

Simulation Models For Economics-2014/2015

NETLOGO PROGRAM: Microcredit with different categories of agents

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What is it?

The goal of our model is to check whether the GDP of a country may increase with the presence of banks and microcredit agencies and to analyze its behavior according to the different forms of credit, applied in that particular economy.

How it works?

We have decided to create two different kinds of financial institutions:

- One normal bank: they ask for a collateral, lend money at a lower real interest rate, provide bigger loans;
- Two microcredit financial institutions: they do not ask for collateral, ask higher real interest rates than the normal bank and provide smaller loans. Each microcredit financial institution offers one kind of lending program: bounded or not bounded to a specific use of this money (see later on).

Only wealthier people (with the initial wealth higher than the collateral) can ask for a loan to the normal bank. It's too risky indeed for a bank to lend money to poorer people, who will likely not repay back the debt (too big principal for them).

For this reason microcredit financial institutions started to be developed in the poorest areas of the world. They ask their debtors higher interest rates, but the time of repaying back is usually shorter and they lend money to groups of people so that it is easier for them to give back the interests and the principal.

Looking at the reality, we can see that microcredit is not always the solution in order to increase the richness of a country; sometimes indeed it creates even more poorness. For this reason we want to check in our model which are the possible causes of a long-term substantial increase in the GDP rather than a temporary one and the possible outcomes in case of different forms of microcredit.

We start our model defining three “**global variable**” to which every agent can access: consumption, investment, and education.

Then we define the **agents**. We have a number of them defined by a slider and we give them the following **characteristics**:

- wealth (random amount, from 0 to 99)
- age (random numbers between 0 and 79)
- gender (0 if the agent is a woman, 1 if the agent is a man – random characteristic)
- income (what is gained from a job – either working or household production - or the amount lent by credit institutions)
- debts (the amount lent by the bank or the microcredit institutions)
- defaulter? (if the agent has done default)
- loan_eligible? (characteristic defined according to the initial wealth level and the product between financial illiteracy and propensity to risk)
- MC_eligible? (characteristic defined according to the product between financial illiteracy and propensity to risk)
- borrower? (if the person has obtained a credit)

- bank_borrower? (if the person has obtained a credit from the bank)
- MC_borrower? (if the person has obtained a credit from the microcredit institutions)
- MC_good_borrower? (if the person has obtained a credit from the microcredit institution that offers the bounded program)
- MC_bad_borrower? (if the person has obtained a credit from the microcredit institution that offers not bounded program)
- working? (broad variable; it defines people who work as entrepreneur, as student or as employee)
- entrepreneur? (if the person works as entrepreneur)
- firm_builder? (if the person is interested in building a new firm with the loan received from microcredit bounded program)
- employed? (if the person is employed by an entrepreneur)
- student? (if the person has invested the credit in his personal education)
- leader? (if the student that has invested the money in his personal education is able to get a really good job)
- myBoss (characteristic that the employees own, with the “address” of their boss)
- failed_boss? (if the entrepreneur, who was employer, makes default)
- employees (number of employees for each entrepreneur)
- years_study (the years of study spent by the student)
- risk_propensity (random numbers from 0 to 99)
- financial_illiteracy (random numbers from 0 to 99)

The **microcredit institutions** “own” the following **characteristics**:

- bounded? (if the microcredit institution offers a bounded or not bounded program)
- microcredit_fund (amount of reserves; every 52 ticks, the reserves are refunded)

What is important to underline in our model is that:

- We have decided that the bank can always provide new loans: this is a difference with respect to microcredit institutions. Indeed, the bank provides loans to the minority of the population, so it’s always able to have sufficient money to provide new loans. Instead the microcredit agencies have many people that ask for a credit, so it may happen that they finish the money and have to wait for a while (a certain amount of “ticks”) before providing new loans.
- The wealthier people (with initial wealth higher than the collateral asked by the bank) can obtain a loan from the bank. They become from the very beginning entrepreneurs and can hire people. We have fixed a maximum amount of employees (five in our simulation) for each entrepreneur. Both the entrepreneur and the employees earn a higher income. If entrepreneur’s income starts to become really high (we have introduced a slider named “income_threshold”), the entrepreneur stops asking continuously new loans to the bank.
- The people who cannot apply for a loan to normal banks can choose among two different programs offered by the two microcredit institutions according to their level of financial illiteracy:
 - **the “bad” one**: a loan that is not bounded to a specific use (investment). This program is chosen by the people who are more ignorant about finance. Their financial illiteracy is higher than the financial illiteracy threshold and they ask money to the microcredit institution just to consume more, without a long-term view. If they finish these additional money before completing the repayment, they make default, wait to be saved (see later on) and ask for a new loan in order to increase again their consumption;

- **the “good” one:** a loan that is bounded to investment either in production (in order for the borrower to become an “Entrepreneur”) or in education (to become a “Student” and then a “Leader”). The people who choose this program are more financially literate than the others. They ask money to the good microcredit institution in order to make some investments. The choice on how to invest this additional money (if for becoming entrepreneur or a student) depends on their level of propensity to risk. If they are enough risk lover, they would invest in education, otherwise they would spend those money to create a firm.

It’s important to underline that there is a difference between men and women in obtaining the loan through the microcredit institution. Indeed women will always get the credit, while men will have a lower probability of obtaining it. We have decided to put two different probabilities in order to make our model closer to reality, where actually more women than men are able to get the credit.

- There are also people who do not apply for a loan. Indeed, if their age is lower than 16 years old and higher than 65 or if the product between their financial illiteracy and their propensity to risk is too low, these people would not be able to ask for a loan. They keep on working in their houses in order to get something to eat and to produce the minimum to survive. Some of them, if lucky, manage to work for the richest people being able to get a higher income.
- All agents can be employed by the entrepreneurs (wealth people or poor that got bounded microcredit), leading to a higher income. This happens according to their nearness to the entrepreneurs (within a given radius, determined in the program by a slider). The employees set their variable “myBoss” equal to the “address” of the agent who is hiring them, who in turn increase by one their number of employees.
- All agents with exception of the students earn something; they can have a job (entrepreneurs, employees or leaders) or can live thanks to their household production (people who do not apply for a loan). In any case they receive an income. So they would have a positive and changeable income. As we have seen at the beginning, this is something different from the “wealth” (that is what everybody owns from the very beginning and that is untouchable, with exception of the students): all agents can have their household production and gain something from there or they can work as entrepreneurs/leaders or can be employed. So there would be a positive income for everyone.
 For each tick, we would have for the leaders an increase of the income by 6, for the entrepreneurs by 5, for employees by 3 and for the people who are not working (for those who are just doing household) by 1,2.
 The students are the only ones who would not gain anything: they would only consume and increase the variable “education” according to the years spent studying.
 All agents would also consume. So we would have a decrease in income (and an increase in consumption with opposite sign) of 1 for the people who are not working, of 2 for the employees and of 3 for the entrepreneurs and for the leaders. Moreover, if they are borrowers, there would be an additional decrease of 0,5 (which can be interpreted as a higher propensity to consume due to the higher disposable income) and if the income of the agents is particularly high (≥ 1000) we would have an additional decrease depending on their income, proportionally. The students would consume part of the income (-1) and then, if income reaches 0, part of the wealth (-1): they are the only one with this particular characteristic, but this is specific to their high propensity to risk and necessary in order to allow them to pay back the principal and the interests without incurring always in default (since they do not receive any income).

