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The Students Black Market: an analysis on behaviors

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Abstract

The goal of the model is showing what the results of the investment process in education are in terms of knowledge and grades of students. Therefore, different outputs may be possible according to some changing of the variables. Moreover, how can we end up in the perfect Platonic Academia in which knowledge and grades are consistent contra the dystopia in which grades and knowledge have an inverse relation?

1.0 Introduction[1]

The role commonly attributed to University as an institution is to provide technical and cultural knowledge to its students certifying their skills through an information mechanism easily understandable by external agents and highly reliable thanks to a multiple evaluation made by different agents over time (Stiglitz 1975). Therefore, final grades and evaluations are considered a rough indicator for both the knowledge and the skills acquired by a student during the course of study. Indeed, in a selection process for a job or in the admission requirements to more specialized studies, the quality of how candidates has obtained a certain degree matters. This mechanism of screening for selecting candidates has indeed some costs for the private and the public sector as Arrow pointed out clearly with "Higher Education as a Filter" (1973). Therefore, the positive externalities of high education could be exceeded by the costs. It is also difficult to estimate those positive externalities and they might be easily nullified under some specific circumstances.
Our model is designed in order to explore some of these unfruitful environments to which we refer as "the Students' Black Market". It is the case of an informal market in which agents share past examination questions that they are not supposed to have, creating an information asymmetry in the system. This can display highly negative outcomes for society, when those students enter the labor market. Inspired by Gary Becker's distinction between specific and general training, we enlarge and modify this condition focusing on a negative aspect. Regardless of the importance of the knowledge for the human capital, it may occur that under the pressure of competition among students, intensified by the role of time, the aim of students might turn to be, if anything, the grade only. Once analyzing all those factors incentivizing this negative externality, we highlight the importance of the Socratic Method in teaching. The Socratic Professor has a crucial role in reducing the effect generated by the Student Black Market. Due to the maieutic method he induces students to spread knowledge among each other, arising creativity as a successful method both for passing the exam and for increasing personal competences.

2. The Method and The Assumptions

2.1 Inspiration from Object-oriented modelling

Our program is partly inspired by the Object-oriented approach in "Coordination in Transient Social

1 Note that there is an appendix at the end with an explanation of how we define key notions, concepts and words in this context. If an already existing concept is not further explained it means that we follow the official definition, see for example "Socratic method".

Networks: An Agent-Based Computational Model of the Timing of Retirement" by Axtell and Epstein (1999). Objects, as defined by Axtell and Epstein are are contiguous blocks of memory that contain both *data* ("instance variables") and and *functions for modifying this data* ("methods"). The ability of objects to hold both functions and data operating on data is called encapsulation. In Agent-Based models an object's data is interpreted as an agent's *state information* and the functions as the agents *rules of behaviour*. A population of agents with the same behavioural repertoire but *local state information* can then be implemented as multiple representations of a single agent object type or class. It shall soon be explained how object-oriented elements has been implemented in our model.

Agents as objects

The agents objects has *state variables* and behavioral *methods*. In our model the state of information variables are student type (grade, pass, or knowledge oriented student), two different grades and knowledge levels; one obtained from black market collaboration and one from the positive type of interaction, and network propensity regarding both the positive collaboration and the black market. The behavioral methods are whether or not to participate in networks, and whether or not to end existing network collaboration. This decision is, as previously noted, affected by a random element, and the respective grade and knowledge[2] levels obtained.

As economics students we are quite familiar with modelling representations of behaviours. It therefore comes natural to us to implement these concepts into our own world and experience. We would like to represent our student environment as a market of different possible interactions. In order to do so, we will use NetLogo 5.1.0 programming. In this modelling we have been inspired by the available programs of our classmates that we thank a lot.

The agents in the market are professors and students, obviously with various individual features to which we shall return shortly. The students' behaviours revolve around the availability of course material needed to either pass, achieve top grades in the course and/or obtain knowledge about the subject. We assume a dichotomy in the material available due to the presence of "black" unofficial material (such as past exams from older students, solutions from other students and general notes) and official material given without any significant asymmetry to students. We also consider knowledge as a gathered ability of understanding and reprocessing in a critical way given information. According to this, it is consistent to assume that two possible type of knowledge arise:

2 If the student is knowledge oriented

the one from the black market (SBMknowledge) and the one from normal academic interactions (Nknowledge). This is because we believe that other possible kinds of general understanding can arise in conditions of black market too. A small example to be more realistic: from the black market, students may learn how to be efficient in time limited conditions or how to behave in a competitive world. Even if it doesn't increase the knowledge strictly related to the course of study, it is still an ability gained.

One of our main assumptions related to students is dividing them upon three different aims:

1. there are students maximizing their grades regardless of the knowledge gained in the process of education
2. there are students aiming at arising their knowledge
3. students whose target is only passing the exams

To do so, we have implemented the following command: *breed [type of students type of student]*[3]. This enables us to define different "breeds" of turtles that are the agents of the program.

Moreover, we assume the existence of three types of links that arise from the relations of agents in the environment. We define therefore the following:

- *undirected-link-breed [SBM-networks SBM-network]* to depict the student black market types of collaboration in spreading unofficial material.
- *undirected-link-breed [link-networks link-network]* to represents "positive" collaboration between students
- *directed-link-breed [Pro_networks Pro_network]* professors' links to students. It is our deep belief that those kind of relations are crucial to arise knowledge and to encourage students to develop positive relations and cooperation forms.

