A SYSTEM DYNAMICS MODEL OF A LOCAL ECONOMY WITH BI-CURRENCY SYSTEM

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Local communities have no control on national and global monetary systems in spite of the fact that they are hit and damaged by economic crisis, unemployment, and other instability and insecurities caused by them. To overcome these problems, communities depending on their priorities, needs and resources, design their currency and local exchange schemes. The former research has claimed that they stimulate local production, support local businesses, create local jobs, develop sustainable consumption and enhance ecological & social wellbeing. These hypotheses are derived from relatively short-term observations due to fact that this is a new research area. However, a dynamic system modeling of a local currency system with two currencies can provide a valuable and in-depth insight into the system's structure and its behaviors in the long run. I create a system dynamic model of a local economy with two currency sectors. I formulate a discounted exchanged rates policy, define model components and their interrelations, describe the structure, analyze the possible behaviors. My aim is to introduce system dynamics approach as a testing tool to communities that are planning to introduce local currency into their local economy. This is an exploratory and an experimental study.

INTRODUCTION

Global climate change, high oil dependency, oil price volatility, world financial crises, and political instabilities are the challenges urging humanity to re-think and consider changing on many personal, social, ecological and economical fronts. Resilience and re-localization will be key concepts initiating this change in local communities. Re-thinking money and re-designing local economy are required for the community resilience.

Economies run on exchange of goods and services. Monetary systems facilitate these exchanges. Central banks, governments and corporations control the global economy and the financial system. A few global currencies dominate global and local exchange of goods and services. Money circulating within communities is not the communities' money any longer. Local communities have no control on national and global monetary systems and on global economy although they are hit and damaged by economic crisis, unemployment, and other instabilities and insecurities caused by them.

To overcome these problems and obstacles and to build resilient local economies, local exchange circulation systems are proposed. These local systems may be uneconomic from a pure classical economic viewpoint, however they incorporate environmental and social factors into the economical equations (Schumacher, E.F. 1989; Greco, 1994). Communities, depending on their priorities, needs and resources, design their currency and local exchange schemes. Local currency systems function together with national currency in a local economy. The former research has shown that they stimulate local production, support local businesses, create local jobs, develop sustainable consumption and enhance ecological & social well being (Greco, 1994; Boyle, 2003; Lieataer, Belgin, 2004; Seyfang, 2006). These evidences are derived from relatively short-term local currency and local exchange experiences. Systems approach to bi-currency problem in local economies can provide valuable and in-depth insights into the system's structure and its future dynamics.

Radzicki define three principle ways used in system dynamics modeling of an economy (Radzicki, 2007). The first approach is to translate an existing economic model into a system dynamics format. The second approach is to create an economic model from scratch by following the rules and guidelines of the system dynamics methodology. Third one is a hybrid approach, a well-known economic model is translated into a dynamic systems model and then modified. In this paper, I will employ the second approach.

In this study, I create a dynamic systems model of a local economy with bi-currency sectors, one working with the national currency, the other working with the local currency. The influence of bi-currency system with discounted exchange rates on consumption and investment will be analyzed. My aim is to introduce system dynamics approach as a testing tool to communities that are planning to introduce local currency into their local economy.

LITERATURE REVIEW

The current monetary system seeks continuous economic growth by consumerism instead of enhancement of real standard of living. It fuels up conflict between short-

term financial gains and long-term resilience and sustainability. It also causes massive job-losses and crash of local and national economies. Global monetary system creates great instability and insecurity. Therefore, for the communities to build resilient local economies is becoming crucially important.

Economies run on exchange of goods and services. Monetary systems facilitate these exchanges. Money is a community agreement on a piece of paper that it has an exchange value. In other words, it is a community's or a group's choices like a social contract (Lietear, Belgin, 2004). The developments in 1970s and 1980s shaped the new global economy and financial system. This system now determines value of our money, goods and services produced locally. But global money system is not neutral. In other words, it is not value free. On the contrary, it is controlled by central banks, governments and corporations, and dominated by a few global currencies. Monetary markets show no tendency to evolve toward a state of long-term equilibrium as classic economic theory claims. Instead, they were proved to become systemically unstable (Lietaer & Brunnhuber, 2003). When a financial crisis explodes in a country, it triggers a domino effect toward other countries' economies and like a tsunami wave hits even very far and small local communities.

Worldwide growth of unemployment is another negative tendency created by global economy. 700 million people are out of work or under-employed worldwide (Lietear, Belgin, 2004). Unemployment is not a Third World problem anymore. Global economy moves production from developed countries to where wages are lower and causes vast job cuts. Mobility of global job market hits local economies very strongly due to limited local employment opportunities.

Economic growth is one of the primary goals of global economy and it promotes consumption without any social and environmental concerns. In addition, global economy inhibits sustainable consumption. Seyfang defines sustainable consumption as "calling citizens to use their consumers' sovereignty to transform local markets by demanding environmentally friendly goods and services" (Seyfang, 2006). Reducing consumption and purchasing goods and services locally are the attributes of sustainable consumption.

