Simulating a job market with migration and different skill levels

Matteo Assandri, Noemi Oggero

Simulation models for economics
Academic Year 2013 – 2014

Contents

1 Introduction

1.1 Job market and migration

Quoting Nobel laureate John Hicks "differences in net economic earnings, mainly salary differentials, are the main cause of migrations"[1]. According to economic theory, migration can be simply seen as an investment: workers look for opportunities of a higher salary in foreign job markets and if the return over the long run is high enough to compensate the several costs of moving abroad, they decide to change country.

There are a lot of factors that increase the probability of migration. The wage differential is the most strong and immediate to spot, while others may be important as well, like worker's age and skill set: young and highly educated people are more likely to move away from their own country because on one hand they have the whole life in front of them, hence they have a longer time span to benefit from the investment, on the other hand highly skilled workers face a broader job market, hence when they look for a job their geographical research area is wider than for low skilled comparables. Moreover, highly skilled workers may decide to move because of the development of their careers: an experience abroad can be really valuable to obtain a promotion or to come back in a comparable position in the native country if they're not completely satisfied by the foreign way of life. From another perspective people with basic skills may decide to move in order to try to improve their situation, while this may not be the case for people with an average skill level, because they may be afraid not to find a comparable job environment as far as the value attributed to their skills abroad being forced to accept a worse one. To support this hypothesis it is worth to mention that probably the basic levels of knowledge needed are not too different among countries, while for the middle level there may be barriers, like the language. In the highly skilled job market competences are more homogeneous and communicative barriers are less likely to exist.

It is also necessary to mention facts that decrease the probability of migration that up to now we have simply called "costs", that in empirical works are mainly proxied by the distance between the country of origin and destination. In order to break down this category it is important to draw a distinction between material and psychological ones. Material costs are easier to spot, like airplane tickets or the higher cost of living, but probably they are less important than psychological ones: leaving a known environment, friends, family, the house where you grew up is what

[1] J. R. Hicks, *The Theory of Wages*, (1932), *MacMillan*, p.76.

really stop people from moving instantly as soon as they learn they can increase their salary somewhere else. Given the fact that the latter type of costs are harder to estimate the phenomenon of the "immediate return" is quite common because the projected return of the investment may be drastically revised once the worker is effectively in the new environment. When we analyze workers' costs related to the family we have to take into account the phenomenon of the so called "tied movers" and "tied stayers", that are people migrating because their partner can obtain an higher salary. Their decision to move can be formalized as if the couple behaves as a unique individual, hence they will opt to go abroad considering the sum of salaries in the native versus the foreign state.

1.2 Immigrants' effect on local job market

Once the migrants are in the new country they will interact in the job market with native workers and several layers of interaction can take place.
The simplest possible scenario economic theory suggests relies on the assumption that natives and immigrants are perfect substitutes in the production process, provided that they have the same skills, hence they will compete for the same open positions in the job market with a negative effect on salaries for a fixed demand.
However, also interactions among the different job markets within a country are worth to mention: each immigrant, no matter his skills, is not likely to have an impact simply on the sub-market of workers with comparable skills, but the externalities of the migration process will spread among the whole job market. A simple example of this pattern is the specialization of local workers when foreign ones come in, that is formalized by economic theory labeling these two categories as complements. Without the international flow of people some middle-skilled locals may choose to apply and obtain jobs that require only lower abilities in order not to be unemployed. Given the existence of non-natives immigrants with low skills, the just mentioned local category can specialize and strengthen their knowledge, in order to be more competitive as far as middle-level positions are concerned and increase consequently the salary. To sum up, they will not necessarily compete for the same jobs with incoming immigrants, but the presence of foreign workers may allow native to be better off. Conversely also the opposite can happen: middle-skilled immigrants may accept low-level jobs because they are discriminated or because their abilities are not recognized in the new country, competing with low skilled natives.
A still more complex pattern of interactions among job markets can be a positive externality of high-skilled immigration, that is usually mainly directed towards

industrialized and developed countries, especially, but not only, in high-tech sectors. An example of such mechanism can be the following: this particular type of immigration can increase the salary of lower skilled natives (and possibly attract lower skilled immigrants as a consequence) through their demand for services because those "special immigrants" are likely to have a salary above the average, hence they will demand premium services from the economic environment they live in. They may demand for high quality public services, hire a baby sitter for the children and eat in local restaurants. All these actions are likely to stimulate an increase in job demand in the region and spur its economic growth.