Those relations have been implemented through the following code:

```
ask grade_students
[     set shape "person"
  set color 85]

ask know_students
[     set shape "person"
  set color 95]

ask pass_students
[     set shape "person"
  set color 105]
```

```
ask turtles with [shape = "person"] [
set net_alt random(10)
set net_social random(10)
set net_time random(10)
set Ngrade 0
set SBMgrade 0
set Nknowledge-1 1 + random(10)
set Nknowledge Nknowledge-1 + random(10)
set SBMknowledge 1 + random(10)
setxy random-xcor random-ycor
```

We ask all students to be of the same shape ("person"), in order to later be able to use subsets to ask all the students to perform the same task. In some cases we want the student's behaviour to depend on which kind of students they are. There will be some examples of this later in the text.

3 Respectively: grade_students, pass_students and know_students.

```
ask turtles with [shape = "person"] [
  set networking random(100 + net_social + net_time + net_alt + Socratic_approach - Scholarships)* 0.1
  set SBM_networking random(100 + net_social - net_time + exam_type - Socratic_approach + Scholarships - Official_material)* 0.1]
ask professors [ set pro_networking random(10 + Socratic_approach + availability + Creativity_level)* 0.1]
```

All the students have a randomized propensity between 0 and 99 of creating a fruitful network that is going to be positive related to the sociality, the time available for studying, the altruism and the Socratic approach[4]. We do believe instead that the presence of scholarships in the university world, even if it helps the flourishing of capabilities in the presence of inequality of opportunity (Sen), it affects negatively their propensity in sharing and cooperating in positive network due to the presence of strict requirements of grades, credit and deadlines. Reversely, the presence of scholarship is assumed to be highly relevant in a more competitive market, the one of black notes and mock exams, since it represents a unfair vehicle through which achieving personal goals faster and with ease. The presence of official material spread directly by the University system of course reduces the emerging of such a market.

For what concerns the presence of time, we allow this variable to enter with different sign. The idea is that if students have really a lot of time to dedicate on their studies they would probably try to establish profitable relations and they are not so incentivized to go for the black market that normally exhibit higher level of volatility.

Professors instead form their networking initial propensity according to a random number from one to ten plus some level alterable in the interface. Another variable which has a crucial role in developing the emerging of the perfect Platonic Academia[5] is creativity as a broad behavioural concept of openness. We assume that the more open professor are, the more incentivized they are to arise this characteristic among students too. Their creativity is thought separated by the way they develop the exam type.

According to this variable that takes values in a set $A = \{[-100,100]\} \setminus \{0\}$ if the exam takes negative values, it is highly foreseeable by students (the type of test repeats frequently over time). The reverse obviously occur. Since we consider students as rational individuals, we believe that even those students that are interested in gaining knowledge are fascinated by the possibility of having an easier chance to reach higher grades. For this reason we assume that the variable exam_type enters with the same sign in the way students count their levels of both networks.

```
to setup-turtles
  create-grade_students 5 + random(10) + Sample_of_students
  create-know_students 5 + random(10) + Sample_of_students
  create-pass_students 5 + random(10) + Sample_of_students
  create-professors 1 + random (7) + Sample_of_professors
```

Before the relations among agents starts, we allow for a random number of students and professors entering the market, controlling for the presence of at least one professor and 15

4 Since it requires a greater effort for students.

5 A world in which all the positive condition arise: maximum level of creativity, Socratic approach, availability of professors, unpredictable exams and minimum presence of scholarships.

students. Since results might turn differently according to the size of the sample of agents, we have decided to include a slider in order to make it possible to differ the number of agents interacting by shifting the slider in the interface. Moreover, to ensure the presence of a various and realistic setting, we choose randomly initial values of students' propensity to collaborate in the two types of collaboration defined above.

The propensity is set according to: altruism, sociality, time available for collaborations. Every individual is also created with an empty endowment of grades but a small (from 1 to 9) base of knowledge which can be thought as a background from high school. Since a minimum level of knowledge of any type is commonly present among individual, we set 1 as a not random minimum level. This we will turn to be helpful to avoid mathematical mistakes in further formulas in the model. Among the elements settled there is a "lag" variable of knowledge in both of our markets. This is extremely important due to our assumption of knowledge acquisition behaving with autoregressive path of order 1 plus a randomly, unpredictable and range limited element. The different type of students in the market are recognizable thanks to different colours: intense blue (for pass students), light blue (for pass students) and very light blue (for knowledge students).

```
ask professors
[ set shape "person graduate"
  setxy random-xcor random-ycor
  set color 125
  set networking 0
  set SBM_networking 0
  set available availability
  set socratic Socratic_approach
  set creativity Creativity_level]
```

We also randomize the professors' propensity to help students by interaction. Professors are represented as persons with mortarboards without any relation at the beginning (since interactions applies after the go process is run). They create their connection in relation to their office hours availability which we assume to be limited thanks to the following command: if random-float(500) < 100 [ask pro_networks [die]] . The random-float reports a random floating number up to a level of 500. If this number is less than 100 the relationship created between the students and the professors stops happening. We have created some sliders to modify the level of availability, Socratic approach and creativity in order to allow the user to interact actively within the environment. This decision has been moved by our idea that those are the very characteristics determining the likelihood of the emerging of a market or the other.

```
to evaluate
if random-float(1000) < 100 [
ask pass_students[ if Ngrade < 18 [ask my-link-networks [die]]]
  ask pass_students[ if SBMgrade < 18 [ask my-SBM-networks [die]]]
ask know_students[ if Ngrade < 25 and Nknowledge < 10 [ask my-link-networks [die] ]]
  ask know_students[ if SBMgrade < 25 and SBMknowledge < 10 [ask my-SBM-networks [die]]]
ask grade_students[ if Ngrade < 27 [ask my-link-networks [die]]]
  ask pass_students[ if SBMgrade < 27 [ask my-SBM-networks [die]]]]
end
```

As well as it happens for the links between professors and students, also the relationship between students can vary. To do so, we implemented the following command that allows for the possibility of a certain type of link to die according to students grade performance. After participating in a network and taking an exam there is a 10 % chance that they evaluate whether to leave the network, according to their results of grade and knowledge. In the case of knowledge oriented students, there is a double condition to be satisfied simultaneously though an "*and*" condition. Students break their links if they receive a grade lower than 25 and they reach a normal knowledge less than 10.

