individuals in low-income communities, but these can be difficult to implement and can have unpredictable results. One commonly-used approach is to focus investment on the education of the inhabitants of the communities, such that they may develop important skills that will enable them to achieve greater incomes in the future. However, education, despite its proven benefits, may not be an effective solution by itself to improve the quality of a whole community. Given the opportunity to earn a higher income, an individual may be better off, but subsequently choose to move somewhere else, therefore not producing a large benefit for the greater community. Other strategies exist, such as investments in infrastructure, donations and the creation of better-quality jobs. These are all effective strategies which can produce positive effects, but also have their own shortcomings. The analysis of their effectiveness is beyond the scope of this paper, and their mention is used to outline that the proposed solutions to the issue are multiple and go beyond the strategies discussed in the research. The key point to be addressed is that despite the existence of a myriad of solutions, a replicable and surefire method has not yet been developed to improve the quality of living of these communities.

The main problem with traditional models for aid in low-income communities is their limitation to addressing topical problems which may not have an overall long-term benefit. This is not necessarily attributable to poor models but perhaps a reflection of the shortcomings of the overarching economic system (Powell, 2002). The socioeconomic structure of modern society leads wealth to flow to a few large pools where it fails to benefit the whole of society as it is predicted to do, through the assumed correlation between economic growth and economic development. Nevertheless, this paper does not mean to assess capitalism as a system, nor suggest that it is inferior to existing alternatives. Rather, the research presented here explores the opportunities present in tinkering with the economic system at the local level, such that it benefits from the overall macroeconomic structure, while offering features that are developed to suit specific environments. This solution is based on the use of a local currency, which is money that can only be spent in a specific geographical location (Longhurst, N. Seyfang G., 2013). The premise of local currencies is to strengthen the economy of a given community, while not limiting its access to the greater economy they are a part of.

Local currencies are also often denominated complementary currencies, as they do not seek to undermine sovereign money, but rather complement it. As expected, their implementation is faced with a variety of difficulties and local currency projects have experienced fates that can be placed at every point of the success-failure spectrum. This paper aims to analyse some of the literature describing these failures and successes, outlining the defining characteristics which tend to lead to a positive outcome. It is argued here that the concept of a local currency is a coherent one, which fails not due to an inherent flaw but rather a difficulty of implementation. In arguing that the challenge is one of implementation, the paper denotes areas for improvement, henceforth proposing the use of a blockchain-based system to enhance the likelihood of success of these systems. An example implementation is provided using the Ethereum protocol as the foundational layer, adding improvements to a traditional digital token model that is commonly used by developers in the field. The hope is that this research can successfully express the benefits of applying distributed ledger technology as the underlying mechanism for a local currency and encourage its application in practice.

2. Traditional approach

2.1. Motivation for local currencies

Local currencies, often called complementary or community currencies, are monetary systems created to function in one location only, serving as an addition, not a substitute, to the sovereign currency present in the jurisdiction. They are described by Collom (2011) as “collective efforts to form an alternative market with the hopes of empowering the economically marginalized and building social capital”. As such, they are tailored to better suit the needs of the locality at hand when compared to the sovereign currency and create a network where wealth generated by or for the community remains within the community. Joaquim de Melo Neto, the founder of Brazil’s most well-known and successful local currency project, Banco Palmas, commented that the idea for his project came from analysing why the people in these communities were poor, which led to the conclusion that a key reason was that most of their spending was directed outside of the neighborhood, rather than inside of it (UOL Economia, 2018). Data compiled by a local currency project for the Paraisópolis *favela* in São Paulo uncovered that only 21% of the neighborhood’s inhabitants worked inside of the *favela* (UOL Economia, 2018). Working outside of the neighborhood, for example, can act as an incentive for these workers to consume outside of their local community for matters of convenience, which generates a negative effect for that neighborhood, which could have otherwise appropriated of the value spent.

In addition to serving the purpose of empowering the inhabitants of low-income communities to spend their income within the neighborhood, local currencies are also useful for targeted microcredit (Place, 2011). By providing loans in a complementary currency, project leaders can ensure that the credit is being given to those who in fact live inside of the community, as well as it forces the lendee to make use of the loan internally. An entrepreneur, for example, will have to seek the resources for his/her business from inside the community, guaranteeing that even as the value of the loan is spent, the neighborhood appropriates of its full value, with limited leakages. Furthermore, credit can also be offered at lower rates than those set by commercial banks, as well as reach a greater number of people, given that many of the households in low-income areas are credit-constrained. Ultimately, the goal of these projects is to ensure that the benefits described by the multiplier effect (Keynes, 1936) are reaped solely by the community following an injection of capital. The macroeconomic effect of injections into low-income communities can be powerful, but its benefits are rarely felt at the epicenter of the injection. Due to their low income and inability to access credit (or cheap credit), it would be expected that the marginal propensity to consume (MPC) of poor households is significantly higher than the average for the country, hence producing a larger multiplier effect[1]. However, as previously mentioned, individuals in these communities spend most of their income outside, which would produce a multiplier effect nonetheless, but a limited one within the community. Through the use of a local currency, injections will be more effective, as the money injected only has value locally.

The aforementioned analysis is supported by macroeconomic examples such as France and Germany in the 1980s. Following the election of France's first socialist president, François Mitterand, in 1981, the French government increased spending, turning a budget surplus into a deficit and leading to an increase in its government spending as a percentage of GDP of around 13% in less than five years (Trading Economics, 2019). This increase in spending led to France's GDP growth rate topping Germany's in 1982, but Germany would experience a greater increase than France in 1983. This phenomenon is attributed to the growth in imports from Germany into France as the French economy boomed and supported by France's lower-than-normal balance of trade between 1982 and 1983, while Germany's balance of trade reached historical peaks at the time (Trading Economics, 2019). This event is one representation of what can happen to injections into an economy when there is a

[1] i.e. The likelihood of poor households investing or saving additional money given to them is low, meaning that they are likely to spend it, which provides an even greater positive effect of growth for the economy.

disparity in the location of acquisition of income versus the location of its absorption (the target of the spending). Despite the obvious differences between a country and a small community, similar economic principles still apply, and ensuring that capital inflow will have an impact where it is targeted at is a key aspect of local currencies which helps mitigate unexpected consequences following a monetary stimulus.

Lastly, Sobiecki (2018), who studied the local currency projects in Poland, believes less in the economic motivation for these new monetary systems, but more in their use as a social tool, claiming they can be used as an "institution for activating the elderly or unemployed, intergenerational exchange or social integration". However, despite the direct social benefits mentioned by Sobiecki, he fails to recognize the economic consequences that arise from the social empowerment. By itself, a focus on social development is a worthwhile goal to be pursued, but its pursuit can also generate positive economic results. Activating the elderly or unemployed is a way to increase productivity and engagement in the local economy through the use of underutilized labour and skills. The injection of a complementary currency into the community may lead to an excess of cash for those who generally spend most of their income outside of the community, therefore prompting them to put the cash to use by hiring an unemployed person to perform a service, for example. Additionally to the empowerment of underutilized labour, an argument can also be made for increasing the usage of underutilized assets. By stimulating the local economy, new opportunities can arise for generating wealth from assets that have no value outside of the locality. The idea of encouraging the use of underutilized assets is especially predominant in systems denominated Time Banks, which will not be directly addressed in this research but are explored in depth by Seyfang and Smith's "*The Time of Our Lives: Using Time Banking for Neighbourhood Renewal and Community Capacity-Building"* (2002). Indeed, the question is one of empowerment, as Sobiecki pointed out, but the empowerment is not merely social, but also economic. A more comprehensive argument is offered by Hughes (2015), who highlights the important educational and political roles played by these systems in raising awareness to important socioeconomic issues and incentivizing change, but without disregarding the potential economic benefits that can arise from a successful implementation.