To overcome these problems and obstacles created by global economy and financial system and build resilient local economies, new systems of exchange need to be invented, specifically designed to employ the 'whole systems' approach to the economy-society-environment aspects of the local economy. As Richard Douthwaite stated "All monies should be created by, or on behalf of, their users and not by institutions wishing to profit from the activity" (Douthwaite, 1996, chp.2). These local systems may be uneconomic from a pure classical economic viewpoint, however they incorporate environmental and social factors into the economical equations such as preferring local products even if they are economically expensive than imported ones, promoting non-consumption (Schumacher, E.F. 1989; Greco, 1994).

In local economies, local currencies and local exchange systems are used to facilitate community exchanges. History of local currencies goes back to 1830s. They are again becoming popular and widespread due to problems and obstacles created by global economy and financial system discussed before. Local currencies are available in sufficiency, non-interest bearing and circulate more dynamically. They act like a real exchange medium rather than a value of stock. Local currency systems are

diverse. They use various financial instruments such as money, time, goods or services. They are either paper based or an electronic. Some of them are backed by national currency and some not. Issuer can be the community itself or the municipality or an NGO or a local person. Local exchanges mobilize well the skills, time and resources of community members and improves community integration. They provide means to match unmet needs with unused resources (Lietaer, Belgin, 2004, pg. 178). Together with local currencies they develop local production, support local businesses, create local jobs and lead sustainable consumption. (Greco, 1994, Boyle, 2003; Lieataer, Belgin, 2004; Seyfang, 2006). Therefore, they are required to make local economies resilient.

A very limited research has been done on local currencies and exchanges. Past research and experiences with local currencies and exchanges have claimed that they develop local production, support local businesses, create local jobs and lead sustainable consumption. (Greco, 1994, Boyle, 2003; Lieataer, Belgin, 2004; Van Sambeek, Kampers, 2004; Seyfang, 2006; Covey, Richards, 2010). Another claim is that local currencies provide informal employment for the socially excluded (Seyfang, 2004; Seyfang, 2006; Covey, Richards, 2010).

Community currencies benefit people with low income and outside the labor market (Seyfang, 2006). These currency systems value unpaid social work and reward it and hence cultivate social capital. Local currency system grows social networks, build friendships, drives community members to involve more with community issues and to participate to community decisions, and overcome social exclusion (Seyfang, 2006). Local shops act like a buffer against large retailers that drain the local earnings away and keep the local money within community. Product choices offered to local people are made local people rather than by distant executives. Local shops also provide social glue that holds people together and builds social capital (Boyle, 2009).

These hypotheses were based on findings of relatively short-term local currency and local exchange experiences. The validity of community decisions, for example; amount to issue and circulation duration of issued money, are justified by "apply and observe" method. Testing alternative local currency strategies over a long period of time has not been done. Impact of local currencies and exchanges on local economy has been analyzed from various aspects independently rather than by a holistic systemic approach. Past research describes the behavior of the local currency and exchange systems but doesn't give comprehensive information about the structure causing these behaviors. Therefore, a dynamic modeling of a local currency system with two currencies can provide a valuable and in-depth insight into the system's structure, interrelations of the flows of goods, money, information and labor, clarify the feedback loops, set a mechanism to test community decisions, and analyze the overall structure of the system and its behaviors.

This study is an exploratory and preliminary. Simulation modeling can provide a virtual world (Sterman,2000). I aim to introduce system dynamics approach as a testing tool to communities that are planning to introduce local currency to their local economy. They scan gain an insight on the local economy, its components, and their interrelations, feedback loops by analyzing the structure.

MODELING A LOCAL ECONOMY WITH BI-CURRENCY SYSTEM

PROBLEM

Small communities are under attack of multi-national brands. Prices of goods and services are determined by global market. Local people cannot value their product anymore. In communities, local money spent on goods that are not locally produced quickly leaves the community without re-circulating in local-economies (Boyle, 2009). Only 20% of money spent stays within the community (North, 2010).

National and global currencies serve to global market and global multi-nationals not to the local economies. Lietaer states "Money matters. The way money is created and administered in a given society makes a deep impression on values and relationships within that society. More specifically, the type of currency used in a society encourages – or discourages – specific emotions or behavior patterns" (Lietear, 2001: pg. 4).

Previous research claims that local economy resilience requires a local currency, which will circulate along with national currency to develop and support local economic and social activity in such a way that local currency dynamics develop local production, support local businesses, create local jobs and lead sustainable consumption via localization of production activities and reducing carbon footprints. In this study, I will investigate some of these claims by system dynamic modeling approach. In local currency schemas, most favored mechanism is to use an incentive rate in the exchange of money. I will use it in my model.

I have two goals, contextual and simulation modeling and analyzing. My modeling goal is to determine the structure of a local economy with bi-currency as a dynamic system, to understand causal relations between system elements and to define decisions and decision rules. And then I will analyze how this dynamic model behaves as it operates over time and what are the dynamics influencing volume of the circulating local money, local production and local employment.