2.3 Some comments on an extension used

```
to betweenness
    nw:set-context turtles links
  ask turtles [
    let res0 nw:betweenness-centrality
    if is-number? res0 [set label res0
      set label precision res0 5]]
end

to clustering
  nw:set-context turtles link-networks
  ask turtles [
    let res2 nw:clustering-coefficient
    set label res2
    set label precision res2 5]

end
```

From the first line of the code it can be noticed we have been exploiting the *nw* extension. It is the case of an extension that provides network analysis of primitives. It is a new version with the respect to the one used in NetLogo 5.0.5. Compared to the previous one, this new edition offers some elements helpful in explaining our results. Among this we highlight the centrality measure to calculate the betweenness centrality and the clusterer so as to find weak component clusters in your network.

We found useful to add this measure to derive some conclusions relevant as our network develops.

The betweenness command calculates the betweenness-centrality of a turtle taking every other possible pairs of turtles and, for each pair, calculating the proportion of shortest paths between members of the pair that passes through the current turtle. When the size of our sample students increases most of the betweenness label measure display value 0, indicating that there are too many connections to highlight the presence of a shorter path, therefore the size of relationships among individuals are uniform.

The clustering command, instead, reports the local clustering coefficient of the turtle. The clustering coefficient of a node measures how connected its neighbors are. It is a ratio value in the [0,1] interval since it is the number of links between the node's neighbors divided by the total number of possible links between its neighbors. The nw:clustering-coefficient takes the directedness of links into account. A directed link counts as a single link whereas an undirected link counts as two links. With this way we can

```
to l-circle

  ask grade_students [ set label Ngrade ]
  layout-circle sort-on [ Ngrade ] grade_students max-pxcor * 0.8
  ask pass_students [ set label Ngrade ]
  layout-circle sort-on [ Ngrade ] pass_students max-pxcor * 0.7
  ask know_students [ set label Ngrade]
  layout-circle sort-on [ Ngrade ] know_students max-pxcor * 0.6
  ask professors[ set label pro_networking ]
  layout-circle sort-on [ pro_networking ] professors max-pxcor * 0.45

end
```

derive some consideration about the increasing or decreasing propensity to generate links between agents.

In order to visualize the relationship in an easier way, we created a bottom in order to organize the students in a circle with the professor in the center, recalling simultaneously the importance of the circle in the ancient Greek world as a symbol of perfection and having so an easier glance on the concentration of the links between agents.

Depending on the networking propensities, students will invite and accept network and SBM network invitations. Students who are mainly interested in grade have a lower threshold value for inviting others to network. Network links are pink and black market networks links are black. When participating in networks, students obtain different types of knowledge from the different types of networks.

```
to invite_to_network
  ask grade_students [ if networking > 10
    [ create-link-networks-with other turtles with [networking > 20] in-radius random(100) [set color pink]]
    obtain_Nknowledge]
  ask pass_students [ if networking > 30
    [ create-link-networks-with other turtles with [networking > 35] in-radius random(100) [set color pink]]
    obtain_Nknowledge]
  ask know_students [ if networking > 30
    [ create-link-networks-with other turtles with [networking > 35] in-radius random(100) [set color pink]]
    obtain_Nknowledge]
end

to invite_to_SBMnetwork
  ask grade_students [ if SBM_networking > 10
    [ create-SBM-networks-with other turtles with [SBM_networking > 20] in-radius random(100) [set color black]]
    obtain_SBMknowledge
    ]
  ask pass_students [ if SBM_networking > 30
    [ create-SBM-networks-with other turtles with [SBM_networking > 35] in-radius random(100) [set color black]]
    obtain_SBMknowledge
     ]
  ask know_students [ if SBM_networking > 30
    [ create-SBM-networks-with other turtles with [SBM_networking > 35] in-radius random(100) [set color black]]
    obtain_SBMknowledge
    ]
end
```

Knowledge from the positive networking is obtained as a function of the level of contact with professors (which is obtained through professor networks) and its own growth rate. We model the changes in knowledge in this manner because we make the assumption that the more knowledge one has on a subject, the harder it is to reach higher levels; the improvements are diminishing as the total value of knowledge increases.

$$\Delta NK = professor\ contact + \frac{NK - NK_{t-1}}{NK_{t-1}}$$

$$\Delta SBMK = unofficial\ material - \frac{NK - NK_{t-1}}{NK_{t-1}}$$

Where NK is knowledge from the positive networking and SBMK is the knowledge from the student black market.

