UNIVERSITÀ DEGLI STUDI DI TORINO

School of Management and Economics

SIMULATION MODELS FOR ECONOMICS

Final report

Migration, Unemployment and Development: A Two-Sector Analysis.

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Summary

1. Introduction

The aim of the essay is to simulate migration movements from rural areas to urban ones. Indeed, especially in the developing countries, despite positive marginal products in agriculture and high urban unemployment, migration flows from country to city are increasing. The Harris and Todaro model (1970) analyzes this phenomenon.

The world can be seen as a two trade sectors: the permanent urban and the rural. The urban sector is the one producing manufactured goods. The rural sector produces agricultural goods. It is worth noting that urban areas experience unemployment while all rural labor force is hired. So there exist two kinds of agents, the citizens and the farmers, who decide to move according to the expected wage. The crucial assumption to be made in our model is that rural-urban migration will continue as long as the expected urban real income at the margin exceeds real agricultural product.

Proceeding with the analysis, we take into account the following formulae:

Agricultural Production Function:

$$X_A = q\ (N_A, L, K_A), \qquad q' > 0,\ q'' < 0$$

where

X_A is output of the agricultural good, N_A is the rural labor used to produce this output, L is the fixed availability of land, K_A is the fixed capital stock, q' is the derivative of q with respect of N_A, it's only variable factor.

Manufacturing Production Function:

$$X_M = f\ (N_M, K_M), \qquad f\ '> 0,\ f'' < 0$$

where

X_M is the output of the manufactured good, N_M is the total labor (urban and rural migrant) required to produce this output. K_M is fixed capital stock, and f ' is the derivative of f with respect to N_M, its only variable factor.

Price Determination:

$$P = \rho\ (X_M/X_A), \qquad \rho' > 0$$

where

P is the price of the agricultural good in terms of the manufactured good, (i.e., the terms of trade) is a function of the relative outputs of agricultural and manufactured good when the latter serves as numéraire.

Agricultural Real Wage Determination:

$$W_A = Pq'$$

where

W_A, the agricultural real wage, is equal to the value of labor's marginal product in agriculture expressed in terms of the manufactured good.

Urban Expected Wage:

$$W_u^{\epsilon} = (W_M * N_M)/N_U$$

where

the expected real wage in the urban sector, W_u^{ϵ}, is equal to the real minimum wage W_M adjusted for the proportion of the total urban labor force actually employed, N_M/N_U. Only in the case of full employment in the urban sector $W_u^{\epsilon} = W'_M$.

Labor Endowment:

$$N_A + N_U = N_R + N_U = N$$

there is a labour constraint which states that the sum of workers actually employed in the agricultural sector (N_A) plus the total urban labour force (N_U) must equal the sum of initial endowments of rural (N_R) and permanent urban (N_U) labour which in turn equals the total labour endowment (N).

Equilibrium Condition:

$$W_A = W_u^{\epsilon}$$

derived from the hypothesis that migration to the urban area is a positive function of the urban-rural *expected* wage differential.

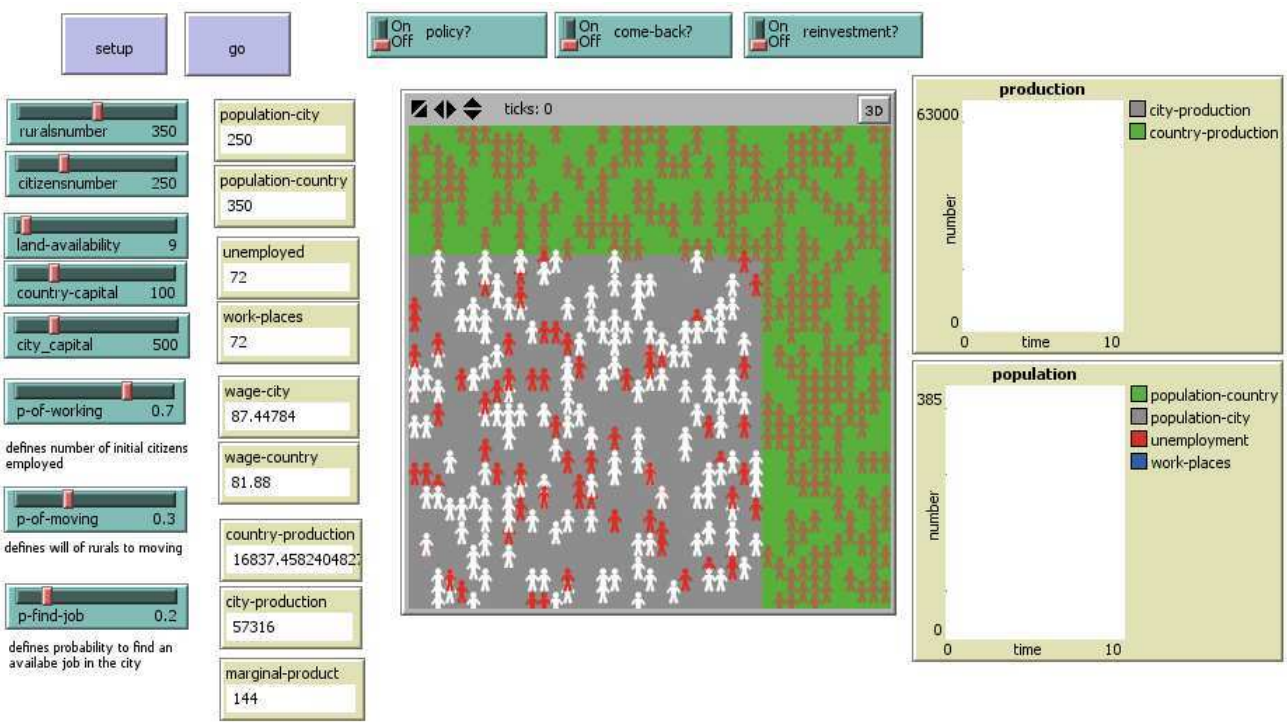
Clearly then, migration will cease only when the expected income differential is zero.