MODEL DESCRIPTION

Lets assume that there is a local community in a town who want to introduce local currency into their local economy, circulating together with the national currency.

In the town, there are national shopping stores and firms. Representing national business. They accept only national currency. They transfer their earnings away from local economy.

Local businesses are owned by local people and they sell both locally produced and imported goods, and provide local services. They work with both national and local currency. They sell imported goods in national currency, local goods and services in local currency.

Wage income is the only external income source of the local economy. Households have a fix monthly income. When people have national money to consume, they can spend it either in the national businesses or in local businesses.

National Currency Regulator exchanges national currency to local currency and vice versa. The national money accumulated in National Currency Regulator doesn't receive any interest to compensate the work done by the regulator. A portion of accumulated national currency money is given as the loan to local businesses to increase local economy capacity. These loans are interest free.

A local committee called Local Currency Regulator issues local currency. They set a maximum amount to be issued and every week if local currency in the stock is less than this amount, they pump the difference into the local economy.

How quickly local households and businesses will accept the local currency is a critical concern. To promote the exchange an incentive rate is applied. For example; when people give 95 National Currency, they get 100 Local Currency. If people want to redeem 100 Local Currency, they receive 95 Local Currency.

People and businesses can exchange their money or they can reimburse it whenever they want. Local businesses get local currency from two sources: by business activities or by purchasing it directly from National Currency Regulator. They use local currency in their trade transactions in local economy. They spend a fraction of their local currency as wage payments in the local economy. They reimburse the amount they can't spend.

Local currency is used only for trading purposes. It is not a saving instrument. All parties can save their money in national currency only. When needed, they direct their savings to investment activities.

Only investment to local capital is possible. There are two ways. Local businesses take interest free loan credit offered by National Currency Regulate and if required they use their business savings to increase their business capital.

The local capital is the total value of locally produced goods and services. It has an average live, therefore every year a certain amount of it is lost. Total demand and available credit drive the decisions related with capital expansion. If local business demand is bigger than existing capital and if there is enough available credit for investment then investment decision is taken. There is a delay associated with the acquisition of the additional capacity. Local capital provides employment called local labor. As capital increases, local employment rises and vice versa.

Model Boundary and Assumptions

Labor has a fix monthly income and they spend a fix ratio of it as consumption. Their payments to external authorities such as utilities are not in the scope of this study and either their savings. Wages are paid in national currency.

There is no inflation or deflation on both currencies. Market prices are fixed.

Money exchange on both directions is possible anytime and in any amount.

Local currency is not an investment or a finance tool. It is a trading tool only circulating within the local economy.

No bank interest is applied to national currency stock accumulating in National Currency Regulator Reserve due to exchange and redemption transactions. Interest free loans are given from this stock to local businesses to expand their capacity.

Capacity productivity is set to be 0.12. That is for every National Currency value worth of capital invested, 0.12 value of product is produced every month.

Unit labor requirement is set to be 0.001 for local capital.

Local Capacity is lost due to obsolesce by a monthly fixed rate.

Two local committees, National Currency Regulator and Local Currency Regulator, administer the local currency system, and decide when and how much to issue local currency.

Time scale is month.

DT is set at 1/8.

Model testing period is 10 years. If and when required, the testing period can be extended by simulation program.

Sectors of The Model

The model consists of three major sectors related with currency movements (Figure 1):

National Currency Sector: This sector consists of six stocks and all currency transactions done by national currency. Households, Local and National Businesses and National Currency Regulator are the key players. Exogenous money enters the local economy as household income. All income available for consumption is collected under National Currency Household stock. This money is either consumed in national business and leaves the local economy or is consumed to buy imported goods from local businesses or is exchanged to local currency or when can't be spent, leaves the sector. Local businesses are either use national currency for trade transactions or exchange it to local currency. When a currency exchange takes place, money is transferred between National and Local Currency Sectors. They can decide to invest into their local business and then his amount goes to Local Capacity Sector.

Local Currency Sector: All local currency transactions are carried in this sector. Households, Local Businesses and Local Currency Regulator are the key players. Local currency sector has three stocks. Issuance of local currency is the only exogenous money source. When people and businesses purchase local currency, they can either consume it in trade activities and local currency circulates within local economy or they decide to reimburse and exchange it to national currency. Through exchange and reimbursement transactions, money moves between National Currency and Local Currency Sectors.

