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A COMPARISON IN TRANSACTION EFFICIENCY BETWEEN DISPERSIVE AND CONCENTRATED MONEY CREATION

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ABSTRACT

In this paper, we have compared concentrated creation of money with dispersive creation of money, and try to show, by using the results of computer simulation, the advantage of the method of dispersive money creation embodied into LETS in comparison with concentrated money creation. However, both ways of money creation have particular merits and demerits. We also estimate the effect of different rules for restricting the upper limits of debits of all participants in LETS on the rate of realized transactions in order to prevent free riding.

First, we give an overview of LETS. Second, we show, using a computer simulation, the advantage of the method of dispersive money creation compared to concentrated money creation. Finally, we have demonstrated the validity of the 'transaction indexation method' to set the rules of determining the upper limit of debits in LETS to avoid free riding and to enhance transaction efficiency.

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1. INTRODUCTION

The market is usually visualized as a 'concentrated' market with an auctioneer and tâtonnement (Walras 1874=1954, Arrow & Hahn 1971); however, the market where we really need the money as a means of exchange is not this kind but instead is a 'dispersive' market without such an auctioneer or an invisible hand. That is, it is a network of bilateral transactions, buying and selling, formed over a certain time. Most of the markets we face in daily life are surely of the 'dispersive' kind. Money matters in such a realistic market (Jones 1976, Kiyotani&Wright 1989, 1993, Matsui&Shimizu 2005).

The important function of money in such markets is decoupling: separating the buying from the selling of a commodity temporally or spatially as mutually independent processes. Thus, money holders can obtain the freedom to buy any commodity at any time and in any place or to keep on holding it without buying anything. Money thus establishes autonomy in the decision making of an economic agent. But 'Say's Law' which ensures equilibrium between supply and demand of all commodities does not hold in this situation; neither does the 'law of one price'

In a large-scale economy, all economic agents face bounds of rationality, so they have to decide the price and the quantity in such negotiated transactions as buying and selling, and then dispersively and sequentially execute transactions by using money for payment. They cannot start it over even though they may regret it later on. Accordingly, money is thought of as a communication medium (Luhmann 1984=1995, ch.4. sec.7-8) that reduces the complexity of external environments so that agents can make autonomous decisions and that conveys 'value' from a buyer to a seller. Money thus generates a dispersive market as a network of transactions (Nishibe 2006, Kichiji&Nishibe 2008).

Money usually reminds us of cash or banknote, but the main form of present money is deposit money based on bank credit. Banknote is monopolistically issued and controlled by central banks. We call such a method of banknote issue 'concentrated.' On the other hand, deposit money is created when banks make "loans." It is based on bank credit that is independently created by many private banks. Then we call such a method of creating deposit money 'dispersive'. We now have a classification of market and money creation (currency issue) as 'concentrated' and 'dispersive.' In a similar comparison, mutual credit clearing associations and LETS (Local Exchange Trading Systems) are thus classified as 'dispersive' money creation, and paper type of community currencies are classified as 'concentrated' money creation.

Money as an information medium can exist prior to its being a medium of exchange. The necessary condition of money is not its general acceptability as the means of circulation. Even if only a small number of people receive it as a stand-alone information medium or as a measure of value, we could call it "money". In this sense, each form of electronic money, shopping point, mileage, exchange coupon and community currency should be all called "money". We summarize the different types of money according to money creation or issue and other features in Table 1.

Community currencies (CC) have such features as i) negotiated transaction, ii) free negotiation of price and quantities, iii) relatively small sphere of circulation, iv) non-convertible or hard to convert into legal tender, v) freely issued and shared administrative costs by citizens, citizen groups or local government, vi) bearing zero or minus interest rate. i) and ii) are the features in common with legal tender observed in a large commercial sphere, and iii)-vi) are the general features of local currencies.

WIR (Wirtschaftsring) and concurrent currencies, however, are exempt from this classification. WIR-bank offers finance of WIR-money for registered SMEs at lower interest rates than normal loans. We find all features of CCs but vi) in WIR-money. On the other hand, concurrent currencies in a free banking system that Hayek (1976) proposed have common features of CCs but iv) and vi). So we locate WIR-money and concurrent currencies as intermediate configurations between legal tender and community currency.