The core of our model is that in many developing nations the existence of an institutionally determined urban minimum wage at levels substantially higher than that which the free market would allow can, and usually does, lead to an equilibrium with considerable urban unemployment.

2. The model

2.1 Interface

Before describing the code, we would like to take a brief look at the user's interface and its functions.



2.1.1 Buttons

- The *setup* button runs the initial world, dividing it into two sections one representing countryside (green patches) and the other representing urban environment (grey patches). Setup also creates turtles, in our case “person” shape, assigning them different colors. Brown means rurals, white characterizes citizens and red represents urban unemployed people.
- The *go* button starts the simulation.

2.1.2 Sliders

- *Ruralsnumber*: controls the number of initial rural agents;
- *Citizensnumber*: controls the number of initial city agents;
- *Land-availability*: represents the agriculture productivity of countryside fields;
- *Country-capital*: controls the amount of money invested into country activities;
- *City-capital*: controls the amount of money invested into city activities;
- *Probability of working*: defines number of initial citizens employed;
- *Probability of moving*: defines will of rurals to moving;
- *Probability of find a job*: defines probability to find an available job in the city;
- *Policy?*: when on, policy influences model;

- *Come-back?*: when on, assumes that unemployed rurals in the city move back to countryside;
- *Reinvestments*?: when on, assumes that capitalists reinvest part of gains.

2.1.3 Graphs

- *Productivity*: represents city and country productivity trends;
- *Population*: draws people living in country, people living in city, unemployed people and available work places trends.

2.2 Code

At the very beginning we assign *breeds* and variables required by the model. Therefore we create *rurals breed* representing initial people living in countryside and *citizens breed* representing initial people living in the city. We assign to them exclusive variables (*wage* and *employed*) via the *citizens-own* and *rurals-own* functions. Finally we allocate the sets of variables which are common to the all agentsets using the "*globals*" command.

2.2.1 To setup

This part of code is devoted to the creation of the “world” box.

We start creating the backgrounds setting all patches green and then asking to the ones between defined coordinates to change color in grey; we do that thanks to:

```
ask patches[set pcolor green]
ask patches with [pxcor < (10) and pycor < (10)][set pcolor grey]
```

We then create agents: rurals with color brown living in the green area. Citizens with color white living in the grey area:

```
 create-rurals ruralsnumber
[set color brown
 set shape "person"
 set size 2 ]

 create-citizens citizensnumber
 [set color white
  set shape "person"
  set size 2]

 set city-capital  city_capital

 ask rurals [move-to one-of patches with [pcolor = green]]
 ask citizens [move-to one-of patches with [pcolor = grey]]
```

Moreover we assign to them employment, setting all rurals employed and dividing citizens into employed and unemployed according to the *p-of-*

working. We do that using *ifelse* command which states employment true if *p-of-working* > *random-float 1* or employment false if not, setting color red for those agents.

```
ask rurals [set employed true]
ask citizens [ifelse  p-of-working > random-float 1
[set employed true ][set employed false set color red]]
```

Finally we create the global variables according to the formulae provided into the Harris and Todaro paper. We choose *country-production* equal to:

$$Xa = L * Ka * (Na)^{(0.5)}$$

The *city-production* equal to:

$$Xm = -Nm^{(2)} + Km*Nm$$

And set *marginal product* equal to the first derivative of *city production* with respect to Nm.

```
set population-country count turtles with [pxcor >= 10 or pycor >= 10]
set population-city count turtles with [pxcor < (10) and pycor < (10)]

set unemployed count turtles with [employed = false]

set country-production
 ((land-availability)* (country-capital) * ( population-country)^ 0.5)
set city-production
 (-((population-city - unemployed )^ 2) +  ((population-city - unemployed ) * ( city-capital)))

set marginal-production
(- 2 * (population-city - unemployed ) + (city-capital))

set wage-country
((city-production / country-production)) * (0.5 * ( land-availability * country-capital)
   * ((population-country)^(- 0.5 )))

set wage-city
(1.5 * wage-country * (population-city - unemployed )/ population-city)

ask citizens [ifelse employed = true [ set wage wage-city ][set wage 0 ]]
ask rurals [set wage wage-country ]
```

- We use *marginal product* to define the number of new working places available according to the law of diminishing returns.

```
if marginal-product > 0 [set work-places int((city-capital / 2) - (population-city -  unemployed ))]
```

- As usual in Netlogo programs we exploit the setup phase to reset any previous action through the commands:

```
clear-all
reset-ticks
```

2.2.2. To go

With the *"to go"* command we create the working process of the model defining agents' behavior.

It is made by nested orders:

- *Migration*: orders to the rural agents to move (with certain probability) to the city if *wage city* is greater than their wage and there are available working places

```
to migration

  if population-country > 10  [ask rurals with [pxcor >= 10 or pycor >= 10]
   [ if wage-city > wage[if work-places > 0
   [if random-float 1 < p-of-moving
   [move-to one-of patches with [pcolor = grey]
    set employed false set color blue set wage 0 ]]]]]

end
```

- *Find job*: assigns available working places to unemployed agents

```
to find-job

ask turtles  with [pxcor < (10) and pycor < ( 10)]
 [if employed = false
 [if work-places > 0
 [if random-float 1 < p-find-job
 [set employed true set color  white set wage wage-city set work-places(work-places - 1)]]]]

end
```