The impact on knowledge from the student black market is negative. We assume this since there will be less time for obtaining knowledge for a student who focuses on path dependent exams and so called "learning by heart". The higher the growth rate of knowledge in the "positive" participation market, the lower the knowledge you need from the black market. Instead, the positive effect on knowledge and grades comes from obtaining unofficial material. We assume that the domain of the knowledge is bounded between [1, 100]. This might seem strange, but is explained by the fact that we assume this knowledge not to be the overall knowledge of students, but the knowledge relevant for an exam subject. In principle, depending one how one views human nature, knowledge could be infinite, but there is a finite part of this possibly infinite knowledge which can be used in specific exams. A clarifying example is the fact that a person can know all there is to know about for instance dinosaurs or cat food, but there is a very low probability that this information will be useful in an Econometrics exam.

```
to obtain_Nknowledge
  set Nknowledge Nknowledge + pro_contact * 0.1 + 0.25 * (((Nknowledge - Nknowledge-1) / Nknowledge-1))
  if Nknowledge > 100 [ set Nknowledge 100 ]
  if Nknowledge < 1 [set Nknowledge 1 ]
  obtain_Ngrade
end

to obtain_SBMknowledge
  set SBMmaterial 0
  set SBMmaterial SBMmaterial + random(10)
  set SBMknowledge SBMknowledge + 0.2 * SBMmaterial - (((Nknowledge - Nknowledge-1) / Nknowledge-1))
  if SBMknowledge > 100 [set SBMknowledge 100]
  if SBMknowledge < 1 [set SBMknowledge 1]
  obtain_SBMgrade
end
```

The amount of unofficial material (SBMmaterial) is reset to zero every time a student participates in a new network and takes a new exam. This is because we assume that the material is linked to specific exams; since it is though of as material such as exam questions and solutions.

Both kinds of knowledge enters positively into the networking grade and material enters positively into the SBM grade. Students with a greater level of knowledge when taking the exam will have a greater coefficient.

$$Grade = f\left(Knowledge\,,\, SBM\ knowledge\,,\, professor\ contact\,,\, official\ material\,,\, Socratic\ approach\right)$$

$$SBM\ Grade = f\left(Exam\,type\,,\, SBM\ material\right)$$

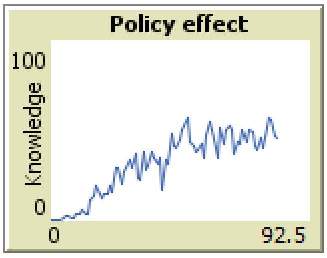
```
to obtain_Ngrade
  set Ngrade 0
  if Nknowledge > 75[
  set Ngrade Ngrade + random(3 * Nknowledge + SBMknowledge + pro_contact + Official_material + Socratic_approach) * 0.5 - random(2) + random(2)]
  if Nknowledge < 75 [
  set Ngrade Ngrade + random(2 * Nknowledge + SBMknowledge + pro_contact + Official_material + Socratic_approach) * 0.2 - random(5) + random(5)]
  if Ngrade > 30 [ set Ngrade 30 ]
  if Ngrade < 0 [ set Ngrade 0 ]
  ask pass_students [if Ngrade >= 18 [
      set networking networking + 10 + random(50)]]
    if Ngrade <= 18 [ set networking random(10)
      set networking networking - 10 - random(100)]
  ask grade_students [if Ngrade >= 27 [
      set networking networking - Scholarships + 10 + random(50)]
    if Ngrade <= 27 [ set networking random(50)
      set networking networking - 10 - random(100)]]
  ask know_students [if Ngrade >= 25 and Nknowledge > 100 [
      set networking networking + 10 + random(50)]
    if Ngrade <= 25 and Nknowledge < 100 [ set networking random(10)
      set networking networking - 10 - random(50)]]
  evaluate
end
```

To both the functions we have added a random negative and a random positive value between zero and one and zero and five respectively for the students of higher and lower knowledge when obtaining the grade and between zero and nine for the SBM grade. This represents luck or bad luck in our model. For instance it is possible that a student who studied well has a bad night of sleep before taking the exam, or was in a fight with a friend, or something else outside of the model. As mentioned earlier, the outcome in terms of grade and grade and knowledge (for the knowledge students) will affect the students propensity to participate in the respective networks.

```
to obtain_SBMgrade
  set SBMgrade 0
  set SBMgrade SBMgrade + exp(random(15) - 0.1 * exam_type + 0.25 * SBMmaterial) + random(10) - random(10)
  if SBMgrade > 30 [ set SBMgrade 30 ]
  if SBMgrade < 0 [ set SBMgrade 0 ]
  ask pass_students [if SBMgrade >= 18 [
      set SBM_networking SBM_networking + random(10) + 0.5 * SBMknowledge]
    if SBMgrade <= 18 [ set SBM_networking random(40)
      set SBM_networking SBM_networking - random(40)]]
  ask grade_students [if SBMgrade >= 27 [
      set SBM_networking SBM_networking + Scholarships + random(10) + 0.5 * SBMknowledge]     ;Grade studen
    if SBMgrade <= 27 [ set SBM_networking random(10)
      set SBM_networking SBM_networking - random(40)]]
  ask know_students [if SBMgrade >= 25 [
      set SBM_networking SBM_networking + random(10) + 0.5 * SBMknowledge]
    if SBMgrade <= 25 [ set SBM_networking random(40)
      set SBM_networking SBM_networking - random(40)]]
  evaluate
end
```

For pass students the grade threshold deciding whether the effect on networking will be positive or negative is 18. For the grade students it is 27 and for knowledge students it is 25 and value of knowledge above 100. In other words, they will only find it fruitful to participate if they reach the maximum level of knowledge.

2.3 The policy effect and its interpretation



Policy effect is defined by the following function where $\overline{NK}$ is the mean of network knowledge obtained by the students and $\overline{SBMK}$ the mean of the student black market knowledge obtained by the students, N_L is the number of network links and SBM_L is the number of black market links.

$$PE = \overline{NK} * \left(\frac{N_L}{N_L + SBM_L}\right) + \overline{SBMK} * \left(\frac{SBM_L}{N_L + SBM_L}\right)$$

In the interface it is shown in a plot. By changing the values of environmental variables with the sliders the user can see how much effect policies to promote knowledge have on the knowledge in the model. It can obviously also be seen how useful policy is in different state of worlds. The Y-axis from 0 to 100 shows how great the impact of policies are and the X-axis shows time.

