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Agent Based Analysis of a Pension Systems with Network Effects

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Chapter 1

Introduction

Over the past twenty years, the pension systems in Western countries are subject to changes in order to adapt to the changing socio-economic conditions of the environments in which they operate.

These conditions are linked to demographic factors (increased life expectancy, low birth rate), economic factors (globalization of production and supply chain, relocation, competition between countries with different social and fiscal legislation and incentives), organizational factors (flexible labor relations , being late at work), and the resulting economic and social policies designed to control cost increases in the system. As a result, it is possible to directly measure the pension expenditure on GDP.

In Italy the pension system environment is in constantly evolving to fit the times, in fact, nowadays, the pension system is divided into three pillars. The first pillar is public and compulsory, therefore, consists of entitlements derived from mandatory contributions to retirement saving scheme. The other pillars are supplementary pension schemes.

The gradual transition to contribution-based system requires the Italian workers that contribute to the pension system to change their approach to the issues rising from this scheme of contribution since the future benefits will depend on consistent contributions made over time during working age.

Starting with the reforms of the early 90s and with the latest changes

of the legislative decrees it can be noticed that the soundness of Italian's pension-system increased ensuring a stable funding. Although the future pension's expenditure is under control, it is critical to keep track of the impact the future reforms will have on the adequacy of the benefits that will be provided to the workers.

Particular attention should be focused on future benefits that under equal terms, they can be smaller than the amount of contributed.A fair system is required to ensure the sustainability and stability of the pension system. In general, the gradual transition to contribution-based system requires the Italian workers to change their approach to the system itself. With the contribution, in fact, the amount of the benefit depends on the payments made during the working life.

The reforms of the 90s were inevitable: the discrepancy between active population and retired, the changes in demographics, the increased life expectancy indicates that the transition to the defined- contribution based system was necessary.

The contributions to the Italian pension funds now come from almost all sectors of employment. For self-employed are available "open pension funds" and "Pip", as well as some specific pre-existing pension funds. The level of transparency of the Italian pension funds reached higher level of standards than in Europe. The costs, with few exceptions, are sustainable or otherwise acceptable. The quality of financial management is in continuous improvement. The Italian pension funds are therefore meet high quality standards.

In the thesis I have chosen to study the issues arising from pensions systems through the use of agent-based models and Social Networks.

The analysis of their interactions enables the creation of an experimental simulation, where the autonomous agents can act as models for real-world computational problems, thus assessing the possible effects on it. Due to the easy modeling properties of such agents, it is possible to use them in other fields, like in game theory , complex systems,emergence, computational sociology, multi-agent systems, and evolutionary programming.

On the hand, a social network consists of a group of individuals connected by various social ties and is often used as the basis for cross-cultural studies in sociology, in anthropology and ethology.

The program chosen for the creation and simulation of the model is that NetLogo, is a program that mimics a world where it is possible to simulate the natural and social phenomena.

The model consists of agents (workers / pensioners) that simulate the effects of a pension system through social networks. These agents will have to decide whether to retire or not, such a decision can be taken autonomously by the agent or may be influenced by the behavior of other agents in the model.

The following variables are relevant for this model:

- Consciousness;
- Probability of an independent decision;
- Radius of imitation.

The main characteristics of the simulation are :

- We do not consider a representative agent. Rather we analize an heterogeneous population of individuals having a imitative behaviour.
- The model allows agents to retire when they wish (after 60 years old).
- Agents types Cohorts and Social Networks.
- The agents actively partecipate in the Social Networks with interactions and imitative dynamics.
- Description of agents behaviour through the simulation.

From the simulations it can be seen that the change of the variables used in the models examined influence the behavior of the agents involved. In order to ensure the reliability of the models analyzed, data

obtained through simulations with Netlogo will be further compared with real data concerning the number of retirees and workers, as measured by respective statistical institutions in Italy and Ecuador.

The thesis is structured as follows:

The **First Chapter** presents a detailed description of the Italian pension system.

In the chapter is introduced a brief introduction on the origins of this system and the main changes made to it over the years starting from the first reforms of the 90s up to present.

After, a detailed explanation of the three pillars of the Italian pension system is provided, following an accurate definition of retirement and the entitlement to retirement according to Italian law.

Then, the operations and the different types of pensions schemes are explained: closed pension funds, open pension funds, individual retirement and pension funds already in existence.

The chapter also provides two possible investment strategies:

- monocomparto (a line of investment)
- multicomparto (multiple lines of investment).

And finally there is a brief introduction to the longevity risk and a description of the functions attributed to Covip.

The **Second Chapter** represents a series of pension systems in the world with particular emphasis on the Anglo-American, Latin and European. Moreover, are explained in detail the pension system in Argentina, Chile and Ecuador. And finally is introduced brief description of existing pensions systems in Mexico, Colombia, Costa Rica, Peru, Uruguay.

The **Third Chapter** presents a description of agent-based models and why they are particularly well suited to the study of the pension system issues.

In the **Fourth Chapter** describes the method of the social networks that I used for the development of my thesis.

In the **Fifth Chapter** is explained the code in order to run the

simulation model, the results of the experiments, and finally to the case studies in Italy and Ecuador compared to result of the simulations.

Part I

Pension Fund

Chapter 2

The Italian Pension System

2.1 Origins and Development

The Italian pension system has its roots in the medieval guilds, mutual aid societies of the beginning of the 19th century. Initially, the concept of retirement had as its objective the protection of the worker who was no longer able to perform his duties due to an injury, a disease, or simply because of old age.

Over time, the concept of retirement has shifted to a more comprehensive security system in which the Italian state have a central role. Specifically, it has the task of helping all citizens who might find themselves in difficult situations.

The Italian model, based on the principle of voluntary worker contributions, have moved to a social security system extended to all participants, although in recent years it seems that it is shifting back to a situation where it is the worker who has to pay the necessary contributions to create his own retirement fund. The Italian pension system was created as a voluntary pension system similar to a state-run or private insurance.

- Only in 1919 the disability, unemployment and old age insurance became mandatory.

To fund such a system each worker paid contributions, in some cases

supplemented by the employer or the state. These funds were then used to build the workers future pension.

- In 1945, the state had to switch to a mixed regime, since the high inflation linked to the II World War had eroded almost all of the purchasing power accumulated by employees in the period before the war.

In the new system there was a contribution based on a capitalization system (the contributions made by each worker will be used to pay for the retirement) to which supplements, like the endowments the worker received at the retirement, were added.

Those endowments were funded by contributions of all employees in the system. The system have further changed in the years after the war. To calculate the pension, the coefficient of the base pension increased from 45 in 1952 to 72 ten years later. Moreover

- In 1952 the thirteenth pension is also introduced.
- In 1957 the mandatory retirement is extended to all self-employed and farmers.
- In 1965 the concept of the welfare had further improved with the introduction of a minimum social pension for all workers.
- In 1966 commerce employees were added to the category, too.
- In 1969, the social pension was extended to all low-income citizens over 65 years old .

In addition to the salary received in the last three years, the contributions were based on a moving index to try to match the pension to cost of living index.

- In 1970, the capitalization system was finally abandoned in favor of the sharing system four years later.

The method to calculate the pension amount changed gain: the policymakers considered the pension base on the average salary of the three more favorable years to the employee in the last decade.

- The pension was set up to a maximum of 80% of the worker's salary, or two points for each year of service up to a maximum 40 years of contributions.

The calculation of the pension is also linked to wages in the industrial sectors with a higher growth than the current inflation.

- The 80's were a time with a lot of discussed issues in the pension system: first of all the retirement age, the connection salary-pension, or the calculation of the pension when other income were present.

In those years new indexation formula are introduced: disability pensions were for the first time not only linked to the income of the applicant, but also to his degree of inability.

- Since the 90s, a series of structural reforms have been done, addressing the problem of identifying the impact on both the tax structure of the pension income and the age of retirement

The reforms have focused on creating and maintaining a balance between public spending on pensions and the government budget.

2.2 The Italian Pension System

2.2.1 The reforms

The nature of the Italian pension system is a PAYGO (Pay-As-You-Go) one and it is characterized by a very high fragmentation. Indeed, we can individuate more than fifty different schemes. A main role in the administration of the public pension system is played by INPS (Istituto

Nazionale della Previdenza Sociale), whose activity interests a relevant part of private sector employees' and self-employed workers' pensions. Looking at the composition of expenditures for pensions, divided by sectors, data show the following trend:

- In 2000, 62% of them were directed at the above mentioned private sector employees;
- 24% at public sector workers;
- only 14% at self-employed workers.

A relevant-and problematic- feature of Italian pension system before the year 1992 has been its generosity. To understand why, it is sufficient to think about the fact that the average pension benefit was equal to the 80% of wage income (OECD, 2005). At this time, retirement benefits were computed based on a defined benefits (DB) principle.

The related DB formula is influenced by the annual accrual rate, pensionable earnings computed over the last years' earnings and the number of working years. A key point is the fact that the number of years over which the pensionable earnings have been averaged was different for different working sectors.

- For example, it referred to the last one month public sector workers, to the last five years for private sector employees and to the last ten years of taxable income for self-employed.

This fragmentation is one of the causes of the largesse in benefits payements, so that in early 1990s Italy's pension expenditures were one of the highest among OECD (Organization for Economic Cooperation and Development) countries, if related to its GDP.

Another problem related to financial stability was the aging of population.

From 92 onwards, Italy have gone through a series of reforms of the pension system. The focus of the reforms was to control the social security expenditure. To meet the future pension payments, the public pension system is now structured by a system of allocation.

“ The contributions that workers and businesses pay to social security funds are used to pay the pensions of the retirees. Meaning that there is a net transfer of wealth from one generation of active workers to the retired ones” Cellini (2004)(2004).

In this system, the revenues are made by the contributions from workers, that have to balance the amount of outputs represented by the paid pensions.

The gradual increase in life expectancy of the Italian population have heavily burdened the social security system since it has to pay pensions for a longer period of time. Therefore it caused a decrease in the expected economic growth which has, among others, led to a decrease in revenue contribution.

To cope with those events, new reforms have been issued to control pension expenditures. The system was modified through the revaluation of pensions payments that now are linked only to the inflation and not to the dynamics of real wages anymore.

Requirements for obtaining both an old age and a seniority pension have also changed with the new reforms.

In chronological order, the principal reforms : The Italian pension system has been strongly reformed through a series of legislative measures in the 90s. Specifically we consider the three major reforms:

- Law 503 of 1992, known as the Amato reform.
- Law 335 of 1995, the Dini reform.
- Law 449 of 1997, the Prodi reform.

The Amato Reform

The Amato reform (Law 503 of 1992) was introduced with the objective of stabilizing the ratio of pension expenditures and gross domestic product (GDP).

The need of introducing a framework for the supplementary pension was the base of the establishment of pension funds with open collective

access negotiations (law 124 of 1993). The principal changes introduced in the pension system are:

- The retirement age was increased from 60 to 65 years for men and from 55 to 60 years for women.
- The minimum contribution to the retirement pension was increased from 15 to 20 years of contributions, too.
- Increasing the reference period for calculating pensionable earnings from the last 5 years to the last 10 years.
- Increasing contribution rates to 33%.
- The benefits were no longer indexed to real wages.

Baldini, Mazzaferro and Onofri (2002) point out that the reform had a major effect on the perception of households, mostly on those where the breadwinner was employed in the public sector.

The Amato reform (law 503 of 1992) showed, for the first time, that the level of wealth the workers expected to receive from the social security system during their lifetime was no longer sustainable.

According to Beltrametti (1994), total outstanding liabilities were reduced from 389% to 278% of GDP (a 29% cut). Using estimates by Beltrametti (1995 and 1996), D'Amato and Galasso (2002) suggest that the largest burden of the reform was beard by individuals with less than 44 years. Rostagno (1996) estimates that the liabilities of the scheme for private sector employee were reduced by 27%. The cuts were unevenly distributed. Rostagno estimates reductions of

- 8% for pensioners;
- 42% for male workers;
- 94% for female workers with long working history;
- 42% for those with short or discontinuous careers.

The Dini Reform

The Dini Reform (Law 335 of 1995) had changed the system for the calculation of the pensions from the pay system (the pension was based on the average earnings over the last 10 years of work) to the contributory system (based on the amount of contributions paid by the employee during the entire working life). The workers shift from one system to the other differed according to the contributions paid.The Dini reform established the rules for transition generations. Therefore, five different situations have been created:

- The workers with at least 18 years of contributions up to the 31/ 12/1995 were not touched by the reform, they were still under the pay system;
- The workers with under 18 years of contributions up to the 31/12/1995 were subject of a mixed method;
- For employees hired after 31/12/1995 the calculation method applied is the pro rata contribution that results in a decrease of the ratio pension over last salary received;
- The income testing of survivor benefits;
- The standardization of rules for public and private employees.

The pension for the employees with 35 years of contributions useful retirement pension, was equal to 50 - 60 % of last salary. The ratio was slightly lower for the self-employed. The amount was to be revaluated only on the basis of the rate of inflation.

“ The belief behind this measure was that contributions would be better perceived as a deferral of earnings, thus reducing the distortionary effect of labor income taxation ” Brugiavini and Fornero (1999)

Moreover, The reform called for the creation of the supplementary pensions, that were related to the start of the pension funds.

It is noteworthy that in spite of the change of the pension system, the 1995 reform Dini (law 335 of 1995) did not significantly affect long-term expenditure trends.

In 1996 Rostagno estimated that the reform increased the liabilities of the private sector employees pension scheme by 4% to 9% of GDP, depending on the GDP growing rate.

The Prodi Reform

The Prodi Reform (Law 449 of 1997) amended certain points of the Amato reform in 1992 to adjust it with the need to reorder public finances.The Prodi reform of 1997 have advanced the transition to a new pension system.

This reform was characterized by the increase of the age requirements for the retirement, and a change in the early retirement pension in the public sector.

- The transition phase was accelerated for the harmonization of the private and public pension system;

- The employees, to attain the retirement pension had to have at least 35 years of contributions and a minimum age of 57 years or 40 years of contributions regardless of age;

- For the employees of the public administration, the reform the schemes designated a portion of the current contribution rate to the supplementary pension.

Legislative Decree 47 of 2000 has improved the tax treatment for those who adhere to a pension fund and are introduced new opportunities for those who want to join in an individual supplementary pension through enrollment in an open pension fund or Individual Plan pension (known as PIP).

The Maroni Reform

Incentives for postponing the retirement pensions were introduced by the Maroni reform of 2004 (SI243 of 2004): those who chooses the postponement may benefit from a super bonus that consists in the payment of payroll social security contributions that would have been paid to the pension institution (an amount approximately one-third of the salary)

The reform's objective was again to ensure financial sustainability of the pension system through a harmonization of the different pension systems. The main points of the reform were:

- Increasing the retirement age from 57 to 60 years for women and 65 for men;
- Increasing the minimum contribution for access to a retirement pension: for male employees the threshold was to have at least 35 years of contributions and having at least 60 years of age in 2008;
- The minimum age was set to increase to in 61 years in 2010 and then again up to at least 62 years in 2014;
- Men had however the possibility to gain the access to retirement if they have 40 years of contributions regardless of age;
- For the self-employed the age requirements are higher than a year to those set out in the various deadlines for employees.

The later retirement was set to slow the growth rate of the aging elderly population, decreasing the dynamics of pension expenditures. Changes of the requirements for the access to old-age pension in the contributory system have also been made.

The Prodi Reform

The Prodi reform(Law 247 of 2007) introduces the so-called“ quotas ” for access to a retirement pension, calculated from the sum of age and years worked: in 2009 the share to reach is 95 (with at least 59 years of

age), that increased to 96 in 2011 (with at least 60 years of age), while in 2013 will be increased to 97 (with at least 61 years of age), it is also automatic and triennial the revision of the coefficients for calculating the mandatory retirement as a function of life average calculated on ISTAT (The Italian National Statistical Institute) data.

- The employee can retire after 40 years of contributions regardless of his age;
- Women can access old age pension if they have reached 60 years of age;
- In addition to the retirement age, policymakers have decided that from 1/1/2010 transformation coefficients that determines the amount of the contribution-based pension will have to be reviewed, updating them every 3 years.

The Fornero Reform

The Fornero reform, known as the " Salva Italia"(Law 201 of 2011) the pension system calls quotas introduced by the reform of 2007, were removed. The system will switch to the contribution for all starting from 1/1/2012.

Moreover, the increase of the retirement age for the access to the retirement pension was introduced. therefore, The minimum retirement age rose from 60 to 62 for female employees. The minimum age was set to increase to 64 in 2014 , 65 in 2016 and 66 in 2018. For the self-employed females, The minimum age is set to a year more. The minimum age was set to 66 for all men.

- The reform introduces a flexible range for the retirement, differentiated between women (63-70 years) and men (66-70 years): the worker who will choose not to retire and stay at work longer, will get a pension increase;

- The minimum age to retire is raised to 42 years and 1 month for men , and 41 years and 1 month for women;

- moves towards a single retirement age for women and men, for the self-employed and the employees in both the private and public sectors;

- from 2012,The application of a defined contribution pension system introduced in earlier reforms to replace the earnings-related defined benefit system.

Workers that will have completed this requirement but not the minimum number of years of contributions will have a penalty of 2% for every year missing.

For the fixed-term contracts the new reform allows the first one not to specify the reason and its maximum duration is set to of one year. The first fixed term contract may be resigned for a maximum of 3 time period of 1 year. After the end of the last contract renewal the employer have only 2 options. or a renewal of the contract for an indefinite period or termination of it.

With the Fornero reform the so-called Apprendistato contracts is set to be the main route to the employment for young people.

- The contract will have with a minimum duration of 6 months and employers are obliged to employ at least half of the apprentices that worked the firm in the last 36 months span.

The Article 18 have been modified, too. In the event of redundancy the automatic reintegration is no longer required. The judge may however decide to close the case with a monthly compensation for the worker that can last up to 27 months.

2.3 The pillars of the Italian pension system

The protection of workers who for age, illness, injury, maternity or other reasons temporarily or permanently interrupt their work is one of the most important goals of modern states' social security systems.

Lifetime pensions are paid to employees that have the minimum age to access the pension or that unable to perform their duties in case of the occurrence of any of the events mentioned above. For the workers that doesn't meet the requirements, monthly payments are set in every case.

Despite the reform process of the last twenty years, the Italian pension system has maintained its basic structure, which is based on three main pillars:

- The first pillar of the pension is the statutory pension system that is funded directly by the workers through the payment of compulsory contributions required by law and is run by public agencies such as Social Security, the National Institute of Social Security of the Italian State (INPS);
- The second pillar is instead made up of the supplementary pension system. Pension funds are part of this pillar that can be managed by multiple parties, such as banks, insurance companies, asset management companies (SGR) or brokerage companies (SIM);
- The third and final pillar provided for by the law is represented by forms of individual savings, also called PIP that stands for the Italian equivalent of "Individual pension plans". They are made up mainly by the employees subscription of life insurance policies.

2.3.1 The First pillar

The Article 38 of the Italian Constitution provides that " Workers have the right to be provided with and assured adequate means for their needs

and necessities in cases of accidents, illness, disability and old age, and involuntary unemployment".

The first pillar of the Italian regulation is actually the mandatory pension system that was regulated by the Dini reform in 1995 and it is financed through taxation.

This mandatory pension system is managed according to the PAYG system. it means that Italian social security system (INPS) and other public and private corporations use of the individual contributions of active workers to support the cost of pensions in payment. In practice:

- The contributions paid by workers now are immediately used for the payment of pensions to retirees;
- Today's workers will have the right, in the future to receive a pension that will be paid by those who will work at that time in the future;
- The system is governed by a strong inter-generational solidarity rule, according to which to each generation is guaranteed the same income that they helped to finance.

The first pillar is moreover characterized by high fragmentation: many pension funds for different occupational groups. But, despite the different forms, the main characteristic of the PAYG system is the balance between the contributions paid by the working population and pensions paid to retirees.

- The contributory system in allocating workers' contributions are indexed to GDP growth
- In Italy, contributions are revalued on an annual basis at the average rate of GDP growth over the last five years.

The Dini reform also introduces the calculation of the hope of life expectancy for the pensions to be paid to reflect not only the growth of employment and wages ,but the demographic problem too.

The new measures aims at progressively eliminate the issues due to the increase in average life.

- The main index in the calculation of the contribution is the ratio between the number of pensioners and the number of workers.

An increase of this ratio in this ratio corresponds to a decrease in the payments to retirees, and thus to a reduced pension .

In addition, the increase in retirees to workers ratio translates in an overall slowdown of the economic growth , and it may reduce GDP growth. This reduction can have an additional adverse effect on the growth rate of contributions.

Therefore, as a consequence of the increase in life expectancy , the pension amount has to be divided over several more years and retirees will have a lower monthly pension.

The resolution of the demographic problem is simply dealt with by decreasing the individual worker's pension. Policymakers, to compensate for this decrease, have proposed private supplementary contributions.

To sum up, in the contributory system the state receives every year contributions that are immediately directed in the pensions payment. In other words, the system is balanced if each year the pension debt of the State is equal to the resources available to pay the pensions.

2.3.2 The Second pillar

The supplementary pension scheme (introduced by the Amato reform in 1992) aims to assist the mandatory public pension system in an attempt to increase the level of social security coverage.

The supplementary pension scheme can be managed by the state or private insurance and banking corporations whose main role is the administration and management of occupational or collective pension funds, typically based on a system of capitalization.

- Participation in a pension fund or an individual retirement plan is not mandatory;

- The contributions that the employees pay are set aside and generally re-invested in financial markets;
- At the time of the worker's retirement, the accumulated capital will is converted in an annuity that will act as a supplementary pension.

The second pillar is relevance especially for the closed pension funds. These kind of pension funds aim of providing additional retirement benefits to a defined group of people with a common characteristic, like employment relationships or the membership to a definite category of workers.

- The closed pension funds constitute saving centers with social security purposes;
- Funds are built by the employee's (or employer's, too) payment of contributions;
- Their management aims at medium and long term investments.

These kind of funds constitute the reserves through which additional pension benefits are paid in the form of lump sum or annuity once the workers have fulfilled the number of years of contributions required by law.

- The COVIP (Italian equivalent for "Commission for Supervision of Pension Funds") is the only authority in Italy that can approve the management of supplementary pensions through pension funds.

The entity that wants to start a pension fund is subject to a prior authorization by COVIP, specifically established by law. The types of supplementary pension schemes can be the following:

Defined contribution plans

In this type of fund the main factor is the amount of the contributions. The contributions are usually calculated :

- As a percentage of gross annual salaries for employees;
- As a percentage of the income declared for income tax for the self-employed and freelancers.

It is therefore not possible to determine the amount of the final endowment because it depends on two variables:

- The total amount of contributions paid;
- The yield obtained from the financial management of the contributions.

Defined benefit plans

In this case, the Fund will pay a predetermined sum of money (for example, the integration of 20% of the pension amount established by law). Obviously:

- The endowment must be systematically examined during the contribution period to make sure that the amount of the contributions is sufficient to ensure the pre-defined benefits.

In practice, this type of fund allows the members to know from the beginning the amount of the final endowment, but not the amount of contributions that he must pay.

Indeed, the member should check the contributions paid frequently, because there could be the case of the need to significantly increase the amount of contributions to achieve the target.

This type of benefit plans is not applicable to employees by law, but only the self-employed and freelancers.

2.3.3 The Third pillar

The third pillar is made by individual supplementary pensions plans. Those plans can be achieved through forms of individual savings to that

integrate both the public pension system and the supplementary one regulated by the second pillar. The Third pillar aims at enabling workers to maintain the same standard of living even after retirement.

- The main financial tools that form the third pillar are the traditional life insurance and the non-traditional ones such as index-linked and unit -linked products, mutual funds , stocks, bonds.

The association to the third pillar is voluntary and it can be made regardless of the employment status of the worker (both self-employed and employees can adhere to supplementary pension plans).

The third pillar is made from Individual Retirement Plans may also be made by insurance contracts modeled on the rules of open funds. These contracts have a specific purpose of building a supplementary pension, that can be paid to the retired worker as an annuity.

- The law provides that the supplementary pension may be paid partly as a lump- sum. However, at least 50% of the amount should be paid as an annuity.

The third pillar is similar to the second one since it has the same funding mechanisms that generates financial gains for the worker at the time of the retirement.

The individual pension plans do not fall within the second pillar since they are organized on an individual basis. However, individual pension plans are in any case one of the choices the workers have when they can decide the destination of their severance indemnity payment.

2.4 Definition of pension

A pension is a fixed amount of money that is paid to an individual when he retires. It is a granted payment for a specific period of time that is fixed by a country's law, either with a national social security system (in Italy it is called INPS) or private entities. A pension may be contributory or non-contributory.

In the defined contribution system the amount of the pension is determined by the sum of the accumulated contributions, reassessed during the individual's working life.

The exact amount of the pension is then given by the transformation coefficients that vary in relation to the worker's retirement age.

Therefore, the amount of the pension is proportional to the contributions paid, following the principle " the more you pay, the more you get."

The factors that have a significant contribution in the calculation of the pension are:

- the contributions paid
- the retirement age
- the growth of the country's wealth

The defined benefit method is a PAYGO (Pay-As-You-Go) system calculation to determine the amount of the retirement pension after individuals reach the legal requirements to retire, namely a minimum retirement age and seniority.

This method requires the pension to be linked to the appreciation of the earnings of an average person, relative to a fixed number of years. Currently, the defined benefit system is used only by governments managing statutory pension systems that have no capital to cover their reserves, as the cost of public services is higher than the social security contributions paid by the insured to the AGO (General mandatory Insurance).

The laws determining the amount of the pension with the defined benefit system are subject to ongoing review to ensure the sustainability of the welfare institution.

With the defined benefit system the amount of the pension is calculated on the average income of (to the extent of 2 % of this average for each year of contributions):

- The last 10 years of work for employees

- The last 15 years working for the self-employed

In the defined Mixed System the amount of the pension is calculated separately according to the defined benefit system and in part by the defined contribution system.

There are different types of pensions :

- Old age pension
- Retirement pension
- Disability pension
- Indirect pension
- Survivor's pension

2.4.1 Old-age pension

The old-age pension is the main form of public pension. It consists of monthly payments of a sum of money from the Italian Social Security System (INPS) in favor of an employee who has :

- Reached the age prescribed by law.
- Paid a certain amount of contributions.

The worker must have reached a certain age regardless of the working years he has had. Males and females can require to retire at a younger age, respectively at 65 and 60.

The right to a earlier retirement pension arises only if the employee is able to prove that they have paid at least 20 years of contributions, paid by the worker or credited at any title to him.

2.4.2 Retirement pension

The retirement pension (or early retirement) can be achieved by the worker even before reaching retirement age or the maximum working years if he has achieved a certain number of years of contributions and the age determined by law.

- The employee (public and private) may retire if the sum of his years of contributions, set at a minimum of 35 and his age, set at a minimum of 59, is at least 95. Alternatively, if he has 40 years of contributions regardless of age.

- The self-employed, on the other side, may retire if the sum of his years of contributions, set at a minimum of 35 and his age, set at a minimum of 60, is at least 96. There is the possibility of retiring if the self-employed has at least 40 years of contributions regardless of age.7

- From 2011, the sum increased to 96 for both categories, as the minimum age will 60 years old.

- From 2013 the share will increase up to 97 as the minimum age will 61 years old.

In years to come the retirement age will gradually increase. The worker's minimum age to retire will be 67 years and 2 months in 2021, without distinction between sex or profession. those who want to retire before retirement age must meet a certain requirements about contributions paid.

Precisely, to criteria is to have achieved of 42 years and 1 month of contributions for men and 41 years and one month for women. For those who want to leave before age 62, the law sets a penalty of 1% of the coefficients for calculating the mandatory retirement for the first two years of retirement and 2% thereafter.

2.4.3 Disability pension

The Invalidity pension is granted to a person, with reference to the degree of his physical or mental incapacity to work, permanently of temporarily.

It takes on different names depending on how the fund is managed and on the level of invalidity, namely disability allowance or disability pension. The contribution requirements of access and the calculation of the pension vary with each type of provision.

To get the permanent invalidity pension one must have a reduced capacity to work of at least two-thirds (67%) and a minimum of 5 years of compulsory contributions of at least 3 (12 quarters) have been paid in the last five years.

2.4.4 Indirect pension

The indirect pension is paid, instead to the worker, to his family in case he died in active service. This contribution is moreover entitled to:

- Separated or divorced spouse and minor children
- It can be paid even once the child is over 18 he/she is disable, still a high school student (up to 21 years of age), or a university student (up to his/her 26th birthday) still dependent on the deceased.

If, on the other hand, the deceased have no spouse or children, the indirect pension may be paid to his parents, brothers, sisters or nephews.

The payment varies on the number of beneficiaries and of their income .

To be entitled of an indirect pension, the deceased worker must have, regardless of his age, 15 years of paid contributions or a minimum of 5 years of contributions, of which at least 3 have been paid in the last 5 years.

2.4.5 Survivor's pension

The survivor's pension is a financial benefit paid in the event of the death of a person entitled to a pension (old-age pension or disability) or whose surviving relatives had already acquired right in favor of it. This amount can therefore be allocated to the spouse, even in the event of separation or divorce, or children. Breakdown of shares in the survivor pension :

- 60% of the pension will be paid in favor of the surviving spouse.
- 70% of the pension will be paid in favor of a child left alone.
- 80% of the pension will be paid to a spouse and a child or two children without a spouse.
- 100% of the pension will be paid to a spouse and two or more children, or three or more children.
- 15% more for any other family members can be different from the recipient spouse, dependent children or grandchildren.

Survivor's pension (direct):

In the case in which the assignor was already a pensioner.

Survivor's pension (indirect):

In the case where the assignor was not already a pensioner, but he had the legal requirements for a retirement pension or an invalidity pension.

2.5 Public Support for the Elderly

Population ageing has emerged as a major demographic worldwide. An increasing urbanization rate and rapid improvements in life expectancy have started in the early 1900s and continued for the whole century, up to the first decade of the twenty-first century.

In this situation public support for the old aged plays an important role in the all countries. There is the necessity to focus on specific pension plans for retirement age. A pension plan is the program in which the employer makes contributions toward a pool of funds, that are set aside for the employee's future benefit.There are two main types of pension plans: defined-benefit plans and defined-contribution plans.

2.5.1 The defined-benefit plans

The defined-benefit plans (DB) guarantees the employee a definite amount of benefit at the time of retirement. The pension benefit is not linked to the performance of the fund where the contributions are invested, therefore the pension benefit is, as the name says defined regardless of future conditions.

2.5.2 The defined-contribution plan

The defined-contribution plan (DC), on the other side, set for a predefined amount of contributions that the employer pays on behalf of the employee. The final amount of benefit received by the employee at retirement depends on the investment's performance and will, consequently, vary from investment to investment.

- Public plans are usually PAYG-financed.

The principal function of public pension plans is to grant minimum (flat or/and earnings-related) benefits on retirement for the whole population. In the other words:

- Private pension plan a pension plan where an institution government organized the payment of pension benefits.

These plans are managed by the employer acting as the plan sponsor, a pension entity or a private sector provider. Therefore, during the retirement age, the beneficiary can choose to either receive the benefits in a

lump sum or as an annuity where the benefits are spread in monthly payments throughout the beneficiary's lifetime. This plan is different from a fully funded pension where the company funds, manages and distributes all the benefits at retirement. Regarding to all that we mentioned before, we can see the necessity of well-organized procedure for old aged as a private and public pension for future. Because the world will, get older and the govermet and private institution should organized for this huge amount of elders.

2.6 Introduction to pension funds

Pension funds are comparable to financial institutions since their purpose is gathering contributions from both employees and self-employed workers during their working life, then investing them in real or financial assets. Pension funds have a restricted category of investment permitted by law. The final goal is to provide the workers a pension, a supplementary pension or replacement one, additional to that provided by mandatory pension schemes.

The pension funds provide proper retirement schemes at the attainment of the minimum age required by law to access pension benefits. It consists of :

- The pension funds are useful to build additional pension income for the retired, since they integrate the annuity already guaranteed by the national social security systems.

- The pension funds are regulated by a specific law that set for the necessary funds to put aside in order to provide a supplementary pension plan.

  Therefore the characteristics of the pension funds are very different from other funds.

- The pension funds are usually operated by large companies or, alternatively, by insurance companies. The periodically paid contri-

butions are used to constitute a capital that is subsequently used to provide a future pension.

- " The pension funds have, however , additional economic purposes: since they have large amounts of financial resources they are considered as institutional long-term investors. Therefore, they are similar to mutual investment funds ". (Marchesi 2008).

- Traditionally there are two different types of pension funds: closed funds and open funds. The difference depends on whether they are established by an employer and offered to its employees, or established and offered by financial intermediaries.

- They are characterized by a stricter regulations in case the worker wants to end the contract. This gives the pension funds the character of long-term horizon institutional investor, without any risk of unexpected divestitures from clients.

- In Italy, in order to encourage competition between pension funds, workers have the possibility to transfer to another pension fund. This option may be exercised on the condition that at least 3 years have passed from the beginning of the contract. The time is extended to 5 years if that was the worker's first pension fund contract.

In order to ensure the safety of pension fund members, the pension funds must necessarily be characterized by strict autonomy.

The assets are therefore safe in case of third parties demands. These rules are similar to those of mutual funds. The purpose of both funds is the accumulation over time of capital that can be redeemed, even in part, when the worker have the minimum age required by law to access to the pension.

The pension funds give the workers the option to complement or even replace the pension.

- Pension funds are divided in open and closed pension funds.

- The difference is the method of participation: the open pension funds are free, in sense that they can be utilized by every worker, whereas the closed ones participation is exclusive for very specific category of workers.

There can be several investment strategies for pension funds that, of course, contemplate different risk profiles and therefore a different level of expected return.

The Italian pension system have been a subject of a deep restructuring, and the authorities are strongly oriented towards a greater participation and, particularly from 2007 onwards have tried to sponsor pension funds.

Therefore the issue of supplementary pensions is taking more and more importance , becoming a viable option for the workers.

Italy, compared to other large countries, differs greatly in the weight that national pension funds have in financial markets. In Switzerland , the Netherlands, Great Britain, USA or Japan, for example , pension funds are heavily used.

As for Italy , despite the important reform process started in the last decade of the last century, most of the retirement benefits of 2010 were still supported by the national social security system.

To support this argument, it is enough to take a look at a specific indicator, the ratio between the value of assets held by pension funds and the Gross Domestic Product of the country of interest. COVIP data of 2010 shows that in the Netherlands and Switzerland the value of this indicator reached, respectively, 136% and 111% .High values are also recorded in Australia (80%), Great Britain (80%) and Finland (76%), while the figure falls in the U.S. (67%) and especially Japan (25%). In Italy , however, the recorded value stood at a meager 4%.

It is worth noting that, however, the Italian pension system have of a large number of subjects and regulations, that were changed many times. Therefore a schematic description of the pension system and of the role of pension funds is very difficult.

The powers of the , the Italian supervisory authority, comprise the custody of the national book of the pension system and the authorization to the establishment of a pension fund issuance. The authorization is necessary for the recognition of legal personality.

In Italy , pension funds are allowed to pay pension benefits on the basis of two different regimes : defined contribution plans and a defined benefit plans.

2.6.1 Defined contribution pension funds

The pillar individual pension is calculated directly from the investment of contributions (and the accompanying profits) paid by the worker during the working years. At retirement , the principal is converted , in part or entirely, in annuities.

The pension benefits will be proportionate to the contributions paid by the worker and to the investments that the fund has done .

2.6.2 Defined benefit pension funds

The amount of the pension income is calculated as a function of several variables : the most important are the average income of the worker in the last years of his career and the age at retirement.

To maintain the actuarial balance , then , the amount of contributions paid are dependent to the services provided . The actuarial balance is moreover determined by a number of demographic as well as economic variables which are, however, difficult to predict.

2.7 The Closed Pension Funds

The closed pension funds are an instrument of the supplementary pension system. The closed pension funds arise from collective contracts that aim at a specific category of workers.

In other words, the possible beneficiaries of the fund all share a particular sector, company or are linked to a particular territory, like in the

case of autonomous regions.

Therefore, the closed pension fund gets its name from the fact that they are "reserved" for specific workers in certain sectors, areas or businesses.

The fund is an independent legal entity. Therefore it has its own management, boards and directors, that generally coincides with the general manager. On the other side, to carry on certain definite activities, the closed fund relies on specialized external subjects, like banks or insurance companies.

Being a legally independent entity , the closed pension funds are separated completely from their promoters.

The closed funds were created in aiming at :

- The public and private employees within the same category (same working sector, company or same particular specific territory);
- Worker of labor or production cooperatives;
- Self-employed and freelancers, if organized in professional or territorial areas.

In the first two cases, the employees can subscribe only to funds that implements the defined contribution system.

- By trade unions and employers, that can promote collective agreements for the employees;
- As agreements between the members of cooperatives. This funds are promoted by the national association of the cooperatives;
- Agreements between self-employed and freelancers promoted by their unions or associations at least regional.

2.7.1 The Enrollment

The membership is voluntary. Each pension fund is targeted at certain categories of workers .The members of the pension funds have the right to elect their representatives in the fund's Assembly

The closed pension Fund access is also entitled to temporary workers or to those hired under the new contract types. The workers may take part in the fund only if the representatives of the workers and employers have signed an accession agreement. Moreover, the rules of the Fund have to permit their access, too.

the worker can also join the closed Pension Fund in an implicit way, if he does not express any choice about the destination of his severance indemnity (TFR).

In this case the worker is automatically enrolled in the collective pension scheme adopted in the sector or in the company.

After two years of contributions to the fund, the member may request the transfer to another supplementary pension fund without any charges.

2.7.2 The Contribution

The contribution of the members to the fund is established in the collective contract. The employee shall, through the employer, pay to the Pension Fund the:

- Employee severance indemnity accruing after the accession to the fund;
- His own the contribution;
- The contribution of the employer.

It is possible to pay only the severance indemnity. In this case, the employer has no obligation to pay their contribution.

In the case of the self-employed pension fund contributions relates only to his own ones. the public administration employees' contribution

is made by the individual contribution, employer one as well as a virtual severance indemnity.

2.7.3 The Investments

The pension fund offers to members different combinations of financial instruments. Therefore the members may choose a different risk return strategy.

The decision can however be changed after one year have passed from the contract signature. In any case the Pension Fund may set different time clauses.

The investment strategy followed by each sub-fund is synthesized in the benchmark portfolio that defines the percentage and the quality of the assets to be used in the various investments.

The benchmark portfolio is therefore a reference for the results of the investments. The Funds are classified into the following categories:

- Equity funds, that invest mainly in equities;
- Balanced funds, that invest in stocks and bonds in the same proportion;
- Bond funds, that invest mainly (or only) in bonds ;
- Guaranteed funds, that offer a guaranteed minimum return or the repayment of the sums paid on the occurrence of certain events (for example, at the time of retirement).

The closed pension fund does not directly manage the contributions and relative yields but entrusts, within the limits and criteria established by the DM Economics 703/1996, this task to banks, insurance companies, investment companies or asset management companies. In managing the resources, the fund managers must follow the criteria set by the investment policies established by the Board of Directors of the Pension Fund.

> The financial resources of the pension fund are kept by a custodian bank. The manager of the fund therefore works with the custodian bank when he needs to purchase or sale the securities in which assets are invested. The custodian bank verifies that such financial investments comply with the law or the rules set in the Regulations of the Pension Fund. (from Covip (2013), p. 46)

2.7.4 The Pension benefit

The pension benefit is proportional to the contributions paid and to the returns achieved from the fund's investments.

The member of the fund may request the payment of the benefit when the conditions provided for by the rules of the fund are met. The performance take the form of a:

- Supplementary retirement pension;
- Supplementary seniority pension.

Alternatively, at the time of maturity of the pension requirements , the member can ask for the payment of the sum according to its present value , but only up to a limit of 50% of the amount accrued.

In the event that the member of the fund doesn't meet the requirements for membership to the pension fund anymore, he may pursue, one of the following options.

- Transfer of the whole sum that the individual accrued to another pension fund or individual pension scheme;
- Withdrawal of the whole sum.

All closed pension funds are supervised by COVIP .

2.8 The Open Pension Funds

The Open pension funds are the most used supplementary pensions that consent members who do not have the opportunity to access to the defined funds for their category, or simply do not want to join them, to have a social security coverage that suits their needs.

The open pension funds are financial instruments that provide additional pension income in two possible ways: individual funds and collective pension funds contracts.

They may be compared to closed funds if, instead of establishing a new collective pension fund for a specific category of workers, an already set up fund is chosen.

The open pension funds are established by financial institution authorized by law to carry on the pension fund business. These financial institutions are mainly banks and insurance companies.

The companies have to hold in a separate, independent fund the assets belonging the pension fund, in which all the contributions to the pension fund as well as profits earned from the investments of the pension fund should be directed. The assets can therefore be used uniquely to provide pension benefits to the members of the fund.

The objective of the Open pension funds is to create a form of supplementary pension security in addition to the mandatory public pension system. The pension benefits are paid according to the financial management of the fund and to the contributions paid by the members.

The open pension funds may accept new members that transferred from other existing pension funds. In this way pension funds gains a key role in the context of the increasingly important trend of labor mobility.

The regulation on the open fund must specify the management criteria and its internal investment limits, enabling in this way the potential member to assess the suitability of the fund for his needs, both in terms of risk and of future expectations of the retirement income.

The financial management of the fund can by carried on by the authorized company, but the custodian bank must be an external entity .

The Covip is the Italian supervisory body that represents the interests of members.

2.8.1 The Retirement benefits

The company managing the pension fund may pay the retirement benefits to the worker when the he achieves the right to the mandatory pension, basically when he reaches a given age defined by law or a given seniority.

The worker can achieve the right of the benefit even though his work activity ceases without having met the conditions set by law or in the case a he had changed his job and didn't change the specific reserved category of pension fund. The benefit consists of:

The old-age retirement benefit

The old-age retirement benefit, when the worker reaches the retirement age established in the mandatory system and he has at least 5 years of contributions in the Fund.

The seniority retirement benefits

The seniority retirement benefits, when the workers retire with an age not more than 10 years less than the one prescribed for the old age pension in the mandatory system. Moreover, the worker must have at least 15 years of contributions in the Fund.

2.8.2 The Enrollment

The participation to Open pension funds may be individual or on a collective contract. The association is on voluntary basis, however the workers have to agree all the terms and conditions of the funds prior to the association to the fund.

The individual participation is allowed also to subjects that are not employed or that are not part of some compulsory pension scheme. Persons that are legally still dependent on others, like children, may take

part of pension funds, too public and private employees, self-employed individuals, freelance and cooperative workers can join on a collective open pension fund contract if there are no established funds for their category.

Participation to the pension fund involves, in general , the possible risk of negative changes in the value of the Fund's assets as a result of price fluctuations of the securities in which the fund invested.

Therefore, there is the possibility, at time of retirement, of retirees not obtaining the repayment of the contributions paid or, however a final pension income that meets the expectations. Conversely, this is not the case of guaranteed returns funds.

Each Fund offers several investments, with different levels of risk depending on the presence of a guarantee and on the investment policy.

By purchasing the shares of a company one become a shareholder, taking the full economic risk of the investment, although with the right to receive dividends, if distributed. purchasing bond securities (stocks , bonds and deposit certificates) one become lender of the issuer , and have the right to receive interest and , at maturity, the principal.

The open-end funds on the contrary, are not intended for a particular class of workers but are open, in fact, to anyone who wants to join the pension fund. The workers may join the open pension due to many reasons: for example, they do not have a closed fund specific for their class, or simply because the worker wants to exit from their specific pension fund.

However, this is possible only after five years from the worker's first contribution in the closed fund.

An essential difference with respect to closed funds is that open funds can be marketed directly by financial intermediaries like banks or insurance companies . The closed funds are established on the basis of national contracts and are promoted by

- trade unions
- employers

- national cooperative associations
- (at least) regional associations for the self-employed.

There is a major difference between funds that pays pension income with the defined contribution plans and those which will pay the retired worker as provided by a defined benefit plans.

In the first category the contributions to be paid to the pension fund are fixed and the actual payment once the worker retire is not predetermined. In the case of defined benefit, the payment is fixed and contributions may vary from time to time to achieve the set goal.

