AGENT-BASED MODELING OF MIGRANT WORKERS RESIDENTIAL DYNAMICS WITHIN A MEGA-CITY REGION: THE CASE OF PEARL RIVER DELTA, CHINA

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medium
New pathways for sustainable urban development in China's medium-sized cities

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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, Gulden & Mellander, 2008).

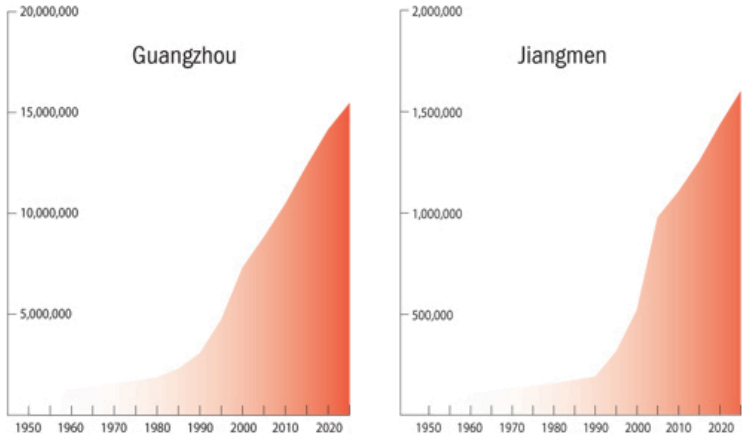
Main characteristics:

- symbiosis between urban and rural areas
- migration flows
- density of connections
- regional migration patterns

Pearl River Delta (PRD) represent the most prosperous and dynamic mega-city region in term of migration waves

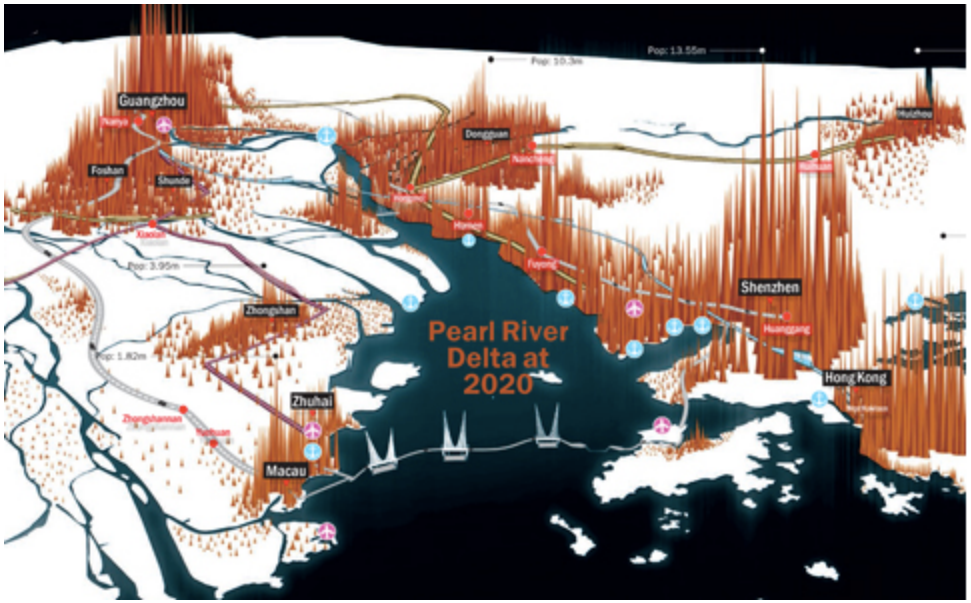
PRD Mega-city regions characteristics

Exponential rise of population



Source: Time Out HK

Polycentrism



Source: Time Out HK

This agent-based model simulates migrants residential patterns taking into account the full range of migrants' socio-economical status and their evolution