2 The NetLogo simulation

In our simulation we will consider an economy made up of three countries and three kinds of workers, high-skilled, middle-skilled and low-skilled. At the beginning of the simulation workers are placed randomly in countries: each patch will be characterized by a wage for each of these categories and some basic economic fundamentals as the number of available job per category, GDP, indicators of job market flexibility and an initial average unemployment. There is a high probability that each type of worker will face three different wages in the different countries. This is indeed what happens in realty since jobs which require the same capabilities are remunerated differently depending on the country. In our simulation we will assume that workers perfectly know the wages in all three States. Once they observe how much their job is remunerated in the two countries where they do not live in, they can decide to move with their family towards the country with the highest profitability.

It would be too unrealistic and not interesting to impose that the wage is fixed over time, so we will let it change over time: an increase in the GDP with respect to the previous cycle will create new jobs and the variation of salaries will be function of the difference between demand and supply. We will implicitly assume that in a country all employers of a specific category of workers pay the same wage, which we think is quite plausible. If in a country the wage for a category of workers, suppose low skilled one, is relatively high, low skilled workers in the other two countries will start migrating there, after having evaluated the economical convenience considering the costs of moving. However, we do not know in advance if all low skilled workers will move there since the wage fluctuates over time and families may be composed by workers with different skills, hence different "best destinations".

The aim of this work is to look for reactions of the agents to the simulated economic

environment as far as the migration of families with more than one component *vs* singles, the return in the native country after being abroad and the skill composition of the migration are concerned.

2.1 Setup of the world

The first procedure that is ran as the simulation starts is the setup of the world. In this passage we create the three countries of equal size and square shape, identifying them with different colors and we attribute to the patches the values of their own economic fundamentals as the *initial average unemployment rate* and the *salary base*.[2]

Then the world is populated: we create a *number of workers* that are sent to one of the countries with equal probability: if the user decides to keep in off-mode the *AsymmetricSkills* switcher, in each country the will be the same distribution of skills, while if the switcher is on the simulation will try to reproduce the situation of a world with a developed country, a developing one and one in the middle of them as far as skills distribution is concerned.[3]

Once workers own skills, they are grouped into families: each worker will be attached a "surname" and will be linked with its relatives behaving as a unique individual (i.e. maximizing the familiar income rather than the individual one[4])

```
ask workers [
   if pcolor = gray [ set familyN random(count(workers with [pcolor =
      gray])) + 1000]
   if pcolor = yellow [ set familyN random(count(workers with [pcolor =
      yellow])) + 2000]
   if pcolor = sky [ set familyN random(count(workers with [pcolor =
      sky])) + 3000] ]
```

notice that in this step we made the important assumption that families are formed only among individuals in the same country thanks to the per-country constant, but on the other hand the procedure allows to have families with only one member, for a better fit of reality. In that case the procedure below will recognize only one worker as member of its family.

[2]Variables in italic are user's inputs, mainly through a slider.

[3]The composition of the workforce in developed and developing countries has been obtained from R. J. Barro, J. W. Lee (2010) A New Data Set of Educational Attainment in the World 1950 – 2010.

[4]J. Mincer, (1978) "Family migration decision", *Journal of Political Economy*. J. DaVanzo, (1976) "Why families move: a model of the geographic mobility of married couples". S. Sandell (1977), "Women and the economics of family migration".

```
ask workers [set myFamily workers with [familyN = [familyN] of
    myself ]]
```

Obviously workers will have to take into account costs of migration in taking their decision. As previously mentioned, we can divide costs of migration into material and psychological: the first type of costs is set equal for all workers who live in the same country since they include the cost of travel and comparables and are proxied by the *distance between the country*[5] of origin and destination. Psychological costs differ among people since they depend on the network of relationships built with family and friends, moreover we cannot assume them constant over time since the underlying relationships are not, hence we let them be different for each worker and we set the psychological costs of the family as the sum of the costs of each member. The only assumption we have made about these costs is that they are lower when the worker is abroad, assuming an emotional tie with the native country, and if the workers is highly skilled, since it is likely to have a bigger ability of finding new opportunities, hence it is more prone to leave.[6]

Since we have assumed that workers have perfect knowledge about job markets in foreign countries, they will collect information about what they could earn moving (in the `collect_info` procedure), then compute the total familiar income and the total familiar costs.

