LABOR MIGRATION, FROM AN ECONOMIC MODEL TO AN AGENT BASED MODEL

Samira Boulahbel-Bachari – Nadjia El Saadi

Abstract

The proposed migration model of workers considers migration as a multifactorial and multidimensional phenomenon. Multifactorial because it considers economic and socio-demographic aspects in the decision to migrate in the two regions concerned by migration (origin and destination), and multidimensional because it integrates micro and macroeconomic analysis levels according to their economic, social and political dimensions.We use an agent-based model (ABM) that allows us to consider several parameters simultaneously unlike conventional methods. It also offers the opportunity to study the interactions at the micro economic level and simulate the emerging macroeconomic behavior. ABM also facilates testing multiple configurations of the studied process quickly, unlake intuitively or analytically methods.Two types of agents are considered: regions and individuals. Their behavior is controlled by a set of evolution's rules and constraints and is formulated by mathematical equations.

Key words: Agent Based Model, Economic Model**,** Internal Labor Migration, Mathematical Equations.

JEL Code: J101, J662, R223

Introduction

Currently, migratory movements in the world concern almost a billion people and are made mainly inside the countries. Developing countries are the most affected by these internal movements which often explain the high rate of urbanization of these countries.

Despite the fact that internal migration can occasionally creates considerable richness, it still remain the most notable representation of the regional disequilibriumin in terms of development programs, employment, endowments amenities and local public goods.Given the subjacent social and development problems it causes, the internal migration represent an interesting study topic for researchers and policy makers.The main economic theories of migration generally study migration from a single angle of approach. According to the dual economy's models (Lewis, 1954; Harris & Todaro, 1970), labor migration results from an imbalance in the distribution of labor between regions presenting different levels of

development. The transfer of labor will continue until the surplus of the agricultural sector is absorbed. In human capital theory (Sjaastad, 1962), the decision to migrate is seen as an investment and its cost represents the key element of displacement. The gains and costs of the migration process depend strongly on the individual characteristics of migrants, allowing a self-selection of migrants and a heterogeneity in the ability to migrate for different categories of people. Human capital models take into account several factors in migration's analysis but unfortunately remains difficult to test empirically.At the end of the 1970s, Stark's work (Stark, 1978), revitalized the debate on migration by placing the migrants' behavior in a wider societal context. The New Economy of Labor Migration(Taylor, 1999) introduce the family's support in the migration decision and consider migrants'cash transfers. These transfers represent a kind of insurance from labor risks for the family and diversification of its income resources. Despite the enrichment of migration's analysis by adding new variables (like labor's turnover rate, the presence of a syndicate, migration networks…), the majority of current models simplifies behavioral mechanisms and decision-making of migrants.

In this paper, we propose an agent-based model of internal migration of workers that considers economic and socio-demographic aspects in the decision to migrate in the two regions concerned by migration (origin and destination). Modeling migration with agent-based models is very recent and models can range from minimalist modelling (Espindola et al, 2006 and El Saadi et al, 2010) to more sophisticated modelling (Naqvi, 2014).However, the level of modeling especialy in the migration decision in these works, remains aggregated (Klabunde, 2016).

The proposed model considers several parameters simultaneously and integrates micro and macroeconomic analysis levels. The migration decision is described by a process of two stages that guarantees auto selection of migration. The paper is structured as follows. In Section 1 we present our economic model of labor migration. Section 2 is avoid to the agentification of the economic model proposed. In Section3 we present our simulation and discussion resluts. A conclusion summerizes the essentiel work presented.

1. The economic model

The proposed model aims to produce a complete and quite realistic migration model. It describes the behavior of individuals at a non-aggregated level ensuring heterogeneity of agents and finesse in the analysis. The model also tends to capture the impact of individual actions on

aggregate variables and regions. The main assumption of the model is the objective of individuals to find a decent job to protect them against potential risks they may be exposed, such as health problems and conditions of insecure work.

The proposed model is inspired by Todaro's models of rural urban migration. Todaro's models (Todaro,1969; Harris–Todaro,1970) are based on the foundations of technological dualism and explain the growing rural-urban migration in spite of an increase of urban unemployment.