The law sets that employees and members of cooperative association can join only funds that use defined contribution plans . For the self-employed and freelancers both types can be set up.

2.8.3 The Contribution

- The frequency of the contributions (monthly, quarterly, semiannual or annual) and their amount is decided by the worker, that can modify these variables over time. The worker may however decide to pay only the severance indemnity;
- The worker employed in the public administration cannot put the severance indemnity with the contributions in the pension fund, that therefore will be made only by his individual contributionS;
- The employee who joins on a collective basis have to follow the rules as stated in his collective contracts and agreements, that may include the amount of the contribution, establishing therefore the minimum amount of the contribution.

  The Employee may, of course, decide to make higher contributions to the fund. If the worker decides to contribute to the fund even with his severance indemnity, then also the employer's contribution, as established in the collective, is put in the fund;

- Finally, the self-employed worker can freely determine the amount and the frequency of the contributions over time, with the possibility to change his choices freely.

2.8.4 The Investments

The pension funds offers more possible investment strategies with different combinations of financial instruments and, consequently, different profiles of risk and return. The choice, however, is not definitive since after one year the member of the pension fund may change the investment strategy. The procedure is specified by the pension fund rules.

The investment policy of each portfolio is compared to the benchmark portfolio, which is used as a reference parameter and it defines the proportion of resources to be invested in various assets. The benchmark portfolio is used to verify the results from the management of the various investments.

The different investment strategies are classified into the following categories:

- Equity:Invest solely or mainly in shares;
- Balanced:They tend to invest in stocks and bonds in the same proportion;
- Bonds:Investing mainly in bonds;
- Guaranteed:They offer a guaranteed minimum return or the payment of a capital sum upon the occurrence of certain events, such as at the time of retirement.

If the worker takes part of the pension fund on a collective basis the Regulations of the funds provides a special category that collects the severance indemnity (TFR) payments of the "tacit" members of the fund.

The fund may however delegate other qualified entities to manage some investment categories.

2.8.5 The Performance

If the worker is part of the supplementary pension fund for at least five years, he can transform his individual position in the fund in an annuity.

In addition, the member may decide to opt for a lump-sum of the individual position , but for an amount not greater than 50% of the total accumulated capital. However, if the yield of 70% of the amount accumulated is less than half of the annual amount of the mandatory pension payment, the sum can be paid entirely in capital.

The annuity payments are made by the insurance company the Fund has an agreement with. The member who has acquired the right to pension benefits can opt to transfer his contributions in a different supplementary pension scheme to benefit from better pension payments.

During the accumulation phase and however only in the cases provided by law, the member may request advances payments on his individual position, up to the total redemption of the sum. In order to redeem their individual position in before the date of retirement, the members must not fulfill anymore the requirements for participation in the pension fund.

For the members that have took part on a collective basis, the redemption can occur only as a result of the worker's resignation or dismissal, or in all other terms provided by the Rules of the Fund or by law).

2.9 Individual Insurance Pension Plans

In Italy, individual pension plans are known as PIP (piani individuali pensionistici).

They are independent from the worker's employment status (e.g. employee , self-employed...), that benefits from a special pension fund policy that relies on the signing of insurance life contracts.

This insurance contract allows the individual to get a capital sum if, at the time of maturity of the policy, the insured individual is still alive. The policies are however different from the traditional life insurance policies,

since they are subject to the laws governing pension funds.

Specifically, the law specifies the type and the method of payment of the sum, as well as the terms and conditions for the transfer or redemption of the accumulated contributions.

Only companies authorized by the Insurance supervision authority (IVASS) can offer IPPs (individual pension plans).

Workers employed in the public administration can join IPPs (individual pension plans) only on an individual basis.

Moreover, they can add family members to the plan.

This option depends however of the specific rules of the fund. after two years, the member may transfer the capital accumulated to another pension scheme without any charges.

The person who want to take part in an IPP can choose, according to his needs, between different contribution amounts and different investment strategies that will result in different supplementary pension incomes.

Like any insurance policy, they have a loading on premiums paid, on the principal and on the minimum guaranteed return.

IPPs use defined contribution schemes. The amount of the pension benefits of the IPP are determined by the contributions made and are based on the capitalization principle.

2.9.1 Individual Pension Plan typologies

- Traditional policies, that guarantee a minimum rate of return;

- Unit-linked insurance policy, that are pegged to the value and the yields of the insurance funds, of the unit trusts Investment or the of the UCITS (collective investment funds) value;

- Mixed type policy, in which the reassessment of the individual position is a combination of the two previous policies (traditional and unit-liked).

In the traditional policies that can be revalued, the capital is revalued annually, based on a the performances and the returns earned by the insurance company from the investment strategies.

Instead, in the unit-linked insurance policies, the premiums paid are converted in shares of the insurance company's or in the company's internal or mutual funds. In this case, the accumulated capital is linked to the fund's yields.

But these policies does not guarantee a minimum rate of return. They are however seen as the best option for the medium and long term investment, although this kind of investment is not riskless for the worker.

2.9.2 Individual Pension Plan Purpose

The IPPs allows the worker to accumulate additional capital that will be paid either in a lump sum or with the payment of an annuity when he retires.

This income will complements pension income from the mandatory pension schemes.

When the worker takes part in an IPP, the insurance company will provide for a pension benefit when he will retire.

To join an IPP the worker must have at least 5 years of contribution payments before the retirement, but we must consider that the lower are the contributions by the worker and the lower will be the accumulated capital that will be used to constitute the additional pension income.

At maturity of the IPP, the worker may choose between the following types of income:

1. Life income: it is a payment made to the beneficiary until he dies;

2. Reversible life income : it will be paid at the beneficiary's death to the person he have designated on the contract.

3. Certain income and further annuity : the payment to the beneficiary or to the person designated n the contract both if the bene-

ficiary is alive or dead. This type of IPP provides payments for a maximum of 5 to 10 years.

After this term, the annuity will continue to be paid only if the beneficiary is still alive. the At the maturity of the IPP contract, the beneficiary has the possibility to withdraw up to 50% of the amount accrued to that point.

It is however possible to claim the whole accrued capital of the IPP only in the following cases:

- Permanent disability of the beneficiary;
- The beneficiary is jobless for more than 48 months. In case the beneficiary is not employed for a period longer than 12 months, but shorter than 48 months, he can withdraw only 50% of the capital accrued;
- Death of the beneficiary.

2.9.3 The Costs

The cost of a IPP policy are greater than both the open and closed funds. The costs depends on the product, structure, duration, premium payment and to the type of guarantees entered.

Specifically, every policy may have a different:

- Loading on the premium;
- Management charges, that may be fixed or applied as a percentage of the policy;
- Additional costs that may be applied to the policy
- Transfer to another pension plan scheme (to a pension fund or to another IPP);

- Policy redemption, where the beneficiary will stop paying the premiums and will terminate the contract.

  The charges for the redemption are defined in the contract.

- Policy switch (transfer from one investment fund to another).

  The costs of this operation are quite low and maybe not applicable in the case of "automatic switching".

2.9.4 The Contribution

The worker when taking part in the IPP have the free choice regarding the frequency and the amounts of the contributions. Specifically, the contributions may be paid monthly, quarterly, semiannually or on annual basis. The worker has the possibility to change the frequency of the payments over time.

The contributions may be as well made by the accruing worker's severance indemnity.

The worker has the option to stop temporarily the payment of the contributions.

That does not involve the contract end. The contract can be reactivated at any time, when the worker decides to pay the contributions again.

The employee may choose to continue paying the IPP contributions even after achieving the mandatory retirement age as set in the mandatory pension schemes provided that, at the retirement, the beneficiary has at least one year of of supplementary pension schemes contributions.

2.9.5 Supervision Authorities

IPPs are registered pension funds and are supervised by the COVIP, that monitors the behavior and the fulfilling of the transparency conditions as well as the fairness of product offered to the customers.

2.10 The Existing Pension Funds

The category of the existing pension funds comprises those funds established before the big pension reform of the 1990s. They are completely free of charge for the employees and can be seen, in practice, as a benefit from the company, that has paid all the necessary contributions. Since these pension funds were already operating at the time force of the first laws that regulated pension funds they have kept special regulations. Workers that were already members of mandatory pension systems before April 29th, 1993 have been transferred to a Pre-Existing Pension Fund and are therefore are considered as "Old Members".

Pre-existing pension funds are subject to some criticism due to their low level of transparency, especially in their relations with members and on their organization and activities.

Brugiavini (1999) states that :"The law decree 124/1993 have classified in a coherent way the various forms of supplementary pension schemes, providing the rules to increase their transparency for the benefits of the workers. These funds manage assets directly, without the need for specialized intermediaries."

The existing funds represent more than 50% of supplementary pension schemes. Therefore, existing pension funds represent an important component of the industry that, although gradually less relevant, is still superior in terms of both number of member and assets managed.

The participation in a pre-existing pension fund is voluntary. Temporary workers as well as those hired with new types of contracts may also take part of the fund if the Rules of that specific fund admits such members. Moreover, family members depending on worker that participate in the pension fund may be added, provided that the Statute of the Fund does not have any rule against it.

The worker, to take part in the pension fund, have to pay the severance indemnity that matures after his entry and the pension contributions at his own expense, to the extent provided for by the contract. The existing pension funds should ensure that the minimum information

provided for by the fund Statute are submitted to the Covip.

There are two special cases:

2.10.1 The pre-existing autonomous pension funds

They have legal authority and have administrative and management structures that are separated from the entity, that can be an association, a foundation or a non-profit organizations such as the Fondo Pensioni Dipendenti DOW, these funds may work with defined benefit schemes, defined contribution schemes or mixed systems.

2.10.2 The existing domestic pension funds

They are not a separate entity, and they are a part of the company (banks, insurance companies).

The existing domestic pension funds assets are however separated from the company's ones. They have been established especially for the workers employed in such companies.

The RAI employees, for example, can participate in such a supplementary pension scheme.

Such funds do not have autonomous administrative structures and accounting systems, and may work with contributory defined benefit, defined contribution systems or mixed systems.

The transformation of a pre-existing pension fund into a pension fund that complies with the new laws will normally result in the change of the contribution regime with which the performance of the fund is determined.

In case the fund works with a defined benefit pension fund it may have to change the regime to a defined contribution or to a mixed system.

Fornero and Castellino (2001) states that :

- In the defined contribution system the pension annuity is proportional to the accumulated capital and to

the yields of the investments, as it happens in the new pension funds.

The existing pension funds that works with the defined contribution schemes may add new members to the specific fund only if they are employed in the same sector as the existing members and cannot extend the fund for workers employed in other companies or sectors;

- In the defined benefit system schemes the amount of pension income is fixed and it corresponds to a percentage of the income or of the guaranteed pension income.

  Therefore the amount of the contribution to be paid by the member is determined accordingly. The regulations for the existing pension funds working with the defined benefit schemes issued on April 28^{th}, 1993, have forbidden them to add new members to the fund.

  Such pension funds can only keep the existing members. Therefore they are characterized by the low percentage of workers with respect to retired members;

- Mixed forms: when within the same pension fund both pension schemes co-exist.

The defined contribution schemes and the complementary pension funds have been introduced by the existing pension funds, which in their turn invest 11. 9% of their total assets in real estate.

If the worker has been a member of the pension fund for at least 5 years, at retirement he is eligible to request, in special cases foreseen for by the law,a partial or even a total liquidation of the accumulated contributions.

For example in case of the loss of the job the worker can require up to 50 % of the total amount contributed, furthermore the worker may get up to 70% of the contributed amount in case of converting the sum into an annuity.

The old funds have different characteristics from the new funds established after the Amato and Dini reforms. They may invest in real estate, and since such investments are prohibited to the new funds, the comparison between the returns of the funds is difficult.

However, the existing funds are slowly adapting to the new management and organization criteria to follow the new laws. Such funds are in any case supervised by the Covip.

In the last few years adjustment to the existing pension funds have been introduced. The Ministerial decree 62 of 2007 have modified the rules in the sector. Specifically, the management and the organization of the existing pension funds as well as the allocation of severance indemnity payment have been modified.

2.11 One-strategy and Multi-strategy Pension Funds

A pension fund can be structured in the following way in terms of investment profile offered:

Italian pension funds are characterized by different investment opportunities. A pension fund can offer a single line of investment (in Italian this kind of funds are called monocomparto) or more lines of investment (in Italian this kind of funds are called multicomparto).

The pension fund in the early stages are obliged to manage a single line of investments and only after the fund may decide to introduce the multicomparto management.

2.11.1 Monocomparto Pension Funds

A monocomparto pension fund provides only one line of investment, and is characterized by the fact that the contributions of the members are managed in a unified way, therefore the same investment policy is shared by all members.

The members will benefit from the same result from financial operations carried out by the fund in terms of yield.

The investment strategy of monocomparto pension funds takes into account only a particular category of financial products.

This portfolio of investment can be defined as cautious, since it provides the members from excessive risks.

2.11.2 Multicomparto Pension Funds

A multicomparto pension fund with is characterized by a structure where more investment lines are present within the same pension fund.

That is, more diversified portfolios with different degree of risk and expected return are offered to the members, responding flexibly to their different characteristics. Members of the multicomparto pension funds can pass from one strategy to another over time, even once a year if they want.

Since there are several investment strategies available, the fund and provides the member the opportunity to choose freely the strategy that best suits his needs and personal characteristics like his age or the risk he wants to take.

As it says in Messori (2008) : "In the case of younger workers, they could be more likely to opt for aggressive investment strategies (with a prevalence of shares) which have a higher degree of risk, but also are more likely to have higher yields in the long run. The negative effects due to higher risk, particularly evident in the short run are, in fact, lower with long-run investments. The workers closer to retirement, however, may prefer to join a managed portfolio that follows a more "conservative" strategy, investing in government securities or bonds."

The investment strategies (lines) are classified by the Covip in the following four categories:

- Bond lines:Investing only in bonds, excluding share;
- Mixed bond lines:Investing in shares is allowed, but in any case no

more than 30% of the assets;

- Equity lines:At least 50% of the fund assets are invested in shares;
- Other lines:Investment strategies different from the previous cases.

2.12 The Longevity Risk

The possibility of having a pension when reaching retirement age marks a significant milestone in everyone's life.

The change from the working salary to the retirement income have an impact on the lifestyle and on financial possibilities of all the individuals, that may reconsider the management of their assets in order not to risk insolvency in the years after retirement.

Financial decisions can be affected by two main factors:

- The lifestyle of a retiree is influenced by market factors, such as the volatility of the financial markets in which he invested the money saved. The inflation risk can reduce his purchasing power.

  For example, an annual inflation of 2% can decrease about 40% of the actual value of a given annuity over a average pension period of 25 years;

- Today, a retiree faces an increased longevity. Life expectancy is a measure of the state welfare, the environment and health in which a population lives.

  It is inversely correlated with the level of mortality in a population, therefore, in addition to representing a demographic index, it is also useful in assessing the development of a country.

In the 2010, the average life of the Italians was:

- 84.3 years for women;
- 79.1 years for men.

In 2010, life expectancy at age 65, or the number of years that an average person aged 65 have left to live, was 18.3 for men and 21.9 for women. In Italy 18% of the population is above 65 years of age. According to many forecasts, in 2030 this percentage will constitute almost 30% of the total population.

"In particular, in a period of time between the year 2000 and the year 2050, there will be a significant shift of the age profile to the over- 65 individuals. In fact, a 75% increase in the over 65 population is expected with a particularly rapid pace around 2030" Cigno and Werding (2007).

This kind of trend is positive from a social point of view, but it can generate significant problems when we are trying to estimate future financial needs, both from a country's and from an individual's point of view.

In the numbers just mentioned it hides what experts call the longevity risk: the risk that the average lifespan of a generation of individuals is greater than expected.

Today

- A 65 year old woman is almost 60% more likely to be alive at 85, and she has more than 30% chance of being alive at 90 years of age;
- A 65 year old male have nearly 50% chance of being alive at 85 , and nearly 30% chance of reaching 90 years of age.

Even more significant is the fact that for the male population now aged 65 there is at the same probability, around 8%, of reaching the age of 70 in or the age of 95 alive. Therefore a male that have reached retirement age today has the same probability of being in front of 5 or 30 years of retirement income.

Consequently, the individual have to make a difficult decision on how to spend its severance indemnity ,indicating his preference for a lump-sum of capital in a single installment or the payment of an annuity.

Longevity risk, since it has a very complex nature, is not well managed by investors.

Fenge *et al.* (2008) states that:

> From recent U.S studies (Fidelity 2007), where the life expectancy is similar to the Italian one, it is clear that normally we tend to underestimate the individual's longevity risk and thus the duration of the pension. Retired Americans are estimated to recourse to their retirement savings until the age of 85, while workers close to retirement will use it on average until 83 years.

2.13 The Supervision Commission of Pension Funds

The Supervision Commission of Pension Funds (COVIP) is the surveillance Authority in charge of supplementary pension schemes. It was created by in 1993 by the Legislative Decree 124 /1993. The Covip was given legal personality under public law in 1996, and it moreover control the financial investments and the assets of the Professional Pension Funds , that manage the pension contributions of specific categories of workers.

The COVIP is an independent administrative authority whose duty is to ensure the proper functioning of the pension funds system. It is Covip's responsibility to ensure the protection of the savings allocated to supplementary pension schemes, aiming at a higher transparency and fair conduct as well as a sound and prudent management of supplementary pension schemes.

The COVIP is under continuous supervision of the Ministry of Labour and Social Security, but it has however a great autonomy in carrying out its duties.

The COVIP ensures the transparency of supplementary pension schemes by defining specific rules on:

- The management of the fund;

- The investment strategies;
- Individual investment positions amounts;
- Administrative and management expenses;
- The rights of the pension fund members.

The supervisory activity of the COVIP is done through the verification and analysis of documents, information, accounts and annual reports that the supplementary pension schemes are required to submit to the Commission.

The COVIP authorizes new supplementary pension schemes after having verified the fulfillment of the conditions provided for by law and by the Commission. The authorized firms are listed in the register of supplementary pension schemes firms, that is kept and updated by the Commission itself.

To sum up, the COVIP:

- Allows pension funds to carry out their activities and approves their statutes and regulations;
- Keeps the register of authorized pension funds firms to engage in supplementary pensions;
- Ensure the proper technical and financial management of pension funds and the adequacy of their organizational structure;
- Ensures compliance with the transparency principles in the relationship between pension funds and their participants.

The Covip supervises only In Italy 8 million of workers member of supplementary pension funds, with a total of 177 billion euro in assets.

Divided into:

- 116 billion euro for pension funds;
- 61 billion euro for Professional pension funds.

This figure is equal to approximately the 10% of the Italian GDP. In 2013 12.5 billion euro was collected, of which 5.2 billion euro have come from severance indemnity payments (TFR) that were directed to supplementary pension schemes.

If we categorize the supplementary pension funds by the assets amount we have

- 330 existing funds that manage 50 billion euro in assets, making up approximately 40% of the total assets;
- 39 closed pension funds with 34.5 billion euro in assets;
- 59 open pension funds with 12 billion euro in assets;
- The firms that manage individual pension plans have 19.5 billion euro in assets.

2.14 Severance Indemnity to the Pension Funds Transfer

Membership to the voluntary pension funds is free (Article 1 of Legislative Decree no. 252/05).

The employee within six months may decide to:

- Allocate the portion of severance indemnity not yet accrued to the supplementary pension scheme;
- Leave the severance indemnity in the company he is working for do not decide the specific allocation.

  In this case, the employer transfers the severance indemnity accruing to the collective pension scheme provided for by collective agreements or contracts, unless otherwise agreed. In case there are more pension schemes, the severance indemnity is transferred to the pension fund with the largest number of members, unless otherwise agreed by the company.

In the absence of a reference collective supplementary pension scheme, the employer must transfer the severance indemnity accruing to the supplementary pension scheme set up specifically at INPS (FOND-INPS) (Article 9 of Legislative Decree no. 252/2005);

The worker may decide the specific allocation of the severance indemnity even later. The accrued severance indemnity is left in the company accounts and will be paid at retirement.

Chapter 3

The Pension System around the World

In foreign countries important reforms have been introduced in the system, so now the three pillars pattern is now the most widespread thanks to both private and public designs.

This is due to the fact that many countries (particularly, the U.S.A.) have spotted the negative consequences that the demographic issue has on the pension system.

The most common choice is the one in which we see a simultaneous private capitalization and pay-as-you-go financing method. More specifically, the private pension is based on a defined contribution scheme as well as on a defined benefit one; the public pension bases its calculations on a defined benefit formula.

What differentiates one country from another is the choice of how to mix the two types of scheme. In particular, two main patterns can be individuated:

- The Anglo-American one, where great relevance is given to the private capitalization scheme and the public one has a function near to a supplementary one;
- The euro-continental system, where the weight are reversed: here the public branch is prevalent and the private one has a very re-

duced dimension (notice however that in the last years it is gaining more and more importance, due to the reforms that take into account the increasing demographic issue).

3.1 Anglo-American Pension System

3.1.1 United Kingdom

Differently from many of its European neighbors, the UK assigns a dominant role to the private pension pillar. Another relevant difference with respect to them, consequently, is about the public expenditures on pensions: they are expected to stay still in the next fifty years, equating about the 5% of the country's total GDP. This brings to an absence of concern about the financial sustainability of the pension system.

At this regard, we must notice that the amount of accumulated pension savings is the highest in the European Union, allowing to counterbalance the negative effects that today's demographic changes have on public pension expenditure. Indeed, a private-based pension system translates into very close amounts of individual contributions and paid benefits.

Anyway, public pension schemes are based on a PAYG principle and the payments that finance it come from the National Insurance Contributions, which are proportional to the income on the person.

At the moment, UK's pension system is made of three different levels (and notice that the first two are compulsory):

- Basic State Pension or BSP: is the first level, totally public, adopted by employees and self-employed workers. Its amount doesn't depend on the subject's income;

- State Second Pension or S2P: is the second level, again with public nature. Differently from the BSP, the benefits are proportioned to the income of the subject and to the contributions to be paid at the National Insurance.

In this case workers have an alternative: they can contract out and put past payments into a private pension scheme with individual or corporate nature;

- The third and last level has a completely voluntary nature. This means that each subject can decide to pay additional amounts through personal, occupational and stakeholder patterns.

3.1.2 United States of America

In the U.S.A. a very important role is played by the second and third pillars, and it's easy to see why. On average, indeed, United States' workers get their income covered by public pensions by a 40%, with a small increase in the case of workers with a lower salary.

In that case, we observe a coverage equal to the half of the $ 15,000 per year.

Currently, we can individuate three elements constituting the American's pension system:

- Primary Insurance Amount (PIA): represents the public pension branch. Its strongest characteristic is its redistributive nature, that aims at assigning greater replacement ratios to those workers who earned lower salaries during their working life.

  At the same time, this public choice boosted the development of the private branches of the system, thus to allow workers with lower replacement ratios to compensate. The pension payment is computed considering the highest thirty-five years (in terms of income), revaluing them with regards to the wage growth rate an then applying to them a factor that can oscillate from the 15% to the 90%;

- Corporate pension funds. As a general rule, they are funded by the employer and they are typical of the smaller firms. Because of the amount of workers involved, those kind of funds represent the majority of the sector.

One of the most relevant contribution plans is the so called 401 (k), which takes its name directly from the related section of the taxation code. The proposal to the workers is made by the employer. whose success is closely linked to their fiscal flexibility and convenience for the employee and to the lower administrative cost borne by the employer with respect to defined benefit plans.

The accumulated capital may be liquidated only after a certain age and it is taxed only at this time; there is also the possibility of making withdrawals from the account, without facing penalties, in the some special events such as disability, death, unemployment and so on. The contribution of the employee, within certain limits is tax deductible.

The returns earned on the capital are not taxed, unlike the benefits. The companies which sponsor 401 (k) plans must provide to the members at least four investment options and the employee who moves to another company can move her pension plan without any penalty or tax charge.

These plans are managed by a trust and the legal form of a trust ensures the separation of the assets of the plan with respect to those of the sponsor company.

- Individual Retirement Accounts (IRA): are individual plans, based on defined contributions, specifically designed for those workers who have no possibility to enter a corporate fund.

  Such accounts feature an annual contribution sum that cannot be exceeded by the worker who, in the case of earnings lower than a certain threshold, can deduct such payments from its taxes.

  Among the IRAs, have relevance the so called Self-Direct IRA (thanks to which the worker pays the contributions to a custodian bank) and Roth IRA (which doesn't feature the tax deductibility but ensures complete tax exemption after the reach of an age limit).

We can therefore deduce that one of the most important factors for

the great boom of private pension funds is to be individuated in the related tax advantage.

3.2 Eurocontinental Pension System

The continental Eruopean systems are instead very different and much less based on pension funds, although the weight of supplementary pensions is increasing and it is expected to increase even more in next years.

The German system provides for example a high public pension and a second complementary pillar present mostly in large companies in the form of occupational pension schemes.

In France there are instead two pillars, both compulsory: a primary pension, function of years of contributions, and which covers up to a maximum of 50% of the last income perceived, and a secondary pension based on the PAYG scheme.

There is not a supplementary pension based only on the pension funds managed by private individuals, and generally the capitalization regime is not applied.

The Swiss system is instead based on three pillars: the first one provides a basic pension which varies greatly depending on income.

This first pillar has a redistributive role of the wealth and it is financed from the contributions of workers and employers, and by the state. The second pillar is compulsory, based on a funded scheme, but where a minimum level of return is guaranteed.

The third pillar consists of an individual pension for self-employed.

More generally in continental European countries there is often a first pillar (public pension) which is quite consistent with the function of income redistribution. This first pillar is usually integrated with other social security systems, in PAYG schemes (France), or more generally funded schemes.

It must be noted, however, that if the funded supplementary pension is mandatory, usually it provides a minimum return or a guarantee scheme, as in Switzerland, Denmark or in the Dutch model. The case

of Sweden is particular,where there is a system of funded pension funds managed by the state and not by private individuals.

3.3 Latin American Pension System

During the 40s of the twentieth century, several Latin American countries founded social security as part of the responsibilities of the State and employers with respect to workers.

Changes in the economic model in Latin America have been involved in a great socio-political instability with strong signs of ungovernability; however it is noted that despite the lack of stability and governability, the neo-liberal and privatization politics have definitely been consolidating covering social Security.

The development of pension funds in Latin America has grown from a concrete and random phenomenon, to an international one with only favorable and beneficial consequences for both future generations of retirees, and the States, facilitating the development and stability economic of countries which implement this pension system.

The beginning was marked by Cile in the 80s which was the pioneer in changing the reforms of pension systems based primarily on savings and the Individual capitalization, where the most important pension reform was the privatization of pension system and it continued for many countries such as Peru, Colombia and Argentina, which currently are the countries with the most years of experience and which reflect the greater diversification of the investment portfolio.

In these countries the process of diversification has been coupled with the development of their own capital markets, allowing them to diversify risk and get higher returns.

With the passing of the years were added, to this new reform, countries such as Mexico, Uruguay, Bolivia, El Salvador and it is in phase of analysis in other countries like in the case of Venezuela, Ecuador, Brazil, Honduras and so on.

Mainly, the innovation is using the system of individual capitaliza-

tion as a method of financing of the public pensions of future retirees, compared to the outdated and inefficient traditional distribution system.

As say Trigilia (1999) :“ The public pension system is not the right tool of the State to redistribute wealth or taxes among its population”.

The doubtless advantages of this individual capitalization system are:

- Transparency and benefits throughout the working life, preventing fraud among them;
- Reduction of evasion of the informal economy and of corruption;
- Independence of the usual economic cycles which may cause higher unemployment rate and may endange the payment of pensions to retirees, as in PAYG systems;
- Independence of the economic situation and State revenues to receive the pensions;
- Independence of the demographic evolution of the population, like the aging issue, the lower birth etc ;
- Important economic resources volume of internal savings to be invested and which are the key for the sustained economic development of a country.Weyland (2009)

In last years, the development of pension funds in Latin America allowed the transparency of the pensions schemes of people and of the funds between different countries and it alloewd the total internationality in the broadest sense, standing outside those countries which do not implement it.

Currently most of Latinoamerican countries is part of the International Federation of Pension Funds Administrators (FIAP) whose aim it to keep updated about the pension system, its operation, its contribution to profitability of funds and the benefits it gives, all of which is the key for affiliates to make better decisions and thus achieve better pensions.

Where The FIAP is a meeting point for the exchange of experience between countries that have adopted systems based on the capitalization of private savings and on the management of them, providing information and support in improving the system.

Currently there are 19 countries which take part of the FIAP and work on the improvement of the systems and on the consolidation of the system of capitalization in their respective countries.

- In the following chart we can see the world different countries have incorporated the individual capitalization in a compulsory scheme (in green) and hose who have no individual capitalization (in yellow).

It can be noticed that in the chart there are European, Asian countries and Nigeria as the only African country, that have incorporated this system. (see Figure 2.1)

In recent years there have been many studies on the trend of pension funds but a recent study, in particular, analyzes the impact of these reforms on the economic development of these countries. For example the growth of pension funds deepened capital markets in these countries. Financial deepening, measured with variations according to the economy, increased:

- In Chile from 46% in 1981 to 276% of GDP in 2011;
- In Colombia, 45% in the mid 90's to 137% of GDP in 2010;
- In Mexico, 42.6% in 2001 to 64.8% of GDP in 2012;
- In Peru, from 26% in 1993 to 99% of GDP in 2009.

This progress can not be attributed exclusively to the pension reform, but the fact that pension funds are major investors in corporate bonds indicates that they significantly contributed.

Figure 3.1: Source: Federation of Pension Funds Administrators (FIAP)

3.3.1 Privatization of Social Security Systems

Social security systems in Latin America and in different countries of the world began with the first changings on reforms of their pension systems, completely replacing the old system of social solidarity for a system based on savings and individual capitalization to boost the economic growth. With the current Social Security system, each generation loses the difference between the actual interest on capital which would get in a funded system, and the benefit (much lower) which is derived from established saving program.

Therefore, the shift to a system of mandatory private individual accounts that would invest in a mix of stocks and bonds would allow individuals to get all the pre-tax real return on capital, which would result in higher capital and higher national income.

- Privatization of Social Security can increase worldwide real incomes while ensuring a worthy pension for future pensioners.

The first latin american country using the mandatory privatization system was Chile in the year 1981 under the dictatorship of Augusto Pinochet (1973-1990) becoming one of the first fully funded systems in the world.

- The Chilean model has been a benchmark for many other countries;
- The Chilean model was based on the private retirement system of the United States fashion totally applied to all workers in the economy starting from the old public system.

Its main feature is that its full mobility is:

- When a worker changes job, he/she preserves the benefits;
- Managers of pension funds operate as mutual fund as restrictions according to the degree of investment risk that the saver wants to take from his/her resources.

With the introduced compulsory privatization system it is recommended to use a system of multiple pillar containing 3 pillars:

- The first pillar may resemble the existing public pension system so it is publicly managed, defined benefit and tax financed. However, the reformed public pillar will focus on providing a net redistribution social security in old age, particularly for old individuals and throughout their working life especially if their incomes were low.

  The beneficial formula can be keeping a low benefit as in the models of Argentina and the United Kingdom or an assessment of assets as in the model of Australia, or through a guaranteed minimum as in Chile pension model.

- The second pillar is handled privately with individual capitalization for savings; this pillar differs dramatically from current systems because a significant number of people does not save enough for their old age in a voluntary pillar and it can become a burden to society when they reach old age.

  An important point is that individual funding for the second pillar can be used to help building the national long-term savings and to help financing pension plans for future returns of these savings; the funds will be handled privately and competitively and to maximize the probability of economic objectives. Berstein *et al.* (2006)

- The third pillar is a voluntary savings kind, for people who want more protection in their old age and it could provide an additional pension income to people inclined to save more. An important public politic is that governments could offer tax incentives for voluntary savings.

In Latin American Reforms introduced in the individual capitalization systems followed three alternative ways:

- Chile (1981), Bolivia (1997), Mexico (1997), El Salvador (1998) and the Republic Dominican (2003-2005) developed alternative reforms,

eliminating gradually their former public distribution systems to replace them with funded systems. They also left the management of the funds to private sector, with defined contribution into individual accounts for beneficiaries.

- Colombia (1994) and Peru (1993), however, established parallel or dual systems, where the privately funded system administration did not replace the distribution, but was offered as an alternative subject to a worker's decision.

- Argentina (1994), Uruguay (1996), Costa Rica (2001) and Ecuador (2004) created mixed or complementary systems, where both regimes (capitalization and distribution) are mandatory and integrated.

Despite the different paths that the reforms adopted in response to specific circumstances of each country, all shared similar goals, whose best known are:

- Improving the coverage of the pension system;

- Avoiding the risk of vulnerability and poverty in old age;

- Increasing replacement rates;

- Reducing actual or potential financial imbalances;

- Reducing the pressure on resources;

- Improving the transparency of the system and minimizing its susceptibility to political interference.

LATIN AMERICA (17 COUNTRIES): PENSION COVERAGE In 12 out of 17 countries considered for Latin America, social security benefits and pensions reach less than half of adults over 65 YEARS.

In the graph we can see that only 7 countries exceeded the average (40%) of pension coverage to people over 65 years. Are distinguished countries such as Uruguay (84.5%), Chile (84.2%), Brazil (85.1%) and

high coverage of Argentina (89.3%) whereas in other countries there is a low pension coverage. (see Figure 2.2)

3.4 The Ecuador System

The System of Social Security in Ecuador, as in other Latin American countries, at the end of the 20s was conceived on the basis of a system of capitalization for the pension fund and of a PAYG system for health benefits, but in 1987, according to the Official Gazette No. 21 of September 8th, was estabilished one form of financing called "Global" for all programs and services currently in force, that is all the resources from contributions, entering the social insurance fund, are distributed and they finance both economic benefits, and health benefits, which currently are poor and expensive.

In 1992, the Commission of Ecuadorian Institute of Social Security (IESS) proposed, as an alternative to the crisis, the creation of a pension savings market in which, in addition to the Ecuadorian Institute of Social Security (IESS) and its affiliates, involving new financial, public and private entities, called AFPs and Insurance Superintendency.

Ecuador's social security system is composed of the following institutions:

- Ecuadorian Institute of Social Security (IESS);
- Social Security Institute of the Armed Forces (ISSFA);
- Social Security Institute of the National Police (ISSPOL).

The Ecuadorian Institute of Social Security (IESS) is an entity created for the purpose of providing, administering and offering the social security service. Its organization and operation is based on the principles of solidarity, compulsoriness, universality, fairness, efficiency, subsidiarity

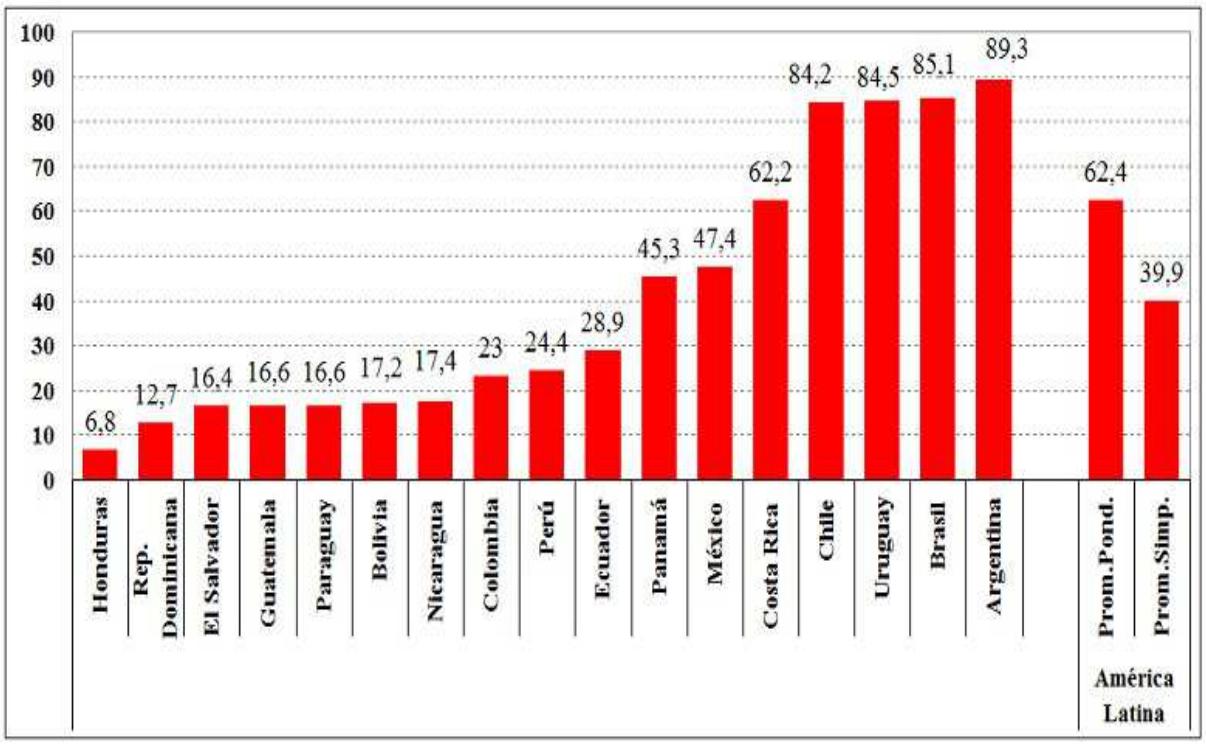

Figure 3.2: Pension Coverage in Latin America, Source: Federation of Pension Funds Administrators (FIAP)

and sufficiency. It is responsible for implementing the General Compulsory Insurance System.

The November 30th, 2001, in the Official Gazette No. 465 the LAW OF SOCIAL SECURITY was published.

The IESS's mission is to protect the urban and rural population, with or without labor relationship, against the contingencies of sickness, maternity, work injury, disability, unemployment, invalidity, old age and death, in the terms enshrined in the Law of Social Security.

The IESS, as determined by the current Law of Social Security, is maintained as an autonomous entity with legal personality, distinct from the revenue authorities.

Also changes are set, in order to separate funding and administration of the contingencies covered by the Mandatory General Insurance administered by the IESS.

In 2001 one of the greatest challenges in the legal reform in the pension system of Ecuador was the case in which it was approved a mixed funding contributions, that is a system of individual capitalization with solidarity intergenerational to improve the benefits and to increase the contributions of insured individuals and employers.

With this system of individual capitalization there exist advantages and disadvantages for which they can cause many doubts.

One of the main advantages of the system is that it maintains a financial balance: this system is self-financing, because all members save in order to fund their own retirement; therefore, there is a direct relationship between contributions and benefits and overall there is an intergenerational insurance.

They can be efficient under private aministracion of affiliates contributions; efficiency gains are achieved, as well as costs and quality of services.

Members would be well informed about the assessment of their pension funds and about the political management of the funds and above all about the generated savings.

The disadvantages of the system of individual capitalization are the

principles of solidarity and redistribution which all pension system has to keep; moreover there are high administrative costs, which introduce elements of uncertainty about the amount of the pension.

The Constitution of the Republic of Ecuador contains clear provisions on a universal social security and on solidarity with a pension system financed in the long term and technically administered.

- Currently the pensions management is in charge of the state and they are administered by the Ecuadorian Institute of Social Security under the PAYG system.
- The Pension Fund Administrators and Unemployment are based mainly on a voluntary pension system, which is supplementary to the compulsory State pension system.

The pension system is controlled by the Ecuadorian Institute of Social Security. The benefits offered by the Pension Fund, according to a pure distribution system, through this scheme are:

- Old-age pension
- Disability pension
- Temporary partial disability aid
- Pensions for widows and orphans
- Funeral aid
- Old-age assistance pension
- Invalidity pension financed by the state.

In the system of Ecuador a member can retire with 4 different options:

- The minimum retirement age for men and women is alike 60 years old with 30 years of contributions.

- The retirement age for men and women is 65 years old and 15 years of contribution.

- Minimum age of 70 years old for men and women and 10 years of contribution.

- Having 40 years of service without age limit.

The law provides a non-contributory social pension for poorest retirees by the State, however with this benefit, Art 205 Social Security Act (LSS) is not met.

The Ecuadorian Institute of Social Security also administers a Special Regime, the Rural Social Security, which provides services such as health, disability, old age, death and funeral assistance. Uthoff, 1995

To the old-age benefit is entitled only the householder who hath between 65 and 70 years and has completed 10 years of contributions.

The funeral assistance is given to any member of the family, 134 of Law of Social Security (LSS). In this pension system there are other ways to go retire which are administered by other institutions.

In the Social Security Institute of the Armed Forces (ISSFA) it is necessary to have 20 years of active and effective service in the institution to have the right for a pension.

At the Institute of Social Security of the National Police (ISSPOL) also it is necessary to have 20 years of active and effective service in the institution to qualify for a pension.

“ In Ecuador there is a population of 13.2 million people, where only 2.3 million holds a pension, that is that only 15.3% is assured.

Among the economically active population, only 23% are listed in the IESS. This means that 11 million Ecuadorians are marginalized and in the country, poverty has increased significantly.

The women has a coverage of 13.5 percent compared to men with 17.1 percent of the population.” From Social Security Department OIT (2012).

3.4.1 Pension funds in Ecuador

A pension fund is a long term investment made by the member in order to get his/her retirement when he/she retires, handled in individual accounts through monthly employee salary contributions during his/her working life.

The pension fund is managed as an investment fund. The investment fund attracts the money through various natural or legal investors for managing large amounts and invest them into a portfolio with different levels of risk and return, with investments in shares (equities) and state bonds; thus members actively participate as shareholders of companies in the country, generating recovery in the production system and creating a system of borrowing cheaper for businesses.

In Ecuador managers of investment funds are supervised by the Superintendency of Companies and can not concentrate investments in more than 20% in the same entity or in the same group, or allow a participant to have more than 15% share in a fund, in order to eliminate the risk that this investor retires. Ayuso *et al.* (2009)

Later, there follows an explanation of the pension funds and of the approximate amount of each that currently exist in Ecuador, either as part of a social security institution, or insurance, or even as supplementary closed pension funds.

Private ones:

- IESS, Pension Funds: $ 1073 billion.
- Rural Social Security: $ 160 million (including health) (within the IESS).
- ISSFA: retirement, disability and death (RIM) $ 132 million.
- ISSPOL: retirement, disability and death (RIM) $ 56 million.
- closed complementary pension retirement funds: $ 520,701,130,4.

3.5 The Chilean system

Chile in 1981 was the country which made the first reform in the retirement system where the PAYG system was replaced by the individual capitalization.

In this new system the concept of social security disappears and with it, the intergenerational solidarity, and it is replaced by a system in which the worker becomes a customer of private financial institutions.

They manage their resources throughout the working life; they charge a fee for the management and they invest these accumulated funds into the financial market. At the end of their working life, workers buy insurance through a programmed withdrawal or through an annuity, according to what they may earn.

If they do not reach a minimum pension, the State guarantees an addition, if they meet the requirements of the laws in this regard.

It was no a coincidence that Chile was the first country to adopt this system, since in those years the country was under Pinochet's dictatorship which allowed that this application does not adversely affect its operation.

The Chilean system is of a pure capitalization kind, although there remains a residual distribution scheme, funded with tax revenue, which will disappear over time because since 1983 no worker could enter the old system.

In Chile, the pension system is organized around a three basic pillars:

- A poverty prevention pillar
- A mandatory contributory pillar
- A voluntary savings pillar.

Through these components, on the one hand the aim is trying to ensure that people can carry a similar standard of living between the active working life and the retirement period and on the other hand, trying to eliminate the incidence of poverty in old age or in case disability.

The solidarity pillar is the one aiming to prevent poverty in these vulnerable situations. This pillar is comprised of a non-contributory pension, basic solidarity pension (PBS), and a supplement to the contributory pension, the solidarity pension benefit (APS).

The mandatory contributory pillar is a single national scheme of financial capitalization in individual accounts managed by private companies, the Pension Fund Administrators (AFP). This is a defined contribution scheme, i.e., where the contribution rate is kept constant and the benefits are calculated using formulas based on the actuarial accrued by each individual at the time of retirement.

In order to complement the compulsory savings made through the AFP system, there exist tax incentives for people to make voluntary contributions through a series of financial instruments: voluntary savings accounts managed by the AFP itself, mutual funds, life insurance products etc.