- There is always the possibility that the agents make default, when they reach the zero level of income, with a difference if the agent is a student or not (i.e. when they reach also zero wealth).
- We have introduced also the failure of a firm. According to given probabilities (determined by the sliders “prob_failure_men” for men and “prob_failure_women” for women) the firm can make default each tick with some probability according to the entrepreneur’s gender. In such case, the income falls to zero, we set the variable “defaulter?” on true, the characteristics “failed_boss?” equal to true, “entrepreneur?” equal to false, “working?” equal to false, the “borrower” characteristics all equal to false and the number of employees equal to zero. In this way, we are able to fire the workers that that entrepreneur had hired previously.
- We have decided also to introduce the possibility to save all the agents who were doing default, so that we would not have dead people but always agents that can start again their cycle.
- After each tick the debtors must repay back part of the debt. We would have higher interest rate for the microcredit institutions but larger principal for the bank. Once the debt is paid back, the characteristic “borrower?” is set again on “false”, so that they can start again (if they want) to ask for new credit.

We underline that our goal is to monitor the GDP behavior, which will be plotted in our program, as:

$$\mathbf{GDP = Y = C + I}$$

Where C: consumptions (consumption in normal goods and in education)
 I: investments (every time a new firm is created with a loan, the investments’ amount increases by that value)

We have an additional variable that is “Education”. This variable increases tick by tick every time there is someone who is studying and increases more also when a student is able to become a “leader”. “Education” continues to increase due to the fact that more and more acculturated people exist in the country and education has thus a spill over effect on society, a positive externality.

We have also four plots:

- The “GDP” graph represents the trend of the GDP (brown line), given by the sum of consumption (green line) and investment (blue line).
- The “Education” graph represents how the value of the variable “education” varies tick by tick.
- The “People” graph represents what the agents have become as the time goes by: we count at each tick the number of students (violet line), leaders (grey line), borrowers from the “bad” microcredit who want just to consume more (green line), entrepreneurs (yellow line) and employees (orange line).
- The “Borrowers” graph represents the borrowers’ categories of our model: we would have bank’s borrowers (black line), microcredit institutions’ borrowers (light blue line) and the defaulters (red line).

The commands

The commands of our program are:

- **to setup**

```
ca
  setup-turtles
  reset-ticks
end
```

- **to setup-turtles**

create-peoplenumber people

Create agents with the following characteristics;

```
[set shape "person"
 set color white
 set wealth random 100
 set age random 80
 set gender random 2
 set income 0
 set debts 0
 set borrower? false
 set MC_borrower? false
 set MC_good_borrower? false
 set MC_bad_borrower? false
 set bank_borrower? false
 set loan_eligible? false
 set MC_eligible? false
 set entrepreneur? false
 set student? false
 set employed? false
 set leader? false
 set working? false
 set defaulter? false
 set risk_propensity random 100
 set financial_illiteracy random 100]
```

create-microcredits 2

Create two microcredit institutions, set one of the two with the variable “bounded?” equal to true and differentiate them with colors. Give them two equal funds.

create-banks 1

Create one bank.

ask turtles [setxy random-xcor random-ycor]

Ask all agents of the program (“turtles”) to set up randomly their initial position.

- **to go**

```
move
apply-loan
non-apply-new-loan
obtain-loan
apply-microcredit
```

get-bad-microcredit
get-good-microcredit
restore-fund
become-entrepreneur
produce
become-student
study
become-leader
be-leader
hire
get-income
consume
repay-debt
default
business_failure_men
business_failure_women
fire
save-them-all
reset_GDP
tick
end

Let's now explain in detail each procedure within the "go" command:

- **to move**

We ask people, who are not entrepreneurs and who are not employed, to move in the world. So we would have the entrepreneurs (yellow) and the employees (orange) fixed on their patch.

- **to apply-loan**

The people, who have the initial wealth higher than the collateral of the bank (determined with a slider), an acceptable age (between 16 and 65 years old), the product between the financial illiteracy and the risk propensity higher than the threshold defined by the slider ("loan_threshold") and who are not defaulter can ask for a loan to normal banks. So they would be set "loan eligible".

- **to non-apply-new-loan**

The people who have an income that is already too high (higher than a threshold determined by a slider) would be declared not "loan eligible" anymore, since they can live even without asking continuously for new loans.

- **to obtain-loan**

If the people that have been declared "loan eligible" and are not already borrowers, they would get the loan from the normal bank. So they would increase their investment amount and their debt by the loan size. Moreover, they would become immediately entrepreneurs (we assume, they spend this additional money to create a firm).

- **to apply-microcredit**

We ask women with an age between 21 and 65 years old, who are not defaulter and with the product between the financial illiteracy and the risk propensity higher than the threshold defined by the slider “microcredit_threshold”, to become “microcredit eligible”.

The same procedure is set for the men, but they have a lower probability to obtain the loan through microcredit institutions (probability defined by the slider “man_threshold”).

- **to get-bad-microcredit**

If the people that are “microcredit eligible” and that have a level of financial illiteracy higher or equal to what is determined by the slider “fin_illit_thresh”, walk close to a microcredit institution that offers a not bounded program, they receive a loan from that microcredit institution (those people would just spend these additional money to consume more).

The microcredit institution would decrease its reserves according to the loan given.

The “bad” microcredit borrowers would have an increase in their income and in the debt amount according to the loan received. Moreover, they would be declared not eligible to microcredit anymore (in order to not receive any other loan).

- **to get-good-microcredit**

If the people that are “microcredit eligible” and that have a level of financial illiteracy lower than what is determined by the slider “fin_illit_thresh”, walk close to a microcredit institution that offers a bounded program, they receive a loan from that microcredit institution. The microcredit institution would decrease its reserves according to the loan given.

The “good” microcredit borrowers would have an increase in their income and in the debt amount according to the loan received. Moreover, they would be declared not eligible to microcredit anymore (in order to not receive any other loan).

- **to restore-fund**

In order to restore the reserves of the microcredit institutions, we ask the program every 52 ticks to set again the reserves at their initial level.

- **to become-entrepreneur**

The agents that have decided to take the money from the microcredit institution that offers the bounded program can decide to invest this money in order to become an entrepreneur or a student.

If their propensity to risk is lower than threshold defined by the slider “risk_prop_thresh”, they

want to become an entrepreneur. So we set the temporary variable “firm_builder?” on true and we increase the investment of those agents according to the amount of money received.

- **to produce**

As they want to build a firm, they receive the money and become entrepreneur. Immediately the variable “firm_builder?” is set on false so that we would have just only one increase of the investments, as the firm is built.

- **to become-student**

If the agents have a risk propensity higher or equal to the threshold defined by the slider “risk_prop_thresh”, they want to become students and we set the variable “student?” equal to “true”.

- **to study**

The agents with the variable “student?” equal to “true” would be able to study. So they increase their variable education by 1, their consumption by 1 and their years of study by 1 tick after tick.

- **to become-leader**

All students can become leaders after some time. Being a “leader” means having a good and important job also for the society. After a certain amount of years spent on studying (defined by the threshold “leader_threshold”), the agent become a leader and we set the variable “leader?” true.