Unlike the Todaro's models, we distinguish between workers in the informal sector and the unemployed workers because we admit that the integration of informal employment is not spontaneous, and that working in this sector does not leave much time for job search.

Workers migrate from an origin area with a rate of creation of decent jobs relatively small, high dispersion in income and a small formal sector, to a destination region with greater potential (most important economic activities).

We suppose in this model that migration is a selective process. We assume that young people and singles are more mobile than older. They get from migration more profits over a longer period than older and married people with children. Also according to gender, we suppose that men migrant have a higher propensity to migrate than women migrant. Concerning the level of education, we assume that qualified individuals can move quickly and have a higher probability to find a job probably due to their efficient use of information.

The decision to migrate depends on the expected gains in the rural and urban region. We admit that the gain calculation depend on the difference between expected wages like in the Todaro's models:

$$W_{i,j}^{e} = P_i^{j} \times W_{i,j} \qquad (1)$$

Where:

- $W_{i,j}^{e}$ is the expected wage for individual i in Region j;
- $W_{i,j}$ is the wage of individual i in Region j;
- P_i^{j} is the probability of finding a decent job in Region j,

The probabilities of finding a decent job depend on qualification of agents. If the individual is

$$P_i^{j} = \begin{cases} \frac{NQPos_j}{A_j} \\ \frac{Pos_j}{A_j} \end{cases} \qquad (2)$$

Where

- $NQPos_j$ is the unqualified formal positions in Region j,
- Pos_j is the total formal positions in Region j,

- A_j represents agents searching a decent job (unemployed one and workers in the informal sector).

Wages are different from an individual to another to guarantee their heterogeneity and depend on individuals' qualification, the minimum salary and the region's wage dispersion:

$$W_{i,j} = \bar{W} \times Q_i + \sigma_j \times \mathrm{r}(0, \sigma_j) \qquad (3)$$

Where

- $W_{i,j}$ is the wage of individual i in Region j,
- $\bar{W}$ is the minimum salary,
- σ_j is the wage dispersion of Region j,
- $\mathrm{r}(0, \sigma_j)$ is a random realization of uniform law

The migration process concerns both the unemployed persons and the workers in the informal sector.

The proposed model studies the job search process in all regions. We suppose that the probability to be hired increase with the qualification and the time spent on the search. Todaro formulated this probability (Todaro,1969):

$$\pi_i^j(t) = \pi_i^j(t-1) + (1 - \pi_i^j(t-1)) \times P_i^j(t) \qquad (4)$$

Where

- $\pi_i^j(t)$ is the probability to be hired for agent *i* in Region *j* at time *t*,
- $P_i^j(t)$ is the probability to find a job for agent *i* in Region *j* at time *t*.

Population's evolution is a fundamental element for the model since the study of the phenomenon is largely dependent on the individual characteristics and on the current and expected demographic changes. The individuals' state evolves in time and change throughout their life cycle. The main simulated demographic events are births, deaths, marriages, divorces, promotions and school dropouts.

For agents' economic transitions, a proportion of inactive persons will enroll in vocational training, while other inactive people will start looking for work and become unemployed. Some unemployed workers will create their own business while other employers will lose their jobs due to a deficit in their business. Some workers in the formal sector will lose their jobs because of job destruction and become unemployed.

2. Agent-based migration model

Our migration model was was realized by the use of Multi-Agents System (MAS). According to the definitions given by J.Ferber (Ferber,1995), a MAS is a system composed by an environment, a set of agents and rules. The environment is represented by a space that usually has a metric. The agents represent the active entities of the system. They can create, destroy and modify a set of objects. These objects can be associated to a position at a given moment. A set of operations allows agents to perceive, produce, consume, transform and manipulate objects.

For our model, we use the bottom-up approach by making assumptions about individuals' behavior and their motivations and then we observe their collective behavior. This approach makes possible to discuss hypothesis taken at the individual level and allow us to understand the resulting collective behavior.