Local Capacity Sector: This sector consists of local business capacity and investment related decisions and currency movements. Local Businesses and National Currency Regulator are players in this sector. Local capacity sector has one stock. National Currency Regulator provides interest free loans to local businesses. Local businesses

preferably get this no-interest loan and in addition to this option, if needed use their savings to expand their capacity. Capacity loss due to obsolesce leaves this sector.
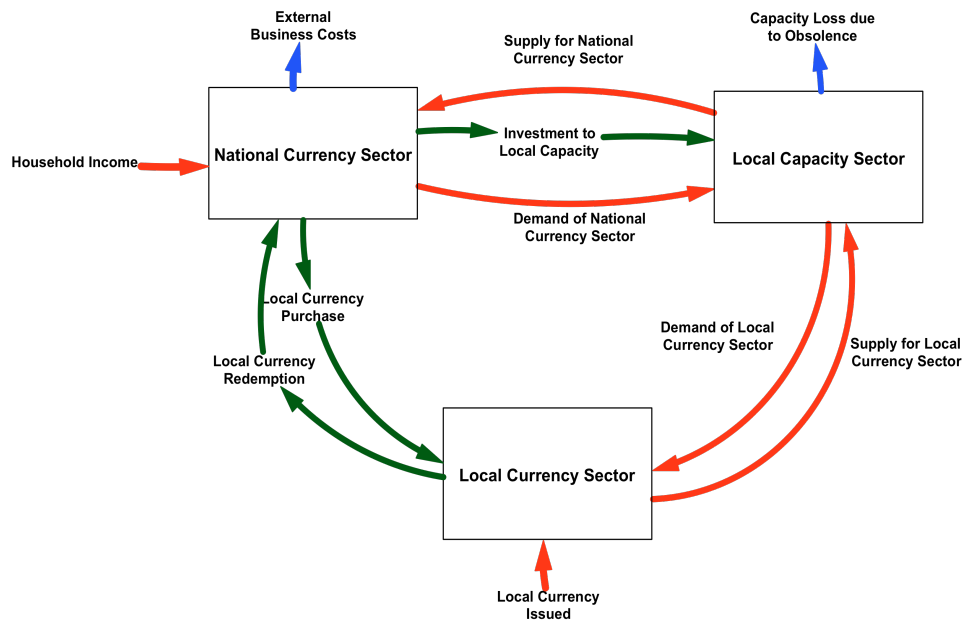

Figure 1. Sectors and Interrelations.

Stocks, Simplified Stock-Flow Diagrams and Effect Functions

Model has ten stocks, twenty-seven flows called decision rules, three affect functions, and various endogenous and exogenous variables. The stock definitions are listed in Table 1.

Table 1. Model Stocks

Stock	Definition
NCH_SPENDING	The amount of National Currency people desires to consume.
NCLB_SPENDING	The amount of National Currency Local Business desire to consume.
LCLB_SPENDING	The amount of Local Currency Local Business desire to consume.
LCH_SPENDING	The amount of Local Currency people desires to consume.
NCR_RESERVE	The National Currency Reserve amount.
LC_RESERVE	The Local Currency Reserve amount.
NCLB_SAVING	The savings of Local Business in National Currency.

NCR_LOAN	The amount of loan given by National Currency Regulator to Local Business.
LOCAL CAPACITY	The Local Business Production and Services Capacity
EXPECTED REIMBURSEMENT	The National Currency Reserve of National Currency Regulator i.e. backup money.

National currency circulates within national currency sector. This sector consists of saving and consumption activities, wage payments in national currency, currency exchanges, credit taking and loan payment activities (Figure 2). Local Currency Regulator manages the local currency. When required, it is authorized to issue Local Currency. Local currency circulates in local currency sector. Money transactions are related with consumption, spending and money exchange (Figure 3). All activities related with local capacity are in local capacity sector (Figure 4).
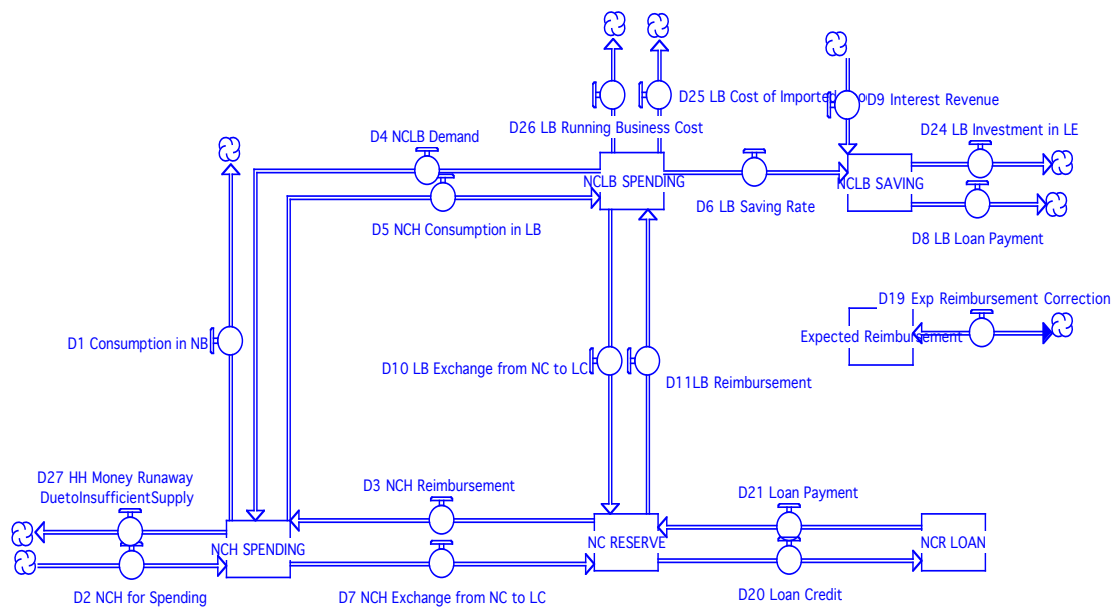
Figure 2. Simplified Stock-Flow Diagram of National Currency Sector.

