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Simulation Models for Economics
Migration in Europe (Simulation in NetLogo 5.0.5.)

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Introduction

What drives human migration? This question is both simple and difficult. On the one hand, it seems reasonable to assume that most people migrate hoping to find better conditions or opportunities elsewhere, such as jobs, higher wages, safety or freedom of expression (Neoclassical Economic Theory). On the other hand, already established Networks (Networks & Systems Theory) may drive migration. The immigration agent based model in this paper is designed to examine various factors responsible for triggering migration. The model will enable us to compare the explanations given by two of the famous economic theories, namely Neoclassical Economic Theory and Networks and Migration Systems Theories. In addition the model will compare these two established theories with a new approach of utilizing people_happiness, measured by gross national happiness index as a measure of happiness among already established networks of immigrated people.

The model is based on four European countries: Germany, France, Romania and Moldavia. Therefore, the simulation is based over two developed countries that is reasonable to assume that neoclassical factors driving migration will be persistent (higher wage, jobs, higher happiness index), and the last two countries are the least developed where conditions to push migration are in place. In order to understand how the simulation works and which factors have been chosen as "drivers" for migration, hereinafter is a brief description of the main theories explaining migration patterns.

Neoclassical Economic Theory of Migration

Ernest Ravenstein is regarded as the earliest migration theorist. He assumed that migration is closely connected with "push-pull" factors. Both push factors such as low wages, high unemployment rates, and lack of health care and pull factors such as: high wages, low unemployment incline people towards leaving their countries of residence. In other words, the primary cause for migration is better external economic opportunities.

According to the theory we find the following assumption:

The main cause of labor migration is differences in wages between a sending country and a receiving country. In other words, wage differentials elimination will end international migration of workers and migrants will not migrate if such differentials do not exist.

Gross National Happiness Index and Migration Systems Theories

Happiness Index

It is often assumed that development generally increases people's capabilities to migrate over larger distances. However, this does not necessarily lead to migration. People will generally only migrate if they have the aspirations to do so. Migration aspirations depend on people's more general life aspirations, as well as their perceptions of life 'here' and 'there'. Both are subjective and likely to change under the influence of broader processes of structural change. Improved access to information, images and lifestyles conveyed through education and media tend to broaden people's mental horizons, change their perceptions of the 'good life', and typically increase material aspirations

Networks and Migration Systems Theories

It is a theoretical model explaining international migration through presenting a concept of migrant networks. According to this approach: international migration expands until network connections are wide enough that all people who wish to migrate to that country can do so without difficulties. Although the Neoclassical Theories hold that economic forces often play an important role as one of the root causes of migration, and people tend to move to places where the standards of living are better, this alone cannot explain the actual shape of migration patterns. This draws our attention to the role of nation states, geographical proximity, institutions, social networks, and cultural and historical factors in creating new migration patterns. There is an argument that migration facilitates the flow of information back from the place of destination to the origin, which facilitates the passage for later migrants. Moreover, there is evidence that the already settled migrants function as "bridgeheads" (Böcker, 1994), reducing the risks as well as material and psychological costs of subsequent migration. Therefore, a factor which will be simulated in the model is gross national happiness index.

Therefore, based on Neoclassical and Network economic theories the model will test:

➤ **Go** - will simulate wage based migration; a turtle will decide to migrate if it finds out about better wage in a different country. Furthermore, wage which is the most relevant factor to influence migration decision at this stage will be set both fixed and variable, variability in wage (*measure-wageVariation*), will allow us to have a model closer to reality taking into consideration GDP growth of each country to drive up wages and thus migration.

➤ *measure-people happiness* will illustrate gross national happiness of each country, which is a variable dependent by the wage of each individual country. Therefore, the level of happiness in a given country will depend by general economic conditions such as growth. In this mode the turtles which have

already migrated and found similar co- nationals will increase the gross happiness index.

What is the reason for increasing happiness. Through the assistance of friends and relatives, new migrants may more easily be able to obtain information and receive active assistance in finding employment and a place to live, in arranging residence papers, or in finding a marriage partner. Therefore, the formation of an established migrant community at one particular destination will increase the likelihood of subsequent migration to that particular place (Appleyard 1992). Therefore, the model will take into account such small networks created among already immigrated workers in host country and increased total gross happiness index as a result of cooperation between people.