3. Results

Let's assume we have developed this research in order to help a decision maker to improve an educational system affected from a SBM mechanism. The aim of this reform is to restore an efficient educational system that rules out the distortions induced by SBM and at the same time provides students with suitable technical and cultural tools; the ruler can choose how to allocate funds in order to achieve his purpose, in particular he can decide whether increase the scholarship availability (enlarging their income and reducing the opportunity cost of studying, students will have the chance to spend more time at studying rather than working, for instance) or raise the quantity of Socratic Professors in the system. It's quite easy to show that this second strategy would have a positive effect on some environmental variables of the model: the more Socratic Professors are hired in the system the more likely creativity, availability (in term of office hours) and the variability of exam typology will increase.

In other words, we could consider the ruler as a benevolent central planner that intend to maximize the student's stock of knowledge under the limit of a budget constraint that forces him to find the optimal funds allocation among the scholarship availability and the hiring of Socratic Professors.

In order to discuss the final results from our model and provide policy advices to the the Dean or the Ministry, we need first of all to illustrate the model behaviour under some specifications of the external environment (Scholarships, Creativity, Exam Type, Socratic Approach....).

We focus the analysis on three states of the world we consider pivotal to understand how the model runs and how it could help the decision maker to implement an effective policy. The differences in the knowledge outcome among these three scenarios is induced from a deviation in the level of some environmental variables that the central planner (or the Netlogo user) is able to modify using the sliders.

We recall one of the model fundamental assumption stating that the Scholarship availability and the quantity of Socratic Professors affect the SBM-networking propensity and the usual networking predisposition of students in two very different way.

SBM-networking propensity, which identifies the student's inclination to join the Student Black Market, is influenced negatively from the Socratic approach of professors and positively from the number of scholarship available in the market. Intuitively, this result comes from the idea that SBM mechanism is the more efficient vehicle to get an high grade at the exam in a time limited condition. It's not hard to understand why this structure perfectly matches the needs of those students that own a scholarship, since they must pledge to satisfy the requirements in terms of time and grades to maintain their privileges. On the other hand, the maieutic approach overcomes the

SBM mechanism by inducing students to build up their creative skills and critical thought.
In a certain way, it forces them to cooperate to deal with difficult problems favouring the attitude of spreading knowledge and developing innovative solutions. Consistently, we face the opposite effect for N-networking, that describes all those social relationships that allow students to create networks for collaboration and the spread of knowledge. The Socratic approach boosts this type of network, for the reasons outlined above, while the availability of scholarships favors competition among students, reducing the chance of sharing knowledge and building relationships of mutual assistance in study. Before analyzing the three scenarios set out in this paper, it should be useful to focus on other environmental variables included in our model. In particular, we could appreciate the positive correlation between the number of professors with Socratic approach within the network, and creativity, availability (in the term of office hours) and variability of exam typology.
The Socratic approach makes these teachers more likely to adopt teaching strategies that aim to develop the individual abilities of each student.
To achieve this purpose, they endorse the improvement of critical and creative thoughts, developing types of examination that cannot be predicted trough the SBM and providing support through a greater office hours availability than other Professors. The latter, which the model does not consider, have a less didactic and more professional approach to education. For a lack of time or aptitude, they care less about educational aspects described above, preferring evaluation and examination methods that are repetitive and standard; consequently they involuntary stoke the SBM mechanism.

