Internal migration, labour market. An agent-based model

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Theme: Macroeconomics; Microeconomics; Labour economics and human capital.

Abstract

This article proposes an agent based-model of the labour market integrating internal migrations of workers. The model considers the individual characteristics of the worker and the attributes of the regions where they reside: an origin region and a destination region.

Multi agent modelling has facilitates the description and the analysis of two labours market with heterogeneous workers that can move to search job. The model introduces the selective aspect of migration and allows the analysis of the labour market in the two regions concerned.

Keywords: Multi-Agent System, Internal Migration, Labour Market, Heterogeneity, Mathematical Equations.

1. Introduction:

The rapid urbanization of the planet is certainly the major challenge of this century. The evolution of transport's modes, the development of information and communication technologies and the increase of employment opportunities in an unequal way, have strongly encouraged the spread of this phenomenon.

In 2014, more than half of the world's population lived in urban areas. In the coming decades, almost all population's growth in developing countries will be in urban centres. In the Developing Countries, and according to United Nations projections, the urbanization rate of these countries was estimated at 44% and is expected to increase to 70% in 2050 (UN Habitat 2008).

Even if this rapid increase in the urban population can help to ensure sustainable economic growth, it nevertheless puts pressure on the infrastructure, the environment and the social fabric of cities in developing countries.

This strong urban growth comes generally from internal labour migrations reflecting the deep regional imbalances in the provision of amenities and local public goods and employment and in turn, reinforcing these imbalances.

Considering internal migration in the analysis of labour market gives a better evaluation of national strategies and a better adaptation of public policies.

Unfortunately, the internal mobility of workers is almost never integrated into the planning and implementation of employment policies in developing countries. One of the main reasons for this absence is the scarcity of data.

In general, the description of labour market dynamics simplifies the behavioural mechanisms and decision-making processes of agents and does not consider the migrant workers. This description is often made by a system of equations that supports a representative individual who is attributed total rationality and perfect information on the labour market.

In this perspective of analysing the labour market, we propose this work. Particular attention is paid to the consideration of internal migrants in the evolution of the labour market in developing countries.

The proposed model describes behaviours at the individual non-aggregated level to ensure heterogeneity of agents, and analyses emerging macroeconomic behaviour.

The proposed modelling is based on mathematical equations describing the socio-economic characteristics of agents and their behaviour. The model differs from other labour market researches by the consideration of internal migrations of workers, the analysis of the two labour markets concerned (relating to the regions of origin and destination) and by the simulation tool used: "multi agent systems".

Multi agent systems (MAS) are a very interesting simulation tool for labour market modelling. Unlike commonly used mathematical models, MASs allow for multiple levels of analysis, model interactions at the microeconomic level, and simulate emerging macroeconomic behaviour. MASs also make possible to quickly test several configurations of the process studied, exercise difficult to achieve intuitively or analytically.

The article is organized in three sections. The first section presents a brief review of the literature on the study of the labour market. The second section concerns the proposed labour market model. Finally, the last section will focus on the simulation of the labour market and the analysis of the results obtained. A conclusion will summarize most of the work presented.

2. Labour market modelling literature

Labour market analysis is based on microeconomic or macroeconomic techniques. Microeconomic to understand interactions at the individual level, and macroeconomic for interactions that influence global variables such as level of unemployment, labour market participation rate or aggregate income. In general, the empirical and theoretical study of the labour market focuses on understanding its mechanisms and the behaviour of its agents. The

two most studied aspects concern the determination of wages and the analysis of employment and unemployment. These aspects are fundamental for both researchers and economic actors.
Among the earliest work on labour market analysis, the works related to Walras, Marshall, and Pigou **(Zylberberg, 1987)**. These works identified the deficiency on wage adjustment as the main cause of unemployment. The relevance of these works has been questioned in particular because of its application only in a situation of full employment. Since then, new factors and conceptual frameworks have been considered such like human capital **(Gary Becker, 1964)** and job search **(George Strigler, 1962, 1975)**.