How the model works

This model is based on four countries from the Europe: Moldavia, Romania, France and Germany. At the beginning users set a specific number of citizens for each country, GDP growth and the level of unemployed citizens, starting from the concept that in high-developed country, unemployment has a lower rate. Then following some logic rules, population begins to migrate if some conditions are met. For example, a citizen from Romania, with a lower wage will begin to search a job with a higher wage in other countries.

Among all factors that affect migration are:

1. Wage (fixed or variable)
2. Unemployment / employment
3. GDP Growth
4. Happiness index (fixed or variable)

Procedures



Picture 1: The Interface section of the code

The model we discussed in the previous part, was created using the Netlogo 5.0.5, which helps us to simulate the migration process. From picture 1, we can see the interface section, where are situated four countries, the buttons “go”, “setup”. In addition, you can see sliders, which show you the number of citizens, GDP growth, unemployment and two switchers, first for “wage_variation” and second for “happiness_variation”. Moreover, for a better understanding we have created several graphics, which show you how parameters changes.

The code begins with “patches-own”, “turtle-own”, and “breeds” followed by “globals”, we defined this variables as globals, because they can be used at the beginning of a program, before any function definitions. It defines new global

variables. Global variables are "global" because they are accessible by all agents and can be used anywhere in a model. Most often, globals are used to define variables or constants that need to be used in many parts of the program.

As was said we begin our code with **"patches-own"**– it defines the variables that all patches can use. In our model the variables of **"patches-own"** are:

1. **"wage"**– specified for Moldavia, Romania, France and Germany.
2. **"GDPgrowth"**– which is between 1% - 12%.
3. **"nation"**–name of country.
4. **"new_jobs"**– number of new job created in a specific country.
5. **"happiness"**- assign an initial level of happiness for each country dependent on its wage level.

Any turtle standing on the patch can also directly access all patch variables.

"turtle-owned" – it defines the parameters belonging to each turtle, and in our case we have people, it has the following variables:

1. **"employment"** – meaning the employment of citizens.
2. **"similar"**-helps to identify people of the same nationality.

"breeds"– defines a community, which is made of four countries, any turtle of the given breed: is part of the agent set named by the breed name and has its breed built-in variable set to that agent set, and it has two variables for each country, as:

1. **"moldavianCitizens"** **"moldavianCitizen"**
2. **"romanianCitizens"** **"romanianCitizen"**
3. **"frenchCitizens"** **"frenchCitizen"**
4. **"germanCitizens"** **"germanCitizen"**

Variables in "breeds" are introduced as follow: first is written a name of community and secondly the individual. For example "germanCitizens" is a community, but "germanCitizen" is an individual.

"global" – is used to introduce variables that we will use it in the code. In "globals" are four countries: Moldavia, Romania, France and Germany.

```
patches-own[ wage GDPgrowth nation new_jobs happiness ]
turtles-own [ employment similar ]
```

```
breed[moldavianCitizens moldavianCitizen]
breed[romanianCitizens romanianCitizen]
breed[frenchCitizens frenchCitizen]
breed[germanCitizens germanCitizen]
```

```
globals [
Moldavia
Romania
France
Germany
]
```

In **"setup"**, With the "setup" button, the simulation starts, which follows the instructions contained inside the command: to setup; first of all it clears what

happens before, then, the “*setup-patches*” and “*setup-turtles*” sub-commands define own features of the patches and of the turtles.

In “*setup-turtles*”, we create turtles (persons, for the purposes of this model) and set up their variables:

```
create-moldavianCitizens howManyMoldavianCitizens
  ask moldavianCitizens
  [ set color white
    set shape "person"
    move-to one-of Moldavia
    ask n-of int(howManyMoldavianCitizens * (1 - level_moldavianCitizens_unemployment))
    moldavianCitizens [set employment 1]
  ]
```

This is the procedure of creating citizens for all four countries, and setting special parameters for it’s citizens. For example citizens from:

- Moldova– will be: white color, and setting number of employment, which will be equal to 1– “level_moldovanCitizens_unemployment”, means 100% minus the number in % of that people that don’t work equal to employed citizens.
- Romania – red.
- France – yellow.
- Germany – pink.