3.1 The Three Scenarios

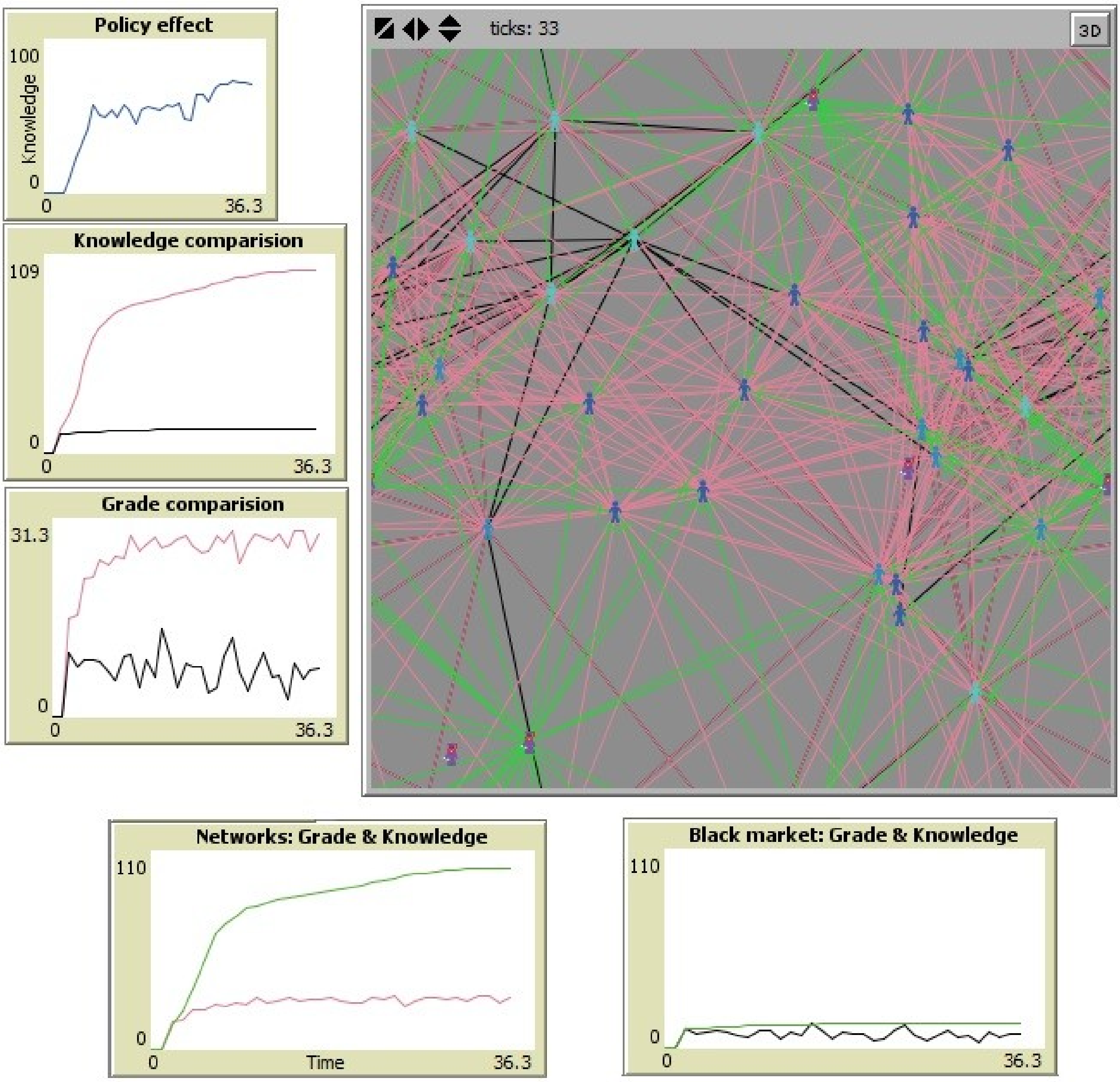


Figure 1

The first state of the world, called Utopia, is the perfect scenario in which all the environmental variables are exogenously set in the more suitable way to maximize the stock of knowledge. In particular, consistently with paragraph 3.0, the model is set in order to maximize the Socratic approach and the number of Socratic Professors, ruling out at the same time any positive amount of scholarships in the system. The variables “creativity”, “exam typology” and “availability” are set to the highest possible level (100), for the reasons outlined above. The number of students in the society is set up at the median value of the range contemplated by the model (12). The data shown in Figure 1 illustrate and compare the trends of "knowledge", "grade" and "policy effect on knowledge" variables. We report the values obtained by analyzing the distributions.

Table 1: ***Grade, knowledge and standard deviations for N-netw.***		
N-grades (exp. value)	N-knowledge (exp. Value)	Standard deviation of N-grades
28.791	100	0.71

Table 2: ***Grade, knowledge and standard deviations for SBM-netw.***		
SBM-grades (exp. value)	SBM-knowledge (exp. value)	Standard deviation of SBM-grades
7.615	13.695	6.42

We note that the correlation among the variable "grade" and variable "knowledge" is strongly consistent. The Students that join the N-network expand their skills and their knowledge at maximum level contemplated by the model (100). Their votes are distributed around a reasonably high average (28,791 / 30) with a relatively low standard deviation, reckoning with the Professors make use of different and unpredictable methods of examination.

The students who join the SBM are in serious trouble. They have a level of knowledge and skill that is about one-tenth of that of the N-Netw colleagues, and the distribution of their votes has mean 7.615 / 30 with a standard deviation quite high, due to the unpredictability of the examination. These conditions, illustrated graphically in Figure 1, provide no incentive to enter the SBM mechanism, which turns out to be ineffective and inefficient. We consider the Utopia scenario as the Utilitarian Benchmark of the model, since it minimizes the impact of SBM on the average level of knowledge achieved by the students, which reaches the maximum value of 70/100 (look at the graph of policy effect in figure 1) . Of course results change according to the drawn sample.

