Breaking the vicious cycle of poverty

Micro-lending

Abstract: Micro-lending has been introduced as an effective antipoverty tool in recent decades. However not all of micro-lending institutes are successful both in accomplishing their mission and in loan recovery. According to World Bank's focus note (2006), less than a quarter of its projects that funded micro-lending were judged successful. This paper describes a specific type of micro-lending (Grameen way of micro-lending invented by Mohammad Yunus, Nobel Peace Prize winner 2006). Then it summarizes the differences of conventional bank and Grameen Bank. Also this paper illustrates the important loops that make the Grameen successful both in the loan recovery and in accomplishing its mission. The final contribution of this paper is to develop a system dynamics model to test some Grameen policies that researchers believe are the key elements of Grameen's success. I find support for the fact that small loan size which is designed to match the client's knowledge maximizes Grameen's capital. Also the model finds that investing some portion of Grameen's capital, giving loan to groups of people and choosing appropriate interest rate are crucial for Grameen Bank.

"Money, says the proverb, makes money. When you have got a little, it is often easy to get more. The great difficulty is to get that little."

Adam Smith

I. Introduction

Of the world's 6.6 billion people, 2.5 billion live on less than 2 dollars a day and 1 billion live on less than 1 dollar a day (World Bank, September 2007). The importance of fighting poverty can be understood from the fact that the global poverty crisis feed other crises like terrorism, environmental destruction and many societal problems. One of the antipoverty tools that have been invented in recent decades is micro-lending. Micro-lending refers to small loans made to low-income individuals to start up very small businesses or sustain self-employment.

Different types of micro-lending institutes are accomplishing their mission around the globe. The Grameen Bank, established in 1976 in Bangladesh by Mohammad Yunus (Nobel Peace Prize winner 2006), is the first and the most famous micro-lending institutes that is growing rapidly. The last 30 years its clients have increased rapidly, from 10 people to 6.9 million. Grameen Bank requires its borrowers to form a group of five and then gives small loans, $100 on average, to each borrower (Yunus, 1999). Borrowers should pay back the loan plus interest which is 20% on a declining basis during one year. Grameen Bank is very successful not only in accomplishing its mission but also in achieving self sufficiency. Interestingly, 98% of the Grameen's loans are repaid (grameen website,2008), a recovery rate higher than that of any other bank in Bangladesh- and significantly higher than that of most consumer- loan portfolios in the United States (Wendt and Eichfeld, 2006).

In India, SHGs (Self-Help Groups) are predominant. SHGs involve larger groups of about 15-20 women who hold a joint bank account and save and make loans among themselves. In Haiti, Fonkoze, founded in 1994, is delivering micro-lending and related educational services to the most economically disadvantaged of Haiti—mostly women. They include education programs in their services which consist of four modules: two on reading and writing, one on business skills, and one on sexual and reproductive health issues.

Fast growth of micro-lending raised many question about its effectiveness as well as reasons of its achievements. Based on household survey data collected in 1991-92 and1998-99 in Bangladesh, Khandker (2005) found that participants' moderate poverty and extreme poverty dropped 8.5% and 18.2% respectively over the period of seven years. Also he showed that micro-lending programs in Bangladesh not only affected the welfare of micro-lending institutes' clients and non-clients but also the aggregate welfare at the village level. Pitt and et al. (2003) found that a 10 percent increase in credit provided to females increases the arm circumference of their daughters by 6.3 percent, twice the increase that would be expected from a similar increase in credit provided to men. Also they showed that giving loans to females has positive and statistically significant effects on the height of both boys and girls. They found no significant effects from male borrowing. Barnes (2001) examined the impact of continuing clients versus new clients, as well as clients who dropped out of the program and a comparison group of non-participants. She found that clients that continue the program benefit the most. EDA Rural Systems (2004) examined the impact of the lending model. It compared two micro-

lending models: “Grameen” and “SHGs”. Although both models are successful, the Grameen model appeared to be more effective at reducing poverty.

Although Grameen and other successful micro-lending institutions are lending to poor borrowers who do not have any collateral, they are achieving robust repayment rates and financial sustainability. What is the reason of their great achievement? Stiglitz (1990) showed that group lending can partially or completely overcome the informational and enforcement limitations that make uncollateralized lending difficult. Morduch (1997) showed that charging a relative high interest rate that cover the cost of the program is a key element of micro-lending success. Jain and Moor (2003), first, presented the widely believed reasons of Grameen successes: Social collateral, borrower participation and absence of subsidy which are either misleading or wrong in their view. Then they illustrated the five elements that they believe are keys: 1-providing a narrow and standardized range of services which reduces the operating cost, 2- matching the income of borrowers and loan size, 3- attractiveness of loan, while it is not cheap, to poor relative to the available alternatives, 4- creating a social and institutional environment that places strong social and moral pressures on borrowers to follow program norms, above all to repay loans on schedule and 5- evolving systems of personnel management and motivation that evoke good work and performance from field staff operating in difficult environments.

In this paper, first, the differences of conventional banks and Grameen Bank are illustrated. Grameen is chosen because it is the most dominant micro-lending model in the world and because many researchers found it successful both in accomplishing its mission and loan recovery. However, despite of lots of marvelous story about micro-

lending success in fighting poverty in the world, not all micro-lending projects were successful. According to World Bank's focus note (2006), less than a quarter of its projects that funded micro-lending were judged successful. Projects were graded on the extent to which they resulted, or appeared likely to result, in sustainable levels of loan repayment and cost recovery. This paper tries to find the important loops that make the Grameen successful both in loan recovery and in accomplishing its mission. The final contribution of this paper is to develop a system dynamics model to test some elements of Grameen-way of micro-lending that researchers believe are the key elements of Grameen's success and shed some lights on the policies that the Grameen-style of micro-lending implements.

II. Problem Definition

a. Grameen case:

Grameen was stablished in 1976 in Bangladesh to help poor families to overcome poverty. It gives small loans without asking borrowers either to provide collateral or engage in paperwork. Grameen requires them to have a group of five and then gives them small loans (around $100/person). All loans are to be repaid on a regular schedule, usually weekly. The process of giving loans is shown in figure 1. First two of the group members receive the loans. After 8 weeks, if they repay their loans regularly the next two can receive the loan. At the end, the last person which is generally the head of the group will receive the loan (Yunus, 1999).

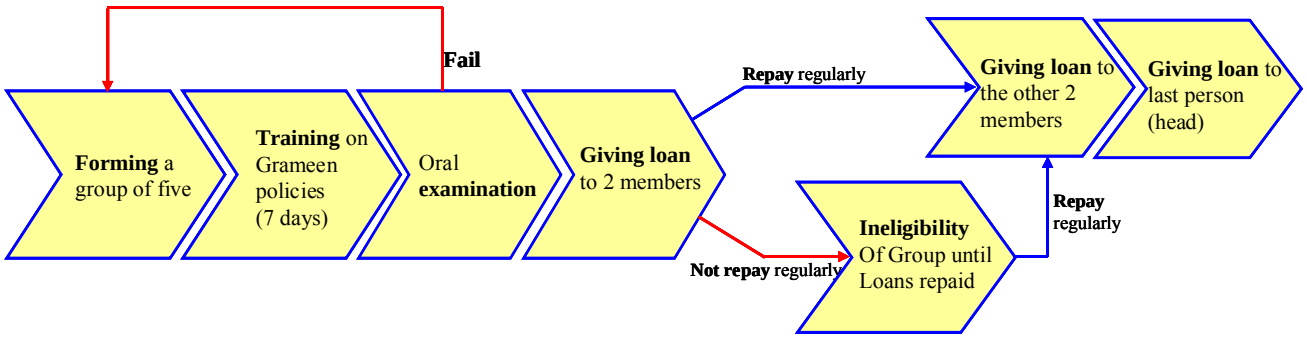

Figure 1: Process of giving loan

The effects of group lending which makes borrowers jointly liable are:

- Reducing the cost of micro-lending institutes and increasing the repayment rate, because each group member has incentive in screening and monitoring the other members and to enforce repayment, since if one of the group member does not repay its loan, it will be costly for her/him and she/he also may loose access to a loan in the future (Hermes and etal, 2005). Joint liability introduces another kind of collateral which is referred to social collateral in the related literature.
- Creating social capital in the groups which increases cooperation and as a result enhances loan repayment.

b. Data

Figure 2 shows the "Loan and Advances" and "Investment" of Grameen Bank from 1983 to 2005 (Grameen website, 2008). As we can see in the diagrams, Gameen Bank is growing exponentially from 1983 to 1995. This growth stopped and even declined between 1995 and 2003. One possible reason is that Grameen decided not to receive any more donor funds after 1995. So they are completely self sufficient after 1995. As figure 2 shows, the growth continues after 2003.

