Agent-based Modeling of Migrant Workers Residential Dynamics within a Mega-city Region: the Case of Zhuijiang Delta, China

Working Paper

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Abstract

Rural-urban migrant workers have played in the last decades an increasing role for China's economy, raising the attention on associated socio-economical issues. The importance of their economic diversity is however poorly known, as the strategy of the State towards these new classes. We propose to investigate both by means of agent-based modeling, at the scale of Pearl River Delta Mega-city Region. Our model couples patch-level population and economic structure, which evolution is determined in a top-down fashion from meso-dynamics following simple growth rules, with microscopic residential discrete choices dynamics of migrant workers. This two level structure is essential to control on city system structure. The model is explored on synthetic data and internally validated for statistical consistence and path-dependancy of temporal trajectories. The application to Zhuijiang Delta region allows first to test the sensitivity of outcomes to population economic structure, for which spread wealth distributions yield more complex trajectories, and secondly to compare the impact of different State policies on migration control.

Keywords : *Mingong ; Residential Dynamics ; Agent-based Modeling ; Zhuijiang Delta Mega-city Region*

1 Introduction

Modeling Rural-urban migrations in China Existing works in rural-urban migration modeling in China are mainly econometric studies, relying on census or on survey data. [Zhang and Zhao, 2013] estimate discrete choice models to study the tradeoff between migration distance and earning difference. [Fan, 2005] shows that gravity-based models can explain well inter-provincial migratory patterns, implying an underlying strong dominant aggregation processes. The positive association between wage gap and migration rates was obtained from time-series analysis in [Zhang and Shunfeng, 2003].

Towards an agent-based modeling approach To the best of our knowledge, there was no attempt in the literature before to focus on China's migration issues from an agent-based perspective. The case of Mexico was tackled by [De Leon et al., 2007], but in the particular case of a border-town, and underlying processes are furthermore fundamentally different. *TODO : find more literature*

Following a logic of *Pattern-oriented modeling* [Grimm et al., 2005], combined with recent advances in multi-modeling [Cottineau et al., 2016], one can use agent-based models as powerful to test qualitative hypothesis, with a reasonable need for empirical data through toy-models or hybrid models.

2   Model

2.1   Rationale

We choose to focus on particular processes and stylized facts to include in the agent-based models, in order to test some hypothesis formulated after qualitative research done in [Losavio, 2016]. More precisely, a recent shift in socio-economic structure of migrating population was observed, including a rise of middle-income migrants and a relativisation of the role of *Hukou* in migration dynamics. The core of the model is thus centered on the exploration of the impact of a varying population economic structure for migrants on system dynamics, and the influence of government migration policies.

Scale   As shown by [Chan, 2012], recent migration dynamics feature a high asymmetry from central region to coastal economically dynamic province. At a macroscopic scale, explanatory variables are relatively well understood and gravity-based geographical models have a reasonable explanatory power [Fan, 2005]. However, at a regional scale, migration dynamics are also highly present and present more complex patterns. The scale of the model is therefore a regional scale, in the spirit of a *Mega-city Region* [Hall and Pain, 2006], in which urban dynamics are highly complex. A relevant case study to apply the model will be the Pearl River Delta Region in Guangdong.

Ontology   At a mesoscopic scale, i.e. for cities within the MCR, growth can be reasonably assumed independent from migrants movements : they follow larger economic urban processes. Conditionally to such population and economic context, migration dynamics occur at the microscopic scale. We postulate a simple utility-maximization process.

2.2   Model Description

Setup   The world consists in a lattice of $1 \leq i \leq N$ cells, characterized by their population $P_i(t)$ and an economic structure $E_i^{(c)}(t)$ which consists in abstract variables representing potential number of jobs stratified by socio-economic classes c. The associated effective number of workers is denoted by $W_i^{(c)}(t)$. For the sake of simplicity, we assume a discrete number of classes. At initial time, the variables are initialized either following a synthetic data generation process (see below), or from real geographical data (abstracted and simplified to fit our context). Cells are grouped into $1 \leq k \leq K$ administrative cities that corresponding to the various centers of the MCR, on which aggregated population $\tilde{P}_k(t)$ and corresponding economic variables can be computed.

Agents   An agent is a household of migrants, whose residence and job are located in cells (that can be different). Socio-economic structure of the population is captured by the distribution of wealth $g(w)$, which are then stratified into categories. At a given time, the utility difference between not moving and moving to cell j from cell i, for a category c is given by

$$\Delta U_{i,j}^{(c)}(t) = \frac{Z_j^{(c)} - Z_i^{(c)}}{Z_0} + \frac{C_i^{(c)} - C_j^{(c)}}{C_0} - u_i^{(c)} - h_j^{(c)}$$

where $Z_i^{(c)}$ is generalized accessibility given by $Z_i^{(c)} = P_i \cdot \sum_k \left[E_k^{(c)} - W_k^{(c)} \right] \cdot \exp\left(\frac{-d_{ij}}{d_0} \right)$, with d_{ij} effective travel distance (in public transportation ; *point to be clarified : for higher classes, car may be an option*) and d_0 commuting characteristic distance ; $C_i^{(c)}$ is the cost of life which is a function of cell and city variables, that will be taken as $C_i^{(c)} \propto P_i^{\alpha_0} \cdot \tilde{P}_i^{\alpha_1} \cdot$; $u_i^{(c)}$ a baseline aversion to move and $h_j^{(c)}$ an exogenous variable corresponding to regulation policies ; Z_0 and C_0 dimensioning parameters.