- **to be-leader**

If the agents have the characteristic “leader?” equal to true, they are leaders. So they increase the education by 2, being even more useful for the knowledge’s quality of the society.

- **to hire**

The people with the variable “working?” equal to “false” can be employed, if lucky, according to their nearness with an entrepreneur. An entrepreneur can hire maximum five employees.

So if in the radius specified by the slider there is an entrepreneur with less than five employees, that agent can be hired. So the entrepreneur would have +1 employee, and the new employee would start working.

- **to get-income**

The people with the characteristic “working?” equal to false (so the people that live just with household production) would have an increase in their income by 1.2;

the people with the characteristic “employed?” equal to true, would have an increase in their income by 3;

the people with the characteristic “entrepreneur?” equal to true, would have an increase in their income by 5;

the people with the characteristic “leader?” equal to true, would have an increase in their income by 6.

- **to consume**

The people with the characteristic “working?” equal to false (so the people that live just with household production) would have a decrease in their income by 1 and a correspondent increase in consumption by the same amount;

the people with the characteristic “employed?” equal to true, would have a decrease in their income by 2 and a correspondent increase in consumption by the same amount;

the people with the characteristic “entrepreneur?” equal to true, would have a decrease in their income by 3 and a correspondent increase in consumption by the same amount;

the people with the characteristic “student?” equal to true, would have a decrease in their income by 1 if their income is still higher than zero; once their income is lower than zero, they would diminish their wealth by 1;

the people with the characteristic “leader?” equal to true, would have a decrease in their income by 3 and a correspondent increase in consumption by the same amount;

the people with the characteristic “borrower?” equal to true, would have an additional decrease in their income by 0.5 and a correspondent increase in consumption by the same amount;

the people that have a particularly high income, would have a proportional decrease in their income and a correspondent increase in their consumption.

- **to repay-debt**

In order to repay their debt, the agents must give back the principal and the interests (equal to what is specified by the slider “int_loan” for the bank and by the slider “int_MC” for the microcredit institutions). If their debt is lower than zero, they can repay the debt. Once the debt is repaid, the agents come back to their initial status (so they are not borrowers any more) in order to ask new loans.

- **to default**

Every agent can do default. We have two different outcomes in case of default, according to the type of agent:

- If the agents are people who have chosen the “bad” microcredit program, they do default if their income goes under zero. Then the characteristic “defaulter?” is set to “true” and the color of the agents becomes red. Moreover, they would not be anymore borrowers.
 - If the agents are students, they make default if their wealth is lower than zero. Then the characteristic “defaulter?” is set to “true” and the color of the agents becomes magenta. Moreover, also in this case, they are not anymore borrowers but also students and general workers.
- **to business_failure_men and to business_failure_women**
Firms (so the agents with the characteristic “entrepreneur?” set on true) can go to bankruptcy with a probability determined by a slider according to the gender of the agent (“prob_failure_men” and “prob_failure_women”). If this probability occurs, the variables “defaulter?” and “failed_boss?” are set on true, the variables “entrepreneur?” and “working?” are set on false, the income is reset on 0, the number of employees is returned to 0 and those agents are not borrowers anymore. The color of those agents becomes red.
 - **to fire**
Once the firm is failed, the employees are fired; the link with “myBoss” disappears (“myBoss” becomes equal to “nobody”), the variables “employed?” and “working?” are set on false and they get again the initial color white. With the variable “failed_boss?” set on true, the employees are not anymore working for that entrepreneur and they start moving again around randomly. Once the entrepreneur is saved (see command “save_them_all”), the variable “failed_boss?” is set on false, meaning those entrepreneurs who were failed can hire again and as a consequence the agents who have been fired previously may be employed again.
 - **to save-them-all**
We have decided to introduce the possibility to save all the agents who were doing default. According to the slider “save_them_all”, that determines a particular amount of ticks, after those ticks all the defaulters are saved and they go back to their initial status: income and debt are set equal to zero and the variables “defaulters” and “failed_boss?” are set on false.
If an agent has a negative wealth, we set “wealth” equal to zero.
So they can start again their cycle.
 - **to reset_GDP**
In order to control by how much year after year the situation of the GDP changes, we have decided to reset on zero every 52 ticks the globals consumption, investment and education.

Experiments

We have decided to try to change some of the variables in our model in order to see which are the effects on the agents and on the GDP.

We have realized three groups of experiments:

1. changing the thresholds of the initial fund of the microcredit institutions, the collateral, the threshold that determines the criteria thanks to which the agents who would take the loan from the bank and the one that determines the criteria through which the agents would take the loan from the microcredit institutions;
2. changing the thresholds of the loan's size and of the microcredit's size, the interest rate applied by the bank and the one applied by the microcredit institutions;
3. changing the thresholds of the financial illiteracy and of the risk propensity.

1) **initial_fund, collateral, loan_threshold, microcredit_threshold experiments**

Our first experiment involves the following variables, determined by four sliders:

- **Initial_fund:** microcredit institutions have an amount of reserves to give as loan that, every 52 ticks, are restored at the initial level. It decreases according to the loan given. It could be a value between 0 and 1000.
- **Collateral:** only wealthier people that have their initial wealth higher than the collateral required by the bank can ask for a loan. It could be a value between 1 and 100.
- **Loan_threshold:** a requirement that the people must have to obtain the loan from the bank is the product between their financial illiteracy and their risk propensity higher than the threshold defined by the slider "loan_threshold". It could be a value between 0 and 5000.
- **Microcredit_threshold:** a requirement that the people must have to obtain the loan from the microcredit institutions is the product between their financial illiteracy and their risk propensity higher than the threshold defined by the slider "microcredit_threshold". It could be a value between 0 and 5000.

During the experiment, we assume as fixed values:

- Number of people = 100
- Income threshold = 1000
- Microcredit size = 50
- Loan size = 70
- Interests of loan = 1%
- Interests of microcredit = 3%
- Probability of failure for men = 3%
- Probability of failure for women = 1%

- Man threshold (probability to obtain the microcredit for a man) = 80%
- Financial illiteracy threshold = 50
- Risk propensity threshold = 50
- Leader threshold (years of study necessary to become a leader) = 104
- Save them all (number of ticks)= 200

FIRST EXERCISE

Selecting the initial values, as following

- Initial_fund = 100
- Collateral = 80
- Loan_threshold = 1000
- Microcredit_threshold = 500

the bank gives the possibility to obtain its loan to a limited circle of people, because the collateral is high related to the initial wealth, that could be a value between 0 and 99, and because it depends also on the limit thresholds (loan_threshold and microcredit_threshold) relative to the product between the risk propensity and the financial illiteracy that are fixed such that the microcredit one is double the loan one. With the initial fund se equal to 100, the microcredit institutions can give only two loans before the restoration of this fund.

After 500 ticks, the bank decides to give more loans as a strategy to control the money in circulation and the market. So they decrease the collateral required and the threshold relative to the loan:

- Initial_fund = 100
- Collateral = 60
- Loan_threshold = 500
- Microcredit_threshold = 500

Now the microcredit and the loan from the bank are given to people that have the product between the risk propensity and the financial illiteracy greater than the same value and more people can obtain the loan from the bank, thanks to the smaller collateral required.

