An Agent-Based Model for Designing a Community Currency Scheme

Mc Angelo Antonio M. Miro[1], Ferdinand C. Maquito[2]
1 Electronics and Communications Engineer, Junior Researcher (Sekiguchi Global Research Association, Philippines)
2 Assistant Professor, College of Public Affairs and Development, University of the Philippines Los Baños

自律的に意思決定する参加者を多数モデル化し、その相互作用をコンピュータでシミュレーションするABMの手法を用いて、真に有効な地域通貨のシステム設計を考察した。

Abstract

This paper reports on the development of an Agent-Based Model (ABM) that could help actual communities in the designing of Community Currency (CC) schemes, which have been deemed, in various seminars held in the Philippines and Japan by the Sekiguchi Global Research Association, as mechanisms for sustainable shared growth. As such, the ABM depicts a CC scheme for a community economy that essentially has no interest rate, but has the two other basic prices: (1) the price for a community-produced private good, expressed in both CC and fiat money (Philippine Peso) depending on the acceptance rate; and (2) the exchange rate between the CC and fiat money. The ABM has three types of producers: community-based private good producers; community-based local public (volunteer) good producers; and external private good producers. The community economy also includes laborers that could work to produce either private or volunteer goods. There is trade between the community's laborers and the private good producers, both community-based and external, where the latter accepts only fiat money as payment. By definition, CC is accepted only within the community as payment. The ABM helps in identifying various combinations of design parameters such as price acceptance rate, and population, which are critical for the sustainability of a CC scheme.

Keywords community currency, agent-based model

Introduction

As the term implies, a Community Currency (CC) is a form of money that is usable only within a certain community. In this paper, we define a community in a geographical sense, as having clear geographical boundaries and much smaller in scale compared to the national boundaries.

In previous seminars held by Sekiguchi Global Research Association (SGRA) mostly in the Philippines, CC's have been deemed as good mechanisms for achieving sustainable shared growth, having the socio-economic goals of efficiency, equity, and environmental friendliness.

One important step in adopting a CC scheme is its design. Yoshida and Kobayashi (2018) recommend that much consultations with the community. Thinking of adopting a CC scheme must be done prior to the actual implementation of the scheme. Through simulations, they found the following factors to be important for the promotion of use of a CC: the premium rate of CC; the proportion of CC in the salaries; and the probability of volunteers with CC. Their simulation model, however, was not publicly available, making it impossible for us to replicate.

Nevertheless, we followed the lead that simulation models would be useful for the design phase of a CC system. Our search for a CC simulation model led us to the graduate report of (Grinza and Beqaraq 2012) which contains the codes for the simulation. The model, however, is designed for the EU setting, and most of the variables considered in the model are not really the ones relevant in an early design of a CC scheme.

In this paper, we share the results of adopting this EU model, called the EAC Model by the authors, to what we think are the important considerations in a developing country case such as the Philippines. We call our model, the Tanuki, or raccoon, Model[1].

Methodology

We use the EAC Model as our basic source for the NetLogo codes of their agent-based model. One very big advantage of NetLogo is that it is available publicly for free. Agents in this model, called turtles, are given simple rules of behavior in a two-dimensional world, formed from a group of patches. Turtles could interact with each other or the environment in a prescribed manner at each run (tick) of the simulation model.

We then proceeded to revise the EU Model to introduce variables that we thought important to designing a CC scheme in a developing country setting. We also ensured that the model did not give strange results, such as money stocks continually increasing.

Once we had a stable Tanuki Model, we did some simple simulations to see how the number of hungry tanukis (rejected transactions) moved with changes in the acceptable combination of CC and fiat money that community vendors, as well as in the population of vendors in the community accepting CC.

The Tanuki Model

The model that we created is called the "Tanuki Model". It is a system with a fixed number of community members (Tanukis), a fixed number of outside vendors (Shops) and a variable number of local vendors (Markets). It is designed in a way where it simulates the everyday interactions of community members and vendors for 1,080 days or 3 years. At the start of the simulation, the Tanukis are given a random amount of cash that ranges from 4,000 to 20,000 PhP and an amount of CC (Tane, or seed) equal to 15 percent of their initial cash. Upon running the simulation, the Tanukis are programmed to move randomly and once they come near a vendor, they spend a random amount of Tane and/or PhP if they have sufficient balance. The amount being paid to the vendors is specified in Table 1 in the next section of this paper.

