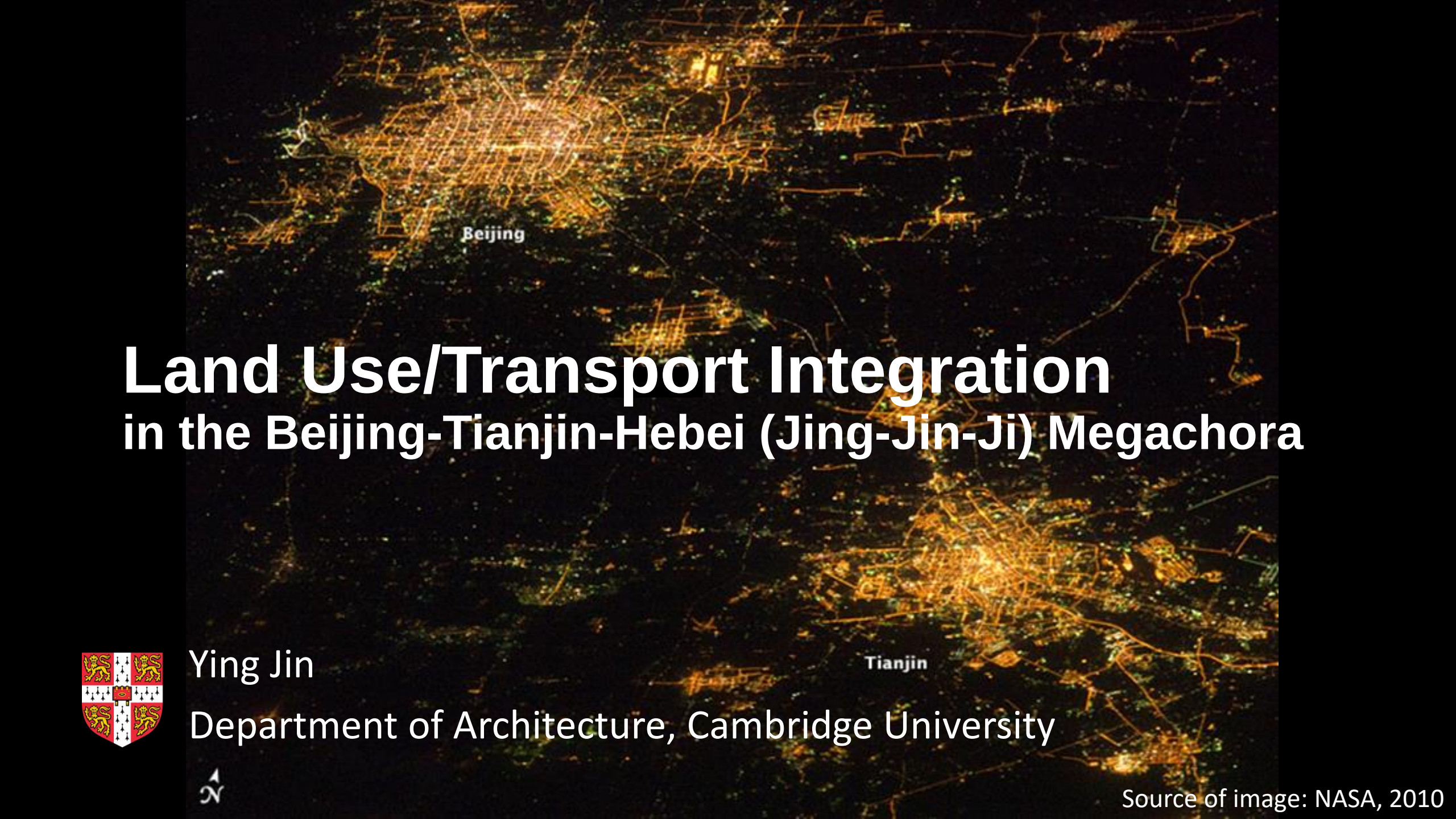


Land Use/Transport Integration
in the Beijing-Tianjin-Hebei (Jing-Jin-Ji) Megachora

Ying Jin

Department of Architecture, Cambridge University

Source of image: NASA, 2010

With contributions from

Cambridge University: Steve Denman, Kaveh Jahanshahi, Li Wan, Xiao Rong, Mingfei Ma, Debbie Bin Deng, Kelly Chengjiao Wang

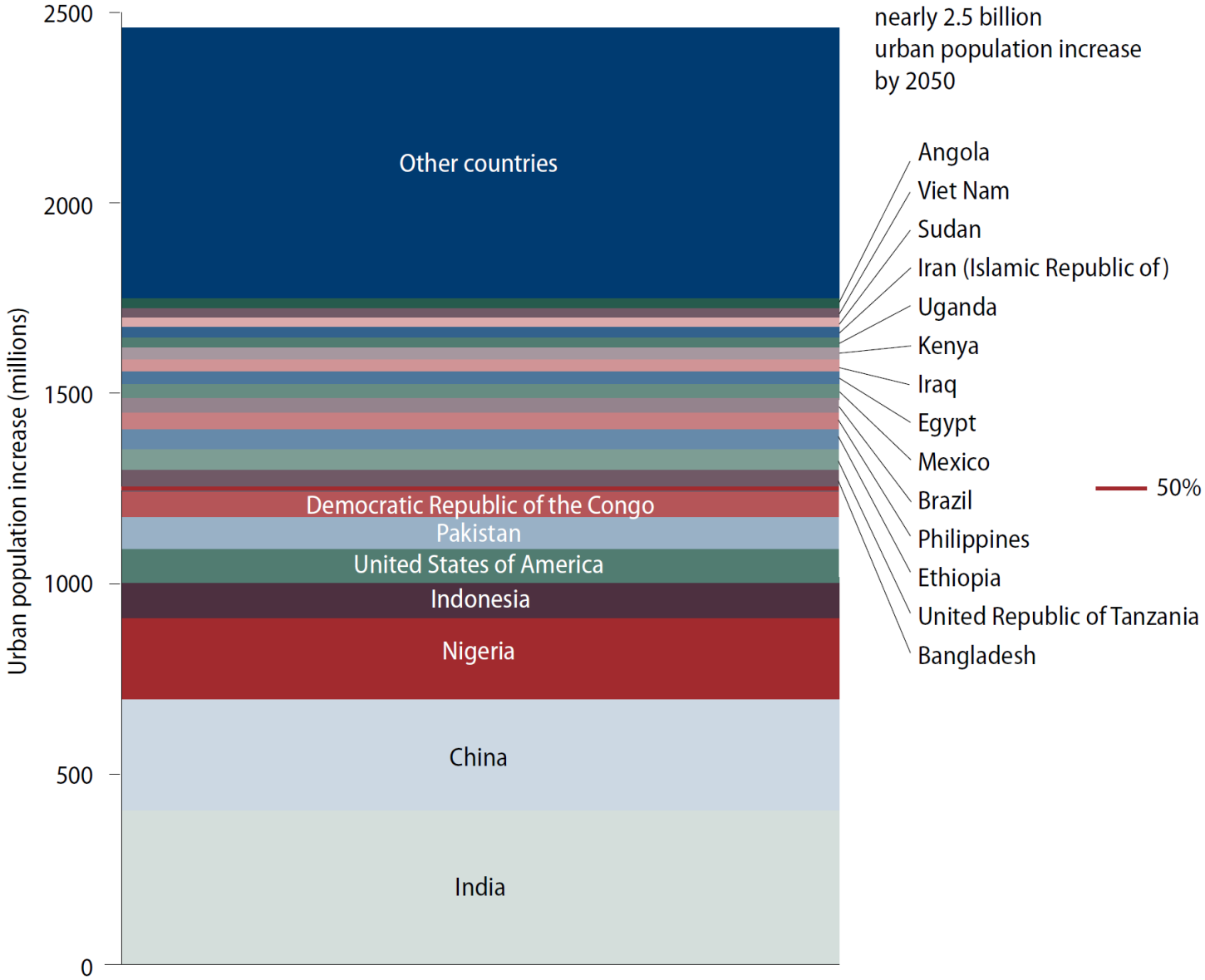
Tsinghua University: Qizhi Mao, Liang Zhao and Ying Long

Acknowledgement and disclaimer

Part funding from Centre for Smart Infrastructure & Construction (CSIC), Cambridge; National Key Lab for Urban Ecology and Green Building, Tsinghua University

Author alone is responsible for any views and remaining errors

Contribution to the increase in urban population by country, 2014 to 2050

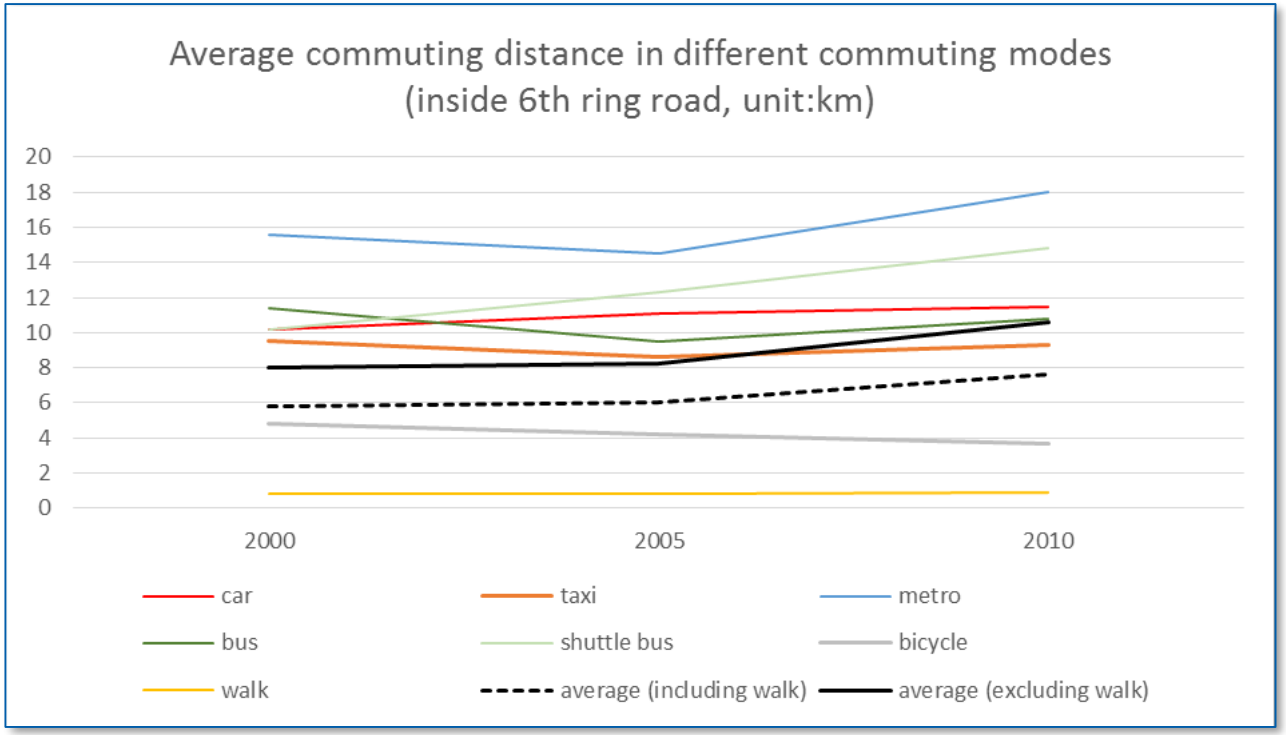


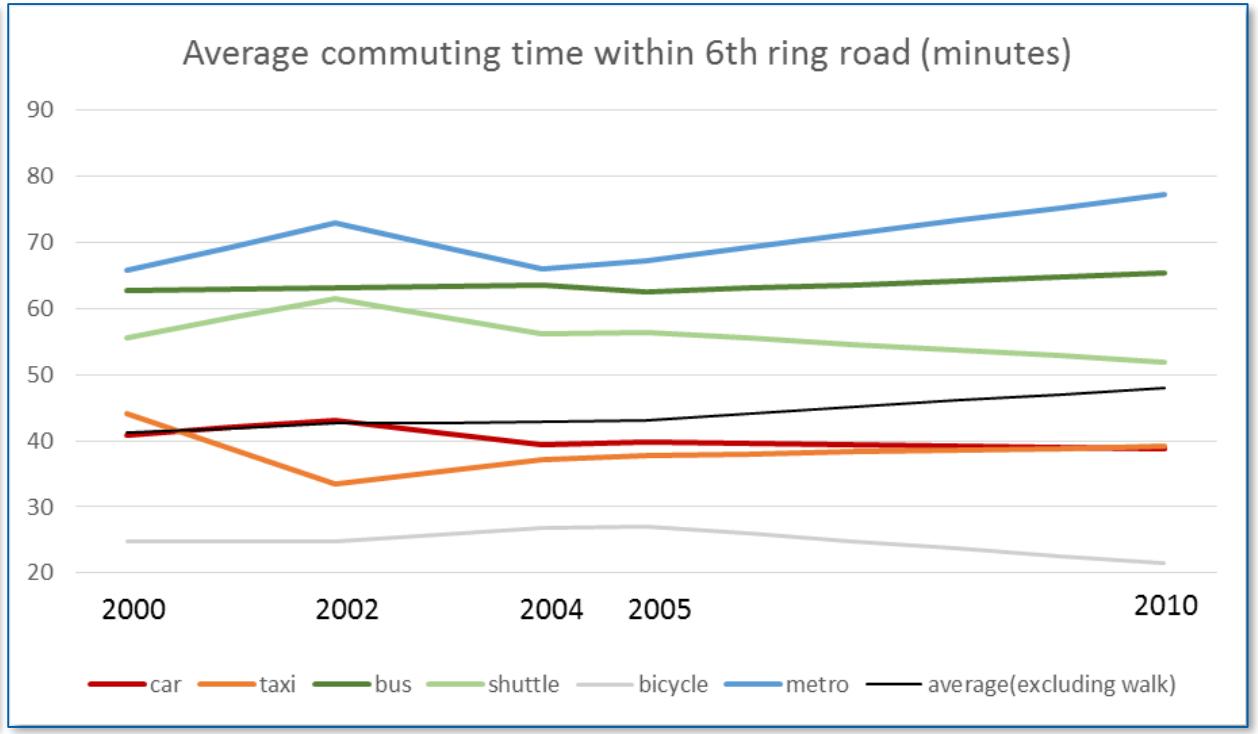
Note: The countries shown are projected to contribute 25 million or more to the global urban increment between 2014 and 2050. The category "Other countries" includes countries with urban increments of less than 25 million each. Source: UN Habitat (2014)

The global context of the modelling work for Greater Beijing

- Part of the **3+2** billion question (respectively of the current urban population and its growth to 2050 in mid/low income countries) – the total urban population is **4+2.5** bn
- Beijing is among the most proactive in terms of infrastructure planning and data provision for modellers
- But good data is still hard to find there, and the policy decision cycle is short

A. Sign of a chronic, rather than a precipitous ‘urban disease’: average commuting distance and time is only creeping up slowly