In order to see the difference of circulation efficiency depending on the different types of money creation, we focus on comparing the two extremes, legal tender and community currency, in particular, banknotes and LETS, among these various moneys.

LETS stands for Local Exchange Trading System. This system represents one of the most popular account type CCs; it was initiated in 1983 by Michael Linton in Comox Valley, Vancouver Island, Canada. This is a mutual credit system based on dispersive money creation. Other than the account type, there are also paper money type CCs. Modern legal tender consists of cash and deposit money. Cash money is central banknote (as non-convertible paper money, or IOU) exclusively issued by central banks and subsidiary coin minted by governments. Deposit money is bank money created by the bank credit (credit creation) of private banks under the constraint of a reserve deposit rate.

CCs are classified into such paper money types as Ithaka Hours, based on concentrated money creation by an administrative committee and such account type as LETS, based on dispersive money creation by individual and group participants. Legal tender is also classified into concentrated money creation in the case of cash money and dispersive money creation by private banks in the case of deposit money. In reality, there is a big difference between community currencies and legal tender in view of their basic features; however, it cannot be denied that there is certainly an important similarity between them. The paper money type of CC is similar to cash money and the account type of CC, including LETS, is similar to deposit money in terms of methods of money creation.

Table 1: The compared characteristics of legal tender and community currency from the point of view of money creation

Type of Money	Banknote	Deposit Money	Concurrent Currencies	WIR money	Paper money type of CC (Ithaca Hours etc)	Account type of CC (LETS etc)
Issuer	Central banks	Commercial banks	Commercial banks	WIR-bank (Wirtschaftsring)	Administrative Committees	Participating individuals and groups
Circulation Sphere	Nationwide	Nationwide	Worldwide, Nationwide	Inter-SMEs	Territorial community; community of interest	Territorial community; community of interest
Type of Issue	Concentrated	Quasi-dispersive	Quasi-dispersive	Concentrated	Concentrated	Dispersive
User	National citizens	National citizens	Clients	Registered and non-registered SMEs	Community members	Participating individuals and groups
	Legal tender		Intermediate configuration		Community currency	

However, we are able to see a clear distinction between LETS and deposit money in table 1. In the case of LETS, issuers generally match users. On the other hand, in the case of deposit money issuers such as commercial banks don't match users such as national citizens. Thus we call such a method of creating deposit money 'quasi-dispersive'.

In this paper, we would like to compare concentrated creation of money and dispersive creation of money such as two extremes of legal tender and LETS in the view of money creation, and try to show, by using the results of computer simulation, the advantage of the method of dispersive money creation embodied into LETS in comparison with concentrated money creation. We also estimate the effect of different rules for restricting the upper limits of debits (negative balances or red ink) of all participants in LETS on the rate of realized transactions in order to prevent free riding.

First, we give an overview of LETS. Second, we show, using a computer simulation, that the ratio of realized transactions to attempted transactions under money stock constraints (budget constraints by money stock held) is determined by such factors as the ratio of agents initially holding money to agents holding no money, and the amount of initial money held per capita.

In more detail, when the distribution of the initial money held by each agent follows a uniform distribution, the amount of realized transactions increases with the initial money stocks held among all agents. Simulation results suggest that each agent has to hold an initial money stock of about 1.7 times as much as the average transaction amount per capita in order to realize all attempted transactions. However, suppose the agents have no upper limit of deficit, in the case of mutual credit and dispersive money creation like LETS, the realized transaction ratio is 100% at all times, even if the initial money held is zero. Finally we show that LETS as a medium of exchange has superior transaction efficiency in terms of the ratio of realized transactions.

2. WHAT IS LETS?

LETS is one of the account type Community Currencies for whoever wants to use it. Transactions using LETS are recorded in each participant's account. Participants can buy and sell products and services from each other with specific terms of price and quantities on a peer-to-peer basis. LETS can only circulate within finite physical or virtual domains. If you have a positive deposit in your account, you will not gain any interest from your savings. If you have no money and you want to buy something, you still can buy it by going below zero in your account by creating money units. The money in LETS can be created by individuals without any limit or with a certain upper limit according to the rules of each LETS. This is completely different from conventional money issued based on the value of commodity as money or the authoritative power of governments as issuers. LETS has properties similar to those found both in money and credit. It is money in the sense that it can function like conventional national currencies, as a means of circulation to mediate exchange, as a measure of value to provide the standard for exchange, and as a means of hoarding to store value.