We take two different situations generated with the same procedure, as described above.

In the first one, initially there are more bank borrowers than microcredit borrowers but the situation changes after few ticks. The bank borrowers hire some people and then someone makes default, so the number of defaulters increases and the number of bank borrowers and employees decreases. Whereas, the number of microcredit borrowers is more fluctuating throughout the observation.

After the procedure "save them all", there is again an increase in the number of bank borrowers.

The distribution of loans from "good" and "bad" microcredit institutions is balanced.

The number of the entrepreneurs is given also by some people that take the "good" microcredit and use it to enlarge their firm becoming entrepreneurs.

The consumptions are high due to a moderate number of entrepreneurs related to the less probability to obtain a loan from the bank, some leaders and a lot of employees that are the people with more consumptions.

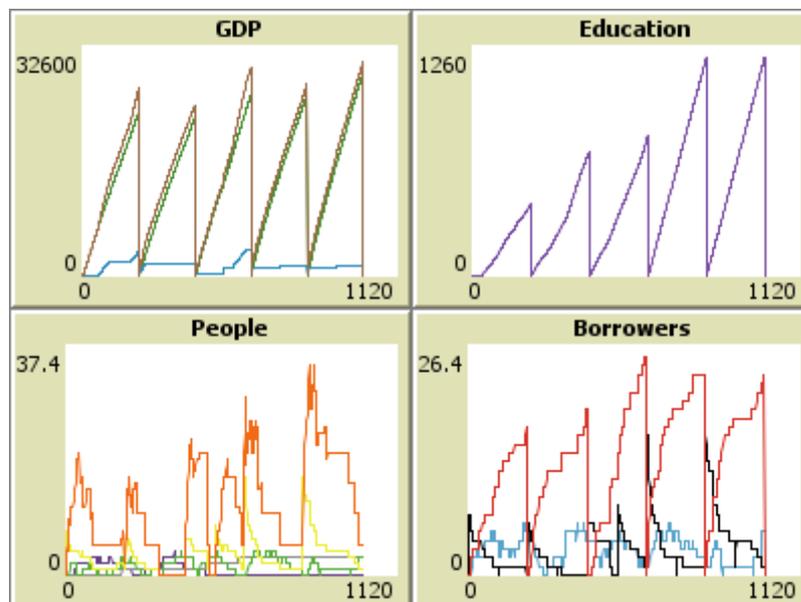
After 500 ticks the change of the values occurs, so the number of bank borrowers increases and consequently there are entrepreneurs and employees, hired by them.

The number of microcredit borrowers has almost the same evolution. It depends also on the fact that everybody knows that the bank exists and people can apply for a loan if they satisfy the requirements. Whereas only the people that are in the fixed radius of the microcredit institutions know that there is an alternative form of loan.

Students, after two years of study, become leaders and do not fail in the considered period, but in the second phase of the observation nobody becomes student, due to the fact that less people take the microcredit. It justifies the increase in the value of “education”, because when a student becomes a leader the contribution gives to this variable is doubled.

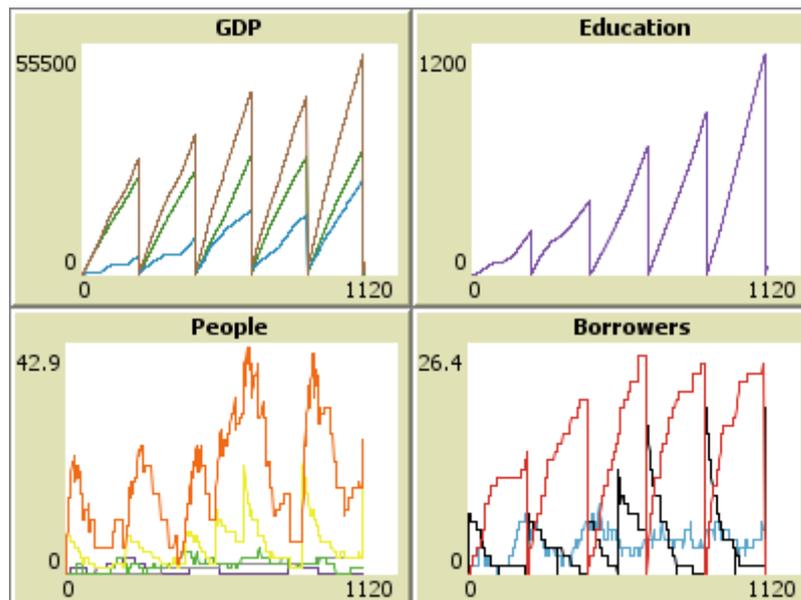
After the 500th tick, there is a peak in the number of defaulters, maybe a lot of entrepreneurs because there is a corresponding decrease in the number of employees.

Since the bank gives more loans that more affect the investments, in the GDP we can see a peak after the change, also because there are more entrepreneurs and hence more consumptions.



In the second one, initially occurs almost the same situation as in the previous case.

Most relevant are the results after 500 ticks when we change the values: there is a substantial increase in the loans given from the bank that significantly affects the investments. Indeed, after 1000 ticks, in the “GDP” graph we can see that the consumption line and the investment line are very close, especially taking in consideration the trend that they have in the first phase of the observation. A reason is that, since the beginning, there is a variability in the number of employees and of students that become leaders. It is clear also in the evolution of the variable “education”.



SECOND EXERCISE

We start the experiment with the following values:

- Initial_fund = 100
- Collateral = 70
- Loan_threshold = 1500
- Microcredit_threshold = 500

After 500 ticks, the microcredit institutions decide to increase their initial fund to provide more loans, but increasing also the threshold relative to the product between the risk propensity and the financial illiteracy. They decide to adopt this restriction to protect themselves, because in the previous years there were a lot of people that did not repay their debts and the institutions had a lot of economic problems before to return to normality.

So the values become:

- Initial_fund = 300
- Collateral = 70
- Loan_threshold = 1500
- Microcredit_threshold = 1000

We take two different situations generated with the same procedure, as described above.

In the first one, the microcredit institutions are very close together in the patch and they are far from the bank.

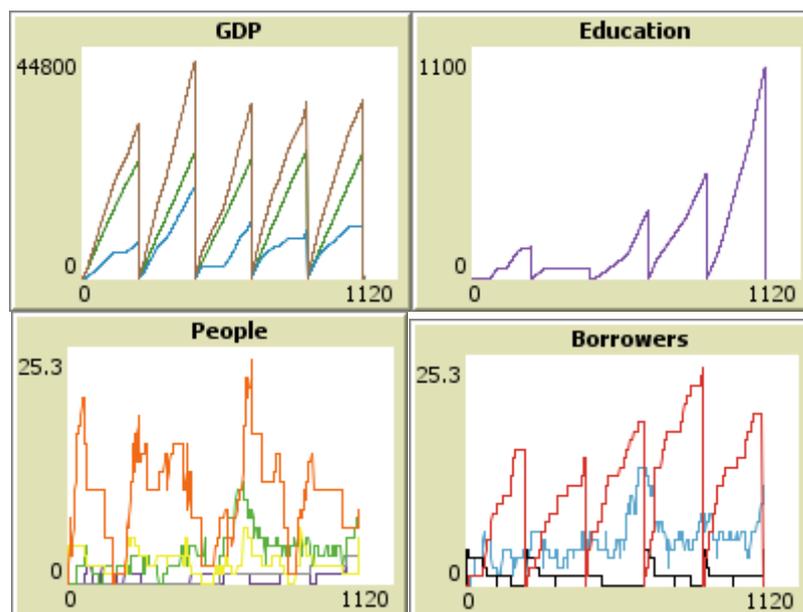
In the first part, most people that apply for a loan obtain it from the microcredit institutions becoming microcredit borrowers, because the collateral is not too high but the bank requires also a higher threshold relative to the financial illiteracy and the risk propensity than the microcredit one. Some of them and who obtain the loan from the bank become entrepreneurs and hire other people (there are a lot of employees at the beginning of the observation) and someone becomes student and then sometimes leaders,

increasing the value of “education”. Moreover, there is a relevant percentage of “bad” microcredit borrowers, who are only consumers.