Additionally, every 30 days, the Tanukis receive payment or salary equal to a percentage of Tane and PHP earned by the vendors. Thus, creating a closed system where the initial Tane and PhP are just being circulated. For a more detailed picture, see Figures 6 and 7 in the next section of this paper.

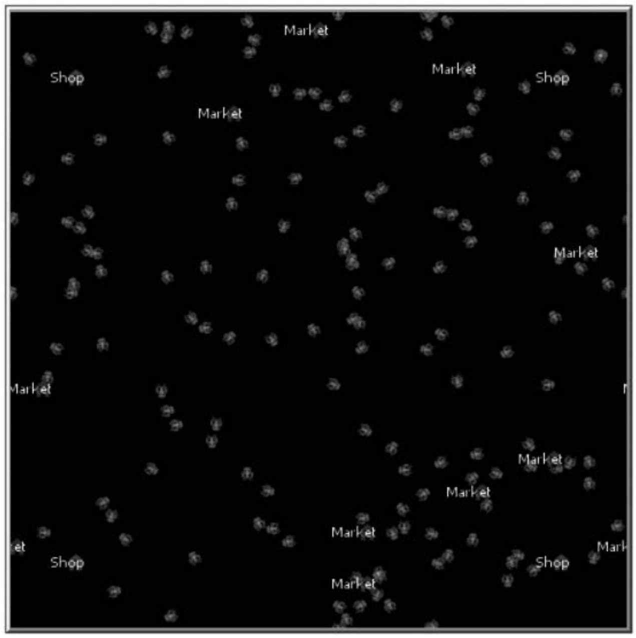

Fig. 1. Screenshot of the community

Fig. 2, 3 and 4. The community members (Tanukis) and vendors (Markets and Shops)

1 In honor of the alumni of the Atsumi Foundation.

The figures above show the community as a whole, as seen in the simulation, and the different characters that interact within the community.

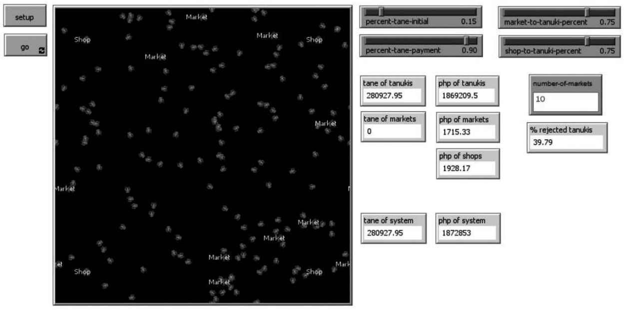

Fig. 5. Screenshot of the entire application.

Figure 5 shows the interface of the application that we developed. The buttons on the left are the control buttons: setup (start) and go (run), the middle part is the visual representation of the interactions of the community, the green boxes are the design variables, and the yellow boxes are the monitors.

To run the application or model, the designer, first, needs to set up the five design variables, the initial CC of the the tanukis (percent-tane-initial), the percent of CC the markets accept as payment (percent-tane-payment), the percent of CC and cash the tanukis receive from the markets (market-to-tanuki-percent), the percent of cash the tanukis receive from the shops (shop-to-tanuki-percent) and the number of markets (number-of-markets).

After setting up the design variables, the "setup" button is clicked to initialize the system. Here you will see the Tanukis and Markets (local vendors) scattered randomly within the system and the Shops (outside vendors) placed in fixed points.

Once the characters are set up, the "go" button is clicked to simulate the interactions. While the system is running, you can freely monitor the amount of cash and CC of the Tanukis, markets and shops; and also, the performance indicator, which is the percentage of which the tanukis have insufficient cash or CC when they go to any of the vendors.

The EAC Model vs Tanuki Model

The table below shows the basic differences between the two models.

