Migrant Workers Residential Dynamics within a Mega-city Region: Challenging Preconceived Ideas with an Agent-based Model

Working Paper

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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

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

  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 :

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

  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 ?*
- ...

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