2.2. Banco Palmas: A case study

2.2.1. A brief history

Banco Palmas (BP) is the first and most prominent *Community Development Bank* (CDB) in Brazil, and the manager of the local currency with the same name, the Palmas (Fare, Freitas and Meyer, 2015). Founded in 2002, Banco Palmas operates in a Brazilian *favela* called *Conjunto Palmares*, located in Fortaleza and with a population of *circa* 36,000 inhabitants (Fare et al, 2015). The neighbourhood is one of the poorest in the city (Borges, 2010) and has faced a long history of social exclusion and community-led initiatives calling for improvements to the locality from the government. This history of conflict and community action has played an important role in the sense of identity of the community and is arguably one of the factors eventually leading to the success of its local currency (Fare et al, 2015).

Following the first mapping of local consumption in 1997 which uncovered that only 20% of the consumption of households of the community was spent within the neighbourhood (Melo and Magalhães, 2008), as well as other compilations of data from the same time, the need for stimulating local consumption became clear, thus prompting the creation of BP in 2002. Initially, the system utilized by BP was the PalmaCard, a credit card which gave families a cash advance that could be spent at specific registered establishments (Melo and Magalhães, 2005). The PalmaCard was then substituted for the Palmares, a barter club based on a model previously implemented in Argentina (Melo, 2009). However, this system was quickly denounced a failure and the Palmas currency, the system used still today, was implemented for the first time (Fare et al, 2015). A key aspect that must be emphasized here is the uncontrollable application of a trial-and-error approach, which led Banco Palmas to attempt three different models within the first year of its founding, but eventually leading to a successful implementation.

The Palmas currency is pegged to the Brazilian Real on a 1:1 basis, but can only be converted by retailers who cannot fully subsidize their value chain through the sole use of the local currency. It is issued by Banco Palmas but the partnerships and development of the project externally are coordinated by Instituto Palmas, a non-profit association (Fare et al, 2015). The primary objective of the currency is to prevent a leak of wealth to the outside, by stimulating consumption locally. It is also used as a form of providing credit to the inhabitants of the community. Furthermore, BP defines and enforces a set of rules that guide the usage of the Palmas, but seeks to encourage democratic and participatory governance (Fare et al, 2015). In 2003, Banco Palmas was sued by the Brazilian Central Bank for creating counterfeit money, but the lawsuit was lost and the Brazilian government subsequently created an organ to oversee local currency projects in the country, the National Secretariat for the Solidarity Economy, an umbrella that includes BP and over 100 other CDBs that have been identified in the country. In 2012, BP experimented with an electronic version of the Palmas, but this project was discontinued a year later, being instead allocated for further development by Instituto Palmas' research lab (Fare et al, 2015).

2.2.2. Consequences of the project

The consequences of the Banco Palmas initiative can be separated into two partly interdependent realms: social and economic. The economic consequences of the project are easier to assess, as they can draw from quantitative data to support their conclusions. Perhaps the most striking consequence of the system was not its stimulating of the local consumption (the primary objective), but the degree to which this was accomplished.

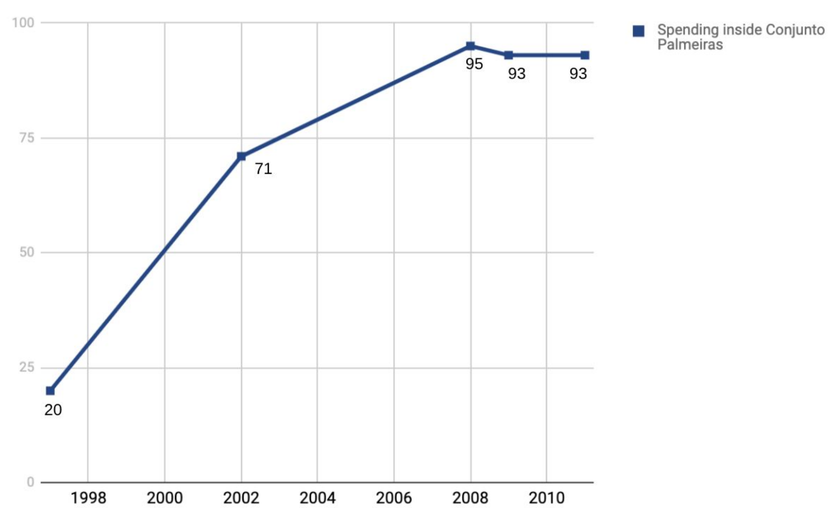

Figure 1: Gradual internalisation of consumption in the Conjunto Palmeiras (as a %)

Sources: Fare et al (2015); Melo (2011). [ADAPTED]

Figure 1 shows how from 1997 to 2011, the percentage of the spending of households outside of the community was reduced to less than 10% of its original value, and has plateaued at around 7%, an extremely low value for any urban community. As predicted, this movement towards local spending has helped improve the quality of life of individuals in the community, with 90% of inhabitants interviewed reporting that the CDB "contributed to the improvement of living conditions in the district" (Fare et al, 2015). Lastly, having started with an initial capital endowment of 2,000 Brazilian Reais (~1,800US$ at the time), the project now manages total assets worth *circa* 3,000,000 Reais (Diniz et al, 2008; Fare at al, 2015).

Regarding social consequences, Fare et al. (2015) emphasize the importance of the Palmas currency as a symbol. The actual usage of the currency is decreasing (Scalfoni, 2014; Meyer, 2012), but the impact remains. Inhabitants have become used to purchasing goods within the community and the sense of unity has been elevated, as the currency provided its users with a sense of belonging. Additionally, the perceived social benefit is felt externally, as well as internally, with 95% of the interviewed members of the community claiming to think that BP's activities have improved the image of the community (Fare et al, 2015). In addition, estimates from ASMOCONP (the neighborhood association of the community) from 2008 suggested that already then, a total of 3,200 direct and indirect jobs had been created as a result of the program, which has a direct economic benefit, but also a significant social impact at the micro level, through the empowerment of the individuals (Diniz et al, 2008).

2.2.3. Takeaways

The brief overview of Banco Palmas presented above is included as an example of a successful local currency project, with the intent of describing the potential of a complementary monetary system and allowing for an evaluation of the process to be performed, helping identify key factors leading to its success. First, Banco Palmas shows the impact of stimulating local consumption and the direct impact that a complementary currency can have in incentivizing households to spend within the community. Having identified the leakages prior to the launch of the CDB, the Palmas currency had a primary objective of economic localization (Kent, 2005), which proved successful in the long-term. Second, the failure of the two initial approaches implemented by BP highlights the importance of a customizable and modular system, open to modifications in order to suit the community at hand. It is unlikely that a *plug-and-play* style system can exist for local currencies, although attempts at standardization and enhancing replicability can lead to significant benefits with regards to scaling the model. Lastly, the BP project echoes the view expressed by Hughes (2015), that the social benefits of a local currency can be as important as the economic consequences, although the two are interconnected to a significant degree. This emphasizes the need for education and the necessity of a clear link between the values of local currency projects and the values of the community, which should be reflected by the currency itself through its use as a symbol of local empowerment.