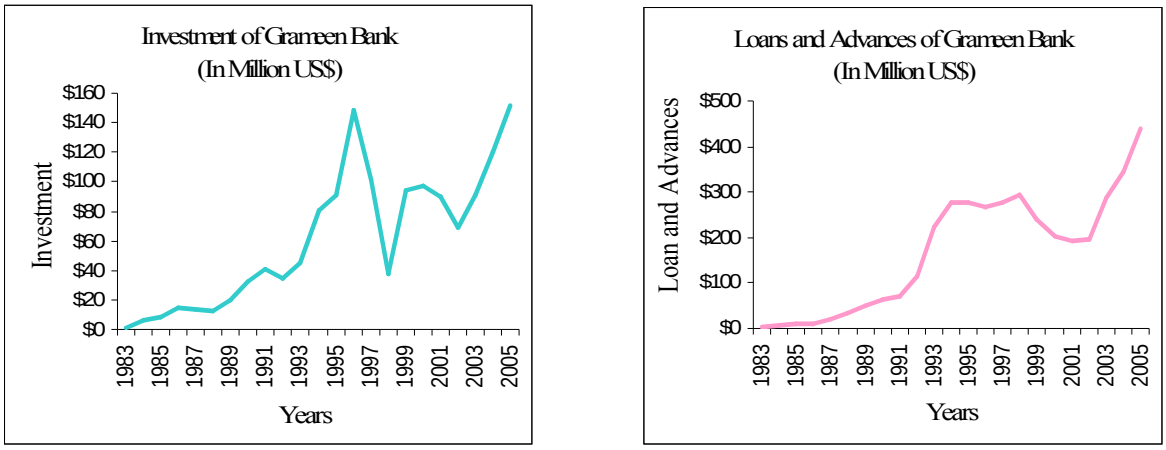

Figure 2: Investment of Grameen and the Loan and advances of Grameen Bank (Grameen website, 2008)

Figure 3 shows the percentage of the Grameen clients who are above the poverty line. They were Grameen clients at least for 5 years. As we can see this percentage has been increased from 15% in 1997 to 55% in 2004.

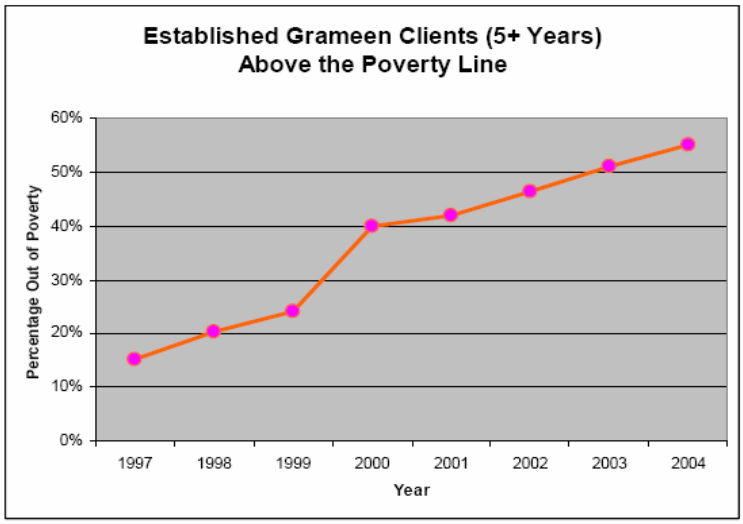

Figure 3: Percentage of Grameen clients (5+ years) out of poverty

Why is the Grameen Bank so successful both in accomplishing its mission and in having a high loan recovery rate of 98%? Ordinary banks do not give loans to poor people because they do not have collateral or any credit and may be because bankers believe that poor have higher risk of not repaying or maybe conventional banks can not

afford the cost of providing services to the poor. What loops does Grameen activate to have such a high recovery rate?

c. Differences of Grameen Bank and conventional banks

As it was mentioned, Grameen Bank requires clients to have a group. If an individual is unable or unwilling to repay her loan, her group may become ineligible for larger loans in subsequent years until the repayment problem is brought under control. This creates a powerful incentive for borrowers to help each other solve problems and −even more important− to prevent problems (Yunus, 1999). Also group lending helps to build social capital. Dowla (2006) showed how the Grameen Bank created social capital by forming horizontal and vertical networks, establishing new norms and fostering a new level of social trust to solve the collective action problems of poor people's access to capital. The creation of such social capital increases the tendency to do things with each other and for each other and also helps to improve the ability to overcome problems in their businesses. For example, if a client falls ill, her group helps with her business until she is well. If a client gets discouraged, the support group pulls her through.

Other features of the Grameen-way of micro-lending also helped to increase the repayment rate. For instance the size of the loan is small because poor borrowers do not have the necessary knowledge of handling large amounts of money; so Grameen designs the loan in such way that poor people can handle and repay it. Also Grameen offers business advice and gives loan for education which increases the aggregate knowledge of clients. By giving housing loans, it helps borrowers to improve their standard of living. Todd (1996) showed the effect of improving standard of living on success of business.

She found that among the long-term clients who are no longer poor, only 18% have been hit with a serious illness, compared to 50% among those who are still in the poverty group.

As I mentioned before, joint liability introduces another kind of collateral which is known as social collateral. Besley and Coat (1995) found that the group lending may allow a micro-lending institute to harness 'social collateral'. Under an individual lending, when a borrower defaults, her fear is the penalties which the bank can impose but under group lending she may also incur the wrath of other group members. They showed that if the group formed from a high degree of social connectedness, then social collateral can increase the repayment rate.

Another difference between conventional bank and Grameen is that most of Grameen clients are female. In the first years after the establishment of Grameen bank, it was found that women are more likely to reinvest their earnings in the business and in their family and as a result improve the standard of living of their family. Pitt and et al. (2003) found that a 10 percent increase in credit provided to females increases the arm circumference of their daughters by 6.3 percent, twice the increase that would be expected from a similar increase in credit provided to men. Also they showed that giving loans to females has positive and statistically significant effects on the height of both boys and girls.

The final difference between conventional bank and Grameen is that conventional banks provide different type of services to their clients but Grameen bank offers focused (i.e. narrow and standardized) range of services (Jain and Moor, 2003). This feature reduces the cost of Grameen.

The differences of Grameen Bank and ordinary banks are summarized in table 1:

Ordinary Bank	Grameen Bank	Possible Consequences of Grameen Style
Individual Lending	Group Lending	• Members' cooperation to avoid become ineligible for next loan • Building social capital •Reducing cost of monitoring
(generally) Loan size is large	Loan size is small	• Small loan does not need high level of investment knowledge • Small loan has lower risk of repaying • Small loan can cover more people
	Offering business advice, giving low interest loan for education and housing	• Increase knowledge of clients • Increase standard of living (health, nutrition,..) of clients
Monthly Payment	Weekly Payment	• Small delays make repaying easier
Requiring Collateral	Building Social Collateral	• high repayment
	Require having a group saving account	• Using in hard time • Using for additional income
Clients are from both gender	Clients are generally female (97%)	• Spending her income in the family thus increasing the standard of living of her family
providing different type of services	providing narrow and standardized range of service	• Providing narrow and standardized services reduces the costs

Table 1: Differences of conventional bank and the Grameen bank

III. Structure

1. Sector diagrams

As it is shown in figure 4, the model has 5 sectors, which are: capital, standard of living, group lending, knowledge and client investment. The capital sector affects clients' investment, knowledge, and standard of living by giving income, education and housing loans respectively, and these sectors affect capital by influencing the repayment. Client investment and standard of living affect each other. Successful investments increase the standard of living of Grameen's clients, on average, and improving the standard of living

enhances the probability of successful investments. The group lending sectors affects investment sector through cooperation in the group and by creating social capital.