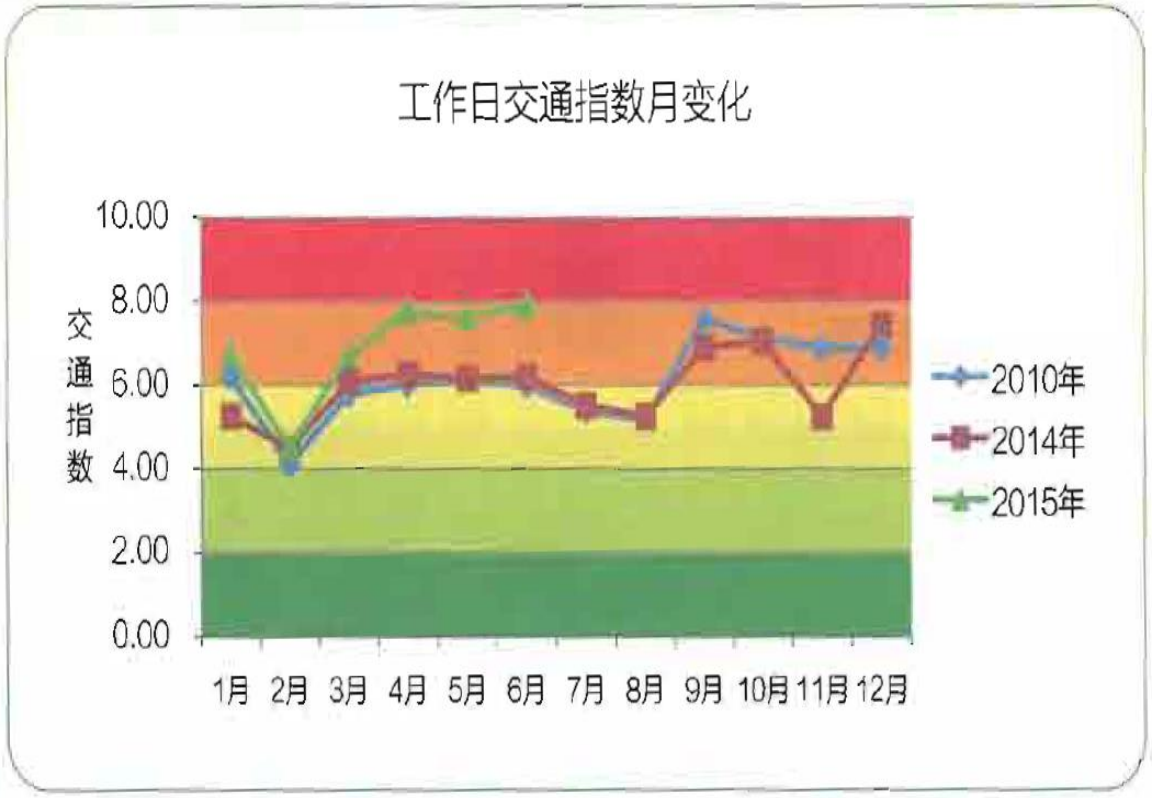


Major events over this period: 2005-2008 major infrastructure build-out for Beijing Olympics; 2008 car restriction by number plate number during weekdays

Source of data: BTRC(2007;2012)

B. we need to engage with wider, and possibly wilder LUTI questions – in the 'transformative' phase of cities

Monthly average road traffic congestion index



Traffic congestion is creeping up in Beijing, but gridlock is prevented by a whole host of adaptations

Road vehicle (dark green) and private car (light green) stock in 10,000 units

An example: car purchase license introduced in 2011 in Beijing

Source: BTRC, 2016

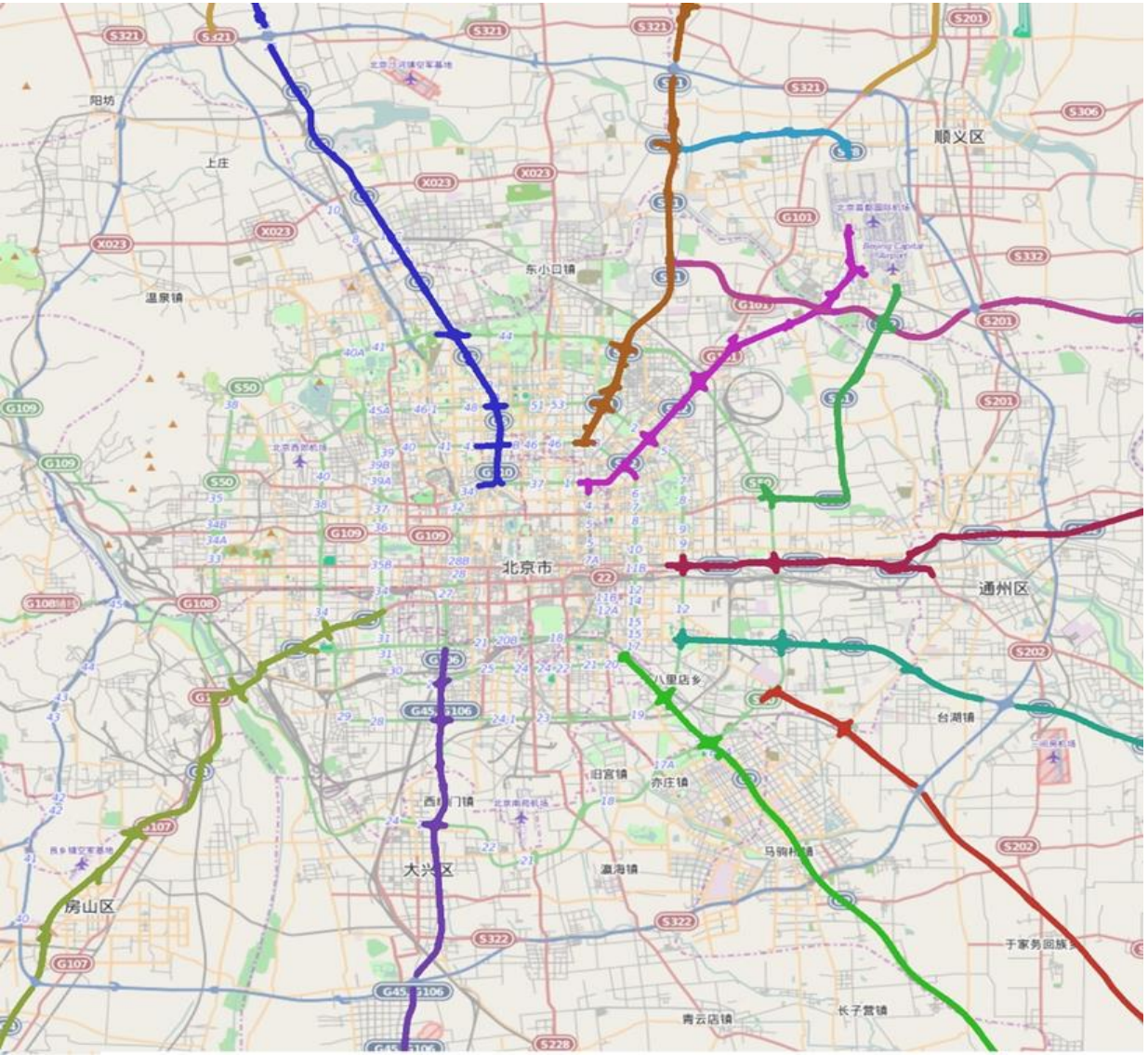
C. Purpose of the model from the practitioners' point of view:

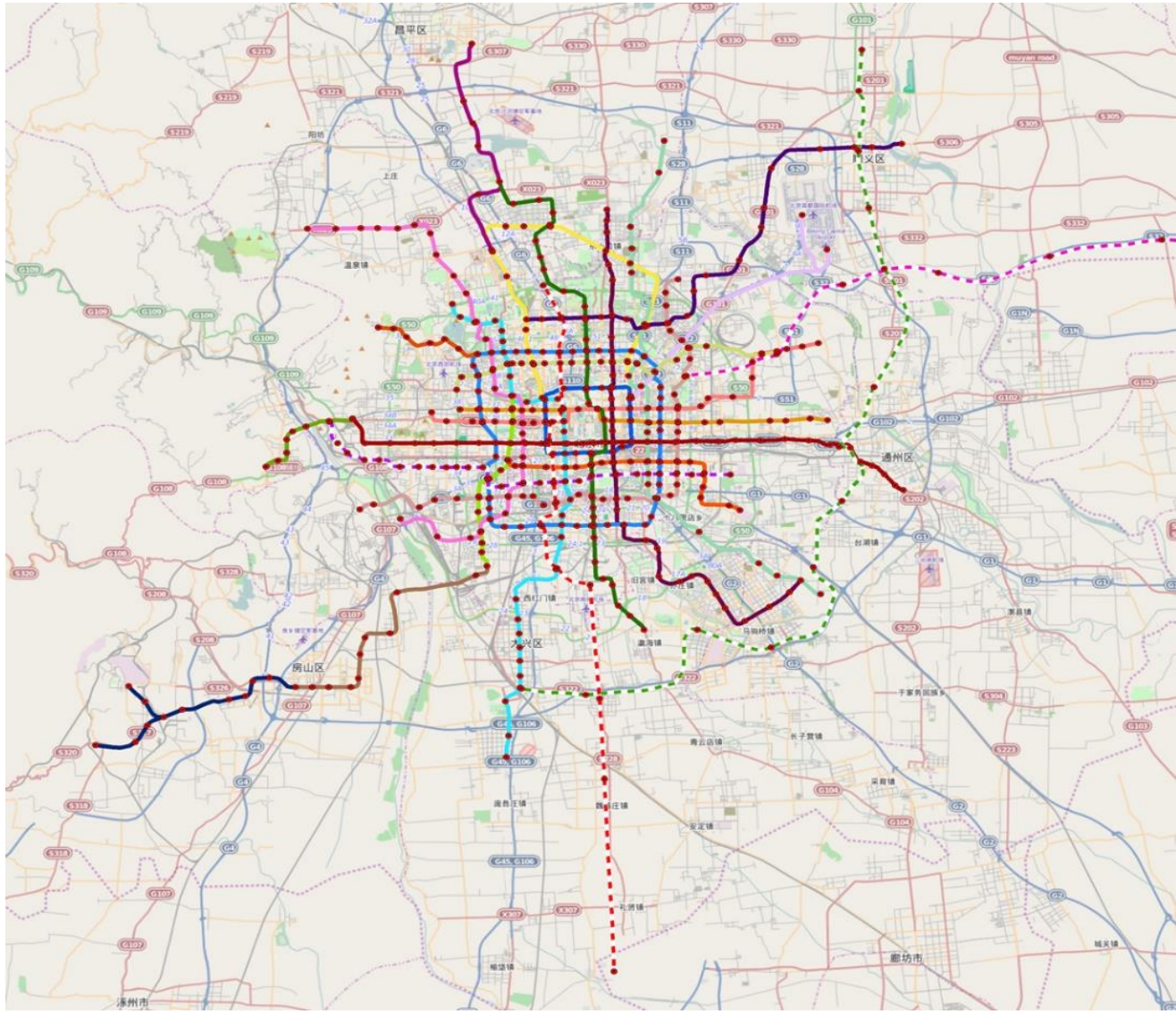
Appropriate land use mix, built form, timing of development and road and PT capacities

The old story

The new story

D. Planned projects form an incomplete package of interventions



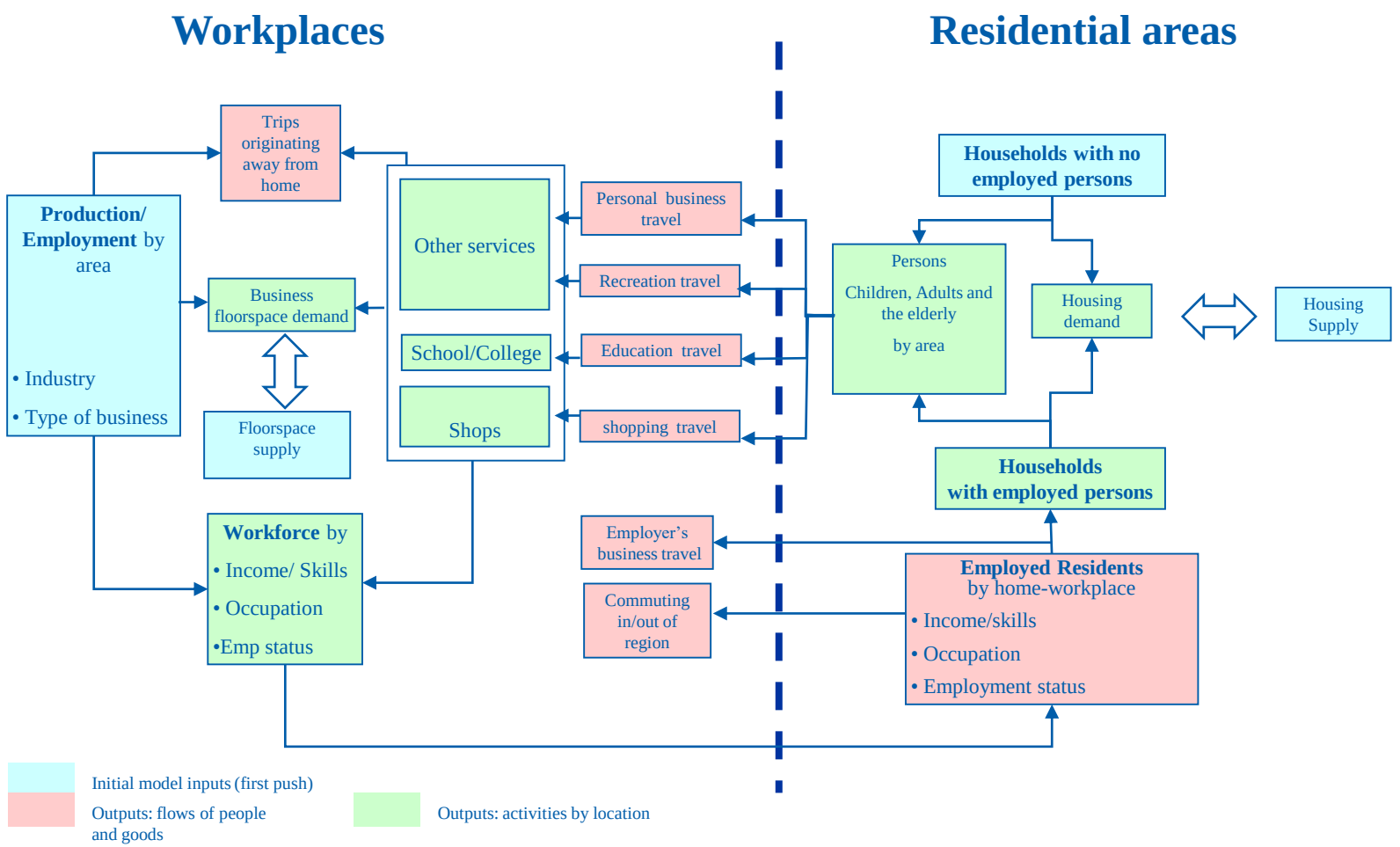


Our underlying model in two parts

- An spatial equilibrium to model the short/medium adaptations of working residents, their families and businesses
  - cf. Anas and Liu (2007)

- A recursive, non-equilibrium model for estate property development, relocation of non-commuter households, changes in transport infrastructure and services
  - cf. IRPUD, DELTA, UrbanSim