Now the job market is created. Since the GDP can be seen as the sum of salaries paid by firms, we fix the GDP of the period before the simulation starts as if each worker in the country earned the *base salaries* divided by 2: this will create a GDP positive shock as the simulation starts, changing salaries and letting migrations happen. The current GDP is simply calculated as sum of the salaries of workers in the country of interest, while we set the initial condition of the job market according to the *initial average unemployment rates* as shown below.[7]

```
ask patches [let x count workers with [skills = 1 and pcolor = [pcolor]
    of myself]
            set jobL round(x - x * initial_unempl_rate) ]
```

Each country will be characterized by a single average unemployment level and not by a per-category one because it would have been probably confusing for the user: according to our simplification the user will have to select only 3 values, while in the other case they would have been 9.

Initially salaries in countries are set as the *base salary* decreased by a simple function of the number of workers per category: this will create an immediate

[5] G. Borjas (2010), Economia del lavoro, *Francesco Brioschi editore*.
[6] U.S. Bureau of the Census, "Geographic mobility: 2004", table 6.
[7] A symmetric code is present for `skills` = 2 and `skills = 3`.

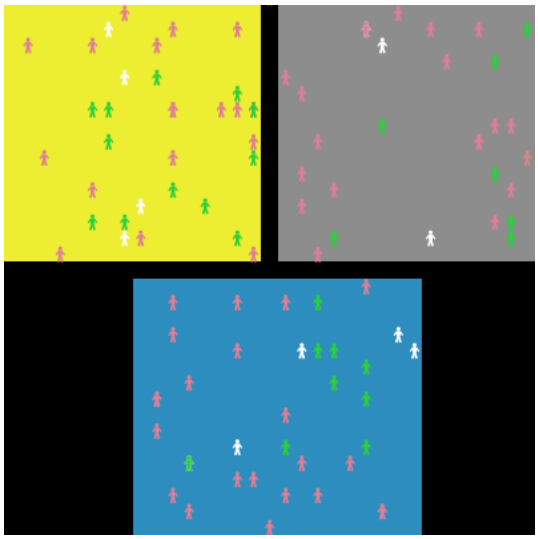


Figure 1: The visual output of the setup procedure with three countries and three types of workers

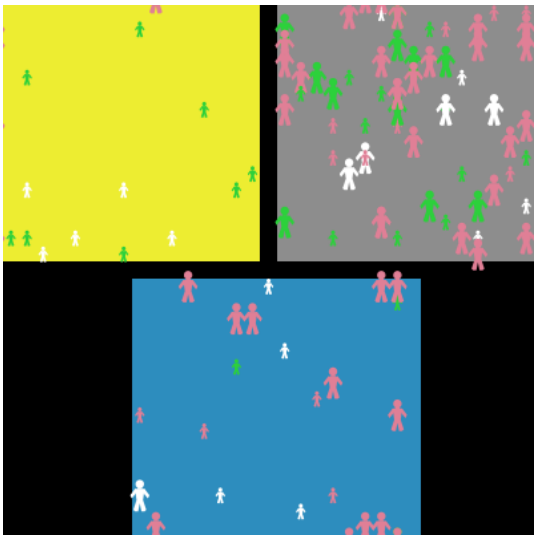


Figure 2: Typical output of a go procedure. Migrants are bigger than natives and mainly in one country

salary differential among countries. In order to keep into account the possibility of being unemployed, the workers consider the expected salary, multiplying it by the probability of being employed. As shown in the code below we will consider the probability of being employed as the ratio between the overall number of jobs and the actual workforce: the expectation is applied to the current familiar income. If the number of available jobs is higher than the number of workers, clearly the probability of employment will be 1.[8]

```
ask workers [let x count workers with [pcolor = [pcolor] of myself]
             let tot_jobs [jobL] of patch-here + [jobM] of patch-here +
                 [jobH] of patch-here
             let prob_employement tot_jobs / x
       set actual-familyIncome actual-familyIncome * min (list 1
           prob_employement) ]
```

Notice that in the model there is no way for a worker to improve his skills and change its category, hence the comparison among levels salaries of different skills makes no sense since the model is based on per-category wage differentials: it only matters that salaries of the same category has the same order of magnitude.