The pension modalities are for the pogrammed withdrawal, the annuity, immediate annuity with programmed withdrawals and temporary revenue with deferred annuity.

The implementation of the new system performs on the November 4, 1980 by Decree Law No. 3,500, where the collective public PAYG system was completely replaced in its civil action by a new private pension system based on individual capitalization. This system became operational in May 1981, under a defined contribution scheme based on individual mandatory private saving plans.

Workers must contribute monthly:

- 10% to finance the old-age pension, disability and longevity.
- An additional contribution, set by each Administrator intended to pay an insurance premium to cover the risks of disability and death of the worker, and also to finance the costs of administration of the AFP.

Pensions depend on:

- Accumulated contributions in individual accounts for workers during the working period;
- The return on investment of pension funds;
- Life expectancy by gender;
- The number, age and life expectancy of employees.

“ The contributions made by taxpayers from the old system to be moved to the new system are recognized through a financial instrument called Recognition Bonds, which was estimated to represent between 50% and 70% of total funds accumulated by insured ”Arellano (1985).

The system variables are expressed in promotion units (UF), account units, indexed to inflation. Thus, pensions are automatically adjusted for inflation, resolving a serious and old problem of public pension system. Men can retire at 65 and women at 60.

Unlike the PAYG system, which entrusted the system management to public institutions, the AFP system is administered by private corporations for profit and for the sole purpose of administering pension funds. The private system is under strict control and heavily regulated by the state through the oversight of AFP.

In addition, the state provides important safeguards, including a minimum pension for all members who made contributions for 20 or more years in working life and who, with their funds, can not meet this minimum amount.

Unlike other pensions, minimum pensions guaranteed by the State are not expressed in UF, however, they are regularly adjusted by the government.

In 2002, the Chilean parliament approved a sweeping reform of individual capitalization regime, to introduce the so-called multi-funds. The aim of this reform was to increase the expected value of the pensions of members and allow them to reach a combination of the portfolio that best suits their preferences and needs, in terms of risk and return. Weyland (2009)

Administrators should keep four types of funds (B, C, D and E) and can hold an additional fund, called A type.

The funds are distinguished by the different minimum and maximum positions in equities. The total balances of compulsory and voluntary contributions and the voluntary savings account may stay in different types of funds.

In Chile, the regulation and control of the system of capitalization is in the orbit of the oversight of AFP (SAPS). The SAPS is an autonomous entity with legal personality and its own assets have indefinite duration.

3.6 The Argentine System

On October 23th, 1993 the Integrated Retirement and Pension System (SIJP) is instituted by Law 24.241.

The starting date was in 1994.

The Integrated Retirement and Pension System (SIJP) eliminated the old system and incorporates old and new workers.

There are two schemes which can be chosen by the workers:

- Capitalization
- Distribution

The new Argentine pension system is conceptually and generically based on the Chilean system, but it presents some significant differences, introducing more effective operational system improvements.

The most important characteristics of the Argentine system are:

- The worker can choose freely between either the distribution system by the state, or capitalization system managed by Afjp (fund managers, pension);
- In the case of choosing a AFJP actually it is a mixed system since the worker in addition to the capitalization pension, receives a universal basic benefit by the state;

- The directors have the obligation to take out a life insurance coverage to cover the risk of death and disability of their affiliates;
- Members can freely change, without any penalty, to any other Afjp, a maximum of twice per year and only if they have made at least 4 monthly contributions. Jàuregui (2002)

It is an individual capitalization regime. The first is administered by the State, through the National Social Security Administration (ANSES); which was run by the Retirement Fund Administrators (AFJP) established with in addiction to receive a capitalization pension has the effect to receive a universal basic benefit by the state.

The Argentine system is mixed, based on Law 24.241 of 1994 and it is comprised of the Public Social Security System or PAYG and of the individual capitalization regime and it has a national court extension. Membership is mandatory for the for employees and self-employed. This pension is similar to the recognition bond considered in the Chilean system, but in the case of Argentina it pays an annuity.

Inserting the Argentine pension system is mandatory for all workers in Argentina being more than 18 with dependency relation to an employer (public or private); there are further specifications for the self-employed as service providers, diplomatic representatives accredited in Argentina and employees of international agencies operating in the country.

In the case of voluntary registration to this scheme there are business owners, top executives, shareholders of companies, housewives, clergy, and others.

The Integrated System of Retirement and Pensions (SIJP) covers the population against the risks of old age, disability and death.

The Argentine model has three pillars: the first is of solidarity kind, and it is funded by the distribution mechanism, and the remaining two, one mandatory and one voluntary, work through individual capitalization of pension contributions.

At the time of the 1994 reform, members had the option of belonging to any of the 2 regimens, with the possibility to change each other, from

the public to the private system, which could be immediate and at any time; in case of change from private system to the public one, it was authorized only for workers in the 2 years following the reform.

The maximum number of transfers between AFJP was 2 changes per year.

In the Argentine system, the personal contribution of employees is 11% of their remuneration and the one of employers is equal to 16% thereof. The percentage of the self-employed is 27% of their income and the minimum age for retirement is 65 for men and 60 for women and a minimum contribution period of 30 years.

3.6.1 Mexico

Mexican pension reform puts in operation the individual capitalization regime since July 1997. The system is of a pure capitalization kind.

It is mandatory for employees and voluntary for self-employed. Its management is run by private companies, the retirement fund managers (Afore). The firms can simultaneously manage more than one pension fund. The system pension covers the population against the risks of old age, disability and death.

3.6.2 Colombia

The Colombian pension system consists of a system of distribution and a system of individual capitalization. The first is administered by the State, through the Social Insurance Institution. The second management was delegated to private companies, the pension fund managers.

The Colombian system is mixed and has a national court coverage. Membership is mandatory for employees and optional for the self-employed. The pension system covers the population against the risks of old age, disability and death.

3.6.3 Costa Rica

The pension system in Costa Rica is scaled-premium and it is administered by the Costa Rican Social Security.

The distribution system is compulsory for employees and voluntary for self-employed. The extension is of national court. In 1995 was created a voluntary system of individual capitalization.

The capitalization scheme is voluntary for all employees and it is administered by the Operators of Supplemental Pension Plans (OPC). The pension system covers the population against the risks of old age, disability and death.

3.6.4 Peru

The Peruvian reform of pension system, conducted in 1993, consisted of the creation of a system of individual capitalization, whose operation is parallel to national pension system existing at that time. The public system operates under the logic of the PAYG scheme and it is administered by the Insurance Standards Office (ONP).

The management of the scheme is funded by companies created for the purpose, that is the pension fund managers. Both schemes work in completely separate legislation, management and control.

The Peruvian system is mixed and it has a national court extension. The membership is mandatory for employees and optional for self-employed (Perroto and Bertin, 1997).

3.6.5 Uruguay

The Uruguayan system is mixed, i.e., public and private. Pension reform began in 1995 by 16,713 law which created the new pension system.

Only banks may constitute the fund managers of pension savings (AFAP), which operate under an individual funding mechanism.

3.7 Overview

Table showing: number of years of contributions required retirement age to apply for a retirement pension and type of pension system for Member States to the EU and Latin American countries. My model simulates a demographics of a country. Analyzing the demographic distributions a pension system or the digestive Intergovernmental species may decide the thresholds retirement more compatible to his reference system, contributory salary and mixed, such as to have a more efficient management of integrated resources. So my model is applicable to any type of system because it provides a 'observation of population dynamics.

States	Retirement age for old age		# of Years of Contribution
	Men	Woman	
Belgium	65	65	45
Denmark	65-67	65-67	40 years lived in denmark
Germany	67	67	-
Estonia	63	61	-
Greece	65	65	35
Spain	65	65	35
France	60+41 years	60+41 years of contribution	41
Ireland	65	65	40
Italy	66-70	63-70	42 men and 41 woman
Luxembourg	65	65	40
Netherlands	65	65	50 years lived in the Netherlands
Portugal	65	65	40
Austria	65	60	45
Finland	63-68	63-68	-
Sweden	from 61	from 61 years	-
United Kingdom	65	65	44 men and 39 women
Argentine	65	60	30
Brasil	65	60	25
Cuba	65	60	30
Paraguay	60	55	-
Uruguay	60	60	35
Chile	65	60	-
Colombia	62	57	-
Venezuela	60	55	-
U.S.A.	65-67	65-67	-
Bolivia	60	60	-
Ecuador	60	60	30
Peru	65	60	30

States	
Belgium	Public and private sector
Denmark	- -
Germany	- -
Estonia	- -
Greece	Public and private sector
Spain	Public and private sector
France	Public and private sector
Ireland	Public sector
Italy	Public and private sector
Luxembourg	- -
Netherlands	- -
Portugal	Public and private sector
Austria	- -
Finland	- -
Sweden	- -
United Kingdom	- -
Argentine	mixed system
Brasil	mixed system
Cuba	- -
Paraguay	mixed system
Uruguay	Regime of mandatory individual capitalization
Chile	Regime of mandatory individual capitalization
Colombia	Regime of mandatory individual capitalization
Venezuela	Public and private sector
U.S. A.	- -
Bolivia	Regime of mandatory individual capitalization
Ecuador	Public and private sector
Peru	Regime of mandatory individual capitalization

Part II

The Method

Chapter 4

Agent Based Models

The agent based modeling is a method that allows the creation of a virtual world were agents interact with the environment. The agents can be set as autonomous "individuals" or clustered together as a group. The analysis of their interactions enables the creation of an experimental simulation, where the autonomous agents can act as models for real-world computational problems, thus assessing the possible effects on it.

Due to the easy modeling properties of such agents, it is possible to use them in other fields, like in game theory , complex systems,emergence, computational sociology, multi-agent systems, and evolutionary programming.

ABMs are also called individual-based models. A review of recent literature on individual-based models, agent-based models and multiagent systems shows that ABMs are used on non-computing related scientific domains including biology, ecology and social science.

But possibly the most interesting application of agent-based modeling (ABM) is in the analysis of complex systems. In this case, a system is said to be complex if it is not possible to analyze it by breaking it down into its constituent parts. Alternatively,Terna *et al.* (2011) defines complexity as "The characteristic of a system in which the action of the agents - who operates and interact individually sometimes following very simple rule - produce aggregate outcomes that are not predictable from the apparent behavior of the individuals".

4.1 Agent-Based Computational Models

The agent's interactions may result in systematic regularities although they may have been set with different decision rules and different information even though this agents, defined by (Gilbert and Terna, 2000) as "simple" often don't have complete, global information about their world. Therefore the results can be seen as a proxy of what can be defined as a "rational" behavior. Since the agents are modeled in terms of individuals, another useful concept in agent-based modeling is the so called object-oriented programming. Objects are contiguous blocks of memory that hold the information, stored both as Instance Variables the actual data) or as methods (the functions for modifying this data).This ability of objects to hold both data and functions is called encapsulation.[1]

Citing Axtell (2006):"Compactly, in agent based computational models, a population of data structures representing individual agents is instantiated and permitted to interact. One then looks for systematic regularities, often at the macro level, to emerge from the local interactions of the agents. The shorthand for this is that macroscopic regularities "grow" from the bottom up. No equations governing the overall social structure are stipulated in multi-agent computational models, thus avoiding any aggregation or misspecication bias. Typically, the only equations present are those used by individual agents for decision-making. Different agents may have different decision rules and different information; usually, no agents have global information, and the behavioral rules involve bounded computational capacities, the agents are "simple". This relatively new methodol- ogy facilitates the modeling of agent heterogeneity, boundedly rational behavior, nonequilibrium dynamics, and spatial processes. A particularly natural way to implement agent-based models is through' object-oriented' programming."

[1] Aaron (2010) , Behavioral dimensions of retirement economics.

4.1.1 Agent-Based Computational Economics

Thanks to computational methods one can easily use agent to model even economic processes. If this is the case, it is defined as Agent-based computational economics. Using ABM, even though the agents do not interact as real people, the programmer can set them, through the set of rules and information, to act as a variety of entities and not only as individuals. This "entities" can include groups, like for example firms or families, or institutions but they can be even programmed to act as a specific geographical region or as livestock. Moreover, in addition to the single entity, agent can be programmed to act as a "pyramid", where agents are composed of other agents. This variety of purposes where agents can be used as well as their ability to adjust to market forces and social interactions is one of the main reasons why ABM is very interesting even in economic fields. Specifically, we can see some similarities even between the AMB and game theory. ACE models apply numerical methods to computer-based simulations for which usual methods can't find solutions to complex dynamic problems. Just by setting the initial conditions, the programmer can use this kind of simulations to aim at finding the equilibrium point. But game theory is not the only area where ACE can be used. For example, it has been applied to asset pricing, industrial organization, welfare economics, macroeconomics or even information and uncertainty. As Tesfatsion (2006) states, the objective of the simulations is to "test theoretical findings against real-world data in ways that permit empirically supported theories to cumulate over time."

The Agents in ACE models can represent :

- Individuals: consumers and producers
- Social groupings: families, firms, communities and government agencies
- Institutions: markets and regulatory systems
- Biological entities :crops, livestock and forests

- Physical entities : infrastructure, weather and geographical regions.

Advantages and disadvantages of ACE

In addition to the variety of purposes where it is possible to use the ACE, it has some technical, programming advantages with respect to other methods.

First of all the ACE permits a more complete and controlled study of complex systems both in terms of structural and "behavioral" aspects, facilitating in this way model validation. therefore, the usual, often non-credible simplifications are no longer required.

Moreover, the code is easily modifiable, and since the programmer receives an immediate feedback it encourages the experimentation and the programming. On the other side there are some disadvantages regarding ACE.

First of all, learning how to code and gaining a creative modeling skills can be very tough for a researcher, but it is the only path when pre-existing solutions on a defined problem are not available.

Moreover, researchers need to adjust a lot of parameters before finding what can be defined as robust solutions. It could take a lot of time to achieve the optimal combination. Another issue may raise from the fact that in various experiments the outcome is a distribution rather than a accurate point prediction.

4.2 Agent-Based Social Simulation Models

In the framework of the Agent-based social simulations (ABSS) the agents of the model are represented as unique individuals. Typically this model is used to represent human individuals, but it can be used also to represent animals, or human collectivities such as firms or states. Since the ABSS are usually created using the object-oriented programming.

Therefore each agent is implemented as an object and can interact with each other and with the environment. If the rules allows him to, he

can even change and learn with time.

The ABSS, as well as the aforementioned ABS, is a mixture of various scientific areas, with elements of social science (social psychology and policies) , agent-based computing and computer simulations, that studies the different simulation techniques, form the object oriented to the equation-based ones (see Figure 3.1).It is possible to simulate different kind of events, from a single one to even a sequence of them, placed in artificial or natural environments.

Simulations are useful to the researcher because they enable him to have a better understanding of the studied phenomenon and on the future possible paths that it can take.

Agent-based social simulation within a complex adaptive system perspective promises to increase understanding of the coupled socio-ecosystems that underlie land use change.

Citing Davidsson (2002) " One way of characterising the research area of Agent-Based Social Simulation (ABSS) is that it constitutes the intersection of three scientific fields, namely, agent-based computing, the social sciences, and computer simulation".

In our case, there are even more deep relations between social studies and computer simulation that specifically intersect in the Social Aspects of Agent Systems (SAAS) and in the related issues. In particular, here the focus is on the study of the issues regarding the norms, institutions, and organizations. On the other side we can list the specific interaction between computer simulation and agent based computing.

In this case, the field is often named Multi Agent Based Simulation (MABS) and it concerns the study of the possible uses of agent theory for simulating and event or phenomena. Therefore, we can firstly see that the computer simulation have various and important implementations in other fields.

Secondly, ABSS is indeed a useful and powerful method when the researcher is investigating a social phenomenon in a context of computer

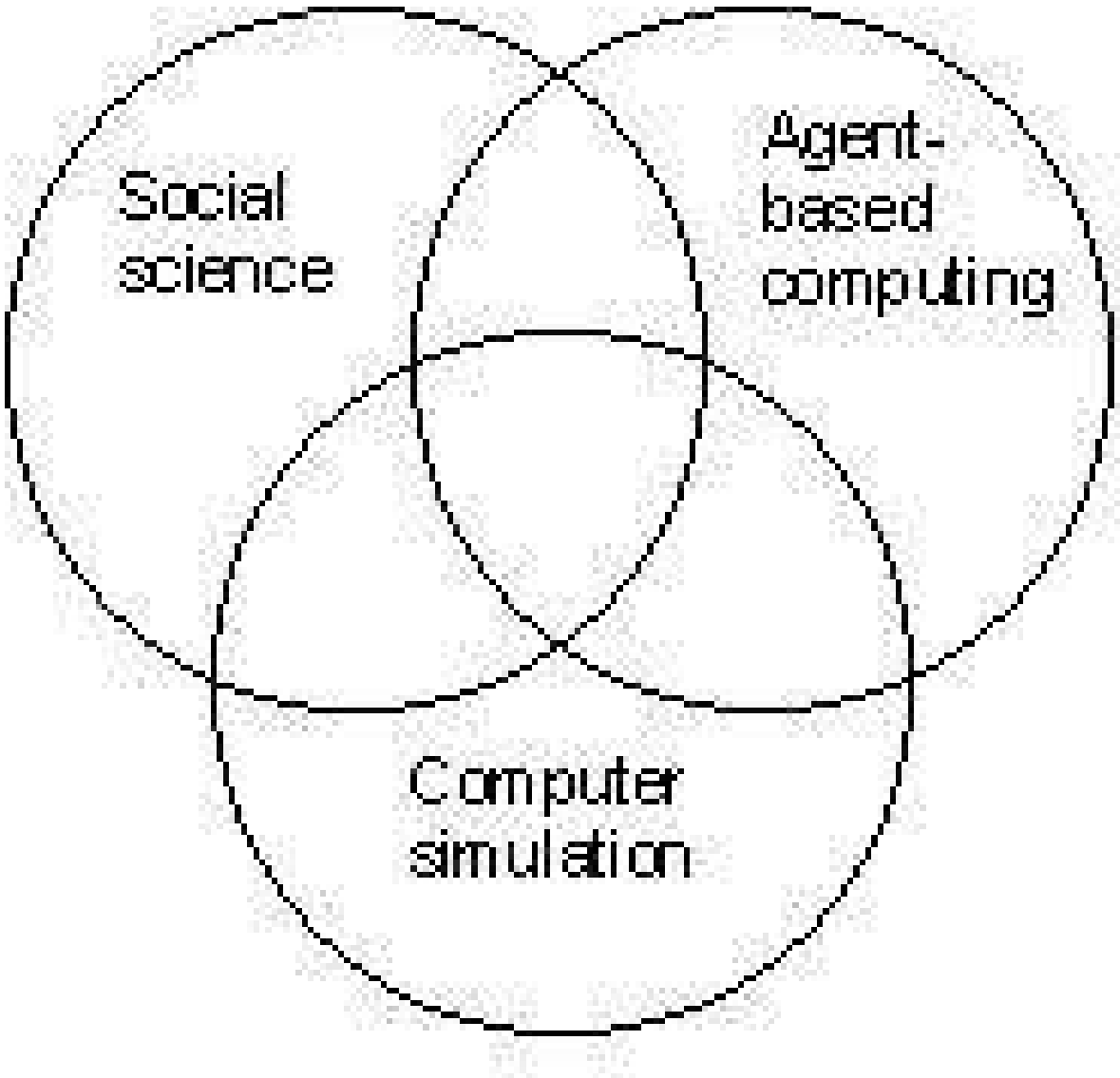

Figure 4.1: The three areas constituting ABSS and their interrelationship. Source :JASSS

simulation. Of course, we cannot include all the sections of computer simulation in the ABSS theories. In particular, simulations that do not include element of either agent technology or social science are to be excluded from the definition.(see Figure 3.2)

In conclusion, the principal function of ABSS systems is related to its potential in enabling the flaw of information and the achievement of more efficient solutions through the union of different fields of research.

4.2.1 Specific relations between fields of research.

As mentioned before, the most close relation of computing simulation and social science is in the Social Aspects of Agent Systems, even if this link is heavily skewed towards social science, meaning that the latter gains much more improved solutions when the first one is added in the system then viceversa.(see Figure 3.3)

For example, the researcher may run a social simulation, computers supports human reasoning activities by executing these mechanisms.

Gilbert and Terna (2000) have moreover developed the idea of individual-based simulation, though it is more connected to the field of micro simulations. Micro simulations have been developed from the interactions between individual agents, rather than groups. Therefore the main focus of this technique is the study of the behavior of specific individual agents.

On the other side, macro simulations are typically based on mathematical models concerning more the average values of a group or a population. Moreover, in this simulations the agents are viewed as a "structure" characterized by a set of different variables. Another set of relations concern the interactions between the fields of social science and agent-based computing.

Tesfatsion (2006) states that:

> ABSS can be said to investigate the use of agent technology for simulating social phenomena on a computer. How-

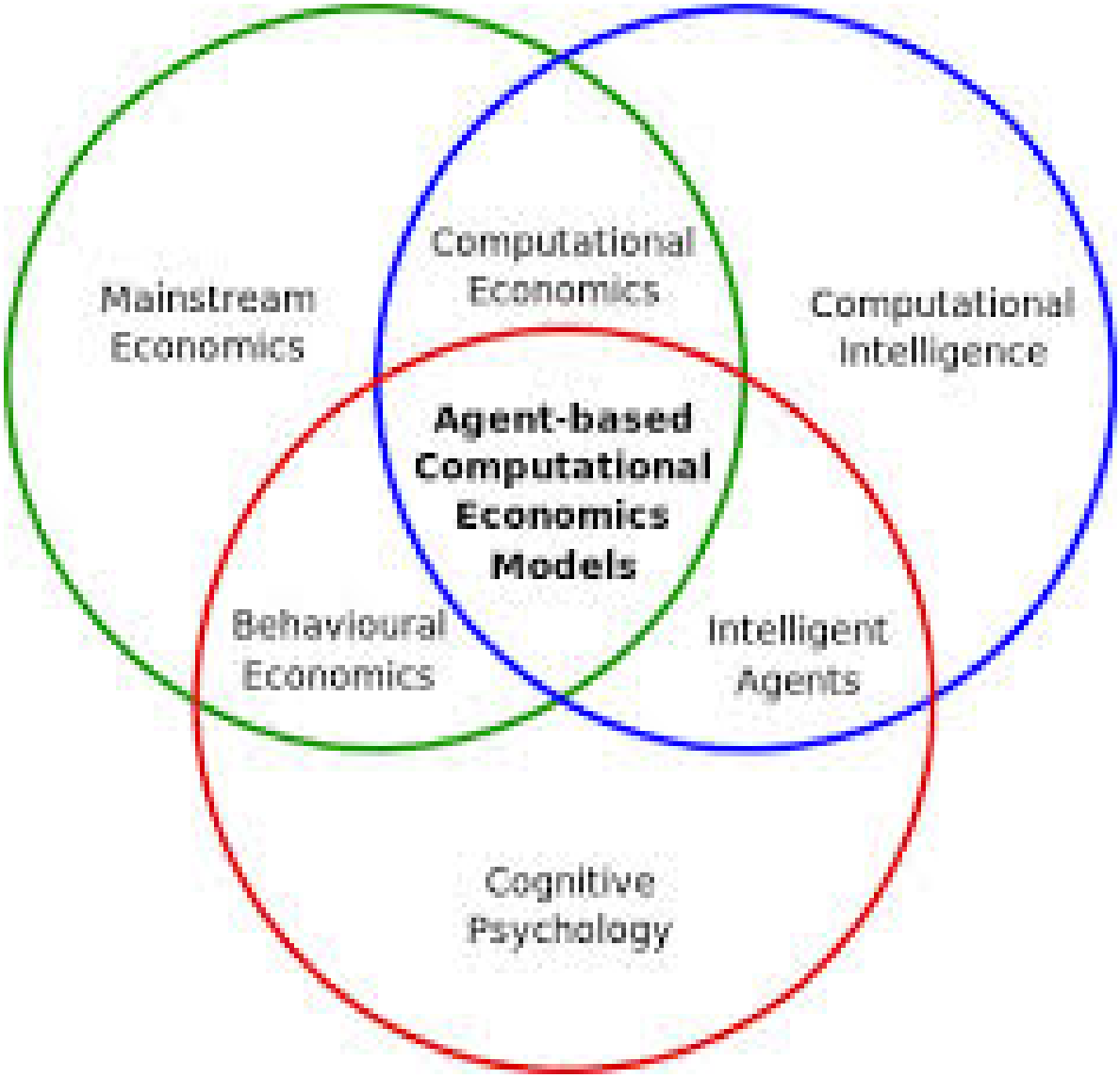

Figure 4.2: The intersections of the three areas defining ABSS. Source : Wikipedia

ever, this is a quite narrow definition and in some situations a wider definition may be useful. As most of the work in all the intersection areas (SAAS, MABS, and SocSim) is clearly relevant to ABSS, a natural extension would be to include them. However, it may be clarifying also to point out areas that clearly do not belong to ABSS, e.g.:

- social science that does not include an element of either agent technology or computer simulation.
- Agent technology that does not include an element of either social science or computer simulation.
- Computer simulation that does not include an element of either agent technology or social science.

4.2.2 Agent-Based Computing and Computer Simulation

Citing Davidsson (2002) :“ The contribution from agent based computing to the field of computer simulation mediated by ABSS is a new paradigm for the simulation of complex systems with much interaction between the entities of the system. As ABSS, and other micro simulation techniques, explicitly attempts to model specific behaviors of specific individuals, it may be contrasted to macro simulation techniques that are typically based on mathematical models where the characteristics of a population are averaged together and the model attempts to simulate changes in these averaged characteristics for the whole population. In macro simulations the set of individuals is viewed as a structure that can be characterized by a number of variables whereas in micro simulations the structure is viewed as emergent from the interactions between the individuals”.

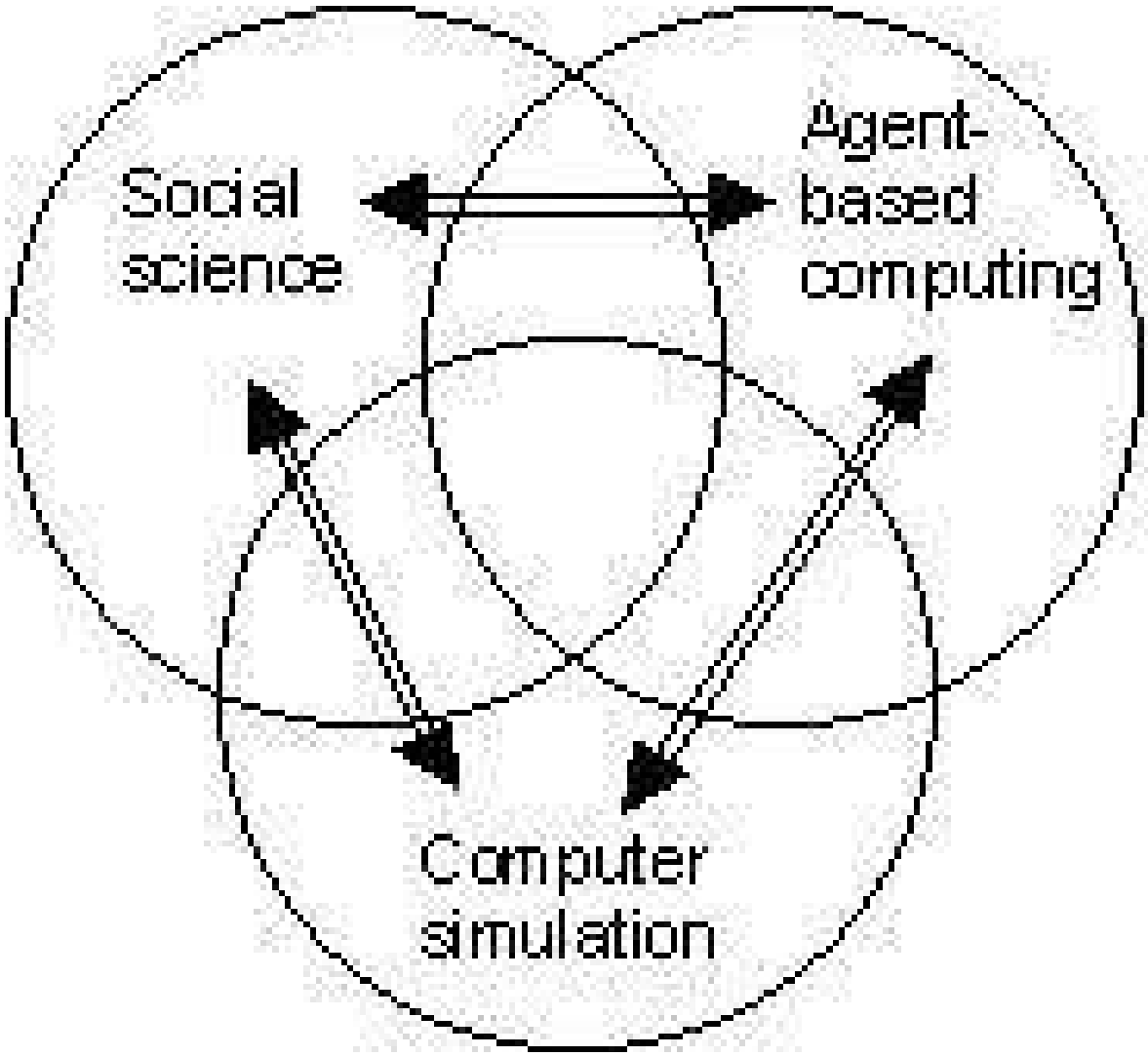

Figure 4.3: Contributions mediated by ABSS from and to agent-based computing. Source: JASSS

Chapter 5

Social Networks

"Social network analysis is inherently an interdisciplinary endeavor. The concepts of social network analysis developed out of a propitious meeting of social theory and application with formal mathematical, statistical, and computing methodology." Stanley Wasserman and Katherine Faust (1994: 10).

"Social network analysis is neither a theory nor a methodology. Rather, it is a perspective or a paradigm. It takes as its starting point the premise that social life is created primarily and most importantly by relations and the patterns they form."Alexandra Marin and Barry Wellman (2011: 22).

A way of obtaining methods to analyze the functioning of social entities, or to explain the patterns that such structures give birth to, is adopting the social network perspective.

We define a social network as a social structure containing a set of actors as well as the set of bonds that link those subjects.

Thanks to social network analysis we can individuate the presence of patterns (local and global ones), the existence of subjects which are more influential than others, and in general analyze all the dynamics that make up the network.

The field of social networks has not a unique nature, but is instead an interdisciplinary topic that has inputs coming from a large variety of studies: from statistics to sociology and social psychology, as well as graph theory.

An important contribution arrived from Georg Simmel, who gave birth to early sociological theories about the dynamics of triads. On the other hand, Jacob Moreno developed, in the 1930s, the first sociograms, helping to analyze interpersonal relationships. Such point of view were later formalized through a mathematical approach in the 1950s, while social network theories actually become widespread in social sciences by the 1980s.

Nowadays, social network is one of the most important sociological standards, being employed in a large variety of other scientific fields. It's not a surprise that it forms the basis for a new, growing field of science: network science.

The term "social network" is used to denote a social structure, which is denoted by a series of interactions. Those are all the connections existing between single individuals, groups of subjects, organizations but also, on a much larger scale, entire societies.

Social networks consisting of actors and social relations are ubiquitous across the social science disciplines.

Social networks have been analysed extensively during the last decade. From the social network of scientists (Newman 2001, 2004; Jeong et al. 2002; Meyer et al. 2009) to the social network of dolphins (Lusseau 2003),

The convergence of all the social links proper of a given unit are then represented by any tie with which such unit connects to the other ones.

The nature of the social network approach must be, by necessity, a relational one.

An axiom of the social network approach to understanding social interaction is that social phenomena should be primarily conceived and investigated through the properties of relations between and within units, instead of the properties of these units themselves. Thus, one common criticism of social network theory is that individual agency is often ignored although this may not be the case in practice (see agent-based modeling).

Precisely because many different types of relations, singular or in combination, form these network configurations, network analytics are useful

to a broad range of research enterprises. In social science, these fields of study include, but are not limited to anthropology, biology, communication studies, economics, geography, information science, organizational studies, social psychology, sociology, and sociolinguistics.

5.1 History

The study of networks has had played a central role in mathematics and the other social sciences. The history of contemporary social network science, which comprises analysis, modeling, and theorizing, is the result of contributions from the social, mathematical, computational, and physical sciences with the latter as the most recent contribution and still rather tentative and hypothetical, but nonetheless intriguing.

The following chronology of social network science:

- Citing Cioffi-Revilla (2010): 1930s The sociogram-the first graph-theoretic mathematical model of a social group is invented by psychiatrist Jacob L. Moreno [1889-1974], founder of sociometric analysis as a modern field of social science.
- 1937 The journal Sociometry is founded with J. L. Moreno as its first editor. The aim of the journal was the integration of all the social sciences through the mathematical medium of graphs for modeling social relations.
- 1940 Anthropologist Alfred Radcliffe Brown [1881-1955], founder of the Theory of Structural Functionalism, develops the term social structure defined as a complex network of social relations and calls for development of discrete mathematical models.
- 1950s and 60s Social network concepts such as density, span, connectedness, multiplex, and others are introduced as SNA experiences significant growth across the social sciences.

- Mid-1970s Social network analysts and graph theoretic modelers begin the study of networks over time, what is now called dynamic networks (Wasserman and Faust 1994: 16; Breiger et al. 2003).
- Early 1980s The SNA computer software UCINET 1.0 is released by Linton Freeman.
- 1994 Stanley Wasserman and Katherine Faust publish the first comprehensive SNA textbook, consisting of 825 pages.
- 1996 B. Wellman and collaborators initiate the study of computer-supported social networks (CSSNs) as a new domain generated by the Internet.
- 1998 A small-world model, based on the exponential random graph model, is proposed as a highly abstract model of a simple social network with g nodes and uniform constant node degree d (the number of links attached to a node), to enable analytical approaches from statistical physics (Watts and Strogatz 1998).
- 2003 The first comprehensive survey of dynamic networks is published by the US National Academy of Sciences (Breiger et al. 2003).
- 2011 The SAGE Handbook of Social Network Analysis is published as "the first published attempt to present, in a single volume, an overview of the social network analysis paradigm" (Carrington and Scott 2011: 1).

5.2 Definition

A social network is composed of several constituent parts which include entities (values, sentiments, ideas, locations, attributes), relations (links, associations, affiliations, interactions, evaluations), and aggregations (dyads, triads).

"A social network is formed by a set of actors (nodes) and the relations (ties and edges) between these actors" Carrington *et al.* (2005). The nodes are for instance individuals, groups, organizations or societies. The ties may fall within a level of analysis or may cross levels of analysis.(see Figure)

Relationships or ties are the basic building blocks of human experience, mapping the connections that individuals have to one another.

Pescosolido (2006) state that:"As network theorists claim, the structure of these relationships among actors has important consequences for individuals and for whole systems".

It is commonly accepted by many sociologists that social networks are the essence of social structure or others see social structure governing these networks , however, others see networks as the mechanism that connects micro and macro level of social life.

Wasserman (1994) say that :"The characteristics of social networks are distinct-structure , content and functions. Structure targets the architectural aspect of network ties(e.g. size , density,or types of relationships).Content taps what flows across the network ties. They are channels for transfers of material or non-material resources"

The social network analysis in sociology, originating from the use of the socio-matrix of Moreno, social networks is now quite commonly used in agent-based simulation to explicitly represent the topology of interactions among a population of agents.

we can list modelling of social networks into three categories:

- static networks;
- dynamic networks with the dynamics independent of the agents' states ;
- dynamic networks evolving dependent on the agents' states.

As says Edmonds and Meyer (2013):" The Networks across all levels are dynamic, non static that represent some structures and processes. The ability to form and maintain social ties is not less important than

their state at one point in time. These may be changes in the structure of networks or changes in memberships".

5.3 Nodes, Social Atoms and Actors:

The terms nodes, social atoms and actors refer to the central networks "units". Social actors are in most of the cases seen as individuals, but can also be families , organizations ,nations or any other entity that can form or maintain formal or informal relationships.

Network analysis focuses on the relations among actors, and not on individual actors and their characteristics. This means that the actors are usually not sampled independently, as in many other kinds of studies (most typically, surveys). (see Figure 4.1)

5.4 Ties, Links,Realtionships,Edges:

The network connections between and among actors are referred to as ties. Ties can be directed or not directed.

5.5 Social Network Analysis

Social Network Analysis (SNA) is a theoretical construct useful in the study of social relations among a set of actors. For instance,people, groups, organizations, computers, URLs, and other connected information/knowledge entities.

The nodes in the network are the people and groups while the links show relationships or flows between the nodes. SNA provides both a visual and a mathematical analysis of human relationships.We can base on the analysis and conduct new form of information and knowledge. (see Figure 4.2)

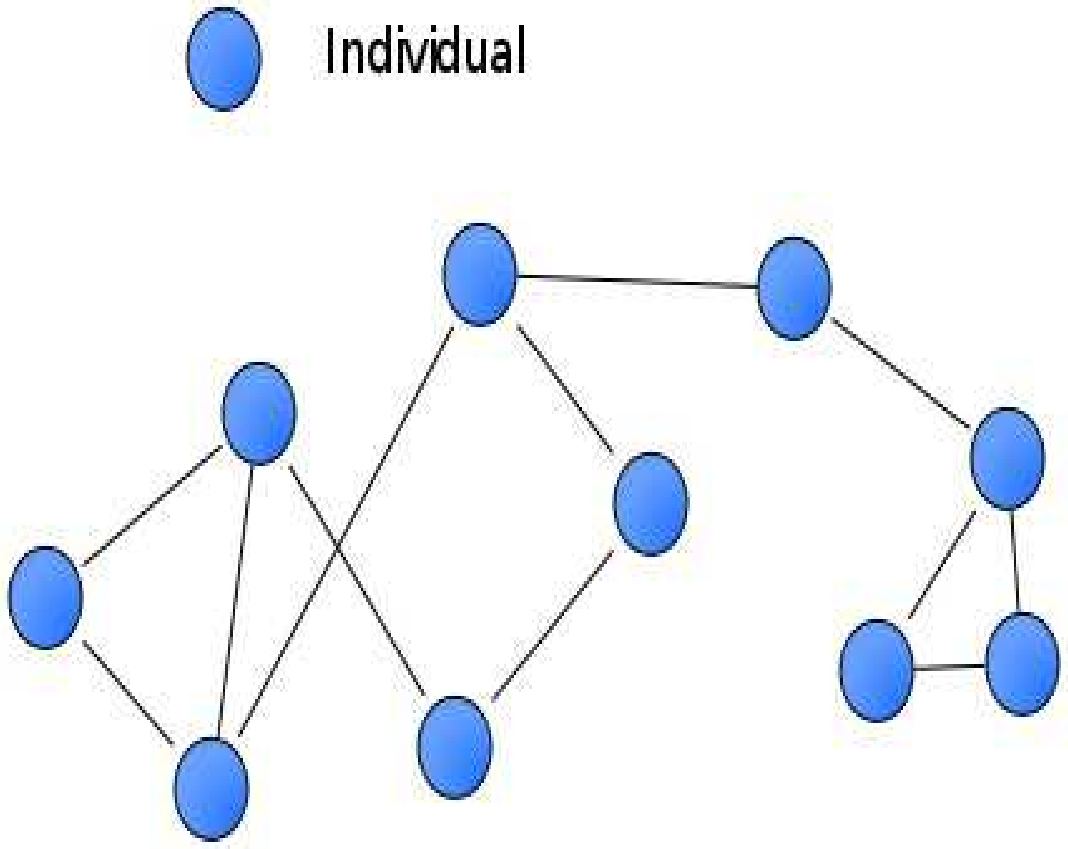

Figure 5.1: Source : Wikipedia , Representation of network; Rapresented as circles are “actors”:

"The social network analysis (SNA) is a methodology used to analyse the properties of social networks. Social networks are represented with Graphs Theory, that depicts relations as nodes and links, where, depending on the level of analysis, the nodes may represent entities such as people, technology, groups or firms "(Zack, 2000). O'Reilly and Roberts (1977), and Tichy, Turshman and Fombrun (1979) affirm that SNA is central to the field of structural inquiry and represents an adequate method to analyse groups.

Social network analysis is strongly empirical, but it tends to be descriptive rather than constructive in nature.

Social network analysis focuses on relationships between social entities. It is used widely in the social and behavioral sciences, as well as in political science, economics, organizational science, animal behavior and industrial engineering.

It is a theoretical perspective, not just a collection of methods. Social network analysis also provides a formal language for developing the science of social networks including a perspective enabling and facilitating Computational Social Science.

SNA supports and extends the analysis of complex human natural-artificial systems by providing useful concepts and principles.

5.6 Modality and Levels of Analysis

The social networks are analyzed at the scale relevant to the researcher's theoretical question. Although levels of analysis are not necessarily mutually exclusive, there are three general levels into which networks may fall: **Micro-level**, **Meso-level**, and **Macro-level**.

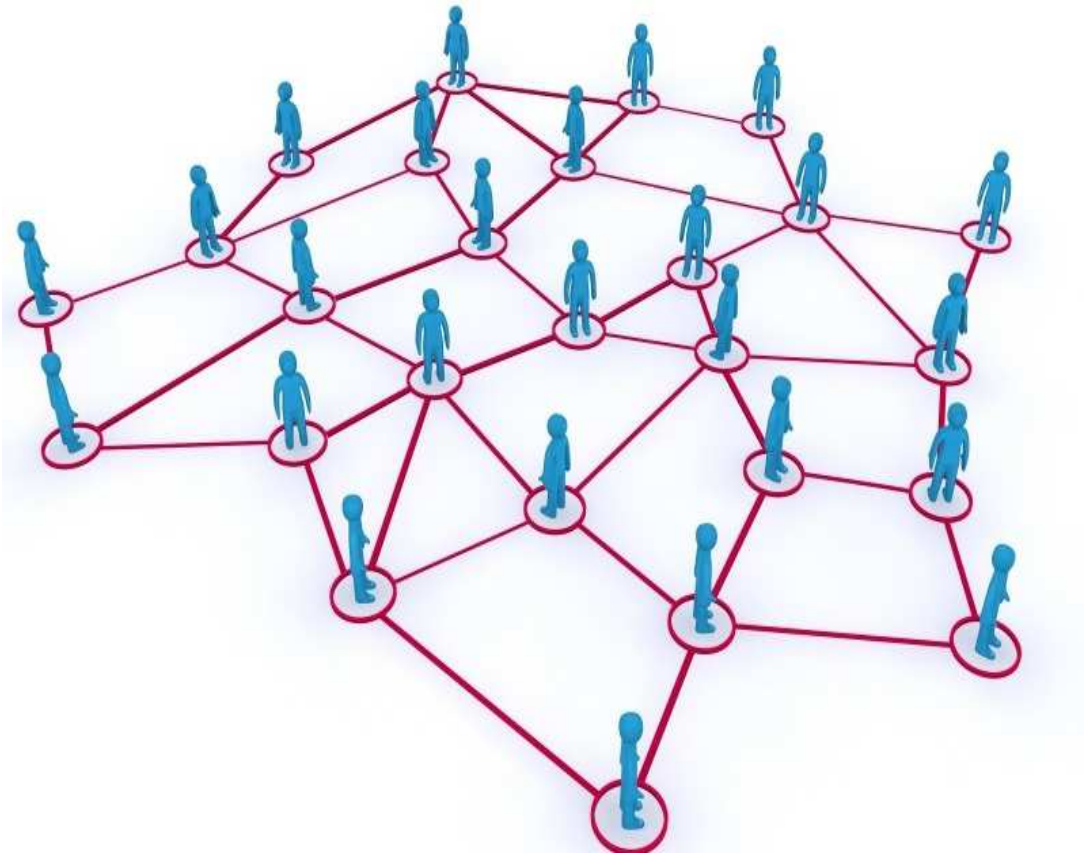

Figure 5.2: SNA. Source : Wikipedia

Part III

The Model

Chapter 6

ABM NetLogo

6.1 A Model

In economics a model is a theoretical construct representing economic processes by a set of variables and a set of logical and/or quantitative relationships between them.