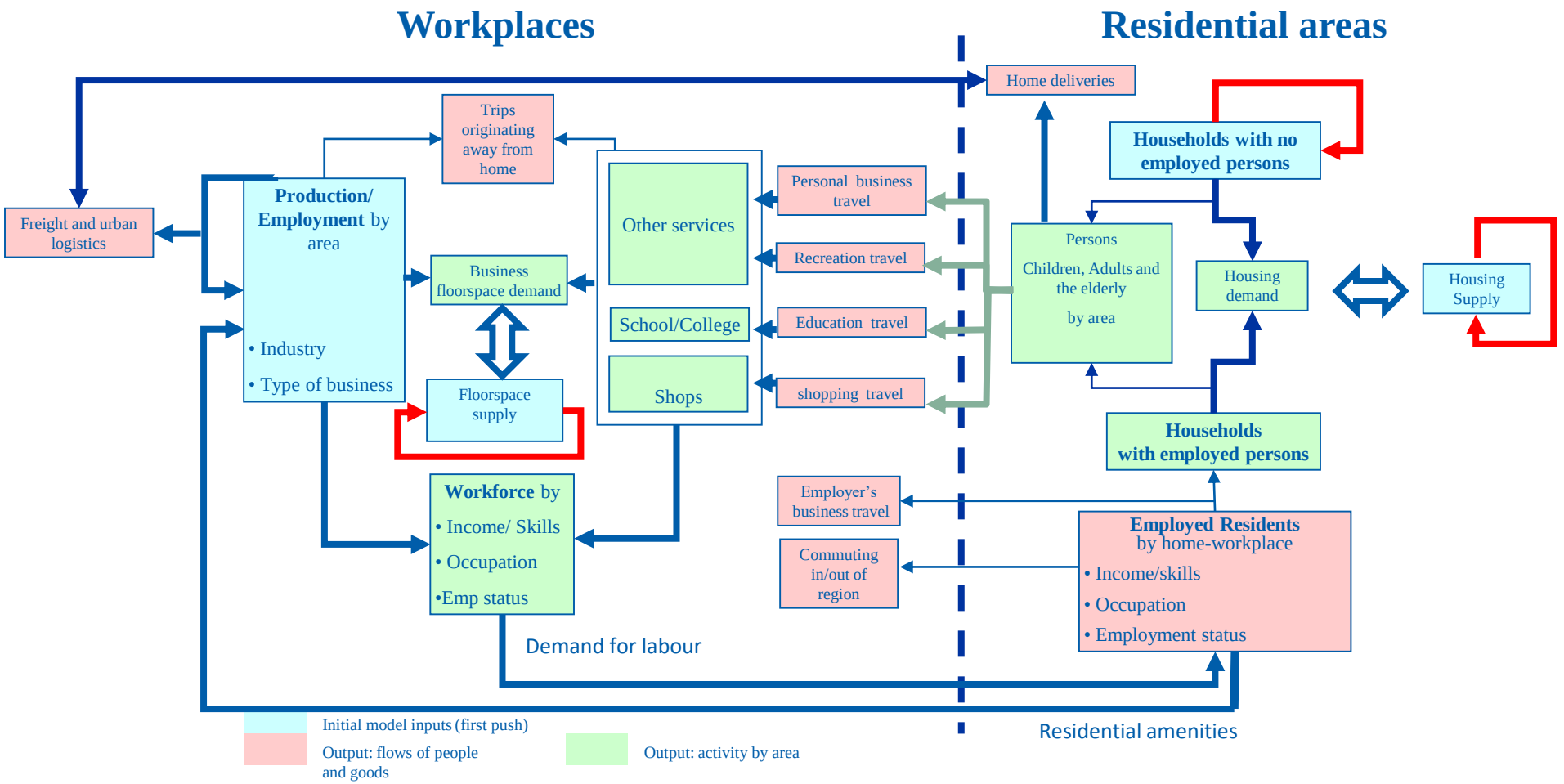
Our past models: a typical MEPLAN application



The tradition of land use and transport modelling: MEPLAN applications to Cambridge Subregion & London

For publications, see Echenique et al (1999); Jin et al (2002); Echenique (2004); the model structure is still being used by e.g. the UK National Transport Model

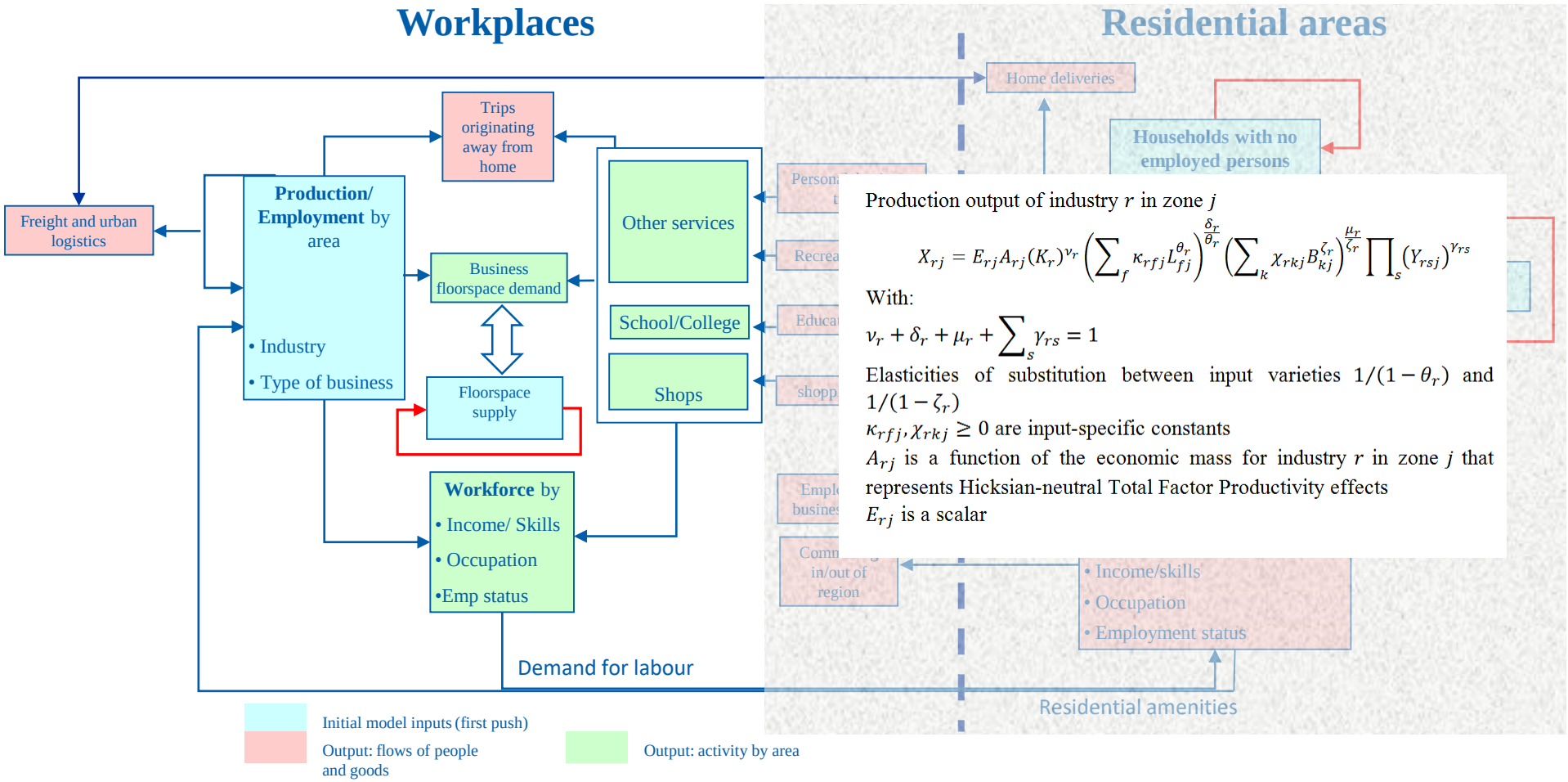
Our New Model Platform: LUISA2.0



A new generation of model for the trade-offs made by businesses and households, and for exploiting new, smart data sources

For papers on model design, see Echenique et al (2013); Jin et al (2013); Jin et al (2016)

Production function for businesses



Production output of industry r in zone j

$$X_{rj} = E_{rj}A_{rj}(K_r)^{\nu_r}\left(\sum_f \kappa_{rfj}L_{fj}^{\theta_r}\right)^{\frac{\delta_r}{\theta_r}}\left(\sum_k \chi_{rkj}B_{kj}^{\zeta_r}\right)^{\frac{\mu_r}{\zeta_r}}\prod_s (Y_{rsj})^{\gamma_{rs}}$$

With:

$$\nu_r + \delta_r + \mu_r + \sum_s \gamma_{rs} = 1$$

Elasticities of substitution between input varieties $1/(1-\theta_r)$ and $1/(1-\zeta_r)$

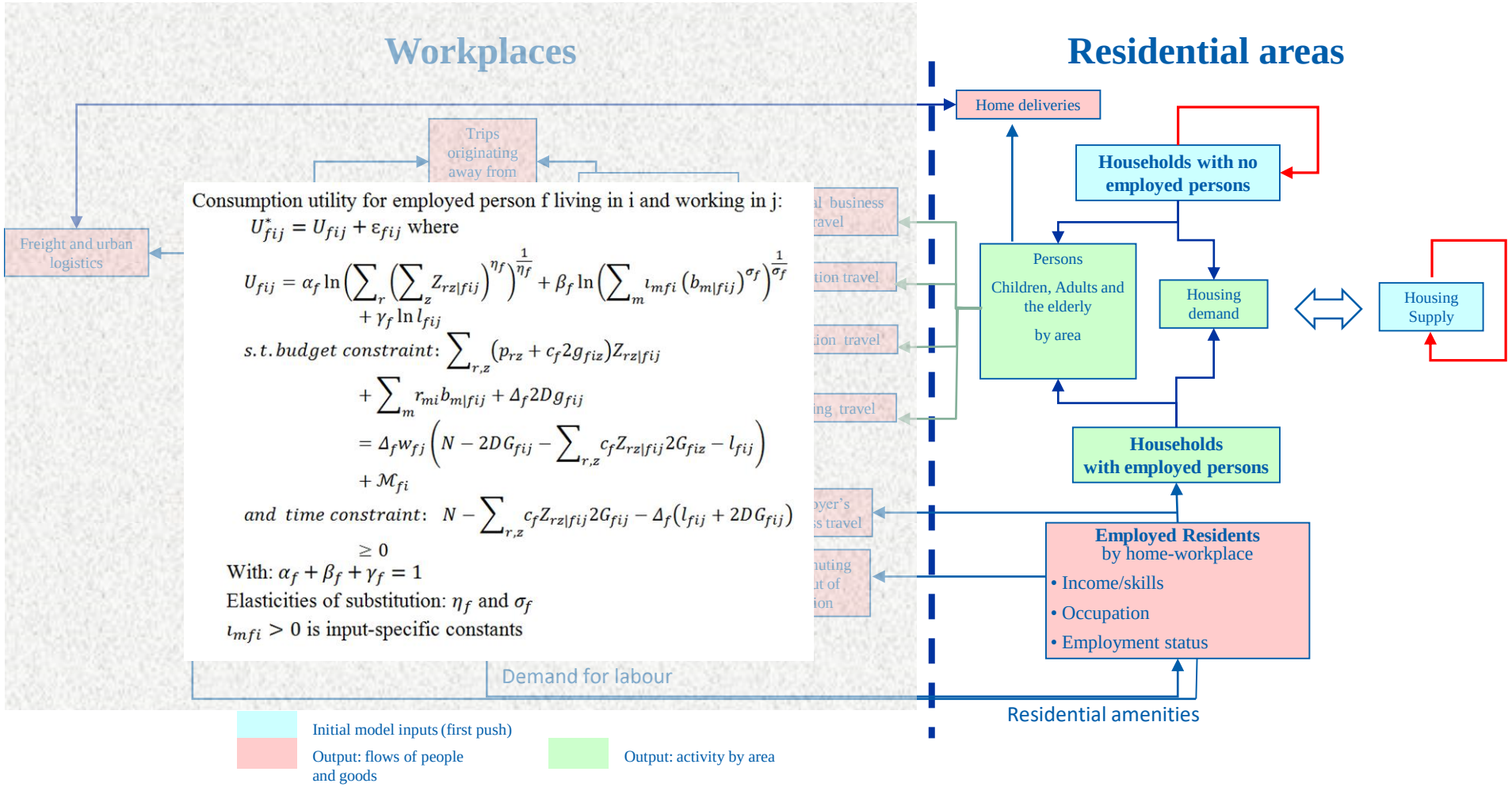
$\kappa_{rfj}, \chi_{rkj} \geq 0$ are input-specific constants

A_{rj} is a function of the economic mass for industry r in zone j that represents Hicksian-neutral Total Factor Productivity effects

E_{rj} is a scalar

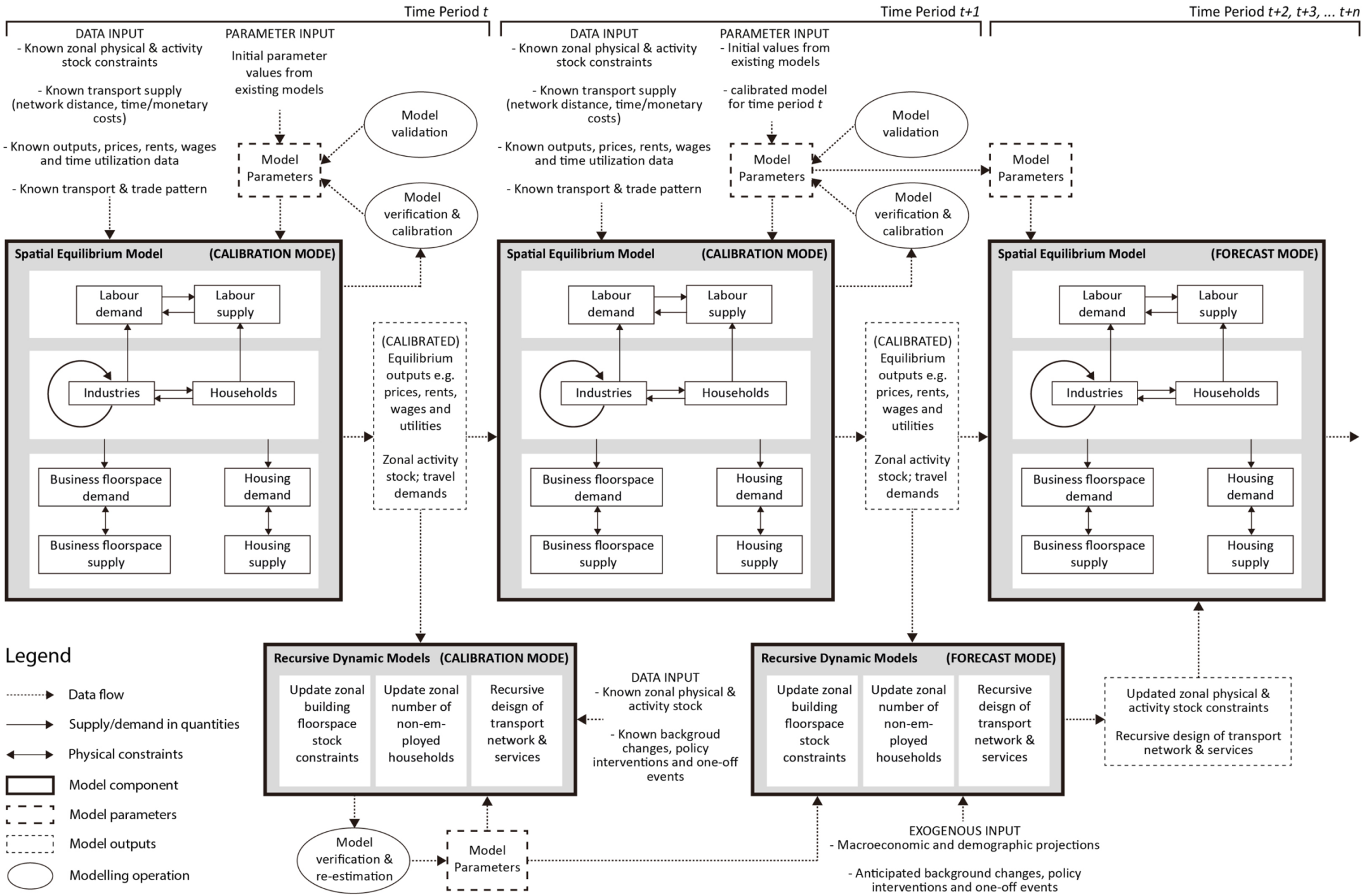
LUISA: core model for the trade-offs made by businesses regarding labour, premises, suppliers and agglomeration effects