[8] A symmetric code is present in order to evaluate the expected value of the familiar salary in foreign countries.

2.2 Migrations and job market adjustment

The go procedure can be repeated as many times the user wants. First of all economic fundamentals of the job markets are updated: if the GDP is bigger than in the previous cycle new jobs will be created, but if it decreases, nothing will happen as far as the number of available jobs is concerned. In order to convert the change in the GDP into new jobs we will multiply it by a *constant* (`GDP_job_multiplier`) that will capture the reactivity of the economy to adapt to the new GDP level, obtaining the effective variation in the number of job positions (`DeltaJob` in the code below). Such first effect is assumed constant for all categories.

```
ask patches [
   if deltaGDP > 0 [set jobL jobL + deltaJob set jobM jobM + deltaJob
      set jobH jobH + deltaJob
```

This is a simplifying solution with respect to the creation of complete demand and offer functions for each category for each country, that would have required a too complex structure. As result of that assumption we will have a non-decreasing number of jobs and given that the amount of workers in the world will be fixed during the whole simulation, we expect salaries to follow mainly an upward trend since demand will probably be higher than supply on average unless the number of workers is higher than the number of jobs.
The increase in the GDP will have also other effects as far as the creation of new jobs is concerned: the effect will be greater for the category in which the country is already specialized. We call x the number of workers with low skills in the country, y the number of middle skilled and z the number of highly skilled

```
   if x > y and x > z [set jobL jobL + deltaJob / 3]
   if y > x and y > z [set jobL jobM + deltaJob / 3]
   if z > x and z > y [set jobL jobH + deltaJob / 3]
```

Up to now we have described a quite ordinary and simplified economy, but we want to make the simulation more realistic by considering the effects that a migration of a category of workers has on others. While the migration of the low skilled workers does not have any effect on the decision of migration of middle and high skilled ones, the converse is not likely to be true. Actually a high number of pretty qualified workers, who earn an important amount of money, can stimulate the migration of low skilled workers by increasing the demand of services that they provide[9] (e.g. we can think about the demand for household chorus by workers who lives alone in the new country). In order to capture this aspect we will increase the number of jobs

[9] E. Moretti, (2012), "The New Geography of Jobs" *Houghton Mifflin Harcourt.*

for low skilled individuals by the number of new jobs for highly skilled multiplied by a *coefficient* that weights this dependence[10].

```
set jobL jobL + deltaJob * snowball_effectLH]
```

The sum of the changes above will have an impact on salaries. If the number of jobs for a given category (e.g. `JobL`) is different from the number of actual workers with that specific skill in the country (e.g. `x`), the salary will be updated of the variation times a country-level *constant* (`job_market_flex`) that will capture the reactivity of the salary with respect to unbalances in demand and supply. Notice that if the number of jobs is greater than the number of workers available, `(jobL - x)`> 0, hence the salary will increase, while it will decrease when the term in brackets is negative.

```
if x != jobL [set salaryL salaryL + [job_market_flex] of self *
    (jobL - x)]
if y != jobM [set salaryM salaryM + [job_market_flex] of self *
    (jobM - y)]
if z != jobH [set salaryH salaryH + [job_market_flex] of self *
    (jobH - z)] ]
```

Once this step is completed, workers will internalize the new salaries around the world and update the expected family-related incomes and costs. Psychological costs are different each cycle, since, as argued above, it would make no sense to let them fixed over time.

As a consequence of salary differentials workers will then migrate.