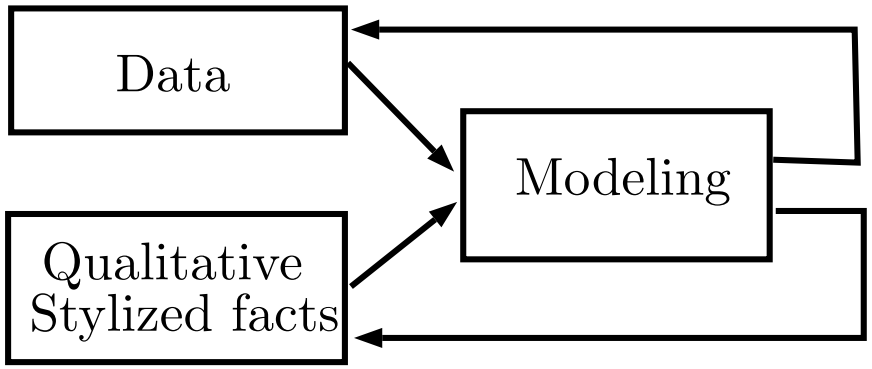
3 dimension to discern migrant-workers diversity:

- **PROFESSIONAL**: industry, construction, private sector, services
- **RESIDENTIAL**:
  - TEMPORARY: migrants working in the construction sector, seasonal migrants workers
  - PERMANENT: migrants living in the urban area for more than 6 months and renting a room or an apartment depending on their:
    - Economic situation
    - Social network
    - Proximity to the work place
- **GENERATIONAL**:
  - The "first generation" is the set of individuals born in rural areas and having lived there for a long period. They carried out agricultural or non-agricultural activities and chose to immigrate to the city on a temporary basis.
  - The "second generation" refers to all individuals originating from rural areas but not necessarily engaged in agricultural work, and who migrate to the city in order to remain there more permanently.
  - The "third generation", the children of migrant-workers who were born in the village or in the city and who grew up in urban areas (and who are effectively urban but with a rural hukou, they are more likely to stay in the city and probably move less then their parents)

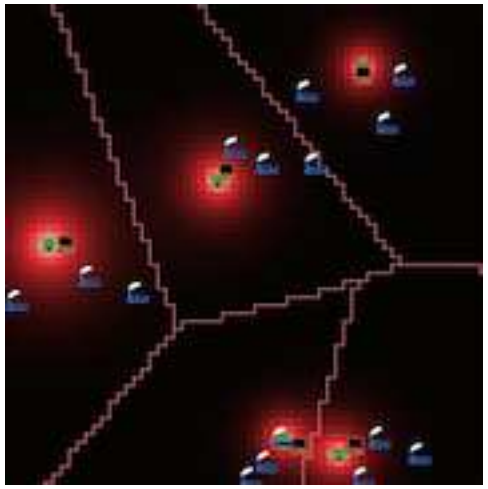
Hybrid Agent-based Modeling

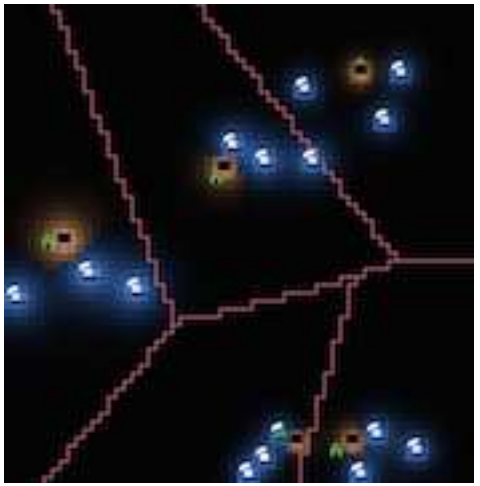
Agent-based Modeling : from toy to fully parametrized models, to infer indirect knowledge on processes in Complex Systems.

Recent trends : Pattern-oriented Modeling (Grimm et al., 2005) as a way to externally validate models ; return of Multi-Modeling (Cottineau et al., 2015) to discriminate alternative explanations ; High Performance Computing calibration bringing “proofs” in Social Sciences (Schmitt et al., 2014).