- *Count*: updates setup information after previous orders launchings.

```
to count-

set population-country count turtles with [pxcor >= 10 or pycor >= 10]
set population-city count turtles with [pxcor < (10) and pycor < (10)]

set unemployed count turtles with [employed = false]

set country-production ((land-availability )* (country-capital) * ( population-country)^ 0.5)
set city-production (-((population-city - unemployed )^ 2) +  ((population-city - unemployed )  * ( city-capital)))

set marginal-production
(- 2 * (population-city - unemployed ) + (city-capital))

set wage-country
 ((city-production / country-production)) * (0.5 * ( land-availability * country-capital)
    * ((population-country)^(- 0.5 )))
set wage-city
( 1.5 * wage-country  * (population-city - unemployed )/ population-city)

ask turtles with [pxcor >= 10 or pycor >= 10][if employed = true  [set wage wage-country]]
ask turtles with [pxcor < (10) and pycor < (10) ] [if employed = true  [set wage wage-city]]

end
```

- *Policy*: when on, sets up strategies able to avoid increasing in unemployment and countryside depopulation. To do that government provides subsidies both rurals and city agents; we set that 0.0001 of *city production* is provided to capitalist for reinvestment and subsidies able to level city and country wages are provided to the rural agents.

```
if policy?
[if work-places = 0 [set city-capital(city-capital + 0.0001 * city-production) ]
count-
update-work-places
if population-country < 0.2 * population-city[count-policy]]
```

- *Come back*: when on, asks unemployed rurals into city to move back to homeland with certain probability.

```
 if   come-back?
[ask rurals [if employed = false [if random-float 1 < p-of-moving
[move-to one-of patches with [ pcolor = green]
 set employed true set color brown set wage  wage-country]]]]
```

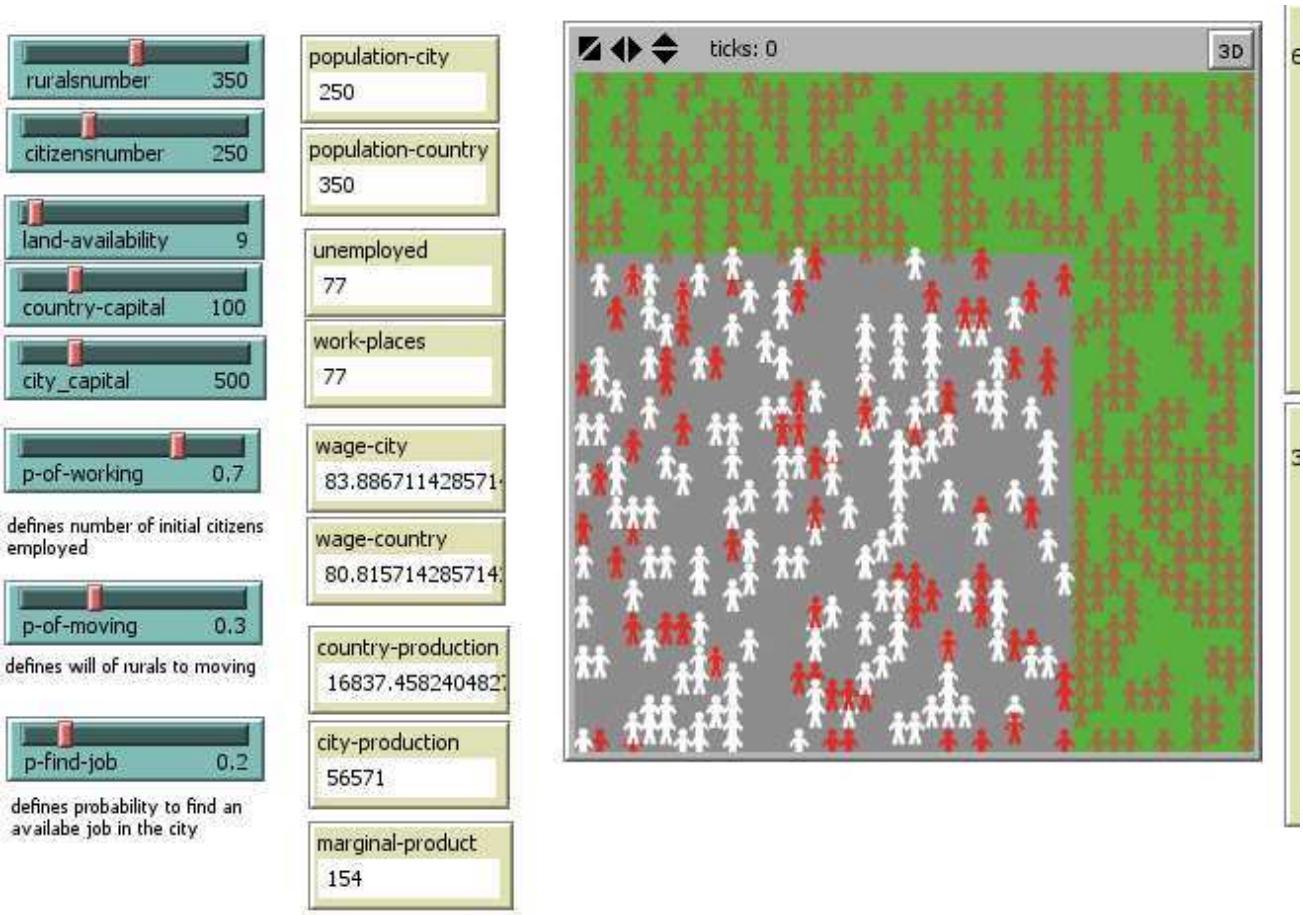
- *Reinvestment*: when on, asks capitalists to reinvest part of their gain in production, creating new working places.

```
if reinvestment?
[if work-places = 0 [set city-capital(city-capital + 0.0001 * city-production)]
count-
update-work-places]
```

