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*

Context 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.

Mega-city Regions Mega-city regions (MCRs) as defined by Florida, Gulden and Mellander 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]. This urban configuration recalls what Gottmann defined as megalopolis [Gottman, 1961] in reference to the north-east coast of the United States. Despite this affinity in their spatial and functional configuration, MCRs perform on a different scale than megalopolis: they operate at a regional as well as at a global scale. Indeed, one of the main characteristics of MCRs is their "connectivity": spatially, they branch out into nearby rural and metropolitan areas, and economically they grow beyond their physical border, becoming international. These densely populated regions do not have a single barycenter but merging into one another they turn into highly networked spaces connected through multiple nodes. The high density of connections and the polycentrism characterizing these new economic units facilitate migrations flows and encourage regional integration. . In China, the development of mega-city regions has started right after the implementation of the Open Door Policy in 1978. But is the gradual decentralization of the State power - which occurred in the beginning of 1990 – that promote cities and more recently mega-city regions as a new scale of Chinese State regulation [**?**]. The process of rapid economic growth and urban development molds new densely populated and industrially dynamic mega-city regions, of which the Pearl River Delta (PRD)[1].is the most obvious example. The area was designed in 1988 as a " comprehensive economic reform area", and was granted many "one step ahead" policies to attract foreign capital. Evolving into the most important exporter center since the economic reform, the Pearl River Delta counts today a population of . . . and represents the most dynamic MCR in terms of migration waves ().

[1] The unit of our model is PRD Mega City Region and not PRD Mega Urban Region which includes also Hong Kong and Macao

Migrant Workers Taking the PRD as the spatial unit of the model, we aim to reproduce migrant workers' residential patterns taking into account the full range of their socio-economical status. Migration patterns and key related issues have extensively been studied from various perspectives. However, i migrant workers are generally considered and treated as a uniform category, which stand at the bottom of the urban society, carrying the stigma of the rural household registration system. The rural-urban dual structure has been for years the only approach to define and understand migrant-workers, but the process of rapid economic growth China have been experiencing accelerated social transformation. We postulate that studying migrant workers, by merely considering their hukou status and place of registration is not sufficient anymore to apprehend such a complex and diversified social category. Others aspects such as migrant workers economical, cultural and human capital should be taken into account. Especially 3 dimension can help differentiate number of migrant-workers sub-categories: (i) the professional dimension, which not only determines migrants' economical situation but also influences their trajectory and the duration of their staying in the city as well as their residential choice; (ii) the residential Dimension : which impacts all aspects of migrants' urban lives – patterns of urban settlement, housing choices, residential conditions, relation with the city, neighborhood activities etc. The Generational Dimension. [2]

All these sub-categories have different mobility patterns, that we simulate in the 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.

0.1 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.

[2] The generational dimension is not taken into account in the model, as simulated dynamics correspond to rather short time scales, between 10 and 20 years.

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, with location for residence and job. 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 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

