Bachelor Informatica

UvA Universiteit van Amsterdam

The Giving Game

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Signed:

Abstract

This is the abstract.

Contents

CHAPTER 1

Introduction

Work in progress!
In today's world money is the primary medium of exchange and is used to define the value of most economic transaction. Besides this well-known economic system there is the economy of giving. The economy of giving is an economic system without money as the medium of exchange. This system does not use a currency to express the value of a transaction. Instead the value of a transaction is based on a social credit. Goods can be given away or exchanged for other goods. Giving away a good is not perceived as a direct loss. Instead it is expected that something will be given in return in the future. Every individual keeps track of their own social credit balance with every other person and bases their perception of the value of a transaction on this balance.

The giving game is a macroeconomic theory about this economic system of giving and giving in real life. In real life people often seem to prefer to give to friends and family rather than to strangers. Thus they value a transaction with them more than with others. Under certain conditions people will assign a preference to a person or persons to who they will give to. When the transactions only take place in a certain group a community effect emerges. The pruprose of this thesis is to research under what conditions a community effect will emerge using a giving game to simulate an economy of giving. This has led to the following research question:

Will the transactions eventually take place within a limited subgroup of the entire population?

If no community effect emerges the transactions can still fall into a repeating sequence of transactions. This has led to the second research question:

Will we see a repeating sequence of transactions or will the transaction sequence look random?

1.1 Related work

W.P. Weijland developed in his article 'Mathematical Foundation for the Economy of Giving' a mathematical model for economies which rely on a system of social credit. This model explains how the value of a transaction changes under certain conditions and defines the relation between two or more agents in an economic environment without a currency as means of exchange. The mathematics behind this will be explained in the next chapter.

A similar research is the article Money Network in Kiyotaki-Wright Model. In this article an environment with three agents and three goods is simulated. Each agent produces one good and consumes another good. The article explains the behaviour of the agents and how the goods are traded. This research differs from the giving game, because the agents can consume goods and only trade their good for other goods they can consume or use to trade for the good they need to consume.

Other research to the specific economy of giving is lacking. Other articles are more psychological oriented like the article A survey of trust and reputation systems for online sevice provision and Giving with IMpure Altruism: Applications to Charity and Ricardian Equivalence. The first article explains trust between people and the different type of trust. The second article explains that giving something for example to charity is not always completely alturistic. The 'warm glow' is explained which is what people get when they give.

1.2 Contribution

With money it is easy to determine the economic value of a transaction and makes it easy to find the optimum economic transactions in a certain trade environment. Calculating the optimum economic transactions in an environment of giving is lacking in todays world. Transactions without money as the medium of exchange happens more often than people think. Calculating the optimum economic transactions and simulating the behaviour of people can be extremely usefull in certain environments, for example with investing.

The goal of this thesis is to design and implement a simulator that can simulate a giving game of N agents and M goods. The simulation should be able to simulate multiple scenarios where the agents choose to who they give based on multiple parameters. The simulator can be used to analyse the behaviour of agents in different scenarios of giving.

In chapter 2 the giving game is explained in detail with all the possible parameters. Chapter 2 also explains the mathematics behind the giving game. Chapter 3 will describe the scenarios which will be used to simulate. Chapter 4 will explain the design of the simulator and chapter 5 shows the implementation. Chapter 6 describes the experiments and gives an overview of the results. Chapter 7 discusses these results and answers the research questions.

CHAPTER 2

Theoretical background

A giving game is a game to simulate giving in real life. A giving game can be very versatile and a lot of variants are possible to simulate different real life economic environments. In this section the basic rules of a giving game are explained and the giving game used for this thesis is explained. The following rules show the basics of a giving game:

- In an environment of N agents an agent is randomly chosen to start with a good.
- Once an agent has the good the agent is meant to give it to someone else.
- Each time an agent receives the good the agent receives a credit point.

The giving game above is a more game theory oriented giving game. For this thesis the giving game will be a more realistic representation of the real life economy of giving.

2.1 The rules of the game

For this thesis the environment consists of a fixed amount of agent and a fixed amount of goods. For every simulation the number of agents and number of goods can be changed, but during the simulation no agents or goods are added or removed. Every agents keeps track of their own account balance and transaction values in relation to every other agent. The agents dont know anything about each other, they operate completely independent.

There are two types of goods, sustainable and perishable goods. Sustainable goods are goods that will exist for eternity. Perishable goods are goods that perish after a certain amount of transactions. Every perishable good has a producer. The producer is also an agent in the environment so the producer also participates in transactions of other goods. The producer reproduces its perishable good after a certain amount of time the good has perished. The value of a good is valued differently by each agent, but this value does not change during the simulation. For the experiments in this thesis the agents are not able to hold on to a good for a certain amount of time. This is a variant which can be used in further research. Holding on to a good will be explained further in the last chapter. At the start of the giving game the goods can either be divided randomly over the agents or are divided by hand. The agents who start with the perishable goods are assigned to be the producers.

