UNIVERSITY OF TORINO
Master Degree in Economics

A NETLOGO MODEL ABOUT WAGE AND PENSION MIGRATION

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SUMMARY

INTRODUCTION TO THE MODEL

This work aims at understanding and explaining the behaviour of workers who face the choice of the best country where they would like to live, according to their preferences about the trade off between wage now and pension tomorrow, their years left before retirement, the income they happen to have and the tax regimes of countries.

The model contains two countries and two different kinds of agent.

Countries are distinguished by different income (in total and in distribution) and tax levels, reflecting the real world, where states have different sizes of the economy, more or less equally distributed earnings, and adopt different fiscal policy choices.

Agents are citizens with distinct characteristics: some are forward looking, and give more importance to their future pension than to their actual wage, whereas some are unforeseeing and care only about their wage today. In the economic theory individuals make their retirement decisions and job choices on the basis of discounted present values of income flows expected for the options. The differences in the perception of time between individuals is captured by their personal discount rate: present oriented persons have higher discount rates than forward looking ones, hence lower present values of income flows in the future. In this work, as we wanted to focus our attention on the outcomes resulting from preference and income distributions, rather than the mathematic representation of those preferences, we have not included present values. Agents simply have inclination toward either wage today or pension tomorrow.

Consequently, every person has a "favourite country", where they decide to move if it is not their state of origin.

An interaction between agents is performed as follows: workers who want to move have an influencing effect on those who want to stay, and have the power of convincing them to leave. The converse is not true, as we thought it is more realistic if the choice of remaining is given by other factors than imitation, as affection to your birth country or patriotic issues. It is more likely

in our view that adventurous people can persuade others while steady people cannot convince adventurous.

Several variables are controlled by the observer, leading to various states of the world, and consequently to different rules for agent's acting, the most important of which are the tax level and the average (or distribution of) wage within each state.

We constructed two versions of the simulation: in the first one every person has the mean salary; in the second there are three income distributions among which the observer can choose.

The interesting part of our job is the variety of situations that can be analized through differently set experiments, ranging from extreme situations where the policies of the two country differ significantly, through cases where the output is not easily forecastable even knowing the rules of the game.

We show several experiments highlighting the major conclusions that can be drawn from our work, but there is an infinity of other combinations of variables that can represent as many situations as one wants.

HOW THE MODEL WORKS

Countries

The two countries are called country1 and country2 and each of them possesses the following features.

Model 1: average wage and personal tax. There are two sliders for each country. The age of retirement is the same, 65, everywhere.

Model 2: there are 3 distributions of income which the experimenter can choose from, namely random drawing, normal distribution and gamma distribution. The respective parameters can be changed from the sliders. The age of retirement is the same, 65, everywhere.

Rules

- number-people: it fixes the number of agents on which the experiment is set up;
- percentage-higher: it indicates the proportion by which a wage or a pension in a country has to exceed the wage or pension of the other country to induce agents to move out.

Agents

The agents have the following variables:

- yearsOld: age;
- preference: 0 if the person prefers high wage [white], 1 if she prefers high pension [black]
- decision: 0 if the agent decides not to move [blue], 1 if she decides to move [red]
- total: sum of the decisions of the neighbours
- yearsb4retirement: 0 if the person is less than 65, 65 – yearsOld if she is more than 65

The two variables “preference” and “decision” differ for the fact that the first one is a quality of the agents, which does not change with ticks – years, while the second depends, other than on preferencies, also on other variables such as total and yearsb4retirement, so it can change from a tick to another.

White color is assigned to people with high wage preference, black to high pension preference ones. This subdivision of colours, though, is visible only at the first tick, as after that agents make their decision and change color: red if they want to move, blue if they do not.

YearsOld and preference are assigned in a random way, the first ranging from 0 to 99; the second from 0 to 1.

Here we have a first difference between the first and the second version of the model: in the second one every agent has his own wage, drawn from the income distribution of the country, so there is one more turtles-own variable, called wage. The first version, instead, is a simplified one where everybody gets the same salary, equal to the average wage of the country.

