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

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Abstract

This paper introduces an agent-based model of regional migration dynamics, applied to the Mega-city Region of Pearl River Delta

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

1 Introduction

Over the last three decades, rural-to-urban migrant-workers have been a driving force for China's economy, raising attention on associated socio-economical issues. However, the importance of their economic diversity and social mobility has been poorly considered in the analysis of urban development strategy. We use an agent-based model to simulate residential dynamics of migrants in Pearl River Delta (PRD) mega city region, taking into account the full range of migrants' socio-economical status and their evolution. Mega-city regions have become a new scale of Chinese State regulation, and PRD represent the most prosperous and dynamic one in term of migration waves, standing as an ideal unit of analysis. Our model unveils emergent patterns of dynamics, from micro behavior rules of discrete mobility choices. These choices are conditional to urban and economic environment, which evolution is controlled by meso-scale independent dynamics. The two scales are coupled through the dependence of discrete choice utilities to generalized accessibility that combines patch-level urban and economic context with a feedback of the dynamics themselves. This multi-scale aspect is crucial to distinguish endogenous form exogenous effects in regional migration patterns. We perform simulations to internally validate the model on synthetic data, by assessing statistical consistence and establishing phase diagrams across the parameter space. The application to the case study allows first to test how variation in socio-economic status yield more complex trajectories, and secondly to identify how the Party-State persist in controlling internal migration flows in a more sophisticated and strategically redefined way. Further work is directed towards a qualitative external validation of the model, by calibrating free parameters to reproduce meso-scale stylized facts, in order to guide interpretations of emergent outputs and potential policy applications.

1.1 Context

Mega-city Regions Mega-city regions (MCRs) are integrated sets of cities and their surrounding suburban hinterlands across which labour and capital can be reallocated at very low cost [Florida et al., 2008]. The expression "Mega-city Region" was first coined by Gottmann [Gottman, 1961] using the term megalopolis, that he defines as "urban area of several tens of millions of people, including several cities and major urban centers, and extending continuously over several 100 km". It represents the new economic unit that emerges as metropolitan regions not only grow upward and become denser but also grow outward and into one another. These spaces result of the networking of a group of metropolitan areas deployed around very large cities and it is characterized by the "symbiosis between urban and rural areas". Other characteristic are migration flows, density of connections, and regional migration patterns.

Pearl River Delta Since the gradual decentralization of the state power which occurred in the beginning of 1990 Mega-city regions have become a new scale of Chinese State regulation, and in particular the pearl River Delta, represent the most prosperous and dynamic one in term of migration waves. That's why we choose PRD as our unit of study. Since the Open Door Policy was implemented in 1978 the PRD launched a process of rapid economic and social transformation, becoming a global manufacturing region attracting an increasing number of migrant-workers from all over China. In fact, PRD was designed as an open economic zone in 1984, and was granted many 'one step ahead' policies to attract foreign capital, becoming the most important exporter center since economic reform. That results in an astonishing rise of population in the area. That today count more than 50 million people. If during the first year of the opening-up reforms the barycenter of the region was Guangzhou - the provincial capital, over the last decade PRD has become increasing polycentric. Taking PRD as the unit of our model we try to reproduce migrants residential patterns taking into account the full range of migrants' socio-economical status and their evolution.

Migrant Workers in PRD Even though migrants workers are generally considered and treated as a uniform category, previous research [Losavio, 2016], based on qualitative interviews and sociological observation, showed how considering their economical, cultural and human capital migrants workers are a very diversified social category. Especially 3 dimension are fundamental to understand migrant workers:

- Professional Dimension : industry, construction, private sector, services (will change not only their economical situation but which influence migrants' trajectory and the staying duration in the city and their residential choice.
- Residential Dimension : We could recognize two subcategories, with different socio-economic situations: (i) Temporary - migrants working in the construction sector, who are really mobile, changing city or province according to the labour demand; seasonal migrants workers, most of the time are peasants working as farmer and cultivating their land who come to the urban area to sell their product at the city price but without paying the running costs temporary migrants' trajectory are more difficult to detect since they move in a discretional way ; (ii) Permanent : Who are living in the city for more than 6 months and are renting a room or apartment depending on their: Economic situation (revenues), Social network, Proximity to the work place
- Generational Dimension. *this dimension is not taken into account in the model for now, as simulated dynamics correspond to rather short time scales, between 10 and 20 years.*

All these sub-categories have different mobility patterns, that we try to simulate in our model.

Considering this diversity and translating it in qualitative stylized facts that correspond to precise patterns of synthetic data, this model aims at establishing a new perspective for understanding China's urban and regional mobility employing a more qualitative approach, specifying the mechanisms through which Party-State shape the parameters of migrants' choices.