In “*setup-patches*”, we divide the graphical interface in four (by countries) called: *Moldavia*, *Romania*, *France* and *Germany*, having individually characteristics. For example, Romania will appear as patche1, having the following variables:

```
set Romania patches with [pycor >0 and pxcor>0]
ask Romania
[ set pcolor blue
  set GDPgrowth romanianGDPgrowth
set wage random 6
set happiness 2 * wage
set nation "Romania"
]
```

Romania on the graphical interface will be colored blue, having and initial level of *GDPgrowth*, level of wage being random (maximum 6), an initial level of happiness dependent on each country’s wage.

“*go*” which is the most important block of commands of the model because it defines how the agents move on the interface has several variables:

```
“find-country”,
“create-jobs”,
“measure-people_happiness”,
“measure-wageVariation”,
“tick”..
```

This allows the process of migration to begin.

“find-country” has the following variables as listed below, which allows population to find countries where to go:

```

to find-country
let currentWage 0
let current-country 0
ask turtles
[set currentWage [wage] of patch-here
 set current-country [nation] of patch-here
ifelse employment = 1

  [ifelse any? patches with [wage > currentWage ]

    [ask patches with [nation = current-country ] [set new_jobs new_jobs]
move-to one-of patches with [wage > currentWage]
  ]

    [set current-country [nation] of patch-here
move-to one-of patches with [nation = current-country] right random360]
  ]

[ifelse any? patches with [wage > currentWage]
 [move-to one-of patches with [wage > currentWage]
 ]
 [set current-country [nation] of patch-here
move-to one-of patches with [nation = current-country] right random360]] ]
end

```

Citizens from a specific country may have a job or not (*unemployed*), even those who have a job and a wage, are looking at the level of wage which is payable in other countries compared to their native country. If peoples' *currentWage* is lower than the *wage* of other countries, then turtles have desire to migrate to other countries where wage is higher, at this point *wage* of each country can be fixed or variable if the user chooses to switch on the “wage_variation” button, in this subsequent case wage is formed by an initial value specific for each country and GDP growth.

“measure-people_happiness”, as mentioned before, each country will have an initial gross level of happiness that depends on the country's wage. However, since through the assistance of friends and relatives, new migrants may more easily be able to obtain information and receive active assistance in finding employment and a place to live, this will allow migrants to increase the level of happiness when they find co-nationals, therefore turtles will look for other turtles of the same nationality and will set a level of happiness higher, this can be achieved only if the user chooses to switch on *happiness_variation*, otherwise the level of happiness remains in accordance to the initial level.

```

to measure-people_happiness

ask turtles[
set similar count (turtles-on neighbors)
with [ color = [ color] of myself]

```

```

ask turtles with [nation = "Germany" ] [ if happiness_variation [ set happiness happiness + similar ]]
ask turtles with [nation = "France" ] [ if happiness_variation [ set happiness happiness + similar ]]
ask turtles with [nation = "Moldavia" ] [ if happiness_variation [ set happiness happiness + similar]]
ask turtles with [nation = "Romania" ] [ if happiness_variation [ set happiness happiness + similar ]]
]
tick

end

```

"measure-wageVariation", we have assigned an initial level of wage for each country that is a random number within a specified range, however while user chooses different level of GDP from the sliders on interface, this will not affect level of wages, but since its more realistic to assume that wages actually depends on **GDP growth**, and changes over time, the user can chose to switch on “wage_variation” in order for the turtles to change the course of their migration over time based on GDP growth and thus based on wages.

```

to measure-wageVariation

```

```

ask turtles with [nation ="Moldavia" ] [ if wage_variation [ set wage int( wage + (10* GDPgrowth)) ]]
ask turtles with [nation ="Romania" ] [ if wage_variation [ set wage int( wage + (10* GDPgrowth)) ]]
ask turtles with [nation ="France" ] [ if wage_variation [ set wage int( wage + (10* GDPgrowth)) ]]
ask turtles with [nation ="Germany" ] [ if wage_variation [ set wage int( wage + (10* GDPgrowth)) ]]

end

```

Experiments

We are going to do three different experiments and to observe the process of migration. Every experiment has its specific variables.