The model is divided into several modules: 1) Definition Of Agents, 2) Migrating Decision Process, 3) Job Searching Process, and 4) Economic And Demographic Transitions.

2.1 Definition Of Agents

Two type of agents are considered:

- Agent individual that can be either employee affiliated to the social security employee not affiliated to social security, unemployed or inactive. He is described by his age, employment status, educational level, and qualification;
- Agent Region represented by a region of Origin and a region of Destination. Each Agent Region is represented by its population, unemployment rate, job creation and destruction rates, salary levels, birth and death rates and its success rates in the diffrent education's levels.

2.2 Migrating Decision Process

Migration decision of individuals is taken in two steps: selection of potential migrants, determination of final migrants. The pseudo code displayed at the bottom summarizes this process:

Migration Decision Process
Take an individual "j" unemployed or informal worker from Origin and aged [15, 59]
Calculation of the propensity to migrate F_j
if F_j> Threshold, then
Migrant_potentiel = True
Calculation of migration's gains G
If **G** > 0, then
Migrant = True
All agents « j » of the Origin region are treated?

No: Return to the first point and randomly choose an agent;

Yes: Go to step job search.

2.3 Job searching Process

All individuals aged between 15 and 59 years, in a situation of unemployment or informal work are concerned by this process in the two regions. Qualified people can apply for skilled and unskilled jobs unlike Unqualified people that candidate for unskilled jobs only.

Job Searching Process

Agents "j" of origin and destination regions, aged[15, 59], unemployed or informal workers

Calculation of π_i (t);

Ranking agents in descending order according to π_i (t);

Assigning Agents to vacancies;

For the remaining job seekers:

If Unemployed = True, then

searching_time = searching_time + 1

If searching_time = searching_time _max, then

Inactive = True

2.4 Economic and Demographic Transitions

The simulator begins by removing the dead agents and incrementing the age of the remaining agents by one year. Then, new agents are added and the simulator affects the initial values of the variables relating to their characteristics. The next step concerns divorces and marriages.

For the education component, the simulator takes into account drop-outs by level of education. For children aged 6 years, they enter school for the first time and change their status from inactive to student, and and their level of education from uneducated to "primary". Students who have dropped out of school will also change their status. Depending on their age, they may become unemployed, inactive or housewives. The rest of the students / pupils will be promoted one year and some of them will graduate.The simulator also deals with the economic transitions described above in the economic model by applying probabilities and random draws.

3 Simulation Results and Discussion

The model of internal labor migration is tested on Algerian labor market data of 2011 in order to simulate the evolution of labor movements from small rural towns to urban centers with

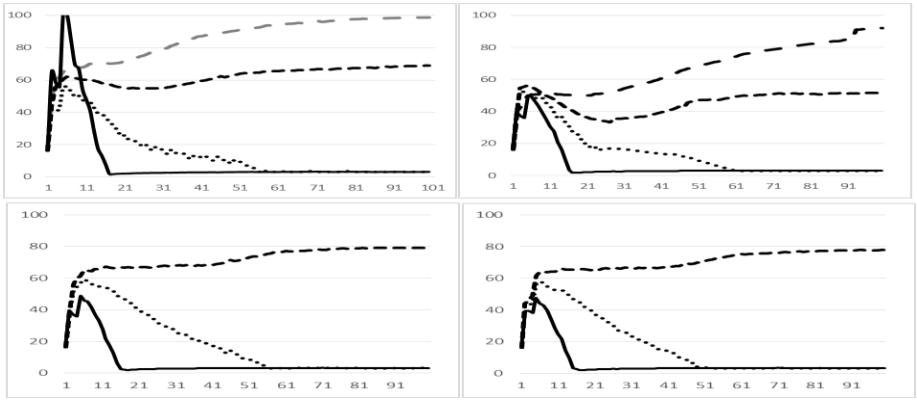
higher levels of development. The General Census of Population and Habitat data is used to determine the demographic properties of population.