The transactions can be executed in two different ways. The transactions can be executed one by one which is a more game theory based approach. A more realistic approach is that the transactions are executed simultaneously, this way agents dont have to wait for each other before they can give away their good. Both types are used in the experiments.

The emergence of a community effect is determined by the amount of transactions each agent is part of. When more than one good is used in the environment there can emerge multiple communities. That is why every good is looked at independently. Every agent keeps track of their own transactions and how much they have traded each good. If for example two agent hold 100 percent of the transactions of good A and two other agents hold 100

The stabilization of the transactions in the environment can be determined by predicting future transactions. If multiple transactions in a row can be predicted or if a pattern is clearly visible than there can be concluded that the transactions have stabilized. The emergence of a community does not mean that the transactions are executed in a repeating sequence. Even in a community the transactions can be executed randomly.

2.2 Paramaters

The following parameters will be used in the environment of the giving game for the experiments.

N: The number of agents used in the simulation

M: The number of goods used in the simulation

Perish period: The perish period is the amount of transactions it takes before a good perishes. For sustainable goods the perish period is 0, because sustainable goods exist forever. For perishable goods the perish period is greater than 0. For example, when a good has a perish period of 3 then this good can be given away 3 times before it perishes. The perish period is a natural number greater than or equal to 0.

Production delay: The production delay is the time between the perish of a good and its reproduction. The time until the production is decreased by one after every iteration over all agents who are currently holding a good. The production delay is a natural number greater than or equal to 0.

Nominal value: The nominal value is an indication of how much a good is worth. The nominal value does not change during the giving game. Every agent perceives the nominal value of a good differently. Agent P could value good G more than agent Q for example. The nominal value is a natural number greater than or equal to 0.

Like factor: The like factor is a real number between -1 and 0 which defines how much agent P likes agent Q. The higer the number the more P likes Q the more likely it is that P will give to Q if the like factor is used in the selection rule. The like factor does not change during the giving game.

Selection rule: The selection rule is an algorithm that decides/calculates the next agent who should receive a good.

2.3 Yield curve

Every agent values the transaction of a certain good differently for each agent. This value of the transaction is called the yield. The yield is calculated using the account balance, the like factor and the nominal value of a good. The following function is used to calculate the yield:

$Y = a*x + b$
$-1 \leq a \leq 0$
$Y, b \geq 0$
Here is a the like factor, X is the account balance and b is the nominal value of a good. With this function we can create a yield curve as follows.
Image of yield curve here
Every agent keeps track of their account balance in relation with the other agents. This means that agent P can have a different balance with Q than with R. The balance is an indication of how much an agent has given and received. From the yield curve it is clear that when the account balance of P with Q gets higher the yield gets lower. This can be interpreted as the more P gives to Q the higher the balance of P with Q thus the more P is in the black with Q and the more Q is in the red with P. This means that Q is in debt with P. The balance after a transaction is calculated by adding the yield of that transaction to the current balance. When the yield gets

lower the balance increases less, so for the next transaction the yield will also decrease less. The yield will never reach zero.

The yield will be important to determine who will receive a good next. If P would for example want to maximize its profit P would only want to give away a good to someone with who P has a high yield. Agents who are in debt with P and are not likely to pay of this debt would be worthless to P in this case. It would be a bad investment if P would give to these agents.

The yield curve can either be used to predict the course of the transactions or to see an equilibrium arise. When an equilibrium arises the yield of a good between two agents switches between two values. Both agents perceive the transactions with each other as the most valuable and will keep giving to each other. These agents have established a community with each other and this community will hold as long as the current condition do not change.

Image of yield curve with equilibrium here

CHAPTER 3

Selection rules

For every transaction the selection rule decides which agent will receive a good. This decision is based on different parameters of the giving game. These selection rules simulate multiple real world scenarios for example: choosing the agent based on maximizing the profit (goodwill rule).

3.1 Random rule

The random rule is the most basic rule for the giving game. The agent who should receive the good during the transaction is chosen randomly. The random rule simulates an environment where the agents do not care about the value of the goods and do not care about who will receive the goods. The *like factor* is therefore 0 for every agent pair. This leads to the following yield curve.
Yield curve of $\mathbf{y = a * x + b}$ where $\mathbf{a = 0}$ and $\mathbf{b > 0}$
This rule is mostly used to see if the giving game enviroment behaves as it should.

3.1.1 Hypothesis

It is expected that there will be no community effect and that there will not be any visible stabilisation of the transactions even though a machine is pseudorandom. The transactions will eventually be more or less equally distributed over all the agents. It will be just like throwing a dice, the next transactions will not be predictable.