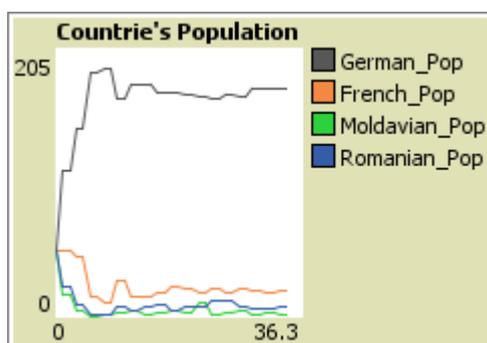
Experiment 1

As we know, under normal conditions people will be induced to migrate based on wage differentials among different countries. If we assume real economic data from observed countries, what will happen if we set Gross happiness index of each country to be fixed or variable?

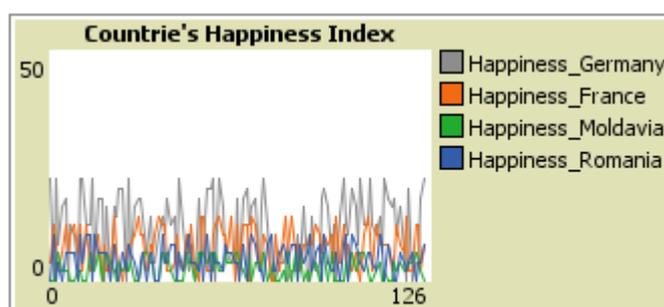
Variables	Moldavia	Romania	France	Germany
Unemployment	30%	25%	10%	7%
GDP Growth	-1%	3%	2%	8%
Wage	Country specific	Country specific	Country specific	Country specific
Wage_variation	Off	Off	Off	off
Happiness_variation	Off then on	Off then on	Off then on	Off then on

Outcomes:

During our experiment number 1, it was expected to see that massive migration occurred in Germany, it is because this country has the highest initial level of wage, if we assume no variation in wage, therefore, Germany will have highest level of inflow of population as you can notice on the picture 3.



Picture 3: Country's Population



Picture 4, no variation in gross happiness

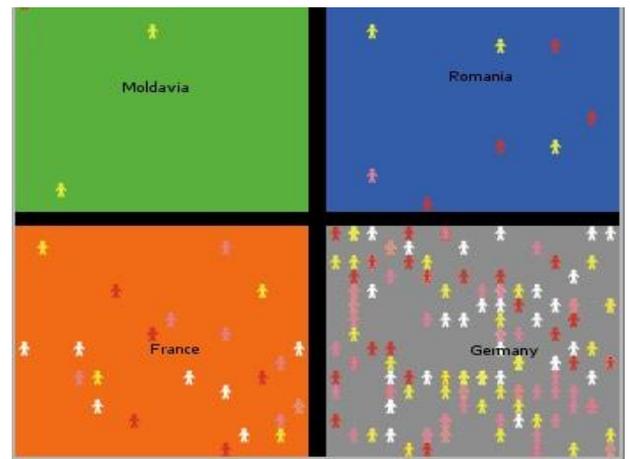
Next graph will reveal an interesting fact, if we assume that happiness index is fixed and it depends just on the country specific wage, then graphically in picture 4, you can notice no significant variations, still Germany will show a dominant trend since as we assumed fixed wages, it is the case that in this country wage is the highest among others and thus the highest gross happiness level.

However, since Systems and migration theories suggest that newly migrated people serve as bridges and collaborate with other co-nationals it is reasonable to predict that their total level of happiness will increase, and this increase will depend by the number of co-nationals nearby, more they are more they may benefit from this collaboration and thus increase total level of happiness . We can notice this effect while switching on "*happiness_variation*", gross happiness level in Germany now is much more higher than in previous case since different nationalities who find themselves together increase its level of happiness.



Picture 5, variation in gross happiness

On Graphical interface we can notice the changes that occurred as a result of migration based on fixed wages and with/without changes in gross happiness index.