Three effect functions are defined to represent the non-linear relations between model parameters and variables, and to normalize their effects. They are;

- Effect of local supply over national supply ratio on local currency purchases: As more goods are produced and more services are provided locally, this ratio will increase and I assume that this abundance will influence people to buy more local currency.

- Effect of Local Currency to National Currency Ratio on Local Currency reimbursement: This is the reverse function of previous effect function.
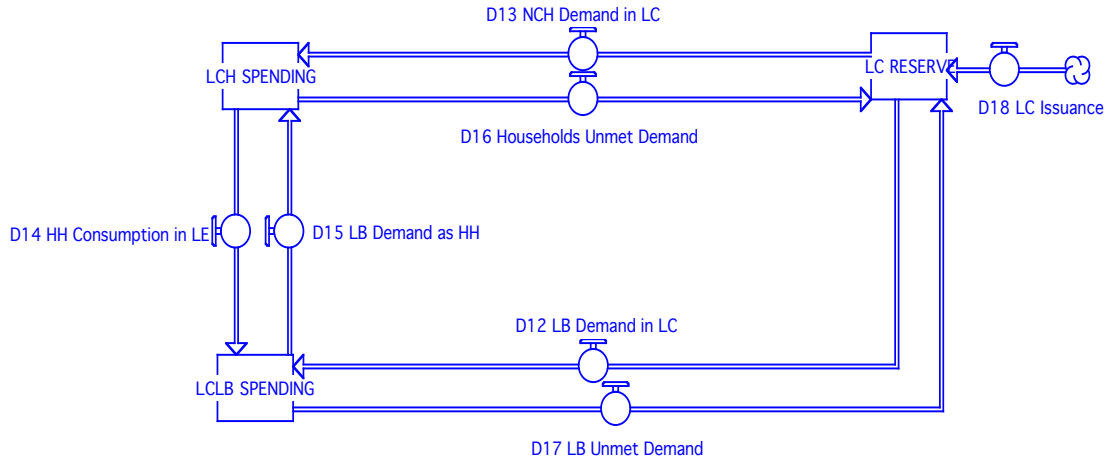
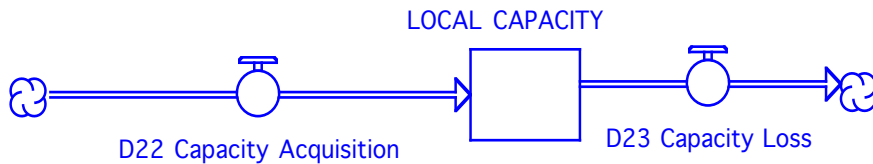Figure 3. Simplified Stock-Flow Diagram of Local Currency Sector.

Figure 4. Simplified Stock-Flow Diagram of Business Capacity Sector.

- Effect of local economy demand over supply ratio on people local currency spending: People will consume more local goods and services as demand over supply ratio in local economy increases.

MODEL VALIDATION

Validation of the model structure is evaluated by direct tests and structure oriented behavior tests. Behavior validity tests could not be done due to unavailability of real data.

Direct Structure Tests:

All along the modeling phase, dimensional consistency of each decision equation is checked and confirmed. The qualitative tests are done. The logical meaning of each decision equation is confirmed. All parameters have real life meaning taken from financial, economical, production and local currency systems. The parameters are assigned numeric values that I could find in my literature review. For the rest, I did educated guesses.

Structure Oriented Behavior Tests:

Extreme Condition Tests: Four extreme scenarios are designed and model based behavior patterns of stocks are compared with expected real life system behaviors.

Test 1: Number of households diminishes to zero, i.e. income entering into the model. In real life, when income generation stops, it is expected to have no consumption.