In the case of a transaction of 1000 dollars, the account of a seller is recorded plus 1000 dollars and the account of a

buyer is recorded minus 1000 dollars. LETS adopts an accounting system that credits black to a seller and debits red to a buyer on each transaction, so that the sum of all participants' accounts constantly equals zero. Because of the zero sum principle, money exists only in the accounts with credit as black at the micro level, but does not exist in the association as a whole at the macro level. Besides, the accounts (both black and red) bear no interest.

As for the paper money type CC, an administrative committee has the exclusive right to issue CCs. Therefore, participants have to hold more CCs than the total amount of payment to buy some goods or services in the same way as when using cash money. In contrast, each participant of LETS has the right to create money freely so that he/she can buy goods or services even if his/her account balance is zero or negative. This is the advantage of LETS. Current money creation (cash money and deposit money) is synonymous with issuing an IOU. Conventionally, a buyer has to pay pre-existing money stock to a seller in order to purchase goods and services. If the seller is willing to accept credit from the buyer, the buyer incurs a debt to the seller. The debt is generated on the side of the payer. When the central bank issues central banknotes, it gives a certificate of indebtedness stating that I (the central bank) owe you (a recipient). Thus legal tender is called an IOU.

However a buyer is not directly in debt to a seller in LETS. Rather, the buyer is thought to be in debt to the community, composed of all the participants in the LETS. The buyer should have an ethical responsibility to repay the debt to the LETS community. In such systems as LETS, debts and credits do not bilaterally but multilaterally balance out. That is to say, LETS do not adopt bilateral netting but multilateral netting. Then we call this kind of money as in LETS, not an IOU but an IOC, which signifies "I owe Community".

Under these circumstances, the larger the community of LETS becomes in terms of the number of participants, the more the degree of anonymity will increase and the harder it will be to maintain trust among the participants in it. Then there is some potential risk of moral hazards that, if there is no limit to the maximum amount of debit, some participants are apt to expand their debt as much as possible and create too large an amount of money to repay. We call them 'free-riders'. Thus the size of a sphere of circulation of an "IOC" depends on the extent to which each participant can have an ethical responsibility to the community smaller than that of an "IOU". Thus each LETS should set up its own rules in order to constrain the volume of money that each participant can create and prevent free riders from being parasites on the community. This rule should clarify how to determine a certain upper limit of debit for each participant. It may vary, and the simplest rule is that the upper limit may be fixed to a uniform amount. There is also a rule which sets the upper limit determined as a linear function of a participant's total volume of transactions during a certain period. The merit of "IOC" is that unrealized transactions caused by money constraints can be reduced or eliminated, even if a buyer has no currency stock to pay to a seller.

Accounts in LETS bear no interest, so participants have no incentives to be in the black or to avoid being in the red. LETS is interest-free and issued freely by participants, and then since there is no such thing as transactions motives, precautionary motives and speculative motives for holding money that originated from 'The General Theory' written by John Maynard Keynes in 1936. Therefore, there is no demand for money depending on liquidity preference, so such real demand as consumption and investment demand should be encouraged. As a result, speculative financial transactions apart from real demand or self-propagation of capital for accumulation are hard to generate in LETS. This is quite a big difference between current legal tender bearing positive interest and LETS, and it is another merit of LETS.

3. ACCEPTANCE AND MARKET AREA

Money with higher acceptability circulates in a wider sphere. The reason why money is accepted by people varies with each type of money. In the past, the acceptability of convertible paper currency was ensured by convertibility into gold coin or bullion. The acceptability of present inconvertible money is self-sustained by people's expectation of the maintenance of its future acceptability and people's belief in the continuance of its past acceptability, and it is finally secured by (1) the financial solvency of central banks and the financial policy for stable money value, and (2) mandatory circulating power by cabinet order or government decree so that it should keep circulating in a nation-wide area.