If the familiar salary in the actual country is less than the sum of wages members can obtain elsewhere (taking into account distance and personal costs), workers will move with the whole family. An example of such code is reported below for people in the Gray country: the first part of each `if` statement will determine if it is convenient to move, while the second one, after the `and`, will ensure that the family will move towards the best destination. The `set size 2` command will allow the user to see migrants in the visual representation of the model, since they will be bigger than native workers.[11]

```
ask workers with [pcolor = gray][
 if actual-FamilyIncome < FamilySalaryYellow - Distance_Gray_Yellow -
    family-costs and FamilySalaryYellow - Distance_Gray_Yellow >
    FamilySalarySky - Distance_Gray_Sky
```

[10] According to the previously quoted Moretti's book each new job for highly skilled people in the high-tech sector will create 5 new jobs for low skilled ones.

[11] Again, a symmetric procedure about other countries is present.

```
[set size 2 set away 1 move-to one-of patches with [pcolor = Yellow]
  ask myFamily [set size 2 set away 1 move-to one-of patches with
      [pcolor = yellow]]]
if actual-FamilyIncome < FamilySalarySky - Distance_Gray_Sky -
    family-costs and FamilySalaryYellow - Distance_Gray_Yellow <
    FamilySalarySky - Distance_Gray_Sky
[set size 2 set away 1 move-to one-of patches with [pcolor = Sky]
  ask myFamily [ set size 2 set away 1 move-to one-of patches with
      [pcolor = sky]]] ]
```

As mentioned in the theoretical introduction some migrants may decide to immediately come back in the native country because they realize the decision of migrating was wrong in the first place, mainly because costs were underestimated, giving place to the phenomenon of the immediate return. We assumed that it is a feature typical of singles, because families are more likely to make carefully pondered decisions and less likely to occur for highly skilled individuals because they probably are less likely to make a wrong estimate of the real costs. The `away = 1` variable means that we consider only workers that have left the native country in the current cycle.

```
ask workers with [away = 1 and count myFamily = 1 and skills !=
    3][let x random-float 1
  if x < 0.10 [set immediate-return 1 set size 1 move-to one-of
      patches with [pcolor = [native-country] of myself]]]

ask workers with [away = 1 and count myFamily = 1 and skills = 3][let
    x random-float 1
  if x < 0.05 [set immediate-return 1 set size 1 move-to one-of
      patches with [pcolor = [native-country] of myself]]]
```

After the migration process took place, values of the GDP are updated: the current one become the old, while the new GDP level is computed in order to be used in the following cycle of the simulation.

2.3 The output

The output of the simulation is constituted both by the visual representation of agents in the states and by several charts that are produced.
Probably the most important charts are the ones showing how salaries change over time in the three countries, because any interpretation of the other ones has to be linked to their behavior.
Other charts show how many migrants come back in their native country each cycle

with reference to the total number of migrants in that moment around the world and the number of migrants that are part of a family with more than one member *vs* how many of them are singles.
The last graphs visualize the migration flows through the number of immigrants in each country, while we keep also track of the changes due to the migration process as far as each country's workforce composition is concerned.

3 Performed simulations

3.1 Preliminary tests

First of all we have performed some simulations with the only aim to test whether our simulation was able to recreate obvious pattern in the job market. As shown in the following figures the creation of families allowed the tied movers and tied stayers effect to take place, in fact those workers are not in the country that maximizes their own wealth, but they accept a lower salary because the family can benefit from migrating (or not migrating).