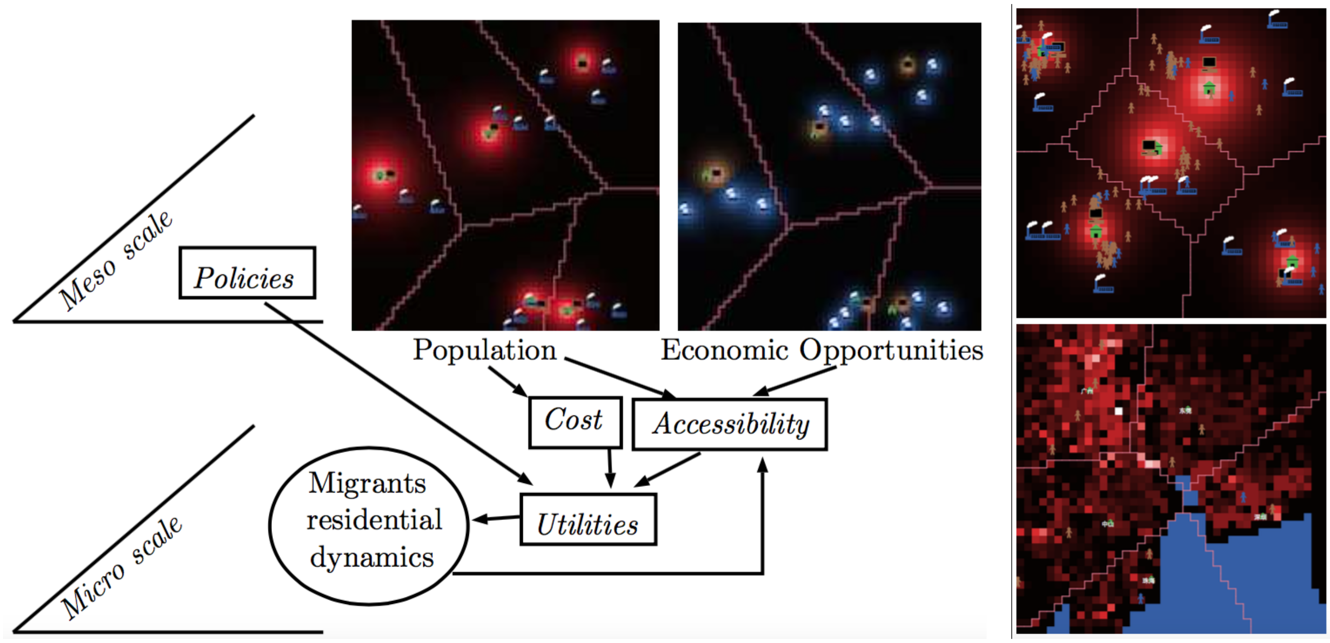

Figure 1: Multi-scale schema of processes included in the model

References

[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.

[Fernandez et al., 2005] Fernandez, L. E., Brown, D. G., Marans, R. W., and Nassauer, J. I. (2005). Characterizing location preferences in an exurban population: implications for agent-based modeling. *Environment and Planning B: Planning and Design*, 32(6):799–820.

[Florida et al., 2008] Florida, R., Gulden, T., and Mellander, C. (2008). The rise of the mega-region. *Cambridge Journal of Regions, Economy and Society*, 1(3):459–476.

[Gottman, 1961] Gottman, J. (1961). Megalopolis. *Twentieth Century Fund.*

[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.

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

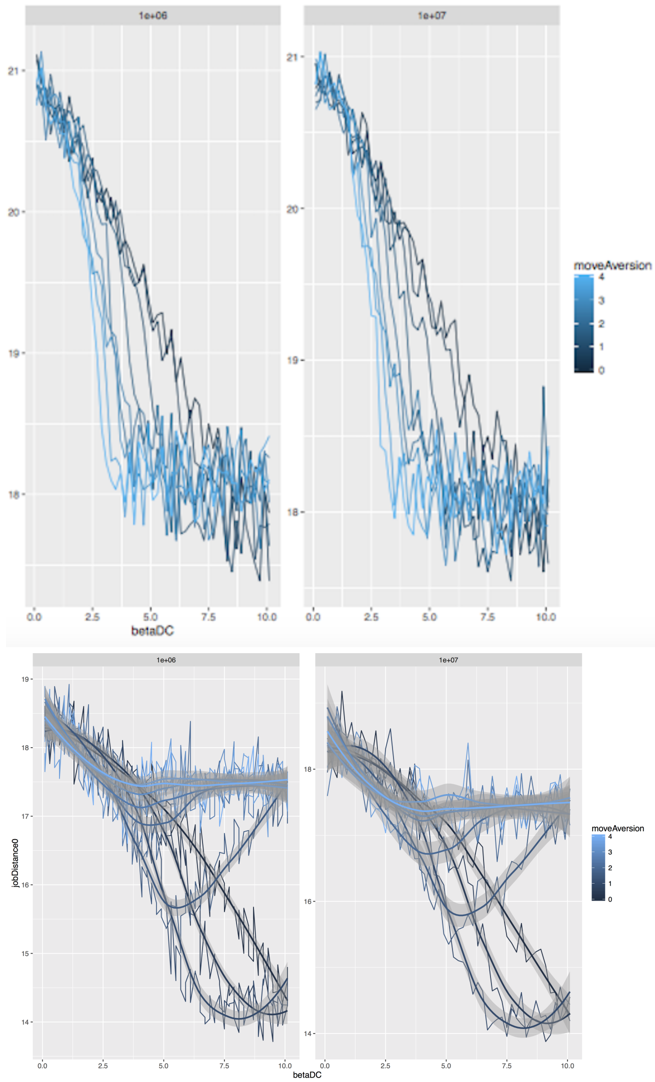

Figure 2: Multi-scale schema of processes included in the model

[Mabogunje, 1970] Mabogunje, A. L. (1970). Systems approach to a theory of rural-urban migration. *Geographical analysis*, 2(1):1–18.

[Reuillon et al., 2013] Reuillon, R., Leclaire, M., and Rey-Coyrehourcq, S. (2013). Openmole, a workflow engine specifically tailored for the distributed exploration of simulation models. *Future Generation Computer Systems*, 29(8):1981–1990.

[Silveira et al., 2006] Silveira, J. J., Espíndola, A. L., and Penna, T. (2006). Agent-based model to rural–urban migration analysis. *Physica A: Statistical Mechanics and its Applications*, 364:445–456.

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

[Wu, 2006] Wu, W. (2006). Migrant intra-urban residential mobility in urban china. *Housing Studies*, 21(5):745–765.

[Xie et al., 2007] Xie, Y., Batty, M., and Zhao, K. (2007). Simulating emergent urban form using agent-based modeling: Desakota in the suzhou-wuxian region in china. *Annals of the Association of American Geographers*, 97(3):477–495.

[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.