In contrast with this, the acceptability of LETS based on mutual credit is ensured neither by convertibility into any good nor mandatory circulating power, but by mutual trust that other participants would accept the currency of LETS as long as they belong to the community or confidence in the continuance of the community itself. At present, it circulates in a relatively small sphere, but the communities vary in value and interest, and their numbers are large.

In order to maintain the acceptability of any type of money, including legal tender, community currencies, and so on, it is indispensable for issuers not to invoke the moral hazard of excessive money creation. If a central bank and a government are unified, the seigniorage is vested in the government by way of the central bank. In this case, the government tends to insist that the central bank should buy deficit-covering government bonds for financing the budget deficit. As a result, the central bank is apt to be exposed to strong pressure from the government to issue excessive money. However since excessive money creation causes the side effect of destabilizing money's value, leading to inflation, the central bank has to resist pressure to create excessive money and, in order to do so, needs independence from the government.

Table 2: The compared characteristics of legal tender and community currency

	Acceptability	Availabiity	Moral hazard	Countermea-sures against moral hazard	Circulation sphere
Legal tender	High	General	Government banks	Laws, acts, fines, punish-ments	worldwide, na-tionwide
Community currency	Low	Specific	Administrative committee, par-ticipants	Ethics, norms, reputation, ex-pulsion	Local area, community

Because the right of issuing money belongs to the participants in LETS, there is the danger of a debtor issuing excessive money and never trying to repay and escaping from the community. Such an individual would eventually ruin the trust of creditors in the community and encourage unfair treatment of participants so that the participants might dislike it and withdraw from the community. Such a problem could knock the bottom out of a mutual credit system in the community. In the case of paper money type of CC, excessive money creation by an administrative committee reduces its money value, so that it would blemish the participants' trust in the money and the community. As shown above, there is a possibility that both CCs and legal tender could invoke moral hazard, but the method of preventing it should vary for different types of money. For legal tender, rigid government rules or laws prescribing fines and punishments are supposed to regulate moral hazard. In CCs, such inner disciplines as ethics and norms, and such outer disciplines as rumor/ reputation and expulsion/ ostracism are expected to softly control any moral hazard. The different ways of preventing moral hazard makes a difference in their circulation spheres. Anonymity in legal tender is high, but participants in CCs make much of face-to-face relationships. We summarize the different characteristics of legal tender and community currency in Table 2.

4. A COMPARISON OF LEGAL TENDER AND LETS AS MEANS OF PAYMENT USING RANDOM NETWORK SIMULATION

In this section, we draw a comparison between legal tender and LETS from the point of view of the transaction efficiency of means of payment. Legal tender plays two roles, both as a means of exchange and as a means of payment. Settlements of transactions are made in two ways. In the first phase, the settlements between debits and credits are made between individuals by private banks and, in the second phase, between private banks by a central bank. Private banks and the central bank can settle the accounts with less money than the total amount of transactions by using netting. But the settlement using legal tender needs money (cash or reserves) in advance. Due to the lack of money stock in advance, we often cannot make the necessary transactions. In comparison with legal tender, accounts of LETS ideally have no constraint to create money, and thus participants can realize all the necessary transactions because they equally have the right to freely issue money. Next, we investigate, by using computer simulations, the ratios of the realized transactions to the attempted ones using legal tender[1].

We study the transaction efficiency of legal tender as the means of payment using random network simulation in a simple model. Firstly, we would like to confirm the technical terms of network theory. A network is a series of points interconnected with lines. The points and lines are called 'nodes' and 'links,' respectively. We assume the firms or individuals in transactions act as nodes and the transactions between firms or individuals act as links.

In the simulation, we select a buyer and a seller at random from K nodes every period and then the buyer pays the money for a good or service of the seller. We model a T period setting, where T is the number of total transactions. We assume, for simplicity, that the volume of all transactions is set at 1 and the price of the goods or service is set at 1. Time is represented by t. However, if the selected buyer has no money, the transaction cannot be realized. In this case, we select a new pair of buyer and seller randomly until they can settle. We call the number of selected transactions 'the number of attempted transactions' and the number of settled transactions 'the number of realized transactions,' respectively. We also define 'the ratio of realized transactions' as the ratio of the number of realized transactions to that of attempted transactions.