The realized simulator considers two regions: Origin Region representing Rural and Destination region with urban character. The number of individuals considered in simulation is 9900.According to the latest estimates of internal migration in the General Census of Population and Habitat, cities with the largest migratory flows have similar population sizes. Several scenarios are tested according to the rate of urban and rural employment job creation. The job creation rates used represent different levels of job creation ranging from low to high rates (0% to 10%). These tests allow us to study the impact of job creation on migration flows and the effect of migration on labor markets' evolution in rural and urban area.

The simulation results obtained are studied over a very long period of one hundred years. For the urban unemployment trends presented in Figure-1, and with respect to the different rates of Urban Job Creation (UJC), the highest unemployment rates are recorded with the lowest rates of UJC. We note a significant increase in unemployment rates whatever the value of UJC. This increase is higher when UJCs are important. This increase is due to the size of the migratory flows that increase with the number of employment opportunities in the urban area. For job creation rates less than or equal to 2%, unemployment continues to increase over the years. On the other hand, when UJCs are above 2%, and after a short period of increase, unemployment rates decline (at differentiated speeds, of course) until almost cancellation. High job creation rates attract more people, but allow them to be absorbed by the labor market in a faster way. If we look more closely at the results, for a 5% UJC (represents a high rate of job creation) we find that it would take nearly sixty years to eradicate urban unemployment in the face of massive rural migration. By applying a rural employment creation rate (RJC) of 2%, urban unemployment decreases and peaks in urban unemployment rates disappear because of the decrease of migration. For RJCs above 2%, the influence of rural migration on urban unemployment is no longer as significant and the changes in unemployment rates are mainly due to variations in UJCs.

Fig. 1. Variations of Urban Unemployment rate for different values of UJC: UJC =0 .10 (solid black line); UJC =0 .05 (dotted line); UJC =0 .2 (dashed line) and UJC =0 (solid grey line). (a) RJC 0%; (b) RJC 2%; (c) RJC 5% and (d) RJC 10%.

(a) **(b)**

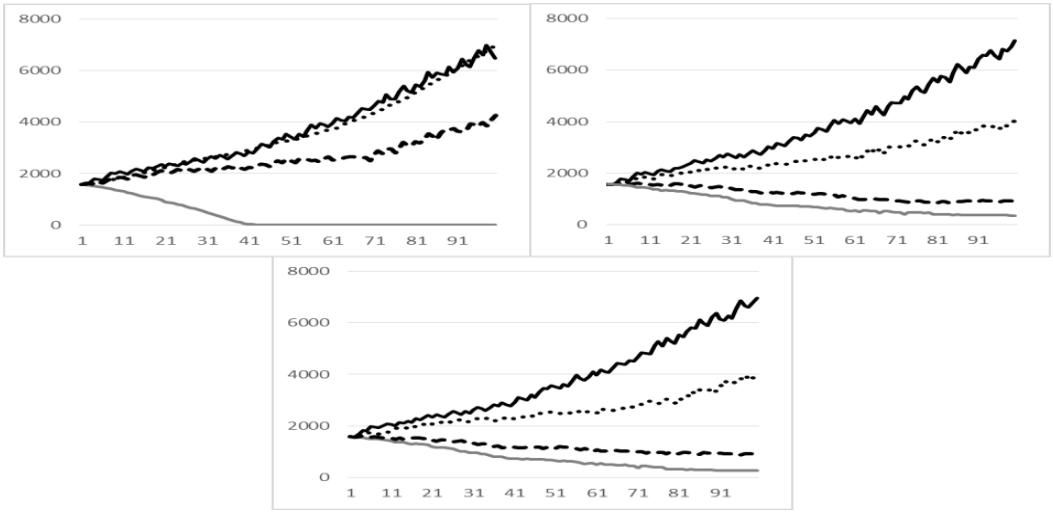


(c) **(d)**

For the evolution of rural employment in Figure- 2, the influence of the UJC is significant for the RJCs less than or equal to 2%. Therefore, when RJCs are low and UJCs are high, rural employment tends to disappear. The influence of the UJC on the Rural is more important than the influence of the RJC on the Urban.