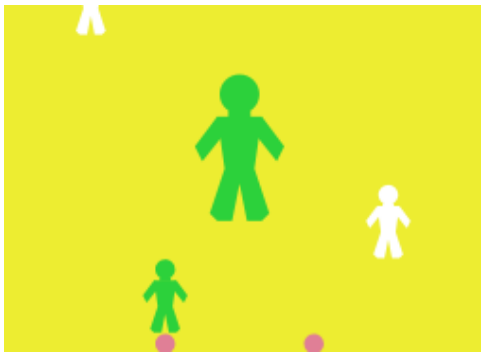


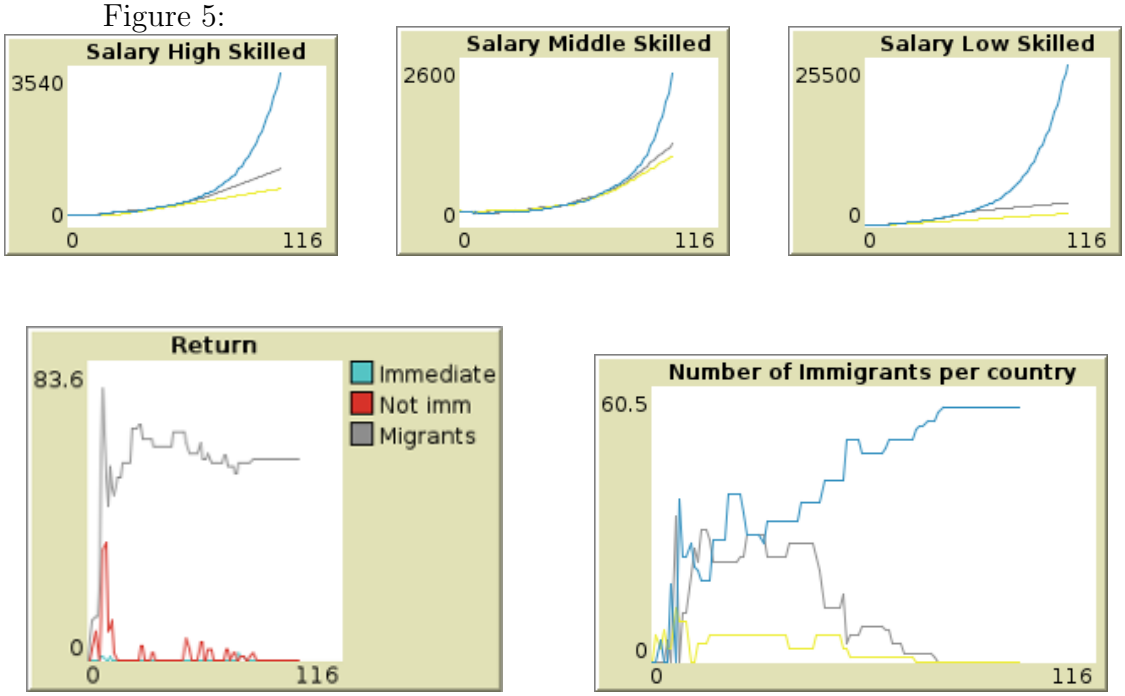
Figure 3: A middle skilled tied stayer

Figure 4: Detail of its internal variables

The example in the figure above shows how the actual salary of the worker is 229 and he could easily move to the country sky to obtain 237. However his familiar situation prevents him to do so: the family would be worse off moving.[12]
Another test for the goodness of our simulation was to check if, when salaries skyrocket in a country, all workers will converge there, and that's the case. As shown in the image below, wages in country Sky are significantly higher than the others for each one of the categories of interest: as a consequence, once the differential is sufficient, each family will move to such place.

[12]In the simulation originating the screenshot the distance and the personal costs would have allowed the migration of the single (i.e. their sum was less than 8) and the unemployment rate was not an issue. Moving to Gray was not an option because of the distance.

Figure 5:



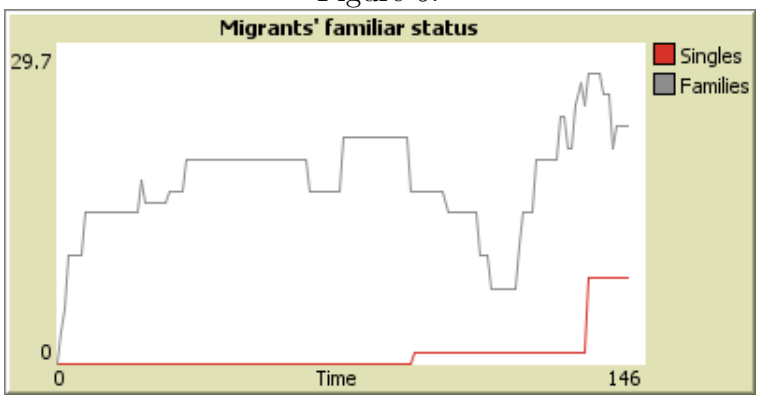
We can notice that, given the above salary distribution, the number of immigrants that returned in their native country is stable and equal to 0 in the last cycles of the simulation, while the number of migrants is below its peak: each worker form country Sky that migrated in the past came back and each foreign worker moved to Sky, as shown in the chart on the right, from where we can notice that no immigrants are present in Yellow or Gray.