Results confirmed it. Local currency and national currency consumption flows diminish to zero (Figure 5).
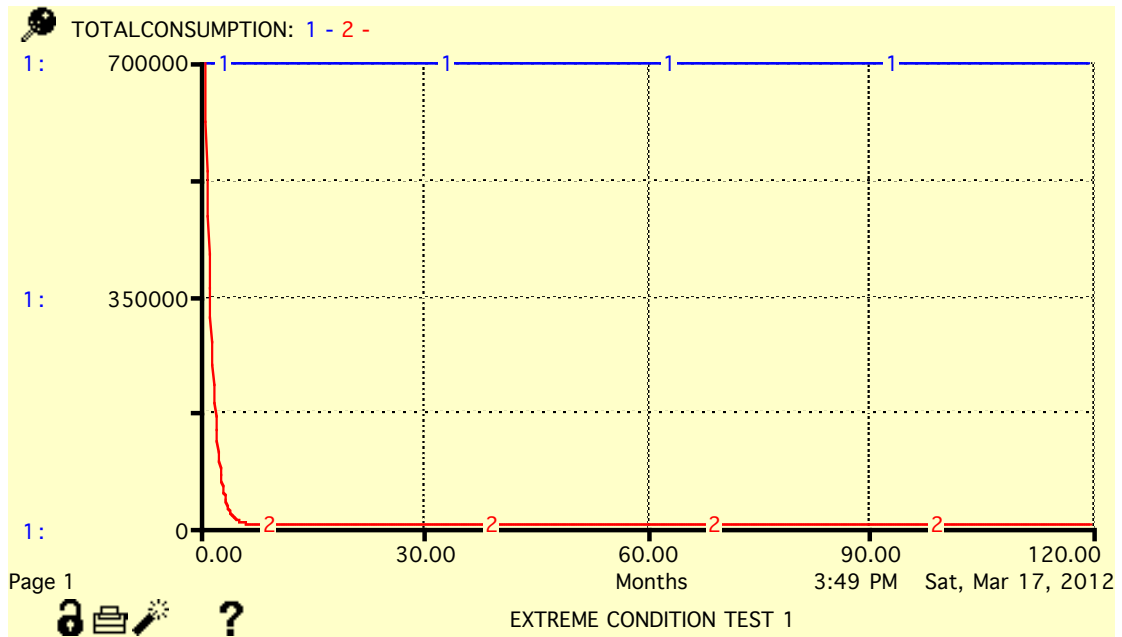

Figure 5. Total Consumption in Extreme Condition Test 1.

Test 2: When no money enters the local currency sector, spending stocks diminish to zero in local economy as seen in Figure 6.
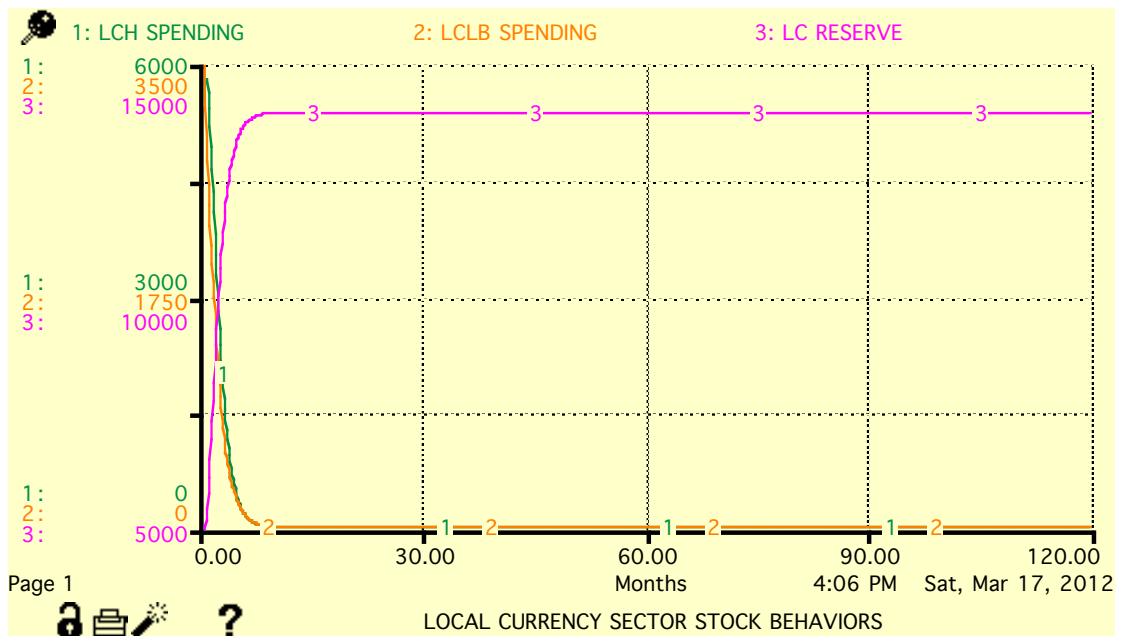