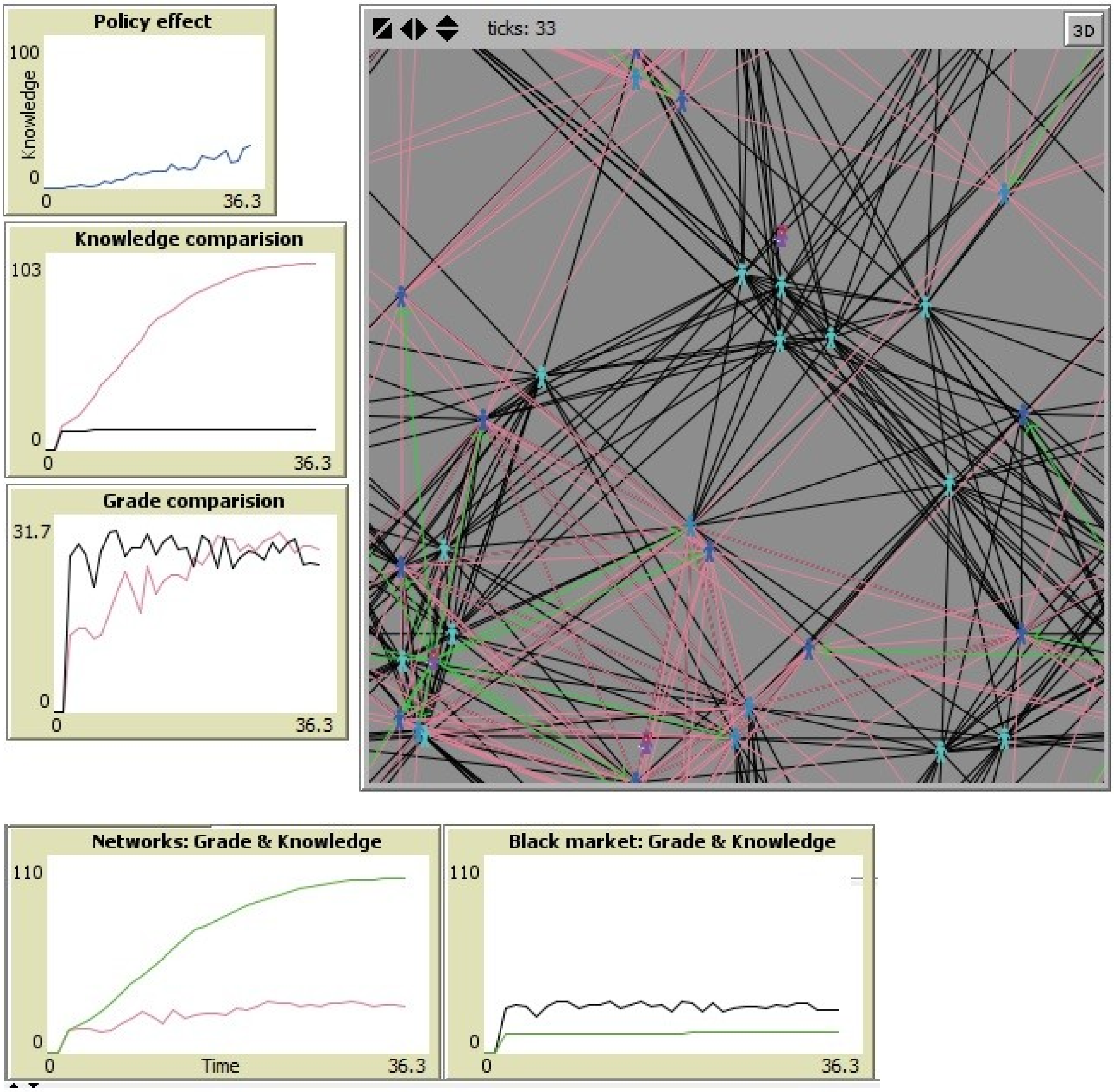


Figure 2

The second scenario, called Midway, is a first level of distortion generated by the SBM mechanism with respect to the scenario Utopia. We consider Midway as the result that more closely matches the real world. To obtain Midway, the environmental variables are set at about half of their possible range variation in the model. The number of students in the society is set up at the median value of the range contemplated by the model (12). In particular, the number of scholarships and the level of Socratic approach is set at 50, while the number of Socratic Professors is 5/10. In line with the assumption we made above, the values of "creativity", "exam typology" and "availability" are set at a median value within their range (50; 1 in the case of exam type). The data shown in Figure2 illustrate and compare the trends of "knowledge", "grade" and "policy effect on knowledge" variables. We report the values obtained by analyzing the distributions.

Table 3: ***Grade, knowledge and standard deviations for N-netw.***		
N-grades (exp. value)	N-knowledge (exp. value)	Standard deviation of N-grades
26.122	98.025	8,49

Table 4: ***Grade, knowledge and standard deviations for SBM-netw.***		
SBM-grades (exp. value)	SBM-knowledge (exp. value)	Standard deviation of SBM-grades
23.755	11.159	8.13

The students of the N-netw have an average grade of 26.122/30 with a standard deviation roughly the same as students in SBM-netw. The grade distribution of the latter group takes value around a mean value of 23.755/30 with a standard deviation of 8.13. However, the level of knowledge of the N-netw students is still very high both in absolute terms and in relation to the level of knowledge of the SBM-netw students (on average they still gain about one-tenth of the knowledge than their colleagues). Midway scenario could be consider the first significant distortion introduced by the SBM, which becomes a valid alternative for all those students who are not primarily interested into improving their stock of knowledge. As a consequence, all those who are interested only in passing the exams or in getting good grades in a time limited condition (scholarship holders) have a extremely high incentive to enter the SBM, causing the discredit of grade as an informative indicator for the knowledge of a student. Indeed, as it can be deduced from the data shown in Figure 2, the impact of SBM on the average level of knowledge achieved by students (59/100) is quite significant compared to the scenario Utopia (look at the graph of policy effect in figure 2).
This variable not only reaches a maximum level strictly lower than before (59 vs 70), but it also takes more time to reach its maximum level.