Temporal Evolution   At each time step, the system evolves sequentially according to the following rules :

- Cities mesoscopic variables $\tilde{P}_k(t)$ and $\tilde{E}_k^c(t)$ are deterministically updated, following the very simple assumption of the expectancy of a Gibrat's law, and a scaling law to determine economic variables from population.

- Patches variables are updated conditionally to the new aggregated values. _Using a simple urban growth model of aggregation, deterministic for population and a bit more random for jobs ; still to be clarified._

- A number of new migrants, proportional to Gibrat growth rate, enter the region and settle randomly, by first choosing a random available job location in their category, and then a residence nearby with a probability function of population density and exponentially decreasing with distance to job, as $\exp\left(\frac{-d_{ij}}{d_0}\right)$. This procedure is also used for initial setup.

- Migration occur following a discrete choice dynamics : the probability to move to cell j is given by

$$\mathbb{P}[i \to j | c] = \frac{\exp\left(\beta \cdot U_j^{(c)}\right)}{\sum_k \exp\left(\beta \cdot U_k^{(c)}\right) + \exp\left(U_{stay,i}^{(c)}\right)}$$

what simplifies into a reduced form, with $\beta' = \frac{\beta}{Z_0}$, $\gamma = \frac{Z_0}{C_0}$ and $\tilde{u}, \tilde{h}$ accordingly rescaled variables, using the above utility expression :

$$\mathbb{P}[i \to j | c] = \frac{\exp\left(\beta' \cdot \left[\Delta Z_{i,j}^{(c)} - \Delta C_{i,j}^{(c)} - \tilde{u}_i^{(c)} - \tilde{h}_j^{(c)}\right]\right)}{1 + \sum_k \exp\left(\beta' \cdot \left[\Delta Z_{i,k}^{(c)} - \Delta C_{i,k}^{(c)} - \tilde{h}_k^{(c)}\right]\right) - N \cdot \tilde{u}_i^{(c)}}$$

Residential movement is drawn randomly according to these probabilities, and jobs are chosen around new residence following an exponentially decreasing probability.

Indicators   _TBW_

Synthetic Data Generation   _TBW_

3   Results

Model Validation

- Internal validation : statistical consistence ; system trajectories ; path-dependency.

- External validation : stylized facts from synthetic data exploration ?

Application   _Stylize Pearl River Delta configuration_

Experience Plan   _concrete qualitative questions that can be asked to the model, e.g. :_

- _what is the impact of varying wealth distribution shape and width on system dynamics ?_

- _what is the impact of various spatial distribution of $h_j^{(c)}$, i.e. different government policies ?_

- _..._

References

[Chan, 2012] Chan, K. W. (2012). Migration and development in china: Trends, geography and current issues. *Migration and Development*, 1(2):187–205.

[Cottineau et al., 2016] Cottineau, C., Rey-Coyrehourcq, S., and Reuillon, R. (2016). Back to the future... of multimodelling. In *RGS 2016, Session Geocomputation : the next 20 years*.

[De Leon et al., 2007] De Leon, F., Felsen, M., and Wilensky, U. (2007). Netlogo urban suite-tijuana bordertowns model. *Center for Connected Learning and Computer-Based Modeling, Northwestern University, Evanston, IL*.

[Fan, 2005] Fan, C. C. (2005). Modeling interprovincial migration in china, 1985-2000. *Eurasian Geography and Economics*, 46(3):165–184.

[Grimm et al., 2005] Grimm, V., Revilla, E., Berger, U., Jeltsch, F., Mooij, W. M., Railsback, S. F., Thulke, H.-H., Weiner, J., Wiegand, T., and DeAngelis, D. L. (2005). Pattern-oriented modeling of agent-based complex systems: lessons from ecology. *science*, 310(5750):987–991.

[Hall and Pain, 2006] Hall, P. G. and Pain, K. (2006). *The polycentric metropolis: learning from mega-city regions in Europe*. Routledge.

[Losavio, 2016] Losavio, C. (2016). *Comment analyser l'intégration des ouvriers-migrants dans la Chine d'aujourd'hui. Le cas de Wuhan.* PhD thesis, Institut d'études Politiques de Paris. Ecole Doctorale de Science Po.

[Zhang and Zhao, 2013] Zhang, J. and Zhao, Z. (2013). Measuring the income-distance tradeoff for rural-urban migrants in china.

[Zhang and Shunfeng, 2003] Zhang, K. H. and Shunfeng, S. (2003). Rural–urban migration and urbanization in china: Evidence from time-series and cross-section analyses. *China Economic Review*, 14(4):386–400.