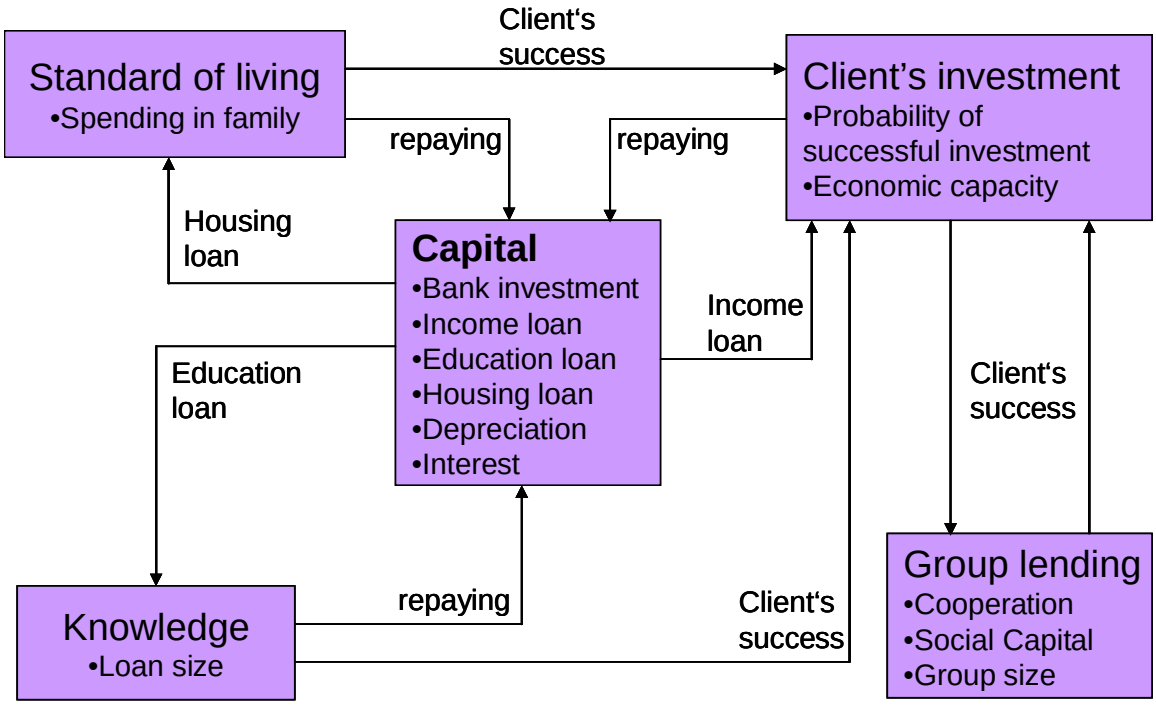

Figure 4: Sector diagram

1.1. Capital sector

As it is shown in figure 5, the capital of Grameen as a stock has three flows which are investment income, net profit and general cost. The income of Grameen Bank, like conventional banks is from interest on loans and from investment. Grameen Bank offers three types of loan which are: income loans, education loans and housing loans. By having more capital, it can lend more money and make more profit (positive loops: income loan, education loan and housing loans). The other income of Grameen is investing some portion of its capital (positive investing loop). A_1 to A_4 determine the proportion of capital allocated for income, housing, education loans and investment.

Not all of clients repay their loans thus some portion of capital will be depreciated (negative depreciation loop). I assume that only income loans can be depreciated because Grameen allocates most of its capital to income loans. Grameen bank incurs costs for providing services to the poor people (negative cost curve). For finding these costs the number of clients are calculated and multiplied by general cost per clients.

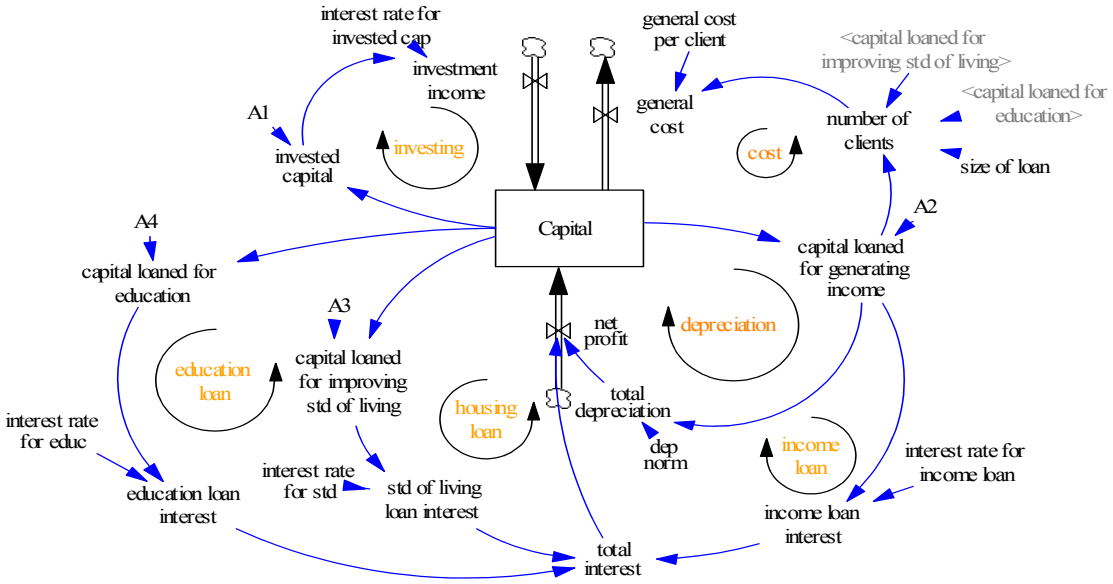

Figure 5: Capital sector

1.2. Group lending sector

As mentioned before, group lending increases the probability of successful investment through cooperation and enforcement in the group and by building social capital (see figure 6). When a member of a group has difficulty in repaying her loan, other members perceive the threat (because their group may become ineligible for the other loans in coming years) and help her to fix the problem or enforce her to repay the loan. The social capital in figure 6 is the average social capital each group has.

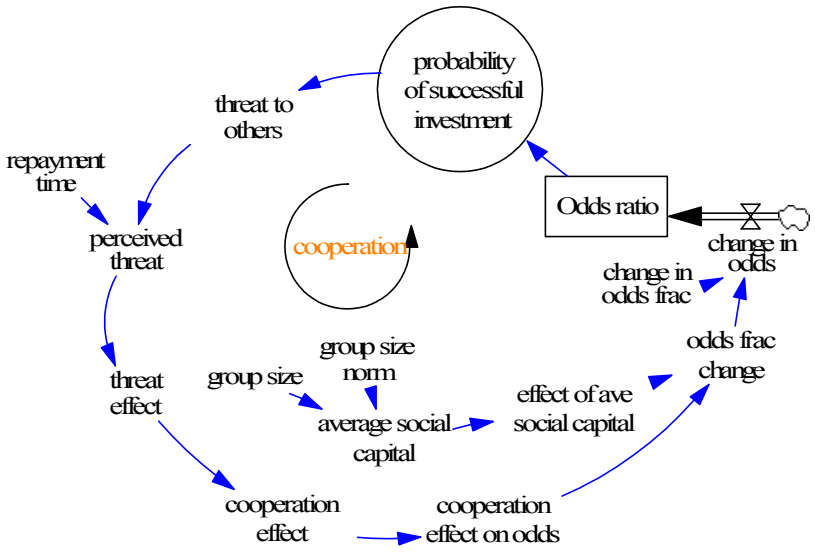

Figure 6: Cooperation in the group

1.3. Standard of living sector

The vast majority of the loans (97%) go to women because studies have shown that women are more likely to reinvest their earnings in the business and in their family. Pitt and et al. (2003) found substantial impact on children's health (as measured by height and arm circumference) from women's borrowing. Khandker (2005) showed that each additional 100 taka of credit to women increased total annual household expenditures by more than 20 taka. He did not find any returns to male borrowing. In fact micro-lending activates two powerful forces: a mother's love of her children and human ingenuity (Grameen website, 2005). The effect of female borrowing is shown in figure 7 (see Gender effect loop).

By spending earning in the family, women improve the standard of living of their families and as a result, the probability of successful investment will increase which increases the spending in the family (positive loop: Gender effect). The effect of the improving the standard of living on the success of business was shown by Todd (1996).

She found that among the long-term clients who are no longer poor, only 18% been hit with a serious illness, compared to 50% among who are still in the poverty group.

From 1984, Grameen Bank introduced housing loan (Grameen website, 2008). Borrowers can improve their standard of living by taking this loan (see standard of living loop in figure 7).