Utility function for households



LUISA: core model regarding on the trade-offs made by households regarding consumer goods and services, housing, leisure time and non-monetary attractiveness of neighbourhoods

Spatial equilibrium and recursive land development and demographic dynamics



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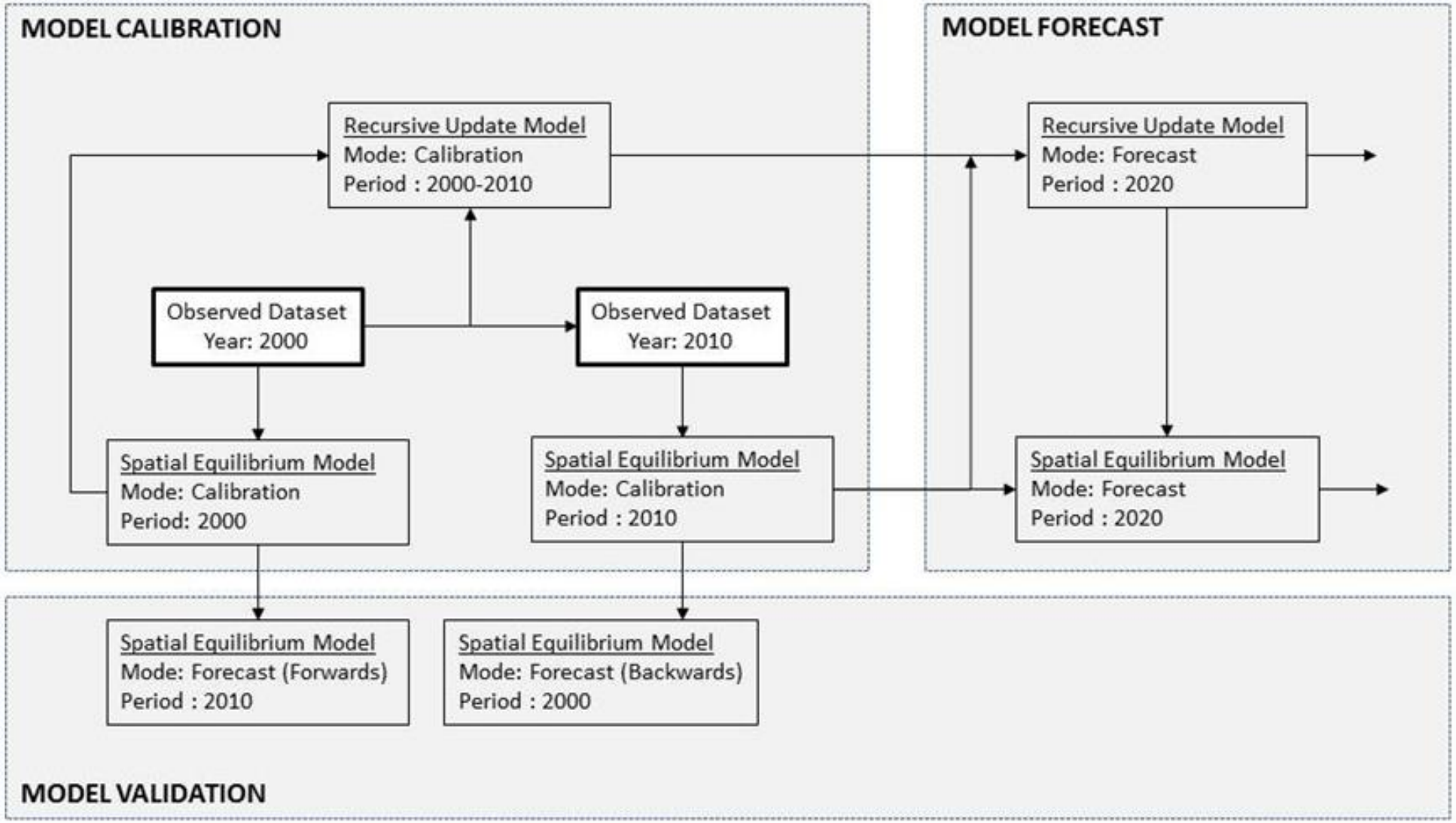
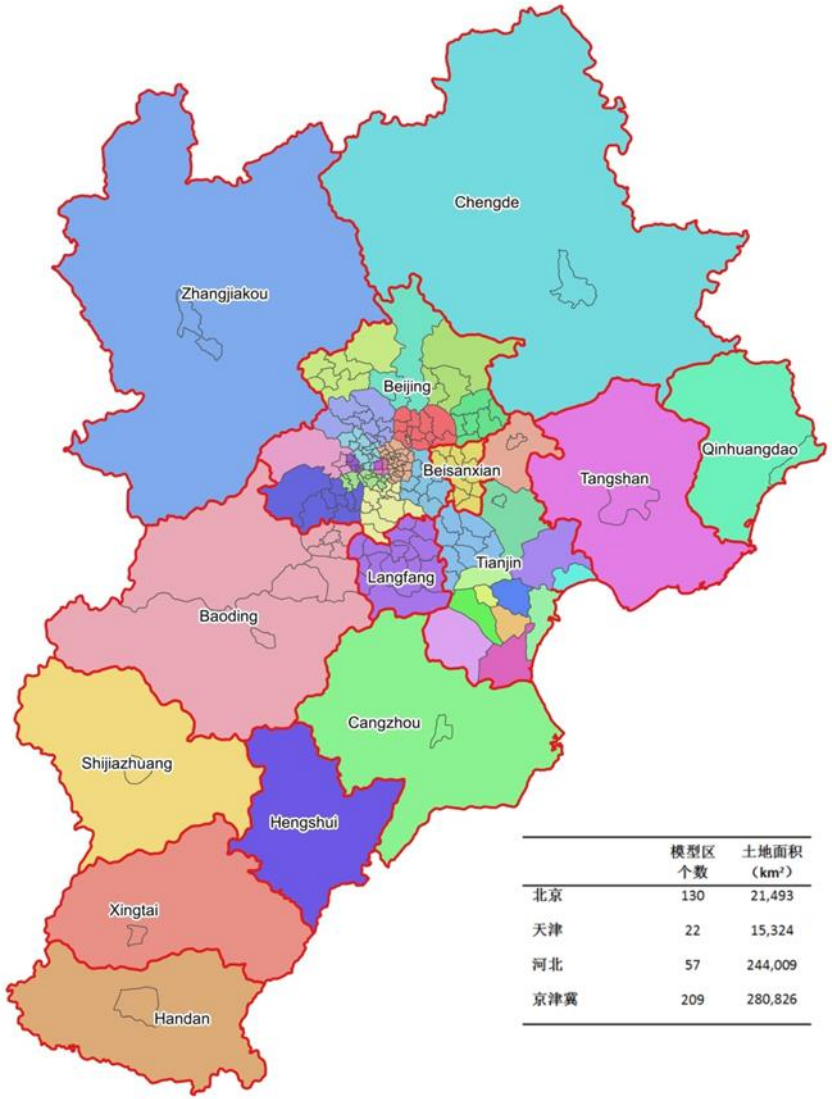
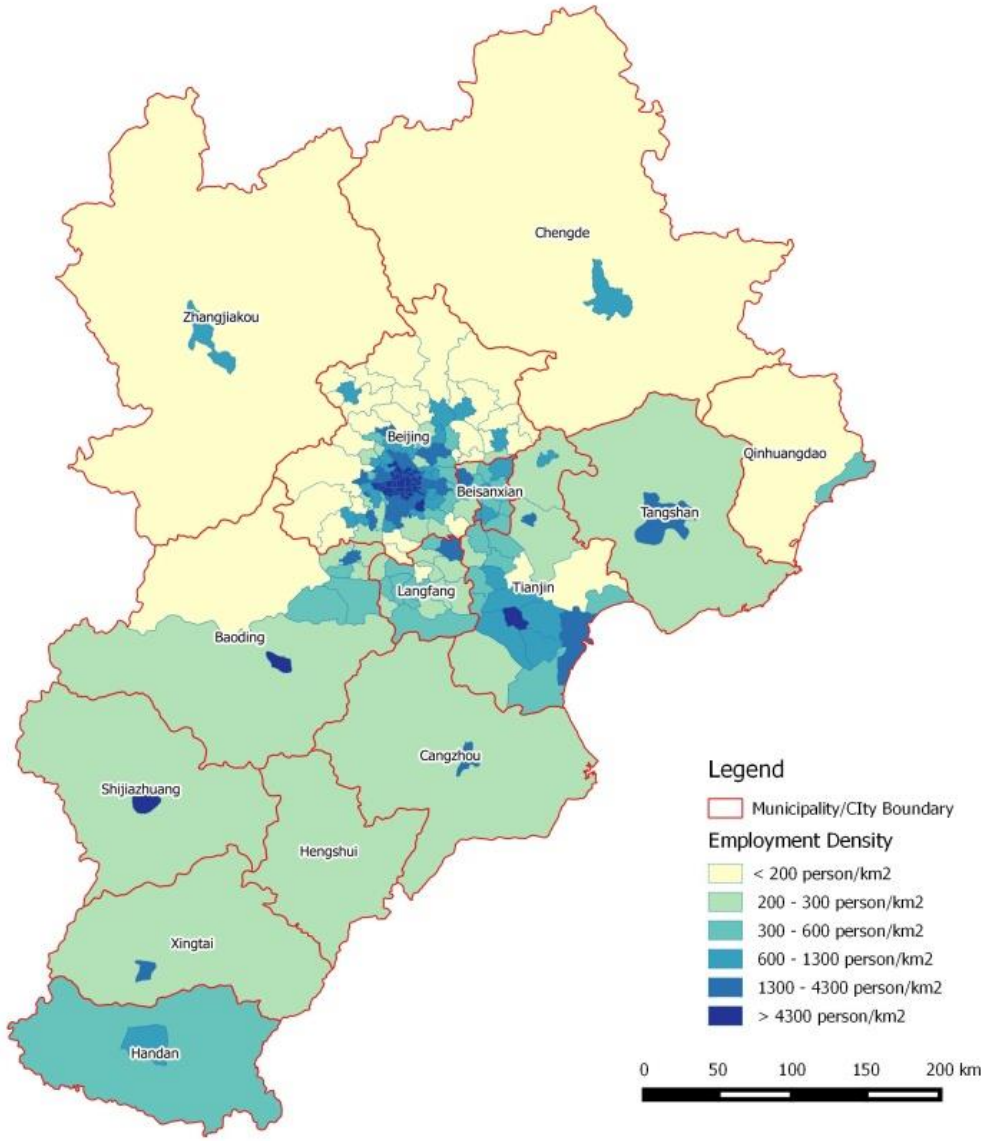
Two cross-section land use model calibration without a transport model



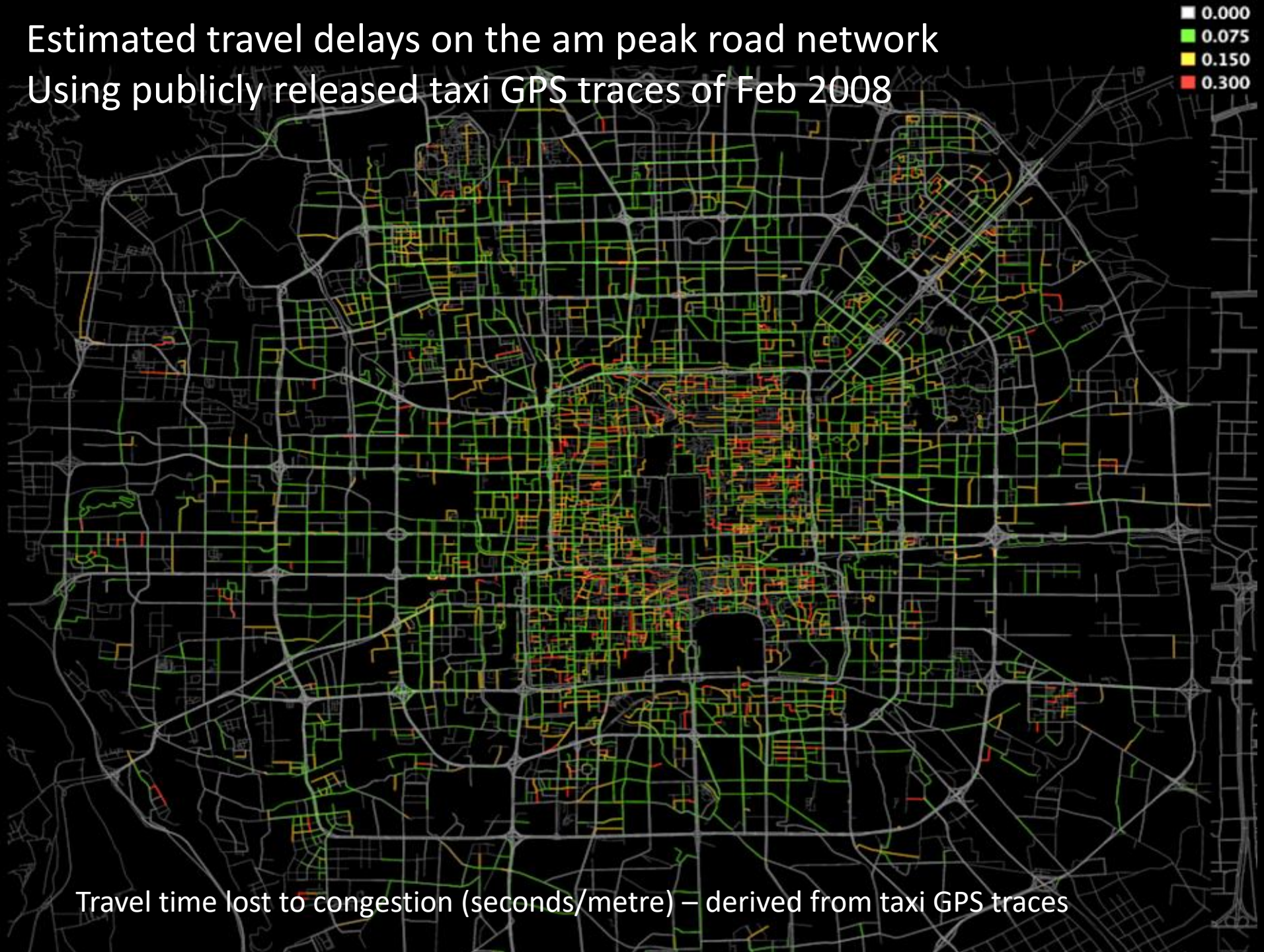
The Beijing-Tianjin-Hebei megachora:
215,870km^2 of land, 110m residents (2014)