1 In this article, we don't mention "demurrage". If we introduce the idea of "demurrage" into our simulation, the results don't change in LETS. In the case of legal tender, the rate of realized transaction goes down by introducing "demurrage". Since the purpose of introducing "demurrage" is to enhance the velocity of money and expand the volume of transaction, this is different from our purpose in this article. We would like to focus on the transaction efficiency. Introducing "demurrage" into LETS needs attention. We put "demurrage" on both debit and credit in the simulation. In the case of no upper limit of debit and credit, even though the volumes of debit or credit decrease by "demurrage", the rate of realized transaction is constant because of freely issued money by participants in LETS. On the other hand, when we regulate only the upper limit of debit, the participants who have debits are likely to commit moral hazard by depreciating both debit and credit.

Table 3: Distribution of initial money holders and rate of realized transactions (the aggregate money stock is constant)

Ratio of initial money holders	100%	50%	25%	10%
Aggregate money stock	100	100	100	100
Initial per capita money stock	1	2	4	10
Number of attempted transactions	1000	1000	1000	1000
Number of realised transactions	550.9	518.6	472.7	335.2
Ratio of realised transactions	55.1%	51.9%	47.3%	33.5%

We performed simulations with a random network model of 100 agents (nodes) by varying the uniform distribution of initial money holders who possess the same amount of money. If all agents have 1 unit of money in the initial condition, the aggregate money stock amounts 100. We define 'the ratio of initial money holders' as 'the ratio of the number of initial money holders to that of all agents.' The ratio of initial money holders represents how equally money is distributed among all agents in the initial condition. If the ratio is 100%, the money distribution is completely equal and as the ratio approaches 0%, the distribution becomes most unequal.

We examine the changes in the ratio of realized transactions by decreasing the ratio of initial money holders gradually from 100% to 50%, 25% and 10%. In the simulation, when we keep the aggregate money stock at 100, the initial per capita money stock increases from 1 to 2, 4 and 10. We repeat the simulation 100 times so that we can obtain the ensemble average. Table 3 shows the average results.

According to Table 3, as the ratio of initial money holders decreases, the ratio of realized transactions decreases. We thus find that the distribution of the initial money holders strongly influences the realization of attempted transactions.

Next, we examine the effects of the changes of aggregate money stock on the ratio of realized transactions keeping the per capita initial money stock constant as 1. In the simulation, as the aggregate money stock decreases from 100 to 50, 25 and 10, the ratio of initial money holders decreases gradually from 100% to 50%, 25% and 10%. We repeat the simulation 100 times so that we can obtain the ensemble averages. Table 4 shows the average results. Keeping the per capita initial money stock at 1, as the ratio of initial money holders decreases, the ratio of realized transactions decreases sharply.

According to Table 4, the average results are influenced by both the inequality of the initial distributions and the decreasing aggregate money stock. The results show that the ratio of realized transactions decreases as the ratio of initial money holders decreases.

Finally, we estimate the amount of the initial per capita money stock required to realize all the attempted transactions.

In order to keep the number of per capita attempted transactions constant as 10, although the number of total participants increases from 100 to 250, 500 and 1000, we need to increase the number of attempted transactions from 1000 to 2500, 5000 and 10000 in the simulation. We show the results in table 5. In the case of 100 participants,

Table 4: Distribution of initial money holders and ratio of realized transactions (initial per capita money stock is constant)

Ratio of initial money holders	100%	50%	25%	10%
Aggregate money stock	100	50	25	10
Initial per capita money stock	1	1	1	1
Number of attempted transactions	1000	1000	1000	1000
Number of realised transactions	550.9	358.1	206.0	92.5
Ratio of realised transactions	55.1%	35.8%	20.6%	9.3%

Table 5: Number of total participants and initial per capita money stock required to realize all attempted transactions[2]