G. Becker's theory of human capital focuses on a worker's productive capacities (level of education, experience, know-how) and considers that these capacities can be accumulated, improved or used. Every worker can invest in his human capital, which explains the differences in productivity and income between workers. He can also evaluate the return on this investment. Therefore, each worker compares the future income he is expecting from this investment with the costs on education and training. As a result, the worker optimizes his abilities and invests in order to increase his future productivity and his income.
The scope of the human capital theory remains very limited. Although it incorporates the role of training in economic progress and wage determination, the description used is simple and partial and does not reflect the complexity of the links between the different elements considered.

In addition, according to this theory, the worker is supposed to be fully informed about the wages and the technical characteristics of the jobs and that the company is fully aware of the workers' skills and their motivations, which does not reflect the actual functioning of the labour market.

According to the job search theory **(Stigler 1962, 1975)** the perfection of information in the job search is reduced. According to **Stigler,** for a worker searching for a job, the research costs are related to the costs of the visit (transportation, presentation, fees, documents), the time spent on research, and the psychological cost of being a researcher. The job seeker is supposed to know the wages offered on the market and the companies that offer them. The worker will continue to seek for a job with an acceptable salary if the gain from an additional visit is greater than the cost. Likewise, for the company, it will continue to search for an employee until the cost of the research equals the gain provided by an additional application.
The best way to search for a job, according to this model, would be to overcome research costs and improve access to information. This explanation is unconvincing. If the worker can

overcome the cost of his job search and uses his professional connections when he is in the job, he will not have enough time to devote to his research.

Other theories have emerged in the seventies: segmentation of the labour market **(Piore and Doeringen, 1971, Bulow and Summers 1986, Perrot and Zylberberg, 1989),** implicit contracts **(Azariadis, 1975 and Baily, 1974)** or efficiency wage **(Leinbenstein, 1966).**

Even if these new theories overcome certain limits of the classical theories, they remain difficult to test empirically.

New methods emerged in the 1970s, describing the labour market as a dynamic and complex system: The agent-based models. These models are based on the individual behaviours and interactions of heterogeneous agents in the economy that generate the macroeconomic laws observed in the labour market (bottom-up modelling). Employers and workers are represented by agents who evolve and interact in an artificial market.

This type of model allows for a more realistic modelling of the individual behaviour of human actors (unemployed, employers, employees, etc.) and labour market institutions (employment contracts). Depending on the research objectives, agent-based models can be split into two groups: normative multi-agent models that aim to show the potential of the multi-agent approach over more traditional approaches, and calibrated multi-agents' models to understand the functioning of a particular labour market and to accurately quantify the effect of public policies. These latter labour market models aim to model only the labour market, or to integrate labour market modelling into a broader macroeconomic model.

The first work on the labour market with agent-based models is the work **of Bergmann (1974)**, who models the US economy by taking into account the different sectors of activity, and **Eliasson (1977)** who models the Swedish economy. These models simulate an entire population of a country and are very close to microsimulation models. It was only in the 2000's that the use of agent-based models spread to economics. However, the number of labour market agent-based models remains limited. For example, the **ARTEMIS** model of the French labour market **(Ballot, 2002)**, the Richiardi's model **(Richiardi, 2006)** or the Worksim model developed by **Lewkovicz (2010)** and improved by **Goudet (2015)** are part of this category.

The description of the labour market that we propose takes up some of the postulates of the above-mentioned theories. In the next section, we describe the proposed agent-based labour market.

3. Proposed labour market model

The proposed labour market model describes the socio-economic characteristics of agents and their behaviours through mathematical equations and simulates these behaviours by an agent-based model.

This model is inspired from the theory of human capital by taking into account individual characteristics in the job search and from the dual theory (Harris and Todaro, 1970) in the description of two labour markets and the existence of a migration of workers due to the wage differential.

The main hypothesis of our model is that individuals aim to find a decent job to protect themselves from potential risks they may be exposed to like health problems and unsafe working conditions.

The model simulates labour market in two regions: a first region with a relatively low decent job creation rate, a large income dispersion, a weak formal sector, and a second region with more economic potential activities. These characteristics generally describe the two environments rural / urban.