2.3. Shortcomings of current systems

While it is difficult to gather data on local currencies worldwide, some estimates have been provided by geographically-limited studies which can help determine their success rate. Collom (2004), in his study titled "Community currency in the United States: the social environments in which it emerges and survives", makes no assumptions regarding an overall success rate for local currencies in the US, but denotes that in his research, he found that only 20.7% of the projects identified remained active. Blanc and Fare (2018), in their research of French complementary currencies, do not either provide an estimate of success, but describe the stage of development of such systems in France as "globally disappointing". Nevertheless, authors rarely question the power of the local currency concept, but rather indicate focal points for improvement, suggesting a refinement of the model is necessary for greater overall success.

The first aspect to be considered in assessing the likelihood of success of a non-sovereign monetary system regards not the system itself, but the socioeconomic context. In his evaluation of these system, Collom (2004) concluded that they appear more likely to thrive in areas with younger populations, higher educational attainment, fewer married people, and less residential stability. The age of the population and educational level factors can be explained by easier onboarding and comprehension of the new system by those who are younger and more educated, since they can better understand the long-term benefits, as well as do not have as many preconceptions about the model as an older population may have. Regarding the number of unmarried, Collom suggests that married people, due to the extent of their responsibilities within the household, tend to be less engaged with these systems, as they face greater barriers to participation. His conclusions regarding residential stability, however, are not as satisfying. Collom attributes the greater success of local currencies where stability is low because, as suggested by Pennings (1982), urban volatility tends to correlate with the formation of new organizations. An alternative explanation would be that the communities with constantly changing populations face less integration and overall income is lowered with outflows on inhabitants. As such, a new monetary system might lead to greater engagement which subsequently improves the economic status of the community, thus providing greater incentive for its continuation and hence, its success. Low residential stability may also simply be a reflection of poor communities, which are the ones in most need of, and perhaps most willing, to undergo radical change. Nevertheless, the socioeconomic context appears to be a key component of the equation for success of complementary currencies, and one which is external to the actual system which is implemented.

Regarding the determinant factors of the implemented systems themselves, multiple authors offer their perspective on the shortcomings of commonly-used implementations. Sobiecki (2018) denotes that an important element of the project's structure is that its coordinators are paid. Given the difficulty of operating such an initiative, this is a valid suggestion to improve the motivation of the individuals tasked with operating the project. In order to generate greater attachment to the project, as well as attract those who are genuinely interested in its success, one possibility is also to pay the workers in the local currency. Blanc and Fare (2010) agree that paid employees are crucial to the success of the project, but also mention the importance of collaboration with local governments, the existence of the currency in a digital form and the need for "connecting money to funding". Seyfang and Longhurst (2013), address local currencies as a form of grassroots innovation, which subsequently shares similar success factors with other initiatives under the same umbrella. Most importantly, they mention the significance of building networks and managing expectations. Other key barriers faced by current implementations are also identified by this author: the lack of transparency, the reliance on a centralizing agent, the difficulty of standardization and the resource-intensive nature of maintaining a robust local currency initiative.

Transparency, as addressed here, regards the degree of openness of the operations performed by the maintainers of the project, as well as the ability for stakeholders to audit the system. For example, users should feel secure that the system cannot be cheated by fellow users or the managing team, regulators must be able to verify that the system is not being used for fraudulent activity and investors must be able to see where their money is being applied. In paper-based systems, it is extremely difficult to accurately verify the total value of the money in circulation, as well as inspecting transactions is an impossible task. It is also a non-trivial task to audit the validity of the peg, in the case of a pegged currency. On the other hand, digital systems can be designed to keep track of all the points mentioned above, but can be corrupted by their administrator, as well as a cyber attack. Digital currency implementations rely on trust that the operators of the system have not cheated by manipulating the transactions or the supply, and it cannot be easily verified that the program implemented does exactly what it is said to do, without an extensive code audit. This lack of transparency is, at a minimum, a limiting factor for replicating a successful model elsewhere, and, in a worse case scenario, a method for obfuscating fraud. The lack of transparency is tied to the reliance on a centralizing agent to maintain the system, which also poses difficulties for compatibility of the system. If this system were to be utilized in conjunction with another, it would require extensive work to integrate the segregated architectures, which limits the long-term realm of possibilities for the protocol.

Additionally, the lack of transparency and reliance on a centralizing agent, if non-harmful to the project itself, act against a global movement for local currency usage. Seyfang and Longhurst (2013) observed that the local currency field has shown increased fragmentation, as opposed to the ideals of consolidation and standardization that should be promoted. It would be of great benefit to the global community if successful local currency projects could be replicated, at least in part, to help the overall development of the ecosystem. The existence of separated silos of data and *know-how* also make it a difficult task to create useful standards for practitioners in the field.

Lastly, current systems face a key tradeoff between cost management and security. A digital currency can easily be created, for example, but a widely-used secure local currency is a resource-intensive process to initiate and maintain. Paper systems are expensive since large costs are incurred to create the currency, as well as the usage of anti-counterfeiting mechanisms makes it even more costly. Paper-based systems also require high operational costs to enforce any rules in the system, such as a whitelist of merchants that can accept the currency, as is the case in Banco Palmas. Digital systems, on the other hand, require extensive maintenance to ensure they are not susceptible to hacks, and costs are also incurred to build integrations to third-party systems. As such, a currency can be easily created, especially in digital format, but its maintenance is especially costly, which poses a difficulty for bottom-up systems to emerge.

3. Blockchain as a natural alternative

3.1. Bitcoin

Bitcoin is a "peer-to-peer electronic cash system" initially presented in 2008 and implemented in early 2009, which does not rely on any institutions to create and maintain the underlying currency, the bitcoins (Nakamoto, 2008). The aim of Bitcoin is to remove the intermediaries in financial transactions and its launch marked the creation of the first global decentralized currency (Decker and Wattenhofer, 2013). Prior to Bitcoin, digital money had to, by nature, have a centralizing agent tasked with maintaining the system. Centralization is not inherently bad, but it can lead to abuses of power which significantly harm the users of the system. Furthermore, Bitcoin is not only decentralized, but it is also transparent. All transactions that occur in the network are made public, as are any changes made to the protocol. Bitcoin relies on open participation and public verifiability, such that ensuring the security of the network and its constant development are tasks assigned to any and all of its participants, in a true community-driven model. This transparent, community-driven and decentralized framework aligns strongly with the ideals that should be associated with local currencies, hence the idea to connect Bitcoin's underlying technology - blockchain, with the concept of a complementary monetary system.

3.2. The world computer

The creation of Bitcoin initially sparked a race to create the "next" Bitcoin, as new implementations of decentralized currencies were born claiming to improve upon Bitcoin's failures. However, the realm of possible decentralized applications was significantly expanded with the idealization of Ethereum. Ethereum was a protocol proposed by Vitalik Buterin in 2013 which would apply the distributed ledger model introduced by Nakamoto to create what is now often described as a "world computer": a base-layer protocol to permit the development of global decentralized applications. The description of the protocol is best left to its creator, Buterin, who described it as follows:

> *"The intent of Ethereum is to merge together and improve upon the concepts of scripting, altcoins and on-chain meta-protocols, and allow developers to create arbitrary consensus-based applications that have the scalability, standardization,*

feature-completeness, ease of development and interoperability offered by these different paradigms all at the same time. Ethereum does this by building what is essentially the ultimate abstract foundational layer: a blockchain with a built-in Turing-complete programming language, allowing anyone to write smart contracts and decentralized applications where they can create their own arbitrary rules for ownership, transaction formats and state transition functions." (Buterin, 2013, p. 13)

Ethereum launched in 2015 and it allowed anyone to deploy a program to the network which would inherit the characteristics of the protocol itself: security, decentralization, transparency and open participation. The denomination of a world computer came from the redundancy necessary for determinism in a secure decentralized system, since all nodes on the network must perform all of the same computations to ensure their validity. Essentially, all the nodes collectively act as one computer.