3. Simulations

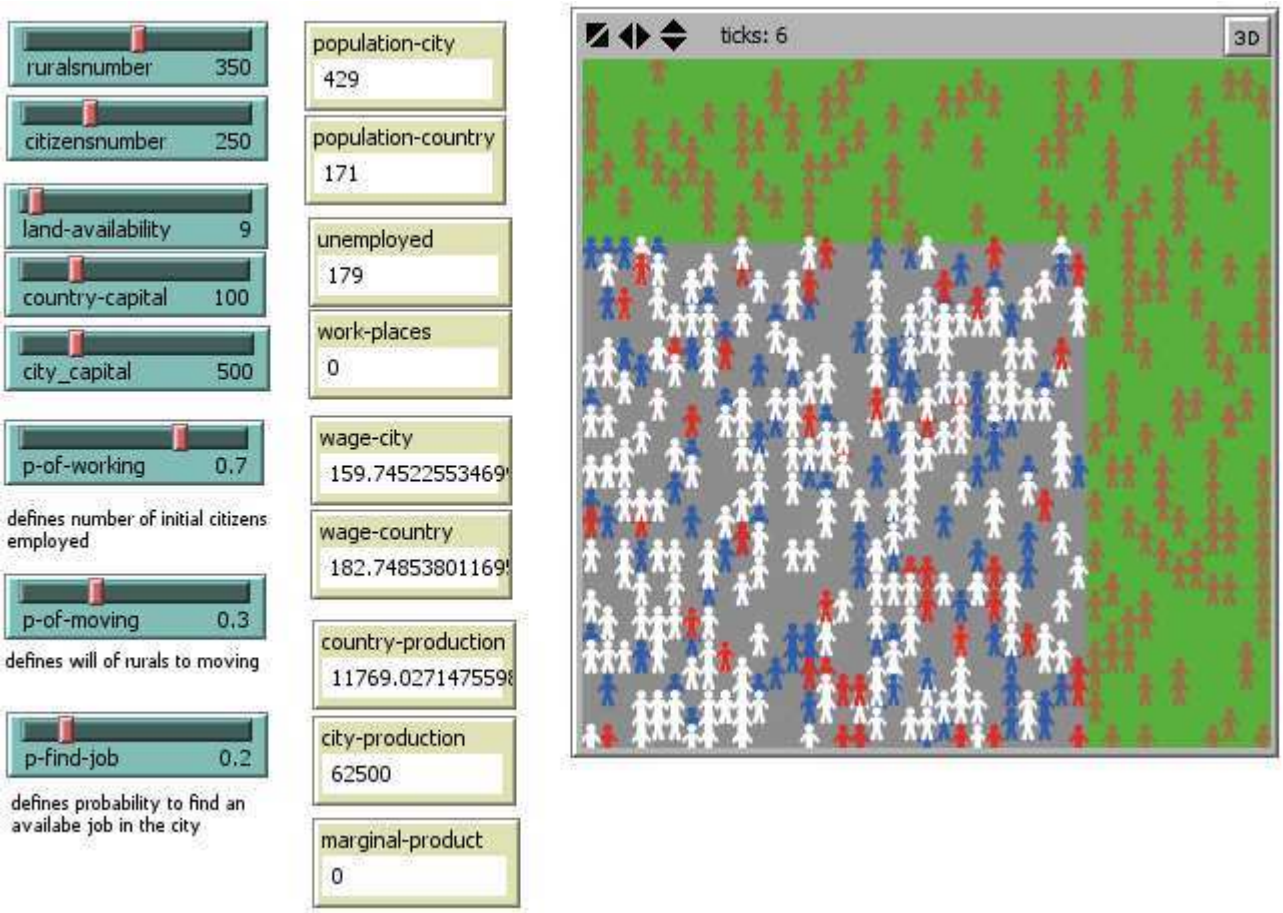
We will now illustrate the results of several simulations with different variables values. Our ultimate goal is to gauge the changes in the unemployment level varying available work places.

In the benchmark case we assume determined values for *citizensnumber ruralsnumber unemployed* and *work-places*;



For example in this case, we have ruralsnumber equal to 350, citizensnumber equal to 250 and resulting unemployed and work-places equal to 77.

One would expect unemployment to fall, but this is not the case. Indeed the resulting outcome is:



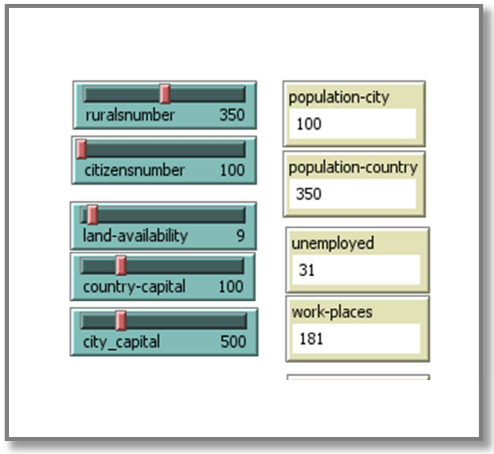
We can see how unemployment increased, despite the creation of new available work places equal to the initial unemployed people.

This phenomena may be explained focusing on migration flows involving country population. Indeed, the new jobs and higher expected wage induce rurals to move to the city. In so doing, the number of jobseekers is greater than the number of available jobs. The result is the creation of a new kind of unemployed, the rurals that have settled down in city (blue people in the above picture).

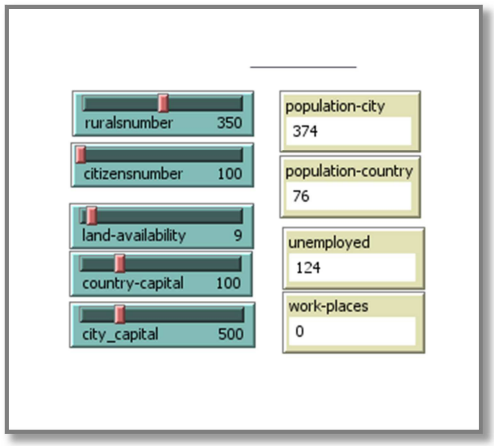
3.1 Changes in benchmark model

We now proceed in changing some of the initial assumptions:

- ***Changes in citizensnumber***: From the very beginning the variable *"citizensnumber"* is one of the most meaningful; it determines many other variables including unemployment level and available working places, that we can consider the main moving forces in our model.