We also assume that individuals living in the first region can look for work in the second region if the expected wage and the probability of finding a job in this region are higher than in the first region.

The agent-based model proposed considers two types of agents:

The Individual Agent, that is the key element of the model. It can be either an employee, an employer, an unemployed or an inactive. He is described by a set of socioeconomic characteristics such as: age, employment status, level of education and level of qualification.

The Agent Region includes businesses and firms. The Agent Region is described by the unemployment rate, the labour market tension, the probability of finding a job and the wages paid. Creation and destruction of jobs occur inside the Agent Region.

The model does not explicitly simulate companies but considers that jobs are randomly distributed according to a job creation rate specific to each region.

The model simulates two important processes: the migration process and the job search process. At the end of the two stages, an update of the demographic and socioeconomic parameters is done (births, deaths, marriages, divorces, entry and exit on the labour market).

The migratory process

The determination of migrants is based on the calculation of a discriminant function of socio-economic variables and the expected gain of migration. The discriminant function (F_j (x_i)) is weighted by the tension of the labour market (MT) and a realization (u) of the uniform variable on [0, 1] allowing to consider the possibilities of employment and to integrate a

hazard in the choice of individuals. This function is the compared to a Threshold to differentiate high potential individuals for migration from others.

The expected gain from migration and the probability of finding a formal job $W^{e}_{i,D,(O)}$ determine who will look for a job on the first region (non-migrants) and who will move to the second region to do it (migrants).[1]

The job search process

The proposed model describes the labour market and the different inputs and outputs of this market. Thus, we consider several statuses for the individual through which he can transit. An Agent Individual can be unemployed, employed, employer, inactive or student. He cannot be considered like unemployed until the age of 16 years. After 60 years, he is no longer considered with the active force of the population.

The following diagram summarizes the transitions that can occur during a person's life cycle:

All unemployed individuals (aged between 16 and 59) are involved in the job search, whether they are native or migrant. Those who are qualified can apply for qualified and unqualified positions unless those who are not qualified will have to settle for unskilled jobs. The qualification of individuals depends on their level of education.

Candidates with the higher probabilities will be hired first. Those who cannot be recruited will keep searching.

In each region and each year, a number of jobs are released as a result of retirements, others are created, and some may be destroyed.

Individuals cannot remain indefinitely unemployed, they can be discouraged after a few attempts and will give up looking for a job and become inactive.

4. Simulations and results

The model was tested on data representing two regions with different levels of development that can be assimilated to rural and urban regions in a developing country. We assume that rural workers can migrate to the urban region to search for a job. We will call the rural-type region the region of origin and the urban-type the destination region relative to the flow direction.

[1] See S.Boulahbel et al (2018) for more details.

The distribution of wages in these two regions is different: the region of origin has low wages and widely dispersed due to the preponderance of precarious jobs. The Destination Region has higher wages and lower dispersion and a larger share of skilled jobs.

We introduce in the model an aspect of migration that is not often considered: the self-selective aspect of migration. Thus, individuals with distinct sociodemographic characteristics and identical wage differentials will have different propensities to migrate. Individuals with limited work experience and no children will have the highest propensities to migrate unlike those with children attending school, for example.

The data used describes a young population with 62% that can be potentially active and approximately 38% of the population is occupied. For the unemployed, 42.7% of them are graduates against 28.9% for the occupied. Employees represent the largest proportion of the employed persons (67% of the employed individuals). The urban-type region has a slightly higher unemployment rate than the other region but remains attractive because of its potential in terms of job opportunities relative to the other region.

The number of individuals in each region is around 9900 individuals.

Table 1: Some characteristics of regions (to insert)

We assume that the birth and death rates are identical in both regions (2.478% and 0.441% respectively).

Scenarios tested

Two scenarios are tested to analyse the evolution of the labour market: considering internal migration of workers and without taking them into account.

At first, we will analyse the evolution of the population and the potential active population. Then, we will analyse the evolution of employment and unemployment in the two regions.