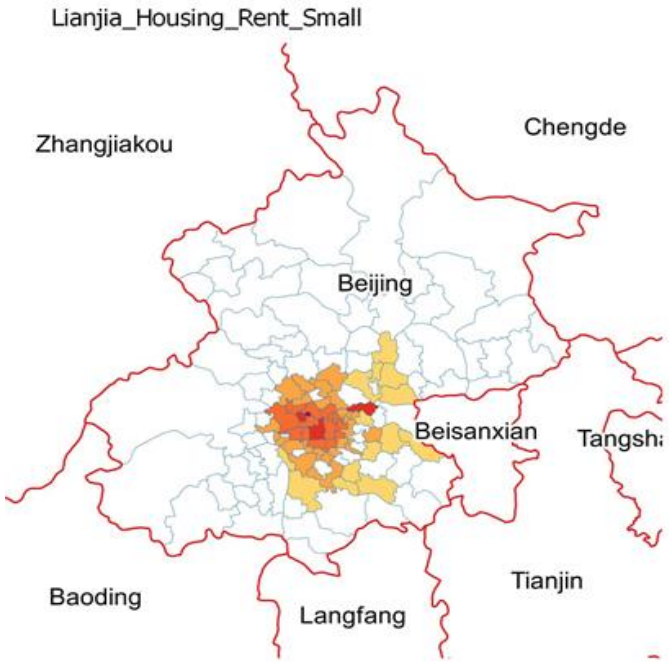
	模型区个数	土地面积（km²）
北京	130	21,493
天津	22	15,324
河北	57	244,009
京津冀	209	280,826

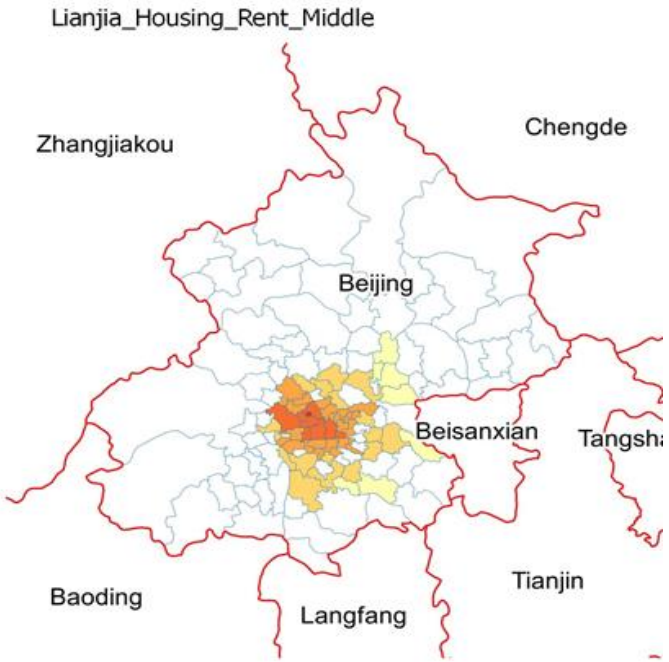


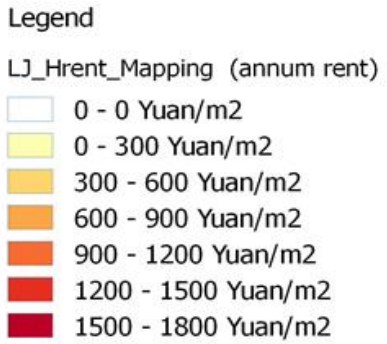
Estimated travel delays on the am peak road network
Using publicly released taxi GPS traces of Feb 2008



Travel time lost to congestion (seconds/metre) – derived from taxi GPS traces



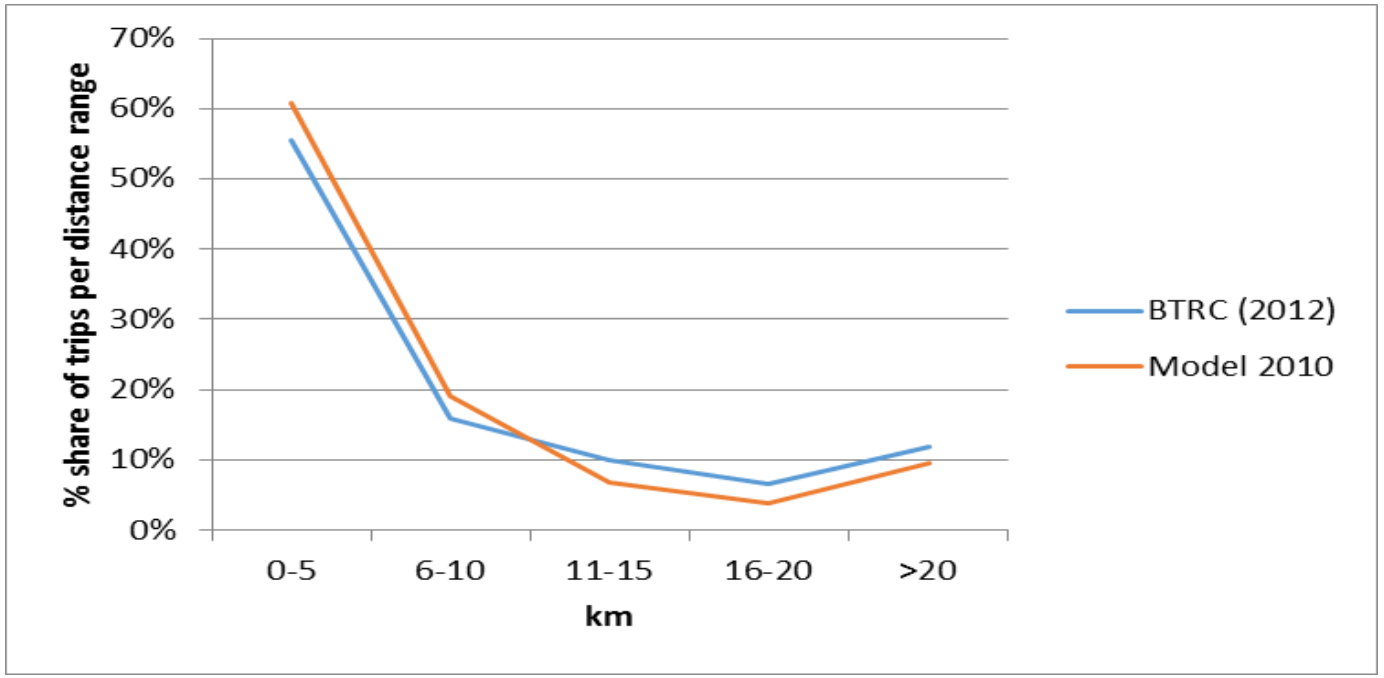




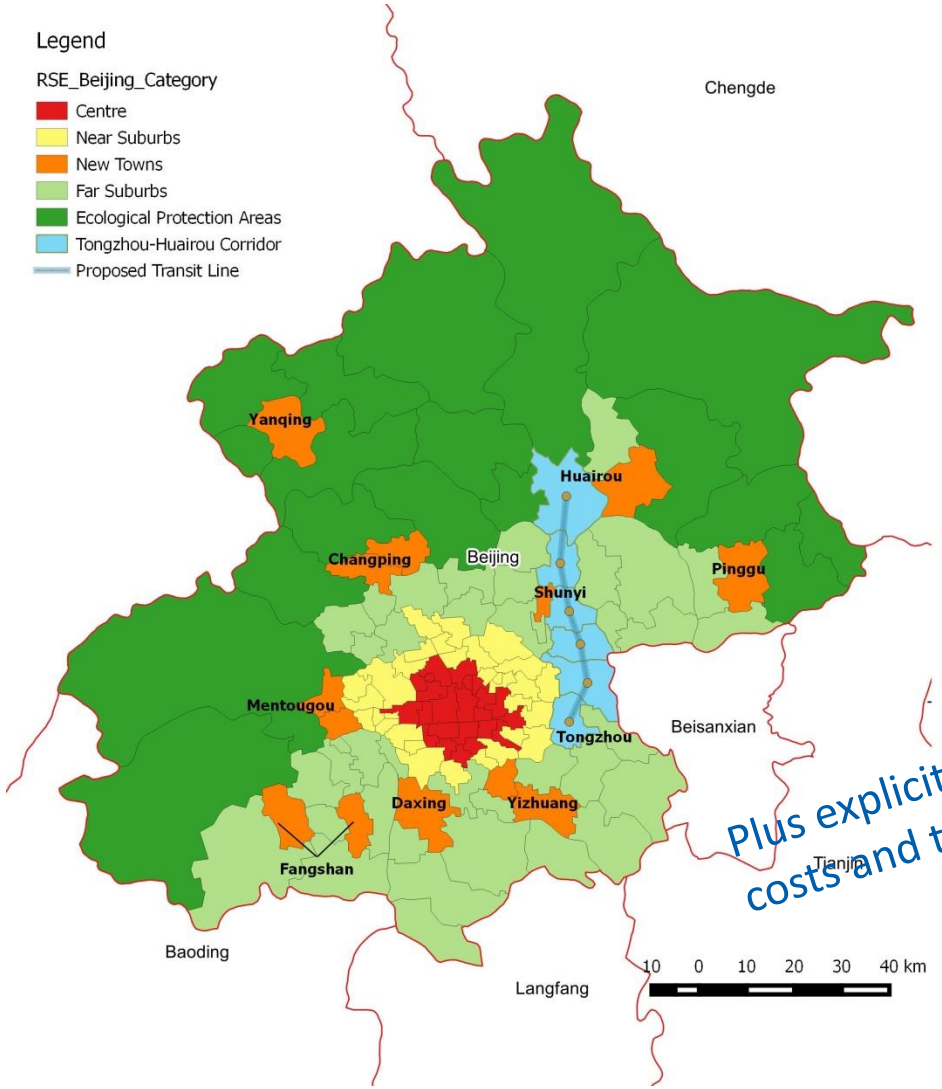
Estimated housing rent levels using data from estate agent website Lianjia.com

Transport model validation: 2010

	Commuting		Education		Business		Other		All purposes	
	Survey	Modelled	Survey	Modelled	Survey	Modelled	Survey	Modelled	Survey	Modelled
Car	26.2%	26.6%	16.3%	23.9%	72.0%	55.8%	26.0%	28.3%	27%	28%
Bus	25.7%	26.7%	32.0%	33.8%	11.0%	14.5%	23.0%	25.9%	24%	27%
Walk	19.4%	19.4%	32.6%	25.8%	3.0%	12.0%	29.0%	28.8%	25%	24%
Cycle	14.8%	9.3%	13.7%	11.9%	3.0%	3.5%	13.0%	8.5%	13%	9%
Metro	13.9%	18.0%	5.4%	4.6%	11.0%	14.1%	9.0%	8.6%	11%	12%

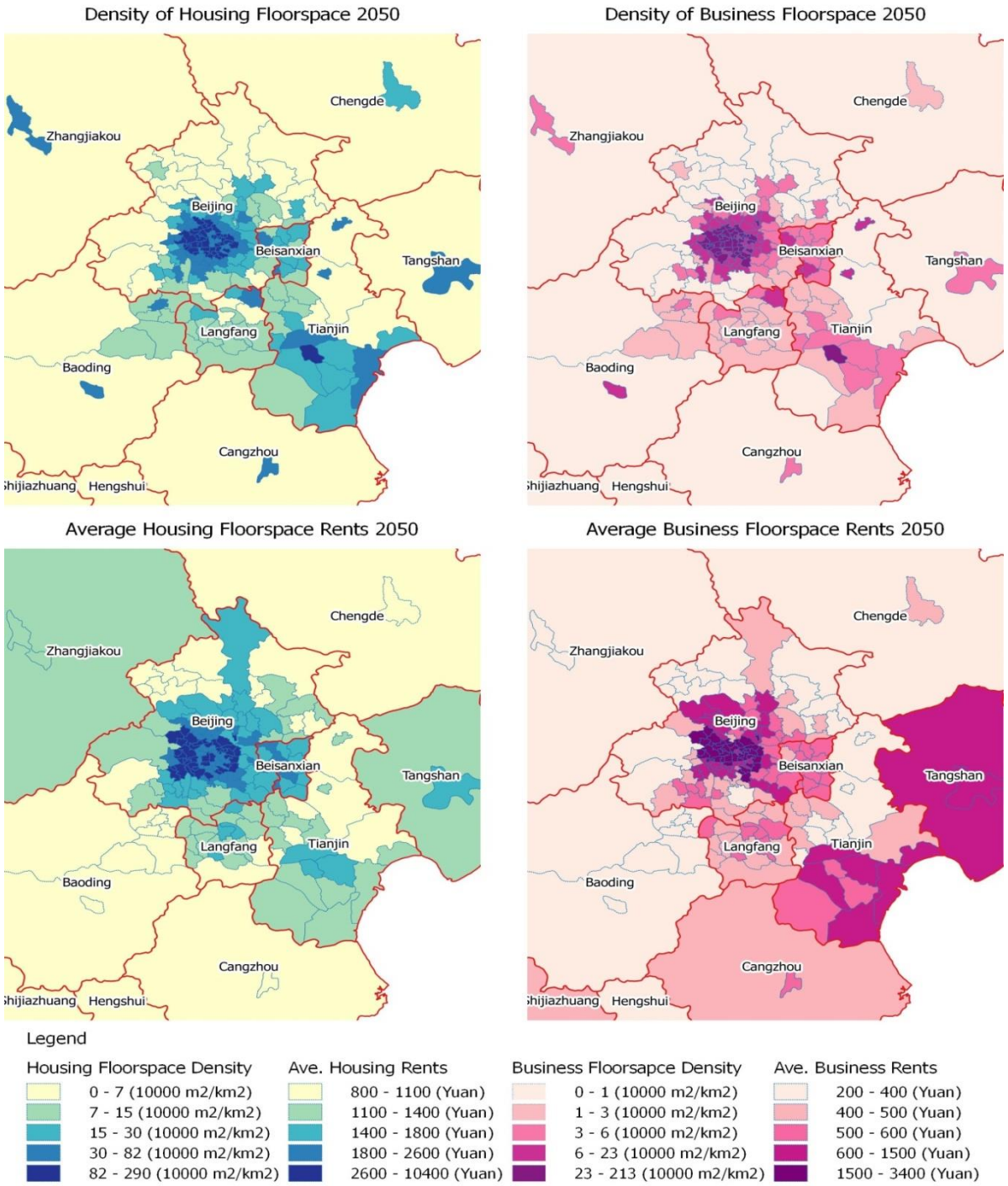


Classifications for land use zones in e.g. Beijing



Plus explicit assumptions regarding travel distances, costs and times between model zone OD pairs