The economic model is a simplified framework designed to illustrate complex processes often but not always using mathematical techniques.

In a economic models posit structural parameters are underlying parameters in a model or class of models.

A model may have various parameters and those parameters may change to create various properties. Methodological uses of models include investigation, theorizing, fitting theories to the world.

Types of Models :

There are four types of models used in Economic Analysis:

- Visual Models;
- Mathematical Models;
- Empirical Models;
- Simulation Models.

My Model is focus on Retirement Ages:

The retirement age is the age at which a person is expected or required to cease work and is usually the age at which they may be entitled to receive superannuation or other government benefits.

The retirement age is different in each country ; In Italy, men in the private sector as well as everyone serving in the public sector retire at the age of 65, while women in the private sector retire at the age of 60. The Italian government has however raised the retirement age by 3 years (to 68 and 63 years respectively), which will be effective beginning 2015. In this context the idea of my work is to generate a model of retirement based on decision of each worker and retired person.

The main charateristic of the simulation are :

- We do not consider a representative agent. Rather we analize an heterogeneous population of individuals having a imitative behaviour.
- The model allows agents to retire when they wish (after 65 year old)
- Agents types Cohorts and Social Networks.
- The agents actively partecipate in the Social Networks with interactions and imitative dynamics
- Description of agents behaviour through the simulation.

Pay-As-You-Go (PAYG) Pension Systems

A PAYG system in its purest state is one in which the pensions that are distributed to the retired population each period are derived from the contributions received from the active population in the same period.

In this way the system is financially balanced every year. However in most countries the system promises a pension which is solely dependent on the evolution in wages and not on demographic evolution.

Fully-Funded Retirement Plan

If you have a fully-funded pension plan you are in relatively safe hands. That means your pension plan has a sufficient amount of assets required to provide all benefits accrued in the plan.

A fully-funded pension plan must be able to make all expected payments to you. This type of plan is most common among private-sector employers.

6.2 The Model 0

In this section of my thesis I will explain step by step the construction of my first program in NetLogo. The main idea of the model 0 is that to create, on NetLogo, a group of Agents connected through mutual characteristics.

Such characteristics will be identified initially with an simple action as get on or get off . The choice of each agents is conditioned by the choices of the agents of the same group.

My agents are random and each one is free to make his choice: whether to go up , down or to stay in the same place (not moving).

In this model 0, to the agents are given the following values for the direction to be followed:

- The value 1 for the agents who will go op;
- The value -1 for the agents who will go down;
- The value 0 for the agents that will not move.

In this model we introduce two variables that will be very important for the subsequent program development: “consciousness” and “probability of an independent decision”. My goal is to evaluate the effects of a change in the variables on each agent.

The variable “consciousness” is responsible for the autonomous behavior of the agent. therefore, he will make his own choice without being influenced by other people’s decisions.

Specifically in the program the agents change their size if they are aware.

The small size agents aren't given nor a "consciousness" nor a probability of deciding for himself , in this case neither of the agents were conscious then they will move randomly because they are not conditioned by the choices of other agents.

Instead the agents of big size are the ones who will be assigned a high "conscious". This means that my agents will all be aware of their choice. The probability to make the same choice made previously will depend on this awareness level.

If the probability to decide independently is low and the level of consciousness is high then the agents will all go in the same direction.

A graphic interface is present In the model 0, that allows the user to change the variables of the model through the sliders.

The procedure can be started with the buttons "Setup" and "Go".

In the specific graphic interface of the model 0 the output is represented by 2 button, 4 sliders and 1 plot.

The number of agents in the model, the probability of an independent decision as well as the consciousness of each agent can be set with the sliders.

The sliders are the following :

- **#BlueAgents**: Indicates the number of blue agents in the model;
- **#RedAgents**: Indicates the number of red agents in the model;
- **quota_conscious**: Represents the consciousness level assigned to each agent of the model;
- **prDecidesForItself**: Represents the probability assigned to each agent to act randomly.

The graphic on the right shows the 6 trends of the agents in the model 0:

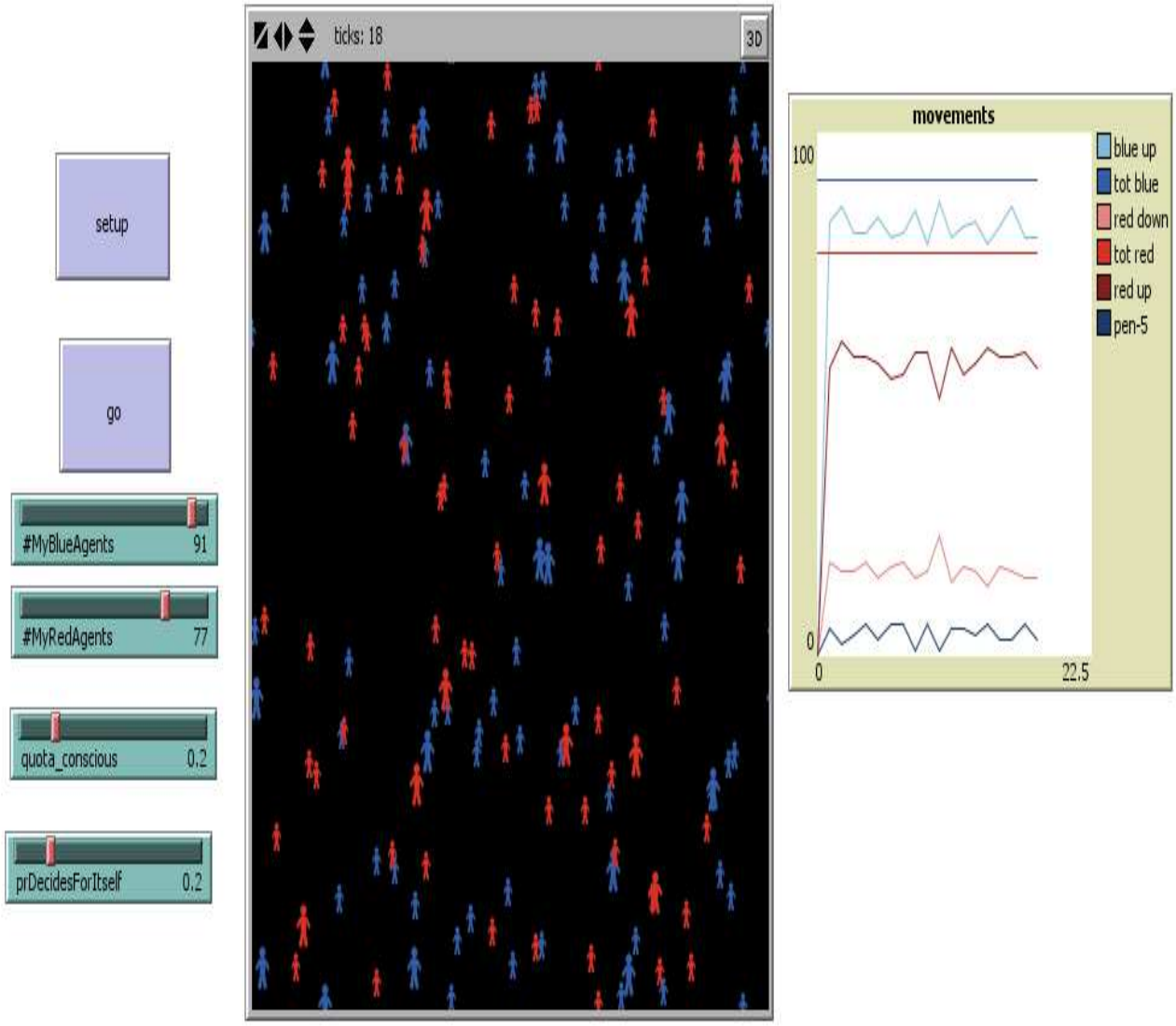

Figure 6.1: Graphic interface

- The dark blue line shows the trend of the agents that have gone up;
- The darker blue line shows the trend of the agents that have gone down;
- The light blue line shows the overall trend of the blue agents;
- The dark red line shows the trend of the agents that have gone down;
- The darker red line shows the trend of the agents that have gone up;
- The light red line shows the overall trend of the red agents.

In this graph the agent's trend will always vary and will be completely different from case to case because it depends on the values assigned to the variables "quote_conscious" and "prDecidesForItself".

6.2.1 Code

In the first two lines of the model 0 we define the types of agents with the keyword "breed" that must be used before writing the procedure.

In the model 0, MyBlueAgents represents the group of the blue agents while MyBlueAgent is the name of each agent present in the group. On the other side MyRedAgents represents the group of the red agents while the single agent of the group is named MyRedAgent.

The third line indicates that both groups are assigned two variables, state and consciousness , that are specified for each breed and are effective only for the agents that are part of that specific breed .

The first variable "state" represents the choice we will make each agent and defines the movements of each agent. There are 3 different values for the variable state.

The second variable " consciousness" indicates the probability of being influenced by the group the agents belong to.

```
breed [MyBlueAgents MyBlueAgent]
breed [MyRedAgents MyRedAgent]
turtles-own [state consciousness]
```

6.2.2 Setup

The Setup button is needed to establish the initial state of the world. The setup procedure, as all others procedures, opens with the command **to** and ends with the command **end**.

This part of code of the model 0 covers primarily the graphical representation of the agents in the world. In the Setup we assign the specific characteristics of each agent, both those from the group #BlueAgents and those from the group #RedAgents.

In this procedure were create two types of agents, that are set in the following way:

- The agents were split in two groups #BlueAgents and #RedAgents. Within each group, all agents have the same color, the same form and the same size and a random coordinate is assigned to each one;
- The agents in the beginning are all static in both the group of #BlueAgents and in the group of the #RedAgents. Therefore, within of each group the state 0 is assigned;
- The procedure starts by pressing the button setup. It will initially run the command **clear-all** which clear the world , making all the previously created agents disappear, enabling us to start a new model;
- **Reset-ticks** is used to reset the tick counter instead.

```
to  setup
   clear-all
```

```
   create- BlueAgents #BlueAgents [set  color  blue
     set  shape  "person"  set  state  0  setxy   random-xcor  random-ycor]

   create- RedAgents  #RedAgents  [set  color  red
     set  shape  "person"  set  state  0  setxy
     random-xcor random-ycor]
   setConsciousness
   reset-ticks
end
```

Once the setup procedure is done, another procedure called "setConsciousness" is set inside first one. setConsciousness controls if the random value, between 0 and 1, assigned to agents of the group #BlueAgents.

The value is smaller than the one assigned in the sliders quota_conscious previously explained in graphic interface of the model 0. The command ask considers one agent at a time. Every agent is therefore tested on the following conditions :

- If the random value **(random-float 1)** is smaller than **quota_conscious**, then the agent it will be conscious and will have a larger size with respect to the "not conscious" agent;
- If instead this value is greater than **quota_ conscious**, then the agent will not be conscious and will act randomly.

```
to   setConsciousness
  ask  BlueAgents [
    ifelse random-float 1  <  quota_conscious
       [set  consciousness  true  set  size  1.5]
       [set  consciousness   false]
  ]
  ask  RedAgents [
    ifelse  random-float  1  <  quota_conscious
       [set  consciousness   true  set  size  1.5]
```

```
      [set  consciousness  false]
  ]
end
```

6.2.3 Go

This part of the program we define the way in which all the agents involved in the simulation act. These two procedures are called **"decide_move"** and **"move"**. They will be explained separately in the code.

The tick is used to count the number of times that the function **"go"** is executed.

```
to  go
   decide_move
   move
   tick
end
```

The first procedure is called by the command **"go"** is **"decide_move"**. The group of MyBlueAgents is tested for consciousness with the following code.

If **Ifelse** is positive agents will be assigned the state 1 and will go up; otherwise if **ifelse** is not positive their decision will be random.

```
to   decide_move
    ask  BlueAgents [
   ifelse  consciousness
     [set  state   1]
   ; random decision
```

If first option is true then the agent will go down, instead with the second option the agent won't move. If the third option is chosen the agent will go up.

```
let  choice   random  3
    if  choice =  0  [set  state  -1]
    if  choice =  1  [set  state   0]
    if choice  =  2  [set  state   1]
;check others
```

In this part, the code is checked for the presence of two conditions: the agent will be "non-consciuos" if a random number in the interval (0,1) is lower than his probability of an independent decision . If this happens, the agent copies the choice taken by the other agents.

```
if  not  consciousness  and  not  (random-float  1  <  prDecidesForItself)
; copy others
```

The following command line counts if the number of the agents of the MyBlueAgents group with the same state 1 is greater than the number of agents of the group MyBluesAgents with the state -1. If this is true, then all the agents of the group MyBlueAgents will go up (that is, state 1).

```
if count BlueAgents with [state  =  1] > count BlueAgents with [state  =  -1]
[set  state  1]
```

On the other side, if the number of agents of the group MyBlueAgents with the variable state equal to 1 is smaller than the number of agents of the group MyBluesAgents with the state -1 then all the agents of the group MyBlueAgents will go down (that is, state -1).

```
if count BlueAgents with [state  =  1] < count  BlueAgents with [state  =  -1]
[set  state  -1]
```

For the group of the MyRedAgents the consciousness is checked with the following code .

If Ifelse is true agents will be assigned the state -1 and so will go down; otherwise if ifelse is false the decision that the agents will take will be random.

```
ask  RedAgents [
    ifelse  consciousness
    [set  state   -1]
; random decision
```

If the first option is chosen, then the agent will go down. Instead, with the second option the agent will not move and if the third option is chosen the agent will go up.

```
let  choice  random  3
      if  choice  =  0  [set  state  -1]
      if  choice  =  1  [set  state  0]
      if  choice  =  2 [ set  state  1]
; check other
```

In this part, the code is checked for the presence of two conditions: the agent will be "non-consciuos" if a random number in the interval (0,1) is lower than his probability of an independent decision . If this happens, the agent copies the choice taken by the other agents.

```
if not consciousness and not (random-float 1 <  prDecidesForItself)
; copy others
```

The following command line counts if the number of the agents of the MyBlueAgents group with the same state 1 is greater than the number of agents of the group MyBluesAgents with the state -1. If this is true, then all the agents of the group MyBlueAgents will go up (that is, state 1).

```
if count RedAgents with [state = 1] > count  RedAgents with [state  =  -1]
[set  state  1]
```

Conversely, if the number of agents of the group MyRedAgents with the same state 1 is smaller of the number of agents of the group MyRedAgents with the state -1, then all the agents of the group MyRedAgents will go down (that is, state -1).

```
if count RedAgents with [state = 1] < count  RedAgents with [state  =  -1]
[set  state  -1]
```

The second procedure called by the **"go"** is **"move"**: The command move describes the movements of the agents by defining the coordinates of displacement.

```
to  move
  ask  BlueAgents  [set  ycor  ycor  +  state]
  ask   RedAgents  [set  ycor  ycor  +  state]
end
```

6.2.4 Simulations

The results of the different simulations of the model 0 with different values of the variables involved (sliders) are described in the following paragraph.

My goal is to study the thresholds of "consciousness" and the probability that the agent decides independently within a group, together with the conditions in which the agents are able to influence each other.

Another interesting objective will be to compare the two groups of agents in the world through the by setting the different variables.

For every simulation I will present two graphs, the first that describes how the agents affect each other and the second focusing on the trends of the agents taken into consideration.

Each simulation is repeated for 100 times in order to gather a statistically significant sample.

In the world there are a total of 380 agents divided into two groups, 200 for the group of agents named BlueAgents and 180 for the group RedAgents.

Case 1

In the first simulations I set a consciousness level equal to 0.1 and a probability that the agent will take an independent decision of 0.1.

Parameters of the first simulation:

#MyBlueAgents: 200

#MyRedAgent: 180

quota_conscious: 0.1

prDecidesForItself: 0.1

The agents of this simulation have a very low awareness, means that a very small proportion, about 10% of each group, decide autonomously. After running the simulation result shows that:

Due to the low consciousness and the low probability of an independent decision the agents are imitators and therefore can have all the solutions.So,the final result are not known in advance.

As you can see from the first graph almost all the agents of their respective teams go upwards and form small groups. However, after 50 ticks other small groups of agents decide to go in the opposite direction and move downward.

In the second graph of the movements that you can see that the trends of the agents of the two groups (BlueAgents and RedAgents) are oscillating, therefore this is not a linear operation.

- In the first pattern (light blue) many agents in the group decide to go up.
- The agent colored in a very dark blue are those who decide to go in the opposite direction and not follow the rest of the group of blue agents.
- The very dark red agents followed an upward path, even though our expectation were that they would have gone down.

  This difference depends on the agent's low consciousness.
- On the other side, the trend followed by the light red agents is linear with our expectations snce they all go down.(see Figure 4.2)

Case 2

In this simulation the consciousness level is set equal to 0.5 and the probability that the agent decides for himself is equal to 0.1 . Therefore agents will have a high awareness and a very low probability of an independent decision

Parameters of the second simulation:
#MyBlueAgents: 200
#MyRedAgent: 180
quota_conscious: 0.5
prDecidesForItself: 0.1

The conscious agents that have an independent of 50% while the remaining percentage moves randomly.

From the first graph it is clear that many agents in the blue and red groups that go upwards and downwards are forming groups that are far more numerous than the previous case.

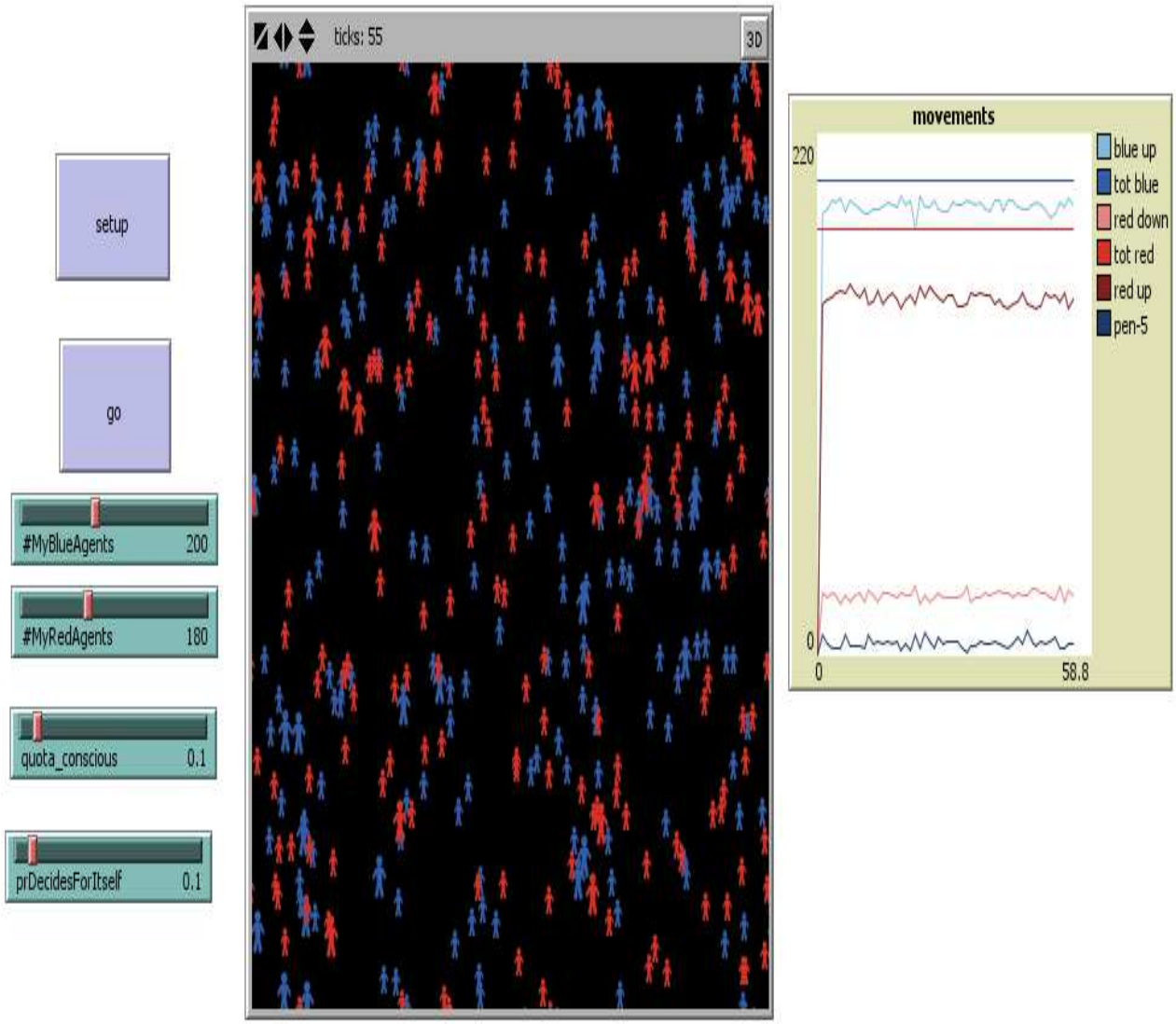

Figure 6.2: Case 1

This behavior respects our expectations, but there are still small groups of agents who decide to move in the direction opposite, but this happens only after about 100 ticks.

In the graph of the movements it is possible to see that the trends of the agents of the two groups (BlueAgents and RedAgents) are highly oscillating and the consciousness within each group expands rapidly then the agents move in the right direction, but this movement is not linear.

- In the first pattern (light blue line) many agents in the group decide to go up, however in the second case (very dark blue).Only a few agents decide to go in the other direction.
- In the third pattern (light red line) many agents of the red group red go down, but in the fourth trend (dark red) we can see that there are few agents who go up.This behavior does not not respect our expectations.(see Figure 4.3)

Case 3

In the third simulations I set a consciousness level equal to 0.9 and a probability that the agent takes an independent decision equal to 0.1.

Parameters of the third simulation:
#MyBlueAgents: 200
#MyRedAgent: 180
quota_conscious: 0.9
prDecidesForItself: 0.1

In this case we can see that the higher the awareness (consciousness) the more the agents of the groups blueagents and redagents go in the right, expected direction,90% of the agents will be aware and autonomous in their choice and whereas only the remaining part of the agents will move randomly.

In the first graph the "conscious" agents of the blue and red groups that moves upwards or downwards meet our expectations. Only a very

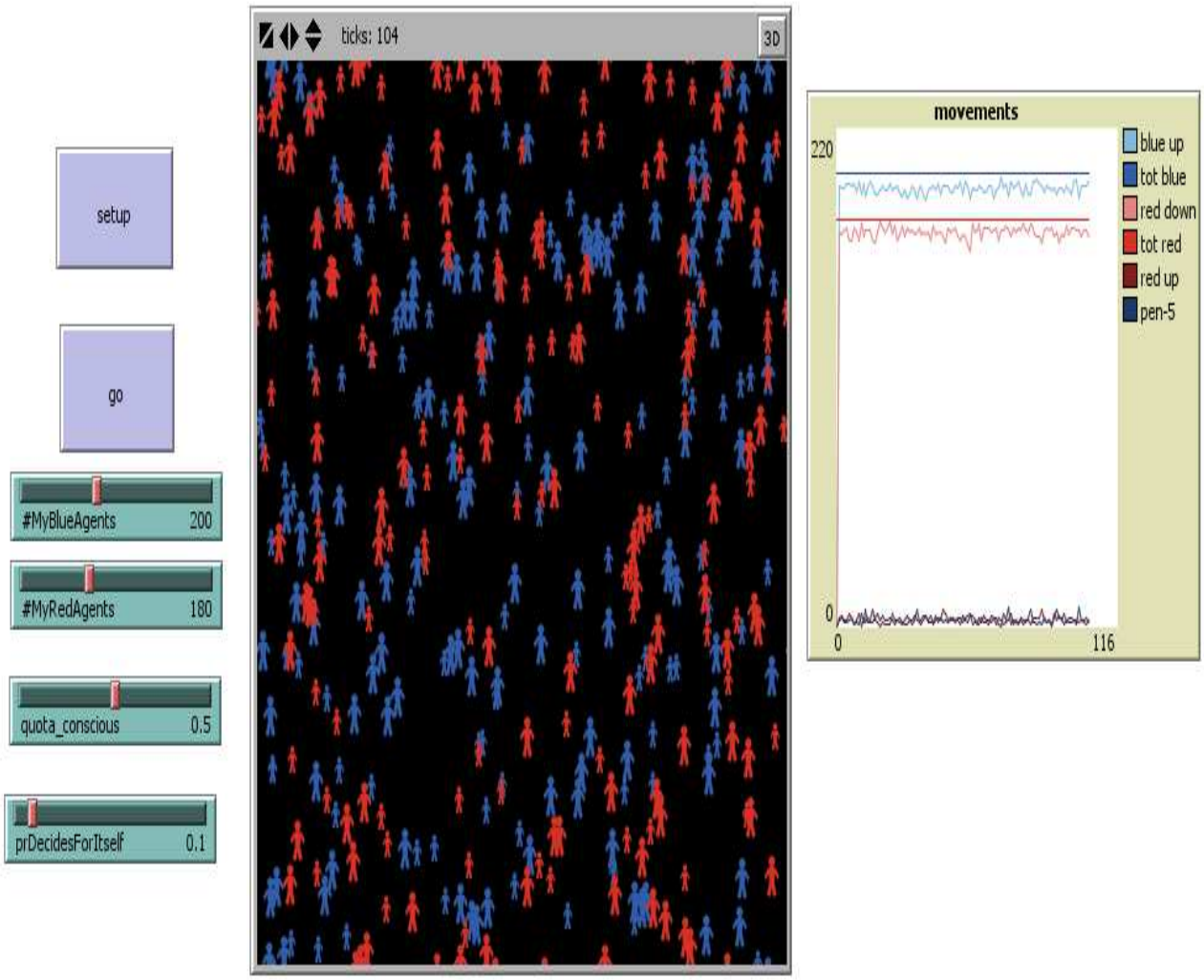

Figure 6.3: Case 2

small number of agents decides to move randomly, but this happens after about 80 ticks.

In the second graph of the movements, it is possible to see that the trends of the agents of the two groups (BlueAgents and RedAgents) are highly oscillating.

Given that the majority of the agents of the two groups are "conscious", the awareness of the choice is expanding much faster than in the previous case, but not in a linear way.

As you can see from the chart movements of agents in the group MyBlueAgents and MyRedAgents reach their maximum after just a few ticks.

- The light blue line shows the first pattern, where nearly all agents of the blue group go up, in the right direction. However, the second patterns (very dark blue) shows that agents who decide to go in the other direction are almost zero.

- In the third pattern (bright red line), nearly all agents in the red group go down (in the right direction), as well as in the fourth case (dark red) we can see that there are very few agents that do not meet our expectations. (see Figure 4.4)

Case 4

In this simulations I set a consciousness level equal to 0.1 and the variable prDecidesForItself is 0.6.

Parameters of the fourth simulation:
#MyBlueAgents: 200
#MyRedAgent: 180
quota_conscious: 0.1
prDecidesForItself: 0.6

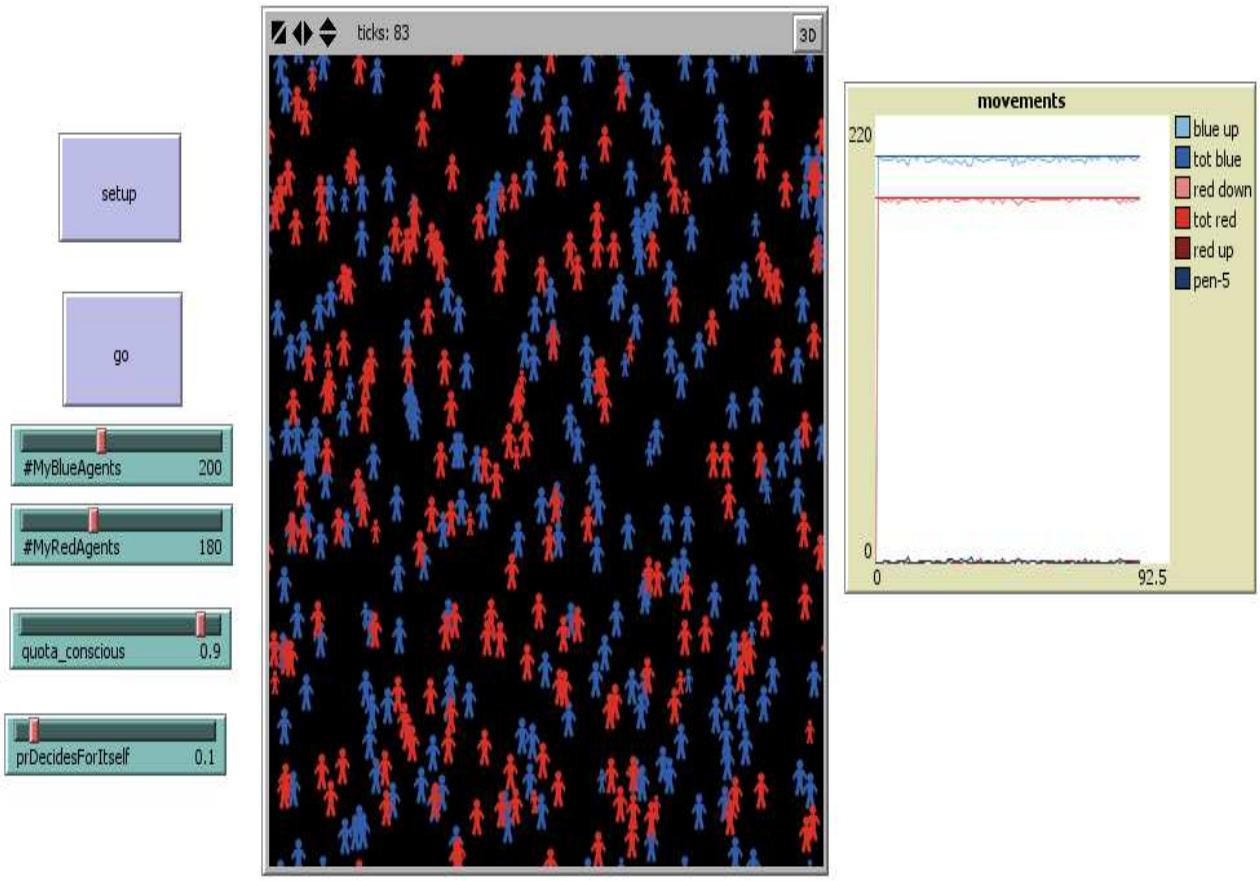

Figure 6.4: Case 3

In this simulation we can see that after 100 ticks agents with a very low level of "consciousness" do not take an autonomous, independent choice.

Therefore the agents of both the BlueAgents and RedAgents group choose to move randomly.

Having a very low awareness, the agents of both groups will go in the wrong direction.

The result is that basically anything can happen, given that the probability of an independent decision is high and therefore constantly changing.

In the graph of the movements you can see that the trends of the agents of the two groups (MyBlueAgents and MyRedAgents) are highly oscillating and do not reach the maximum since each agent randomly decides what he wants to do.

- In the first pattern (light blue line), the agents of the blue group that go up are just a few, however in the second case (very dark blue line) agents who decide to go in the opposite direction, therefore not meeting our expectations, are many.

- In the third case (light red line), the red agents in the group going down in the right direction are very few, however in the fourth trend (dark red) we can see that there are many agents do not comply with our expectations.(see Figure 4.5)

Case 5

In the last simulation I set a consciousness level equal to 0.1 and a probability that the agent decides for himself is set to 0.9.

Parameters of the fifth simulation :
#MyBlueAgents: 200
#MyRedAgent: 180
quota_conscious:0.1

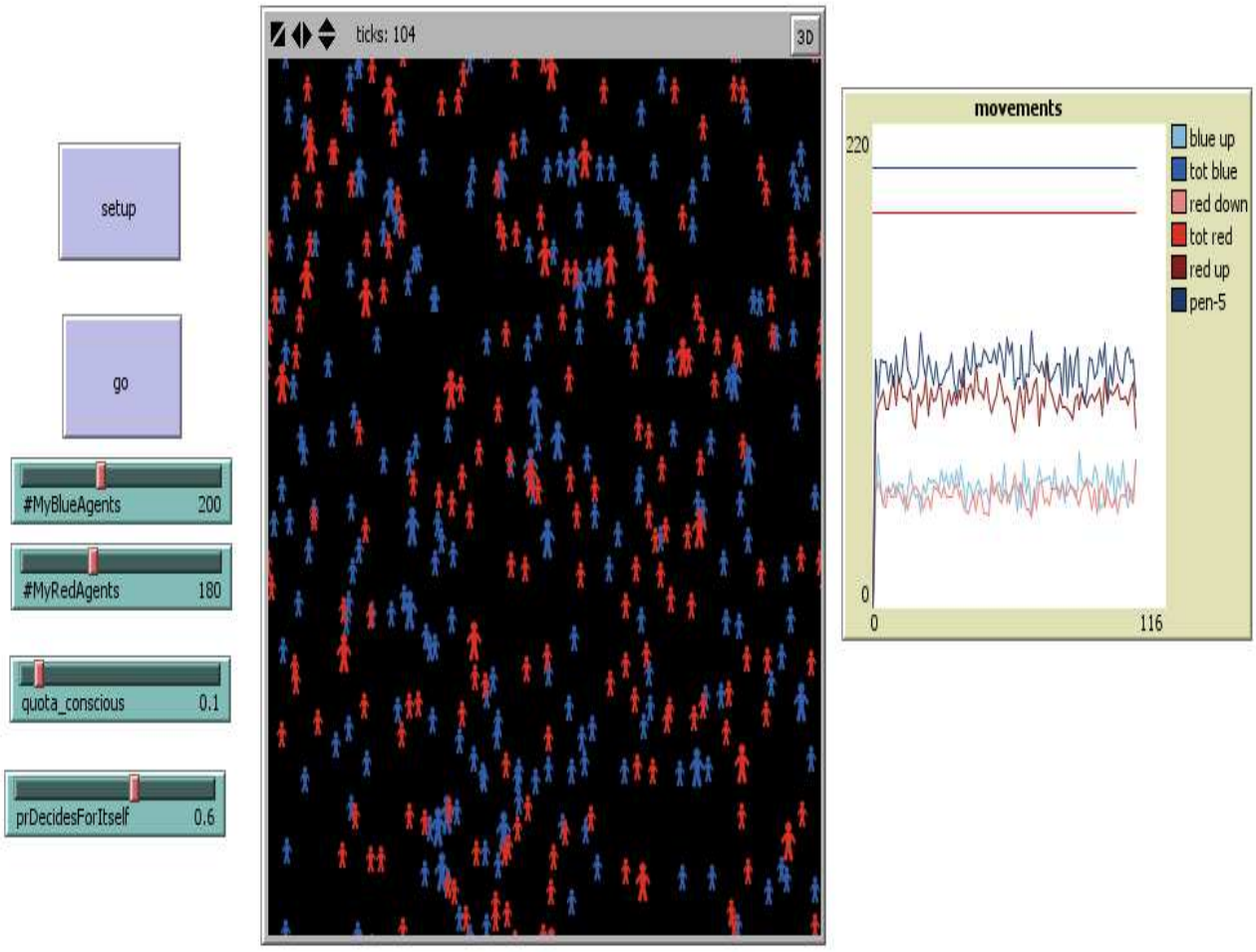

Figure 6.5: Case 4

prDecidesForItself: 0.9

In this simulation we can see that even after about 60 ticks agents that get "conscious" of their choice are very few while the majority of agents choose randomly.

In the graph of the movements you can see that the trends of the agents of the two groups (BlueAgents and RedAgents), as well as in the previous case, do not reach their maximum.

A very high probability of an independent decision associated with a low awareness of the agents' choice involves a complete randomness of the agents' movement.

- In the first pattern (light blue) agents in the blue group moving in the right, expected direction are few, however in the second course (very dark blue) agents who decide to go in the opposite direction are, in effect, not so many, respecting our expectations.

- In the third pattern (red light) red agents in the group going down, in the right direction are few, however in the fourth trend (dark red) there are many agents that do not meet our expectations.(see Figure 4.6)

6.3 The Model 1

Going on with the construction of the Netlogo program, with model 1 we want to procede and explain the modifications done on model 0.

The main idea of model 1 is to create with Netlogo a unique case in which a group of agents (retiree), have not to accomplish an action such as going up or down, but must choose whether to retire or not from work.

Differently from model 0, in this model 1 the agents are not divided into two groups (blueAgents and redAgents), but they all belong to the same group (pensionAgents).

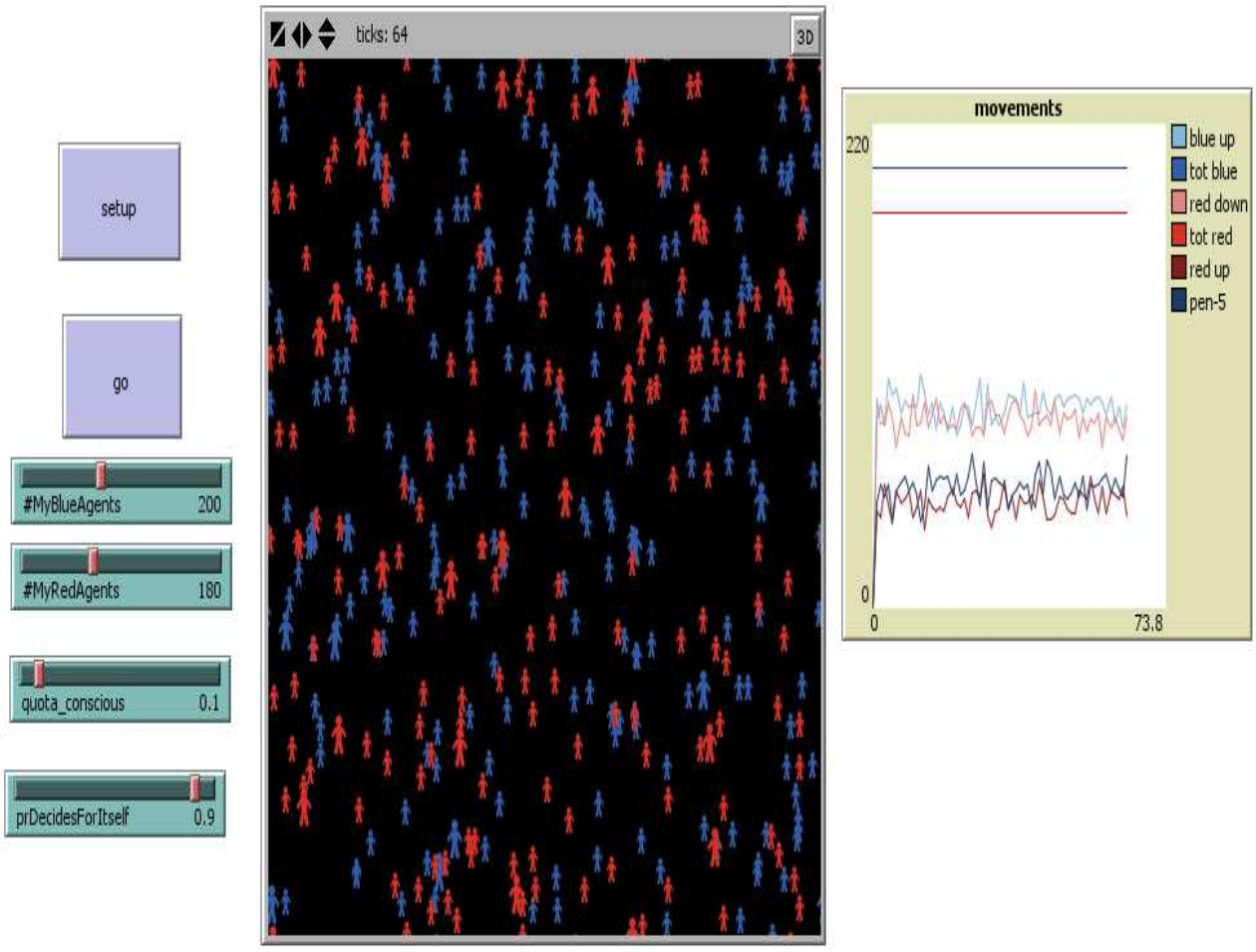

Figure 6.6: Case 5

Within this subdivision we will find different categories of agents, such as friends, co-workers, relatives, neighbors, etc.

In this model the agents have birth randomly and each of them cam make its own choice while taking into account what other agents do in order to decide if it good to retire or not (in this case, it is no more about going up or down).

Once my agent has decided to retire the impression on the other agents will be that my state is "RETIRED".

In model 1 the agents can be influenced only by other agents within a certain distance, thus not all the agents (retiree) will be analyzed but only those that actually find themselves in a certain influence area.

In this model 1 in addition to the two variables that have already been used ("consciousness" and "probability of an independent decision") we will introduce another important variable:

- "radius of imitation".

My goal is to evaluate the effects that the radius has, in the presence of the variable "consciousness" in the agent i twill behave autonomously, without being influenced by others' decisions.

6.3.1 Code

In model 1, pensionAgents represents the entire group of retired agents, while pensionAgent is the name of each single agent inside the group.

In the second line are assigned three specific variables to the pension-Agents gropus :

- State
- Consciousness
- Pension

which are specified for the breed to which they belong and are valid only for the agents found inside such breed.

The first variable, “state”, represents the choice that each agend will take and defines the movement of each agent.

The second variable, “consciousness”, denotes the probability of being influenced by the group.

The third variable, “pension”, denotes when an agent will retire.

```
breed [PensionAgents PensionAgent]
turtles-own [state consciousness pension ]
```

6.3.2 Setup

This piece of code is devoted mainly to the graphical representation of the agents in the world.

Within the setup, the characteristics and the informations proper of each agent belonging to the group pensionAgents have been assigned.

In this procedure, I created and set up the only type of agent, and it is formalized as follows:

- Agents have been created in a unique #pensionAgents and inside the group all the agents have the same color, shape and dimension and a random coordinate is assigned to them;
- Since the state 0 is assigned to each agent, at the beginning of the process they will all be workers;
- The command ask works taking into account one single agent at a time; at first, at each agent a value false is assigned, meaning it is a worker;
- Hitting the setup button, the procedure is started. At first, the clear-all command is executed, bringing the world back to an empty state, deleting all the agents previously created and making the environment ready to start a new model;

- Reset-ticks serves the purpose of resetting the ticks counter.

```
to setup
   clear-all
   create-PensionAgents #PensionAgents [ set color
   blue  set shape  "person"  set state 0
   setxy  random-xcor random-ycor]
   ask PensionAgents [  set pension false   ]
   setConsciousness
   reset-ticks
end
```

Once the setup procedure has been executed, a second procedure is involved, called "setConsapevolezza" which vrifies whether the random value in the range (0, 1), assigned to the agents of the #PensionAgents group, is less than the value set in the slider quota_conscious of the model 1 interface. The ask command acts taking into account one agent at a time; for each of them the following conditions are tested:

If the random value (random-float 1) is less than quota_conscious then the agent will be conscious.

If, instead, such value is greather than quota_conscious then we will conclude that the agent will be non conscious and will behave randomly.

```
to setConsciousness
     ask PensionAgents  [
       ifelse random-float 1 < quota_conscious
       [set consciousness true]
       [set consciousness false]
  ]
end
```

6.3.3 Go

In this part of the program we define the way in which all the agents involved in the simulations will operate; the two procedures decide_retire and retirement are recalled, and they will be explained separately in the code.

To count the number of times the function go is executed, we use the command tick.

```
to go
   decide_retire
   retirement
   tick
end
```

The first procedure which go recalls is decide_retire.

For the PensionAgents group we verify the presence of two conditions: agent's consciousness and whether the worker has the following code.

If ifelse has positive outcome to the agents will be assigned the state 0 and they will not retire; if instead ifelse has negative outcome, the decision the agents will take will be random.

```
to decide_retire
  ask PensionAgents[
  ifelse consciousness and not pension
  [set state  0]
  ;random decision
```

If the first option is picked, then the agent will not retire. If otherwise the second option is picked, the agent will retire.

```
  let choice random 3
      if choice = 1 [set state  0]
      if choice = 2 [set state  1]

 ; check others
```

In this part of the code we verify the presence of four conditions: the non consciousness of the agent, the non retirement, if a random number between 0 and 1 is lower than the probability of deciding alone and, lastly, the program checks how many agents find themselves within the radius of imitation.