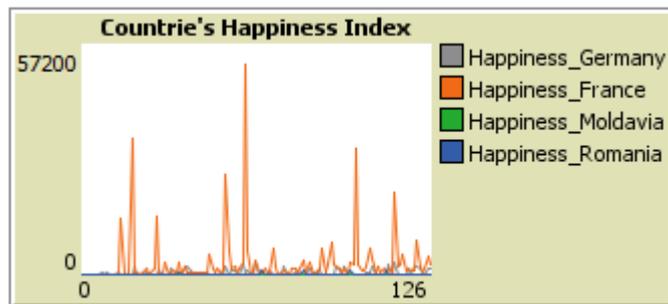
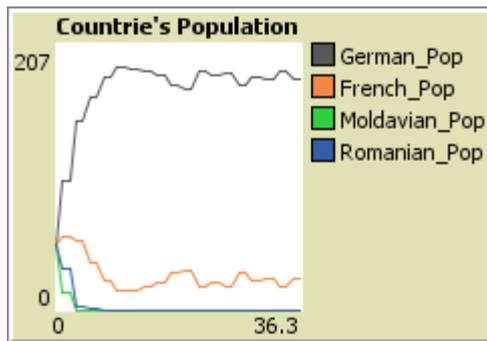


Experiment 2

Variables	Moldavia	Romania	France	Germany
Unemployment	30%	25%	10%	7%
GDP Growth	-1%	3%	2% to 15%	8%
Wage	Country specific	Country specific	Country specific	Country specific
Wage_variation	Off then on	Off then on	Off then on	Off then on
Happiness_variation	On	On	On	On

Outcomes:

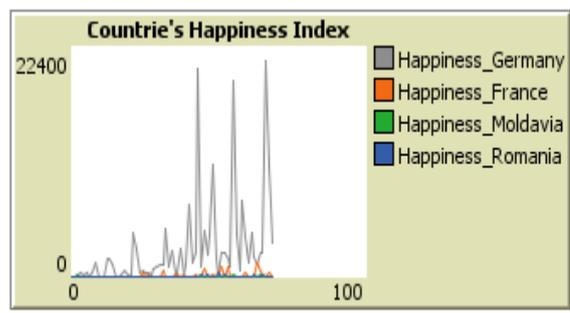
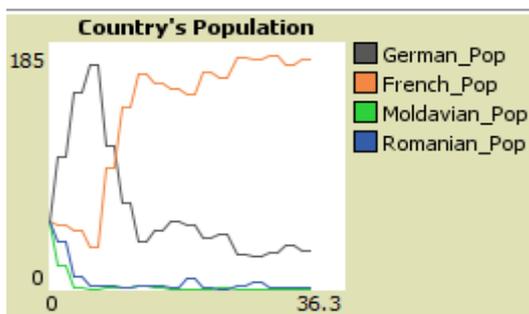
In our last experiment we assumed wages are fixed, therefore a drawback of the model is the fact that despite a huge increase in GDP growth a country may experience, wages will remain fixed and thus migration will occur always the same country, this is the reason why wage variability is introduced at this stage. As you can notice from pictures bellow even if, for example, France will experience an economic Boom and GDP will grow annually by 15%, still population will migrate in Germany implying exogenous wages, as a consequence level of happiness and population will be the highest in Germany.



Picture 6: Country's Pop and no wage variation

Picture 7: Gross happiness I. no wage variation

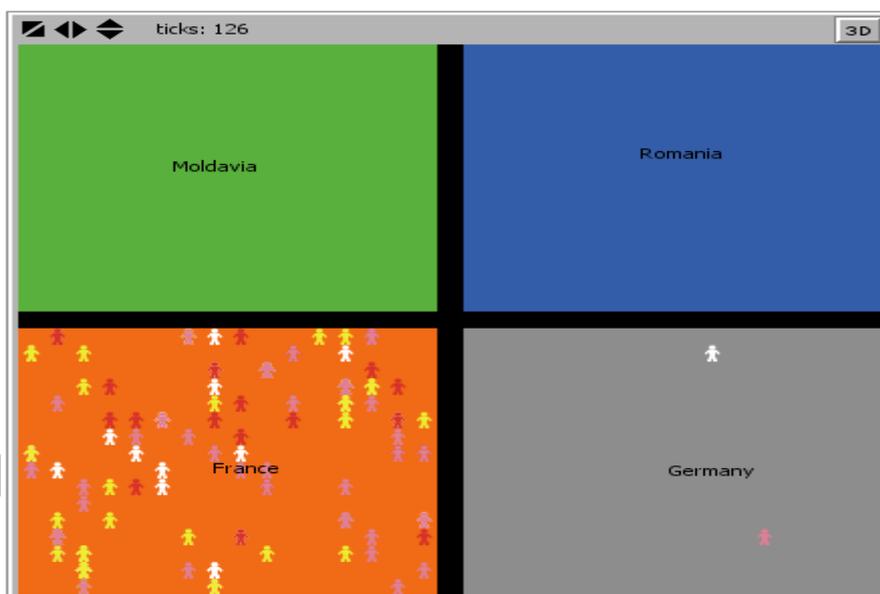
However, in order to make the simulation closer to reality, endogenous wages are introduced, thus wages changes as GDP changes which implies people will migrate in the country that experience a growth.