Table 1. Differences of the two models

Aspect	EAC Model	Tanuki Model
Population	Angents (150)	Tanukis (150)
No. of CC's	2	1
Starting CC1	EAC (random 12,000 + 3,000)	TANE (15% of starting cash)
Starting CC2	Tickets (random 4000 + 1000)	N/A
Starting Cash	EURO (random 80,000 + 20,000)	PHP (random 16,000 + 4,000)
Vendor1 Payment Method	Shops: random 270 + 30 (accepts all by %)	Markets: random 270 + 30 (accepts both by %)
Vendor2 Payment Method	Bars: random 15 + 5 (accepts all by %)	Shops: random 15 + 5 (accepts cash only)
No. of Vendor1's	4	10 and 100
No. of Vendor2's	2	4
No. of Days (Ticks)	1000	1080
Credit & Debit	Yes	No

Note: The "random <number>" is equal to a random number from 0 to <number>.

Additionally, there is also a difference on how the community earns their money and CC. In the Tanuki Model, every 30 days or ticks, the amount of Tane and PhP the vendors have earned are dispersed by percentage, set by the community designer, to the Tanukis and their fellow vendors. This distribution simulates the salary or payment the tanukis receive monthly and the trading system between the vendors. The Tane and PhP flows are further illustrated in the following figures.

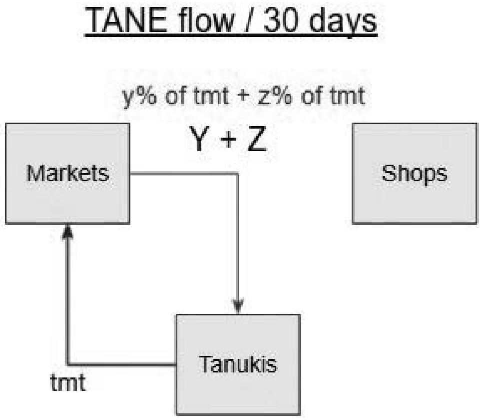

Fig. 6. CC flow every 30 days

Figure 6 shows the CC flow every 30 days where "tmt" is the total amount of CC the Tanukis paid the Markets.

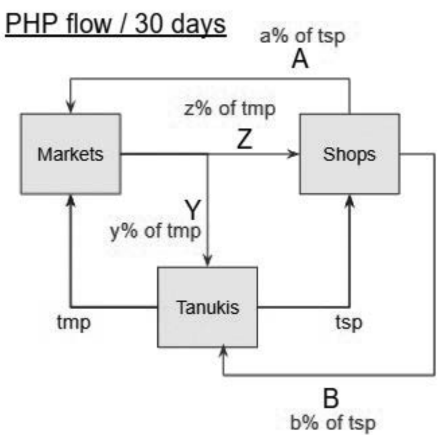

Fig. 7. Cash flow every 30 days

Figure 7 shows the CC flow every 30 days where "tmp" is the total amount of cash the Tanukis paid the Markets and "tsp" is the total amount of cash the Tanukis paid the Shops.

Whereas in the EAC Model, the agents earn a random amount of cash and CC every 30 days or ticks, and appear like manna from heaven.

Results and Discussion

Tables 2 and 3 show the average % rejection rates for the cases of 10 and 100 market vendors, respectively. The maximum, minimum, and standard deviation of the % rejection rates are also shown for each case. The amount of CC in the price varied from 0% to 90% as shown in the tables.

Table 2. Simulation results for case of 10 market vendors

% Tane Payment	*0%*	*10%*	*20%*	*30%*	*40%*	*50%*	*60%*	*70%*	*80%*	*90%*
AVE. % REJECTED	9.2	8.7	11.2	17.6	22.1	27.3	29.5	33.3	34.9	37.6

MAXIMUM	MINIMUM	STD. DEV.
37.6	8.7	11.0

Note: For 50 runs, 1080 days per run

Table 3. Simulation results for case of 100 market vendors

% Tane Payment	*0%*	*10%*	*20%*	*30%*	*40%*	*50%*	*60%*	*70%*	*80%*	*90%*
AVE. % REJECTED	1.2	0.9	1.6	4.9	11.4	21.4	31.0	38.5	44.4	48.8

MAXIMUM	MINIMUM	STD. DEV.
48.8	0.9	19.0

Note: For 50 runs, 1080 days per run

At lower values of % Tane Payment in price, the average rejection rate for the 100-vendor case was lower than for the 10-vendor case. At higher values of % Tane Payment in the price, however, the average rejection rate becomes higher in the 100-vendor case than in the 10-vendor case. This suggests that there are non-linearities in the model that might produce an optimum at some intermediate level of % Tane Payment in the price.