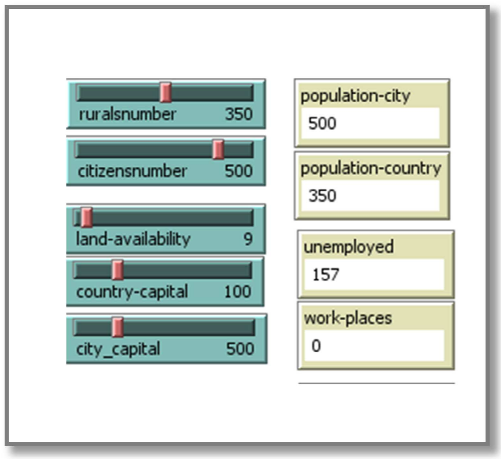


It is natural to ask what may happen to model results changing the number of citizens. In the benchmark model we assume a number of 250 people: let's verify what happen when number of citizens is hardly less, suppose 100. Of course, keeping same probability of working and city capital, unemployed will be less that in the basic model while there will be more available working places.



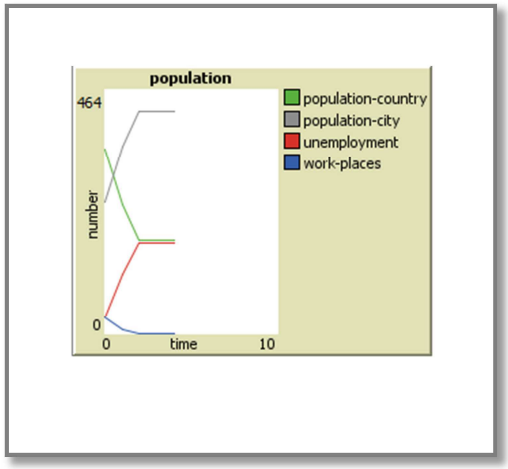
At the end this will generate an even dramatic effect in the number of unemployed: indeed, after migration, with few starting citizens, unemployment will growth for more than 400% against around 50% in basic case.

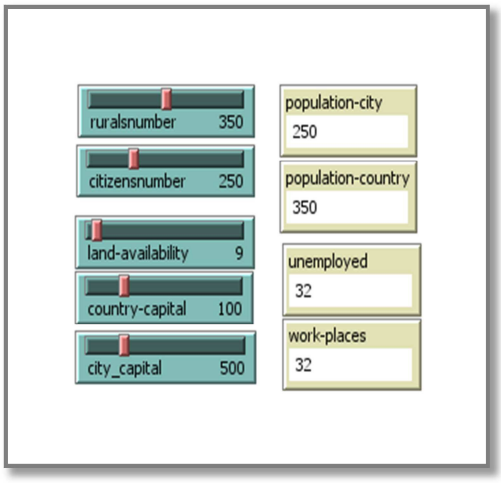
On the other hand, an abnormal number of citizens with respect to the fixed city capital, let's suppose 500, will generate an initial massive unemployment without any available working places, creating a static situation.

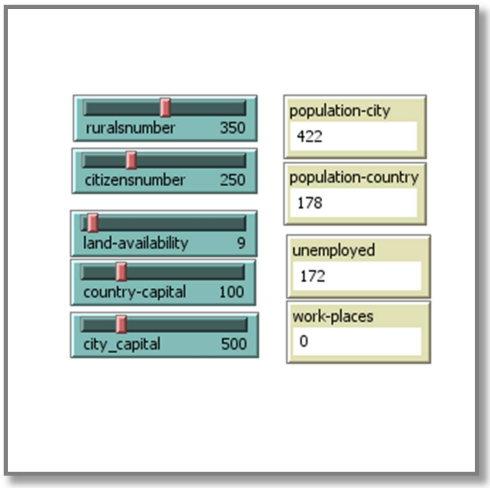


- **Changes in p-of-working:** The following simulation tests how the p-of-working, which define number of initial citizens employed, influences unemployment and difference between *wage-country* and *wage-city*;

Setting p-of-working between 0.6 and 0.9, we notice that the number of unemployed people increase. Indeed, the relative low level of initial

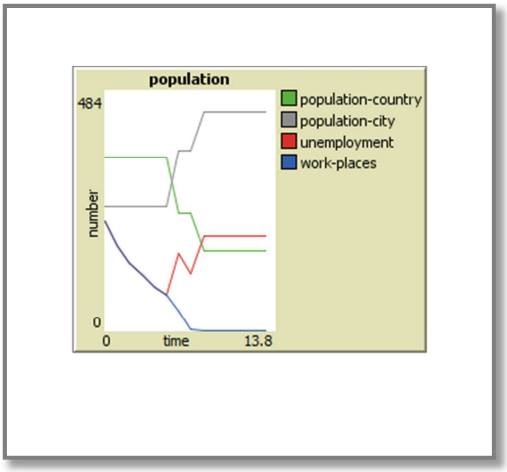






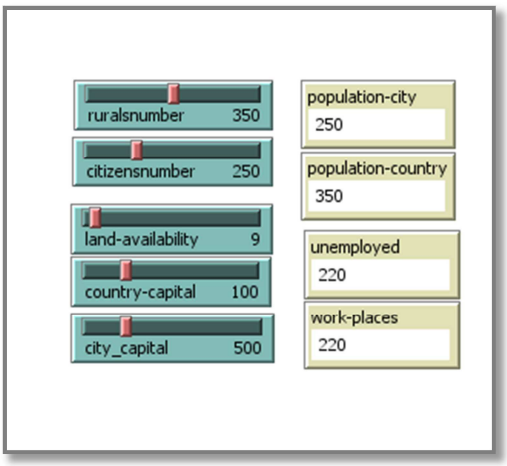
unemployment will determine initial few working places generating a positive effect on *unemployment*, deriving from the country people migration flow.