- ***Population evolution:***

The population of the region of origin varies according to whether or not the migration of workers is taken into account.

During the first 20 years, the difference is not very important. After this period, the gap become larger. At the end of the period considered (50 years), the population of the region of origin reaches 11 526 individuals when migration is considered and 17 754 individuals when it is not. **(Figure 2)**

Fig 2: Population Evolution of the Origin Region (to insert)

For the evolution of the destination population, a discrepancy is also observed between the two situations with and without migration even if it remains less important than the difference in the evolution of the population of the region of origin. **(Figure 3)**

The population of the destination region is larger in the presence of migrant workers and the gap between the two developments in this population is increasing at the end of the period considered. At the end of this period, this population, in the presence of a labour migration exceeds 41 000 individuals while in the absence of these migrant workers, it slightly exceeds the 30 000 people.

Fig 3: Population evolution of the Destination Region (to insert)

- Evolution of potentially active populations (population aged between 15 and 60)

Regarding the evolution of the potentially active population in the region of origin, after a small decrease during the first ten years, it increases slightly and exceeds 6 000 individuals and stagnates around this value for the rest of the period.

In the presence of a labour migration, the potential active population decreases over the entire period at a faster rhythm and decreases below 3 000 persons. **(Figure 4)**

Fig 4: Population potentially active evolution in the Origin Region (to insert)

Conversely, the potentially active population in the destination region increases in both cases (presence or absence of migrant workers). This increase is greater in their presence (20 485 people compared to 16 723 people at the end of the considered period). **(Figure 5)**

Fig 5: Evolution of the population potentially active in the Destination Region (to insert)

In the long term, the effect of migration becomes more and more palpable on the evolutions of populations. Since young people are the most concerned by migration, their departure does not allow the region of origin to deploy in favour of the region of destination. It is important to remember that both regions have, at the start of the simulations, almost the same population size and identical birth and death rates.

- Evolution of employment

In the region of origin, when applying a job creation rate of 3%, employment increases in the absence of migration and decreases in its presence until it cancels at the end of the period.
Workers from origin region move to the destination region which presents a high job creation rate (10%) and therefore better job opportunities impoverishes the region of origin and does not allow it to develop. **(Figure 6)**

Figure 6 : Employement evolution in the Origin Region (to insert)

For the Destination region, we apply a job creation rate of 10% in both situations. Employment is increasing in both cases with higher values in the presence of migrant workers.
Thus, these workers participate in the deployment of employment in the Destination area.

Figure 7: Employment evolution in the Destination Region (to insert)

- Evolution of the number of unemployed:

Relatively to the evolution of the number of unemployed, we note that their number is higher in the absence of worker migration. In their presence, some of the job seekers from the region of origin move to the destination region, which reduces their number.

Fig 8: Unemployment evolution in the origin Region (to insert)

For the evolution of the number of unemployed in the region of destination, we find that the number of job seekers is higher when we take into account the migration of workers, but after a certain period, their number is almost identical in absence of these migrant workers. This is due to the high job creation rate of 10%, which allows this flow of migrants to be absorbed without extending the unemployed population. **(Figure 9)**

Fig 9 : Unemployment evolution il the destination region (to insert)

This section highlights the important role played by the migrant workers in the development or precariousness of regions.

Conclusion

The work presented in this article illustrates the importance of considering labour migration in the analysis of the labour market that is unfortunately not considered in the literature. The scarcity of data is certainly one of the main causes of this absence. The use of multi-agent systems in the study of the labour market has allowed us to take them into account. Their use has also allowed us to integrate the aspect of heterogeneity of individuals in terms of characteristics and behaviour.

The incorporation of the probabilities of finding a job by qualification as well as the individual salaries makes possible the description of the behaviours of the agents according to their profile.

However, the model has some limitations that need to be improved. The integration of a matching function for the job search will allow agents to better target job positions according to their level of qualification. Also, the study of the influence of social networks will a more realistic description of the job search. These extensions could support the design of a more robust and comprehensive integrated model that can facilitate the development and evaluation of public employment policies for sustainable rural development and controlled urbanization of cities.

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