Programs in the network were denominated *smart contracts*, a concept introduced by Szabo (1994) who defined them as "computerized transaction protocols that execute the terms of a contract". Smart contracts, or contracts for short, are programs deployed on the network which become associated with an address that can be used to interact with them. Contracts are globally available to all members of the Ethereum network[2], who can interact with them by triggering (calling) their functions. With Ethereum, those who wish to create a decentralized application do not need to build an entire protocol from scratch, they can simply deploy smart contracts on top of the already existing infrastructure. The capabilities introduced by Ethereum, now also present in a multitude of other protocols, allow for a variety of previously-impossible programs to be created with ease, such as secure, global, transparent, programmable money.

4. An Ethereum-based implementation

The sections below will reference an example Solidity[3] implementation of a local currency deployed on Ethereum. In order to allow for technical and non-technical readers to comprehend the concept alike, no code will be displayed here, only a description of its functionalities. Technical readers are encouraged to view the code on

[2] Contracts can be found and interaction can be attempted by any user. However, permissioning mechanisms can be implemented to limit who can interact with the contract. Think of it like the internet: you may have a website's URL, but be unable to login and access the website's functionalities.

[3] The main programming language used for creating smart contracts on Ethereum.

GitHub[4]. Furthermore, given the lack of available research on the use of blockchain technology for the specific purpose of a local currency, the current section will draw mostly from the author's own research, observations and assumptions. It is to be expected that the model should be improved upon from new developments in this research space.

4.1. Money as digital tokens

Before Bitcoin, creating a digital currency would require aspects of centralization, a lack of transparency, difficult interoperability, among other problems mentioned in the previous section. After Bitcoin, a movement started for the creation of so-called *altcoins,* which were, as the name suggests, alternatives to Bitcoin. Creators of altcoins could now build decentralized global currencies with similar security assumptions and features as Bitcoin. However, developing an altcoin requires a degree of technical knowledge not possessed by many. Developing the entire architecture of a peer-to-peer system is a difficult task, which is prone to error. Thus, multiple creators of altcoins forked Bitcoin[5], for example, such that they could modify only what they wished to change about Bitcoin, without having to design the whole system from scratch. Nevertheless, this still requires some advanced level of knowledge of the inner-workings of these protocols.

Following the launch of Ethereum, creating a currency became a simple task. With Ethereum, developers do not need to build an entire system from scratch, because they can leverage an existing network and build on top of it. As mentioned earlier, Ethereum acts as a foundation for decentralized applications (dApps) to be built on. There is a protocol layer (the foundation) and an applications layer, and developers working on the application layer do not need to understand the protocol layer in its entirety (although this is of course recommended). Thus, creating a cryptocurrency stopped requiring extensive work devoted to designing an entire system, as users could deploy a currency on Ethereum, leveraging its existing secure and multifunctional network. Furthermore, applications were created allowing users to create a cryptocurrency without any knowledge of software development - no code was necessary, the user just had to fill in predetermined fields and hit send. This evolution in the blockchain space permitted the rise of *tokens*, which are digital currencies that are

[4] bit.ly/social-token
[5] In computer science, a fork is a copy of the source code of a program which allows the developer to continue independent development of the program without affecting the original code. One can therefore copy Bitcoin and modify some aspects according to personal preference and launch their own coin. This is possible because Bitcoin is an open-source project.

built on a pre-existing protocol, rather than having its own network[6].

Given that blockchain technology is still in its infancy and public blockchain implementations[7] make all operations public to the entire network, blockchain development is a task that is not only difficult, but also dangerous. The total market cap for cryptocurrencies is in the multiple hundreds of millions of dollars (Coinmarketcap, 2019), meaning that these digital protocols store immense amounts of value, leaving them susceptible to attacks. Furthermore, the transparent nature of these systems means that code published on the network is visible to all of its participants[8], providing an opportunity for malicious actors to scour the network for vulnerabilities. Permissioning mechanisms are also not built-in and must be explicitly set-up by the developer. If they are non-existent or flawed, they can be exploited with ease. For example, a major cryptocurrency application named Parity Wallet suffered a "hack" in 2017 where it lost access to 150,000 ETH (currently worth over 30 million dollars) because it failed to set permissions for who could interact with the "master" smart contract that governed the application. The contract had a *selfdestruct* function and no restrictions in place regarding who could trigger that function (i.e. anybody in the world could do it)[9], and so a user who claimed to be new to Ethereum and was testing the network destroyed the contract which consequently froze all ether in the application[10].

As a result of the issues mentioned above, standardization became a common process in blockchain networks, especially with regards to tokens, the most commonly used applications which happen to also be the ones with the highest stakes involved. New blockchain networks, such as Waves, were designed with built-in simple token creation, such that creating a token does not require any programming, in order to eradicate faulty implementations that lead to security breaches. Ethereum, on the other hand, which aims to provide turing-completeness[11], had to resort to community-driven alternatives, such as the creation of standards. In doing so, the community reviews suggestions of implementations for standard programs, ensures that the code is safe and optimized, and establishes that code as the standard for creating the desired program. Standards in Ethereum are most commonly used for tokens, with the Ethereum

[6] This distinction is of informal nature but generally accepted by the blockchain community. Essentially, *coins* have their own blockchain whereas *tokens* are built on top of Ethereum, for example. Often times the terms will be used interchangeably, however.
[7] A topic not addressed here is the concept of public versus private/permissioned blockchains. For the scope of this research, the reader must only be aware that in public blockchains, any person can join, use and validate the network. Consequently, there is full transparency of operations performed over the network.
[8] The exact code written by the developer is not necessarily public, but all the "machine-level" operations are visible, allowing users to know exactly what the code does, even if they do not know the specific code written by the developer.
[9] This is a simplification. The contract specified that only the *owner* could call the function, but had no previously-determined owner, allowing the user (devops99) to become its owner and call *selfdestruct*.
[10] For the GitHub thread describing the issue, see: https://github.com/paritytech/parity-ethereum/issues/6995#issuecomment-342409816
[11] Turing complete systems are those able to perform any calculation and run any program, irrespective of complexity.

community providing various implementations for different types of tokens, such as ERC20 (for fungible tokens) and ERC721 (for non-fungible tokens), among multiple others. The most well-known and widely-used standard is ERC20, which specifies a simple fungible token contract which implements six essential functions. Despite newer standards claiming to further improve upon ERC20[12], this standard is still the leading force in the Ethereum ecosystem, with a variety of tools having already been built in adaptation to it. Hence, the implementation presented here will follow the ERC20 interface, while adding key functionalities to it in order to allow its usage as a well-designed local currency.

4.2. The Foundation

This section marks the beginning of the explanation of concepts that were implemented in the Solidity example, and might reference the code where appropriate.