Picture 8: Country's Pop and wage variation

Picture 9: Gross happiness with wage variation

In above pictures you can notice now that with an economic Boom in France, with and increase in GDP of 15% annually vs Germany's 8% , people will start to migrate in France and eventually French population will start to increase, since we assumed also variation in happiness index, we can notice



that such variation will lead to an increased level of happiness in France as compared with previous case with exogenous variables.

Picture 10: Wage variation

Experiment 3

Variables	Moldavia	Romania	France	Germany
Unemployment	30%	25%	10%	7%
GDP Growth	3%	3%	10%	10%
Wage	Initial 4	Initial 4	Initial 4	Initial 4
Wage_variation	On then off	On then off	On then off	On then off
Happiness_variation	On	On	On	On

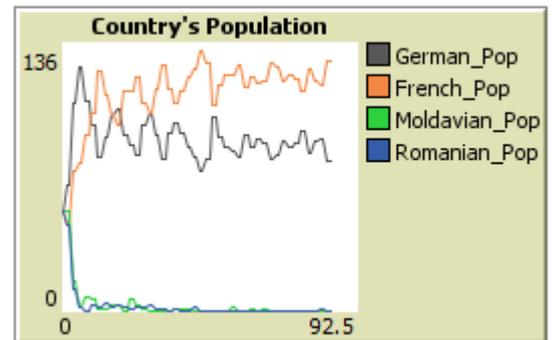
What will happen if under some economic circumstances, two well developed countries will have an equal initial wage and GDP growth, and two underdeveloped countries will have the same low wage and GDP growth, how do people from underdeveloped countries decide to migrate and where given the two developed countries are similar?

Suppose we assume all countries have an initial level of wage, furthermore suppose Germany and France have an annual GDP growth of 10% each.

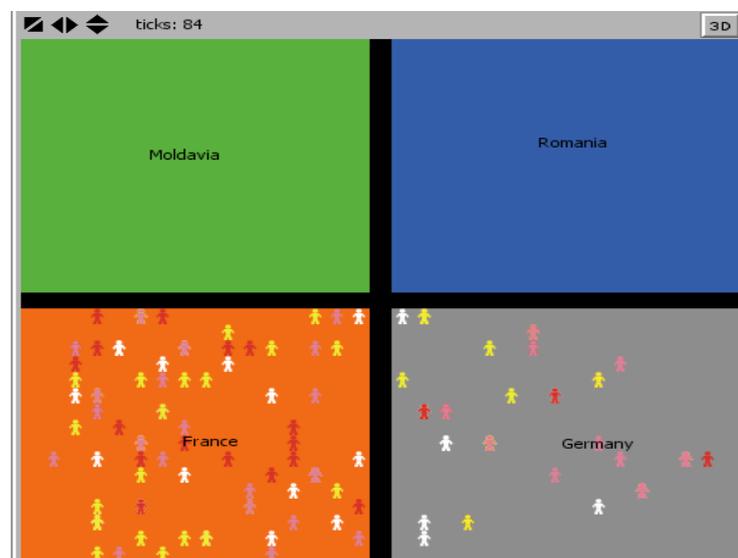
Outcomes:

Given wage variation, under a simulation of 20 trials people from underdeveloped countries decide to migrate weather in France or Germany, and then the population over time is steady in these countries, however it is not easy to explain why a particular country is chosen as compared to other given similar conditions in place, given that countries have

the same population and level of development, they show highly divergent migration characteristics, to what extent migration will occur, and where migrants will go depends on the interplay of many variables such as geographical distance, access to information and the most important which is access to migration networks. Once a certain number of migrants have settled at the destination, they tend to have a great influence on subsequent migration patterns,