3.2 Balance rule

A more advanced selection rule is the balance rule. The agent who should receive the good during the transaction is chosen based on the balance between the giving agent P and the receiving agent Q. Agent P chooses agent Q if P has the highest balance with Q. If P has the same highest balance with multiple agents then the receiving agent is chosen randomly between these agents. The balance rule simulates an environment where each agent only gives to the agent from who they have received the most. Agent P tries to maximize the number of goods he receives. The balance in this case can be calculated as follows:

Balance of P with Q = Number of goods received from Q Number of goods given to Q
The following rule applies:
Balance of P with Q = - (balance of Q with P)
This calculations of the balance is different from the calculation of the balance for the yield curve.

3.2.1 Hypothesis

The expectations are that a community effect will arise with a subgroup consisting of a few agents. The size of this subgroup is based on the type of goods and the amount of goods. All sustainable goods will eventually be traded only between two agents, because these two agents have the highest balance with each other. Every perishable good has a producer, these producers will also be part of a subgroup. If these producers only give each other their goods then the subgroup size will be as large as the amount of producers. If the producers each give to another agent then multiple subgroups will arise with a size of two. It is expected that the maximum size of a subgroup will be the number of producers plus one non-producer who trades with the producers. It will be interesting to see how these subgroups will behave, if they will merge together or operate individually.

3.3 Goodwill rule

The goodwill rule is a more realistic rule. The agent is chosen based on the value of the transaction (the yield) between P and Q perceived by P. Only the agent where the yield is the highest is chosen as the receiving agent. If multiple agent pairs have the same yield the receiving agent is chosen randomly between these agents. Every time P gives good G to Q the value of the transaction of good G (the yield) decreases. As long as Q does not give good G to P, P loses interest in giving good G to Q. Eventually P will stop giving to Q, because P does not expect that Q will ever pay of his debt. The like factor as explained earlier defines how many transactions P can tolerate without getting anything in return from Q. For the goodwill rule the like factor can be set by the user or can be created randomly. The goodwill rule simulates an environment where every agent tries to maximize its profit. Agents who are in debt will less likely receive a good, they are not worth investing in. This leads to yield curves that look like this:
2 Yield curves of y = a * x + b where a $\leq$ 0 and b $>$ 0, one yield curve is mirrored in the y-axis
The steeper the slope for YP the less tolerant P is. In this case the balance is calculated as explained before.

3.3.1 Hypothesis

The expectations are that a community effect will arise. The size of the subgroup will depend on the like factors. The higher the like factor of an agent pair the more likely it is that this pair will join the subgroup. For example if every agent pair has a like factor of 0 then the yield value for every agent pair does not change and is the same for everyone so the receiving agents are chosen randomly. This would lead to a subgroup with a size equal to the number of agents, the same situation as the random rule. If every agent pair has a like factor of -1 then the yield for every agent pair will decrease rapidly. A subgroup with a size of two will most likely arise, because the yield between these two agents will shift between the same values after each transaction. An equilibrium will arise within the yield curve as pictured below.
2 Yield curves of y = a * x + b where a $\leq$ 0 and b $>$ 0, one yield curve is mirrored in the y-axis. two dots are shown where the equilibrium is positioned

CHAPTER 4

Design

Work in progres!

4.1 The simulation model

The simulator had to be able to execute multiple tasks. The simulator must be able to accept user input to simulate multiple scenarios. The simulator should provide a visualization module to visualize the data and to also visualize the course of the transactions. The following shows the simulation proces:

In the following sections the design choices are explained to achieve the ...

4.1.1 Input

The user is able to input the following parameters:

N:

M:

Perish period:

Production delay:

Selection rule:

Nominal value: The user is able to choose if every agent perceives the value of a good differently or not. If the user wants to have a different value of the good for every agent the user can add a xslx file with the nominal values as follows:

Like factor: The user is able to choose between setting like factors by hand or to randomly create the like factors. If the user wants to add predefined likefactors the user can add a xslx file with the like factors as follows:

Balance: The use is able to set the balance at the start of the simulation at 0 or to add different balances for every agent.

During the simulation the user should be able to adjust the following variables:

Subgroup size:

Reset community percentage:

4.1.2 Output

The output data is visualized so that the user is able to analyse and get results without doing any calculations. The simulator is able to do most of the work.

The simulator is able to give the following output:

- Show the amount of goods given and received for each agent in a bar plot.
- Show the yield curve between every agent pair.
- Show the amount of transactions
- Show the visualization of the course of the transactions with a color indication for any emerging subgroups.
- Show percentages of how many times a certain good has been traded by an agent.
- Show every transaction, producting and delay in production.
- Show the community percentage (How many transactions take place in a subgroup with the current set size.)

All the data can be saved and used in the future for another simulation.

4.2 GUI

For the explanation of the use of the interface the use should consult the user manual.