The Foundation defined here is the association or organization responsible for implementing, leading and maintaining the local currency project. Thus, the Foundation's responsibilities should include, but are not limited to: executing changes to the protocol where such are allowed; storage of the collateral which ensures the peg; conversions to and from the currency; onboarding of new users; leading educational projects; seeking investment/donations; establishing partnerships; ensuring the project follows the law. The composition of the members of the Foundation is not addressed in depth, but it is suggested that members of the community undertake active roles in the Foundation, with a high degree of participation. Furthermore, a debate not addressed here regards the reward structure for members of the foundation. Blanc and Fare (2018), argued that the paying the administrators of a local currency is essential to the success of the project, a view that is supported by this author. As mentioned, one possibility would be to pay the members with the local currency itself, but the question of payment structure for Foundation members is one beyond the scope of this research.

In the implementation proposed here, Foundation members have a specific status that allows the control of the protocol. Foundation accounts have no cap (addressed in Section 4.4), since Foundation members are the ones responsible for distributing the newly created tokens. In addition, Foundation members can add and remove addresses to the whitelist (discussed in Section 4.3). A chosen member of the Foundation, denominated Chairperson, also gets access to additional functionalities, which include

[12] Example: ERC223, aiming to solve the problem of locked funds in contracts.

adding an address to the blacklist[13]; increasing the supply of tokens in the network[14] and burning tokens[15]. No multi-signature implementation is used, as the model assumes decisions will take place off-chain. The implementation could easily be adapted to incorporate more levels of permissions, add multi-sig features or institute more of the decision-making process on-chain. As is, the model implements a rough structure and simple functions to select Foundation members and determine the Chairperson, but most likely, these decisions will be made in-person, with the on-chain registry working merely as an attestation to the decision. Given the responsibilities assigned to the Foundation members, a blockchain-based system is the most suitable alternative, due to the transparent nature of the network. All actions by the Foundation are publicly auditable and open to the scrutiny of the public and regulators. For instance, users can always verify the creation of new tokens and ask for proof of collateral to support new emissions.

The implementation suggested also offers a model for decision-making within the Foundation which prevents the system from reaching a state of deadlock, through fluid consensus. The mechanism works by giving permissions to all foundation members to exercise the powers given to them without the approval of other Foundation members. This is contrasted to a multi-signature system where members would need to wait for the votes of other members before proceeding with an action, which can lead to problems if members become temporarily of indefinitely unavailable. However, to prevent abuses of the power invested in its members, the Foundation is in a constant state of election, where new members can be added and removed through a simple majority. Hence, a malicious Foundation member who performs an unwanted action can be quickly removed from their position, and their actions can be corrected by either the other members or the Chairperson. Due to inherent limitations built into the protocol, the action of Foundation members should always be reversible if it does not require further approval. For example, whitelisted addresses added by a malicious Foundation member can be subsequently removed with ease.

4.3. Whitelisted addresses

One of the issues generated following the initial success of local currency is that it can become attractive to investors, speculators or ill-intentioned parties from outside of the community. This problem is a difficult one to coordinate in a physical currency

[13] Addresses in the blacklist can never participate in the network again.
[14] Can only be executed when *collateral > n(tokens in circulation)*, for example after new investment is received.
[15] Tokens can only be burned from the Chairperson's account, used to control the peg of the currency. Tokens in circulation will never be affected by a burn.

system, but facilitated if the currency takes a digital form. In the case of Ethereum, through the use of an address-based system, it becomes easy to limit the network only to a set of whitelisted addresses, which are known to be located within the community. The selection of whitelisted addresses could be determined by members of the Foundation through a face-to-face encounter, or could also allow users to sign-up online using a mechanism of account verification to ensure the account created belongs to an inhabitant of the community. No further comments will be made regarding the sign-up process, but there are multiple ways in which one could establish the whitelist. The importance of enforcing the utilization of the currency solely within the community cannot be understated, and the reasoning was provided in Section 2. In order to achieve a local multiplier effect (Longhurst, N. Seyfang G., 2013) and ensure the benefits of monetary injections are felt only, or at least mostly, by the community itself, the geographical limitation is key, and it can be made simpler if enforced directly via the implemented protocol. This is a view reflected in the Banco Palmas case, which maintains a "whitelist" of merchants where the currency can be spent (Fare et al, 2015).

4.4. Caps on total token ownership

It is essential to ensure that the currency circulates only within the pre-established geographical boundaries, but it is also important to ensure that it circulates. Unlike traditional cryptocurrencies such as Bitcoin, a local currency should not be used as an instrument of speculation, and an argument can be made that it may be more efficient if it is also not a good long-term store of value. The currency hereby presented should be pegged to a sovereign currency on a one-to-one basis, in order to facilitate the onboarding process for the community and the pricing of goods and services. Furthermore, users should be discouraged from storing large amounts of this currency, as it diminishes the purpose of the system. Economics provides a simplification to understand the habits of households and individuals which states that *MPS (Marginal Propensity to Save) + MPC (Marginal Propensity to Consume) = 1* i.e. given 1$, an individual will consume a portion, and save the rest (and the total of both should never go beyond 1). As the Keynesian multiplier is defined by *1/(1-MPC)*, it is inversely correlated with the MPS, leading to the conclusion that the higher the aggregate MPS of a community, the lower the multiplier will be. Thus, in order to achieve a greater multiplier effect, households should save less. In order to achieve this effect, a range of possibilities can be utilized which are defined by a tradeoff between personal freedom and effectiveness. In the implementation suggested here, a light boundary is incorporated, which takes the form of a cap on the total balance of a given account at any point in time. By implementing a cap, users with a balance approaching the cap will not be able to receive payments for much longer, and so must spend before they receive more tokens from others. This way, individuals are allowed to save, up to a certain point, after which they must spend and maintain high circulation of the currency. It is not being suggested, however, that users should not be allowed to save and accumulate wealth. In order to improve quality of life, this is to be encouraged. However, saving should occur in the sovereign currency, not the local currency[16].

A more extreme solution to this problem would be to not only provide the cap, but also a time-limit for spending the coins. With this mechanism, coins that have not been used for $t > threshold$ would be returned to the account of the Foundation to be redistributed. This would prevent saving almost entirely, but is a less morally-acceptable solution which can lead to a boycott of the system.

4.5. Tiers of conversion

A problem foreshadowed in the previous section is the issue of users deciding to convert their currency into the sovereign currency, as it provides them with more freedom. This is an issue that is not faced by systems such as time banks, but is inherent to currencies which use a full peg, especially on a 1:1 basis. Mitigating this issue requires the employment of both social techniques and appropriate system design for maximum efficiency. Social techniques regard education and onboarding programs that emphasize the benefits of the local currency, to keep users engaged and reduce the risks of a "bank run". The purpose and potential benefits of the system must be clear to its users[17]. However, the protocol can be aided by appropriate mechanisms to help its development, especially in the early stages. With no mechanism to prevent conversions, a user may receive a donation and immediately convert it into the sovereign currency without a further analysis of the project. Hence, the solution proposed here is a system of tiers, which specifies at what rate a given user can convert their money. In the example implementation, this is applied through a simple five-tier scheme with tier upgrades happening in a linear fashion.

[16] The issue of mass conversion into the sovereign currency as a result of an impulse to save is dealt with in the following section.
[17] The question of why someone would use the system in the first place has a simple answer: free money.