The GDP has a variable composition due to the investments that are quite high because there are more microcredit borrowers that becomes entrepreneurs, whereas the level of consumptions remains almost the same.

After 500 ticks the values change, so there is an increase in the number of loans provided by microcredit institutions and consequently of people that obtain it. It is curious to see that around the 500th tick, there is a remarkable increase in the number of microcredit borrowers, although the change of the threshold required, that later on does not occur similarly. Most of them take it from the “bad” microcredit institution, whereas among those who take it from the “good” one, almost all of them become entrepreneurs. Then they start to make default and the number of microcredit borrowers decreases, stabilizing until the end of the period of observation.

It is significant the evolution in the “Education” graph: at the beginning, it does not increase a lot, becoming a straight line when all leaders and students make default, whereas after the 500th tick starts to increase more and, when there are more leaders, it is doubled.



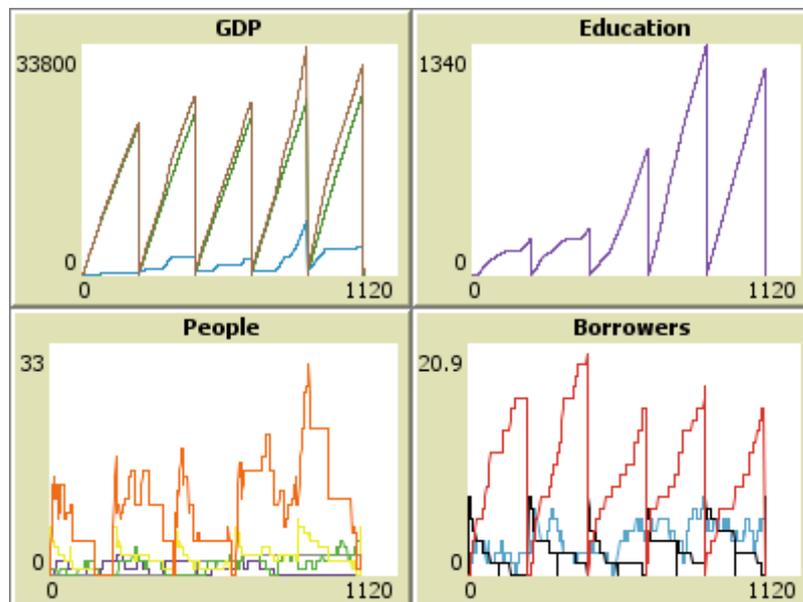
In the second one, we consider a situation where the microcredit institutions are quite nearby to the bank. In the first part, there are a limited number of borrowers from the microcredit institutions and most of them become only consumers or students (there is an increase in the value of “education”).

It means that almost all the entrepreneurs are bank borrowers: we can see it in the “People” graph where the line representing the number of entrepreneurs follows the same evolution of the line representing the number of bank borrowers in the “Borrowers” graph.

The GDP is almost composed only by consumptions, that are high although there are few loans given, because leaders, entrepreneurs and employees consume a lot.

After 500 ticks the values change, so there is the number of loans provided by microcredit institutions increases and becomes stable around a value, as we can see in the “Borrowers” graph.

As a consequence, the number of employees increases with the number of the entrepreneurs that are microcredit borrowers. There are not relevant changes in the number of students, but in this second part of the observation, most of them become leaders and it causes an increase in the value of “education”. In the meantime, the GDP has a peak, because there are more loans and therefore more investments and a small growth in the consumptions.



In conclusion, we can observe that the GDP increases when the financial institutions gives more loans, because it affects the investments (especially loans from the bank) and when there are more entrepreneurs and leaders, because they are the people with the highest level of consumptions.

We can also notice that the effects produced by making changes in the considering variables on the GDP depend on the characteristics of the clients, because we have considered the same situation for two different set of people and the results are very different.

In the first experiment, the bank actualizes a strategy to control the money in circulation, extending the possibility to obtain the loan. It could be due to the fact that a lot of countries where financial institutions operate have a high level of poverty and this change allows people to try to improve their condition and become more able to start more advanced activities with the available resources.

In the second experiment, the microcredit institutions try to protect themselves from people that are not able to repay their debts by limiting the access to the microcredit. This choice does not help people to fight the poverty, quite the contrary. Although, the GDP increases reaching peaks not so different respect to the other case. It means that in this case the financial institutions try to help the poor but not the poorest of the poor.

Simultaneously with this decision, the microcredit institutions could promote a financial literacy program to teach the basic notions of finance that allow people to invest and save money in an appropriate way.

Finally, this analysis underlines how the access of a type of loan determined an increase in the GPD, so the economic growth is proportional to the amount of money made available to the population, in relation to the knowledge that they have about how works the financial system.

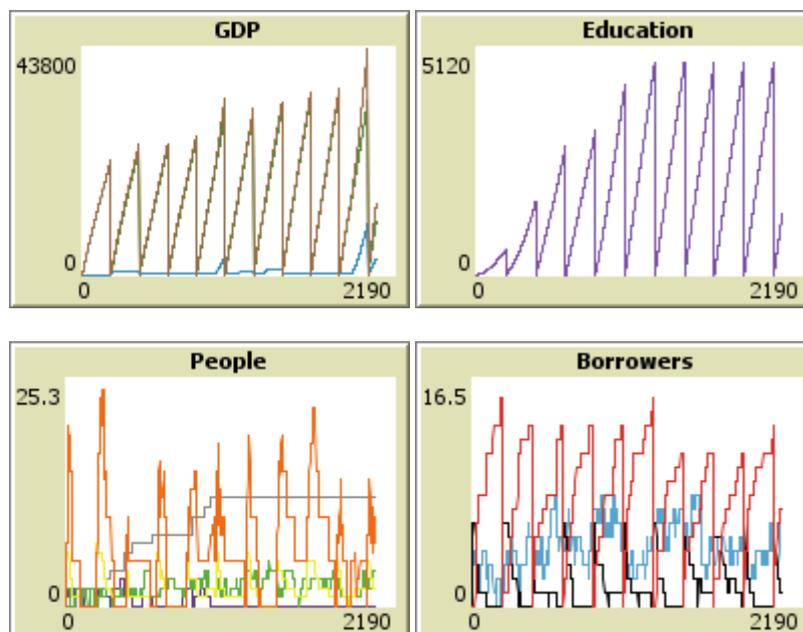
2) loan_size, micro_size, int_loan, int_micro thresholds experiments

In order to better represent the reality, we have decided that in our model the bank would provide larger loans with a lower interest rate applied to it and that the microcredit institutions would offer a smaller credit asking back a higher interest rate. We start from a situation where the loan offered by the bank is equal to 70 (money) with an interest rate equal to 1%; the microcredit institutions offer a loan equal to 50 (money) with a 3% interest rate.