THE PROCEDURES

The model we discussed in the previous part was created using the Netlogo program. In the beginning of the code, we defined global variables, that are accessible from anywhere in the program and *turtle-owned* variables, that belong to each specific turtle.

For the 2 main procedures, *setup* and *go*, we constructed buttons in the *Interface* section. In the first version of the model, the *go* procedure is not running continually, the button must be pressed several times in order for the world to reach the equilibrium. This way the movement of the people is more easy to observe.

In *setup*, the first thing we do is clearing the space from the previous execution of the model. Then, we use two different procedures to set up turtles and patches, so the model is clearer for anyone interested.

In *setup-patches*, we divide the view in two parts (or countries) by naming *country1* the patches with the x coordinate greater than zero (the patches on the right of the screen) and *country2* the other ones (the patches on the left of the screen).

In *setup-turtles*, we create turtles (persons, for the purposes of this model) and set up their variables. We randomly choose an age for the people (with **set yearsOld random 100**). Then, we use an **ifelse** condition to find out the number of years of work each person has before retirement. We set the variable *yearsb4retirement* to 0 if the person is already older than an average retirement age of 65 and to 65 – *yearsOld* if the person is still at an employment age.

```
ifelse (yearsOld > 65)
    [set yearsb4retirement 0]
    [set yearsb4retirement 65 - yearsOld]
```

We randomly set a preference for each person, either 0 or 1, where 0 means he/she is interested in higher wage and 1 means that he/she is interested in a higher pension, rather than higher wage. At the same time, we color white turtles with preference 0 and black those with 1. At last, we place the people at a random location in the *View* box.

The *go* function contains 4 procedures (*decide-by-yourOwn*, *change-decisions*, *move* and *do-plots*), a *tick* counter and an instruction for the *go* procedure to stop when the counter reaches 100, to imitate a human's lifespan.

The *turtle-owned* variable *decision* represents the choice of each person to move out of the country (1) or to stay in the country they are currently in (0). In *decide-by-yourOwn*, we first assume that the people don't want to move, then we revise that assumption. So, for the people that prefer higher wage (*preference* is 0), we check if the net average wage of the foreign country is higher than the net average wage of their own country, at least by *percentage-higher* (a slider set in the *Interface*). The net average wage is calculated as the average wage minus tax for each country.

```
if  ((preference = 0) and ((averagewage1 - tax1) *(percentage-higher + 1)
< (averagewage2 - tax2)) and (xcor > 0))
or ((preference = 0) and ((averagewage2 - tax2) *(percentage-higher +
1)< (averagewage1 - tax1)) and (xcor <= 0))
        [set decision 1
        set color red]
```

For the people that prefer a higher pension, we check if the tax in the foreign country is higher than that in their country, always by *percentage-higher*. If that is the case and the person has more than 15 years of work before he/she can retire **(yearsb4retirement > 15)**, than he/she decides to move. So, if the conditions of the other country are more advantageous, according to the preference of the turtle, then the person decides to move (sets decision to 1) and turns red. Conversely, he/she turns blue if he/she is already in the favourite country.

```
if ((preference = 1) and  (tax1 *(percentage-higher + 1) < tax2) and
(yearsb4retirement > 15) and (xcor > 0))
or  ((preference = 1) and  (tax2 *(percentage-higher + 1) < tax1) and
(yearsb4retirement > 15) and (xcor <= 0))
        [set decision 1
        set color red]
```

In the *change-decisions* procedure every person looks at their neighbors in a radius of 5 around their patch (**count other turtles in-radius 5**), checks how

many neighbors want to move (**with [decision=1])** and initializes the variable *total* with that number (**set total**).

```
ask turtles [ set total (count other turtles with [decision = 1] in-radius 5)]
```