3.2 Experimental results

A very interesting result arises if the distances among the three different countries are pretty high, while other values are neither too high nor too low and similar among the countries, while the asymmetric skills switcher is off. Indeed, as we can notice from the figure 6, at the beginning of the simulation and for many cycles, singles are not able to migrate. On the other hand, there are families made up of more than one component that migrate immediately. This is due to the fact that the income of the family is greater than the income of a single, and this surplus in the income can be used to cover the material cost of the migration that is represented by the distance between the country where workers are and the one where they could earn more. Indeed a worker decides to migrate if the actual family income is lower than the income the family would have in another country subtracting material and psychological costs of the family, which do not play an important role when there are very high material costs. After some time, also singles start

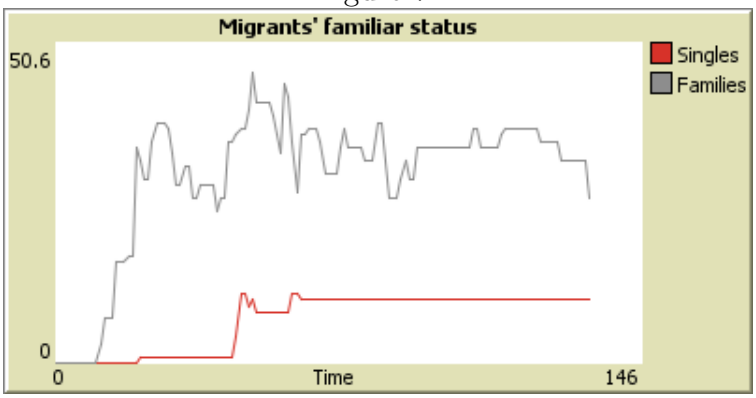
migrating since wages are likely to increase and to become high enough to cover the material costs of migration.

Figure 6:



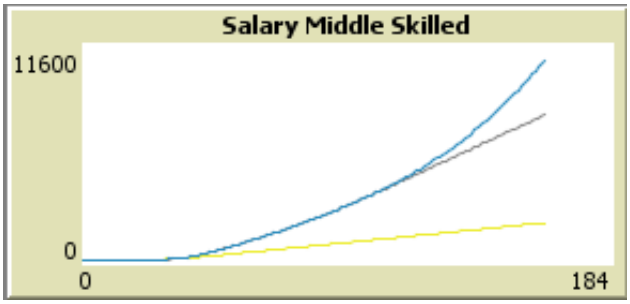
On the other hand, if distances among the countries are not too big, keeping constant the other values, we notice that singles start migrating after few ticks.

Figure 7:



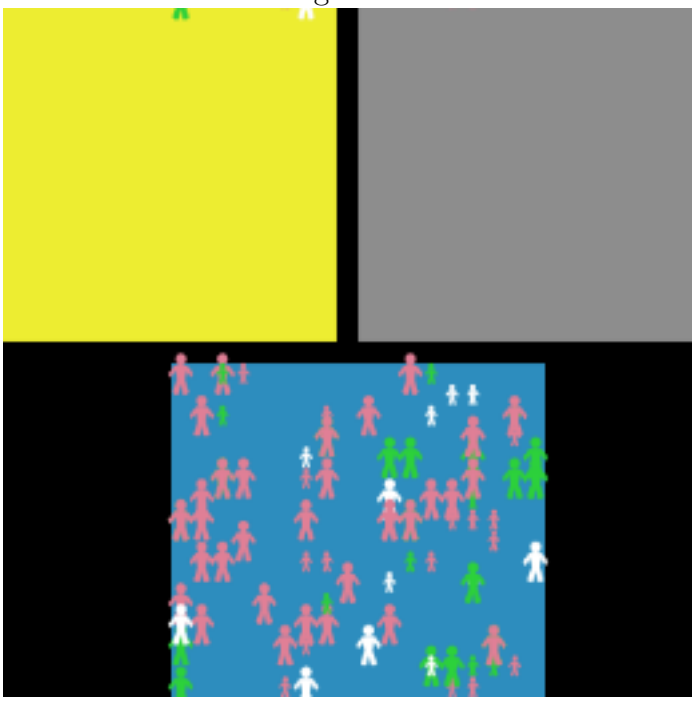
It is also interesting to see what happens if a country (e.g. the Sky country) has a more flexible job market with respect to the other two nations as shown in figure 8.