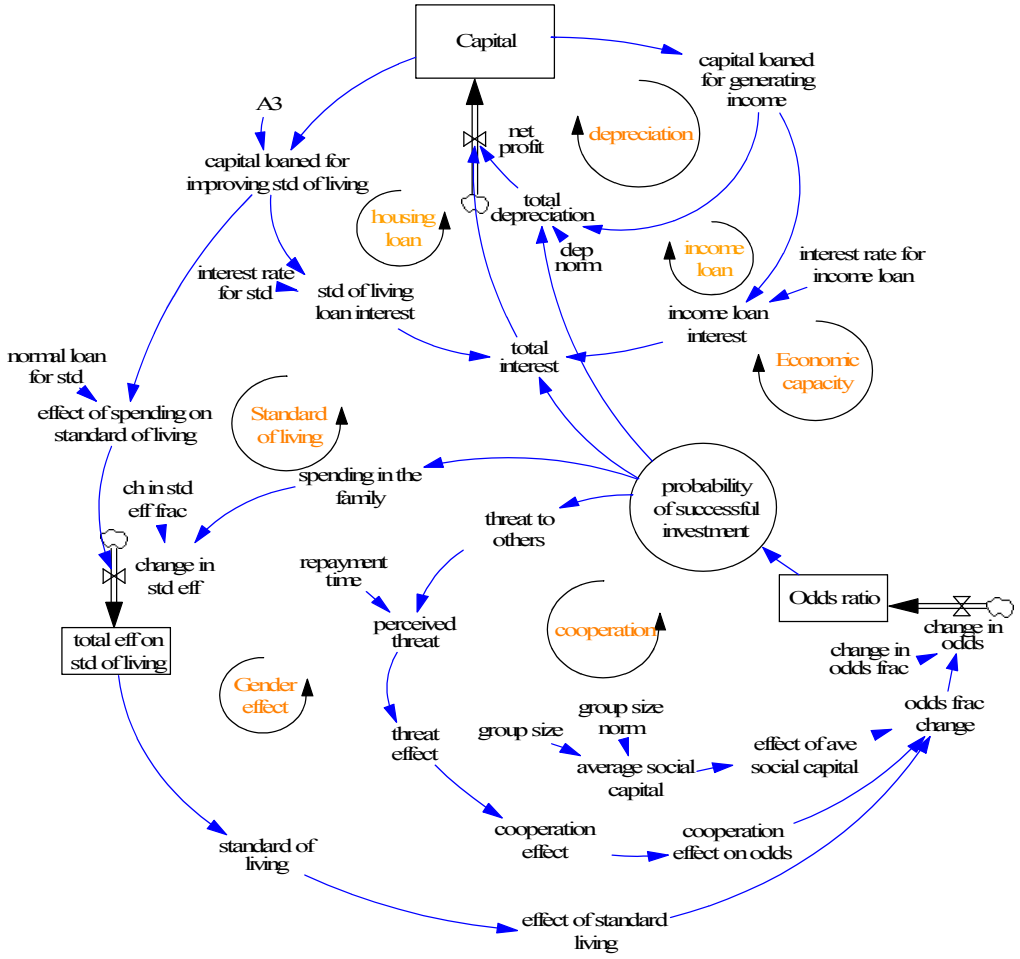

Figure 7: Standard of living's effect

1.4. Education sector

As it was mentioned in table 1, small loans do not need high levels of knowledge; so poor people who are usually not educated can handle them. In the model, the knowledge

of a client is compared to needed knowledge for the loan and the difference between them determines the probability of successful investment (see figure 8). By giving education loan the average knowledge of clients will be enhanced and as a result the probability of successful investment will increase (see figure 8, Knowledge effect loop).

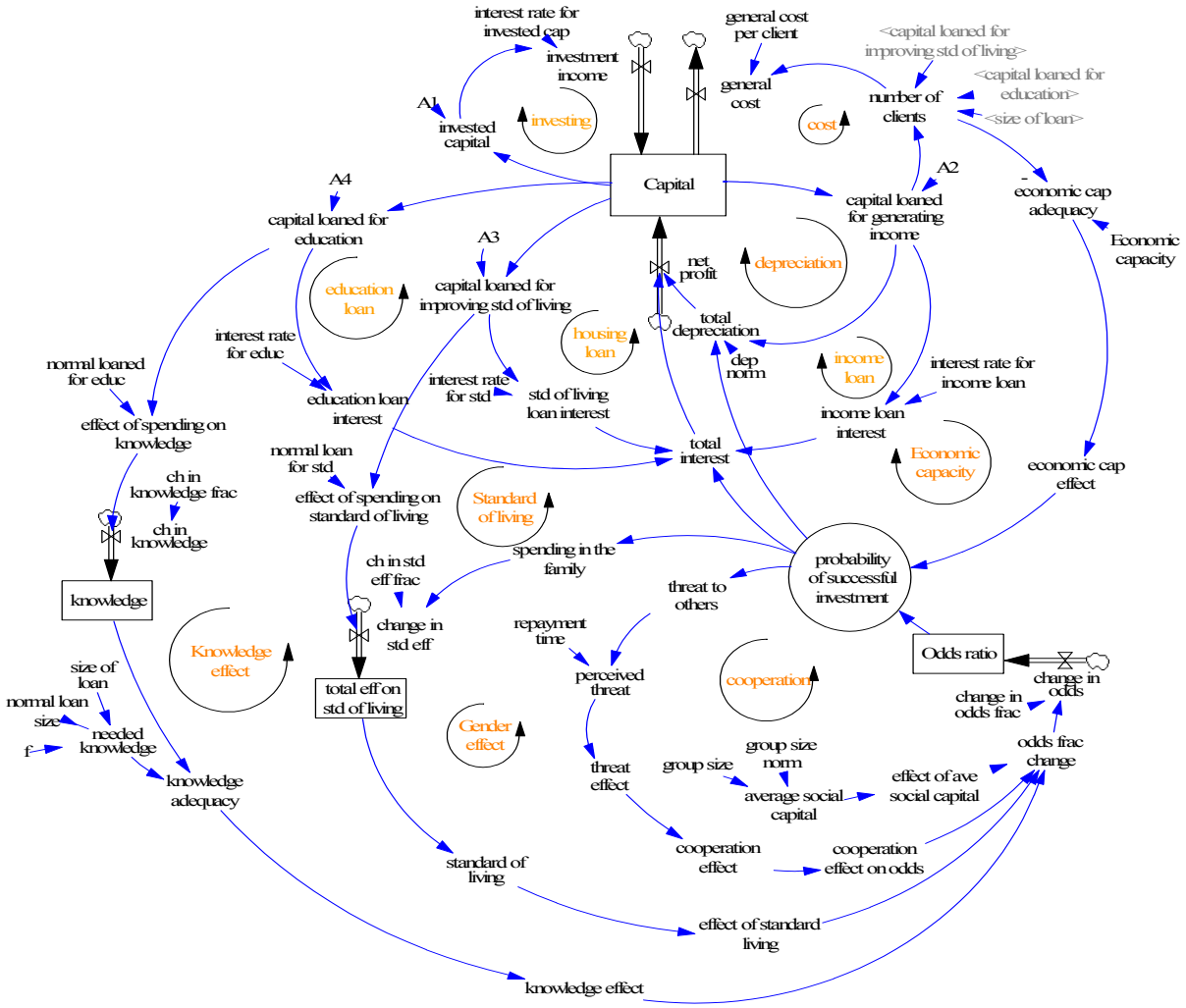

Figure 8: Knowledge effect and economic capacity

1.4. Clients' investment sector

Micro-lending provides the poor with the credit facility to start a small business. But every region has limited capacity for employment. This effect has been shown by

balancing loop, economic capacity (see figure 8). The unit of economic capacity is person and it is the maximum number of people who can have business in a region. In this model, the number of clients is compared with the economic capacity and the differences between them determine the probability of successful investment. I assumed that economic capacity is fixed. If we extent the time horizon, it can be considered as an endogenous variable in the model.

IV. Model Behavior

1. Base run

As it is shown in the figure 9, the capital of Grameen in the model is increasing exponentially like the real Grameen's capital. So the model can reproduce the behavior, but the model can not predict the amount of capital very well because it does not consider any donations before 1995 and any financing activities, other than giving loans to the poor. It does consider the investing activities of Grameen.

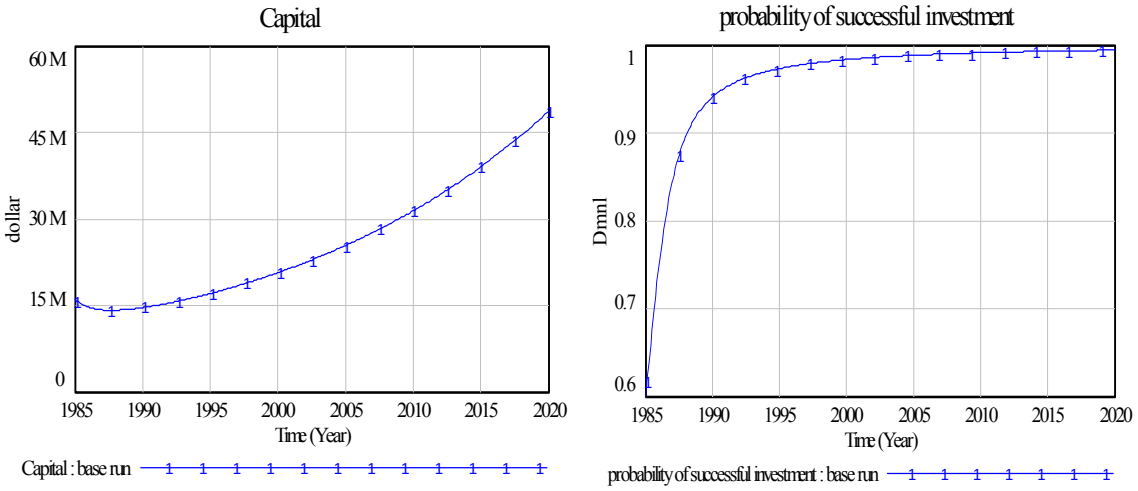

Figure 9: Grameen's capital, Probability of successful

We expect this behavior because Grameen activates many positive loops like investing loop, loan loops, gender effect loop, standard of living and knowledge loop. The negative loops are cost, depreciation and economic capacity. The real world behavior shows that the numbers of businesses have not reached the capacity limit or maybe micro-lending institutes enhanced the capacity. As it was mentioned, the capacity for self-employment is considered exogenous in this model but it is possible that Grameen Bank is increasing the capacity. Economic capacity for employment should be considered as endogenous variable if the time horizon is extended.