Number of participants	100	250	500	1000
Ratio of initial money holders	100	100	100	100
Number of attempted transactions	1000	2500	5000	10000
Number of realised transactions	550.9	358.1	206.0	92.5
Ratio of realised transactions	100%	100%	100%	100%
The initial per capita money stock required to realize all attempted transactions	15	16	17	17

to realize all the attempted transactions, each agent has to hold 15 units of money stock in advance. As the number of total participants increases, the initial per capita money stock increases to realize all the attempted transactions. However, its rate of increase gradually diminishes towards 0 as the number of total participants increases to 1000. As a result, the initial per capita money stock required to realize all transactions is saturated around 17 units of money on the condition that the number of per capita attempted transactions is 10. This result shows that each agent has to hold 17 times the money stock in advance as each transaction value, or 1.7 times the money stock in advance as the total per capita attempted transactions. In normal transactions using legal tender, agents have a great amount of money buffer to fulfill all necessary transactions. The initial per capita money stock required to realize all transactions increases, but the rate of increase of it diminishes as the number of per capita attempted transactions increases.

Table 6 is created by taking the first column of Table 4 in order to show the comparison between legal tender and LETS in terms of the ratio of realized transactions. The total number of participants is 100 people, and the number of attempted transactions is 1000 times. The initial per capita money stock is 1. In LETS, the ratio of realized transactions is always 100% if there is no rule to restrict upper limits of debits of accounts so that there can be no constraints of money to hinder all attempted transactions from being realized. According to the table, it is 1.81 times as high as that (55.1%) using legal tender. We can now understand that a certain amount of money buffer in advance is necessary for the dispersive market to function smoothly with a 100% ratio of realized transactions. But such a high ratio of realized transactions is almost impossible in the case of legal tender because the reality is that a non-uniform and uneven distribution of initial money holders makes the ratio of realized transactions lower, and that a shortage of effective demand in consumption and investment in a period of depression, which is intrinsic in the dispersive market, reduce it, though the increases of per capita money stock in hoarding or saving is supposed to have the effect of increasing it according to the discussion above.

Table 6: The comparison of the ratios of realized transactions between legal tender and LETS

Type of money	Legal tender	LETS
Ratio of realised transactions	55.1%	100%

We can see from Table 3 through Table 6 that LETS need much less of a money buffer than legal tender. LETS thus exhibits high transaction efficiency. On the other hand, however, because every participant has the right to freely issue money, there are naturally some who might not be able to resist the temptation to create excessive money or even others who might be ill-intentioned to do so from the outset. Such risk of moral hazard invoked by a part of participants restricts the circulation sphere to a relatively small area.

It should be noted, however, that, even though such free riders in the community should be ethically criticized, it does not really cause devastating damage to LETS as a monetary system because participants cannot tell the

money created by free riders from other ordinary money. Accordingly, such money, which becomes shared by all participants, can circulate exactly in the same manner as other money in LETS.

Nevertheless, administrators of LETS would be well-advised to set a certain rule to restrict upper limits of debits (negative balance) to prevent such side effects caused by such moral hazard as loss of confidence in LETS and the community, expansion of a feeling of unfairness and the withdrawal of participants[2].

5. THE NECESSITY OF DESIGNING THE RULES TO RESTRICT THE UPPER LIMIT OF DEBIT OF AN ACCOUNT FOR EACH PARTICIPANT IN LETS

The simplest rule to restrict the upper limit of debit in LETS is to fix it to some constant value. For instance, the limit could be completely fixed as, say, minus 100 green dollars for every participant all the time[3]. But this merely wastes the merit of LETS since it is not so much different from the case of uniform distribution of initial money stock for legal tender discussed in the last section, except for the ways of money creation. There are other such rules that effectively utilize the advantages of LETS so that it can increase the rate of realized transactions such as: 1) the step-by-step alteration method and 2) the continuous alteration method. The step-by-step alteration method alters the upper limit of debits depending on the duration of membership or the distinction between provisional membership and full membership. An example is to set minus 100 green dollars for a provisional membership of less than a year and minus 200 green dollars for a full membership. Such a method is realistic and easy to adopt, but too approximate to make the most of the merits of LETS. Then it would be desirable to design and adopt more sophisticated rules to determine the upper limit of debits as long as it is practicable, so that it can utilize the data that administrators are supposed to possess and estimate the difference of each participant in their past performance and activate total transactions as much as possible.