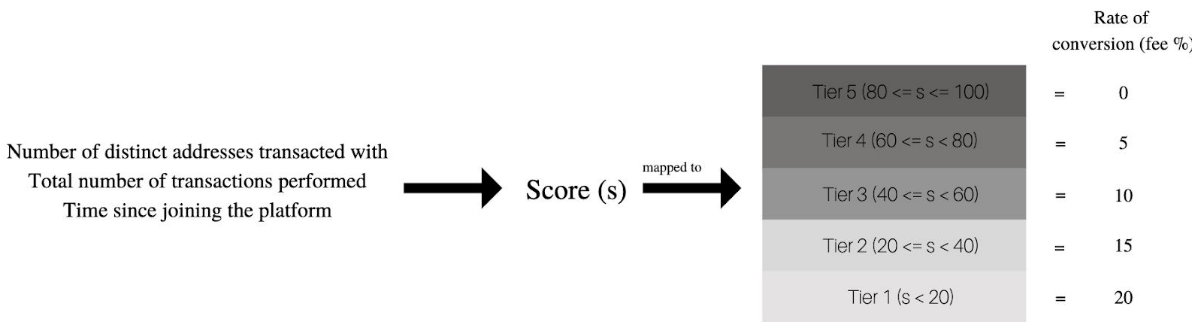

Figure 2: Tiers of conversion - Example model

Figure 2 shows the proposed model, which follows simple linear upgrades over tiers, as well as a negative-sloping linear rate of conversion. As shown in the model, the score of a given user is determined by three factors, outlined below:

1. Number of distinct addresses transacted with
2. Total number of transactions performed
3. Time since joining the platform

All three factors hold equal value, and the score for each of the categories is determined on a scale from zero to one hundred, where 100 is a predetermined arbitrary value. The current implementation defines the upper boundaries as follows: 1000 for number of distinct addresses; 10000 for number of transactions; 730 days (~2 years) for time in the platform. These values are for pure illustrative purposes and in a real setting must be carefully determined and supported by analysis, for greater effectiveness of the mechanism. The user will therefore gain a score based on his/her percentage scores in relation to the upper boundary, which will be averaged out with the other percentages to provide a score out of 100. For example, if a user has transacted with 100 different addresses (10% of 1000), executed 2000 transactions (20% of 20000), and have joined the platform a year ago (50% of 2 years), the score would be 26.7, placing the user on Tier 2. Ideally, it should be difficult to reach the top tiers, such that individuals cannot easily reach a low rate of conversion, which could trigger a “bank run”. Additionally, the high difficulty may imply that users who reach the top tiers do so not out of a wish to convert their money, but rather that it happens as natural consequence of their dedication and usage of the platform.

Number of distinct addresses transacted with

The existence of this category fulfills two main purposes: the rewarding of those who actively use the currency for multiple activities and the prevention of artificially high scores. It is the goal of the currency system that the money is used for a variety of purposes within the community, hence, it should be transacted amongst a multitude of parties. A user who has transacted with various addresses is either an active user of the system, an ambassador for the currency, or both. Therefore, this metric incentivizes individuals to use the currency with as many people as they can, helping onboard new users. Furthermore, with the inclusion of number of transactions performed, this category limits the power of users to artificially inflate their scores by creating multiple transactions with a few select individuals.

Total number of transactions performed

With the exception of users aiming to inflate their scores, the number of transactions performed by a given user should provide a fair indication of how much the individual is using the currency, and therefore a measure of the value added to the system. The difficulty in selecting the upper boundary for this category is finding the right balance between a number high enough to account for artificial scores, yet low enough to be reasonable for all other users. Additionally, other mechanisms could be implemented to limit this issue, such as a cap on the number of transactions that can be executed in a day[18] or a transaction fee model, which could have either a flat or increasing fee (starting at zero and increasing based on the number of transactions in a day).

Time since joining the platform

This category was designed both as a limiting factor to the other two categories and as a method for rewarding early adopters. Since time is independent of the actions of the user, individuals who successfully overcome the barriers set for categories 1 and 2 in order to artificially increase their score will still be limited by time in their ability to upgrade to a new tier. For example, a new user who has managed to achieve the high

[18] As long as the number is high enough (e.g. 50), it should not be limiting to the average user, while proving to be a significant barrier to those hoping to game the system. At the cap of 50, it would take a minimum of 200 days for the upper boundary of 10000 to be achieved, and 50 transactions per day should be enough for any individual to live with.

scores of 70 and 80 on the first two categories will quickly reach Tier 3, but will have to wait over seven months before being able to upgrade to Tier 4.

Presented here are three suggestions for parameters of the function which defines a user's score and consequently the tier of conversion. As mentioned, these are mostly used for illustrative purposes and for outlining some of the main determinants of value added to the network, while preventing cheating of the system. Other factors that could be included as part of the score function could include total value transacted and number of referred addresses who joined the system, for example. A way of decreasing score could also be implemented, which is not addressed here. Ultimately, a perfected system would require a trial-and-error strategy, as well as a retrospective analysis of blockchain-based local currency systems, which is currently non-existent and thus cannot be explored here.

Regardless of the implementation of the function for score, the need for the so-called Tiers of Conversion must be explored further. At a superficial level, it exists to prevent a bank run, following the logic that a new user of the platform would rather have 1 unit of the currency versus 0.80$, and will therefore not convert immediately. However, the rate of conversion for the first tiers is the most important aspect of this system, and it must act as an incentive to experiment with the currency without undermining the perception of the peg. It is assumed here that a user would prefer 1 token over 80 cents of a dollar, but this may not hold true and is strictly dependent on the circumstances. If the user sees no value in 1 unit of the local currency, she will immediately convert at any rate. Therefore, it is important that before the launch of the system, the community is well-aware of its implications, benefits, and most importantly, there must be liquidity from the beginning. For the system to succeed, enough partners and users must be plugged into the system before the currency launches, so that a new user can immediately spend the tokens received. If, given a token, the user has no place to spend it, she will quickly convert into the sovereign currency. In addition to the education and establishment of partners and ambassadors (i.e. the social techniques), there are aspects of protocol design which can help secure the system in its early stages. First, a grace period could be implemented, whereby a new user of the system cannot convert their tokens for the first 30 days of receiving the first tokens, for instance. This would give users time to learn about the system, which may persuade them from converting as soon as the period is over. Another strategy would include raising the conversion rates proposed in this paper, or implementing a nonlinear system. Administrators must aim to determine what the value of 1$ is to users in terms of tokens, and set the rate of conversion higher than the perceived value for Tier 1. For instance, if it is established that the community views the token as having only 70% of the value of the sovereign currency, the initial conversion rate should be greater than 30%. But, as mentioned, a rate that is too high may lead users to question the pegging of the system.

In addition to preventing the system from collapsing due to a lack of liquidity, tiers of conversion can also play an important role in increasing the level of investment into the system. Consider the following scenario:

Conservative estimates forecast that in year one, 40% of users will immediately convert their tokens into the sovereign currency, 20% will convert at an average fee of 10% (Tier 3), and the remaining users will continue using the platform in year two. The Foundation has secured investment and plans to emit 1 million tokens in year one. How much investment is needed in year one to securely maintain the peg to the sovereign currency?

Intuitively, we initially think that to maintain the 1:1 peg, 1 million dollars are necessary to emit 1 million tokens. However, with the implementation of the Tiers of Conversion, that is not the case. In fact, the answer to the problem above is 900,000$[19]. Thus, if the investment committed to the project in year one was of 1 million dollars, the Foundation could use the additional 100,000$ to cover the costs of its operations, fund a secondary injection, or create a transaction fee refund pool (described in Section 5.1). The Tiers of Conversion therefore become a way of sustaining the project to ensure that it can continue over the years.