2. Test for validation

2.1. Setting Economic capacity to zero

For validating the model, the economic capacity is set to zero. The results of zero economic capacity are shown in figure 10. This extreme condition test shows that if economic capacity for employment is zero, the probability of successful investment becomes zero and the capital will depreciate which makes sense.

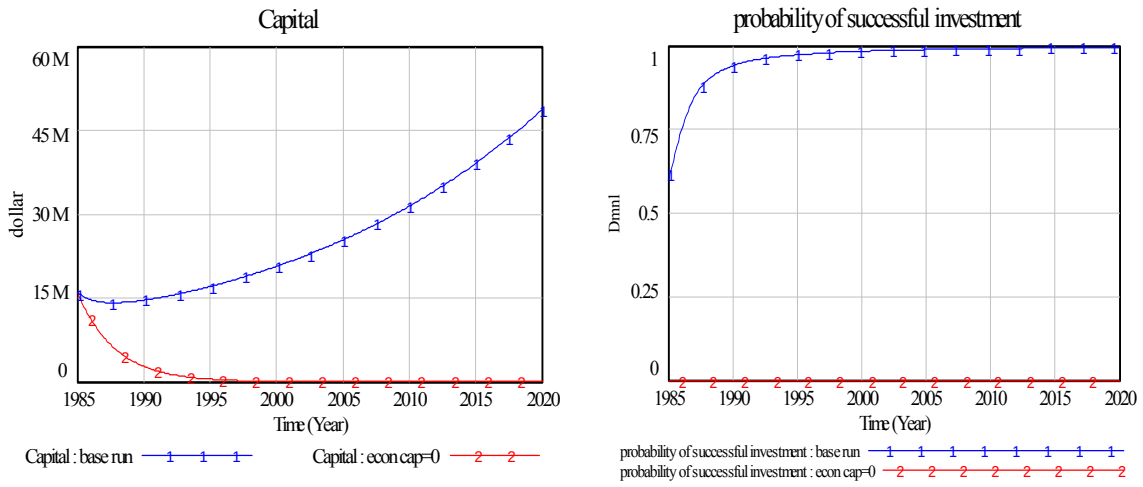

Figure 10: The effects of setting economic capacity to zero on the Grameen's capital and probability of successful investment

2.2. Interest rate on income loan = 100%

Increasing the interest rate from 20% to 100% is another possible validation test. As it is shown in figure 11, if the interest rate is increased from 20% to 100%, the capital will increase but then saturates because of economic capacity limitation. It increases because the boundary of the model does not include the money lenders who charge the poor an interest rate of 50% and the poor will switch to them if Grameen charges them to 100%. This model assumes that micro-lending institutes have unlimited demand because the World Bank's Consultative Group to Assist the Poorest estimates that less than 5 percent of total demand for micro-lending is being met (Wendt and Eichfeld, 2006). I assume that there is still unlimited demand for micro-credit in Bangladesh. However the economic capacity loop works as a negative loop which balances the demand for micro-lending institutes.

Also in figure 11, we can see that higher interest rate leads to less successful investment. This reduction in the probability of successful investment is due to economic capacity effect.

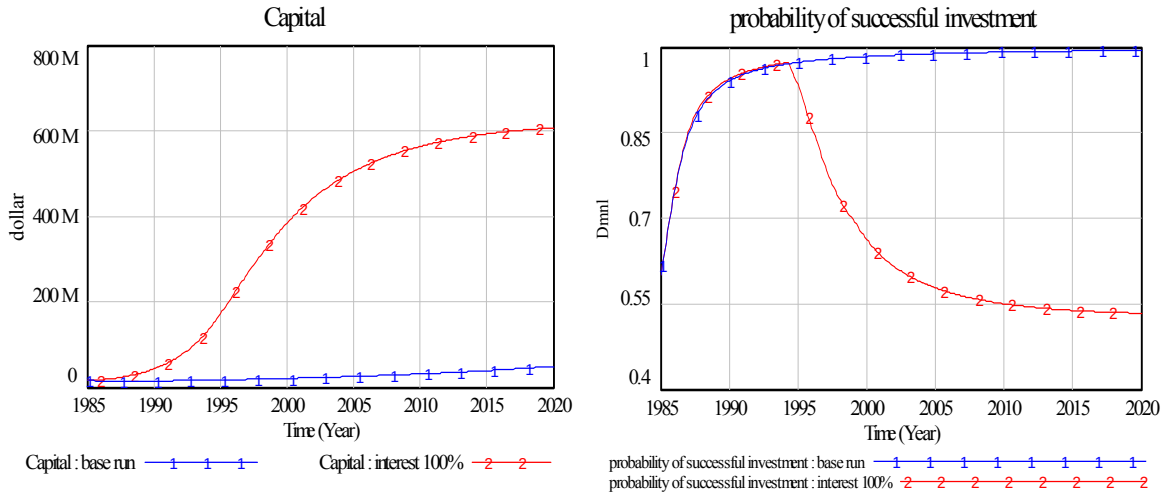

Figure 11: Effects of increasing interest on Grameen's capital and probability of successful investment

2.3. Not giving any income loan and not doing any investment (A_1, A_2=0)

As it is shown in figure 12, if Grameen does not give any income loan or invest any money, the capital will decline but the probability of successful investment will not change. This does not make any problem because the profits from income loan become zero when we set A_2 to zero. The nonzero probability of successful investment shows that if Grameen gave loan to the poor, what percentage of loans would be repaid.

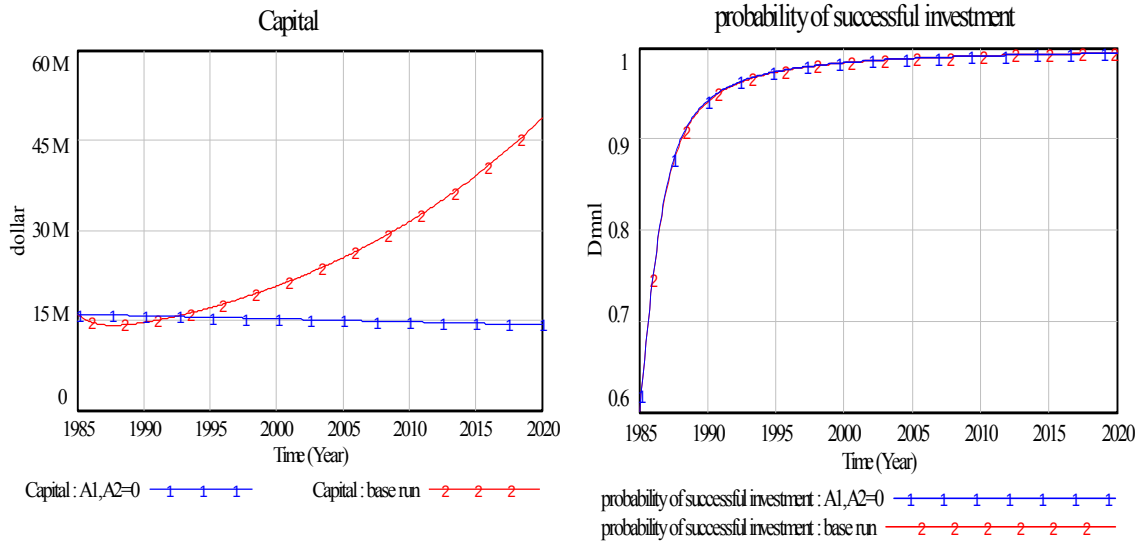

Figure 12: Effects of not investing and not giving income loan

3. Sensitivity Analysis

3.1. Size of loans

As it is shown in figure 13, increasing the loan size by 10 times lead to lower probability of successful investment and therefore lower capital level. Interestingly, although one may expect to see higher capital (because the cost of providing services is lower when the loan size is higher and the number of client is lower), figure 13 shows lower capital.