Then, if more than a half of the neighbors has taken the decision to move (**total * 2 >= count other turtles in-radius 5**), the turtle imitates the neighbors and sets its decision to 1 as well.

```
ask turtles[
   if (total * 2 >= count other turtles in-radius 5 )
        [set decision 1
         set color red]  ]
```

The next procedure in *go* is the one titled *move*. As the name suggests, this is where all turtles that in the previous procedure decided to leave their country do so. Therefore, if the *decision* variable of a person is equal to 1 and if the person is in country 1 (**xcor>0**), then he/she moves to one of the patches that comprise country 2 (**move-to one-of country2**). Similarly, if a red person is on a patch from country 2, then he/she moves to country 1.

```
ask turtles [
   ifelse (decision = 1) and (xcor > 0)
                [move-to one-of country2]
                [ifelse (decision = 1) and (xcor <= 0)
                        [move-to one-of country1]
                        []    ] ]
```

In each realization of this procedure (everytime the *go* button is pressed), all the people age – the variable *yearsOld* is incremented by one unit.

```
ask turtles [ set yearsOld yearsOld + 1]
```

The first version of this program evolved into a second one, as it was explained in the previous chapter of this document. The second version throws away the concept of only one level of wage for every person in a country and introduces wage distributions. So, *averagewage1* and *averagewage2*, the average wages for the 2 countries, become global variables and we add *wage* to the turtle-owned variable set.

In the *Interface* tab we include a chooser from which the users can pick a distribution for the wages, as well as 4 sliders for the parameters of the distributions.

In the *setup-turtles* procedure we use the information we get from that chooser. So, if the user picks *random-numbers*, the *wage* variable is set randomly, for each person, to a number between 0 and 9999 (**set wage random 10000**). If the user did not pick this option, we check whether he chose *normal-distribution*, and if that is the case, the *wage* variable for the turtles will be normally distributed, with the mean *meanDist* and the standard deviation *StdDev* (**set wage random-normal meanDist StdDev**). If neither of the previous 2 options was picked, then we know that the user chose the final one, meaning the *gamma-distribution* and we set the wages of the people in that distribution (**set wage random-gamma alpha lambda**).

```
ifelse wage-distribution = "random-numbers"
    [set wage random 10000]
    [ifelse wage-distribution = "normal-distribution"
      [set wage random-normal meanDist StdDev]
      [set wage random-gamma alpha lambda]]
```

After the individual wages have been determined, we calculate the average wage of each country. We sum the wages of all country1 residents and divide it by the number of country1 residents and then we do the same for country2.

```
set averagewage1  (sum [ wage ] of turtles with [xcor > 0]) / (count
turtles with [xcor > 0])
set averagewage2  (sum [ wage ] of turtles with [xcor <= 0]) / (count
turtles with [xcor<= 0])
```

The other important development in this version of the model, compared to version 1 occurs in the *decide-by-yourOwn* procedure. For the people that prefer higher wage (**preference = 0**), we check whether the net average wage from the country they are not in is higher – by *percentage-higher* – than their own net wage. If that is the case, the people will want to move to the other country (**set decision 1**).

The net average wage of each country is calculated as the average wage minus the proportion of it which must be paid as tax (e.g. **averagewage2 * (1**

- tax2)) and the individual net wage is computed as his/her own wage minus the proportion of it to be disbursed as tax(e.g. **wage * (1 - tax1)**).

```
if  ((preference = 0) and (wage * (1 - tax1)  * (percentage-higher + 1) <
averagewage2 * (1 - tax2) ) and (xcor > 0))
or ((preference = 0) and (wage *(1 - tax2)* (percentage-higher + 1)<
averagewage1 * (1 - tax1)) and (xcor <= 0))
        [set decision 1
        set color red]
```

The final change is in the *move* procedure, where the average wage for each country is again computed, in preparation for the next iteration of the code:

```
set averagewage1  (sum [ wage ] of turtles with [xcor > 0]) / (count
turtles with [xcor > 0])
  set averagewage2  (sum [ wage ] of turtles with [xcor <= 0]) / (count
turtles with [xcor <= 0])
```

EXPERIMENTS

Experiment 1: close averages, similar taxes

Model 1:

number-people: any number

percentage-higher = 0.2

averagewage1 = averagewage2 = 5000

tax1 = 1500

tax2 = range [1300 – 1800]

outcome: nobody wants to move – remember that every agent here has the same wage and tax, equal to the average. Everybody is happy because the differences in wages and pensions of the 2 countries are not wide enough to inducing them to move out.