CHAPTER 5

Implementation

5.1 Back-end

Python

5.2 Front-end

The front end provides the interface between the user and the back end. With this interface the user is able to put data into the simulation to simulate different scenarios. The interface is able to visualize the responses of the back end to analyse the resulting data during the simulation.

CHAPTER 6

Experiments

For now every results is from simulation type: one by one. Also these results assume that at the start of the simulation no agent start with more than 1 good.

6.1 Random rule

6.1.1 Results

RR_N1

No community effect arose and the transaction also did not stabilize. The transactions are still completly random. After 100000 transactions the distribution of the transactions was between 0.9 and 1.1 percent for each agent. More transactions will lead to more equally distributed transactions.

RR_N2

The producer participated in 50 percent of the transactions, because after each time the producer give away its product it perishes. The other agents only received the good during this scenario. The producer kept choosing the receiving agents at random. The other 50 percent of the transactions (the receiving part) is distributed oer the other 99 agents. Each agent participated in approximately 0.5 percent of the transactions. No community effect arose and the transacitons did not stabilize.

RR_3S

The results are similar to the results from RR_N1. No community arose, neither did the transactions stabilize. All the transactions of each good were distributed over all agents. Each agent participated between 0.3 and 0.35 percent of the transaction of each good.

RR_3P

The results are similar to the results from RR_N2. No community arose, neither did the transactions stabilize. Good_1 is the good with the lowest perish period and the lowest production time. This good was therefore participated the producer of this good in approximately 16.7-16.8 percent of the transactions of this good. The producer of Good_2 particiated in approximately 8.4 percent of the transactions of Good_2, which is half of 16.8 percent. This makes sense, because the perish period and production delay of Good_2 is twice the amount of the perish period and production delay of Good_1. The producer of Good_3 particiated in approximately 5.7 percent of the transactions of Good_3, which is almost a third of 16.8 percent. This makes sense, because the perish period and production delay of Good_3 is three times the amount of the perish period and production delay of Good_1. These numbers are the results after 20000 transactions.

6.2 Balance rule

6.2.1 Results

BR_N1

Every time an agent receives the good the receiving agent gives the good back to the giving agent during the next transaction. The moment P gives Q the good Q has the highest balance with P, because Q has received more from P then Q has given to P. This means that Q will give the good to P during the next transaction and all agents have now the same balance with P again. Now P has to choose randomly who should receive the good next. No community arises, but the simulation is partially stabilized. **percentages**

BR_N2

The results of this scenario are similar to the results of RR_N2. The producer participated in 50 percent of the transactions, because after each time the producer give away its product it perishes. Each other agent participated in approximately 0.5 percent of the transactions. The moment the producer gives the good to let's say agent Q the balance of the producer with Q is now lower then the balance of the producer with all other agents. This means that the next transaction the producer will not give to Q but has to choose randomly between all the other 98 agents, because the balance of the producer with the other agents is equal to each other. The same happens after the next transactions, now the producer has to choose randomly between 97 agents. This goes on untill 1 agent is left to choose from, at this point the choice is not random anymore, because only 1 agent is left. After this agent has received a good from the producer everyone is equal again and the whole process starts from the beginning. This leads to the conclusion that after every 98 transactions the next transaction can be predicted. No community effect arisis, but the transactions are partially stabilized.

BR_3S

The results are quite remarkable. As expected after seeing the results from BR_N1 the goods are returned to the giving agent after each transaction, but the only difference is is that the agents who start with the goods at the start of the simulation give in proportion more to each other than to the other agents. **WHY?**

6.3 Goodwill rule

6.3.1 results

GR_N1

Immidiatly at the start of the simulation a community effect arises with a subgroup of size two. The moment agent P gives to agent Q, Q is in debt with P. This means that Q values the next transaction more with P. So Q will give to P during the next transaction. Now P values the transaction with Q more then with any other agent, so P gives back to Q. This goes on in eternity where eventully the yield of the transaction for P with Q an Q with P will switch between the same values. The following yield curve shows what happens.

GR_N2

The results are equal to the results from BR_N2. The value of the transactions will approach zero, but it will never reach zero, because of the way the yield is calculated. No community effect arisis, but the transactions are partially stabilized.

CHAPTER 7

Conclusions and Discussions

CHAPTER 8

Further research

A possible variant on the giving game used in this thesis is that agents are able to hold on to a good. This is leads to a similar simulation as used in the article 'Money Network in Kiyotaki-Wright Model'. Holding on to a good is a more realistic approach, but comes with a few extra parameters. Realistically holding on to a good means that the good needs to be stored somewhere. In the real world this would mean that storage costs have to be paid and certain goods (perishable goods) would not be able to be stored forever. The time an agent holds on to a good is also a parameter that can influence the choice for the transaction.

CHAPTER 9

Appendix A

9.1 Simulator manual

9.2 Code Documentation