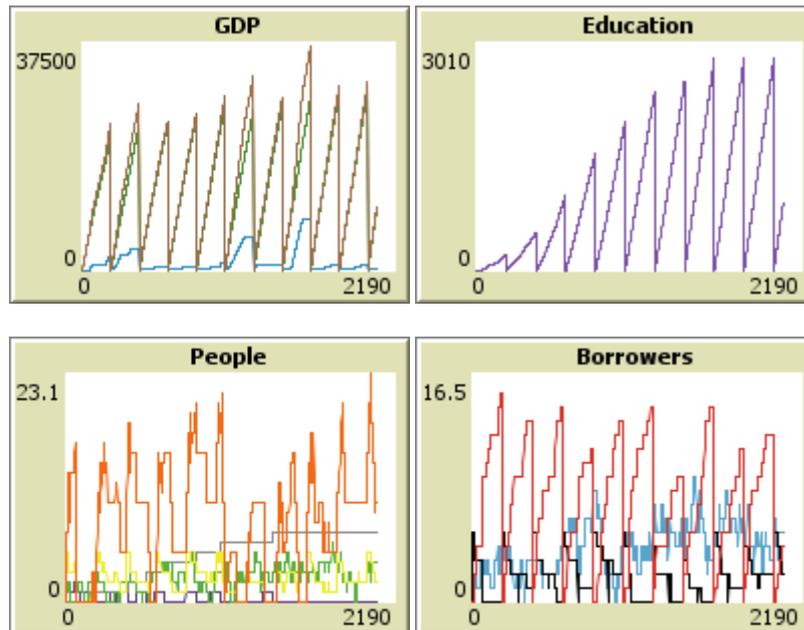
But how can we understand if those values help or not the economy of our artificial world? This is the reason why we have decided to do experiments with these variables.

This is the initial situation of our model, with a loan's size of 70 and an interest rate equal to 1%, a microcredit's size of 50 with a correspondent interest rate of 3% (after 2000 ticks more or less).

Our outputs change continuously according to the characteristics of the agents. So actually this should be a good representation of the reality; every time is unpredictable, the education is higher or lower according to the number of agents who want to become students or entrepreneurs, as the GDP that is higher or lower according to the amount of money spent in investments (to build firms) or in consumption (with the key role of the consumption derived from the education's expenditure). In the first four plots below we can see such representation of our model's behavior.



This is one possible scenario. 10 leaders, very high education level, very high GDP basically due to consumption, 4 entrepreneurs.

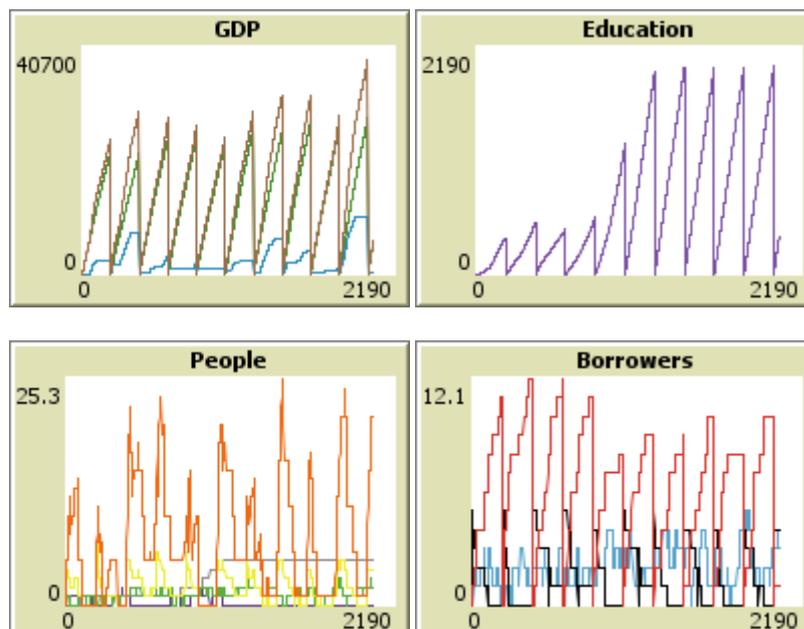


This is another possible scenario. 7 leaders and 6 entrepreneurs. Education is not so high as before. Investments are higher than before.

We can compare these pictures with others developing different situations in order to understand which situation could be better for our GDP.

FIRST EXERCISE

We can *increase the size of the credits*. Now the bank's loan is equal to 90 and the microcredits' one is equal to 70. Suppose the interest rates do not change; they are still 1% for the bank and 3% for the microcredit institutions.

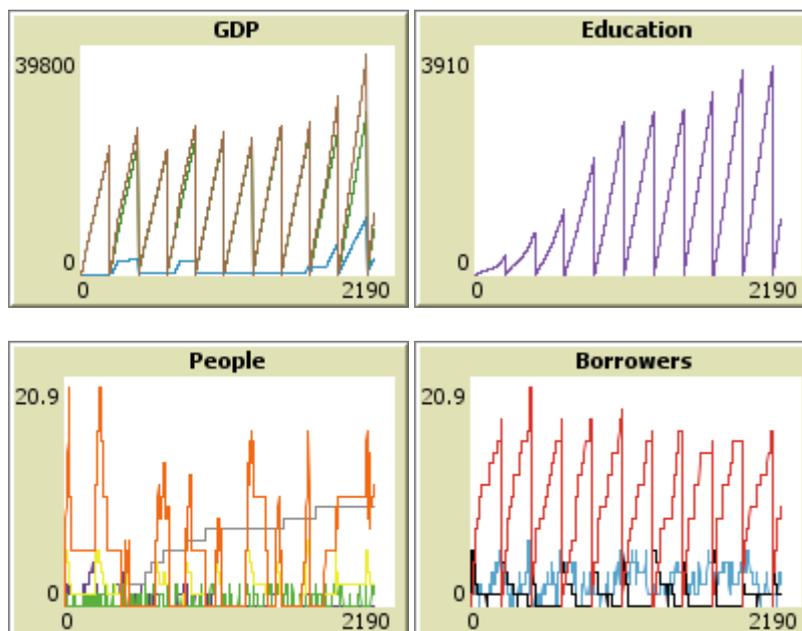


Receiving more money than before without asking also a higher interest rate provokes on one side less defaults of the entrepreneurs (that are generally more than the students – reason why the general amount of defaulters has been reduced), on the other side more defaults of the students. They have to pay back too high principal without earning anything. This is the reason why the leaders are so few with respect of the previous case and also the education has lower values. The negative effect of the lack of educated agents (6 leaders in this case versus 10/7 of the previous ones) compensates the positive effect of an higher number of entrepreneurs (9 in this case versus 4/6 in the previous ones) given the larger amount offered also by the bank and the result in the GDP is that there is not so much difference comparing to the scenario above.