One may think that this resembles a scam of some sort, but a few key facts must be emphasized. First, the Foundation is an non-profit association, such that the more revenue it has, the more investment it will make for the community. Money is not being used to enrich participants of the system, but rather it should be reinvested in full for the benefit of the community. It must also be noted that, ideally, the portion of "extra" money should not be separated from the start. Rather, the surplus currency is "unlocked" as users convert into the sovereign currency[20]. Second, the money injected into the community takes the form of a donation, so it cannot be argued that a scam is taking place when money is being given to the users of the system. Lastly, and most importantly, the key to this system is the perception of value that is inherent to monetary systems. As the money at hand is a local currency, it only has value within the community, and its perceived

[19] 400,000 * 0.8 + 200,000 * 0.9 + 400,000 = 900,000

[20] Think about it like this: 1 million is invested and 1 million tokens are released. As 40% convert into dollars at the 20% rate, there are now 600,000 thousand tokens in circulation and 680,000 dollars in the bank. A surplus of 80,000 has therefore been "unlocked", since the currency became overcollateralized. The surplus collateral can then be removed from the system to stabilize the peg.

value is the important aspect, not its face value. As long as the community recognizes this currency as having the same value as the sovereign currency, then that is the transactional value it has. Furthermore, it is possible to convert the tokens at the full 1:1 ratio, but restrictions are merely placed on it. In fact, this is no different from the system of sovereign currencies. Official exchange rates are provided in theory, but in practice the fees to exchange money lead to a loss of value which varies greatly depending on the system, and can reach fees of over 10% of the value transacted[21]. Even transactions within the same currency carry fees which diminish the value received. Credit and debit cards charge between 1-3% (Federal Reserve, 2017), meaning that the price paid by a customer to a merchant is not the price received by the merchant. Thus, the local currency system merely borrows from existing models in order to create a peg mechanism where fees are appropriated by the system itself, rather than leaking from it through fees for intermediaries. This model also shares a resemblance with Banco Palmas, which is issued at parity with the Real, but can only be converted if a set of specific requirements are fulfilled.

4.6. Wallet

In addition to the smart contract implementation, the wallet used by the project is another key component of the success of an Ethereum-based local currency implementation. Wallets are, for the most part, software applications which provide a way, usually through an interface, for users to store and transact with their cryptocurrencies or tokens. They hold the private keys of the user, allowing the user to sign transactions for the coins owned by them. They are comparable to online bank accounts. Thus, for a successful user experience, the wallet must be easy to use and prevent the user from accessing complicated functionalities that may lead to complications. Due to the use of an Ethereum standard, as mentioned in Section 4.1, the token presented here is readily compatible with most Ethereum wallets, which allows its use with a wide range of applications. However, while more advanced users may wish to pick their wallet of choice, a standard application should also be provided with a specific focus on the local currency at hand. This wallet should satisfy the following requirements: it should have an interface that is representative of the project; it should automatically add the token with no need for manual action; it should prevent the user from transacting with any other tokens; it should abstract away complex Ethereum concepts (addresses, keys, fees, etc.) and it should offer a quick and simple process for creating a transaction.

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[21] See: https://www.westernunion.com/

Out of the requirements mentioned above, the abstraction of complex Ethereum concepts must be explored in greater detail. While using addresses such as *0x06012c8cf97bead5deae237070f9587f8e7a266d*, operating with private keys and selecting gas prices manually may have become an ordinarily simple task for avid users of the Ethereum protocol, these are concepts that can greatly confuse the average person. Thus, the wallet used for the project must allow users to send transactions amongst themselves by using human-readable names, use mnemonic phrases instead of private keys and set transaction fees automatically. Furthermore, the wallet's balance of Ether should be hidden or portrayed to the user in a simpler way than used by most general wallets, a topic further addressed in Section 5.1. By implementing these necessary features, the onboarding process and overall experience for users will be significantly enhanced, increasing the likelihood of success of the project as a whole. The wallet is especially important for the implementation proposed here, as there are rules implemented in the code which could not be enforced if a physical form of the currency were to be used. Therefore, the currency proposed here cannot feasibly be a hybrid like Banco Palmas, and relies heavily on the usability of the application used to manage funds.

A final comment on the use of a non-hybrid system concerns the ability of individuals to use the system if it requires a level of comfort utilizing digital platforms. This is indeed a limitation for the number of communities that can adopt the system proposed here immediately, but by no means a complete limitation. Smartphone ownership is growing significantly throughout the world, with the percentage of adults who reported ownership of a smartphone in developing economies having grown over 40% from 2013 to 2015 (Pew Global, 2016). Furthermore, 96% of Americans between 16 and 29 years of age reported living in a household with at least one smartphone (Pew Research, 2017). As mentioned by Collom (2004), local currency projects have a greater chance of success in communities with younger populations and higher educational attainment, which should be the current targets for the implementation proposed here. Nevertheless, the trend of smartphone ownership growth suggests that within the next decade, the number of communities where a fully digital local currency project could be implemented will rise significantly.

Lastly, a pilot experiment was conducted by this author in collaboration with the non-profit organizations BlockchainBH and NAAÇÃO, where twenty individuals from low-income communities engaged in the full process from downloading and utilizing a wallet application with an ERC20 token we created. No quantitative data was recorded from the experiment, but the all users managed to complete the tasks within the set timeframe and the majority reported that the experience was not difficult. However, the experiment did show us what the difficulties faced by the users were, which prompted the beginning of the development process of a wallet application for the purpose of a local currency. The project is a fork of the open-source wallet Cashu, created by Rodrigo Ferreira, who aided our team throughout the process of idealizing the concept. The source code for the wallet can be found on GitHub[22].

4.7. Local currency factory

With the growing interest for creating Ethereum tokens, applications were created to facilitate this process for non-developers. These applications are commonly called *Token Factories*[23] and allow users to create a fully usable Ethereum-based token with customizable specifications, such as name and total supply. These applications require no knowledge of software development, as a template token is used by the platform, which displays fillable input fields to the user through an interface, which the user utilizes to select their chosen specifications and deploy the contract without ever seeing its code. Following a similar pattern, it is of personal interest of this author to create a similar application for the deployment of local currencies, allowing any individual to quickly launch a usable token, while also offering educational material on the recommended design and setup necessary for a successful complementary currency implementation. This concept will be addressed in the subsequent research conducted by the author.

5. Limitations of the model

5.1. Transaction fees

One major limitation of the Ethereum-based model from the perspective of user experience is the existence of transaction fees for every transaction, which need to be paid in ether, the native currency of Ethereum. Thus, it is not enough for a user to have the sufficient balance of tokens in their wallet to be able to transact with them, but they also must have a sufficient balance of ether. This creates two problems. First, the wallet must handle two separate currencies in a way that is not confusing to the user. Second, the protocol must ensure that users have sufficient ether at all times, which is both an expensive task (given the price of ether) and a difficult coordination problem.

[22] https://github.com/raugfer/gudcoinwallet
[23] Example: https://tokenfactory.surge.sh/

Regarding the first problem, it should be solved by an appropriately-designed wallet. Assuming the second issue is taken care of and the user always has enough ether to perform transactions, the wallet could hide the ether balance from the user, such that it can be completely ignored in the user experience. The wallet would automatically determine the transaction fee and pay it alongside the transaction of tokens without the user knowing that this secondary transfer is also taking place. As for the second problem, the operational burden can be solved by an automated mechanism, but the costs of acquiring and distributing the ether can become large and unsustainable. In order to distribute the ether, wallets could be pre-programmed to call a smart contract every time their balance crosses a threshold to receive more Ether[24]. An example of this contract can be found alongside the implementation proposed under Section 4, under the name *FeePool*. The greater problem, however, concerns the costs of obtaining and distributing the ether (which is a process that is also subject to transaction fees). Unfortunately, the solution to this issue would be (as Ethereum currently stands), to simply include the transaction costs as one of the costs incurred by the Foundation which must be covered by the donations and investment. On the other hand, these funds could come from the surplus collateral that is unlocked as a result of Tiers of Conversion model, presented in Section 4.5. This would be a viable solution and another benefit of the model.