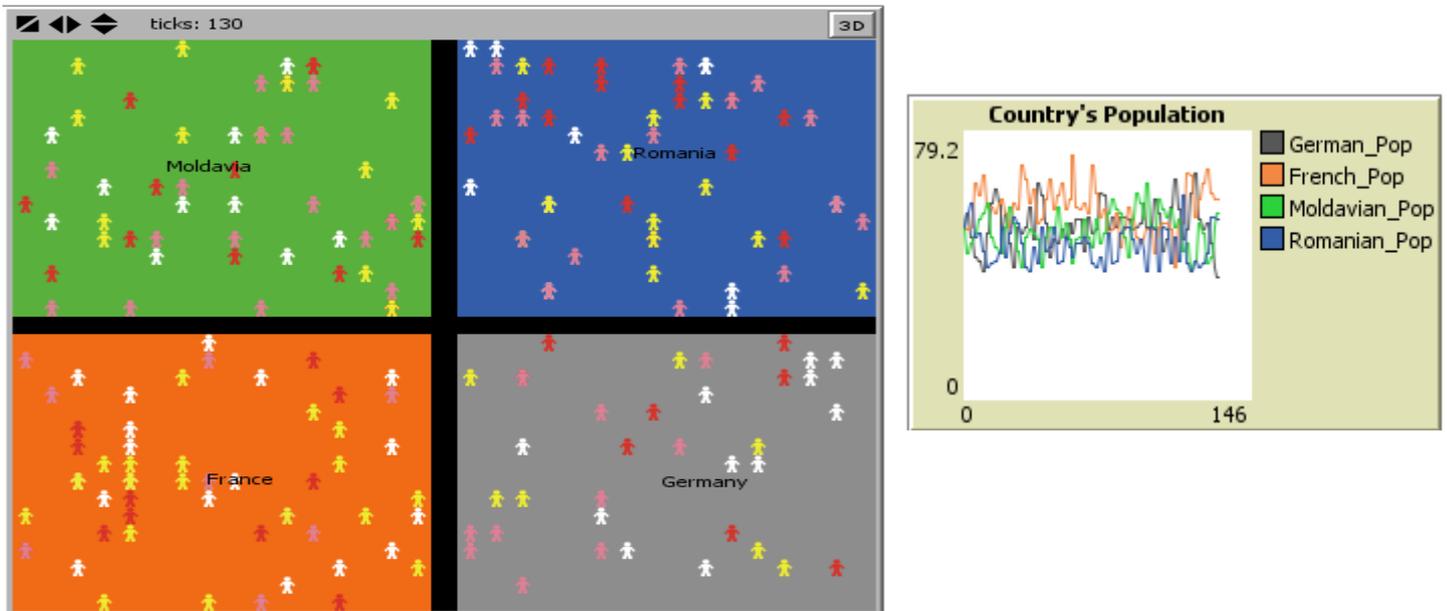


Picture 11: Similar endogenous wages



migration facilitates the flow of information back from destination to the origin which facilitates the passage for letter migrants. There is evidence that already settled migrants function as 'bridges' reducing the cost as well as material and psychological costs of subsequent migration.

If we assume that wages are exogenous, then is the case that people have no incentive to migrate at all, they will decide to remain in their country since wages are all the same. You can notice this in the Picture 13 .



Picture 13: Exogenous similar wages

CONCLUSION

People migrate for many different reasons. These reasons can be classified as economic, social, political or environmental:

- *Economic migration* - moving to find work or follow a particular career path.
- *Social migration* - moving somewhere for a better quality of life or to be closer to family or friends.
- *Political migration* - moving to escape political persecution or war.
- *Environmental causes of migration* include natural disasters such as flooding.

Within our model, the most important drivers of migration are wages and family or friends factors. People are going in the country where are getting a high remuneration for their work and at the same time to meet their relatives or friends.

As we have seen in the last experiments the process of migration is influenced by many factors.

As was shown in first simulation, migration based on exogenous *wages* will attract people from less developed countries into Germany, because level of remuneration is higher, however since its incorrect to assume that wages are exogenous all the time, the model introduces variability in wages based on GDP growth, moreover the model takes into consideration the gross happiness index of each country which is dependent on such growth. As a result the level of migration may depend on the variability in wages and GDP growth and also if we take into consideration "*happiness_variation*", therefore variations in these variables will lead to different results.