SECOND EXERCISE

Now we have decided to leave the loan size as the initial situation (50 for the microcredit institutions and 70 for the bank) but to *increase the interest rate of the microcredit institutions* to the 20% of the loan.

These are the results:

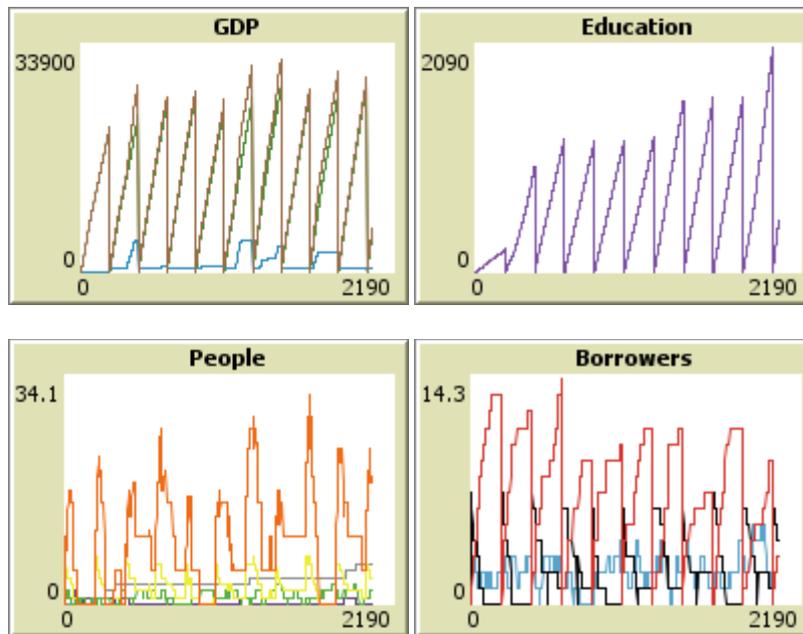


In this case the number of leaders is higher (9 of this experiment versus 6 of the previous one), the number of the entrepreneurs is lower (5 of this exercise versus 9 of the previous one) and the number of defaulters is higher. Actually it seems that the number of educated people is not affected by the increase of the interest rate of the microcredit institutions but still there are more defaults than before.

Given these different scenarios we can draw one conclusion. Actually, since the students can pay their debt not only with their income but also with their initial wealth, in contrast with all the other agents that repay the principal and the interest rates just using their income, if the size of the microcredit has been increased, the students have more difficulties than the entrepreneurs in repaying the principal back and do default more often (since they can repay with their wealth but they do default quickly); instead if the interest rate of the microcredit has been increased, there would be more default by the entrepreneurs, who have to pay back the interests just using their income.

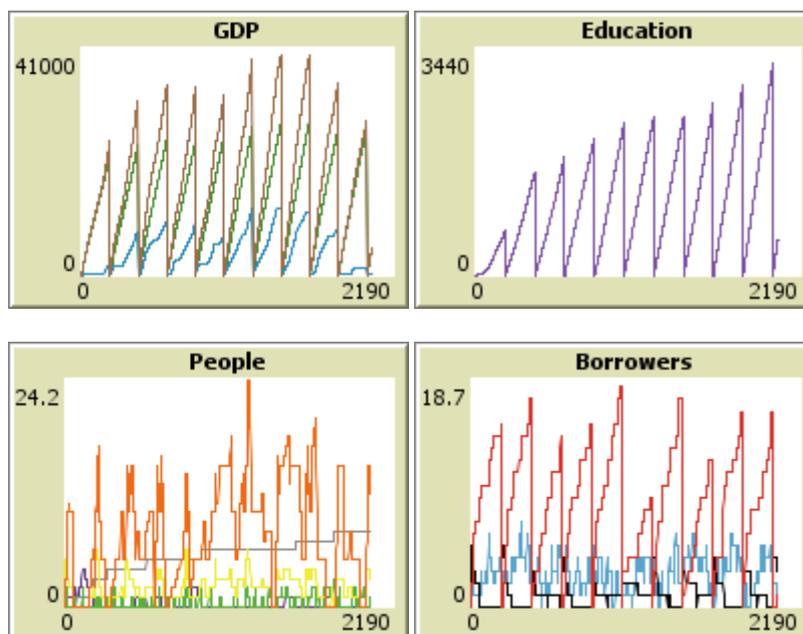
The following graphs illustrate better the two situations in which we have just an increase of the microcredit size and then just an increase of the interest rate asked by the microcredit institutions.

INCREASE OF THE MC SIZE (70 micro, 70 loan)



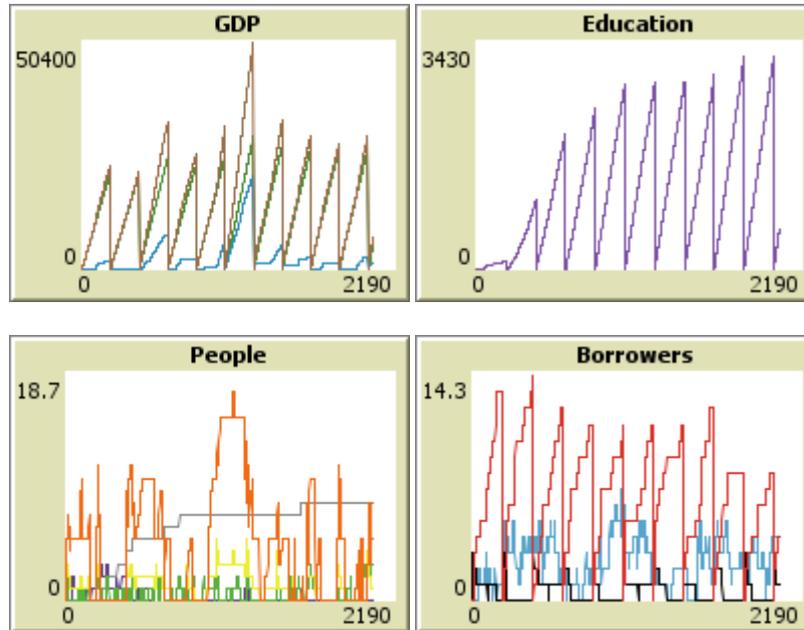
6 entrepreneurs, 5 leaders

INCREASE OF MC INTEREST RATE (20%)



6 entrepreneurs, 8 leaders

For this reason, the best recommendation in order to let the GDP of the country grow with a long term view, i.e. investing in education, is to increase a bit more the interest rate asked by the microcredit agencies, so that less students would do default and could grow as leaders. This is the case with the interest rate equal to 10%:



8 leaders, 5 entrepreneurs.