If this happens, the agent mimics the choice that other agents took, otherwise it doesn't.

```
if not consciousness and not pension and
not(random-float 1 < prDecidesForItself) and
(any?PensionAgents in-radius range)
; copy others
```

Here, we check if the number of the PensionAgents agents with state 0 is greater than the number of agents with state 1. If it is, all the PensionAgents agents will not retire (state 0) and each of them will show the letter "L".

```
If count PensionAgents in-radius range with
[state = 0] > count PensionAgents in-radius range with [state = 1]
[set state 0 set label "L"]
```

Here, we check if the number of the PensionAgents agents with state 0 is lower than the number of agents with state 1. If it is, all the PensionAgents agents will not retire (state 0) and each of them will show the letter “P”.

```
if count PensionAgents in-radius range with
[state = 0] < count PensionAgents in-radius range with [state = 1]
[set state 1 set label "P"]
end
```

The second procedure called by go is “retirement” : The ask command works on an agent at a time; for each agent being in state 1, this agent has decided to retire, and the yellow color is assigned to it, in order to distinguish it from the working agents.

```
to retirement
  ask PensionAgents [ if state = 1 [ set pension
  true set color yellow set label " " ]
end
```

6.3.4 Simulations

As I already did with model 0, I continue explaining the results from the different simulations from model 1, with different values for the variables involved (sliders).

My goal is to study consciousness thresholds, the probability that the agent may decide alone within the group and the effects produced in the area described by the radius of imitation.

Please remember that in the presence of consciousness, the agent decides autonomously and is not influenced by other agents.

In this simulation of the model four extreme cases, as well as intermediate cases, will be explained in detail. As already done for model 0, with each simulation I'll present two graphs.

The first one to illustrate the agent's choice about retirement, the second one to highlight the evolution of the agents taken in consideration.

Each simulation has been repeated one hundred times thus to collect statistically significant data. In the world, we observe a total amount of 1000 pensionAgents.

Case 1

In this first simulation I set a consciousness value equal to 0 and a probability of deciding autonomously equal to 0.

Parameters of the first simulation:

#pensionAgents: 1000

range: 2

quota_ conscious: 0

prDecidesForItself: 0

In the model the agents of this simulation have a null consciousness, as well as a null probability of taking a retirement decision on their own, meaning that no agent has the possibility to take an autonomous decision.

The study of this simulation has been done with a very small radius (equal to 2).

After the simulation have been executed, those results emerge:

- At firts, agents are generated randomly and become workers after few ticks, having set our parameters as null we get that after about 60 ticks no retirees are present in the model.

- Setting a consistently higher value for the radius, equal to 20, and not varying the other parameters, after a certain number of ticks agents become workers and none of them decides to retire, but they take much more time to get such conclusions than if we set a lower radius.

In the second graph, about movements, is possible to observe that the trends of the working agents and of retired agents are constant and they result to have a linear functioning.

In the first trend (red) all the agents are workers while in the secondo ne (blue) there is no retired agent. (see Figure 4.7)

Lowering the number of agents to 100 we can see how with a very small radius (2) and null consciousness and probability of autonomous decision we obtain several solutions.

In the first graph almost every imitating agent decides to retire and only a few of them keep working.

In the graph about movements, after about 10 ticks the retired agents become more than the working ones. Increasing the radius to 20 the agents decide to keep working and never retire.(see Figure 4.8)

Case 2

In this second simulation I set a consciousness value equal to 0 and a probability of deciding autonomously equal to 1.

Parameters of the second simulation:

#pensionAgents: 1000

range: 2

quota_conscious: 0

prDecidesForItself: 1

In this simulation we can observe that after about 60 ticks the agents who are conscious about their choice are null and all the agents will choose randomly.

In this simulation the study is developed for a very small range, equal to 2, and we note that the imitating agents that choose to retire reach a significantly high number after just 1 tick.(see Figure 4.9)

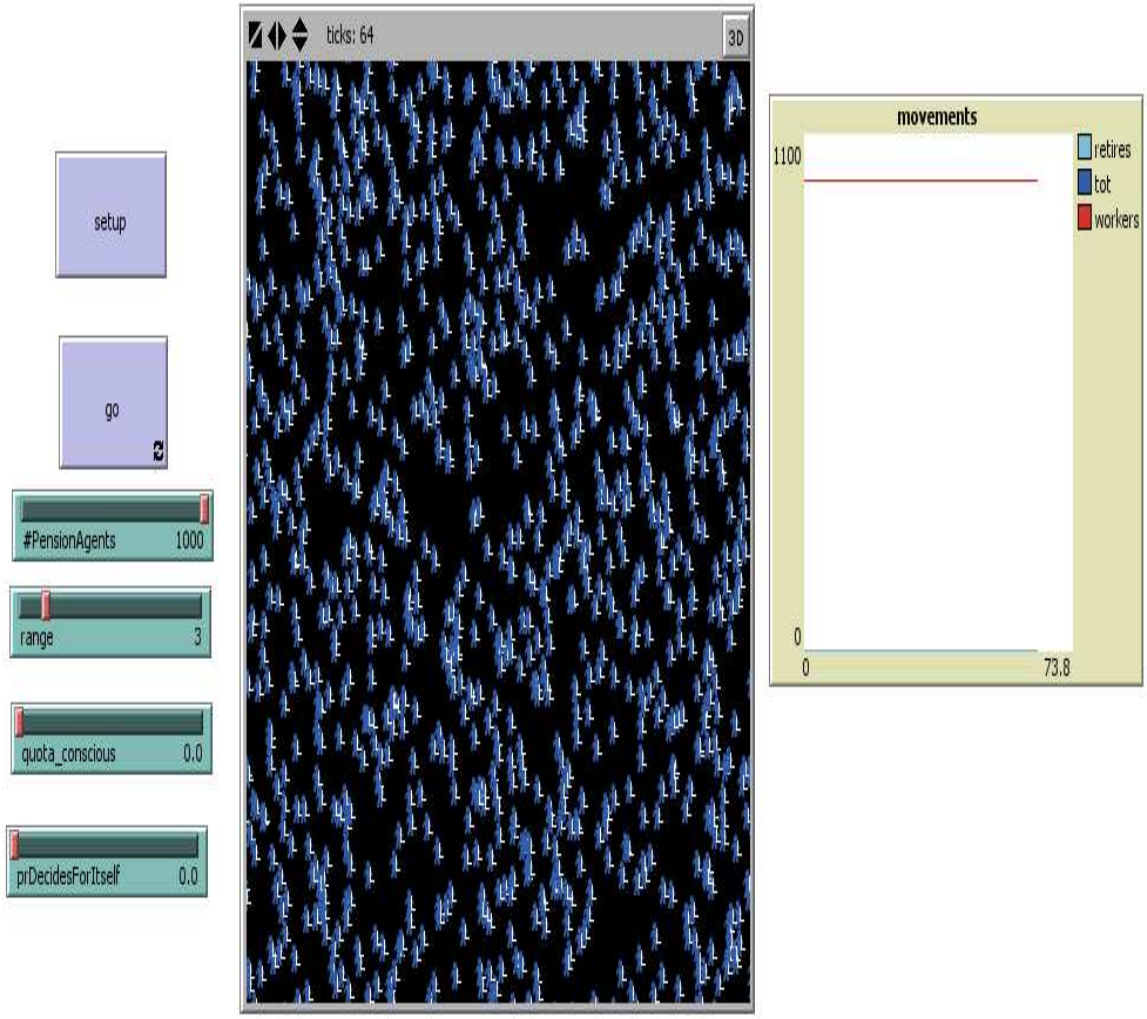

Figure 6.7: Case 1a

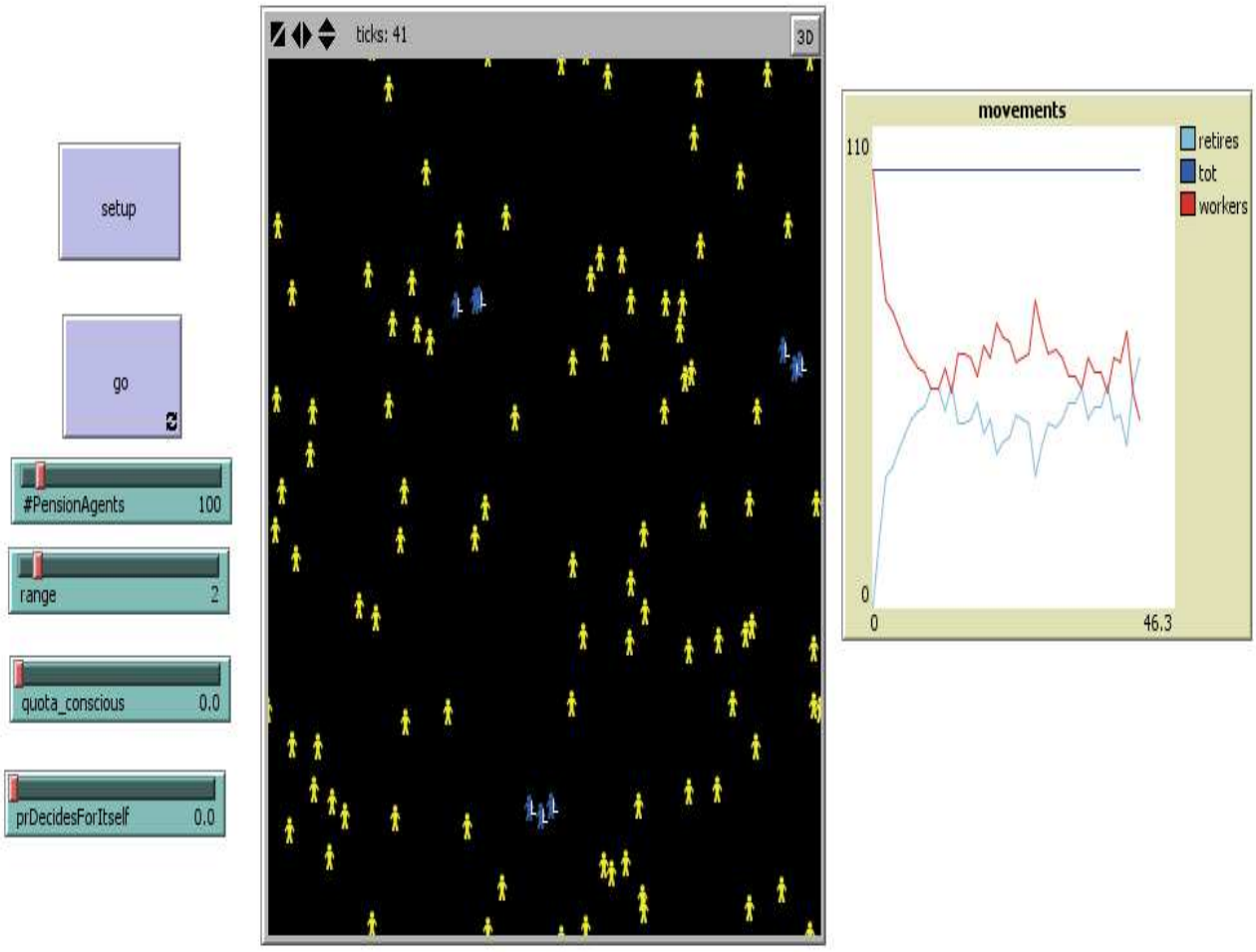

Figure 6.8: Case 1b

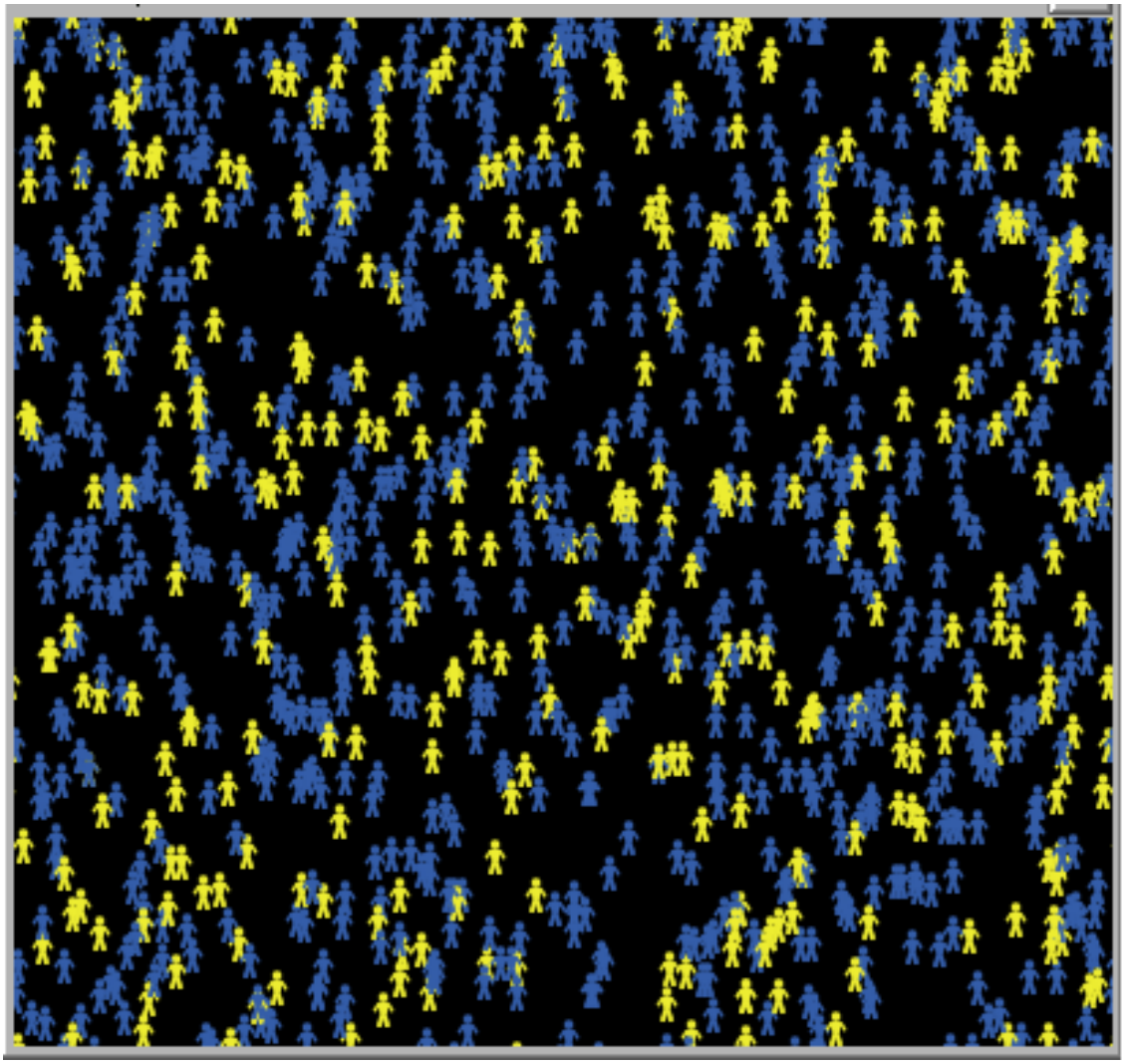

Figure 6.9: Case 2a

As we can see, the more agents in our study the higher the probability of choosing autonomously, meaning that the choice of imitating agents expands very rapidly within a small radius. Studying this simulation for a really high radius of 20, instead, we note that the imitating agents' choice expands rapidly but nota s much as when we set a small radius.

In the second graph , the one about movements, we can see how the working agents and retiree trends are strongly oscillating and don't follow a linear function.

In the first trend (red) all agents are workers and they initially decrease rapidly and the assume a regular trend. For second trend (blue), retired agents quickly increase and after 10 ticks overcome working agents in number.(see Figure 4.10)

Case 3

In this third simulation I set a consciousness value equal to 0.1 and a probability of deciding autonomously equal to 0.1.

Parameters of the fifth simulation:

#pensionAgents: 1000

range: 2

quota_conscious: 0.1

prDecidesForItself: 0.1

Agents of this simulation have a very low consciousness, meaning that a really small quota of them, about 10%, will autonomously decide whether to retire or not. After simulations are run, these results emerge:

- Having set really low values for consciousness and autonomous decision, as well as a small radius of 2, we do not know what would possibly happen since all the agents are imitating and thus can have all the solutions.

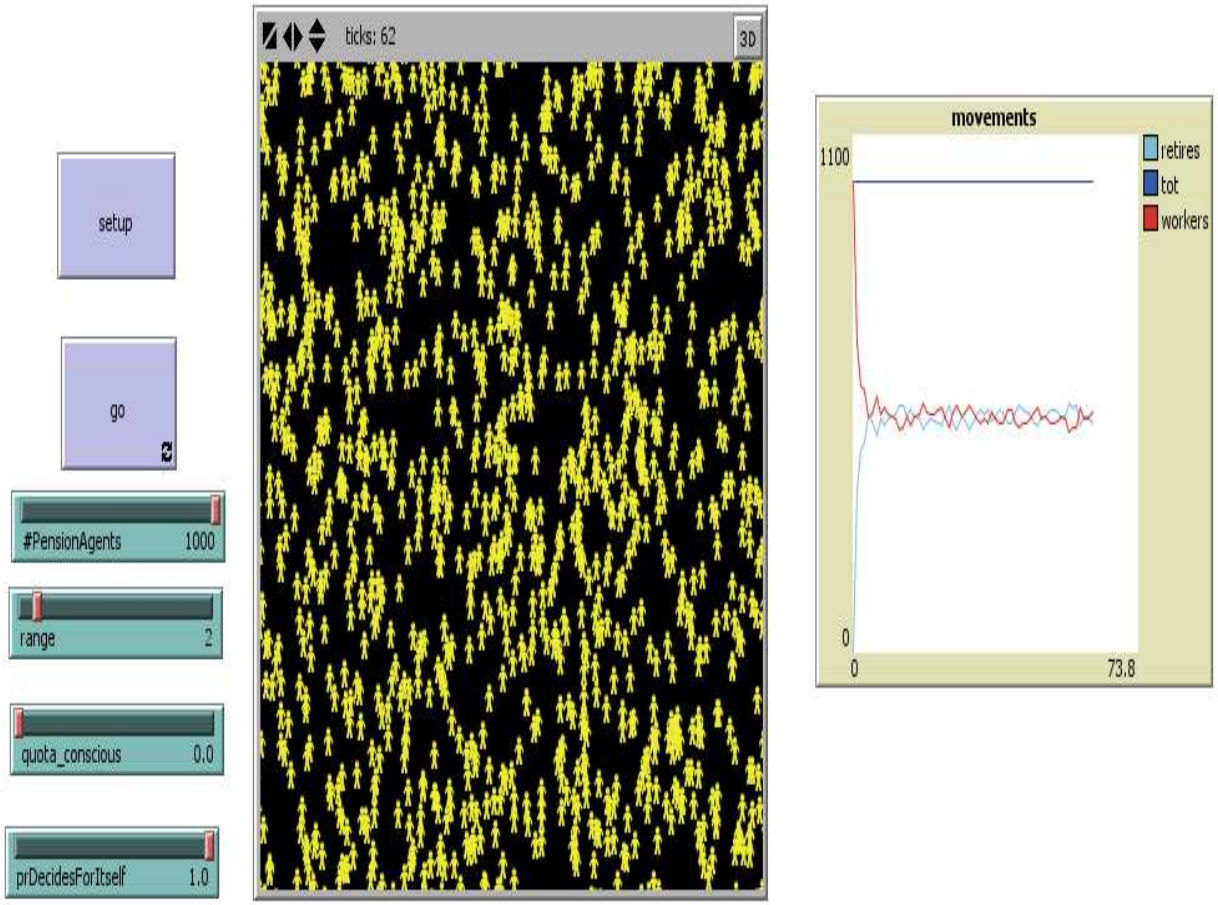

Figure 6.10: Case 2b

As we can see from the first graph, they have birth randomly and almost every agent immediately becomes a worker, only a few decides to retire (yellow) and an extremely low number of them takes no decision at all.(see Figure 4.11)

The study for such a small radius shows how agents decide to retire very rapidly.

In the second graph, the one of movements, we can see how the trends for working and retired agents are very oscillating and do not have a linear functioning.

In the first trend (red) all agents are workers and they progressively decrease stabilizing with a constant oscillating trend. For second trend (blue), retired agents increase quickly.

Studying this simulation for a really high radius of 20, the decision of retiring is much slower than the one taken with a small radius. (see Figure 4.12)

Case 4

In this fourth simulation I set a consciousness value equal to 0.6 and a probability of deciding autonomously equal to 0.1.

Parameters of the sixth simulation:

#pensionAgents: 1000

range: 2

quota_conscious: 0.6

prDecidesForItself: 0.1

In this simulaton the agents who are conscious about their decision areat 60%, while the remaining percentage chooses autonomously.

Having a high consciousness and a very low probability of choosing autonomously and a small radius equal to 2, the agents decide at first to

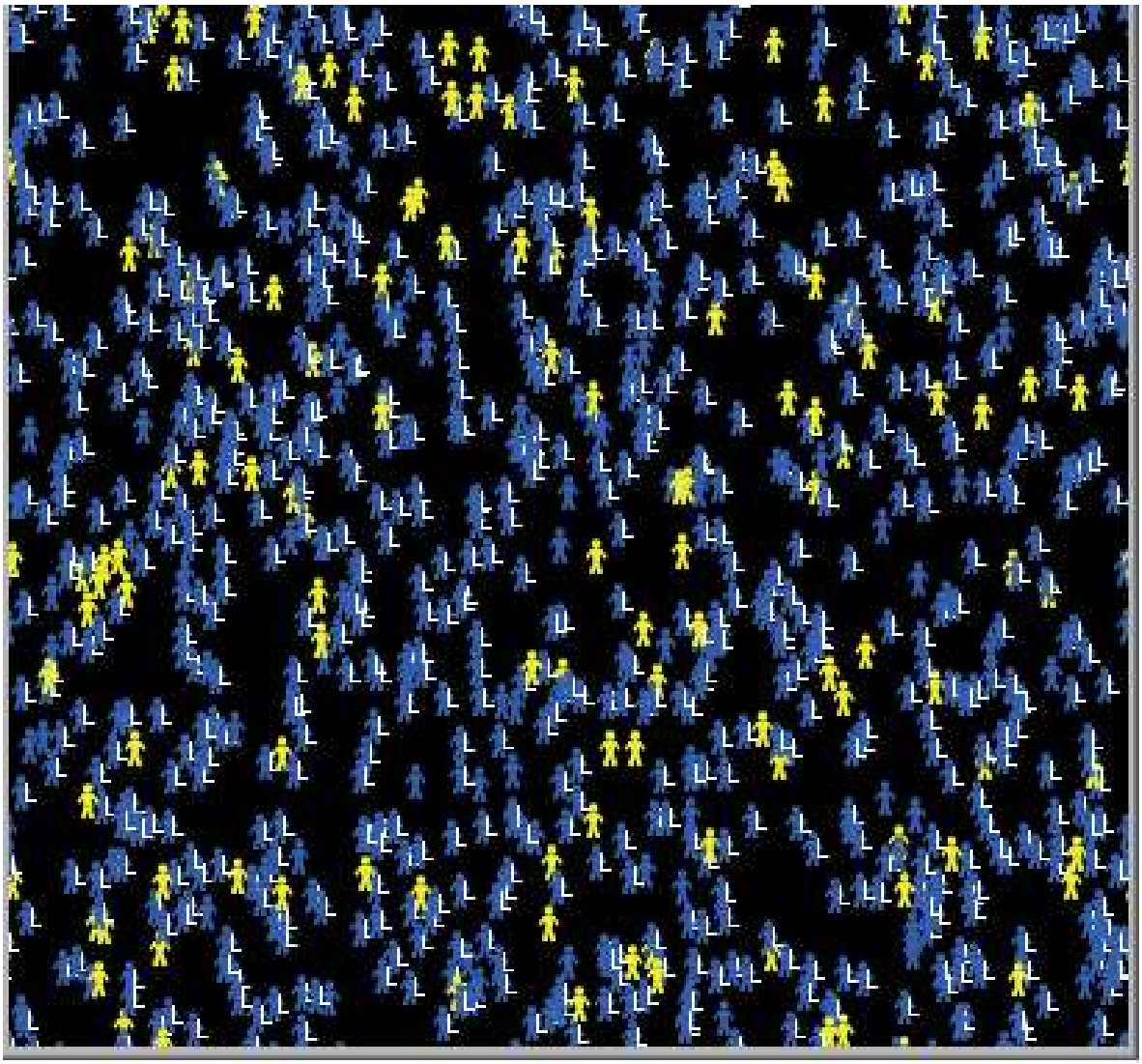

Figure 6.11: Case 3a

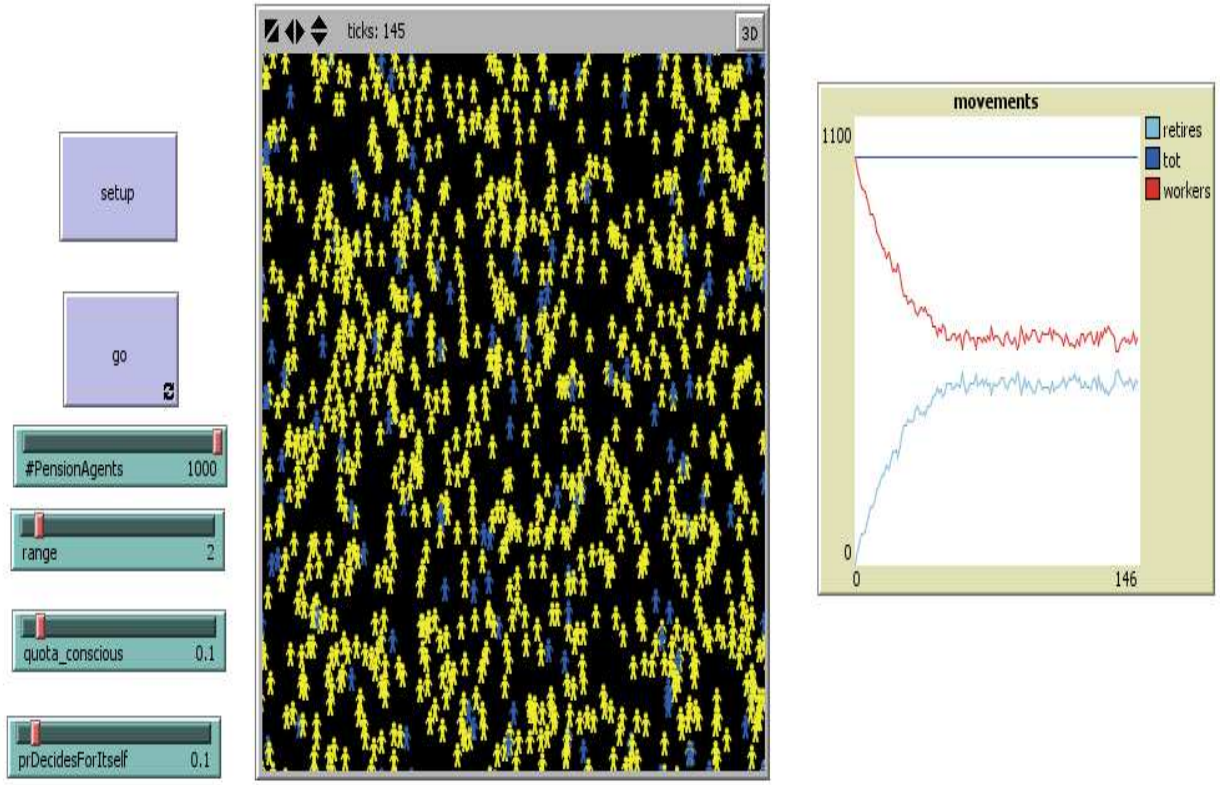

Figure 6.12: Case 3b

become workers that, as time passes by, will retire while the others will keep working. This happens after about 110 ticks.

In the second graph of movements we can see that trends for working and retired agents are oscillatory.

In the first trend (red) working agents slowly decrease while in the second trend (blue) retired agents steadily increase, never touching thw working agents because of the increasing consciousness.(see Figure 4.13)

Case 5

In this fifth simulation I set a consciousness value equal to 0.9 and a probability of deciding autonomously equal to 0.1.

Parameters of the seventh simulation:

#pensionAgents: 1000

range: 2

quota_conscious: 0.9

prDecidesForItself: 0.1

In this case we can observe that the higher the consciousness the more our pensionAgents agents will decide what to do, the 90% of agents will be conscious and autonomous about its choice and the remaining agents will move randomly.

In the first graph most of the agents, having a high value for consciousness, will decide to not retire and keep working. Using a radius equal to 2 it's possible to note that only a few agents qill retire after about 100 ticks.

In the second graph, we can see that the working and retired agents trends are oscillatory, and having a high number of agents the consciousness within the group expands rapidly, thus its functioning is linear.

- In the first trend (red) working agents decrease very slowly while in the second trend (blue) retiring agents increase very slowly.(see Figure 4.14)

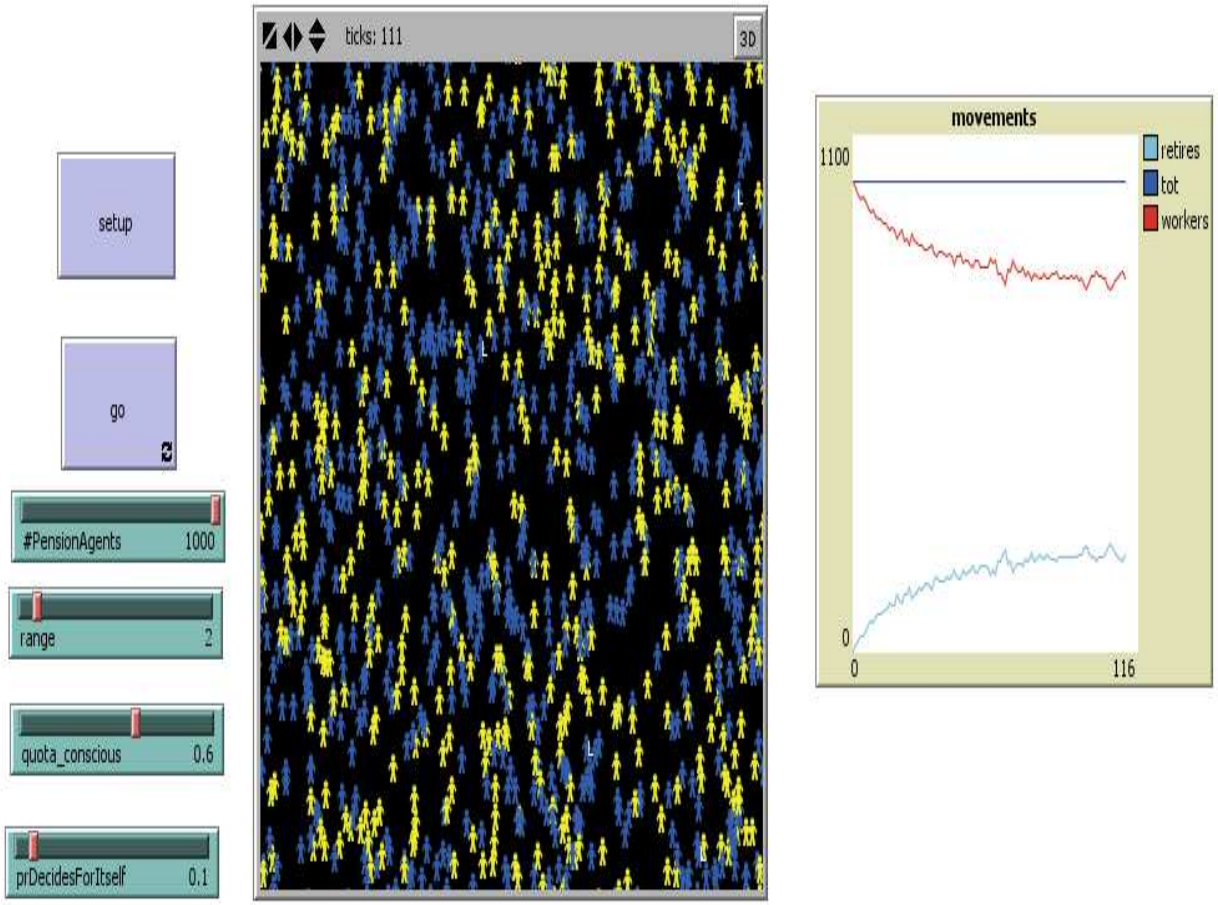

Figure 6.13: Case 4

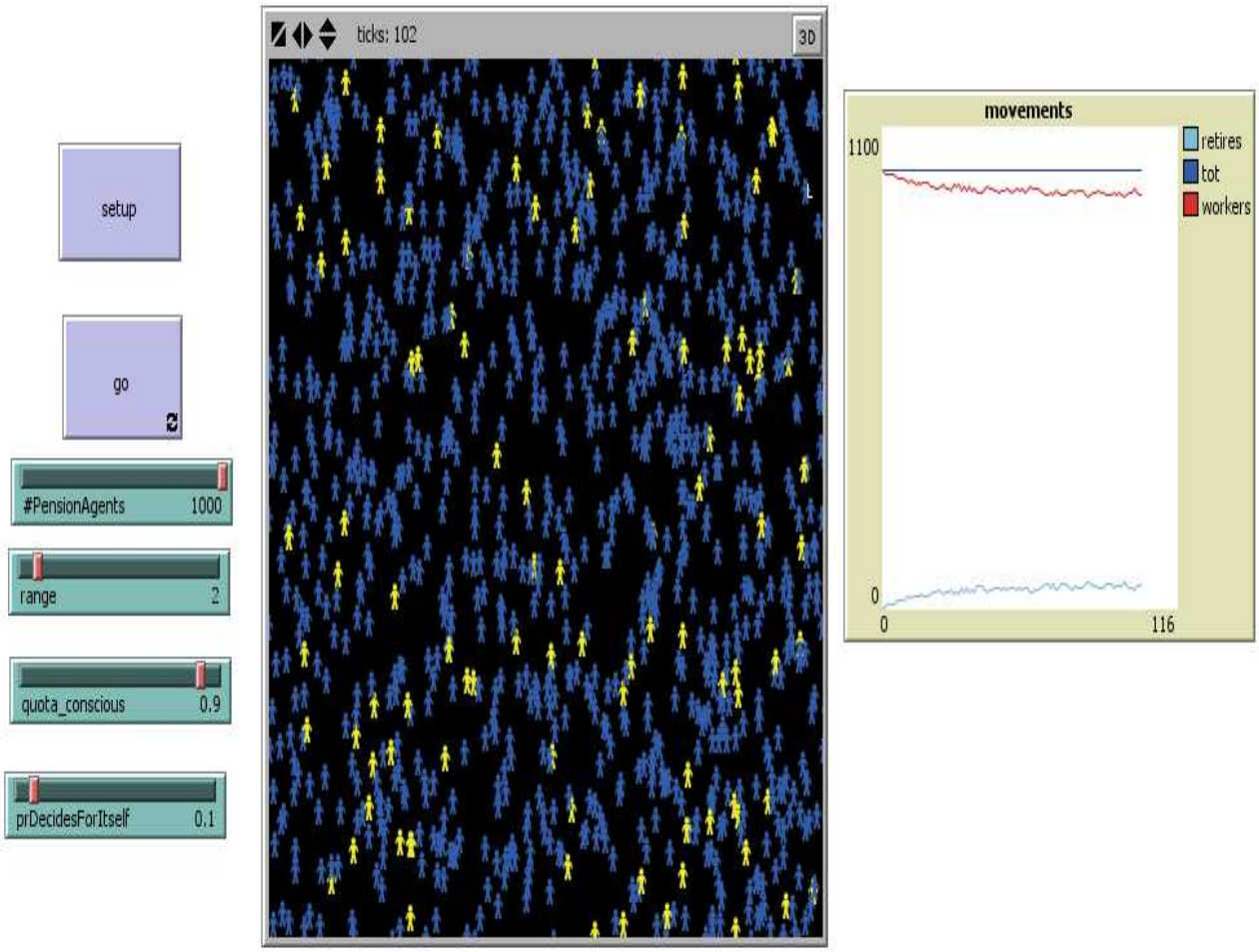

Figure 6.14: Case 5

Case 6

In this sixth simulation I set a consciousness value equal to 0.1 and a probability of deciding autonomously equal to 0.6.

Parameters of the eighth simulation:

#pensionAgents: 200

range: 2

quota_conscious: 0.1

prDecidesForItself: 0.6

In this simulation I studied the case for radius equal to 2 and we can notice that after about 40 ticks only a small group of agents decides to become a worker because the agents with a very low consciousness are not autonomous in their decision.

Having a high probability of deciding autonomously within the radius, the imitating agents will decide to retire.

In the second graph , about movements, we can observe that the trends for working and retired agents are oscillatory.

- In the first trend (red) the working agents decrease rapidly while in the second trend (blue) retired agents rapidly increase and as time goes on the two groups reach an equilibrium.(see Figure 4.16)

Case 7

In this seventh simulation I set a consciousness value equal to 0.1 and a probability of deciding autonomously equal to 0.6.

Parameters of the eighth simulation:

#pensionAgents: 100

range: 2

quota_conscious: 0.1

prDecidesForItself: 0.9

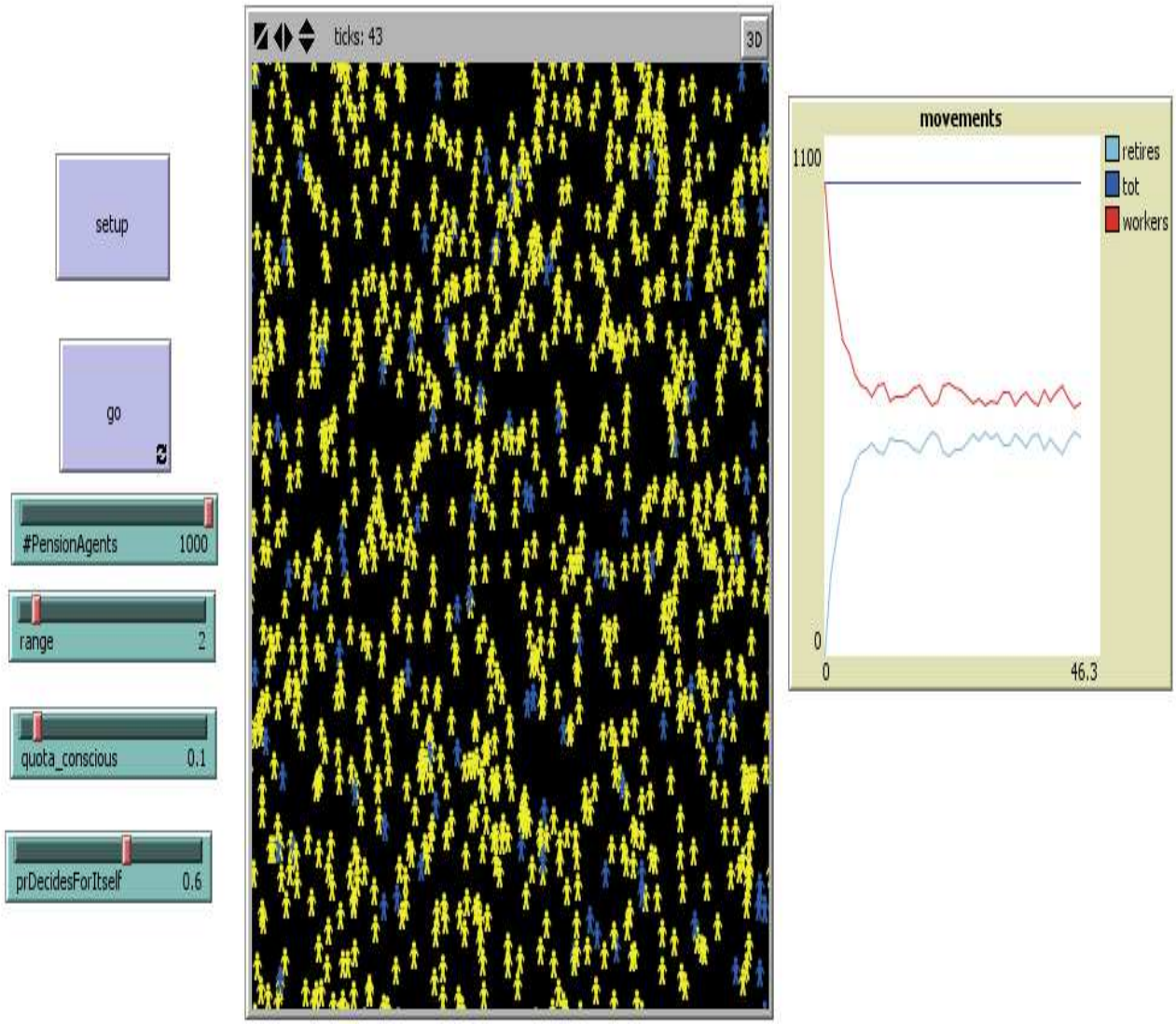

Figure 6.15: Case 6

In this simulation we can note that after about 40 ticks the conscious agents are in very low number while most of the agents will decide randomly.

In the first graph we can note how within a small radius equal to 2 the imitating agents decide to retire and a small group that chose autonomously doesn't.

In the second graph, about movements, we can see that the trends of working and retired agents are oscillatory and do not reach their peak.

- In the first trend (red) working agents rapidly decrease while in the secondo ne (blue) retired agents increase fast and with time passing by they overcome the working agents.

A very high probability of chosing autonomously associated with a low consciousness means a complete casuality in agents movements.(see Figure 4.17)

Instead, using a very high radius equal to 20 in the simulation, after a few ticks the imitating agents choose to retire overcoming the number of working agents, this happens much more rapidly than in the simulation with radius equal to 2 as we can deduce from the graph of movements. (see Figure 4.17)

Case 8

In this eight simulation I set a consciousness value equal to 1 and a probability of deciding autonomously equal to 0.1.