The non-linearities could be due to two opposing effects of increasing the number of vendors on the % rejection rate. A positive one, wherein the higher number of vendors increases the number of purchases of the tanukis, increasing the probability that they would have run out of money. A negative one, wherein the higher number of vendors, increases the number of transactions, increasing the denominator faster than the numerator in the % rejection rate formula.

Patterns

We found the following three encouraging patterns from our simulation of our Tanuki Model.

Pattern #1: Inventory-like pattern of money stocks. This pattern reminded the second author, an economist, of the inventory money demand for money model (Baumol 1952). Figure 3 shows the sawtooth pattern of money holdings, depending on the number of trips to the bank.

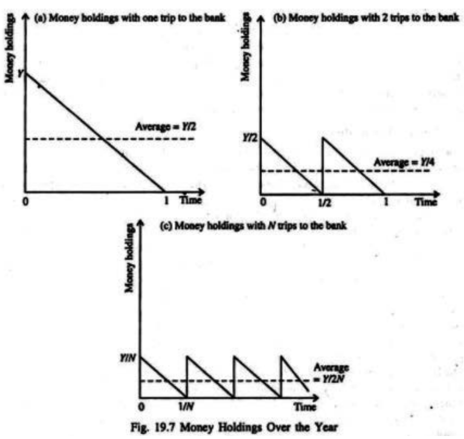

Fig. 8. An inventory model of money

Source: (Karmakar, n.d.)

This sawtooth pattern was seen in the average stock of money held by the tanukis and market vendors in the Tanuki Model, shown in Figures 9 below.

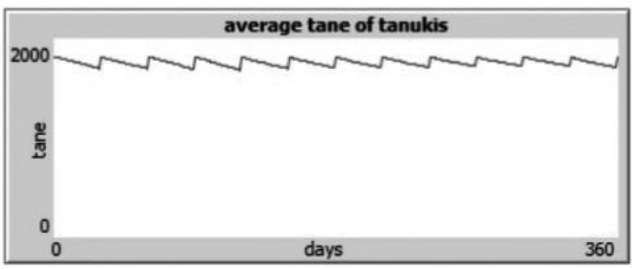

Fig. 9a. Average CC held by Tanukis

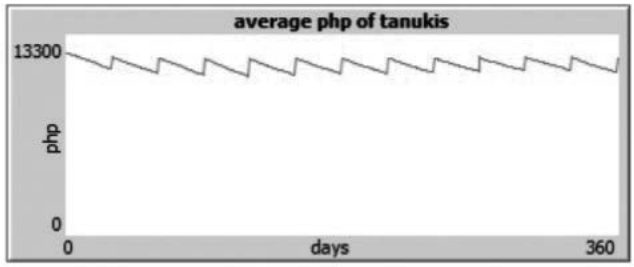

Fig. 9b. Average PhP held by Tanukis

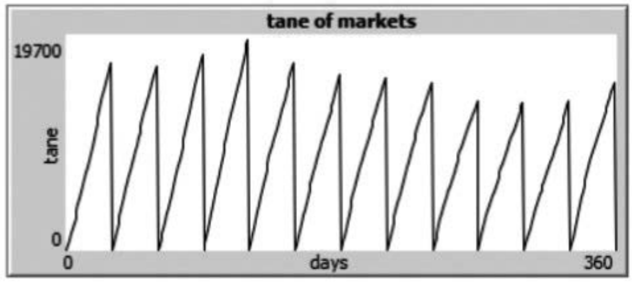

Fig. 9c. Average CC held by Tanukis

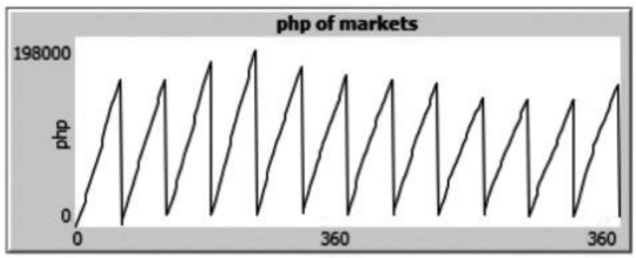

Fig. 9d. Average PhP held by market vendors.