1.2 Modeling Migrations

Modeling Rural-urban migrations [Todaro, 1969] classical equilibrium model

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 trade-off 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]. An empirical study of intra-urban migrants residential dynamics is done by [Wu, 2006].

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.

[Xie et al., 2007] : agent-based model to simulate the emergence of Urban Villages. [Silveira et al., 2006] : Ising model of rural-urban migration. [Fernandez et al., 2005] : study of population characteristics to establish the relevance of a future ABM.

The idea of applying complexity paradigms to rural-urban migration is far from new, as [Mabogunje, 1970] already theorized it in the frame of General System Theory, that for some is viewed as a precursor of complexity theories.

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 tools to test qualitative hypothesis, with a reasonable need for empirical data through toy-models or hybrid models.

Model The model is designed to include targeted stylized facts and experiments, in particular the role of the socio-economic structure of migrant population. The region is represented in the model by N patches, characterized by their population $P_i(t)$ and an economic structure $E_i^{(c)}(t)$ giving a potential number of jobs for socio-economic classes c. The associated effective number of workers is denoted by $W_i^{(c)}(t)$.Urban Centers are characterized by aggregated population $\tilde{P}_k(t)$ and corresponding economic variables $(\tilde{E}_k^c(t))$. 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

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

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 and d_0 commuting characteristic distance ; the parameter γ is the ratio giving the relative importance of life cost compared to accessibility in the migration decisions ; $C_i^{(c)}$ 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. At each time step, the system evolves sequentially according to the following rules : (i) cities-level variables are updated and distributed across patches variables (in our experiments, we will assume short time scale and skip this step); (ii) new migrants enter the region and lean on social network to settle; (iii) migration occur within the region, randomly drawn from discrete choice probabilities obtained with the above utility difference between two patches; (iv) Migrants update their wealth and eventually economic category, according to an abstract "quality of place" that we associate to per-capita GDP which follows a scaling law of population.

Results The model is implemented in NetLogo, the open source implementation being available with results at `https://www.github.com/JusteRaimbault/MigrationDynamics`. We explore the model on synthetic city systems first, to isolate results due to processes from results due to geographical configuration. With such a random model where many parameters cannot be given directly a real-world value, it is necessary to explore intensively the parameter space to obtain robust conclusions. Using the software OpenMole [Reuillon et al., 2013], we proceed to 1,599,495 simulations of the model on computation grid, achieving 15 years of equivalent CPU in around 2 days. We validate the model internally by checking the statistical convergence of indicators. From the baseline experiments we learn that : (i) when migrants have a high propensity to move, the spatial repartition of jobs becomes suboptimal in intermediate