Parameters of the tenth simulation:

#pensionAgents: 1000

range: 2

quota_conscious: 1

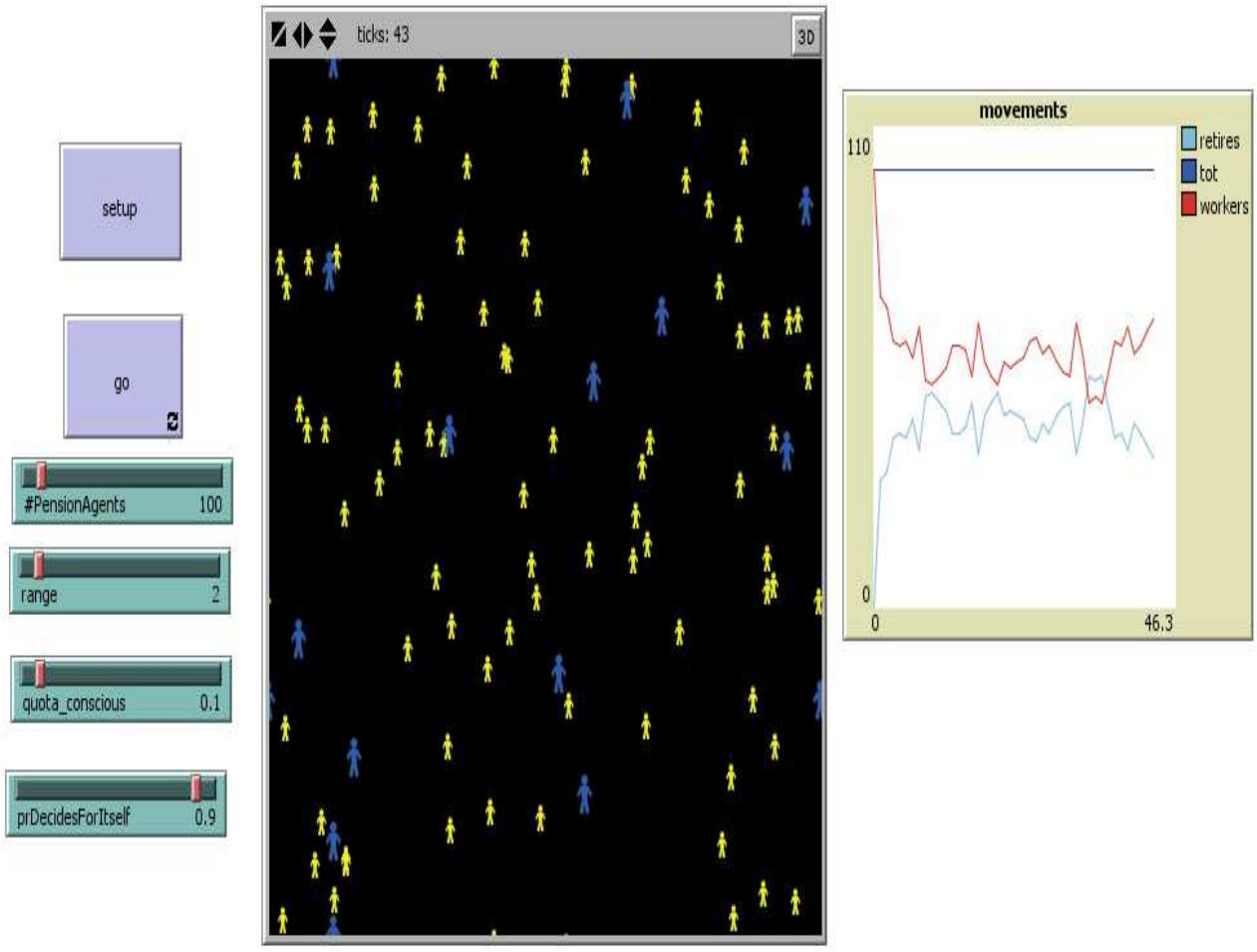

Figure 6.16: Case 7a

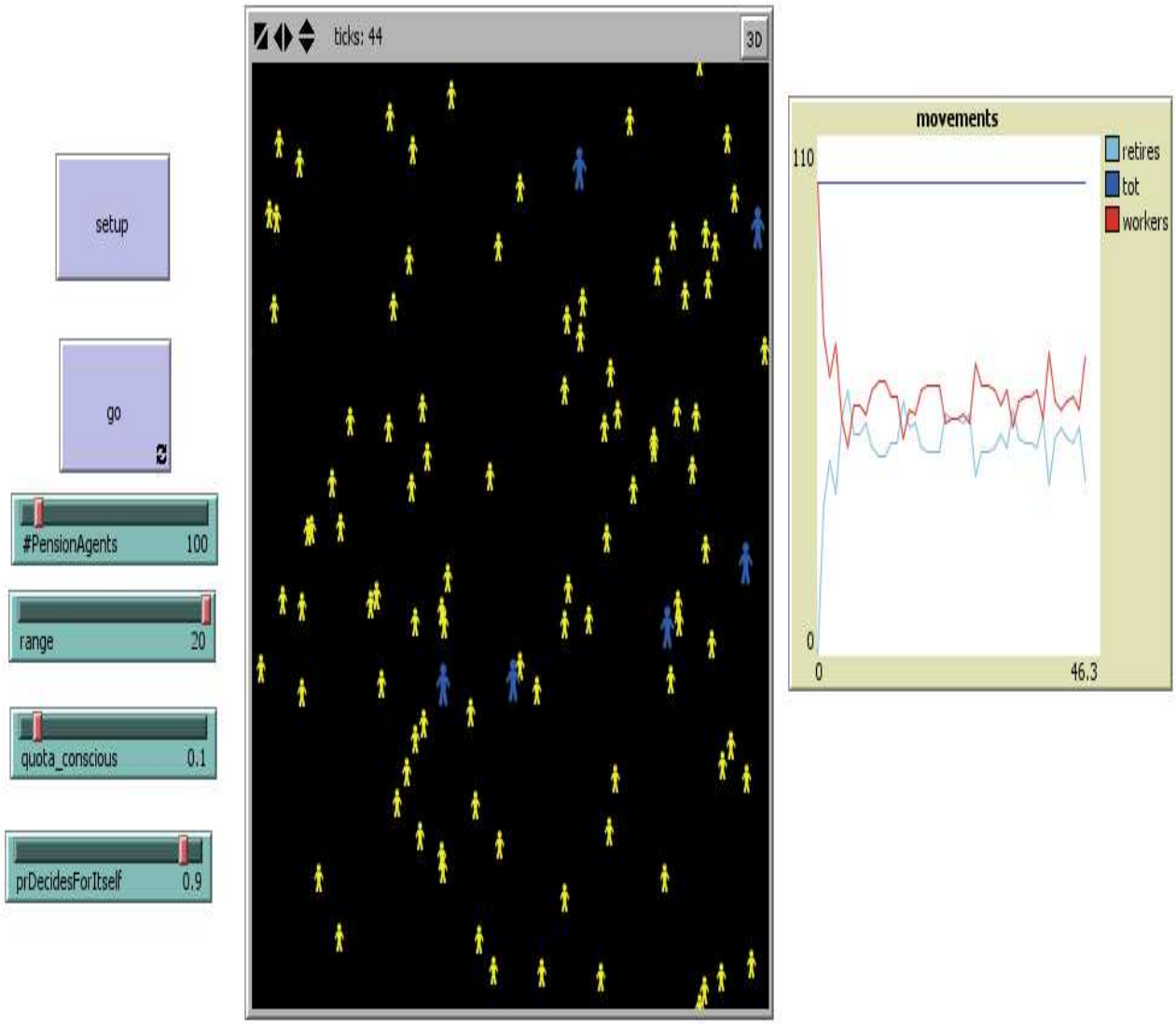

Figure 6.17: Case 7b

prDecidesForItself: 1

In the model the agents have a consciusness and a probability of autonomous decision very high, meaning that each agent chooses autonomously.

After having run the simulation, the following emerges:

The study of this simulation in a very low range equal to 2, the agents autonomously decide to retire, this happens after about 100 ticks.

As we can see in the first graph all the agents choose to work and no agent retires and increasing the radius to 20 the conclusions are the same except for a lower decisional process.

In the second graph about movements we can see that working and retired agents trends are constant and linear.

In the first trends (red) all agents are working and in the second trend (blue) there are no retired agent.(see Figure 4.18)

6.4 The Model 2

Following further the construction of the program in NetLogo, through the second model we want to continue explain the changes that have been done in comparison to model 0 and model 1.

The main idea of this model is to analyze the problem of retirement. Hence, in model 2 have been added further changes as for example the age (workers /retirees). Firstly our population (artificial) will have an age between 18 and 60 years.

Each time that an agent goes beyond the age of 60 years will retire and at the age of 90 the agent will cease to live. At this point another casual working agent at the age between 18 and 35 will spring up to balance our model.

This study will be particularly focused on the retirement problem. At first, we do not consider agents older than 60 years. Hence the reference

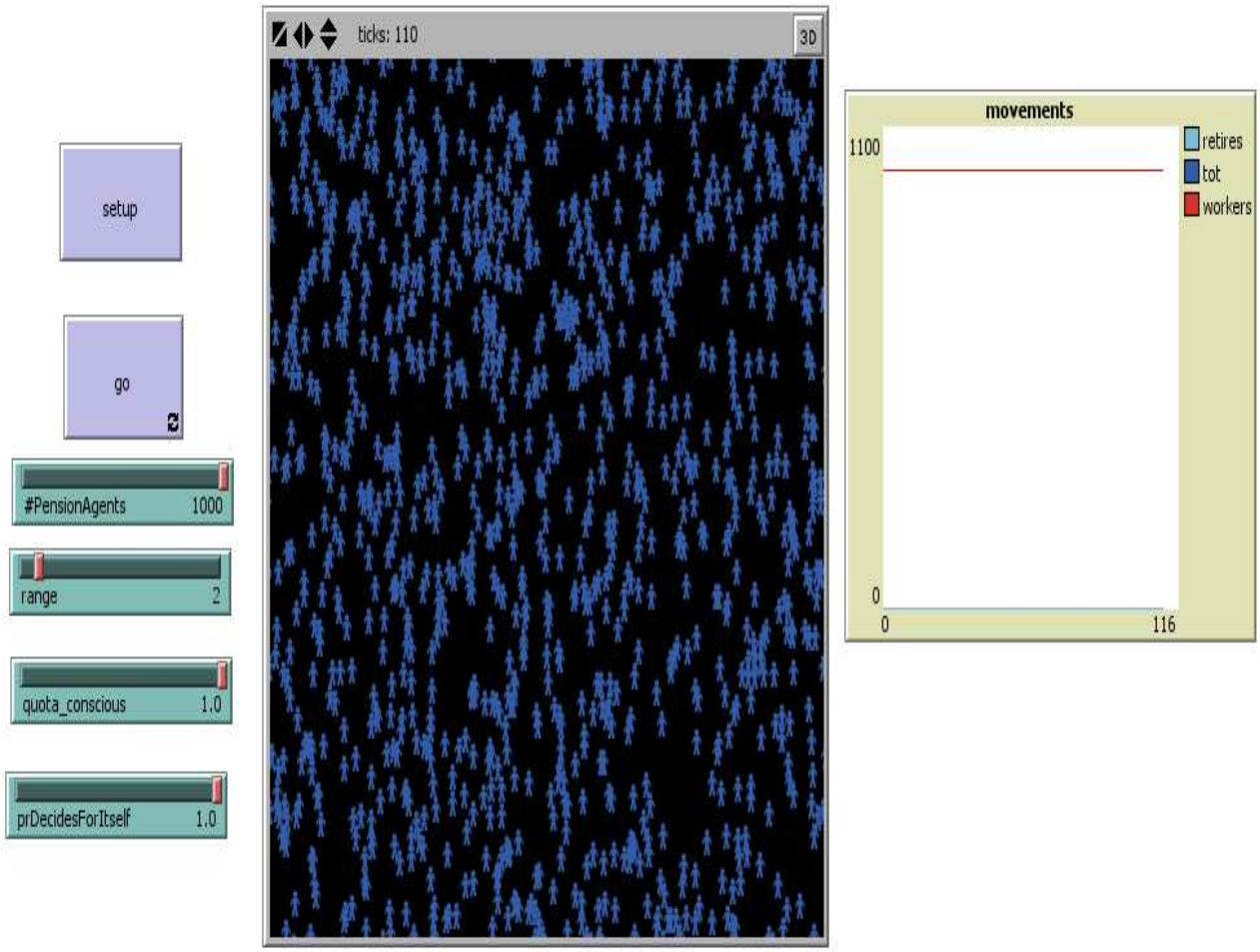

Figure 6.18: Case 8

population (artificial) will have no deaths for a long time. This has been decided to simplify the study.

In this model we will conduct several simulations by changing the sliders "consciousness quota", "probability of deciding alone" and "the amplitude of the imitation radius".

Furthermore, we will compare the results obtained with the real data of the workers and pensioners observed over the last 11 years (2002-2013) in Italy and Ecuador by their respective statistical institutions mentioned below.

Italy table: In the table are shown for each year the number of pensioners and the number of active workers and the sum of this two groups. The total differs from the number of inhabitants as there are individuals not yet at a working age, unemployed and inactive.

Ecuador table: This table the same entries as the table related to the Italian case. The data have been obtained from INEC, the national statistics and censuses institute of Ecuador.

Table Italian Case

Years	Retires	Workers	Total
2002	16.199.141	24.132.234	40.331.375
2003	16.381.112	24.283.564	40.664.676
2004	16.561.600	24.373,345	40.934.945
2005	16.560.879	24.412.456	40.973.335
2006	16.670.893	24.789.098	41.459.991
2007	16.771.604	23.222.000	39.993.604
2008	16.779.555	23.024.992	39.804.547
2009	16.733.031	24.270.455	41.003.486
2010	16.707.026	22.345.653	39.052.679
2011	16.575.900	22.967.000	39.542.900
2012	16.593.892	23.876.345	40.470.237
2013	16.668.585	24.517.522	41.186.107

Table Italian Case

Years	%Retires	%Workers	Total
2002	0,404583	0,595417	1
2003	0,404187	0,595813	1
2004	0,404583	0,595417	1
2005	0,404187	0,595813	1
2006	0,402096	0,597904	1
2007	0,419357	0,580643	1
2008	0,421549	0,578451	1
2009	0,408088	0,591912	1
2010	0,427807	0,572193	1
2011	0,4191877	0,5808123	1
2012	0,4100270	0,5899729	1
2013	0,40471378	0,59528622	1

Table Ecuadorian Case

Years	Retires	Workers	Total
2002	2.078.057	6.240.380	8.318.437
2003	2.260.666	6.070.345	8.331.011
2004	2.193.218	6.545.188	8.738.406
2005	2.192.593	6.486.112	8.678.705
2006	2.253.915	6.772.557	9.026.472
2007	2.152.798	6.548.109	8.700.907
2008	2.254.971	6.536.310	8.791.280
2009	2.399.122	6.685.111	9.084.233
2010	2.260.666	6.535.240	8.795.906
2011	2.324.578	6.647.203	8.971.781
2012	3.056.757	6.913.203	9.969.960
2013	3.457.062	7.222.477	10.679.539

Table Ecuadorian Case

Years	%Retires	%Workers	Total
2002	0,249813	0,750187	1
2003	0,271356	0,728644	1
2004	0,250986	0,749014	1
2005	0,252641	0,747359	1
2006	0,249701	0,750299	1
2007	0,247422	0,752578	1
2008	0,256501	0,743499	1
2009	0,264097	0,735903	1
2010	0,257013	0,742987	1
2011	0,259099	0,740901	1
2012	0,306597	0,693403	1
2013	0,323709	0,676291	1

6.4.1 Code

In model 2, **pensionAgents** represents the entire group of agents with are pensioners, while pensionAgent is the name of each single agent present in the group.

In the second line, to the group **pensionAgents** are assigned the five proprietary variables:

- State
- Consciousness
- Pension
- Old
- Age

which are specific for the breed to which they belong and are valid only for the agents that are part of that breed.

- The first variable “State” represents the choice that each agent will make and defines the movement of each agent.

- The second variable " Consciousness" indicates the probability of being influenced by the group.
- The third variable " Pension" indicates when an agent retires.
- The fourth variable "Old" indicates when an agent becomes old.
- The fifth variable "Age" indicates the age that is assigned to each agent.

```
breed [PensionAgents PensionAgent]
turtles-own [state consciousness pension  old  age]
```

6.4.2 Setup

In the setup were assigned the features and information of each agent of the group pensionAgents.

In this procedure was created and set in the only type of agents and has been formalized in the following way:

- The agents have been created in a single group #pensionAgents within the group all agents have the same color, the same shape and the same size and is assigned a random coordinate to each;
- The agents are initially all workers because within the group is assigned the status 0.
- The ask command acts considering an agent at a time; initially for each agent is assigned a false value which means worker.
- It is assigned to each agent old false which means the young.
- It is assigned to each agent a starting age of 18 and then we sum of normal random variable with mean 30 and variance 14 but only positive ones, so on average the individual generated will be of 48 years old.

- If the age exceeds 60 years, it means that the agent becomes old and chooses to retire.

- If the button setup is pressed, the procedure starts. It will initially run the clear-all command which restores the initial empty state of the world, getting rid of all the agents previously created and leaving the environment ready to start a new model.

- While Reset-ticks is used to reset the counter of the tick;

```
to setup
    clear-all
   create-PensionAgents #PensionAgents [set color blue set shape "person"
   set state 0 setxy random-xcor  random-ycor]
   ask PensionAgents [  set pension false
           set old false
           set age 18 + abs (random-normal 30 14)
          if age > 60 [set old true]
           ]
   setConsciousness
   reset-ticks
end
```

Once the setup procedure is executed, inside it will be recalled another procedure " setConsciousness " which verifies if the random value between 0 and 1 assigned to the agents of the group PensionAgents is less than the value assigned to the sliders quota_conscious determined in the interface of the model 1.

The ask command acts considering an agent at a time; for each agent are then tested the following conditions: If the random value (random-float 1) is less than the quota_conscious, then the agent will be conscious.

However, if this value is greater than the quota_ conscious then we can say that the agent is not conscious, and will act at random.

```
to setConsciousness
  ask PensionAgents [
       ifelse random-float 1 < quota_conscious
       [set consciousness true ]
       [set consciousness false]
  ]
end
```

6.4.3 Go

In this part of the program we define the way in which all the agents involved in the simulation operate; are recalled the three procedures decide_retire , retirement and expire which will be explained separately in the code.

- The command ask acts considering an agent at a time; initially for each agent is assigned if the age, if exceeds 60 years means that the agent gets old.
- The second ask acts considering an agent at a time; if the two conditions are satisfied: if it is retired and also old the agent retires and to that is assigned the yellow color to differentiate themselves from workers agents.

Instead the tick is used to count the number of times that the function go is performed.

```
to go
ask PensionAgents [if age > 60 [set old true]]
ask PensionAgents [if  state = 1  and  old  [ set pension
true  set  color  yellow  set  label""] ]
decide_retire
retirement
```

```
expire
tick
ask PensionAgents [ set  age  age  +  1]
end
```

The first procedure recalled by the go is “decide_retire”.

For the group of PensionAgents is checked the presence of two conditions: the consciousness of the agent and if it is a worker with the following code.

If ifelse has a positive result to the agents will be assigned the status 0, and so they will not retire; otherwise if ifelse has negative result the decision taken will be random.

```
to decide_retire
  ask PensionAgents[
      if consciousness and not pension
      [set state  0]
; random decision
```

If there is the presence of two conditions: the lack of consciousness of the agent, and if is worker with the following code.

If the first option is chose then the agent will not retire otherwise choosing the second option, the agent will go into retirement.

```
   if not consciousness and not pension
    [
           let choice random 3
           if choice = 1 [set state  0]
           if choice = 2 [set state  1]
     ]
```

```
; check others
```

In this part of the code is checked for the presence of five conditions: the lack of consciousness of the agent, the not retirement, if the agent is old, if a random number in the interval (0,1) is less than the probability of deciding alone and, finally, the program checks how many agents are in the range of imitation. If this happens, the agent copies the choice taken by the other agents, otherwise it doesn't.

```
if not consciousness and not pension and old and
not (random-float 1 < prDecidesForItself) and
(any? PensionAgents in-radius range)
; copy others
```

Here is counted if the number of agents in the group PensionAgents with the state 0 is greater than the number of agents in the group PensionAgents with status 1 in the case study of the radius of imitation, if yes then all the agents in the group PensionAgents will not get in pension (state 0) and each will show the letter " L".

```
[if count PensionAgents in-radius range with [state = 0]
 > count PensionAgents in-radius range with [state = 1]

[set state 0 set label "L"]
```

Here is counted if the number of agents in the group PensionAgents with the state 0 is less than the number of agents in the group PensionAgents with status 1 in the case study of the radius of imitation, if yes then all the agents in the group PensionAgents will not get in pension (state 0) and each will show the letter "P".

```
if count PensionAgents in-radius range with [state = 0]
 < count PensionAgents in-radius range with [state = 1]

 [set state 1 set label "P" set pension true set color yellow]

       ]
  ]

end
```

The second procedure recalled by the go is “retirement”:

If a random number within the interval (0, 1) is less than 0.9 means that you have created a whole PensionAgents and is assigned to this the status 0 and an random age from 18 to 35 years old, having the same color, the same shape and the same size and is assigned a random coordinate to everyone.

```
to retirement
  if random-float 1 < 0.9 [  create-PensionAgents int (0.025 * #PensionAgents)
[set age 35 - random 17  set  old  false  set  pension  false
 set Consciousness set color blue set shape "person"
 set state 0  setxy random-xcor random-ycor ]
]
end
```

The third procedure recalled by the go is “ expire”: The ask command acts considering an agent at a time; for each agent with a random number (0.1) is less than 0.1, and if the agent is old dies.

If the age of the agent is greater than or equal to 90 years, this agent will stop living.

```
to expire
  ask PensionAgents [ if random-float 1  <  0.1  and  old  [die]
                      if age  >=  90  [die]
                      ]
end
```

6.4.4 Case Study Italy

Case 1

In this study I set a consciousness level equal to 0 and a probability of an independent decision equal to 0.1.

Parameters of the simulation:

#pensionAgents: 1000

range: 2

quota_conscious : 0.7

prDecidesForItself : 0.1

In the Italian case, every time an agent go beyond the 65 years of age, he will retire from the labor market.

Moreover, at the age of 90 the agent will die and he will no longer be part of the model. He will be replaced by a new random agent aged between 18 and 35 year old.

The initial population of agents set in the program is 1000. After about 12 ticks the population grows to about 1220 agents.

In the second graph, that represents the age distribution of the agents, the presence of a sort of normal distribution can be noticed.

70% of the agents that decide for themselves are aware in this simulation, while the remaining percentage chooses randomly.

Having a high awareness and a probability to decide for themselves very low together with the fact that the simulation is done with a very small radius, equal to 2, the agents will decide to start working, while the remaining art of agents will decide to retire. This happens after about 12 ticks .

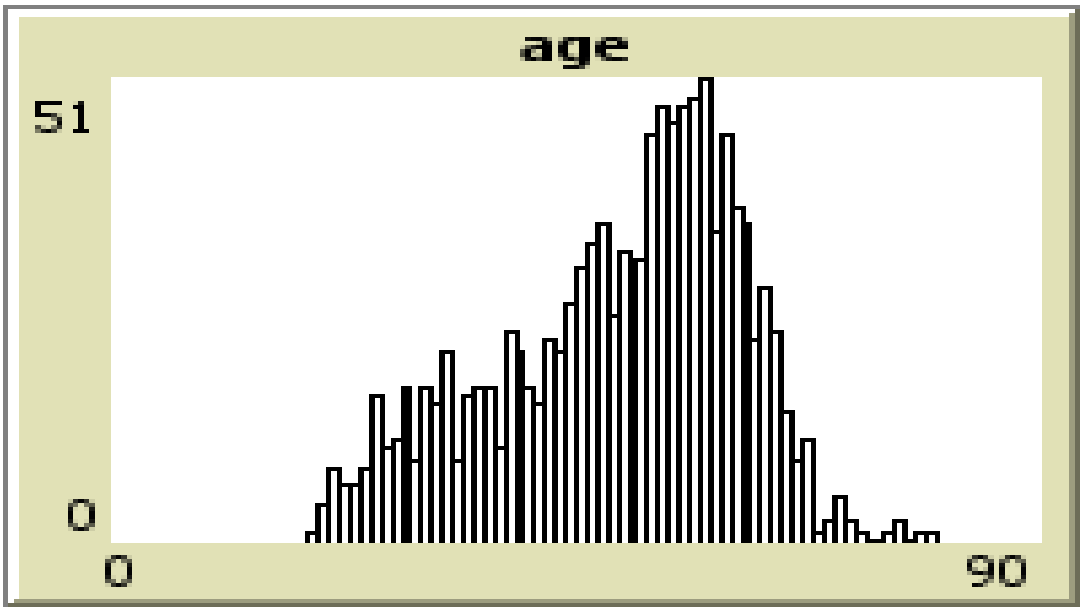

Figure 6.19: Case 1 AGE

In the graph of the movements we can see that the trends of the working and retired agents are slightly oscillating, but with an increasing trend.

In the first pattern (red line), the working agents grow slowly, as those of the second trend (blue line), although the latter are not a lot, since the awareness proportion is high.

By comparing the pattern of results obtained through the simulation with the actual results measured by ISTAT in the years 2002-2013, we can notice that the result are very similar. Therefore it is safe to assume that the simulation is accurate.

In the case study of the simulation with a very high radius (20) the agent's decision to retire or not is much slower than the one made âĂŃâĂŃby the agents with a small radius.

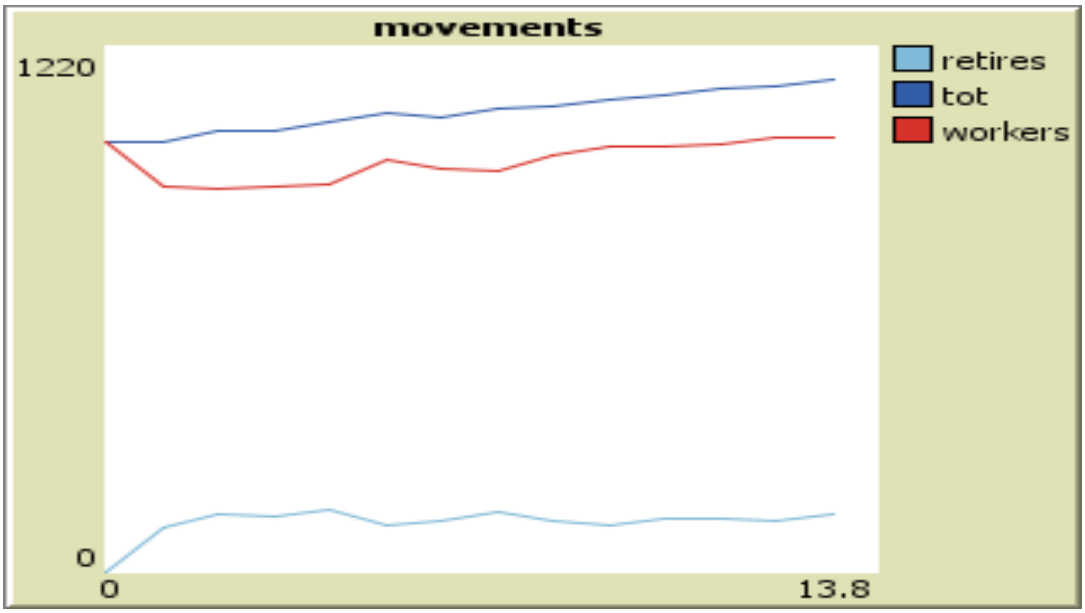

Figure 6.20: Case 1 Movements

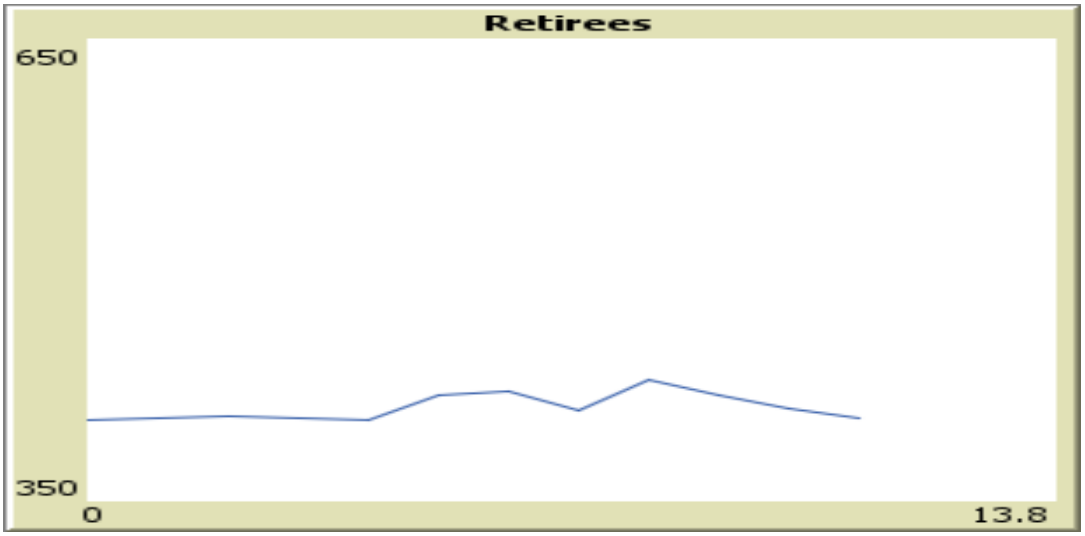

Figure 6.21: Case 1 Retirees

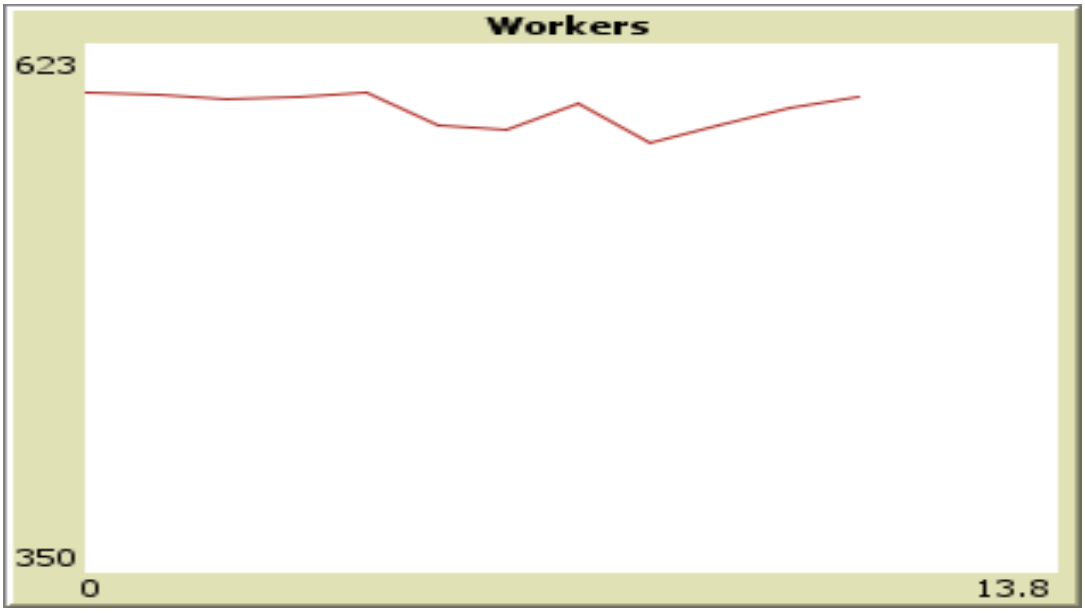

Figure 6.22: Case 1 Workers

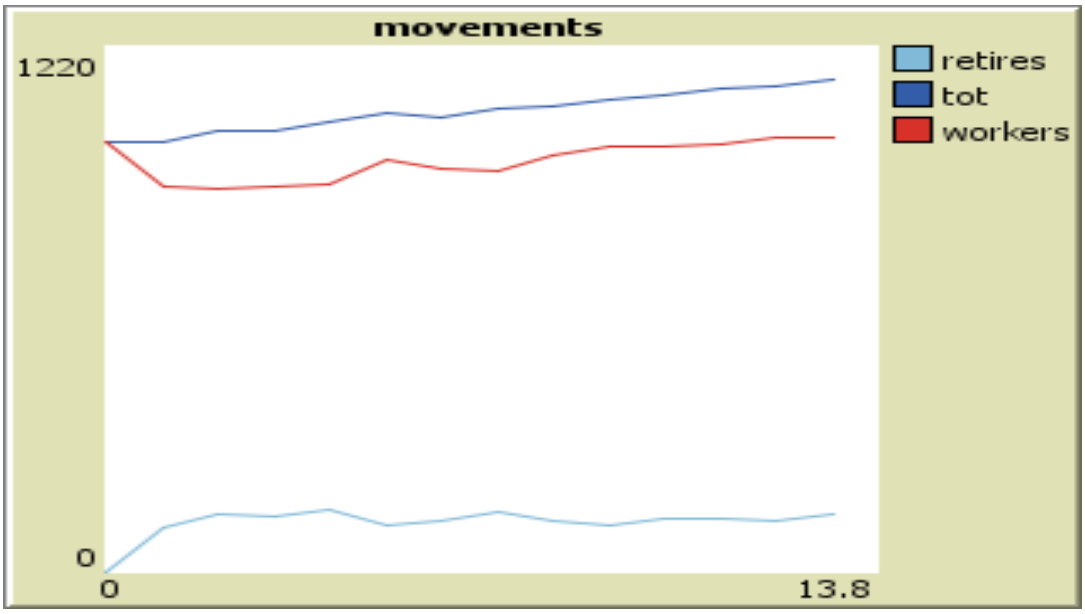

Figure 6.23: Case 1 Movements

Case 2

In the second study reported I reversed the parameters considered in the previous case and therefore I opted for a very low consciousness of 0.1 and a probability of an independent decision equal to 0.7.

Parameters of the simulation:
#pensionAgents: 1000
range: 2
quota_conscious : 0.1
prDecidesForItself : 0.7

As in the previous case, whenever an agent would be more than 60 years old, he will retire. at the age of 90 the agent dies and is replaced by a new random working agent aged between 18 and 35 .

The initial population within the program is 1000 agents and it increases over time.

In the second graph that represents the age distribution of the agents we can note how the age distribution of the agents is better balanced than in the case previously analyzed.

In this simulation, I performed the study in a radius of 2. it can be seen that after about 30 ticks only a small group of agents decides to work. This is due to the fact that agents have a very low awareness and they are not autonomous in their choice. Since the imitating agents have a high chance of an independent decision within the given range, they will decide to retire.

In the graph on the movements you can see that the trend of the working and retired agents is swinging.

In the red pattern, the working agents decrease rapidly, in the second pattern (blue line), where the number of agents that decide to retire increase as well. Therefore, the number of retired agent will surpass the number of working agents over time.

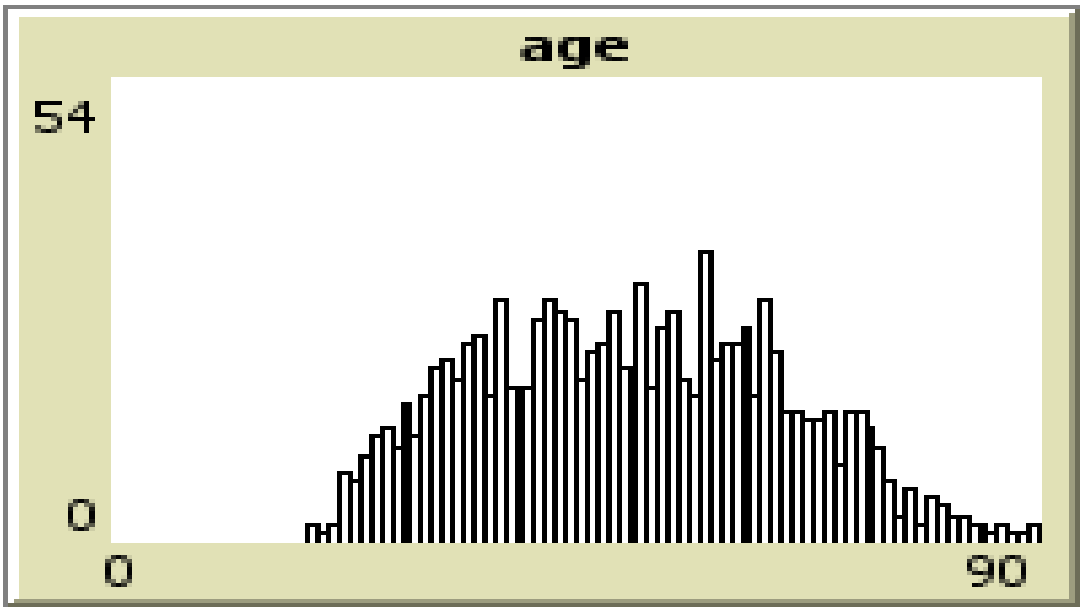

Figure 6.24: Case 2 Age

By comparing the pattern of results obtained through the simulation with the results form ISTAT measured from 2002 to 2013, we can see that the results are not similar. This outcome is due to the fact that the high probability of an independent decision invalidates our model.

In case the same simulation was done with a very high imitation radius equal to 20, the number of retired agents will take a longer period of time to exceed the number of working agents.

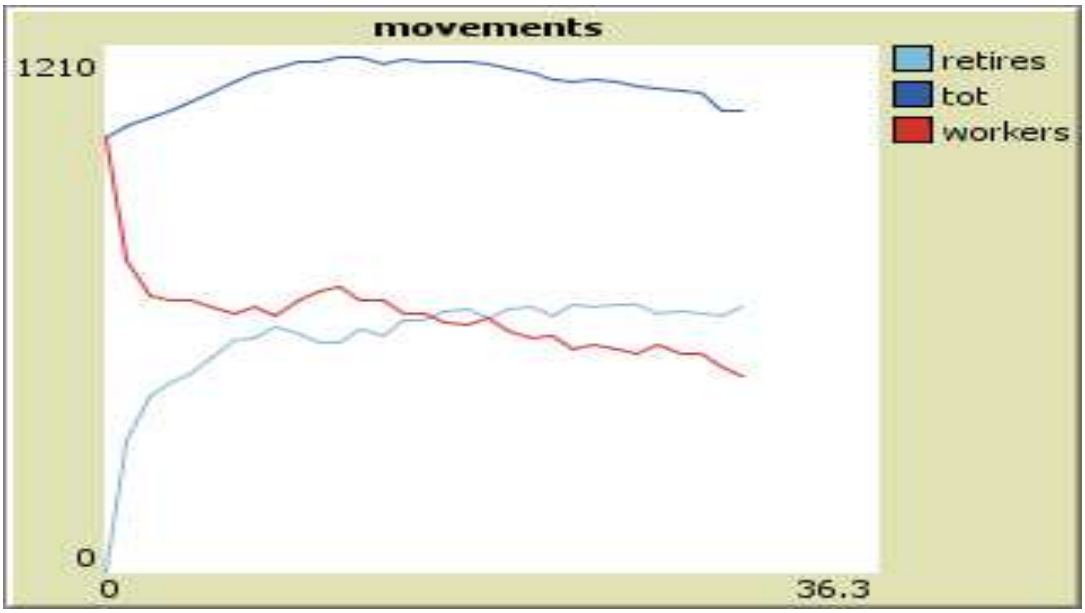

Figure 6.25: Case 2 Movements

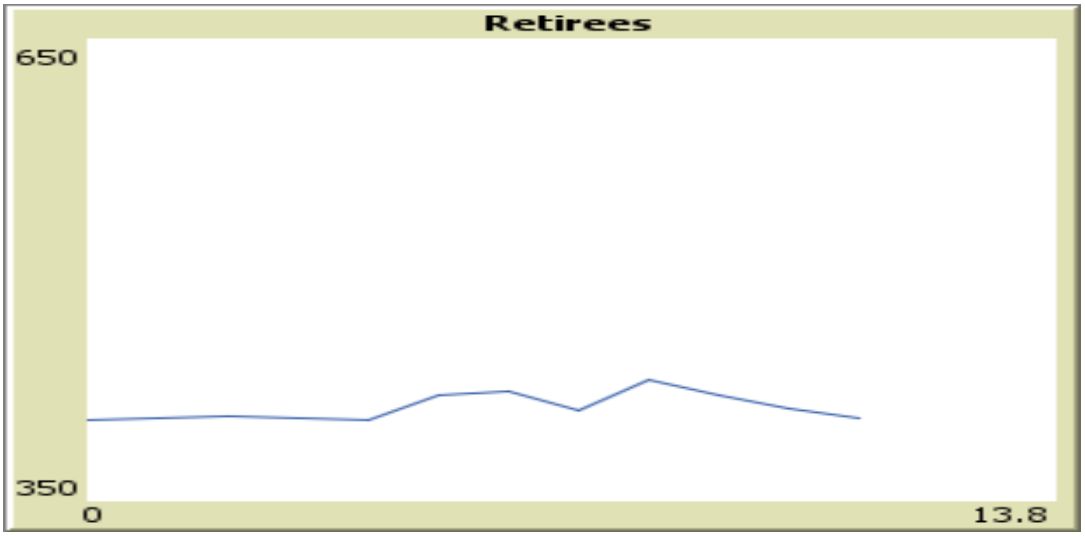

Figure 6.26: Case 2 Workers

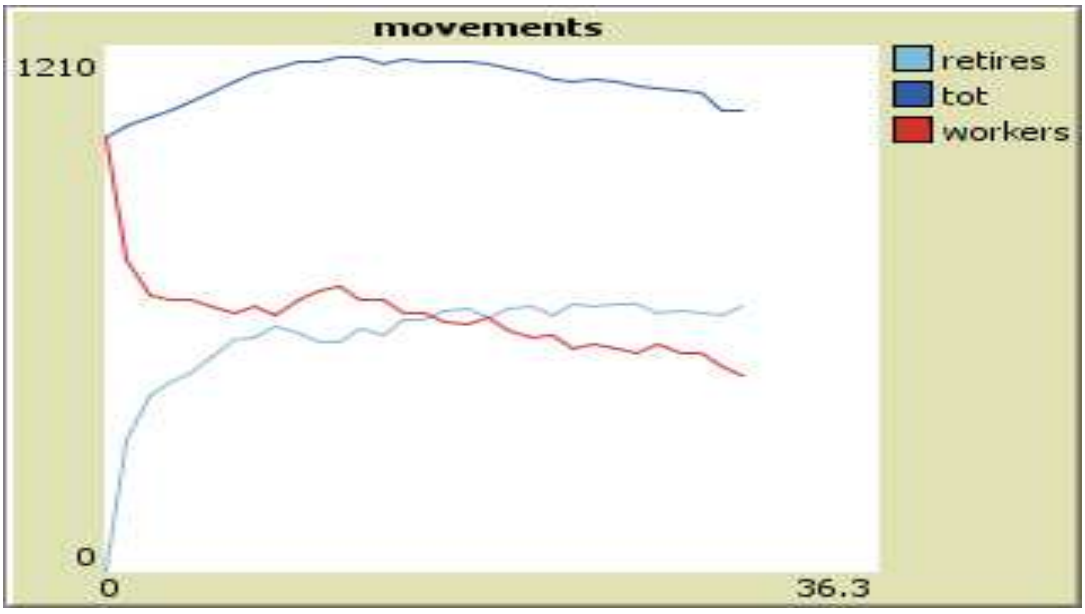

Figure 6.27: Case 2 Movements

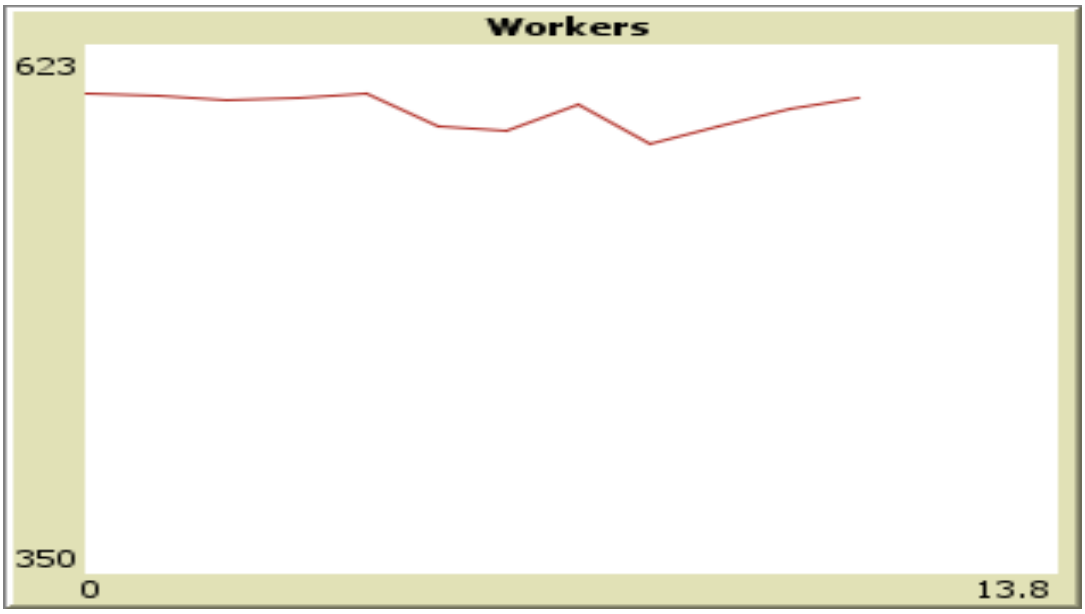

Figure 6.28: Case 2 Retirees

Case 3

In the third simulation of the Italian case I set a consciousness value equal to 0.1 and a probability to decide for himself equal to 0.1.

Parameters of the simulation:

#pensionAgents: 1000

range: 2

quota_conscious : 0.1

prDecidesForItself : 0.1

As in the previous simulations the number of agents in the beginning is equal to 1000. This number will increase until it reaches 1220, and it happens after approximately 30 ticks.

The agents of this simulation have a very low awareness, which means that a very small proportion, will make an independent decision whether or not to retire. After running the simulation result shows that:

Having a very low both awareness and a probability of an independent decision together with a very small radius equal to 2, we do not know what might happen since the large majority of the agents are imitators. therefore, all the solutions are in fact possible.

From the graph of the movements can be seen that after a few ticks a high number of workers decide to retire and after 20 ticks, the number of retirees exceeds the number of workers.