Note that the sawtooth pattern for the markets is inverted due to the fact that the markets collect the payments from the Tanukis.

Such a sawtooth pattern was taken as a signal that the Tanuki Model has stabilized. In its original form, the EAC Model, the money stocks had a tendency to either continuously follow upward or downward movement through time. We thought this inappropriate for the Tanuki Model, where the stock of CC is essentially kept constant.

Pattern #2: Introduction of tane reduces % rejected tanuki. Our simulation shows that in all of the cases studied, the % rejected tanuki drops as soon as a small amount of tane becomes acceptable to the market vendors. This suggests that the CC could be a mechanism for adding cash into a community. This role of a CC is also observed in the case of a developing country like Kenya, where a substantial increase in transactions is observed after the introduction of a CC into the community (Ruddick, Richards, and Bendell 2015). Higher transactions mean lower rejected transactions.

Pattern #3: Having more market vendors in the community helps to reduce % rejected. The initial number of market vendors in the Tanuki Model was only ten, since this was the number of vendors in the EAC model, which is the baseline model. We increased this to 100[2], which is about the number of vendors in the developing country case of Kenya. This finding supports the widespread introduction of a CC into a community with many vendors.

Conclusion

The Tanuki Model is a significant improvement over the EAC model, since the former includes design and community structural variables that could be useful in designing a CC scheme to suit the particular set of structural characteristics of the community considering a CC's adoption. Table 4 lists up the major design and structural variables. In the actual implementation of the model, the design variables are set by the designer of the simulation model, while the structural variables are obtained based on consultations with the community considering the adoption of a CC scheme.

Table 4. Summary of design and structural variables of the Tanuki Model

Design Variables	Structural Variables
-percent of Tane accepted as payment	-number of community members
-initial Tane	-number of local vendors
-percentage of Tane and cash Tanukis receive from Markets	-number of outside vendors
-percentage of cash Tanukis receive from Shops	

The Tanuki Model could be easily further modified as the situation demands. Some of the modifications we are currently thinking about is capturing the interaction between the market vendors in the community, and the creation of a CC bank, where the issuance of CC could be taken to be a measure of the degree of volunteerism in the community.

In terms of methodology, we are thinking of automating the sensitivity analysis of the model, which we did manually in this study. Moreover, agent-based modeling presents an alternative way of research that could be useful in the age of pandemics, where field work has become more risky.

References

1) Baumol, William J. 1952. "The Transactions Demand for Cash: An Inventory Theoretic Approach." The Quarterly Journal of Economics 66, no. 4 (November): 545-556. https://doi.org/10.2307/1882104.

2) Grinza, Elena, and Claudio Beqaraq. 2012. "Economic Simulation with NetLogo "A monetary experiment."" University of Turin. https://terna.to.it/tesine/a_monetary_experiment.pdf.

3) Karmakar, Diptimai. n.d. "The Transactions Demand for Money: A Close Look." Economics Discussion. Accessed March 28, 2021. https://www.economicsdiscussion.net/money/demand-for-money/the-transactions-demand-for-money-a-close-look/16115.

4) Ruddick, William O., Morgan A. Richards, and And J. Bendell. 2015. "Complementary Currencies for Sustainable Development in Kenya: The Case of the Bangla-Pesa." International Journal for Community Currency Research 19.

5) Yoshida, Masayuki, and Shigeto Kobayashi. 2018. "Using Simulation and Gaming to Design a Community Currency System." International Journal of Community Currency Research 22 (Winter): 132-144. http://dx.doi.org/10.15133/j.ijccr.2018.011.

2 (Ruddick, Richards, and Bendell 2015)