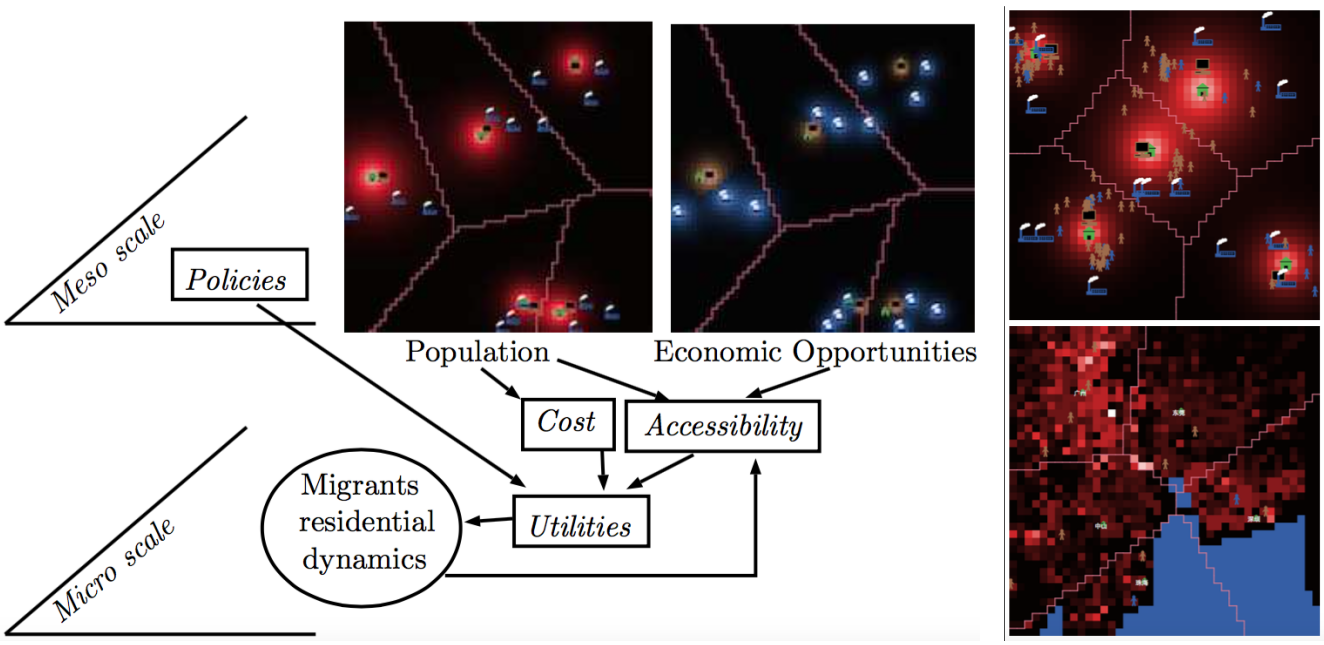

Figure 1: Multi-scale schema of processes included in the model

regimes of stochasticity, corresponding to a regime where congestion dominates; (ii) the congestion regime corresponds to a linear decrease of job distance with randomness, meaning that social determinism creates spatial inequalities; (iii) changing the relative importance of accessibility does not affect much the aggregated dynamics: an increased gain in mobility produced by policies such as individual transportation subsidies will have no effect on migrations patterns; Adding categorization does not change the qualitative behavior of the model.The lower category appears more vulnerable to spatial inequalities created by social determinism. Concerning the influence of economic parameters, namely income inequality and income growth, we find that : (i) larger income inequalities yield stronger spatial inequities in job accessibility; (ii) larger enrichments when migrating induces a suboptimal regime for the upper category. The application of the model on the real population and economic configuration of Pearl River Delta slightly changes conclusions: we witness for example the emergence of optimal behavior ranges for the commuting distance indicators. It means that incentives for migrations have to be specifically tuned depending on the region configuration. Other conclusions mainly hold and are therefore process-specific.

Discussion A last application we are currently developing. This various stylized facts may inform policies

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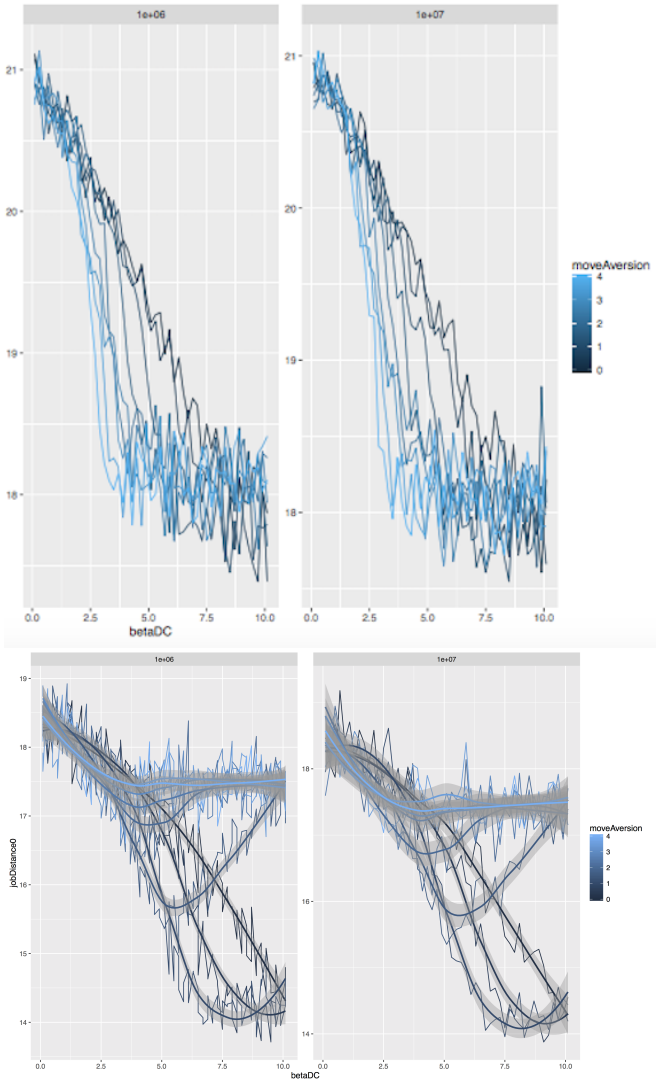

Figure 2: Multi-scale schema of processes included in the model

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