Prediction of housing and business floorspace



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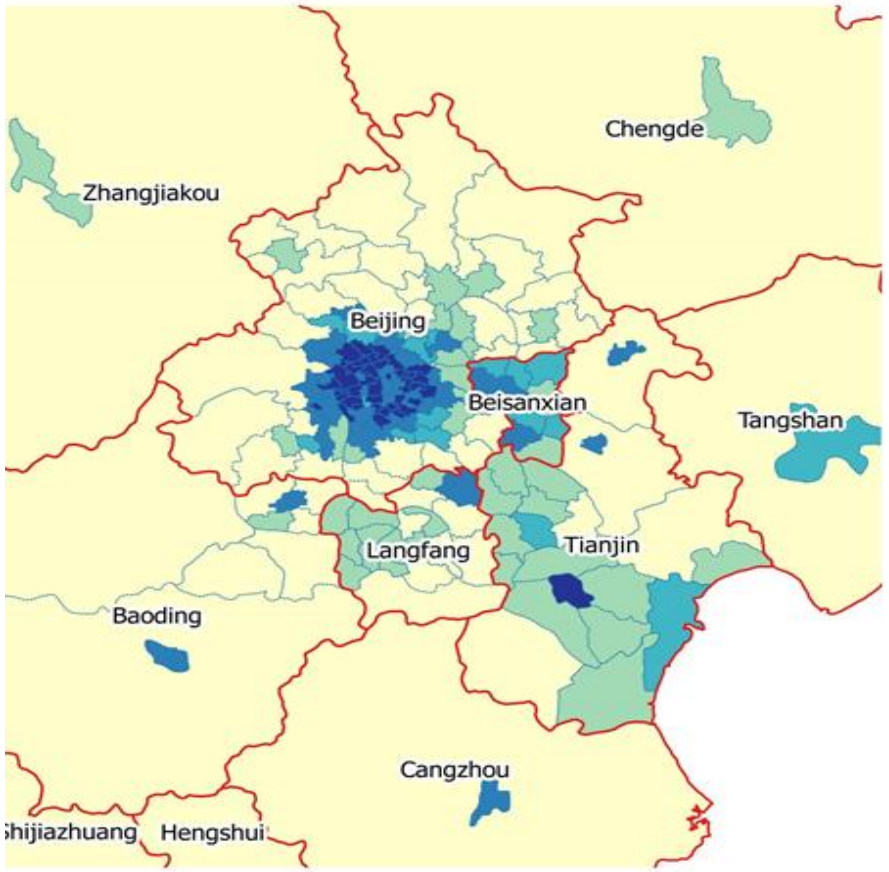
Prediction of locations of residents and jobs

Density of Total Residents 2050

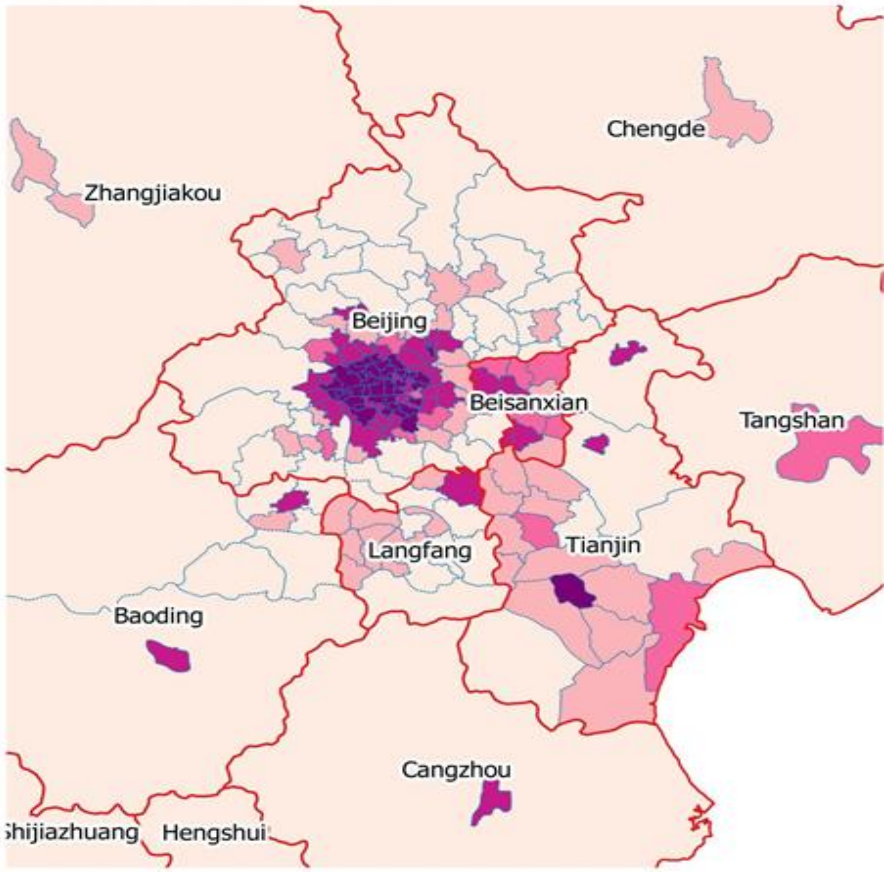


Legend

Total_Resident_Density

- 0 - 1000 (person/km2)
- 1000 - 2000 (person/km2)
- 2000 - 3000 (person/km2)
- 3000 - 10000 (person/km2)
- Above 10000 (person/km2)

Density of Total Employment 2050

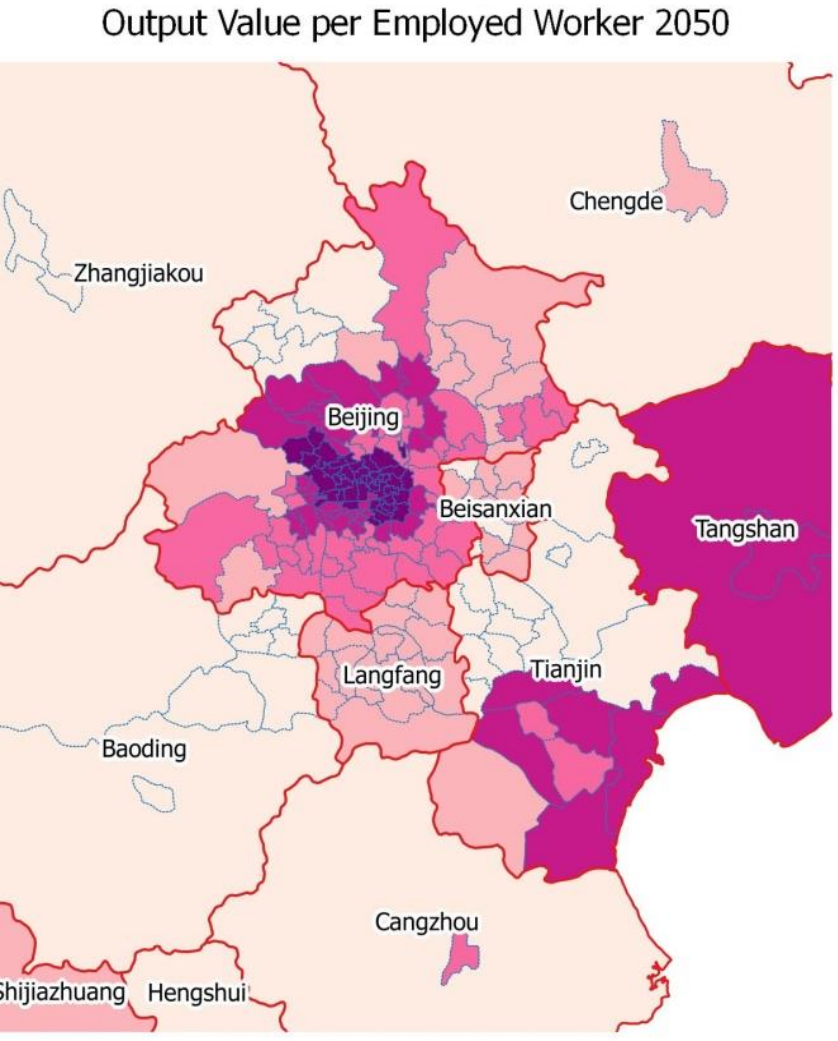


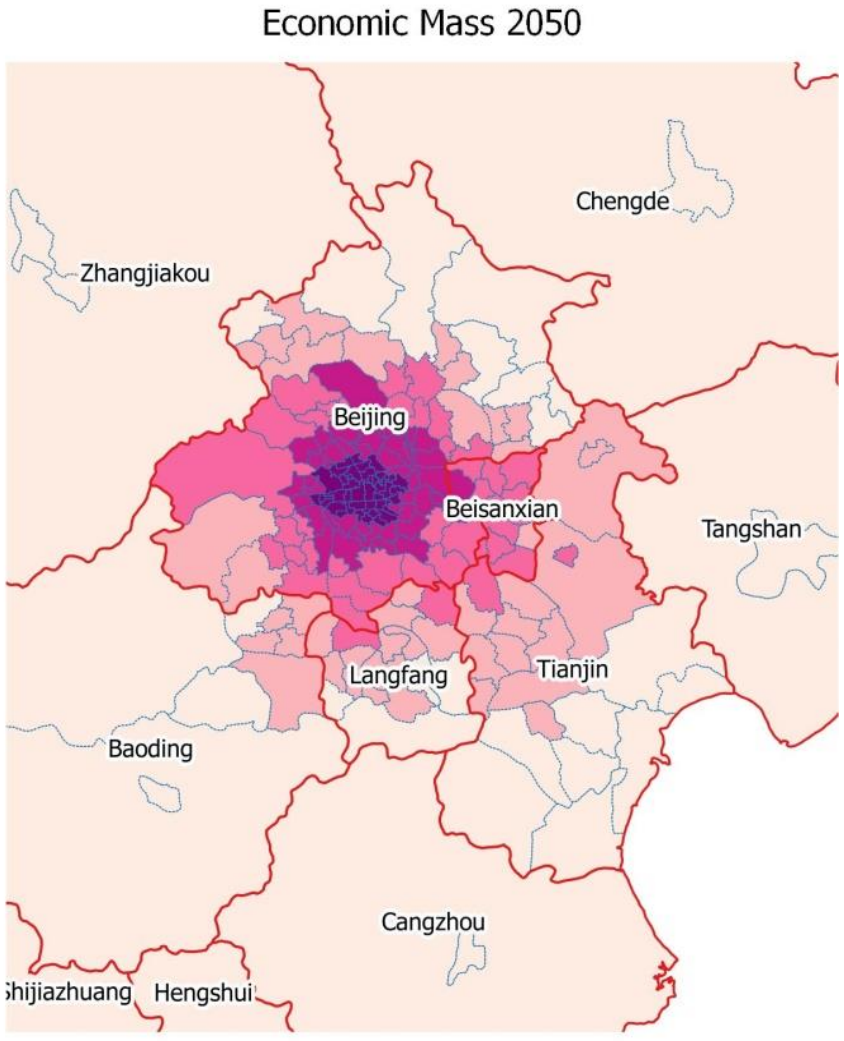
Legend

Total_Employment_Density

- 0 - 1000 (person/km2)
- 1000 - 2000 (person/km2)
- 2000 - 3000 (person/km2)
- 3000 - 10000 (person/km2)
- Above 10000 (person/km2)

Predictions for the workplace





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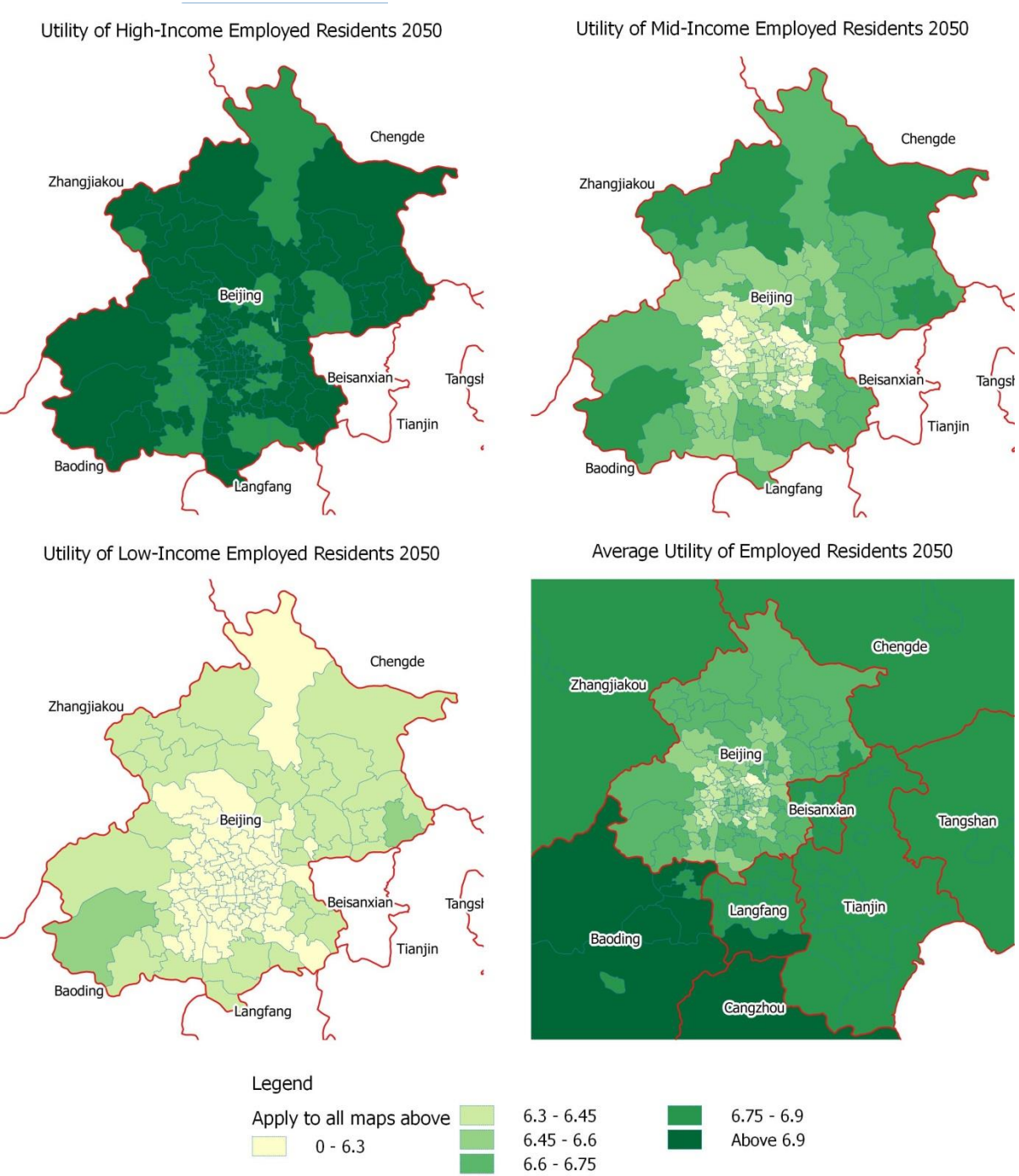
Predictions for residential zones