Model Structure





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Residential Dynamics

- Variety of economic profiles : migrants wealth $w \sim g(w)$
- Corresponding Economic categories
- State regulates dynamics with control term $h_j^{(c)}$
- Discrete Choice utilities include accessibilities, cost of life and risk aversion :

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

Temporal Evolution

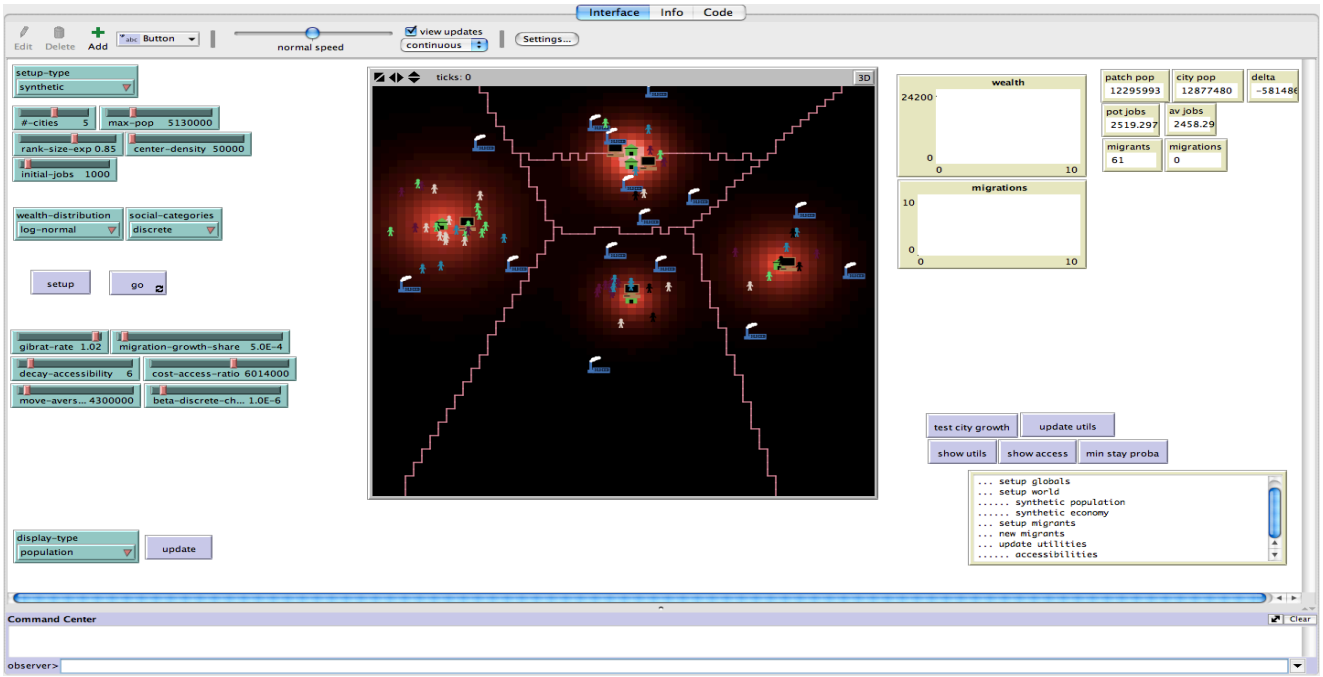
At each time step :

- Cities mesoscopic evolution (Gibrat's laws and Scaling laws) ; patch level distribution through preferential attachment scheme
- New migrants enter the city, settle given their social network (关系)
- Discrete choice migrations (randomly drawn for each migrant)
- Update migrants wealths and economic categories
- Update accessibilities

Model Implementation

Implementation in NetLogo (Wilenski, 1999) ; High Performance Computing exploration with OpenMole (Reuillon et al., 2013)