Figure 8:


Salary Middle Skilled
11600
0
0
184

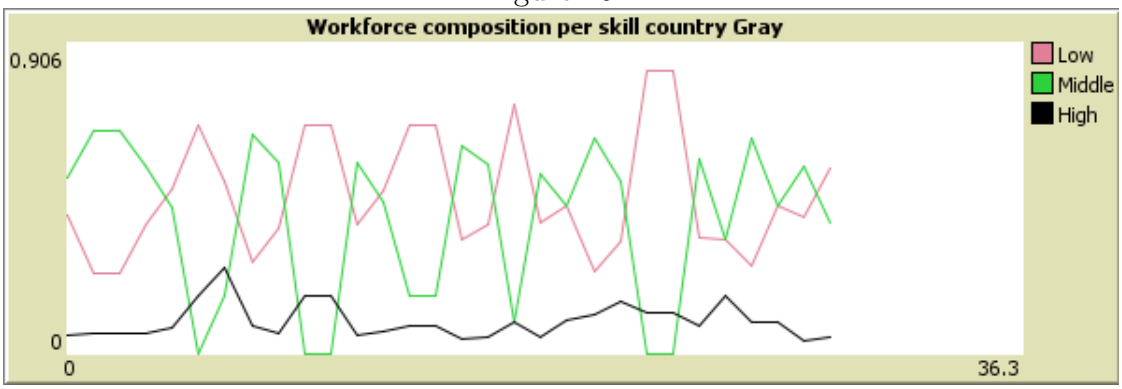

Salary Low Skilled
40200
0
0
184

Figure 9:



An higher salary with respect to the other countries is due to an high job market flexibility in that country since in this way the salary reacts very much to a difference between the number of jobs and the number of workers.
From the three charts about salaries we can see that the salary in the Sky country is the highest for all the three categories of workers. As a result, after some time the economy reaches a steady state equilibrium: almost all the workers are in the country with the highest salary, as we can see in the figure 9. We can see that if the wages differential among different countries is really high, both material and psychological costs become irrelevant, therefore workers decide to migrate.
An higher salary with respect to the other countries is due to an high job market flexibility in that country since in this way the salary reacts very much to a difference between the number of jobs and the number of workers.
From the three charts about salaries we can see that the salary in the Sky country is the highest for all the three categories of workers. As a result, after some time the economy reaches a steady state equilibrium: almost all the workers are in the country with the highest salary, as we can see in the figure 9. We can see that if the wages differential among different countries is really high, both material and psychological costs become irrelevant, therefore workers decide to migrate.
In some simulations, from the charts about the workforce composition per skill we can directly see the effect that an increase in high skilled workers has on the low skilled immigration. Indeed a high number of pretty qualified workers can stimulate the migration of low skilled workers by increasing the demand of services that they provide. Taking a chart about the Gray country as an example, especially at the beginning we notice that an increase in the black line representing high skilled workers corresponds to an upward trend in the pink line representing low skilled category. Obviously this is not always the case since there are other factors that influence the salary and the migration of low skilled.

Figure 10:



4 Conclusions

After having run pretty much experiments, we can affirm that our model reflects some features of real job markets. First of all, we have described how workers are bound by the family when they take the decision of migrating. There are people that would not migrate if they were singles, but they do it because after the migration of the whole family would be better off (tied movers) and others that cannot migrate even if their salary would be higher because the family is better off in the actual country (tied stayer). Secondly, if in our model the wages differential is really high, workers are more likely to migrate since the increase in income is greater than the costs of migration. Moreover, this model allowed us to investigate how being a member of a family helps in migrating when there are huge material costs to face and how the flexibility of the job market attract foreign workers. Finally, thanks to the charts that show the skills of the workforce, we analyzed the effect that high skilled workers have on low skilled ones. Obviously this model could be improved. For example, it could be more realistic to create more complex functions to define the supply and demand of workers and to allow workers to improve their skill level or accept jobs below their abilities. Besides, as we said in the introduction, the migration depends also on the age, a variable that could be added.