Model 2:

b) wage-distribution: random-numbers [0 to 9999]

number-people: any number

percentage-higher: 0.2

tax1 = 0.3

tax2 = range [0.26 – 0.36]

outcome: differently from model 1, not all people are happy because they own different levels of salary and they pay different amounts of tax. Therefore, reactions depend both on turtles-own variables and on countries's characteristics. Performing the experiment several times with several tax rates in the range assigned to country2, we get that only few people decide to move. The populations of the 2 states are initially pretty close and after the 50th tick they start to separate, in the majority of cases in favor of country2 – green patches, regardless of whether we put tax2 closer to 0.26 or 0.36.

c) wage-distribution: normal-distribution

number-people: any number

percentage-higher: 0.2

meanDist = 5000

stdDev = 50 and 1000

tax1 = 0.3

tax2 = range [0.26 – 0.36]

outcome: with normal distributed wages and low variance people are again happy with their initial situation and nobody wants to move out because wages are highly concentrated around the mean – this makes this situation similar to the experiment in model 1. When we increase the variance, though, wages start being more dispersed around the medium and differences in behaviour arise: some agents decide to emigrate every tick, forever. This is due to the fact that those individuals have wages lower than the average so they keep on moving, hoping to be able to reach the average wage of the other country, after migration. We call these agents “hopeless”. Citizens are evenly distributed among countries because preferences are randomly assigned – hence either has a 50% probability; normal distribution is symmetric – so there is the same proportion of people with wage above the mean as of people with below-the-mean wages; and the imitation takes place if more than 5O% or neighbours moves. As a result, in this experiment where average wages are the same and tax rates are close together, population is equally spread out among the 2 countries.

d) wage-distribution: gamma-distribution

number-people: any number

percentage-higher: 0.2

combinations of alpha and lambda, respectively:

[10, 2]; [100, 2]; [1, 10]

tax1 = 0.3

tax2 = range [0.26 – 0.36]

outcome:

- [10, 2]: some people decide to move out and they do it every tick
- [100, 2]: very few people decide to move out, every tick
- [1, 10]: a relatively high number of people moves, every tick

outcome: population in every case is nearly evenly distributed among countries – for the same reason as before. The reason why “hopeless” people are more in the third setting of the experiment is that with those different parameters the gamma distribution is more strongly positively skewed: the variance is higher, relatively to the mean, and the median is more on the left. Consequently, there is a greater number of poor people, the income of whom is below the average. These people are hopeless because every tick they leave to go in the other country hoping to reach its average wage, with no success, so they keep moving.

Experiment 2: different averages, different taxes

Model 1:

number-people: any number

percentage-higher = 0.2

averagewage1 = 5000

averagewage2 = 4000

tax1 = 3000

tax2 = 1000

outcome: in the first tick, roughly half population decides to move out; in the second, only few individuals want to change country; at the third tick everybody is happy and blue. The reason why in tick 2 there are people who want to move is that in the first one they had been influenced by other agents in choosing a country which is suboptimal for them, thus

they want to move out again. The final result is a higher number of people in country 2.