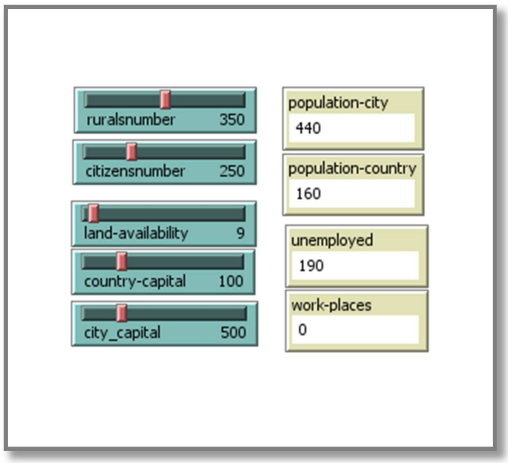
Setting *p-of-working* between 0 and 0.2, we start with a huge unemployment level such that after migration process the number of unemployed people is decreased. Indeed, thanks to higher number of available jobs, the majority of citizens unemployed and migrated rurals succeed in finding job. At the very beginning, the number of available working places is equal to the number of unemployed people, after the migration the number of jobseekers into the city is higher than available jobs.



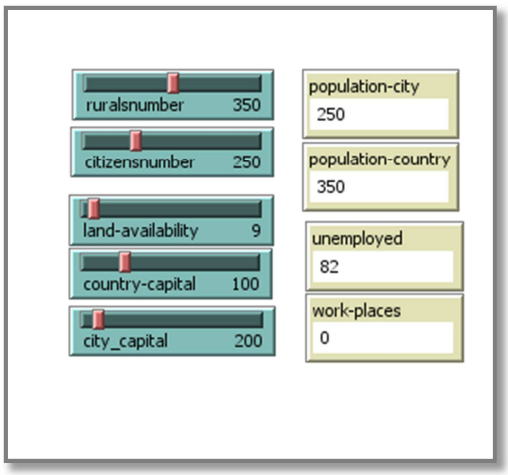
For p-of-working bounded between 0 and 0.6 the value of wage-country is higher than wage-city whereas for values higher than 0.6 the opposite is true, inducing rurals to migrate at the first tick.

The effect in the bound 0.3 – 0.5 is promiscuous and not very significant.



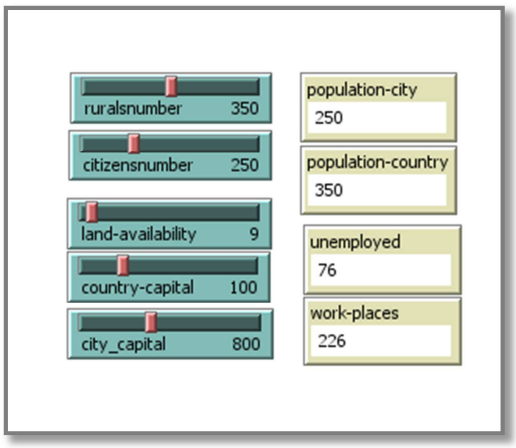


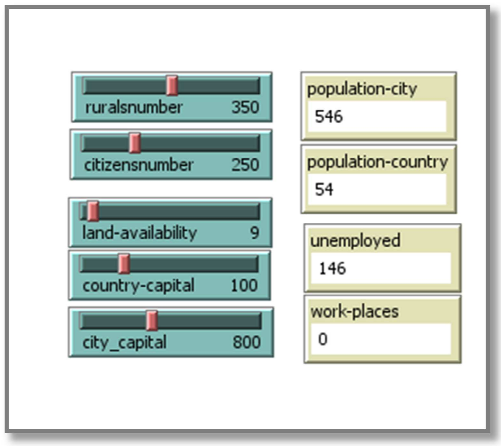
- **Changes in city-capital**: with the third experiment, turning off all the switchers, we want to test how variations in city capital, defined as the fixed capital stock invested in the city, can affect the unemployment level.



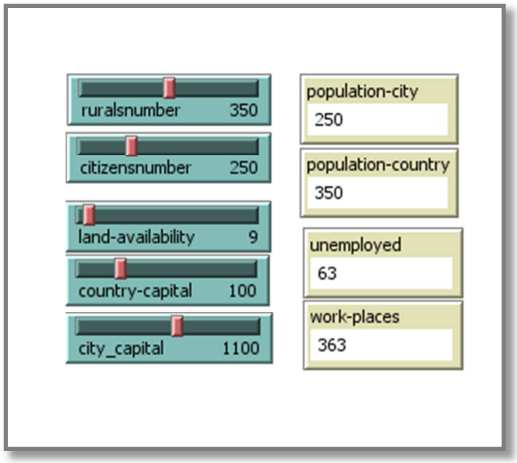
Setting the level of city capital less than 400, there will not be new available jobs, determining a static situation characterized by costant unemployment level.

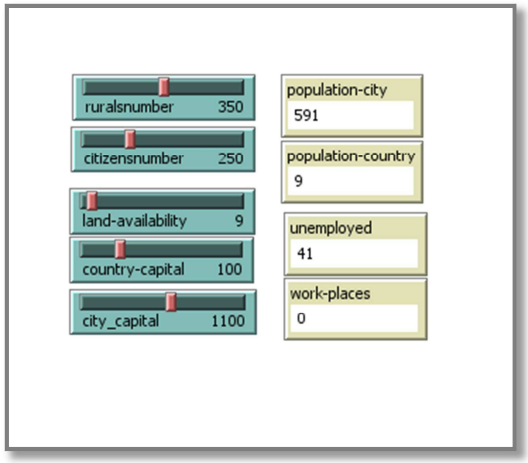
Considering the range between 400 and 1000 the resulting level of new working-places determines an increasing in unemployment by two-fold, while the workplaces go to zero because of the migration flows from the countryside.