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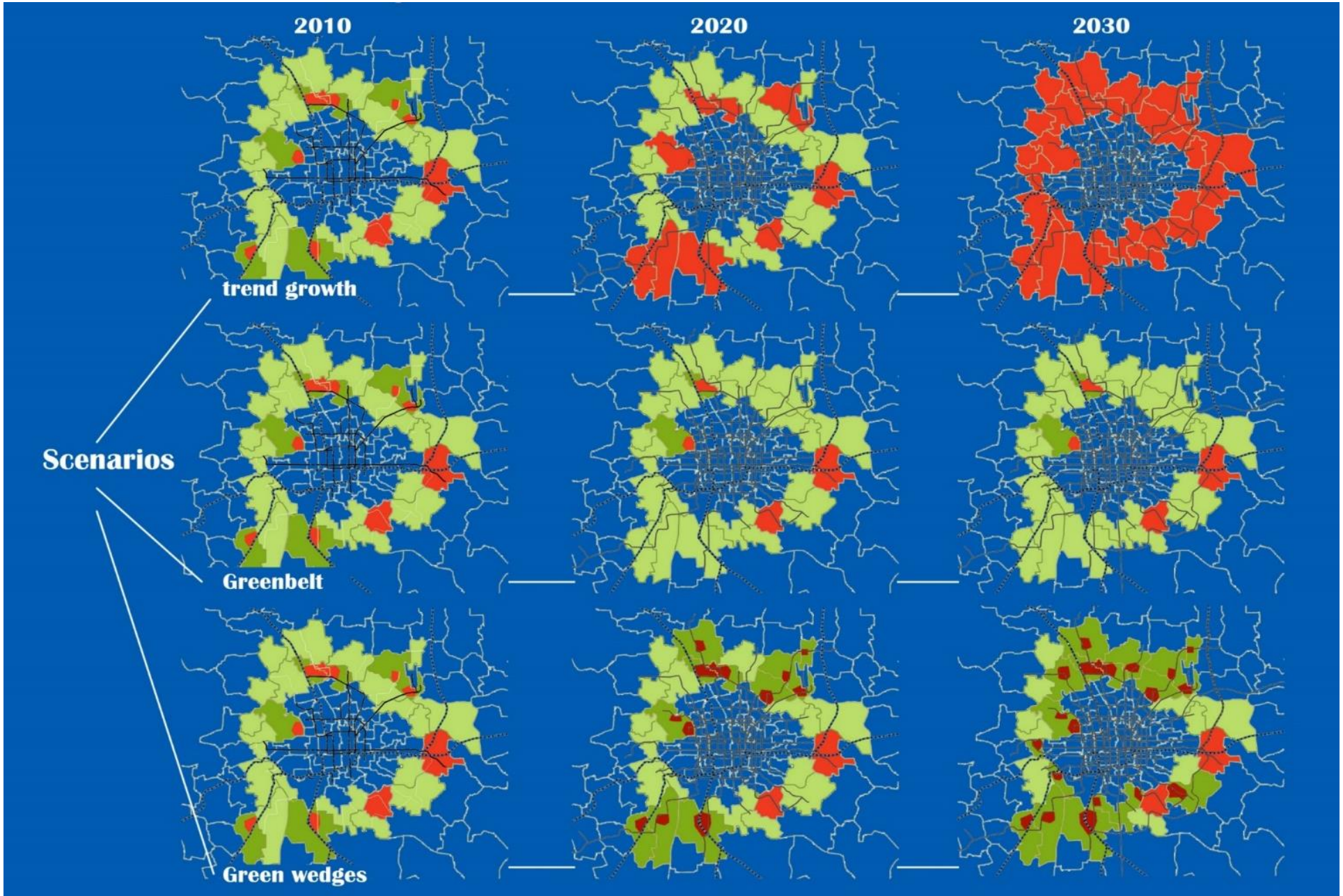
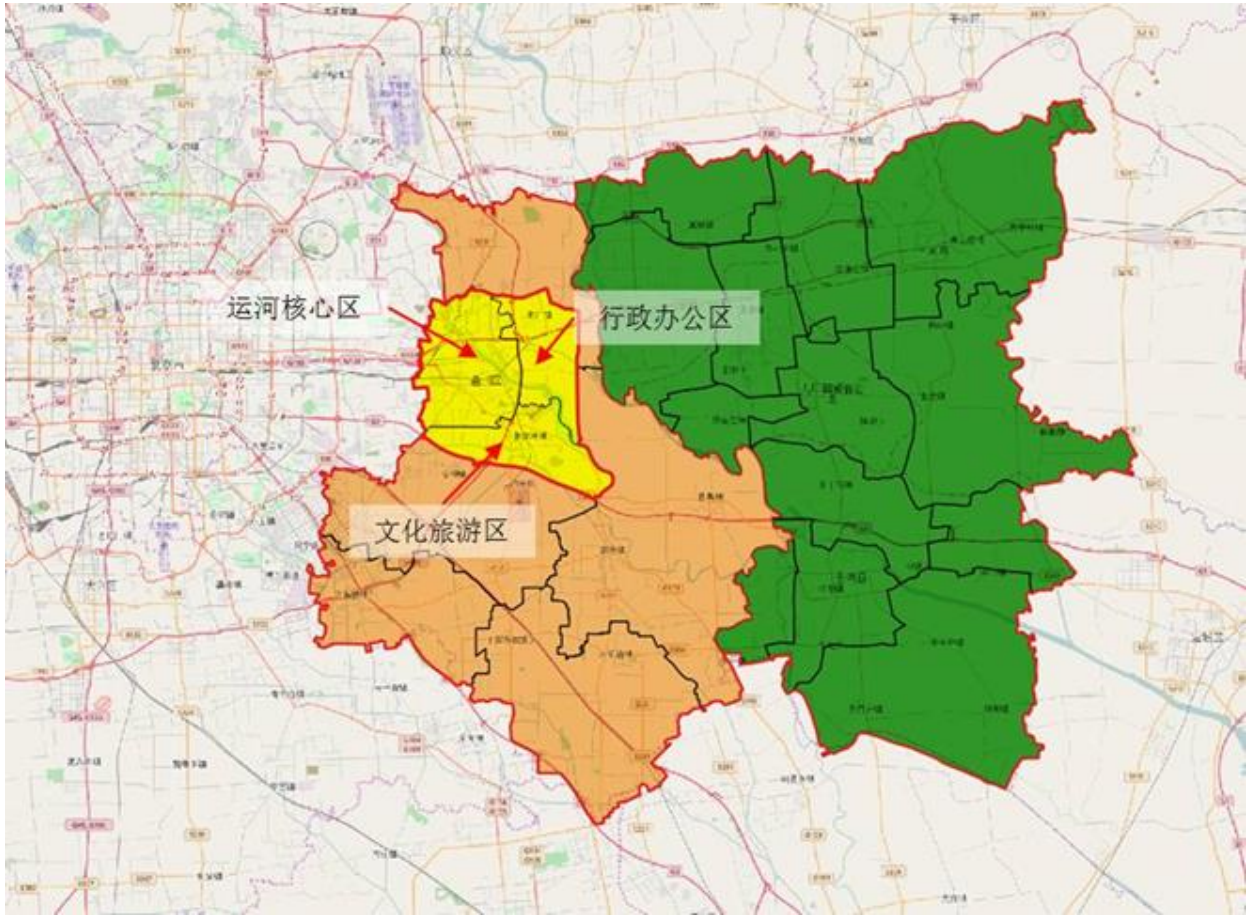
Testing alternative land use and transport scenarios
From top: sprawl (trend), strict control (greenbelt) and green wedges



New land use and transport initiative in Beijing: the Tongzhou sub-centre for the metropolitan area



Summary

- The city regions in the low and middle income countries in the next few decades are unprecedentedly large, with possible ‘parallel worlds’
- Model predictions are urgently needed to improve the land use and transport coordination
  - Necessarily for 20-30 years in timescale for such coordination to come to fruition
  - With scant data and infrastructure plans – the modellers to be the ‘wise guys’?
  - Current trends in Beijing do not bode well – e.g. severely high unmet demand for metro / rail – how much space should we reserve for future demand, given the expected growth in the next few decades?
- Question is: can megachoras in the developing world achieve the same (or better) accessibility and mobility, whilst transforming the existing patterns of development?
- A possible new approach to speed up/simplify : make the LU and T modules even more remote than hitherto, and make better use of new data sources for traffic congestion/crowding, and property rents

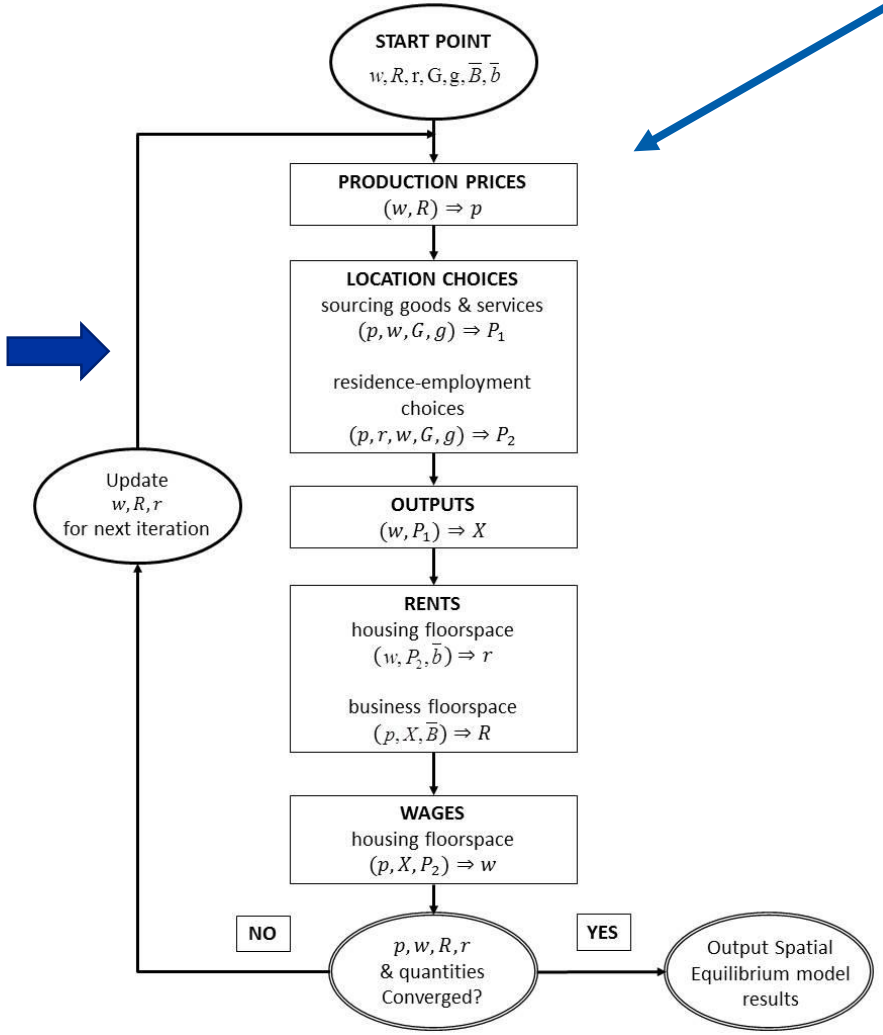
In answer to Rolf's questions

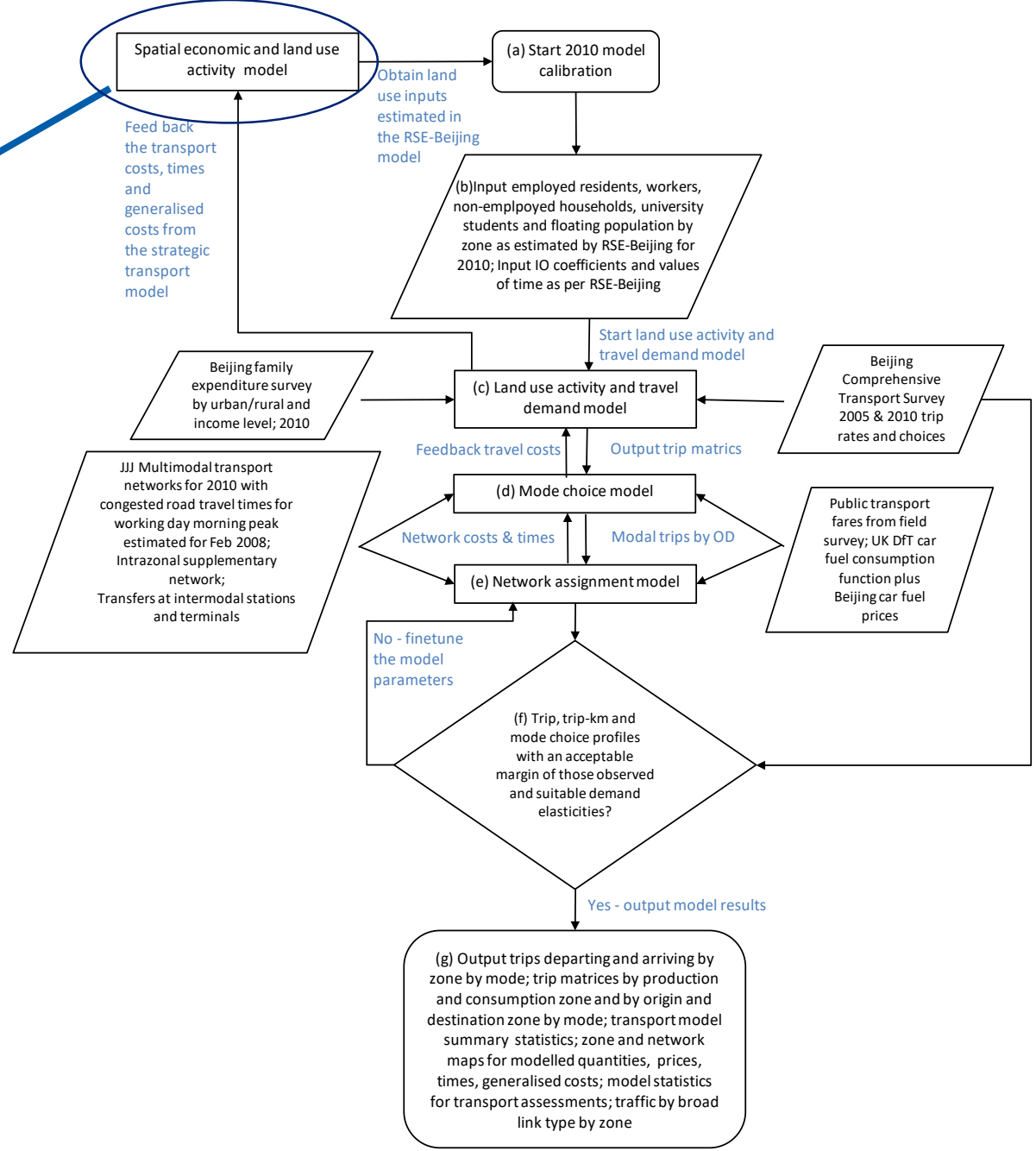
- Can microscopic integration at the agent-level improve the integration of land use and transport models?
  - Absolutely, so long as we could use the insights from this process in aggregate models
- Is there information beyond travel times and zonal location of population and employment that should be exchanged between the land use and transport models?
  - On the one hand, I'd suggest exchange even less information, and on the other hand, let the LU model inform the T model much more about the nature of land use and built form for e.g. improved car ownership and travel demand predictions in the future (Personal characteristics of the travllers are already passed on to T)
- How can we deal with different time scales of ad-hoc transportation choices and long-term housing choices?
  - Through combining dynamic non-equilibrium models with spatial equilibrium ones
- What is the right balance between model detail and reasonable runtimes?
  - For PhD students to finish on time, 1-2 hours per main run
- Do we need additional tools, such as environmental impact models, health impact models, of fiscal impact models, to complement the land use/transport feedback cycle?
  - Yes – but those should incorporate gaming among all main stakeholders