Fig. 2. Variations of Rural Employment Urban Unemployment for different values of RJC: RJC =0 .10 (solid black line); RJC =0 .05 (dotted line); RJC =0 .2 (dashed line) and RJC =0 (solid grey line). (a) UJC 2%; (b) UJC 5% and (c) UJC 10%.

(a) (b)



(c)

Conclusion

The work presented in this article illustrates the value of the use of multi-agent systems in the study of socio-economic phenomena and more particularly in the study of internal migration of workers.

The designed model is quite complex. It incorporates, in addition to individual characteristics, behavior variables of the agents to reflect at maximum real decisions taken by workers.

The decision to migrate of the model and individuals' probabilities in the job search process ensure integration of selective nature of migration.

A test of the model is released on the Algerian labor market data of 2011. This test highlights all the complexity of the exercise in terms of the very large amount of data useful for its implementation and which, unfortunately, is poorly available. The results obtained, as a test of the model, must be observed in the light of this constraint.

However, some limitations to the model need to be improved. Some transitions of states in the labor market are not clearly defined as those for students, employers and self-employed. This limitation is mainly due to the lack of data such as experience in the job, wages offered by qualification, job creation by sector and size of firms. From a theoretical point of view, the integration of a job matching function will allow agents to better target job positions in line with their level of qualification. These extensions could foster the development of a more robust and comprehensive integrated model that can facilitate the development and evaluation of public employment policies for the sustainable development of rural areas and the urbanization of cities.

References

[1] El Saadi, N., Bah, A., & Belarbi, Y. (2010). An agent-based implementation of the Todaro model. In Q. Bai & N. Fukuta (Eds.), Advances in practical multi-agent systems: Studies in computational intelligence (Vol. 325, pp. 251–265). Berlin: Springer.

[2] Espíndola, A. L., Silveira, J. J., & Penna, T. J. P. (2006). A Harris-Todaro agent-based model to rural-urban migration. Brazilian journal of physics, 36(3A), 603-609.

[3] Ferber, J. (1995). Les systèmes multi-agents : vers une intelligence collective. InterEditions.

[4] Harris, J. R., & Todaro, M. P. (1970). Migration, unemployment and development: a two-sector analysis. The American economic review, 60(1), 126-142.

[5] Klabunde, A., & Willekens, F. (2016). Decision-making in agent-based models of migration: state of the art and challenges. European Journal of Population, 32(1), 73-97.

[6] Lewis, W. A. (1954). Economic development with unlimited supplies of labour. The manchester school, 22(2), 139-191.

[7] Naqvi, A. A., & Rehm, M. (2014). A multi-agent model of a low-income economy: simulating the distributional effects of natural disasters. Journal of Economic Interaction and Coordination, 9(2), 275-309.

[8] Sjaastad, L. A. (1962). The costs and returns of human migration. Journal of political Economy, 70(5, Part 2), 80-93.

[9] Stark, O. (1978). Economic-demographic interactions in agricultural development: the case of rural-to-urban migration (Vol. 6). Food & Agriculture Organisation.

[10] Taylor, E. J. (1999). The new economics of labour migration and the role of remittances in the migration process. International migration, 37(1), 63-88.

[11] Technical Directorate for Population and Employment Statistics, "Algerian Demographics", Collections Statistics Nº. 600,2011

[12] Technical Directorate for Population and Employment Statistics, "Employment Survey of Households", Collections Statistics Nº. 173,2011.

[13] Todaro, M. P. (1969). A model of labor migration and urban unemployment in less developed countries. The American economic review, 59(1), 138-148.

Contact

Samira Boulahbel-Bachari
National Center of Research in Applied Economics for Development, Algiers. (CREAD)
Rue Djamel Eddine El-Afghani, El Hammadia BP.197, Rostomia, Bouzaréah Algiers, Algeria
Higher National School of Statistics and Applied Economics, Algiers. (ENSSEA)
Pôle Universitaire de Koléa, Tipaza, Algeria
boulahbelsamira@ gmail.com

Nadjia El Saadi
Higher National School of Statistics and Applied Economics, Algiers. (ENSSEA)
Pôle Universitaire de Koléa, Tipaza, Algeria
enadjia@gmail.com