Figure 6. Extreme Condition Result Behaviors

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Scenario 3. When household income is increased by 1000 fold, I expect sudden and significant increase in local capacity. Result confirms my expectation (Figure 7).
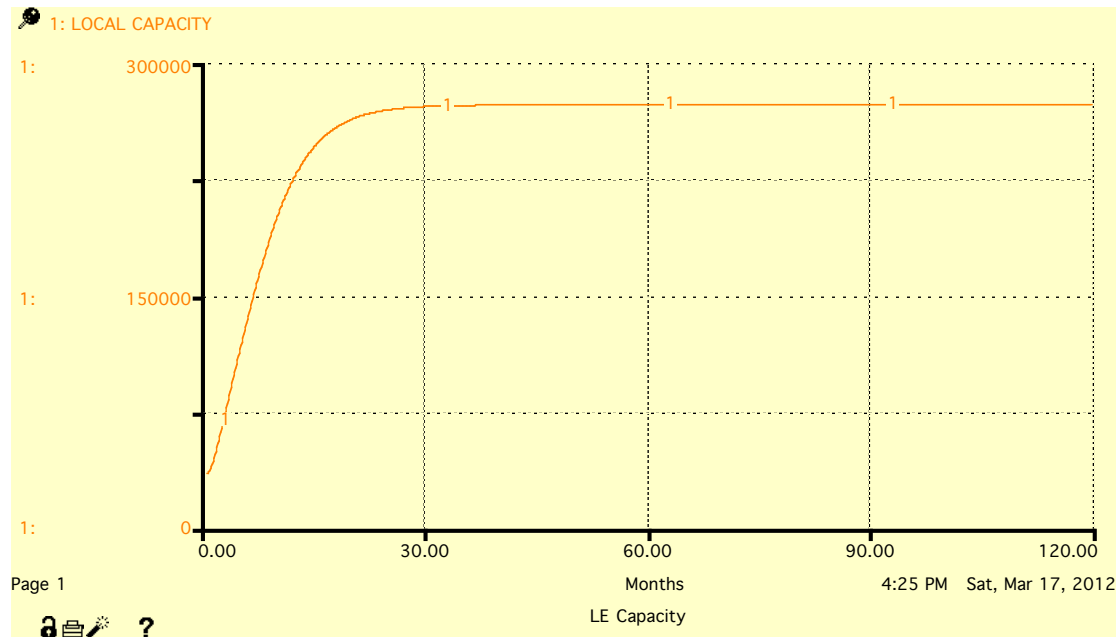

Figure 7. Local and National Business Supply Graphs in Extreme Condition Test 3.

Behavior Sensitivity Tests:

The model is highly sensitive to Loan Giving Period, that is the time taken between loan request and provision of the full loan. It has an impact on the amount of loan taken from National Currency Regulator. As seen in figure 9, as period is shortened from 4 to 1, loan usage increases significantly.
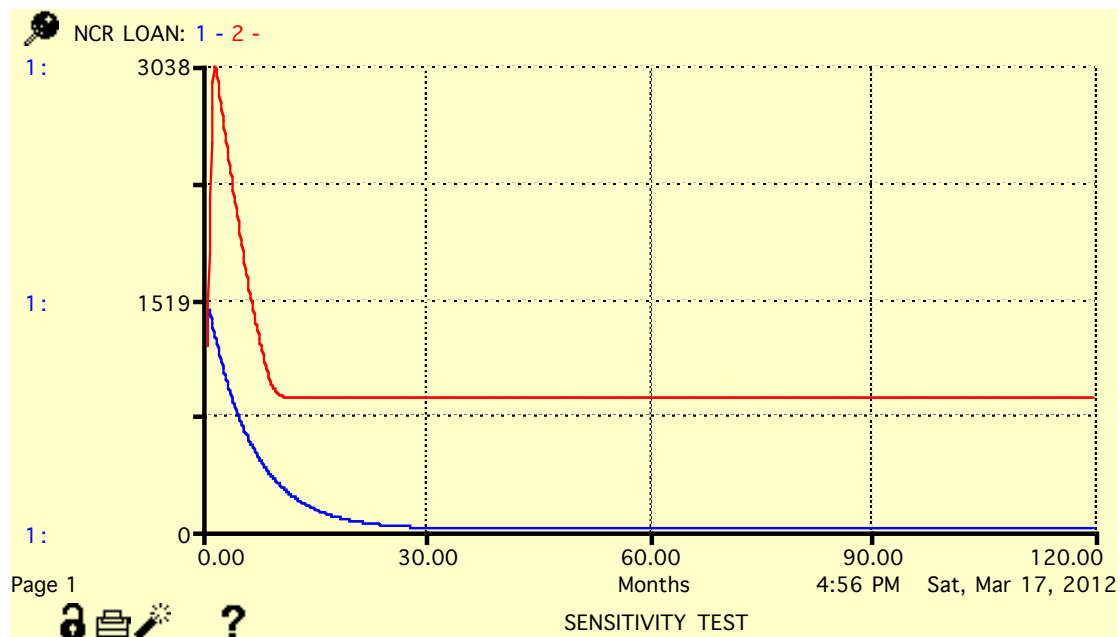

Figure 9. Impact of Loan Giving Time on Local Business Loan Usage.

SCENARIO AND POLICY ANALYSIS

Dynamic system modeling and simulation offers an opportunity to set up different policies, test them, and analyze model behaviors over a long period.