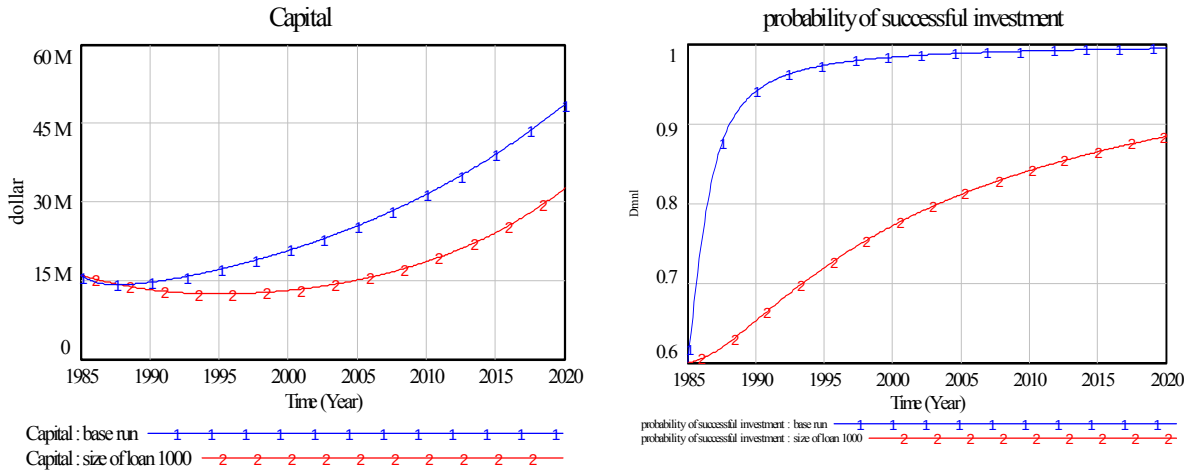

Figure 13: Effects of higher loan size on Grameen's capital and probability of successful investment

Figure 14 shows the sensitivity analysis for the size of the loans. The sensitivity analysis for the loan size indicates that the model is sensitive to this policy parameter.

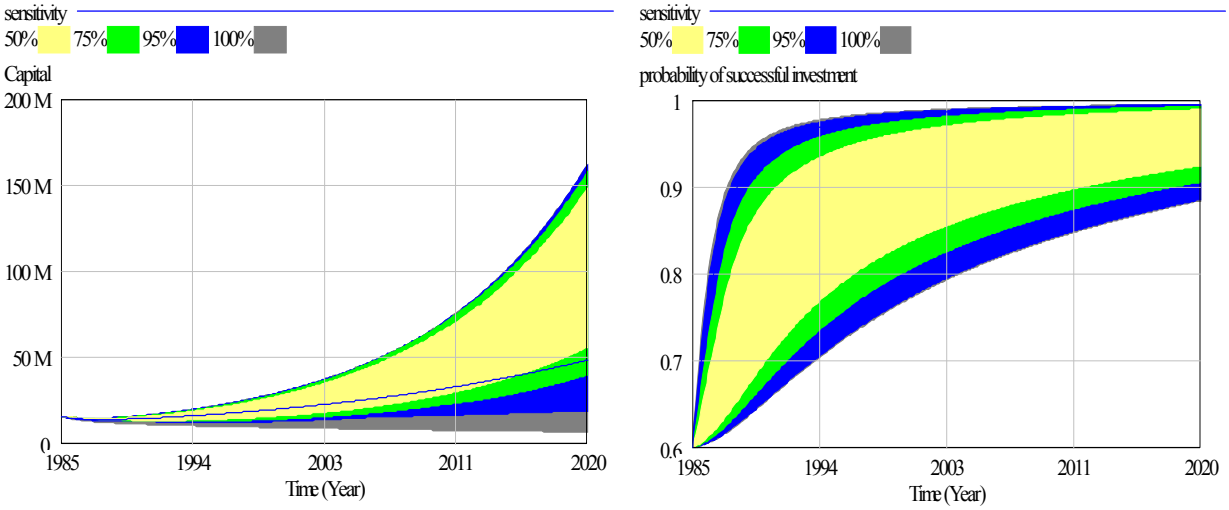

Figure 14: Sensitivity analysis for the size of the loans

In figure 15, I sketched the Grameen's capital versus loan size. Interestingly it shows that in this system, large loan size does not maximize the capital of Grameen. Instead small loan, around $300, maximize its capital which is very close to the reality. According to grameen website, the average loan size in 2008 is $ 327.48. This model is not numerically accurate so I do not suggest that the model can find the optimum loan

size. But the point is that the model shows that in this system small loans maximize the Grameen's capital. Although the higher loan size requires less cost (because the bank has lower clients with same interests), the optimum loan size is not a big number. This finding proves that choosing the right loan size is critical for micro-lending institutes. This also proves the Jain and Moor (2003) finding that one of the key elements of Grameen success is matching the (possible) income of borrowers and loan size.

The model is sensitive to the cost per client too, but I found the average cost per client in Grameen website.

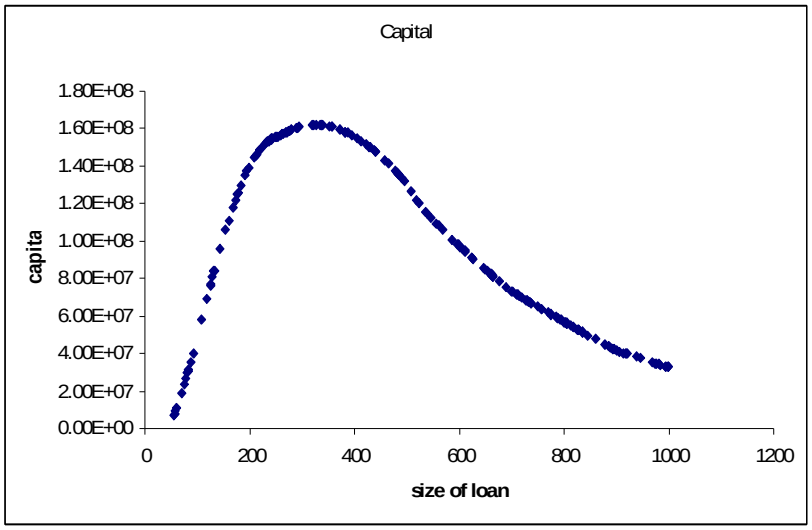

Figure 15: Grameen's capital verses loan size

3.2. Group size

Figure 16 illustrates that the model is sensitive to group size which is a policy parameter. Many researchers worked on the effects of group lending (Ghatak 1999, Besley and Coate 1995, stiglitz 1990, Hermes 2005 and etc), and as I mentioned in the introduction most of them found positive effects on the repayment rate. But I did not find

any research on the size of the group so I assumed that social capital increases linearly with the number of clients in the group and after 5 persons it saturates.

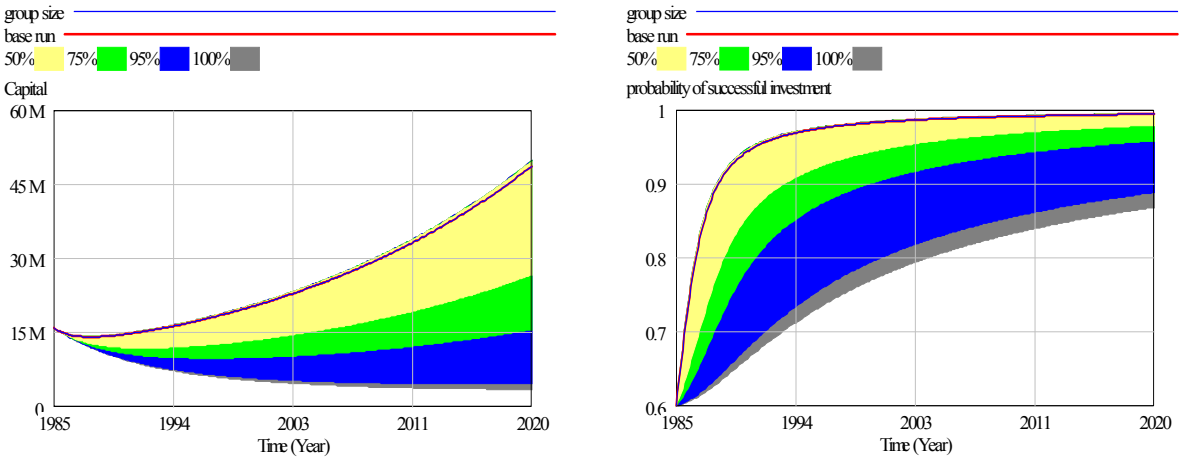

Figure 16: Sensitivity analysis for size of the group

3.3. Repayment time

Figure 17 shows that the model is not sensitive to repayment time, maybe because the model does not consider the effects of repayment time other than delay in perceiving threat.