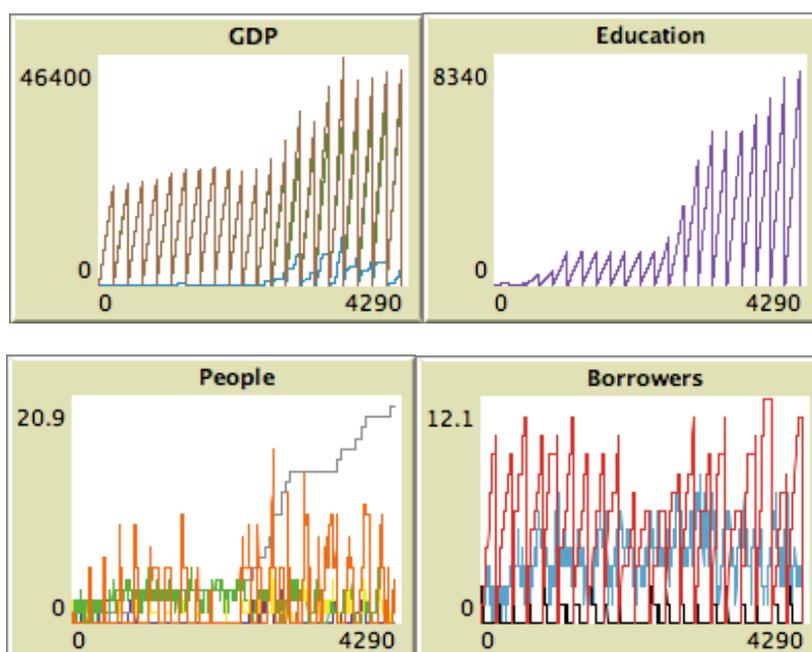
3) financial_illiteracy, risk_propensity thresholds experiments

The following experiments focus on two innate characteristics of the people: the propensity to risk and the financial literacy. We will see what is the effect of changing the thresholds above which a behavior is triggered, different than that typical of values below the threshold. In particular:

- For values below the financial illiteracy threshold, people will apply to the “bad microcredit” institution (that will bring only higher consumption) but not to the “good microcredit” one, because they are more ignorant about finance, and vice versa for values above the threshold;
- Among people applying to the good microcredit (the bounded one), those with a risk a propensity below the set threshold will invest the loan in a new firm and become entrepreneurs, while those above the threshold will invest in education, become students and, hopefully, leaders.

FIRST EXERCISE

We set an intermediate level (50 on a scale from 0 to 100) for the risk propensity threshold and focus on the financial illiteracy: with a low threshold (e.g. 20) most microcredit borrowers will apply to the bad microcredit institution and not to the good one. What is the effect on the GDP and other variables if we suddenly shift such threshold up to 80?

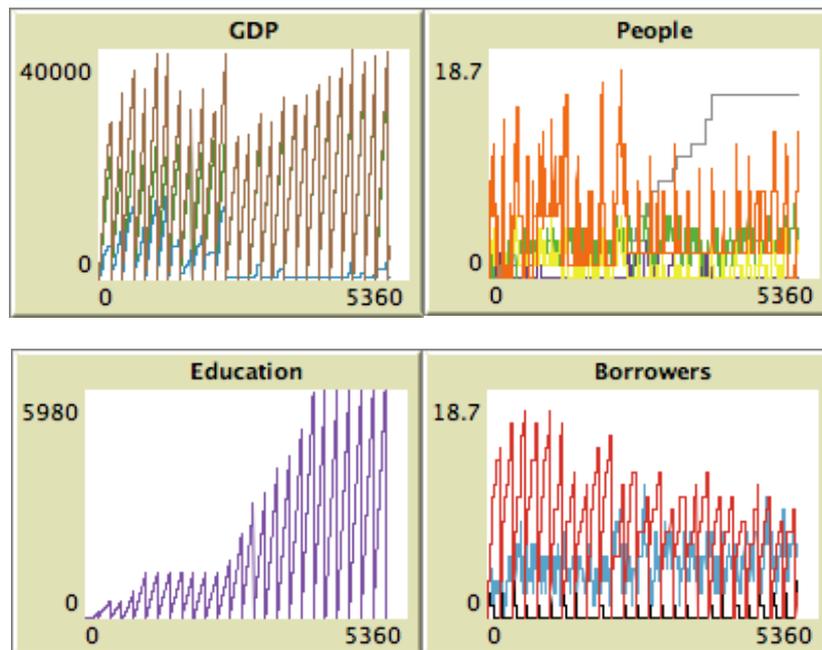


As expected the GDP started to increase and almost doubled: this happened because both investments in physical and human capital jumped (see the “GDP” and “Education” plots), more people became entrepreneurs, students and then leaders, or were hired. Curiously, this was not followed also by a reduction in the average number of defaulters (red line in the “Borrower” graph): apparently the reduced number of bad microcredit defaulters (who increased consumption over their possibilities) has been balanced by the rise in the number of defaulters on good microcredit loans (students and entrepreneurs).

The main policy implication here is that financial literacy matters: an increased cost for the Government of financial education programs can be more than offset by better investment decisions by borrowers, thus boosting output in the long term.

SECOND EXERCISE

Here we focus only on good microcredit borrowers. We set an intermediate level (50 on a scale from 0 to 100) for the financial illiteracy threshold and change the risk propensity: with a high threshold (80) most good microcredit borrowers will become entrepreneurs and not students. What is the effect on the GDP if we then decrease such threshold to 20? Will investments in education bring more added value than new firms?



In the “Education” graph we notice the sharp increase in the level of human capital brought about by the downshift of the threshold for risk propensity, which is accompanied by the gradual increase in the number of leaders and decrease in the number of employees (see the “People” graph). To be noticed also the diminishing number of defaulters, which is due to the drop of entrepreneurs failing to repay their debt. After the shift of the threshold, also many new students will default on their loans, until they all become leaders and do not default anymore: this explains the *gradual decrease* of the red line.

The most interesting result, however, is the sudden drop of GDP due to the smaller amount of investments in production, then followed by a constant recover, up to the levels of output before the change. This could be then interpreted as follows: investing in education can lead to the same level of GDP as investing in production (depending on the borrowers’ preferences determined by the risk propensity threshold), but it takes more time.

In conclusion, should developing countries adopt policies to foster investments in physical or human capital? The answer is two-fold: on one hand new firms bring immediate advantages in terms of output and employment, and in many cases the timing of results may be even more important than their magnitude. On the other hand, adopting a long-term perspective, investing in education yields the same level of GDP together with a drop in the number of the defaulters, increasing the stability of the financial system, and an upsurge in the accumulation of human capital, increasing the positive externalities due to a more educated population.

EXTENDING THE MODEL

- In our model we have simplified the procedure through which the agents can apply for a loan; actually in the real world loans are given to groups of people, so that credit institutions can have more guarantees of receiving their money due to peer monitoring and peer selection effects (the joint liability derived from group lending leads to the so-called social collateral implying higher incentives to repay). A possible extension of this model can be thus to give loans to networks of people that guarantee their debt through the others.
- We have decided to create just one kind of business (creating a firm) for the agents that would like to be entrepreneurs. Actually in the real world there are different businesses that can be created thanks to the loans received by the financial institutions and they can have of course different risk profile, cash flow and impact on the GDP. It would be then interesting trying to introduce different kinds of business activities.
- We have decided to create a world with 100 agents. An extension of this model could be trying to build a similar world with less or more people, for example by letting them increase their age, die and have new born agents perhaps deciding the number of children as a function of the household's economic situation. It is likely that the results would not be the same.
- Another extension of this model could be to introduce negative shocks, such as a natural disaster or a crisis after a certain amount of ticks: how would the situation change? How would agents react? How many ticks would we need in order to recover a similar situation to the one before the disaster?