A strong claim about local currency systems is that they increase resilience of local economy against global economical crises. I test a scenario in which national chain closes its shop and national business supply reduces to zero. I observe how this crisis is absorbed by the local economy with bi-currency system.

Scenario: Closing Down National Chain

I test a scenario in which national chain closes its shop at 24th month and analyze how this crisis is absorbed by the local economy. As seen in Figure 10, when national chain closes, the amount of money runaway from local economy due to insufficient supply rises up, but in parallel local economy starts to flourish. Money exchange significantly increases, volume of circulating local money increases. As demand on locally produced goods and services increases, more money is invested in local capacity. A more detailed analysis of this scenario is possible and it provides valuable clues about which system elements are effective to recover from loss of this significant supply. Accordingly the community can design a policy.
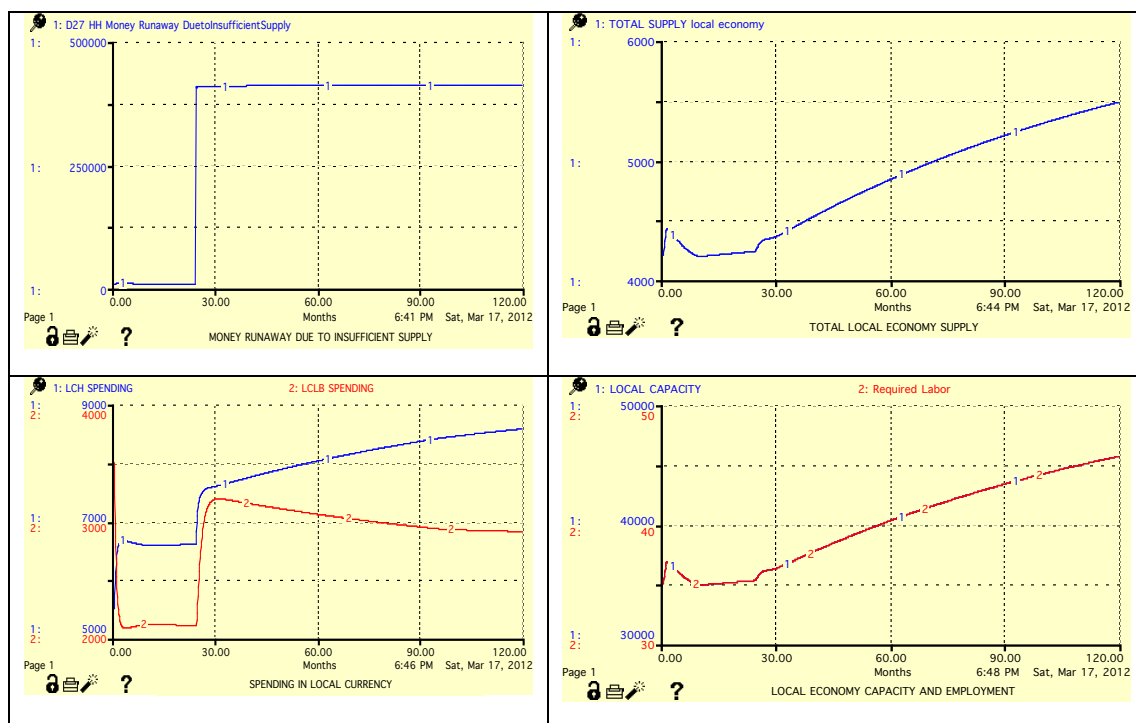

Figure 10. Stock Behaviors.

CONCLUSIONS

Introduction of local currency into local economy can be very beneficial for the local communities. First of all, it can serve to community's needs and communities can take more control of their financial and social wellbeing. In this study, dynamic

system model analysis showed that local currency could support the development of local capacity and provide employment. Besides, more household and local business income stays and circulates within the economy. Back-up money accumulating in National Currency Regulator can be given as an interest free loan to local businesses to expand their local capacity. Another important conclusion is that in case of major crises such as closing down a national chain, local currency sector acts as a reserve goods and services supply, as well as an employment provider and can help the local economy to recover to some extend. Although I suggest more detailed and elaborate testing, these observations support the researchers' claims that the introduction of local currency into a local economy increases the resilience of the local economy.

Until now, case studies and research were based on one or two year data. Results of this study indicate that even behavior of this simple model should be analyzed longer. Because research period could be significantly shorter than actual period required by the real system to reach to a steady state and hence results may not be valid. Sensitivity and policy analysis is done in a very small scale. Sensitivity analysis can be done by using other parameters. Also different policies can be designed and tested for better and deeper understanding of the system's dynamics.

My aim in this experimental and exploratory work is to introduce system dynamics approach as a collaborative learning and testing tool to communities that are planning to introduce local currency into their local economy. They can construct similar models based on their decision rules and system structure. By simulation and analysis, they can understand the dynamics, determine the weaknesses and strengths of their system and design effective policies to improve the bi-currency economy and the resilience of their local economy.

The further research would be to use this model as a preliminary model and conduct a group model-building project with a community that is intending to issue local currency.

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