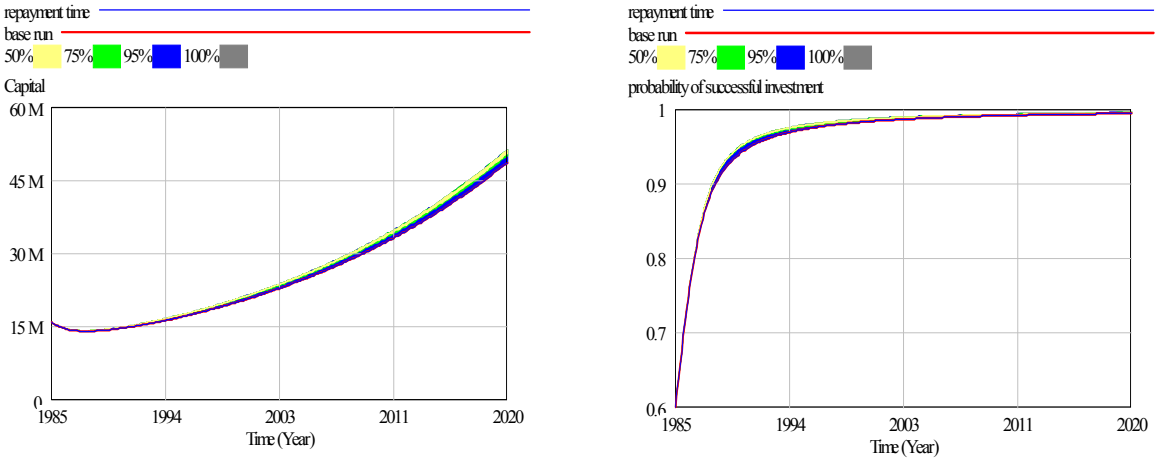

Figure 17: Sensitivity analysis for repayment time

4. Scenario test

Figure 18 shows different scenario tests. The line 2 illustrates the behavior of the model when the money for investing is allocated for education and housing loan. The model shows that if the Grameen bank allocates invested capital for giving housing and education loans, the probability of successful investment will increase a little but the capital will depreciate. So the model shows that investing some portion of the Grameen is really crucial.

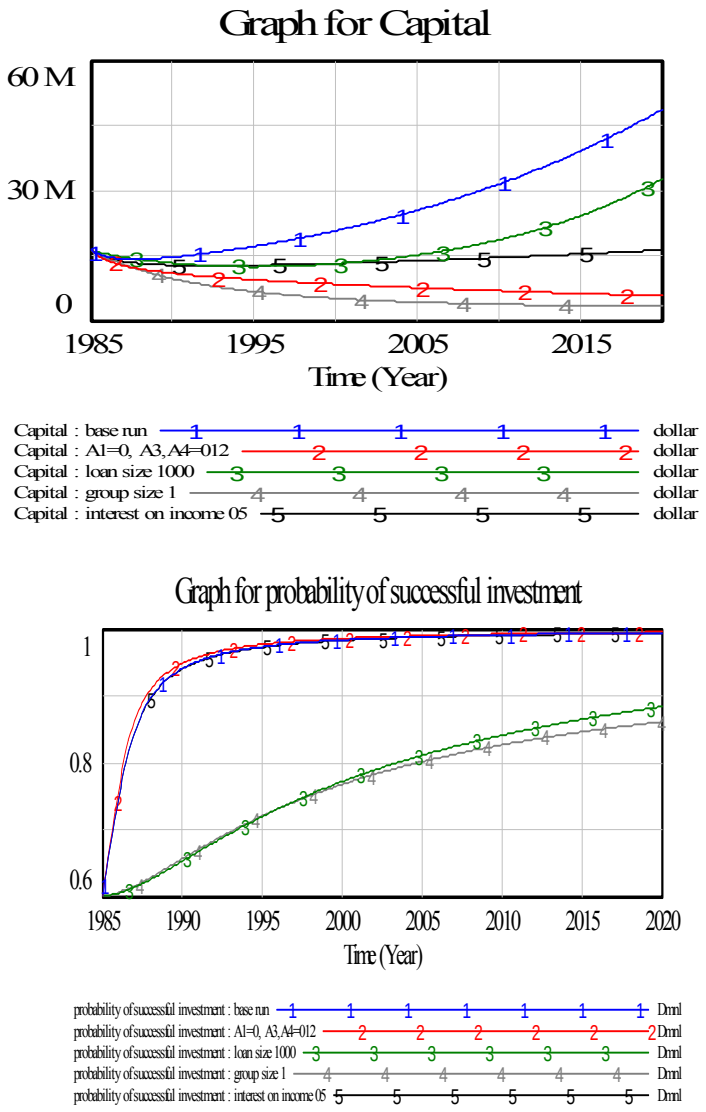

Figure 18: Scenario tests

Line 3 and 4 illustrate the effect of increasing loan size and giving loans to individual respectively. These effects were discussed in section 3.1 and 3.2. The line 5 shows the effect of reducing interest rate from 20% to 10%. It simply shows that Grameen should charge high interest rate to cover its cost.

V. Conclusion

This paper has stated the elements that scholars believe are the key reasons of Grameen success both in accomplishing its mission and loan recovery rate and has built a system dynamics model based on these findings to test their effects on sustainability of Grameen bank. The model generates the behavior of Grameen Bank's capital in the real world but it can not make the real numbers. The model finds support for the fact that small loan size which is designed to match the client's knowledge maximizes Grameen capital. Also this model finds that investing some portion of capital, giving loan to groups of people and choosing appropriate interest rate are crucial for Grameen Bank.

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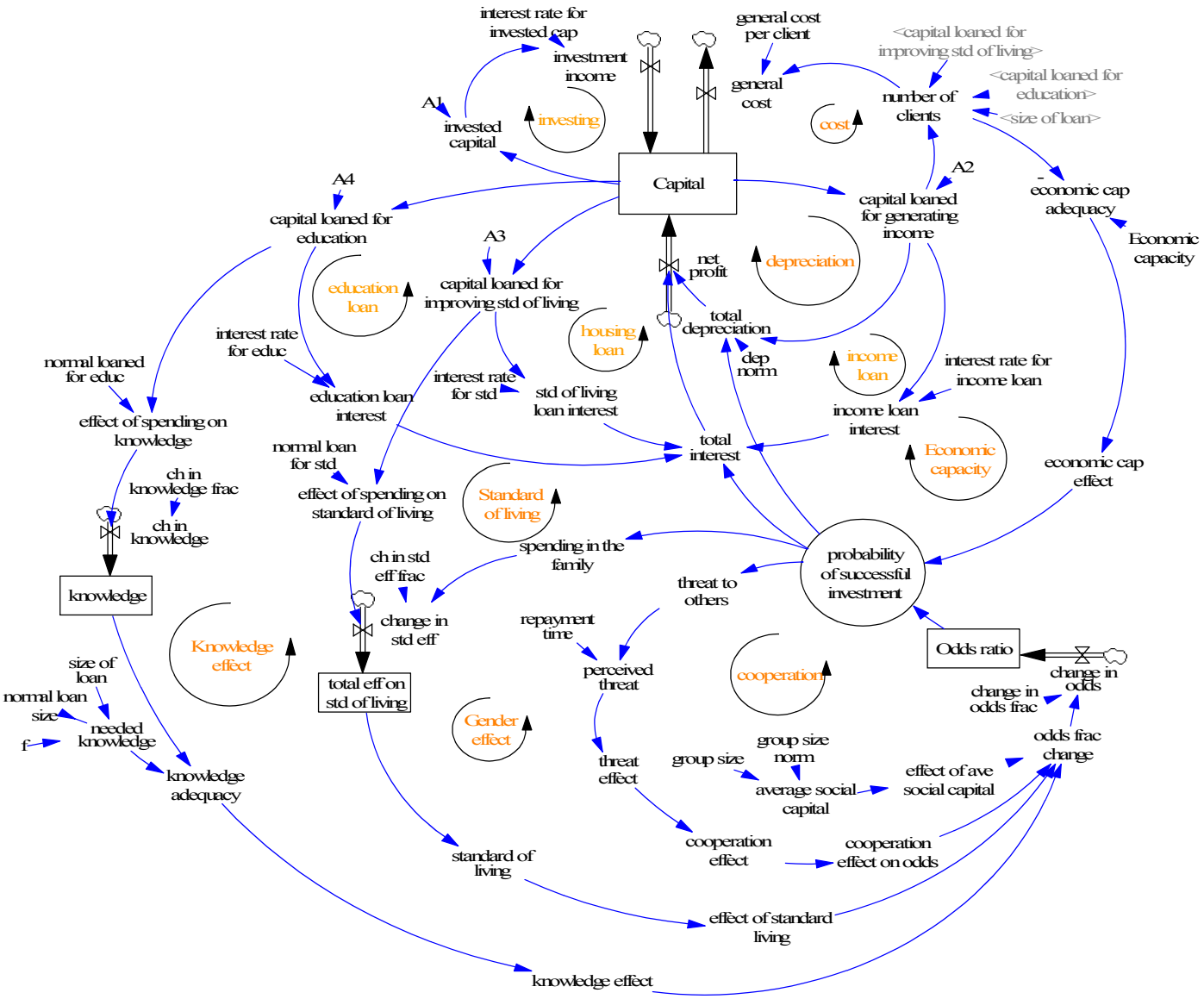
interest rate for invested cap
investment income
general cost per client
<capital loaned for improving std of living>
general cost
<capital loaned for education>
number of clients
<size of loan>
A1
investing
cost
invested capital
Capital
A2
A4
capital loaned for education
capital loaned for generating income
- economic cap adequacy
Economic capacity
A3
net profit
depreciation
education loan
capital loaned for improving std of living
housing loan
total depreciation
interest rate for educ
dep norm
income loan
interest rate for income loan
normal loaned for educ
interest rate for std
std of living loan interest
education loan interest
income loan interest
effect of spending on knowledge
total interest
Economic capacity
normal loan for std
economic cap effect
ch in knowledge frac
effect of spending on standard of living
Standard of living
ch in knowledge
spending in the family
probability of successful investment
ch in std eff frac
threat to others
knowledge
change in std eff
repayment time
Odds ratio
Knowledge effect
cooperation
change in odds
size of loan
perceived threat
change in odds frac
normal loan size
total eff on std of living
Gender effect
odds frac change
f
needed knowledge
group size norm
threat effect
group size
effect of ave social capital
average social capital
knowledge adequacy
cooperation effect
cooperation effect on odds
standard of living
effect of standard living
knowledge effect