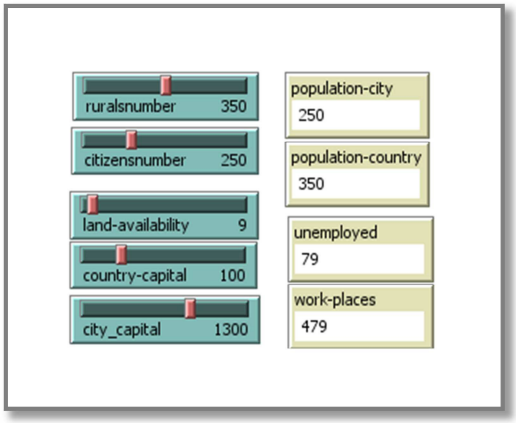


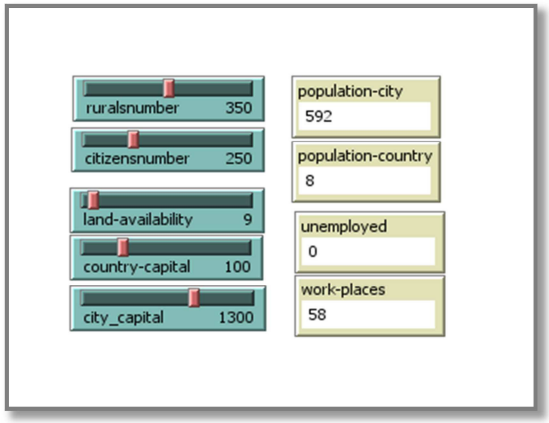
Rising the capital city to 1100, the unemployment starts decreasing related to the huge proportion of new initial available workplaces.





Setting the city capital greater than 1200 the unemployment is completely absorbed going to zero, resulting in depopulation of countryside.

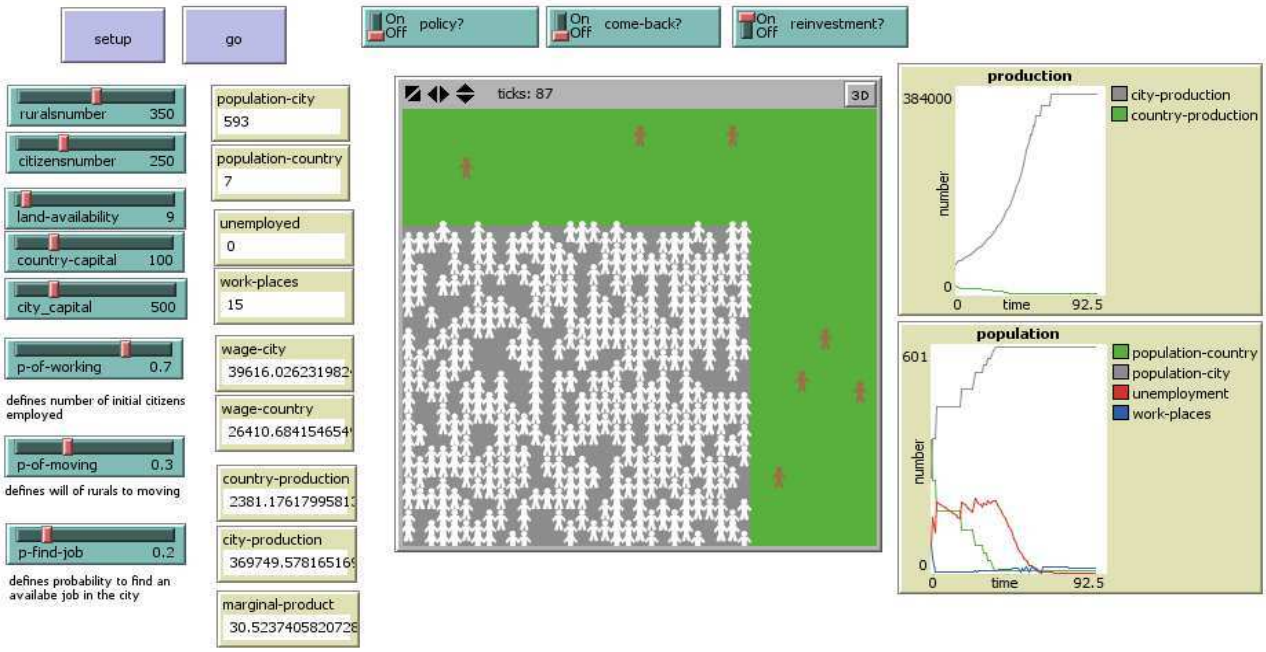




3.2 Implementations

We now introduce some more assumptions to the benchmark model:

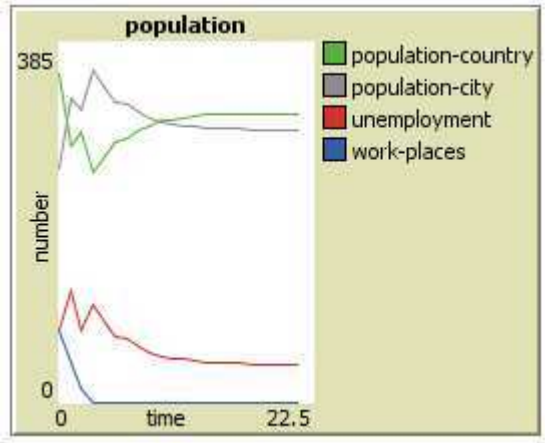
- One possible switcher we have introduced in the model is "**reinvestment**", indicating the case in which capitalists reinvest part of their gain into production. This case naturally increases wage and production in the city environment and most important will continuously generate new available working places every reinvestment cycle. In the long run this last effect on the one hand will totally rule out unemployment in the city but on the other will determine massive migration flows from countryside to city, generating a catastrophic situation in which rural areas end uninhabited.