In the graph representing the age distribution of the agents we can see that it appears more balanced than in the previous study.

By comparing the pattern of results obtained through the simulation done by the program with the actual results measured by ISTAT in the years 2002-2013, it is possible to see that there are no similarity in the patterns. The main reason is the very low probability of an independent decision as well as the low awareness.

In the case where the same simulation was done with a very high imitation radius , equal to 20, the number of retired agents employ a greater period of time to overtake the number of working agents.

Also, the initial population expands with a slower pace compared to

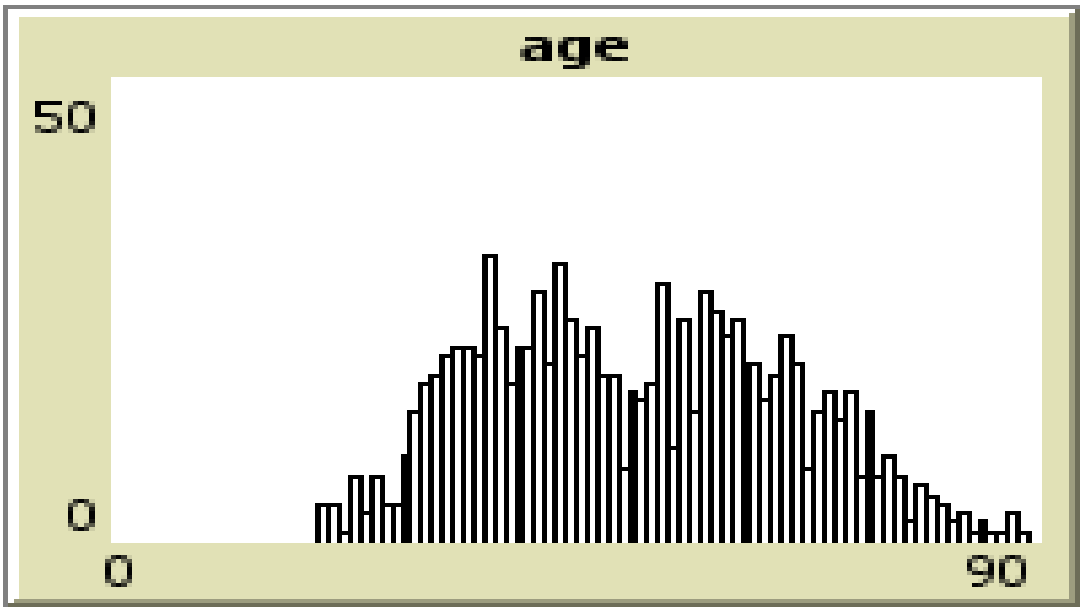

Figure 6.29: Case 3 Age

the case where the imitation radius was 2.

From the results of the case studies, it is possible to see that the higher the agent awareness, the closer will be the results of the NetLogo silmulated model compared to the real data measured by the ISTAT.

6.4.5 Case Study Ecuador

Case 1

In this study I set a consciousness value equal to 0.7 and a probability of an independent decision equal to 0.1.

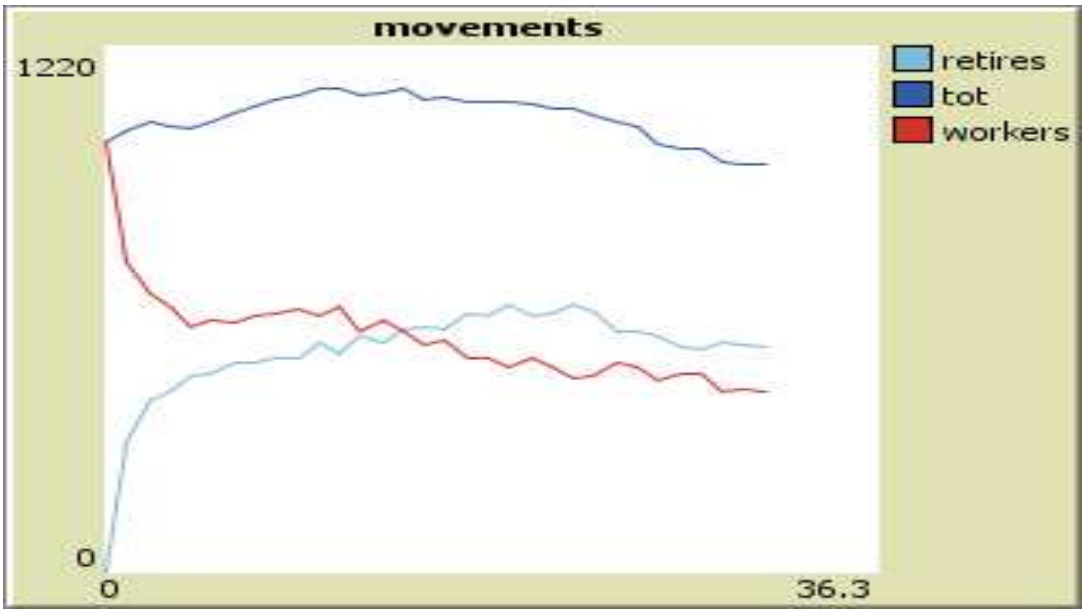

Figure 6.30: Case 3 Movements

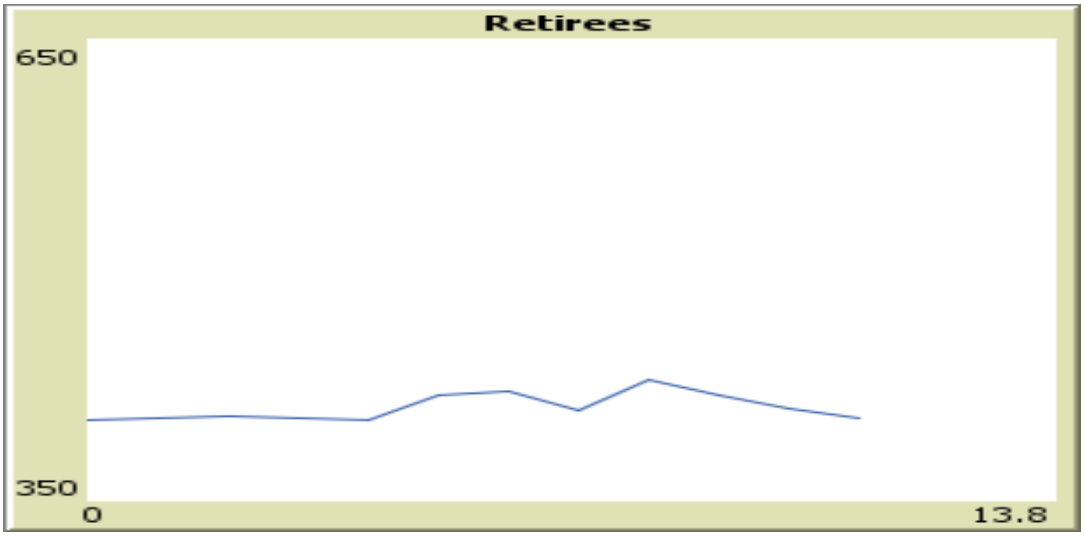

Figure 6.31: Case 3 Retirees

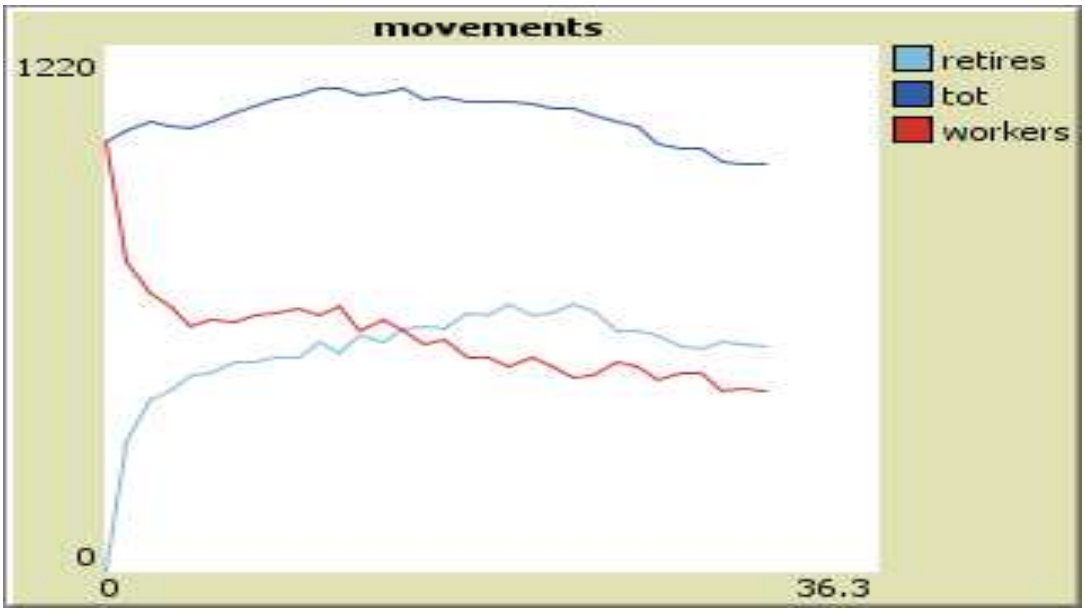

Figure 6.32: Case 3 Movements

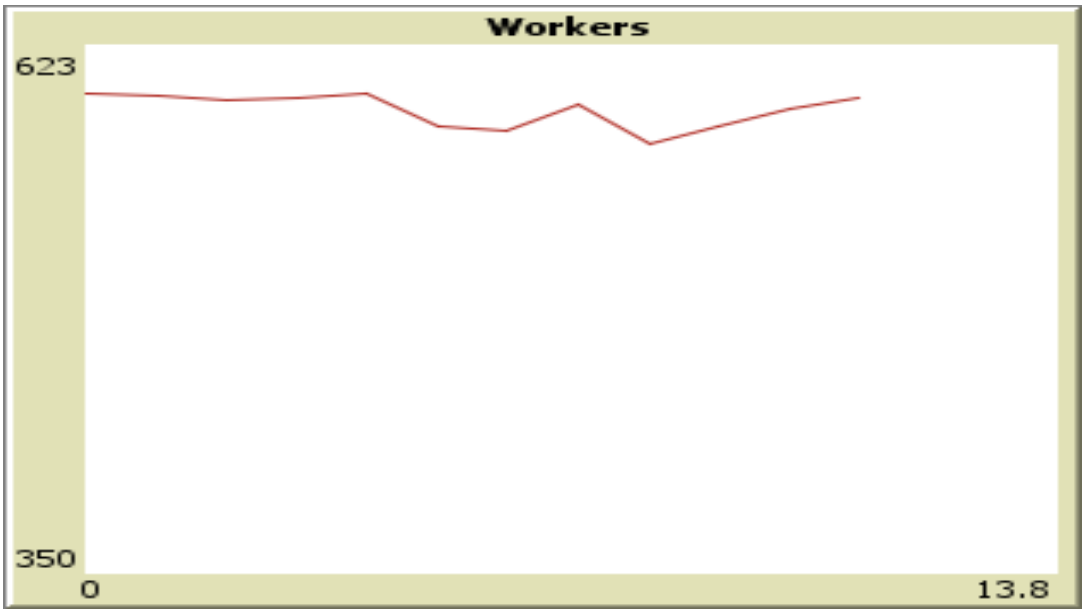

Figure 6.33: Case 3 Workers

Parameters of the simulation:
#pensionAgents: 1000
range: 2
quota_conscious : 0.7
prDecidesForItself : 0.1

In the case study simulating Ecuador, the agents over 60 years of age will retire and at the age of 80 they will die and be replaced by a new agent random worker aged between 18 and 35.

The initial agent population of the program is of 1000 agents and after 20 ticks the population grows to about 1210.

The second graph represents the age distribution of the agents which turns out to be well distributed. Moreover, it is possible to see that a large group of agents aged 60-65 years has decided to retire.

70% of the agents are aware of their decision in this simulation while the remaining percentage decides randomly.

Having a high awareness, a very low probability of an independent decision and a very small radius of 2, after about 20 ticks a much higher number of agents decides to remain in the workforce while only a small proportion opt for retirement.

In the graph of the movements we can see that the trends of the working and retired agents are slightly oscillating, but the trend is fluctuating over time.

In the first pattern (red line), the trend of the working agents is increasing initially, but after about 15 ticks there is a reversal of the trend and the number of workers begin to decrease slowly. The second trend (blue line) shows that, unlike the previous pattern, the number of retired agents is growing slowly and continuously over time.

By comparing the pattern of results obtained through the simulation with the actual results measured by the INEC (Instituto Nacional de EstadÃŋstica y Censos) in the years 2002-2013, we can notice that the result are very similar. Therefore it is safe to assume that the simulation is accurate.

In case the same simulation was done with a very high imitation

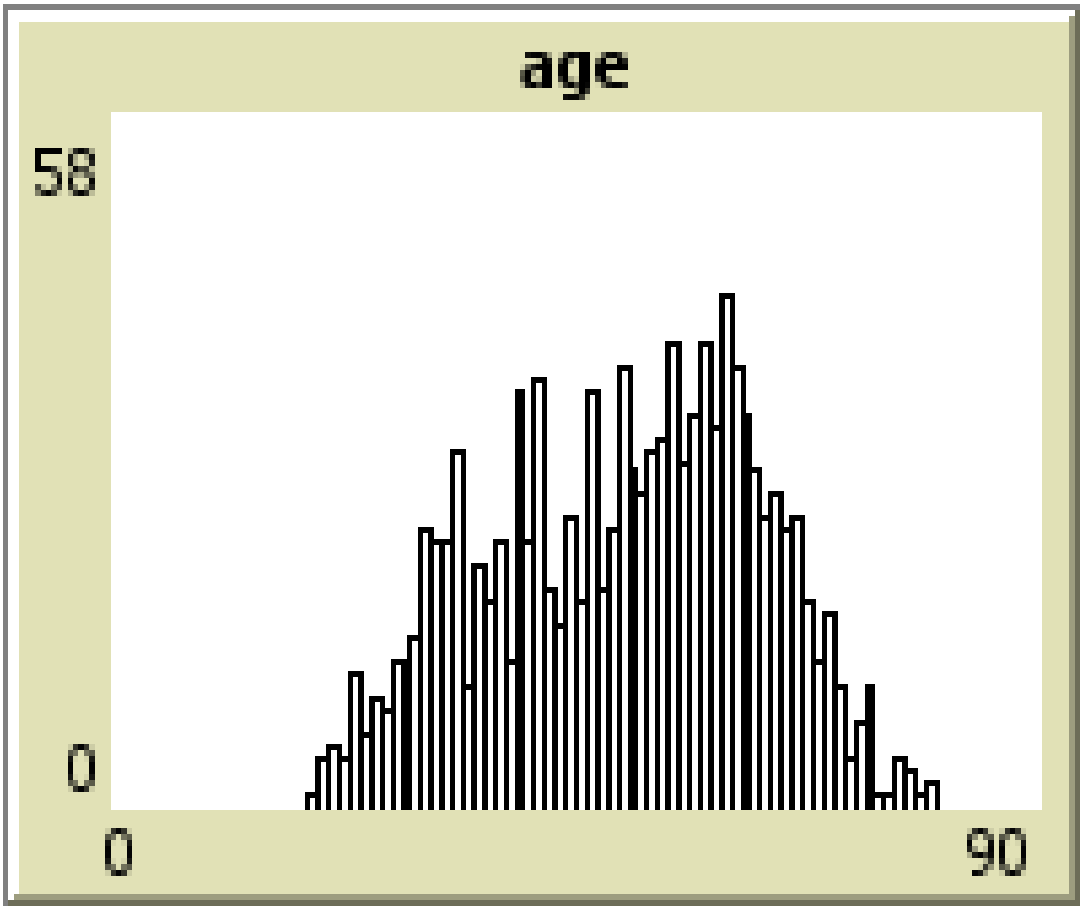

Figure 6.34: Case 1 Age

radius equal to 20, the results are similar, but the agents need more time to decide whether to retire or not than in the case of a smaller radius.

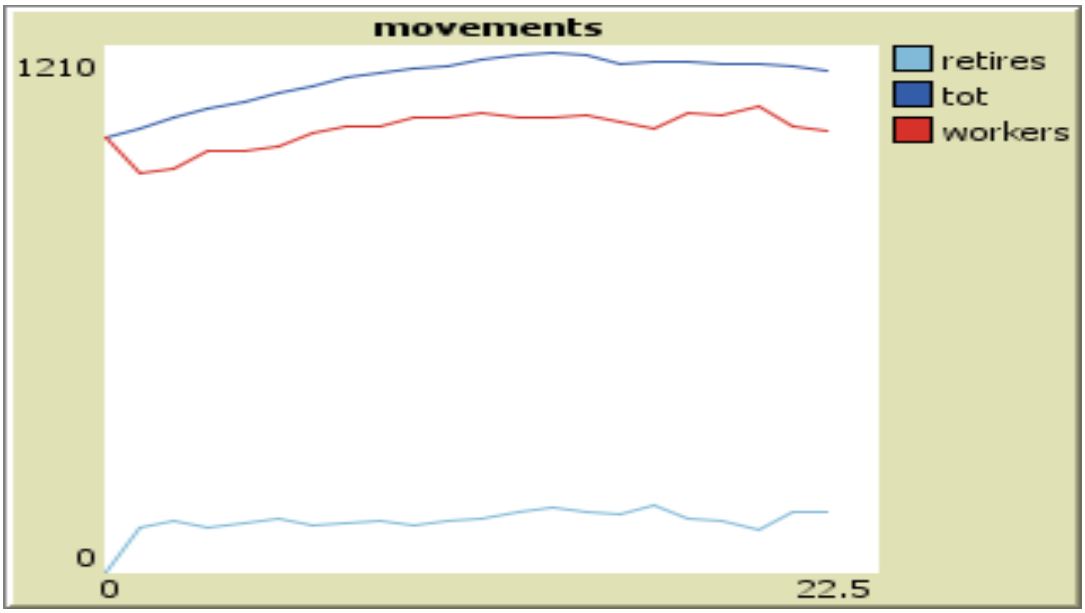

Figure 6.35: Case 1 Movements

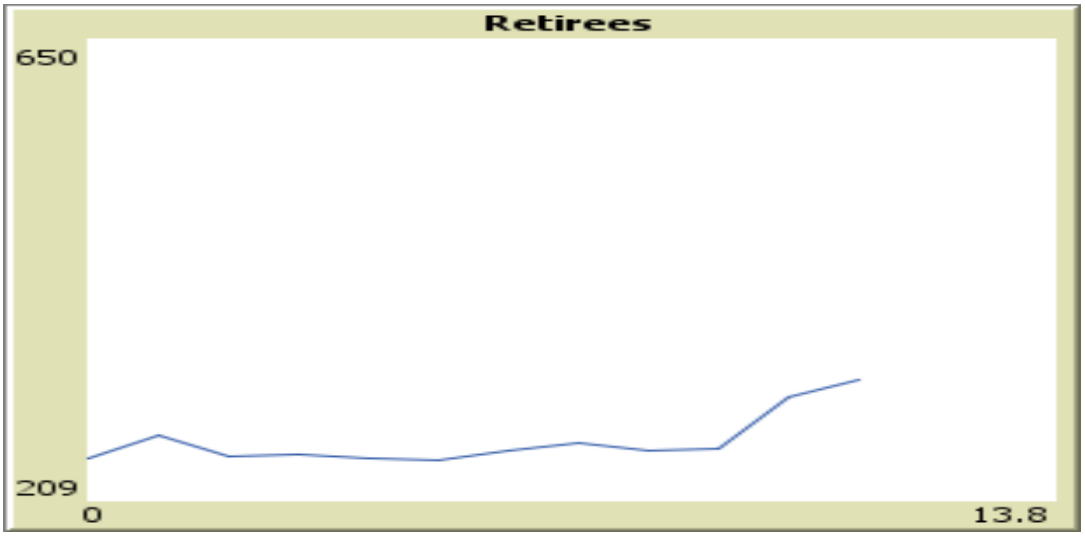

Figure 6.36: Case 1 Retirees

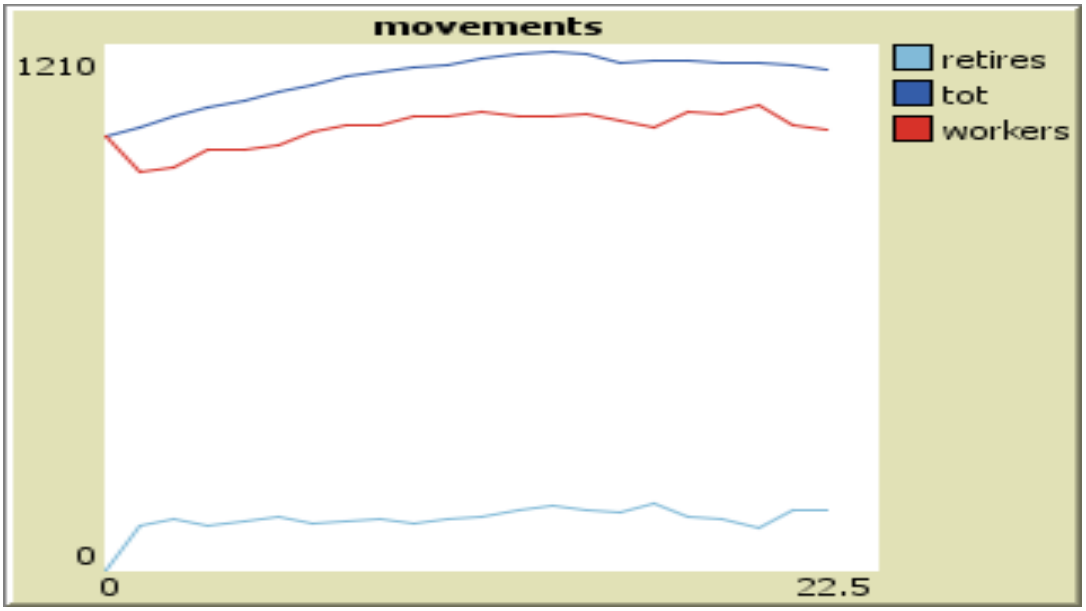

Figure 6.37: Case 1 Movements

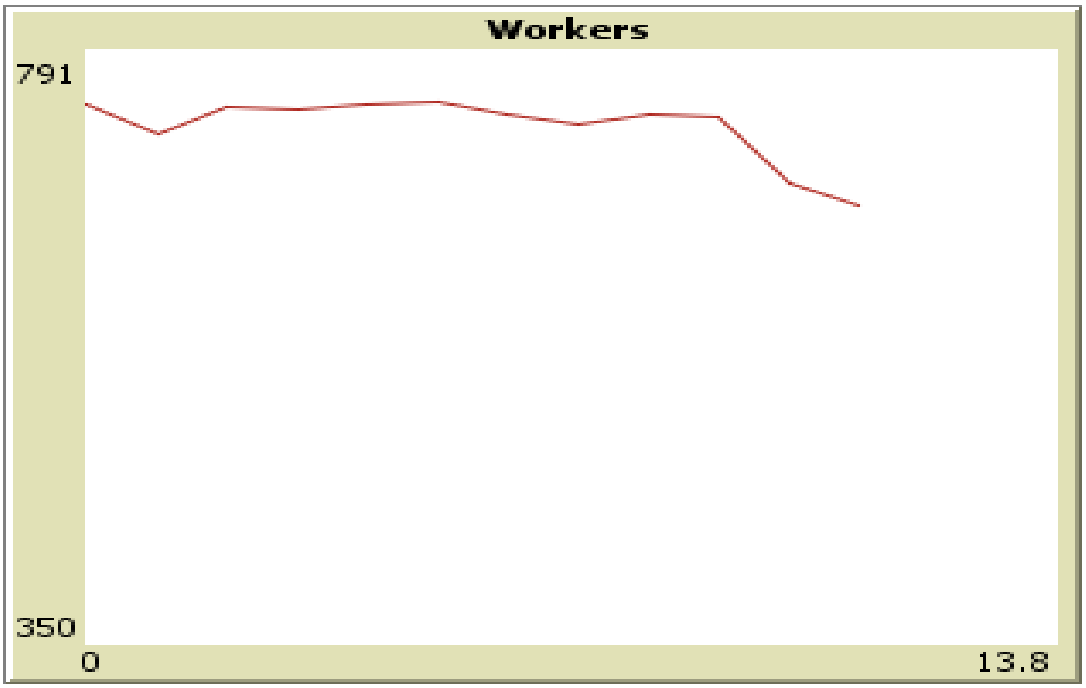

Figure 6.38: Case 1 Workers

Case 2

In the second study reported regarding the Ecuador I reversed the parameters considered in the previous case. Therefore I opted for a of very low consciousness value equal to 0.1 and a probability of an independent decision equal to 0.7.

Parameters of the simulation:

#pensionAgents: 1000

range: 2

quota_conscious : 0.1

prDecidesForItself : 0.7

As in previous cases, whenever an agent reaches 60 years of age, he will retire from the labor market. At the age of 80, the agent will die and cease to be part of the model. His place will be taken by a new random agent, aged between 18 and 35 years.

The initial population of this program is 1000 agents and it increases over time up to 1220 agents. This happens after about 30 ticks.

In the second graph that represents the age distribution of the agents we can see that the distribution of the agents is better balanced than in the case previously analyzed.

In this simulation, the study was performed with a radius of 2. It can be seen that after about 30 ticks only a small group of agents decides to start working because agents with a very low awareness are not autonomous in their choice.

Having a high probability to decide for themselves, the imitating agents will decide to retire.

In the movements graph, it is possible to see that the trends of the working and retired agents are swinging. In the first pattern (red line), the employed agents initially decrease rapidly, but after about 8 ticks that trend continues with a slower pace. In the second trend (blue line), the number of agents who decide to retire grow rapidly and after about 17 ticks it exceeds the number of working agents.

By comparing the pattern of results obtained through the simulation

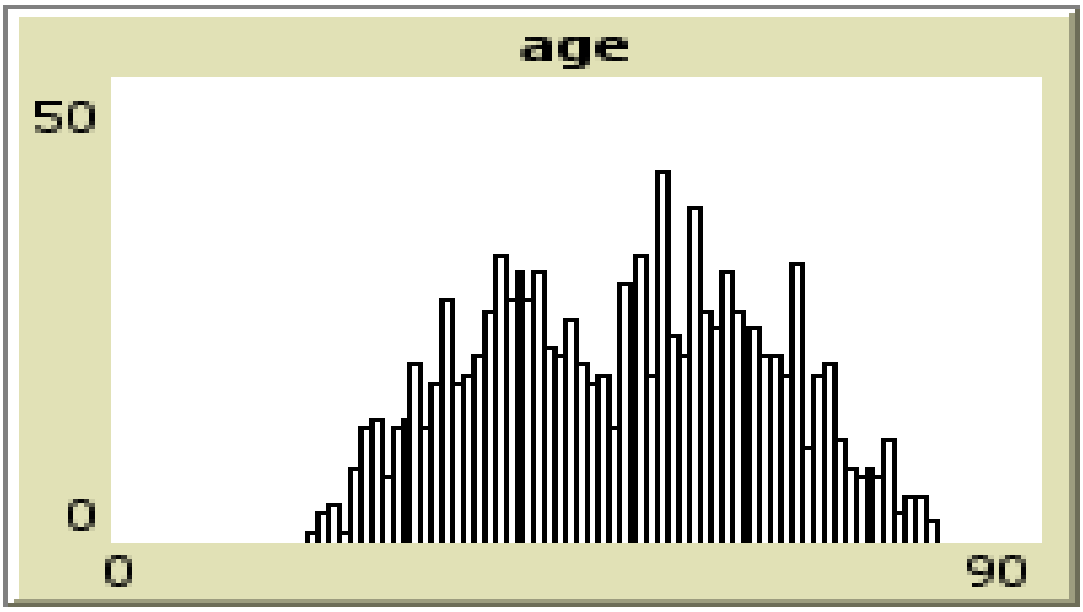

Figure 6.39: Case 2 Age

with the results form INEC measured from 2002 to 2013, we can see that the results are not similar.

This outcome is due to the fact that the high probability of an independent decision invalidates our model.

In case the same simulation was done with a very high imitation radius equal to 20, the number of retired agents will take a longer period of time to exceed the number of working agents.

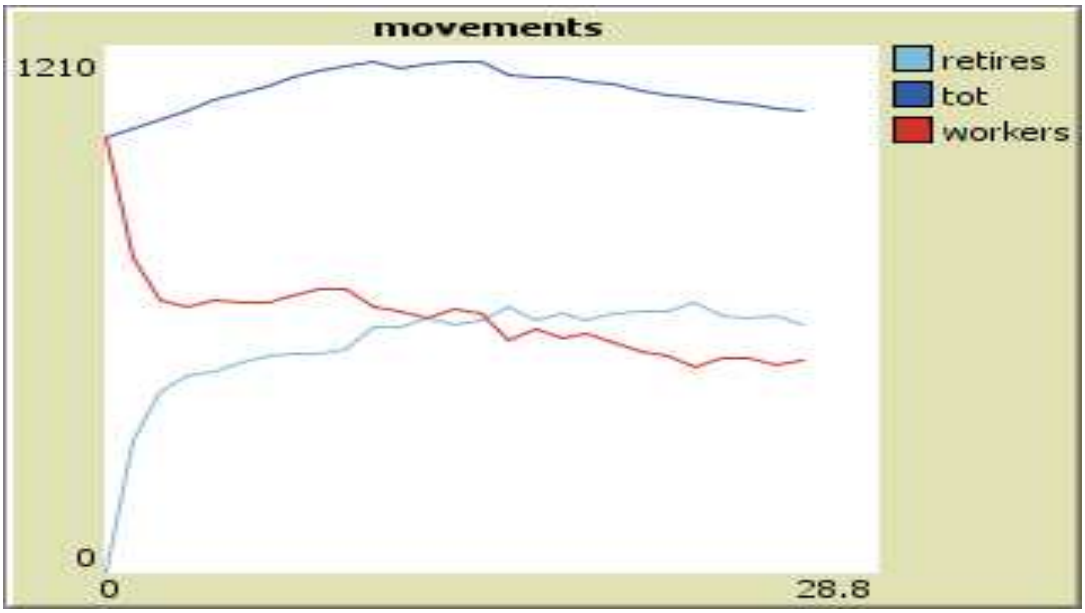

Figure 6.40: Case 2 Movements

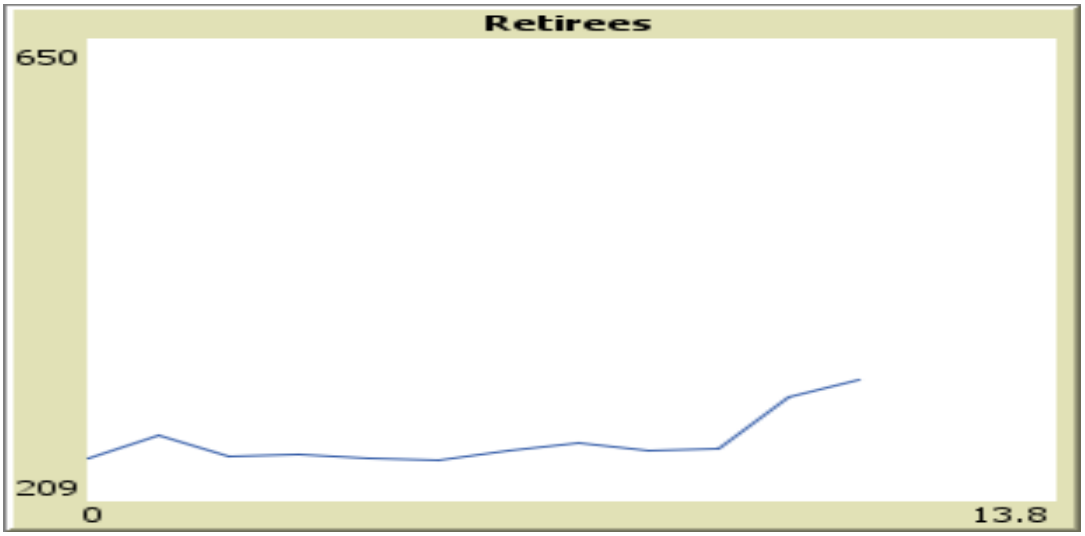

Figure 6.41: Case 2 Retirees

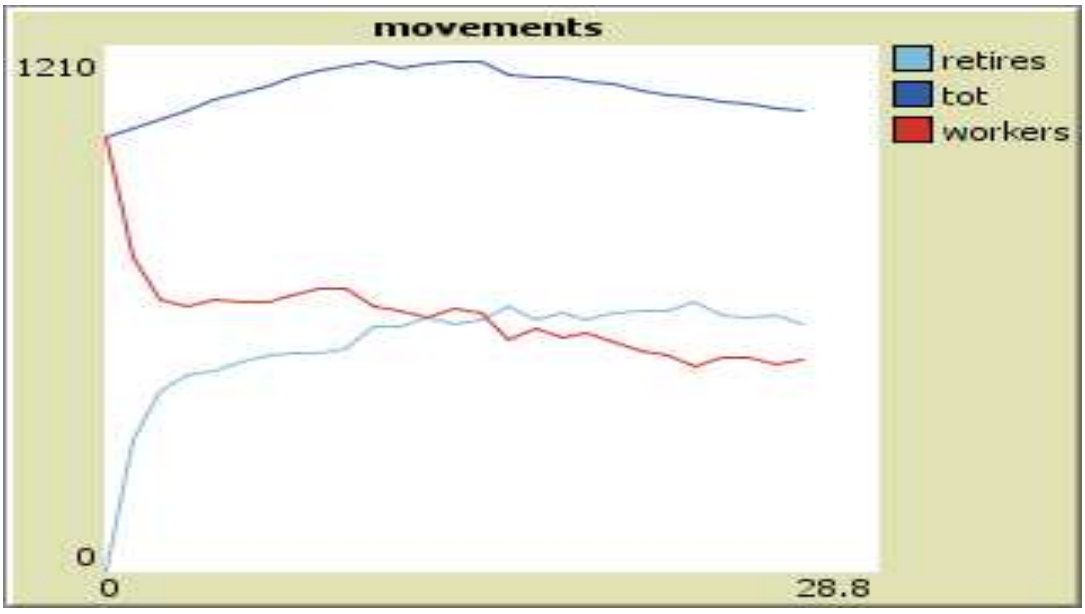

Figure 6.42: Case 2 Movements

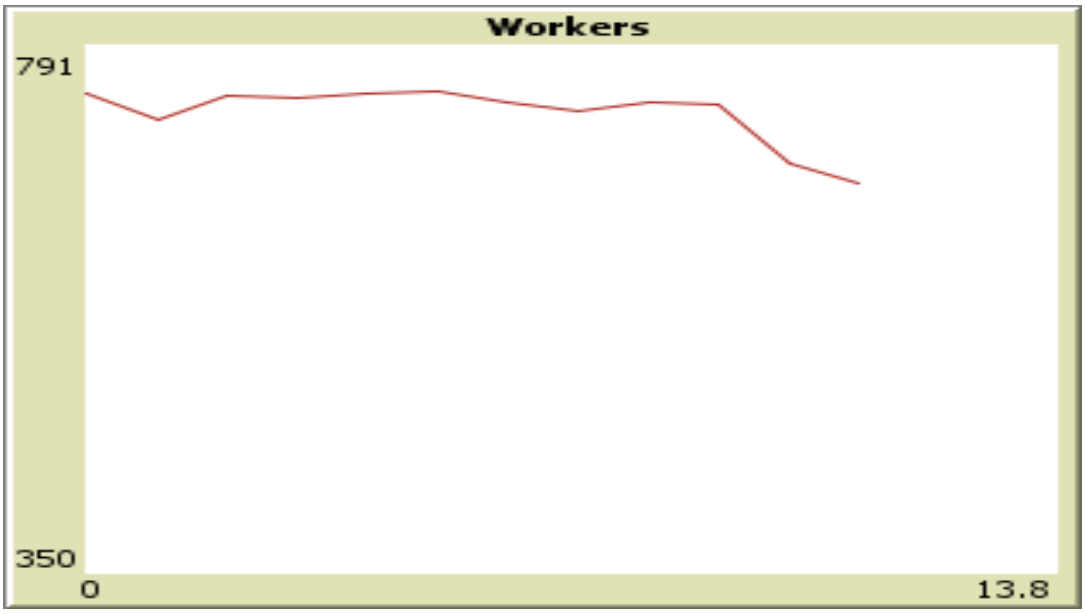

Figure 6.43: Case 2 Workers

Case 3

In the third simulation I set a consciousness value equal to 0.1 and a probability of an independent decision equal to 0.1.

#pensionAgents: 1000

range: 2

quota_conscious : 0.1

prDecidesForItself : 0.1

In the third case study simulating Ecuador, the agents over 60 years of age will retire and at the age of 80 they will die. They will then be replaced by a new random working agent aged between 18 and 35.

The initial agent population of the program is of 1000 agents and after approximately 25 ticks the population grows to about 1220 agents.

The agents of this simulation have a very low awareness, which means that a very small proportion, only about 10% of the group, will decide independently whether or not to retire.

After running the simulation result shows that: Having a very low both awareness and a probability of an independent decision together with a very small radius equal to 2, we do not know what might happen since the large majority of the agents are imitators. therefore, all the solutions are in fact possible.

From the graph of the movements it can be seen that after just a few ticks a high number of workers decide to retire. After 18 ticks, the number of retired agents exceeds the number of workers.

In the graph representing the age distribution of the agents, we can see that the age distribution appears more balanced than in the previous study.

If we compare the results obtained in the simulation done by NetLogo with the actual values measured by the INEC in the years 2002-2013, we can note that, as well as in the previous case, the results are not similar. This is due to the fact that both the agent's awareness and the probability of an independent decision are very low .

If, for example, we increase the imitation radius to the level of 20, it

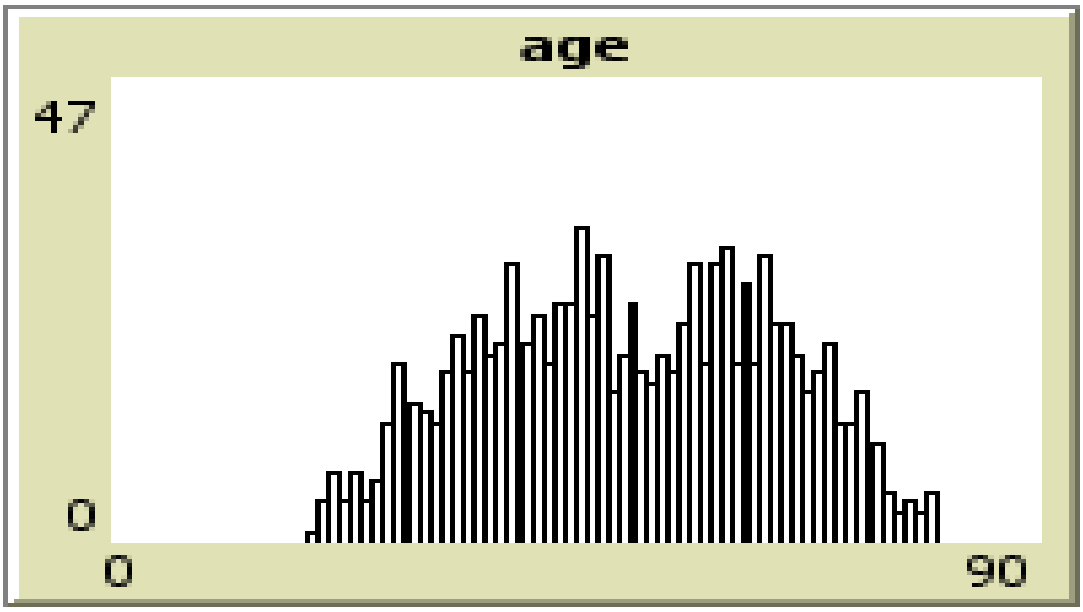

Figure 6.44: Case 3 Age

takes a greater period of time for the number of retired agents to exceed the number of employed agents. Moreover, the initial population expands with a slower pace compared to case where the imitation radius is set to 2.

From the results of the 3 case studies, we can see that the higher is the agent's awareness level, the similar are the results of the NetLogo simulation to the real data measured by the INEC.