Model 2:

a) wage-distribution: random-numbers [0 to 9999]

number-people: any number

percentage-higher: 0.2

tax1 = 0.60

tax2 = 0.25

outcome: roughly 1 nineth of the population moves every tick. As before, the difference with model 1 resides in the fact that the random distribution of income makes people with below-the-average wages be “hopeless”. The proportion of citizens of the 2 countries is the same.

b) wage-distribution: normal-distribution

number-people: any number

percentage-higher: 0.2

meanDist = 4500

stdDev = 600

tax1 = 0.60

tax2 = 0.25

outcome: for the first 2 ticks, there are people who want to move out. Sometimes there are red people also at the third tick, because the assignment of both the position and the preference of individuals is random, so the imitation procedure could make people take the suboptimal choice more or less times, according to the output of this randomness. Moreover, in every try the number of final citizens is

higher in country 2, for the following reason: almost all high wage people move in country2, because the tax is so much smaller there that it makes their present net wage (wage – tax) very advantageous. We still have one or two wage people left in country1, because their wage is still high enough for them. These people leave at the second tick, because the average wage in country2 gets higher, so the value with which they have to compare their salary is higher and this leads them to change country. At the same time, pension people – future looking – see the high tax in country1 and move there (those who have more than 15 years left before retirement). After the first tick, some other pension people follow by imitation.

c) wage-distribution: gamma-distribution

number-people: any number

percentage-higher: 0.2

alpha: 70

lambda: 5

tax1 = 0.6

tax2 = 0.25

outcome: also here equilibrium is reached after 2 or 3 ticks and the majority of individuals lives in country 2 – see the normal distribution case for explanation of this outcome.

CONCLUSIONS

Our model was born following an idea we had regarding the possibility that people choose their country according to their preferences about the welfare state. If it is so, then differences in distributions of income and preferences among individuals, and dissimilarities in tax rate among countries will determine individuals' decisions. At the aggregate level, those choices are reflected in the spread of citizens among countries. We wanted to analize the effects of different states of the economy and different fiscal policies on movements of people between countries, so we decided to explicit our idea to see, according to the assumptions needed to highlight our implicit model, what the results were and what conclusions could be drawn from them.

The experiments showed that the distribution of income matters: when all individuals have the same wage and the level of pensions of the 2 states do not differ significantly, then nobody will want to move out, regardless of their preferences: everybody is happy, because there is not enough difference in the 2 economies to convince agents to move. With the same setting but wages assigned randomly, the result changes since agents have different earnings from one another. For example, some people have salaries below the average of the foreign country, thus they decide to go there, seeking better standard of living. When we modify further the distribution of income, we find that the more wages are concentrated around the mean, the more results are similar to the simplest model. In particular, when the variance increases, people show higher diversity in payments, hence bigger discrepancies in decisions. We also saw that, the more a distribution is characterized by positive skewness, the more people have wage below the average, and the more likely it will be that they decide to move to the other country.

An interesting result we were able to point out from our explicitation of the model is that there are people – wage preferring people, whose salary is less than the average, that move to the other country in the hope of reaching the average wage of that country. Unfortunately, they are not able to improve their stipends, so they remain in the unsatisfied situation of earning below the average, and keep moving from a state to the other, forever. Although our model does not account for the possibility of finding a better job, this situation

is still a realistic scenario, because, particularly for non-skilled workers, it is difficult to increase their productivity – thus their wage – without an appropriate training.

Our suggestion to the government to fix this situation is to create the possibility for these people to increase their skilles through training courses able to teach them new jobs or to increase their knowledge and their know-how.

The second experiment showed particularly well that imitation matters: often people take the wrong decision (according to their preferences) because they follow other people's choices, so, when they realize the error, they have to go back to restore their maximum level of utility. This second setting also made clear that a country is supposed to encounter higher immigration flows if it offers higher wages (attracts more present-oriented people) by a bigger proportion by which the other country offers higher pension.

In conclusion, our results show that different distributions of wage, size of economy and fiscal policies lead to different patterns of migration flows. The model we explicited using Netlogo allows users to set disparate combinations of those variables, hence the yielded reactions, given the assumptions. Of course, these assumptions are restrictive but still permit to highlight important features and consequences of the decisions of migrants, in particular decision based on economic issues.