Alternatively, there are other options to the transaction fee issues, such as migrating this implementation into another blockchain protocol. The Waves protocol, for example, allows the transaction fees for the network to be paid with any token deployed on the network (Waves Platform, 2016), which eliminates the issue of dealing with two currencies. EOSIO, on the other hand, is completely free of transaction fees (Larimer et al, 2018), which would solve the problem altogether. These platforms would be interesting alternatives, and the wallet implementation referenced in Section 4.6 was tested using both an Ethereum and a Waves token to reflect the possibilities available. However, these two platforms, along with the multiple other alternatives, are yet at earlier stages of developments and have shortcomings in other sectors. Currently, Ethereum is still the most established protocol, which is why it was chosen for the implementation presented here. On an additional note, solutions to the transaction fee problem are being developed for Ethereum, which could provide a solution to this issue in the near-future. One example would be to have the local currency run within a state channel, which is a mechanism allowing for off-chain, instant and free transactions while theoretically maintaining the same security assumptions as on-chain transactions (McCorry et al,

[24] To prevent attacks, the contract would perform two basic checks before sending the funds: 1. Does the requesting address have a balance lower than the threshold? 2. Is the account a whitelisted member of the network?

2018). State channels are a common example of Layer 2 scalability solutions, which consist of implementations that build on top of the Ethereum protocol, rather than inherently changing it. Other scalability solutions such as Plasma[25] and Sharding[26], if implemented, could also help drastically reduce transaction fee costs for the local currency implementation proposed here.

5.2. Scalability

With respect to blockchain implementations, scalability is a broad term which can refer to a wide spectrum of factors contributing to the sustainability and efficiency levels of a protocol. Here, scalability will be used in the context of transaction throughput in the network, commonly measured in transactions per second. Ethereum currently supports about 13 transactions per second (McCorry et al, 2018), which is extremely inefficient and can lead to a variety of problems such as sharp increases in transaction fees due to a congested network and slow confirmation times for transactions. Since the system proposed here is a monetary system, it requires transactions to be fast, cheap and that large amounts of transactions can be processed in this fashion. This issue is closely related to the one of transaction fees, and the solutions proposed generally overlap. In order to account for scalability problems, the system could either be migrated to another blockchain protocol, or remain utilizing Ethereum in the hope that the scalability solutions currently under development will soon be released and be as effective as claimed[27].

5.3. Learning curve

Unlike the aforementioned limitations, the learning curve for participants in the system is an issue that can be addressed to a large extent by those who implement the local currency, rather than rely on the outcomes of near-uncontrollable forces[28]. While user experience is a key factor in helping the onboarding of users into the system in the early stages, education is also necessary at all stages of the process. While end users do not need to understand all the intricacies of the protocol, it is important that, at a minimum, they can be satisfied with the value of the currency and the security of the system. Furthermore, potential investors, regulators and members of the foundation must be educated on blockchain technology and the way the local currency is implemented and operated, in order to feel comfortable about the legality and robustness of the protocol. This education process is especially difficult due to the fact that blockchain is not as

[25] https://plasma.io/plasma.pdf
[26] https://github.com/ethereum/wiki/wiki/Sharding-FAQ
[27] This paragraph is a repetition of what was mentioned under Section 5.1, but it was included by this author in order to acknowledge the separate problem of scalability, which has similar solutions but different consequences.
[28] Near-uncontrollable because one can always contribute to scalability research.

widely-recognized as other modern technologies such as Artificial Intelligence and still retains some negative stigma from events such as the rise of Silk Road and the ICO boom. Thus, it is especially important that the Foundation dedicate a significant amount of resources to the education of all stakeholders involved to maximize the chances of survival of the protocol.

5.4. Legal framework

Local currencies and cryptocurrencies already share one thing in common: both often fall outside of the legal framework in multiple jurisdictions. As previously mentioned, Banco Palmas was originally sued by the Brazilian Central Bank, and Congressman Brad Sherman in the United States has recently called for a complete ban on cryptocurrencies in the US (Forbes, 2019). However, the situation for the protocol proposed here is not concerning from legal perspective. First, the case against Banco Palmas in Brazil ended with a victory for the project, followed by a creation by the Brazilian government of a specialized organ to oversee local currency projects. Second, the project of a local currency differs vastly from the traditional concept of a cryptocurrency like Bitcoin, especially because it is pegged to a sovereign currency. Effectively, excluding the fact that the system utilizes a blockchain as the mechanism to keep track of transactions, the proposed currency is more resembling of corporate loyalty programs than Bitcoin. In fact, it is an upgraded version of such programs, as users are allowed to convert their tokens into the sovereign currency, which is often not possible for loyalty points. Furthermore, banks worldwide have begun to experiment with executing transactions over a distributed ledger using a tokenized representation of fiat currencies (CoinDesk, 2017), which does not differ largely from the system introduced here. Additionally, the use of a public blockchain such as Ethereum means that the project can be easily audited and any attempt at fraud, such as tax evasion, is likely to be detected. The issue of tax evasion, as it is naturally a point of concern for the regulating authorities, is also mitigated by the imposed cap on account balances. Overall, the regulatory framework is only a problem to the extent that knowledge is deficient, since the transparent properties of the system make it more regulation-friendly than traditional financial software applications.

6. Conclusion

This paper introduced the concept of local currencies as a mechanism for overcoming economic stagnation in low income communities and proposed the use of a blockchain-based implementation of the model as a strategy to overcome the difficulties faced by current local currency systems. Complementary monetary systems are not widely utilized, and this can be partly attributed to the number of barriers such projects must overcome in order to succeed. Thus, a blockchain-based system, inheriting characteristics such as transparency, decentralization and security from a pre-existing protocol could be helpful in eliminating some of the major issues faced by local currencies today.

Following the analysis of the economic forces contributing to stagnation and an overview of the key properties of public blockchain protocols, an example implementation was introduced, using Ethereum as the underlying network for creating the currency. Ethereum is the most well-established blockchain protocol for the creation of dApps and makes the creation of a highly-customizable decentralized token a simple task, while the existence of standards allows the token to be compatible with a multitude of tools and services from the moment of its launch. As such, Ethereum, despite its notable problems of scalability, is a suitable underlying protocol for the launch of a robust currency system.

The hope for the research presented is that it provides the pillars for the growth of blockchain-based local currencies as both a research topic and a practical application. The lack of available data on the topic poses a significant barrier for those who intend to study it, and it is of the intention of this author to seek the closing of this gap in subsequent research. Finally, given the immediate benefits that distributed ledgers can adhere to the local currency model, we should see a transition from traditional digital implementations into a blockchain-based local currency system in the medium-term, in line with the growing adoption of the technology as a whole.

Acknowledgements

The author wishes to gratefully acknowledge the guidance and support of Victor Silveira throughout the research, for his help in finding relevant material and the constant input that was instrumental in the construction of the model presented.

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