Formula:

A1 = 0.25 Units: Dmnl

A2 = 0.65 Units: Dmnl

A3 = 0.025 Units: Dmnl

A4 = 0.025 Units: Dmnl

average social capital= WITH LOOKUP (group size/group size norm,
([(1,0)-
(16,1)],(1,0),(2,0.2),(3,0.4),(4,0.6),(5,0.8),(6,0.9),(8,0.95),(10
,0.98),(12,0.99),(14,1),(16,1)))
Units: Dmnl

Capital= INTEG (investment income+net profit-general cost,1.6e+007)
Units: dollar

capital loaned for education= A4*Capital
Units: dollar

capital loaned for generating income=A2*Capital
Units: dollar

capital loaned for improving std of living=A3*Capital
Units: dollar

ch in knowledge=effect of spending on knowledge*ch in knowledge frac
Units: knowledge/Year/person

ch in knowledge frac=0.2
Units: knowledge/Year/person

ch in std eff frac=0.5
Units: change in std of living/Year

change in odds=odds frac change*change in odds frac
Units: odds/Year

change in odds frac=1
Units: odds/Year

change in std eff=ch in std eff frac*effect of spending on standard of living*spending in the family
Units: change in std of living/Year

cooperation effect=threat effect
Units: Dmnl

cooperation effect on odds= WITH LOOKUP (cooperation effect,
([(0,0)-
(1,2)],(0,0),(0.1,0.2),(0.2,0.4),(0.3,0.7),(0.4,1),(0.5,1.4),(0.6
,1.6),(0.7,1.8),(0.8,1.9),(0.9,1.95),(1,2)))
Units: Dmnl

dep norm=0.5
Units: 1/Year

economic cap adequacy=Economic capacity/number of clients
Units: Dmnl

economic cap effect= WITH LOOKUP (economic cap adequacy,
([(0,0)-
(2,1)],(0,0),(0.2,0.5),(0.4,0.7),(0.6,0.85),(0.8,0.95),(1,1),(1.5
,1),(2,1)))
Units: Dmnl

Economic capacity=1e+006
Units: person

education loan interest=capital loaned for education*interest rate for educ
Units: dollar/Year

effect of ave social capital= WITH LOOKUP (average social capital,
([(0,0)-
(1,2)],(0,0.05),(0.1,0.1),(0.2,0.2),(0.3,0.3),(0.4,0.5),(0.5,0.7)
,(0.6,1.2),(0.7,1.6),(0.8,1.85),(0.9,1.95),(1,2)))
Units: Dmnl

effect of spending on knowledge= WITH LOOKUP (capital loaned for education/normal loaned for educ,([(0,0)-(1500,1)],(0,0),(5,0.1),(10,0.15),(200,0.5),(500,0.7),(1000,0.8),(1500,0.85)))
Units: Dmnl

effect of spending on standard of living= WITH LOOKUP (capital loaned for improving std of living/normal loan for std,([(0,0)-
(2000,6)],(0,0),(5,1.5),(10,1.6),(200,1.7),(500,2),(1000,4),(1500
,5),(2000,5.5)))
Units: Dmnl

effect of standard living= WITH LOOKUP (standard of living,

([(0,0)-
(1,2)],(0,0),(0.1,0.05),(0.2,0.2),(0.3,0.4),(0.4,0.6),(0.5,0.8),(
0.6,1.2),(0.7,1.6),(0.8,1.85),(0.9,1.95),(1,2)))
Units: Dmnl

f([(0,0)-(2000,10)],(0,2),(50,2),(100,2.5),(200,3),(500,5),(700,7),(900,8.5)
,(1000,9),(1500,9.8),(2000,10))
Units: knowledge/person

general cost=general cost per client*number of clients
Units: dollar/Year

general cost per client=10
Units: dollar/(Year*person)

group size=5
Units: person

group size norm=1
Units: person

income loan interest=capital loaned for generating income*interest rate for income loan
Units: dollar/Year

interest rate for educ=0.025
Units: 1/Year

interest rate for income loan=0.1
Units: 1/Year

interest rate for invested cap=0.2
Units: 1/Year

interest rate for std=0.04
Units: 1/Year

invested capital=A1*Capital
Units: dollar

investment income=interest rate for invested cap*invested capital
Units: dollar/Year

knowledge= INTEG (ch in knowledge,2)
Units: knowledge/person

knowledge adequacy=knowledge/needed knowledge

Units: Dmnl

knowledge effect= WITH LOOKUP (knowledge adequacy,
([(0,0)-
(5,2)],(0,0),(0.2,0.005),(0.4,0.1),(0.6,0.3),(0.8,0.7),(0.9,0.95)
,(1,1.1),(1.5,1.6),(2,1.8),(3,1.95),(4,1.98),(5,2)))
Units: Dmnl

needed knowledge=f(size of loan/normal loan size)
Units: knowledge/person

net profit=total interest-total depreciation
Units: dollar/Year

normal loan for std=100000
Units: dollar

normal loan size=1
Units: dollar/person

normal loaned for educ=100000
Units: dollar

number of clients=(capital loaned for education+capital loaned for generating
income+capital loaned for improving std of living
)/size of loan
Units: person

odds frac change=cooperation effect on odds*effect of standard living*knowledge
effect*effect of ave social capital
Units: Dmnl

Odds ratio= INTEG (change in odds,1.5)
Units: odds

perceived threat=SMOOTHI(threat to others, repayment time*4 , 0.6)
Units: Dmnl

probability of successful investment=economic cap effect*Odds ratio/(1+Odds ratio)
Units: Dmnl

repayment time=0.019 (0.019 = 1/52weeks)
Units: Year

size of loan=100
Units: dollar/person

spending in the family= WITH LOOKUP (probability of successful investment,
([(0,0)-
(1,2)],(0,0.2),(0.1,0.2),(0.2,0.25),(0.3,0.3),(0.4,0.45),(0.5,0.6
),(0.6,0.85),(0.7,1.1),(0.8,1.3),(0.9,1.45),(1,1.5)))
Units: Dmnl

standard of living=total eff on std of living/(1+total eff on std of living)
Units: Dmnl

std of living loan interest=capital loaned for improving std of living*interest rate for std
Units: dollar/Year

threat effect= WITH LOOKUP (perceived threat,
([(0,0)-
(1,1)],(0,0.5),(0.1,0.6),(0.2,0.7),(0.3,0.8),(0.4,0.85),(0.5,0.9)
,(0.59633,0.94),(0.69419,0.97),(0.798165,0.99),(0.9,1),(1,1)))
Units: Dmnl

threat to others= WITH LOOKUP (probability of successful investment,
([(0,0)-
(1,1)],(0,1),(0.1,0.98),(0.2,0.95),(0.3,0.9),(0.4,0.85),(0.5,0.7)
,(0.6,0.55),(0.7,0.4),(0.8,0.2),(0.9,0.05),(1,0)))
Units: Dmnl

total depreciation=capital loaned for generating income*(1-probability of successful investment)*dep norm
Units: dollar/Year

total eff on std of living= INTEG (change in std eff,0.4)
Units: change in std of living

total interest=income loan interest*probability of successful investment+education loan interest+std of living loan interest
Units: dollar/Year