Now we will explain the 'transaction indexation method' as such a possible method. The upper limit of debit of an account is calculated according to the following linear equation where R: is the upper limit of debit, z: is the aggregate transactions of a participant, a: is the variable factor of the upper limit of debt, and b: is a constant factor.

$$R = - a*z - b \quad (1)$$

Let us here observe how the ratio of realized transactions changes as only the parameter b is altered with the parameter a held constant and compare two cases (a = 0.2 and a =0.05) on the condition that the total number of participants is 100 and the number of attempted transactions is 1000, that is, the number of per capita attempted transactions is 10. Table 7 and Table 8 show the results of the two cases as the ensemble average of 100 times experimentations.

Table 7: The ratio of realized transactions and alteration of parameter b (a = 0.05)

Parameter b	1	2	5	10	15
Number of realised transactions	747.41	853.17	967.47	998.88	999.98
Ratio of realised transactions	74.7%	85.3%	96.7%	99.9%	100.0%

Table 8: The ratio of realized transactions and alteration of parameter b (a = 0.2)

Parameter b	1	2	5	10	15
Number of realised transactions	750.88	853.86	981.06	999.46	1000
Ratio of realised transactions	75.1%	85.4%	98.1%	99.9%	100.0%

2 In the following section, we argue the rules that regulate the upper limit of debit. In case of random matching simulations as in the present section, if we regulate the upper limit of credit, the results obtained will almost show no difference. But in the actual non-random transaction, there is the possibility that some participants will commit moral hazard of holding enormous debit balances. That is why we consider the upper limit of debit. But the big debit itself will not necessarily cause systemic breakdown if it is treated as credit creation when the enormous credit is transferred to the common account. Furthermore, we don't think that the enormous credit balance of some participants must be the fatal factor for maintaining LETS.

3 There may be an opinion that regulating the upper limit of debit in LETS to fix it to some constant doesn't violate principle of social equality, On the other hand, altering the upper limit of debit depending on the duration of membership or volume of total transaction violates it. However, in the case of altering the upper limit of debit, equality of opportunity is present in the sense that the upper limit is all the same to participants at the start point and they express approve of the rules even if equality is not present.

First, we take a look at the first columns of Table 7 (a = 0.05, b = 1) and that of Table 8 (a = 0.2, b = 1) in order to compare these with the results in Table 6. It is conceivable that the case for legal tender can be now interpreted as the case of the equation (1) with a = 0, b = 1. To set the parameter a at some positive value instead of zero in the 'transaction indexation method' can drastically increase the ratio of realized transactions from about 55% to about 75%. The increase of the parameter a from a = 0.05 as in Table 7 to a = 0.2 as in Table 8 only makes a small increase (0.4%) in the ratio of realized transactions. These results show that the 'transaction indexation method' that prevents moral hazard as to the excessive creation of money can remarkably enhance the ratio of realized transactions with a relatively small parameter a as long as it is positive. The initial per capita money stock required to realize all transactions can also be reduced to around 10 from 17 for legal tender. This case study exemplifies that such institutional design of rules is essential for community currencies including LETS to function well enough to attain their original goal.

6. CONCLUSION

In this article, we have examined and compared the characteristics of dispersive and concentrated money creation observable both in community currencies and legal tender, rather than just having contrasted community currencies and legal tender. Both ways of money creation have particular merits and demerits. Concentrated money creation causes the problem of restricting transactions by the need for money stock in advance, and it requires a larger money buffer to realize transactions smoothly. Concentration of money creation can prevent free riding and have a broad sphere of circulation, and it creates maneuverability for the monetary policy of a central bank. At the same time, its arbitrariness might lead to a great danger of excessive money creation. On the other hand, dispersive money creation without any constraint exhibits transaction efficiency as in LETS with no upper limit of debit, but it can bring about the moral hazard of free riding taken by some participants. Finally, we have demonstrated the validity of the 'transaction indexation method' to set the rules of determining the upper limit of debits in LETS to avoid free riding and to enhance transaction efficiency. We simultaneously presented the possibility of the institutional design of money by this exemplification.

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