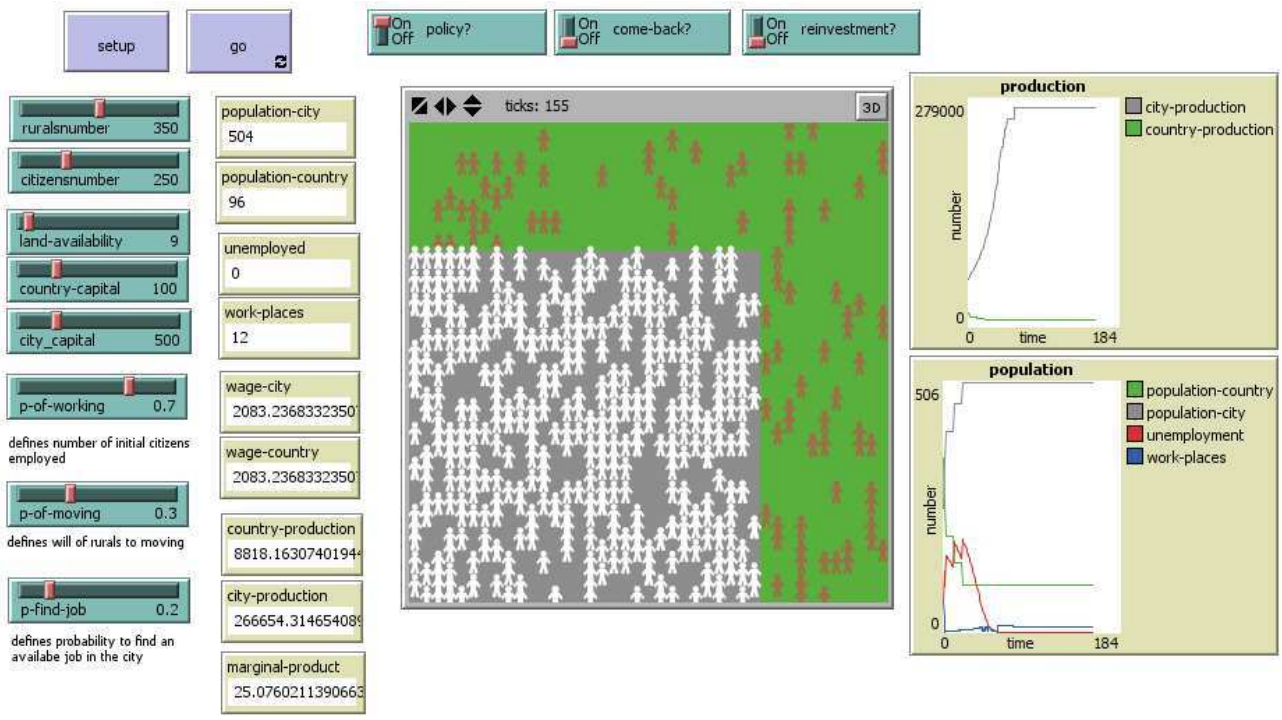
- Further implementation aims at analysing the effect exerted by "**come-back"** on the number of work places and, as a main consequence, on the unemployment level. The come-back is a switcher that, whenever is triggered, induce unemployed rurals, that have moved to the city, to come

back in the countryside in order to get their original job.

As we can see from the picture, as soon as the work places go to zero, the level of unemployment in the city starts to decrease. The interpretation is immediate: the rurals, realizing to be unemployed, start to come back to the countryside and, at the same time, the population country increases.



-The most significant switcher is **"policy"**, representing exogenous public measure aiming at solving unemployment and depopulation problems arising from previous simulations. The policy consists of the provision of subsidies both to citizens and rurals. Indeed, subsidies to capitalists are required to create jobs in order to rule out unemployment and subsidies to rurals are necessary to set city and country wages equal stopping massive migration.



We can now proceed our analysis nesting the switchers:

- The first trial is devoted to examine contemporaneous effect of **policy** and **reinvestment**: in the long-run the general effect will be the same of policy alone, i.e. zero unemployment in the city and a significant number of country population. However, there are some differences: indeed, thanks to the capitalists' willing of reinvest part of their gains, there will be no more need of public subsidies in the city environment determining savings for Treasury that only have to provide subsidies to the rurals to stop excessive migration flows.

- We proceed now to analyse the effect of the **come-back** and the **reinvestment** switchers.

While with come-back alone the unemployment noticeably decreased but without going to zero, now things are definitely improved since after some time the unemployment disappears. Thanks to the independent decision of firms to invest in the city and create new job places, rurals are hired by companies and the unemployment is completely absorbed. Moreover, the population country dramatically decreases and the reason is straightforward. Since in the city there are great job opportunities, rurals are not induced to come back home because they are already employed.

- The last simulation involves the simultaneous use of **policy** and **come-back:** the final result will be the same of the one with only policy on, i.e. zero unemployment in the city and a significant number of country population, but thanks to the rurals' willing of come-back to the countryside when unemployed, the public subsidies to agriculture environment will be more volatile because of the temporary return of rurals to home, which determine a temporary stop in the subsidies devoted to avoid depopulation.

4. Conclusions

The aim of this simulation was to discuss the Harris and Todaro Model from an agent-based perspective. Some remarks are noteworthy. First of all, it is important to highlight that our model disregards a lot of non-monetary variables such as those psychological and social costs which

most of the migrants have to face, like the loss of cultural roots or the condition of outsiders. Secondly, the creation of new workplaces turns to be surprisingly ineffective in decreasing unemployment because of the increasing migration. Therefore in order to deeply analyze this economic phenomenon and its implications, we introduce in the model three switchers. If on the one hand come-back and reinvestment result useless since the former does not annul unemployment and the latter empties the countryside, on the other hand policy results the most effective measure. Indeed the only way to stop migration and to rule out unemployment would be the provision of subsidies both to countryside and city in order to equalize city and country wages. Unfortunately, because of its high costs, it is not implementable in a real setting.