Spare slides

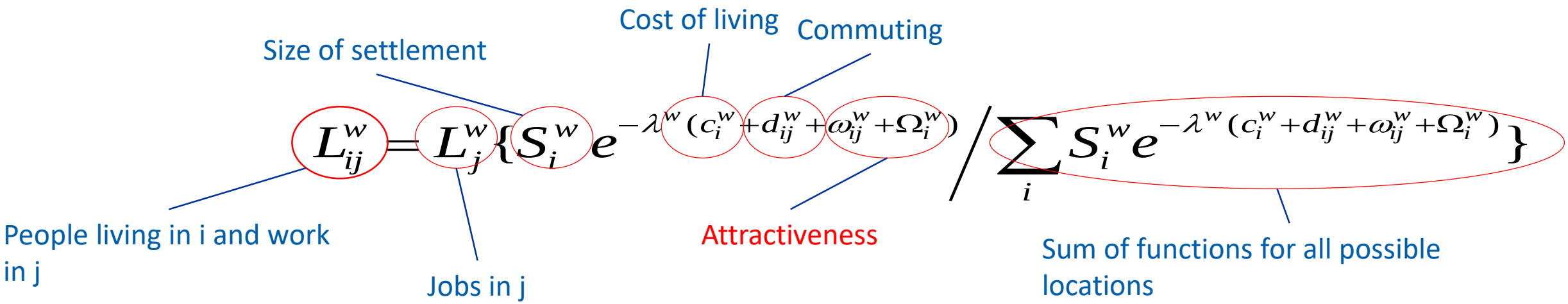
Model calibration

Production and population censuses, average prices, wages and consumption data, micro-data on dwelling rents/prices





Household's choice of where to live:



Source: Jin et al, 2011

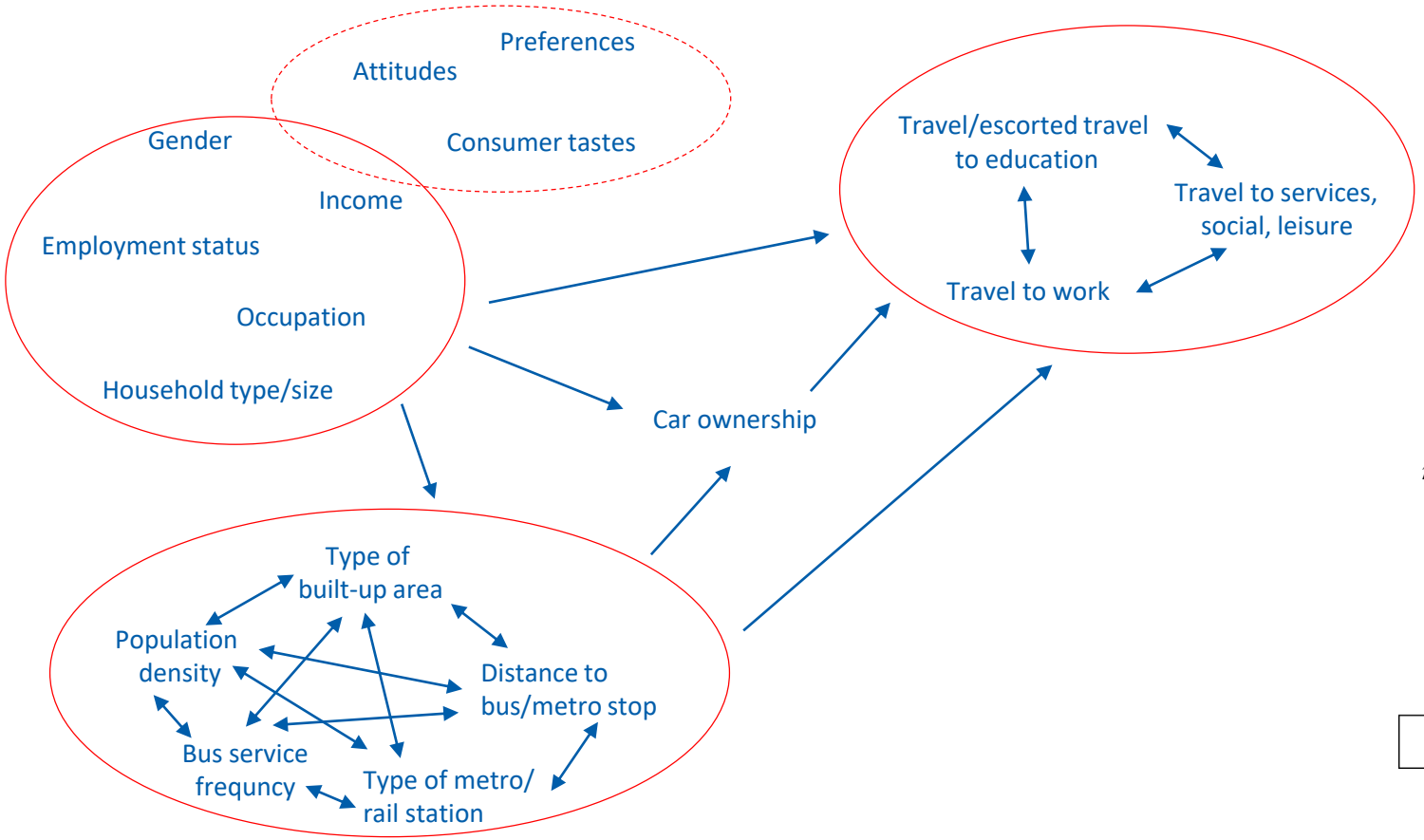
Demographic and socioeconomic projections adopted

	Employed residents	Total resident population	Employed-to-total-resident share
2000	7,116,587	13,522,260	52.6%
2010	11,805,555	19,578,961	60.3%
2020	13,854,166	24,684,221	56.1%
2030	15,902,778	29,789,481	53.4%
2040	17,951,389	34,894,740	51.4%
2050	20,000,000	40,000,000	50.0%

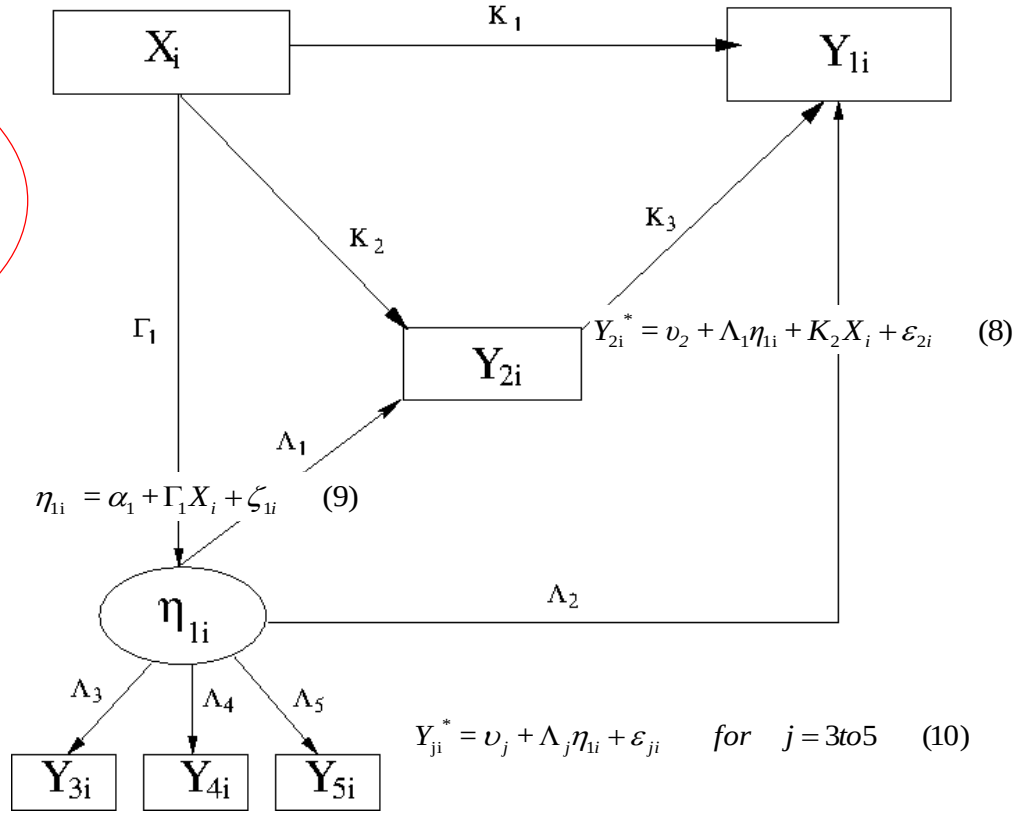
	2000	2010	2050 Following EU pattern	2050 Following US pattern	2050 Following Brazilian pattern
31 (High)	16%	16%	25%	30%	20%
32 (Middle)	46%	56%	65%	45%	55%
33 (Low)	38%	28%	10%	25%	25%
Total	100%	100%	100%	100%	100%

CSIC Cambridge Centre for Smart Infrastructure & Construction

Can LUTI learn something from machine-learning? Structural equation models (SEMs) with UK NTS data



$$Y^{*}_{1i} = \upsilon_1 + \Lambda_2\eta_{1i} + K_1X_i + K_3Y_{2i}$$



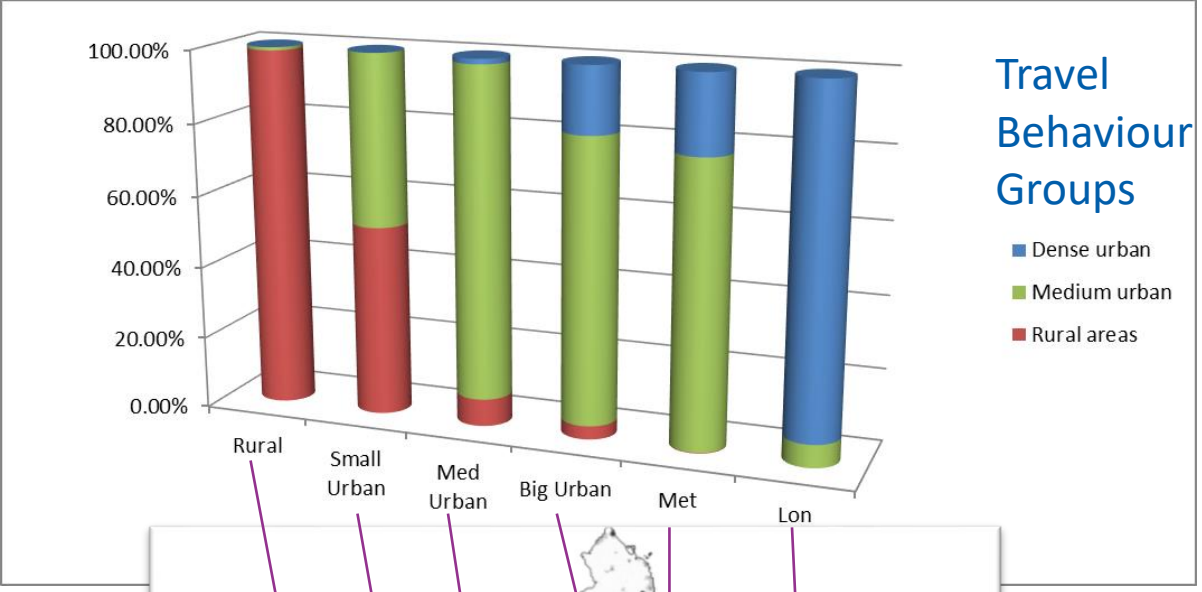
$$Y^{*}_{2i} = \upsilon_2 + \Lambda_1\eta_{1i} + K_2X_i + \varepsilon_{2i} \quad (8)$$

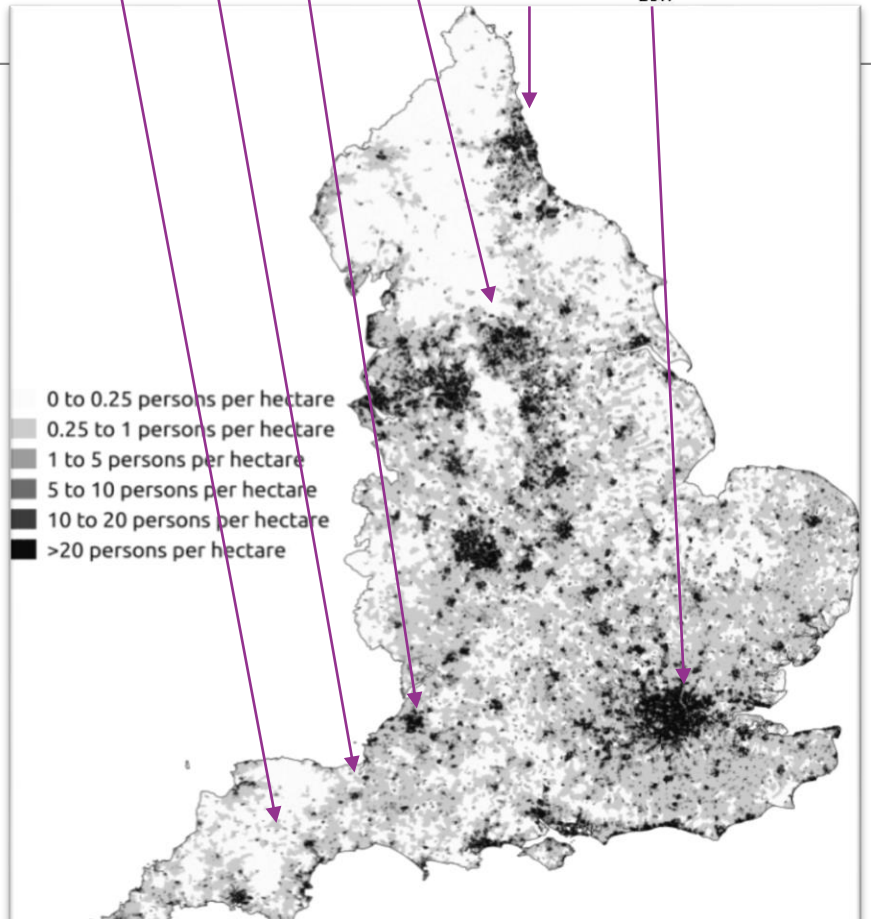
$$\eta_{1i} = \alpha_1 + \Gamma_1X_i + \zeta_{1i} \quad (9)$$

$$Y^{*}_{ji} = \upsilon_j + \Lambda_j\eta_{1i} + \varepsilon_{ji} \quad for \quad j = 3to5 \quad (10)$$

Sources: Jahanshahi, Jin & Williams (2015)
Jahanshahi & Jin (2015; 2016)

- The UK NTS data represents the top range of data availability
- The SEMs are also among the most comprehensive





Findings from the SEMs

- Different typologies of built-form dynamics
  - In “dense urban areas”, where just under 20% of UK population live, restraint in car use & car parking has gained wide support – there may be scope to go further
  - At the other end, in “rural areas” where around 30% of people live, there are few options to car
  - The middle 50% poses the biggest dilemma: they suffer most of the ills of built-up areas with little scope to lessen car dependency
- ‘Compressed’ dynamics with no real finds of causal relationships