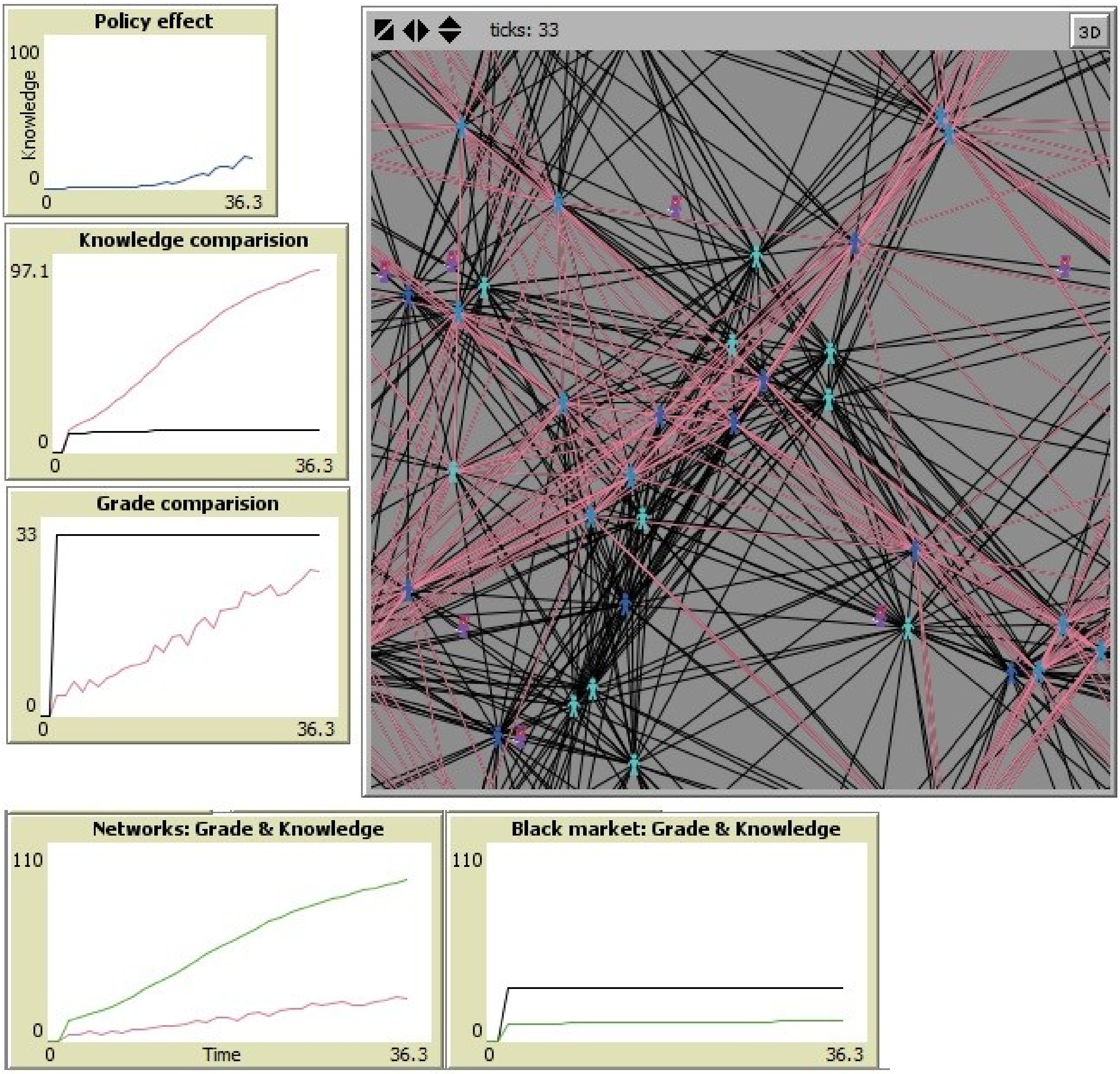


Figure 3

The third scenario, called Dystopia, represents the highest level of distortion generated by the SBM mechanism compared with the scenario Utopia. Dystopia is the worst outcome that can be found to in the society we have created, since the majority of the relationships among students is maintained within the SBM. To get Dystopia, the environmental variables were adjusted exactly at the reverse way of Utopia. In particular, the model has been set by introducing the maximum number of scholarships within the system and ruling completely out the level of Maieutic approach and the number of Socratic Professors.

The number of students in the society is set up at the median value of the range contemplated by the model (12).

In line with the assumption we made above, the values of “creativity”, “exam typology” and “availability” are set at a median value within their range (0; -100 in case of exam type). The data shown in Figure3 illustrate and compare the trends of “knowledge”, “grade” and “policy effect on knowledge” variables. We report the values obtained by analyzing the distributions.

Table 5: ***Grade, knowledge and standard deviations for N-netw.***		
N-grades (exp. value)	N-knowledge (exp. value)	Standard deviation of N-grades
24.237	89.635	8.88

Table 6: ***Grade, knowledge and standard deviations for SBM-netw.***		
SBM-grades (exp. value)	SBM-knowledge (exp. value)	Standard deviation of SBM-grades
30	11.07	0

The students N-netw. have a grade distribution with a mean value equal to
24.237/30 with a dispersion of 8.88 (st. dev.). The students who are part of the SBM record a grade average of 30/30, with a zero dispersion, since they are able to foresee perfectly the text assigned by the teachers at the examination. Although the knowledge level achieved by the N-netw. students is significantly lower than in the previous scenarios, probably due to a less stimulating academic environment, the gap between them and the SBM-netw. students in terms of knowledge is still very high (the latter acquire on average only 12% of the skills of their colleagues). In the Dystopia scenario, “grade” variable completely loses its explanatory value about the knowledge of the students, giving inconsistent signals to the job market in term of graduates’ skills. If this fact is not a common knowledge among agents outside the academic environment, there is a further negative result. The incentive to deviate from the N-netw. to SBM-netw involves not only those students who only care about to pass the exam, but also the students that in previous scenarios were concerned to extend their knowledge and that now, in order to avoid a penalty in terms of grades, join the SMB.

Consequently, as shown by the data represented in Figure 3, the average level of knowledge achieved by the students (25/100) is dramatically lower compared to both Utopia and Midway. We can properly confirm the failure of this educational system, heavily disturbed by the presence of the SBM.

As a final result, the policy that the model suggests involves the effort, by the central ruler, to create consistency among grades and level of knowledge, increasing funding for the quality of teaching, rather than increasing the scholarship availability. Scholarship supply based on the income is actually a good strategy to help brilliant poorer students to continue their studies, but, if the scholarships allocation is based exclusively on merit it could incentive too much competition among students, preventing collaboration and spreading of knowledge among them.

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Appendix: *Definitions of key notions*

Knowledge: gathered ability of understanding and reprocessing in a critical way given information.
Official material: the material provided by professors (lecture notes, exercises, mock exams)
Student black market material: unofficial material such as past exams from older students, and solutions from colleagues, which students are not supposed to have.
Creativity: a broad behavioural concept of openness. We assume that the more open people are, the more open they are to question themselves and by this develop.
SBM-netw.: subset of students who primarily care about maximizing their grades relying on the SBM mechanism
N-netw.: subset of students concerned with extending knowledge trough cooperation and creativity