Synthetic Data : Synthetic city system



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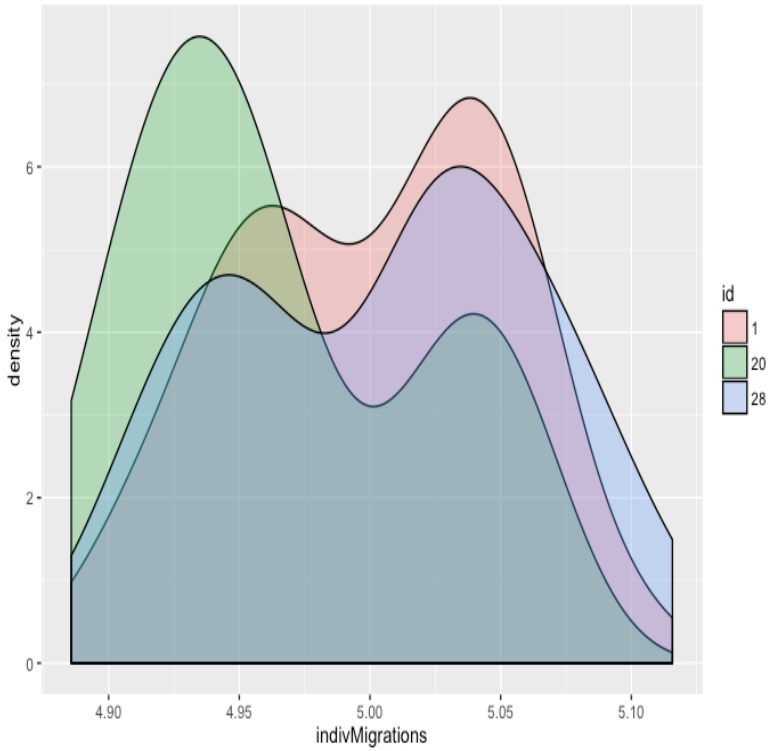
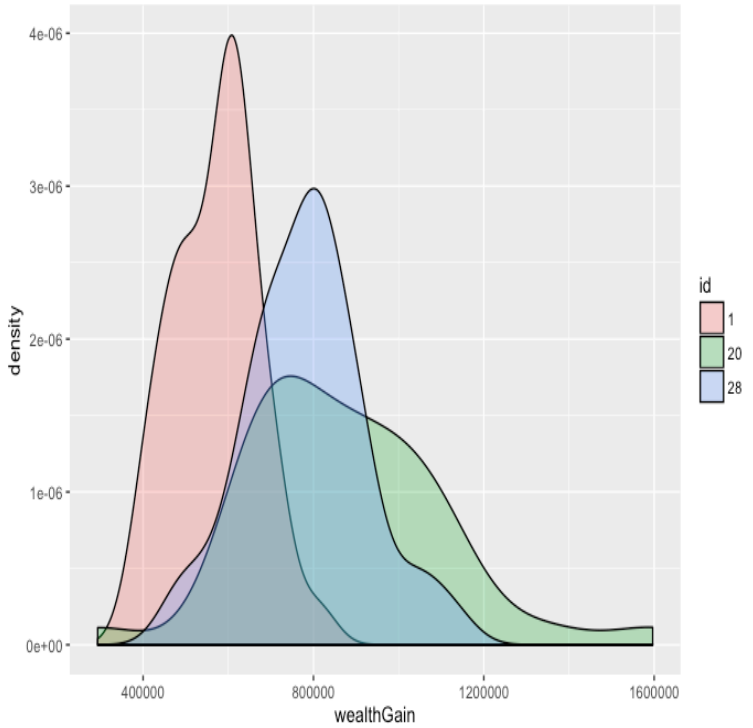
First Results : Convergence

Internal validation by checking statistical convergence and establish number of repetitions needed





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First Results : Phase Diagrams

Grid Exploration of the parameter space

Perspectives

- Next steps :
  - Full exploration on synthetic data : model behavior
  - Stylization and scenarization of real DPR configuration, model behavior on real and hybrid configurations
  - Targeted experience plans (e.g. : role of economic diversity, influence of state regulation)
  - Iterative further construction/multi-modeling (e.g. generations)
- Expected Results :
  - Impact of processes linked to migrants diversities on emergent dynamics
  - Explore or unveil state strategies (through regulations or companies control)

Conclusion

- A first insight into an inter-disciplinary complex approach on Meso-scale migration dynamics
- Cruciality of both qualitative empirical knowledge and quantitative theoretical knowledge
- Complementarity with « classical » approaches, in particular quantitative contributions (statistics, equilibrium economics)

All code and data available for reproducibility at
https://github.com/JusteRaimbault/MigrationDynamics

Reserve Slides

Reserve Slides

Discrete Choice Utilities

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

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.

Discrete Choice Probabilities

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

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