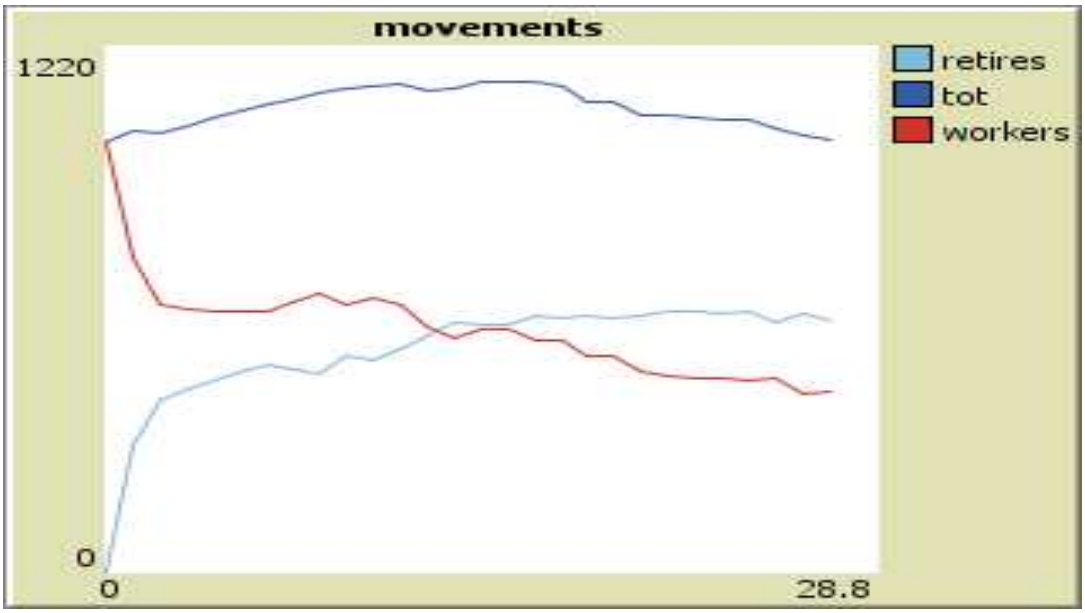

Figure 6.45: Case 3 Movements

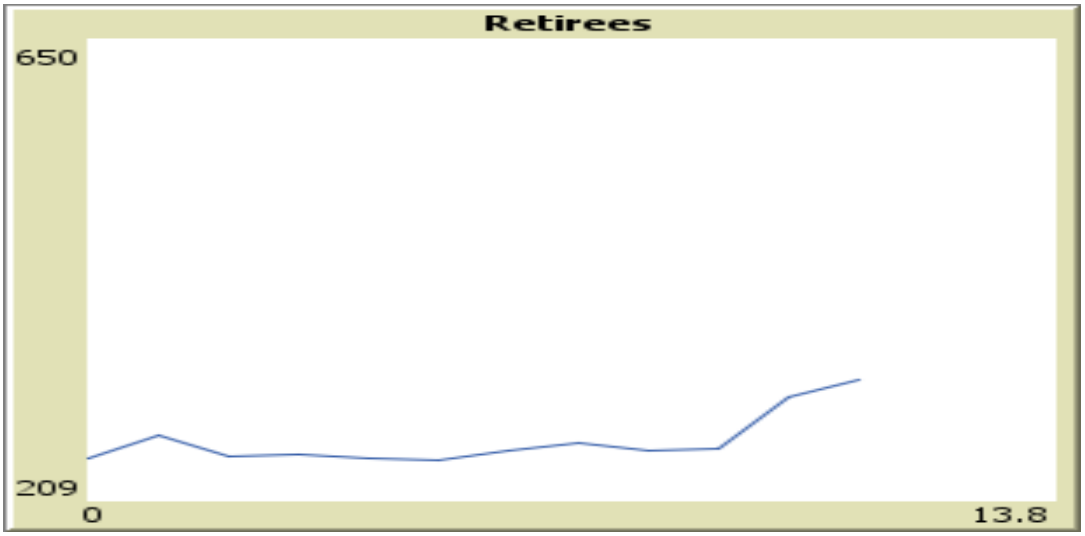

Figure 6.46: Case 3 Retirees

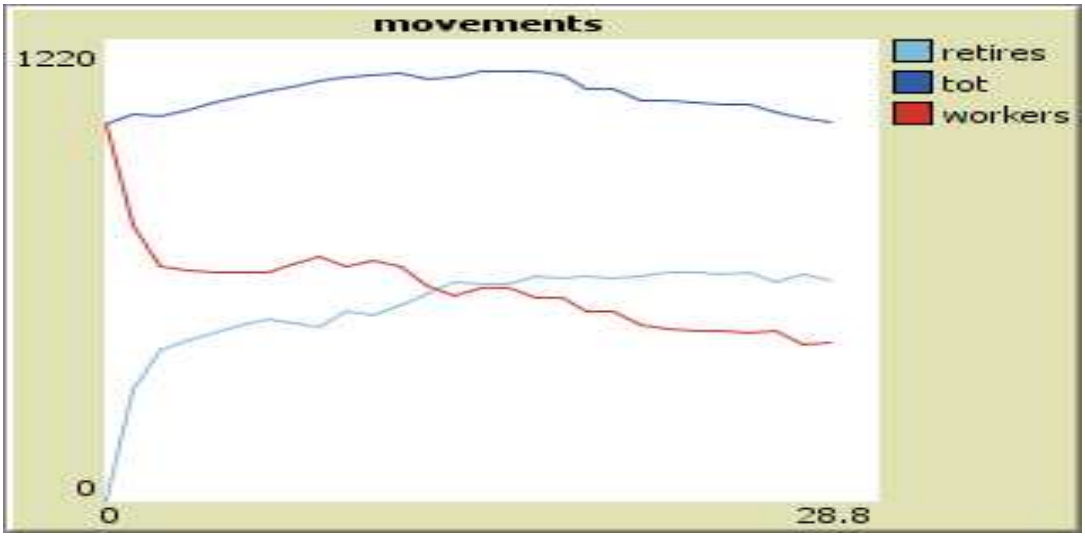

Figure 6.47: Case 3 Movements

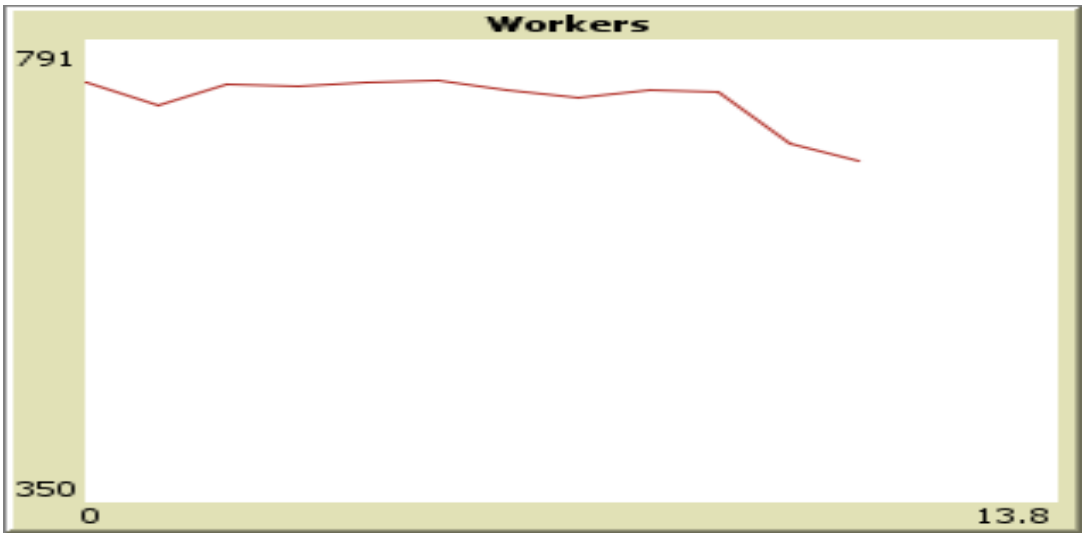

Figure 6.48: Case 3 Workers

6.5 Quantitative Result

In this section I will briefly explain the results obtained in the case studies, making a comparison between the performance of the real and the artificial model.

6.5.1 Case Study Italy

Case 1

We consider a low awareness and probability of an independent decision, both equal to 0.1, together with a small imitation radius of 2.

The sample for this study, for both the real and the artificial model, is of 1000 agents.

We arrived to the conclusion that on average each year there are, from the real model compared to the simulation, 24 more working agents + (red line) and 23 fewer retired agents (blue line). The population increases from 1000 up to 1100 agents after about 23 ticks.(see Figure 6.49)

Moreover, by increasing the radius to 20, the difference between the real model and the counterfactual one is of 38 fewer working agents (red line) and 39 more retired agents (blue line) on average each year.(see Figure 6.50)

Case 2

We consider an awareness of 0.7 and probability of an independent decision equal to 0.1. The imitation radius is still 2. The sample for this study as well is of 1000 agents.

We come to the conclusion that the higher the awareness proportion the greater the difference between the real model and the simulation.

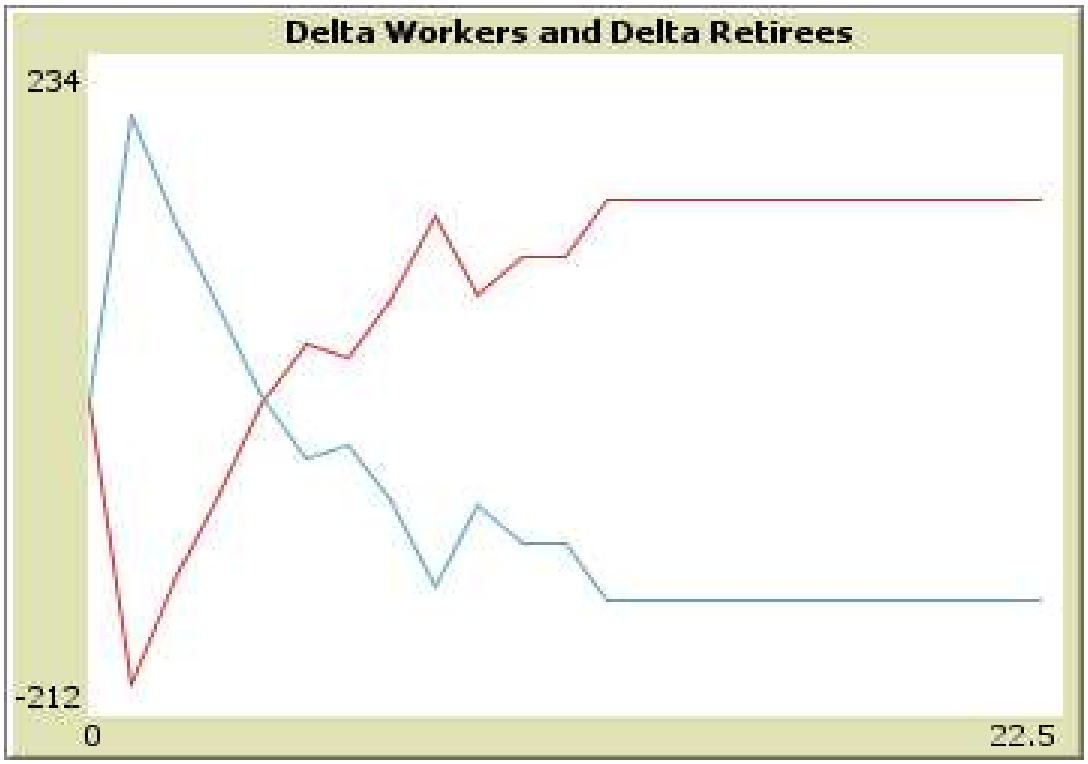

Figure 6.49: Case 1 Range 2

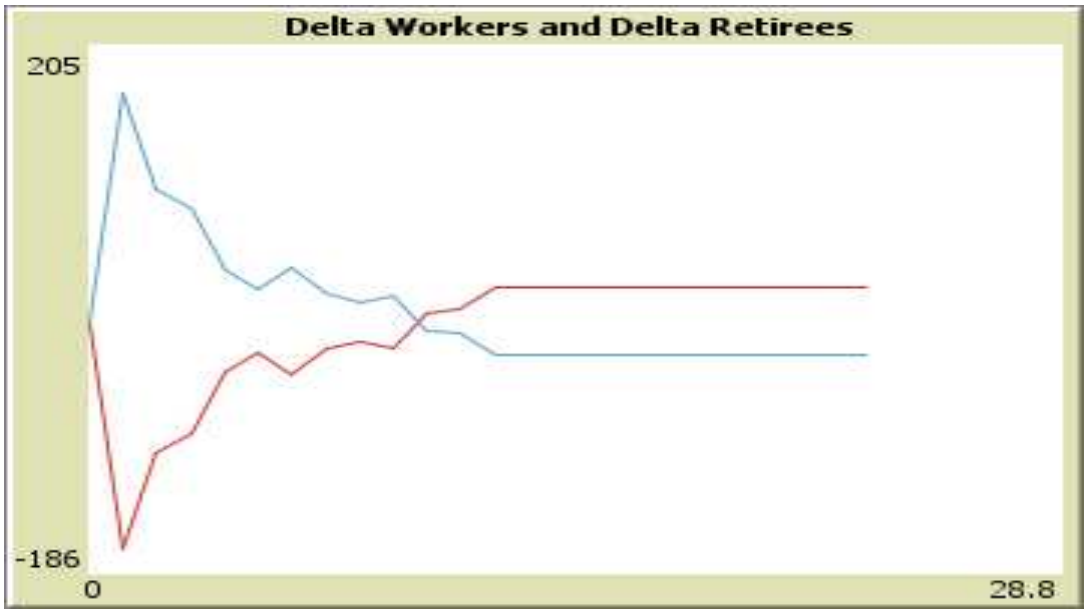

Figure 6.50: Case 1 Range 20

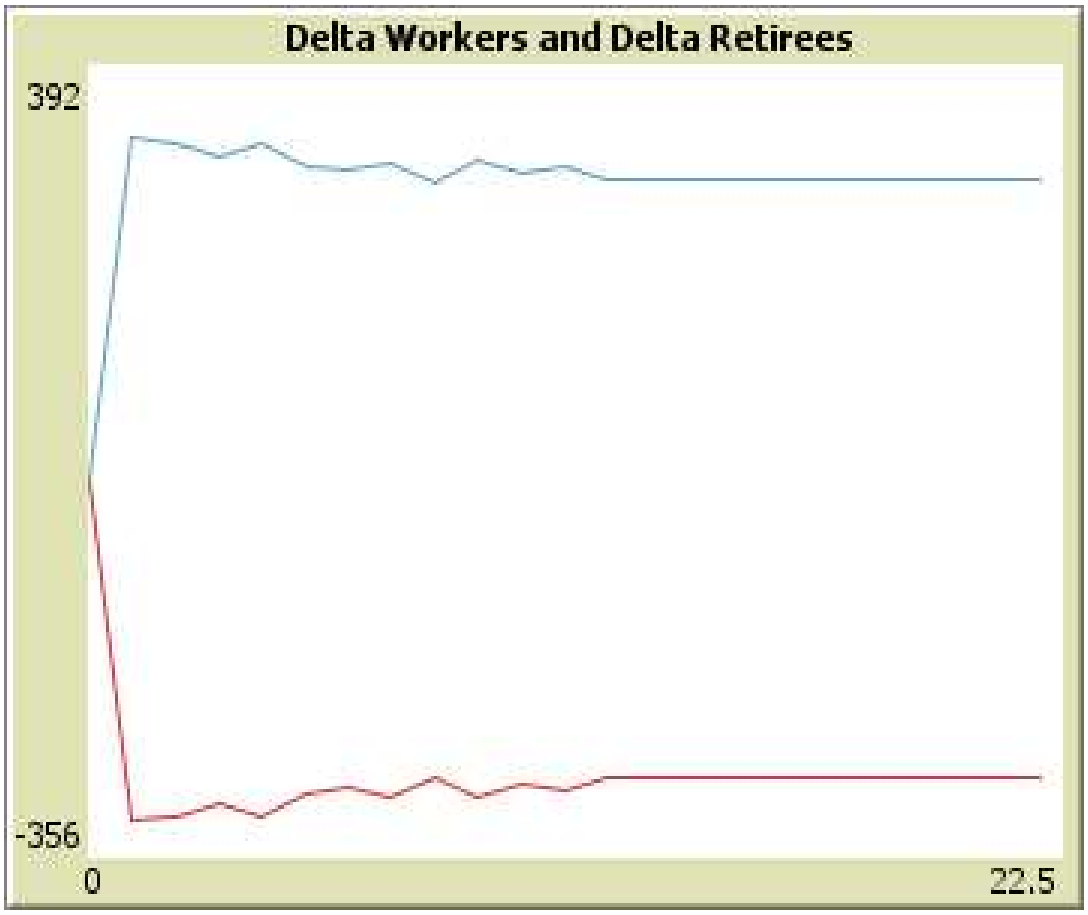

Figure 6.51: Case 2 Range 2

In this case, every year there are on average 300 fewer agents workers and 301 more retired agents. The population grows from 1000 up to 1100 agents over time. Specifically this happens about 20 ticks.(see Figure 6.51)

On the other side, if the imitation radius is increased to equal to 20, it is possible to see that the difference is higher than in the previous case. Specifically, there are 311 less employed agents and there is the addition of 312 retired agents.(see Figure 6.52)

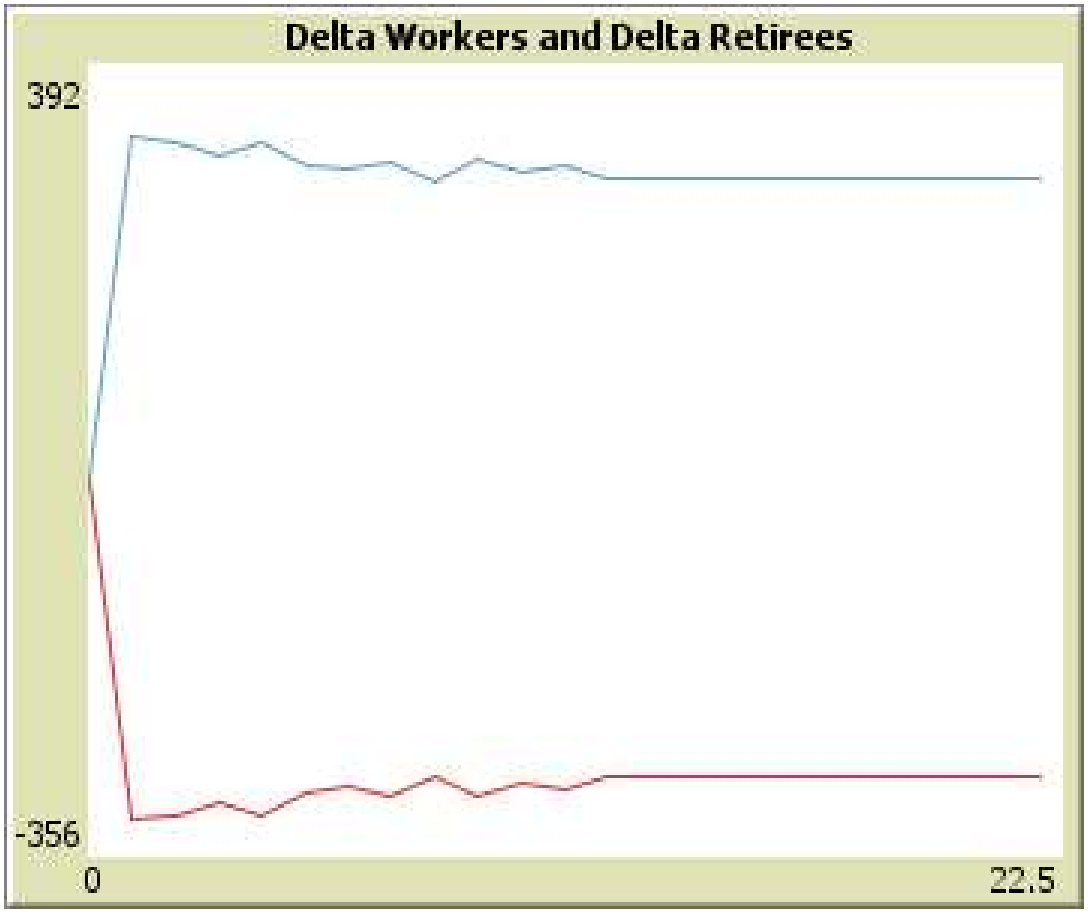

Figure 6.52: Case 2 Range 20

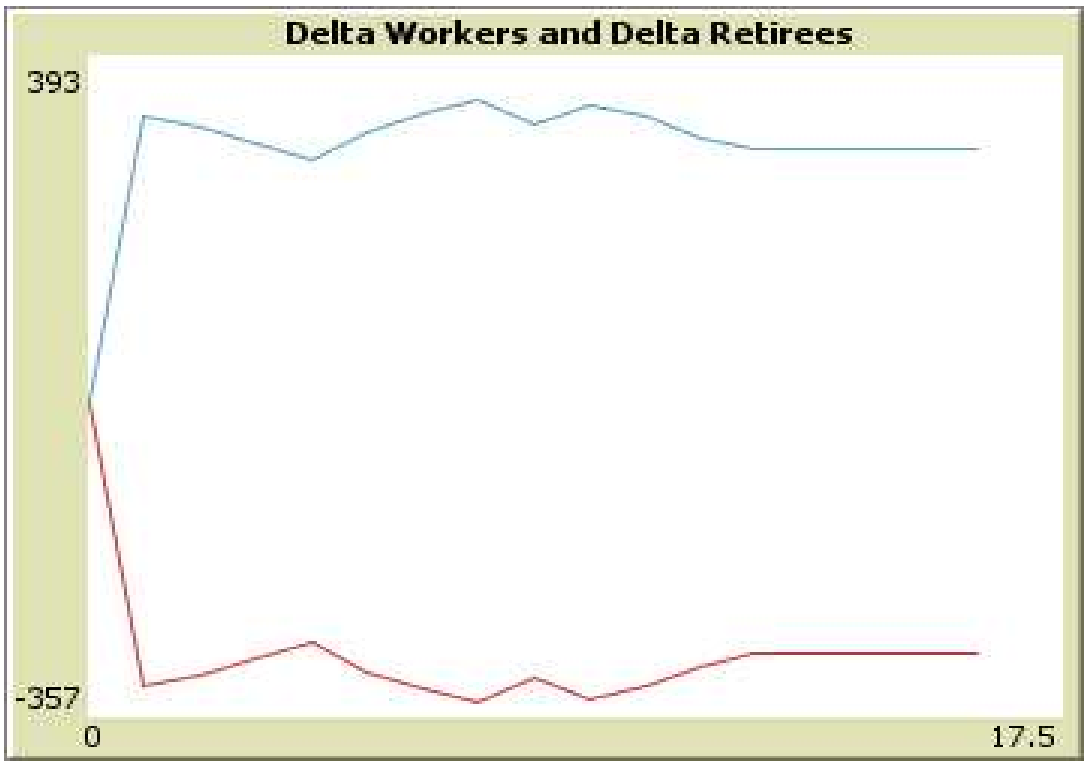

Figure 6.53: Case 3 Range 2

Case 3

We consider an awareness of 0.1 and probability of an independent decision equal to 0.7. The imitation radius is still 2.

The sample for this study, for both the real and the artificial model, is of 1000 agents.

The results show that the lower the awareness proportion, the lower the difference between the real model and the simulation. Here we can see that on average every year there are 65 more working agents (red line), whereas the number of retired agents decrease by 64 units (blue line).

The population grows from 1000 up to 1100 agents over time. Specifically this happens about 23 ticks.(see Figure 6.53)

If s the radius of imitation equal to 20 it can be seen that the difference

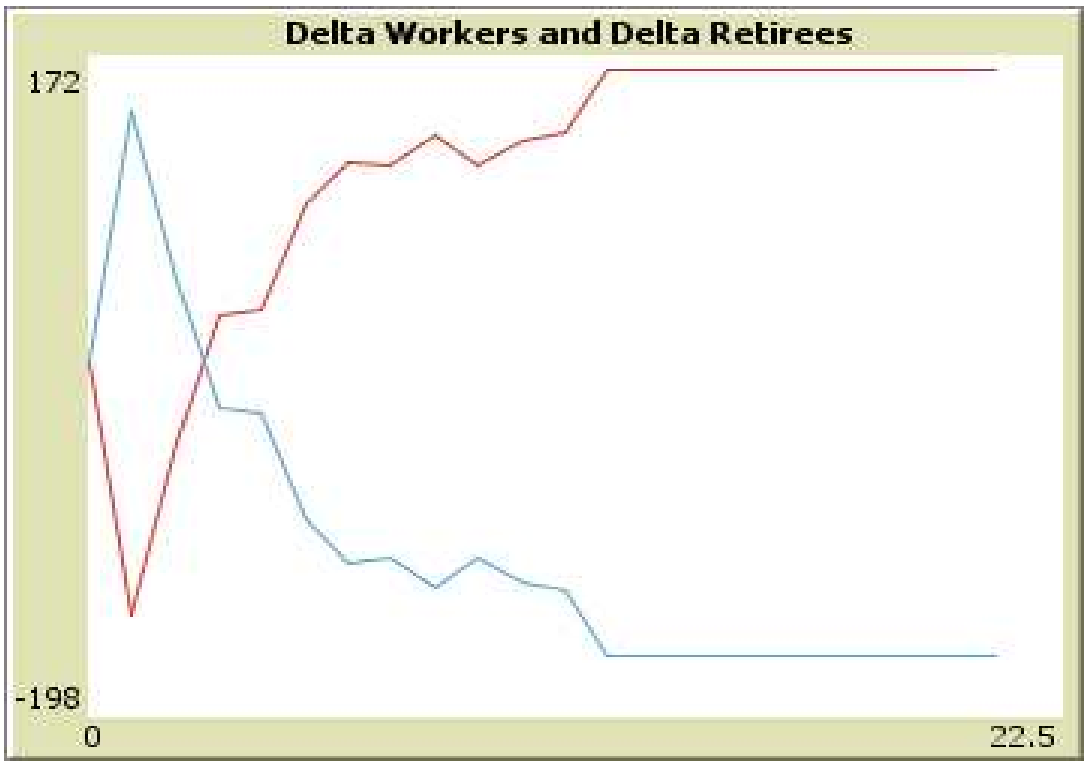

Figure 6.54: Case 3 Range 20

is +75 working agents and -74 retired agents. Therefore the difference is higher than in the case with a smaller imitation radius.(see Figure 6.54)

6.5.2 Case Study Ecuador

Case 1

We consider a low awareness and probability of an independent decision, both equal to 0.1, together with a small imitation radius of 2.

The model shows that, on average, the difference between the real world and the model simulation is of 169 more agents employed (red line) and 167 less retired agents (blue line) in each year.

The population grows from 1000 up to 1100 agents over time. Specifically this happens about 23 ticks.(see Figure 6.55)

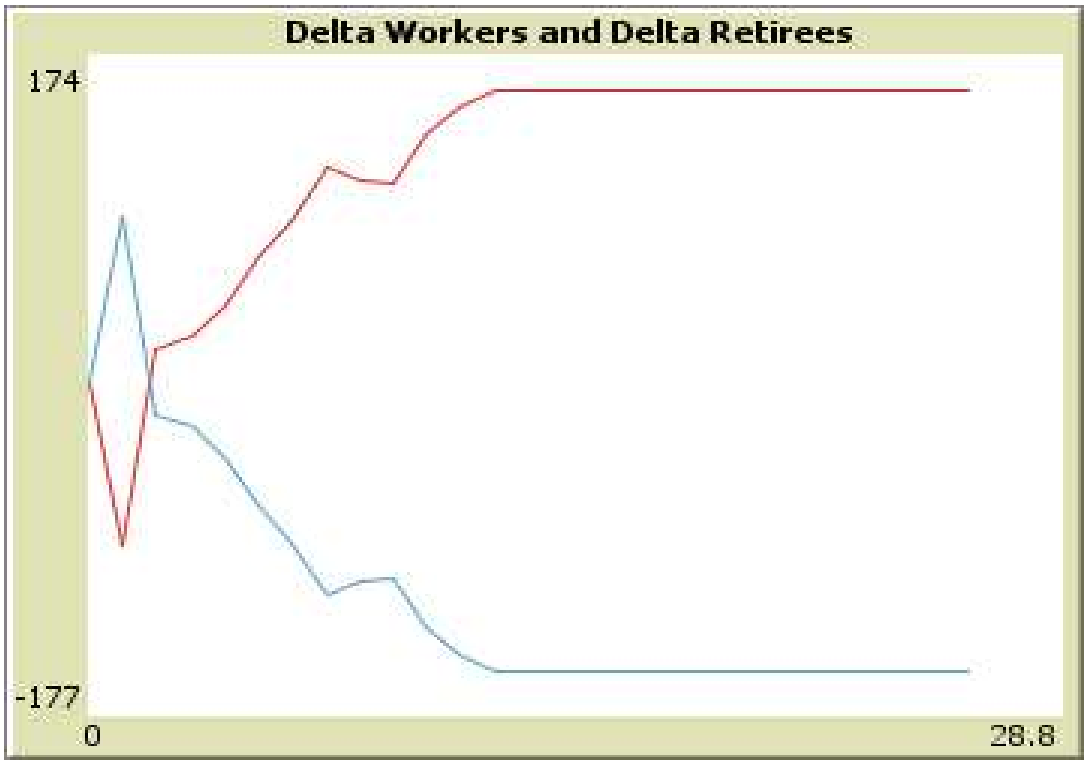

Figure 6.55: Case 1 Range 2

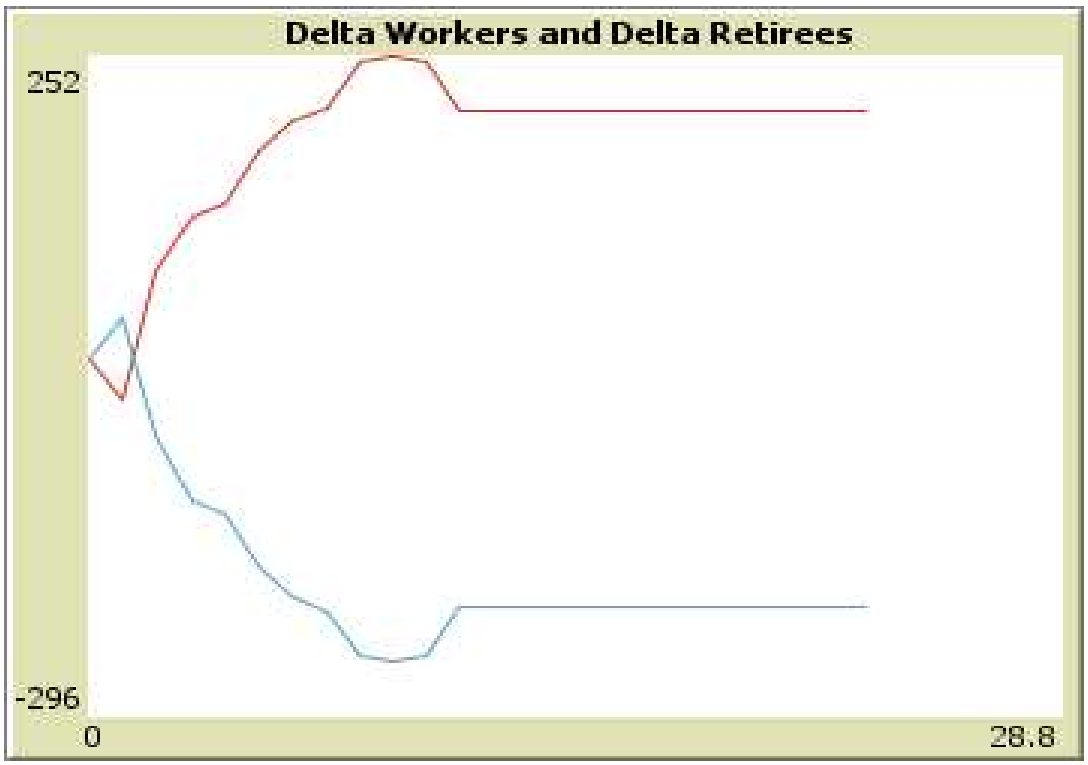

Figure 6.56: Case 1 Range 20

when we increase the imitation radius to 20, we can see that the difference is smaller than in the previous case. Specifically, there are 114 more working agents and 113 fewer retired agents.(see Figure 6.56)

Case 2

We consider an awareness of 0.7 and probability of an independent decision equal to 0.1. The imitation radius is still 2.

The sample for this study as well is of 1000 agents.

We come to the conclusion that the higher the awareness proportion the greater the difference between the real model and the simulation.

In this case, every year there are on average 145 fewer agents employed and 146 more retired agents. The population grows from 1000 up to 1100

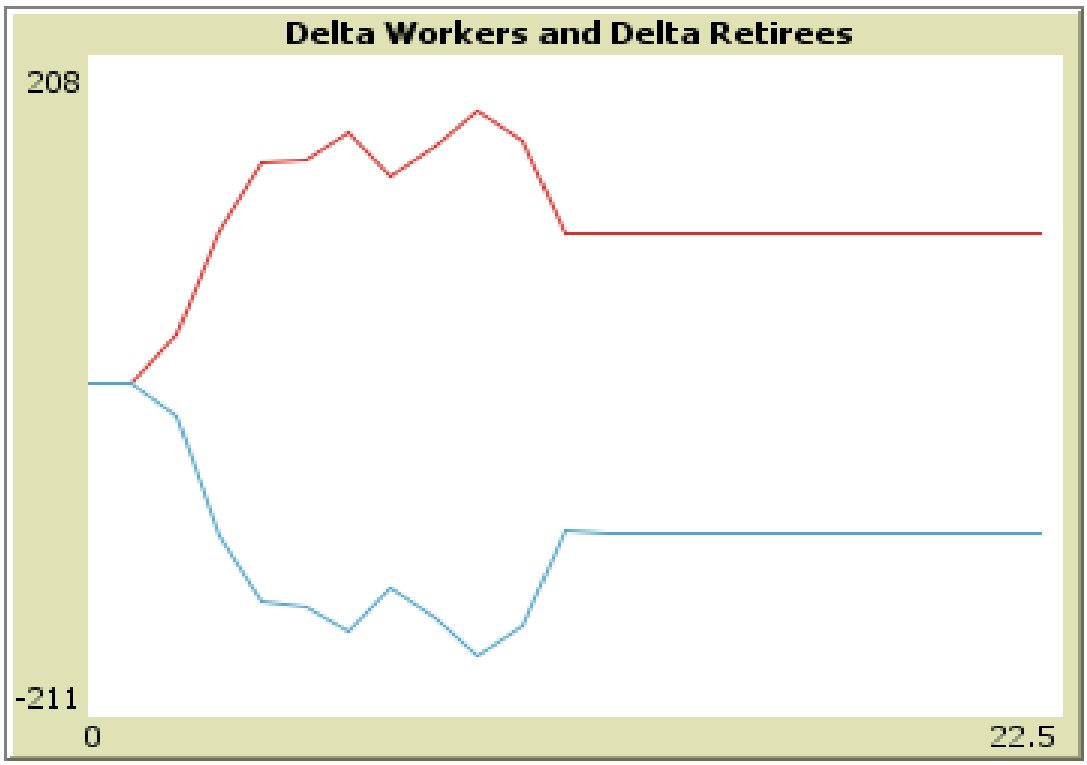

Figure 6.57: Case 2 Range 2

in about 23 ticks.(see Figure 6.57)

On the other side, if the imitation radius is increased to equal to 20, it is possible to see that the difference is higher than in the previous case. Specifically, there are 160 less employed agents and there is the addition of 162 retired agents.(see Figure 6.58)

Case 3

We consider an awareness of 0.1 and probability of an independent decision equal to 0.7. The imitation radius is still 2.

The sample for this study, for both the real and the artificial model, is of 1000 agents.

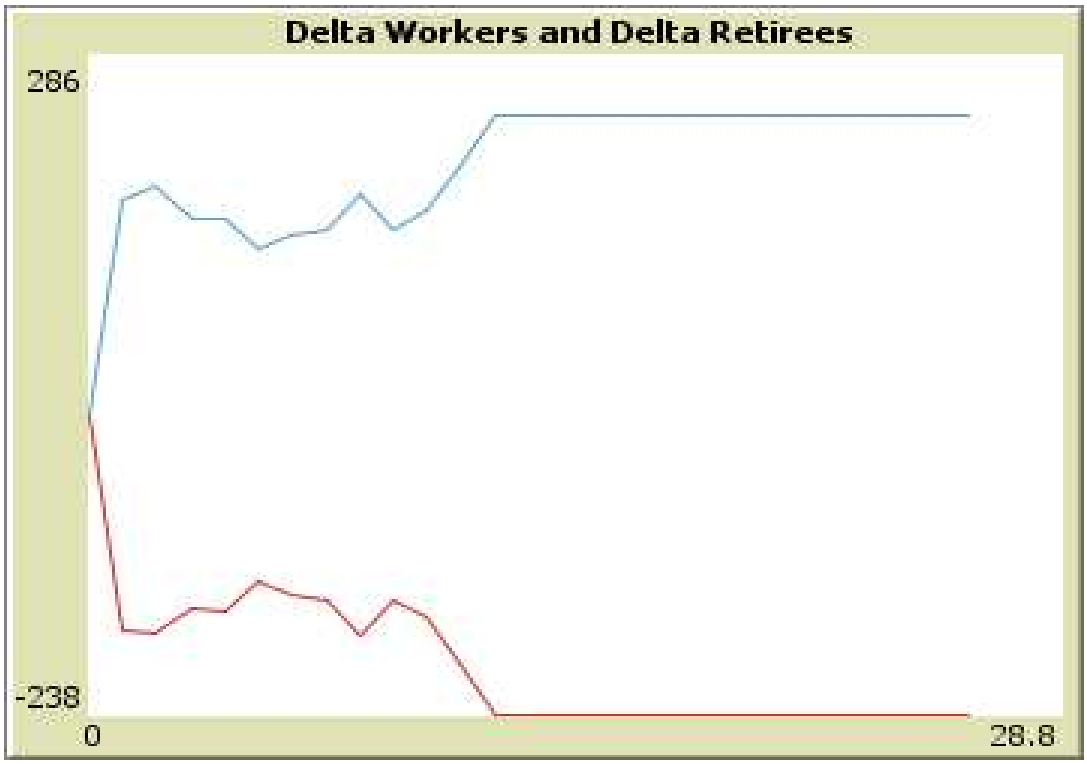

Figure 6.58: Case 2 Range 20

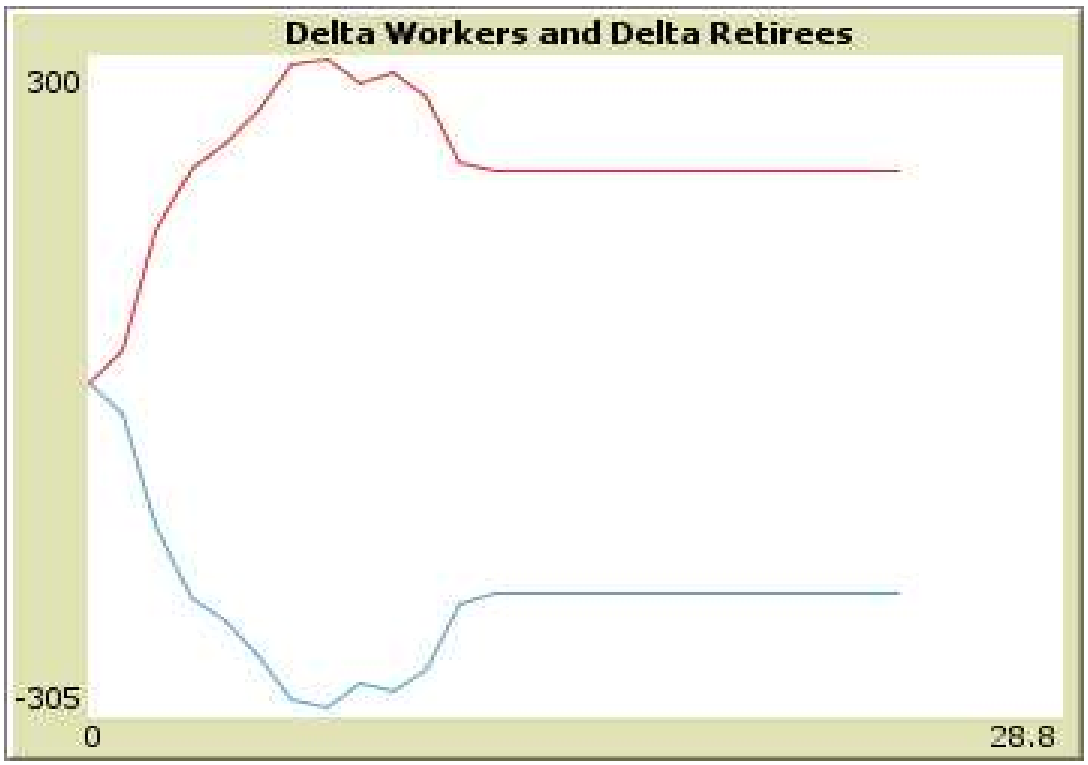

Figure 6.59: Case 3 Range 2

The results show that the lower the awareness proportion, the lower the difference between the real model and the simulation. Here we can see that on average every year there are 220 more working agents (red line), whereas the number of retired agents decrease by 218 units (blue line).

The population grows from 1000 up to 1100 agents over time. Specifically this happens about 23 ticks.(see Figure 6.59)

when we increase the imitation radius to 20, we can see that differences from the previous case. Specifically, there are 217 more working agents and 215 fewer retired agents. (see Figure 6.60)

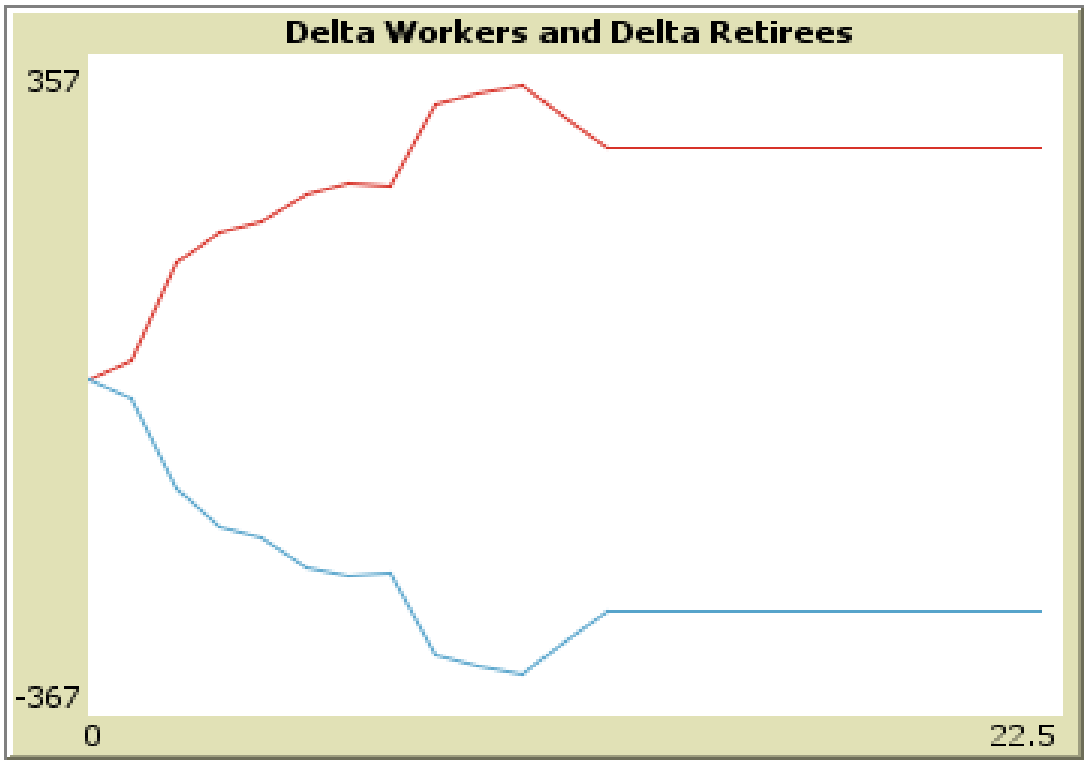

Figure 6.60: Case 3 Range 20

Chapter 7

Conclusions

The aim of my thesis is to analyze and compare the effects of networks and different pension systems based on an agent simulation (Agent Based Models).

The current pension system is gaining a more general attention from the population both in Italy and in the rest of the world because it is undergoing various changes through reforms and legislative decrees.

The changes are needed due to the new demographic trends: from the aging of the populations to the progressive life expectancy increase. All these factors add up to a substantial increase in longevity risk.

In this context, my model simulates the demographic trends of an artificial population consisting only of workers and retirees.

From the construction of the simulation model, we can say that the variables "awareness", "probability of an independent decision" and "imitation radius" play a very important role in the model.

Therefore my goal is to evaluate the effects of these variables on the social network of agents and to find the best combination between the variables.

Having seen all the analyzed cases, we can see how the initial population (artificial) of agents continues to grow over time, just as it happens in the real demographic trends.

Furthermore it can be seen from the results obtained that the effect on the network caused by the increase of the imitation radius from small

to large varies on average about 10 agents employed / retired.

As for the quantitative results of the simulations, we can see that when the values of the parameters of the model are low, the difference between the real and the artificial demographics is minimal.

A high awareness together with a low probability of an independent decision generate a significant difference between the artificial and the real model.

Specifically, the difference between the two models is that, on average, there are 300 less workers and 301 more retired agents). Conversely, if the probability of an independent decision is high and the awareness proportion is low it may be noted that the difference decreases, since the agents are mostly imitators and will have many solutions. the difference between the actual model and the simulated, counterfactual one is lower in this case. On average, each year there are 65 more agents employed and 64 less retired ones).

To sum up, we can say that the efficiency of the indicator that expresses the difference between the two demographic trends is inversely proportional to the imitation radius and to the awareness.

From these results, it is safe to suppose that under the real conditions the individual is will not follow the decisions of the next one, therefore forming an essentially random social network. Moreover, the of the population tends to follow the laws in force in the state.

To conclude in Chapter 2 I have explained how the Italian pension system works. It is essentially regulated by the Dini reform and has been recently modified by the Fornero reform. Social insurance are mandatory, regulated by special laws and managed by the Government through social security institutions.

The public pension system is financed by taxes. The Italian one, like most of other OCSE countries, is run without a pension equity but with future pensions determined by a pension scheme with defined formulas and yields.

A mandatory private system has not been implemented in Italy, therefore second pillar pensions are virtually non-existent.

Chapter 3 contains a detailed description on other pension systems, like the American one, the eurocontinental and latinamerican.

In Chapter 4 I introduced the method for the preparation of model. The agent based modeling is a method that allows the creation of a virtual world were agents interact with the environment. The agents can be set as autonomous "individuals" or clustered together as a group.

In chapter 5 the functioning of the social networks consists in any group of individuals which have any social connection. This chapter has been essential for creating the networks in the artificial model.

In chapter 6 I have created the artificial simulation model to check the network effects on workers and retirees using the Italian and Ecuador pension system. In the end the efficiency of the model has been quantified through a confrontation with an artificial demographic trend (developed continuously in real time, from the model) and the real o (using statistical data on workers, retirees, birth rate, death probability on a sample of 1000 individuals).

Future Developments

One of the possible future developments of my work could be to add to the parameters of the program agent's death probability, consistent with the real one.

In this way we would have result that better incorporates longevity risk. It could be therefore possible to use the model developed in this thesis for some further studies in the actuarial field based on agent-based models and in particular on the NetLogo simulations.

Another possible development is the possibility of including the cash flows of the agents in order to consider the allocation of wealth between workers and retirees; in this way it should be possible, (by adding a set of new assumptions on how capital transactions affect the social network) to study the movements of wealth among generations.

An interesting approach should be that of analyzing the effects on the population , of a changement of pension system: from PAYGO to fully

funding, or vice-versa.

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