STUDI: A model to simulate the impacts of new metro lines on urban development in London

IVT - ETHZ
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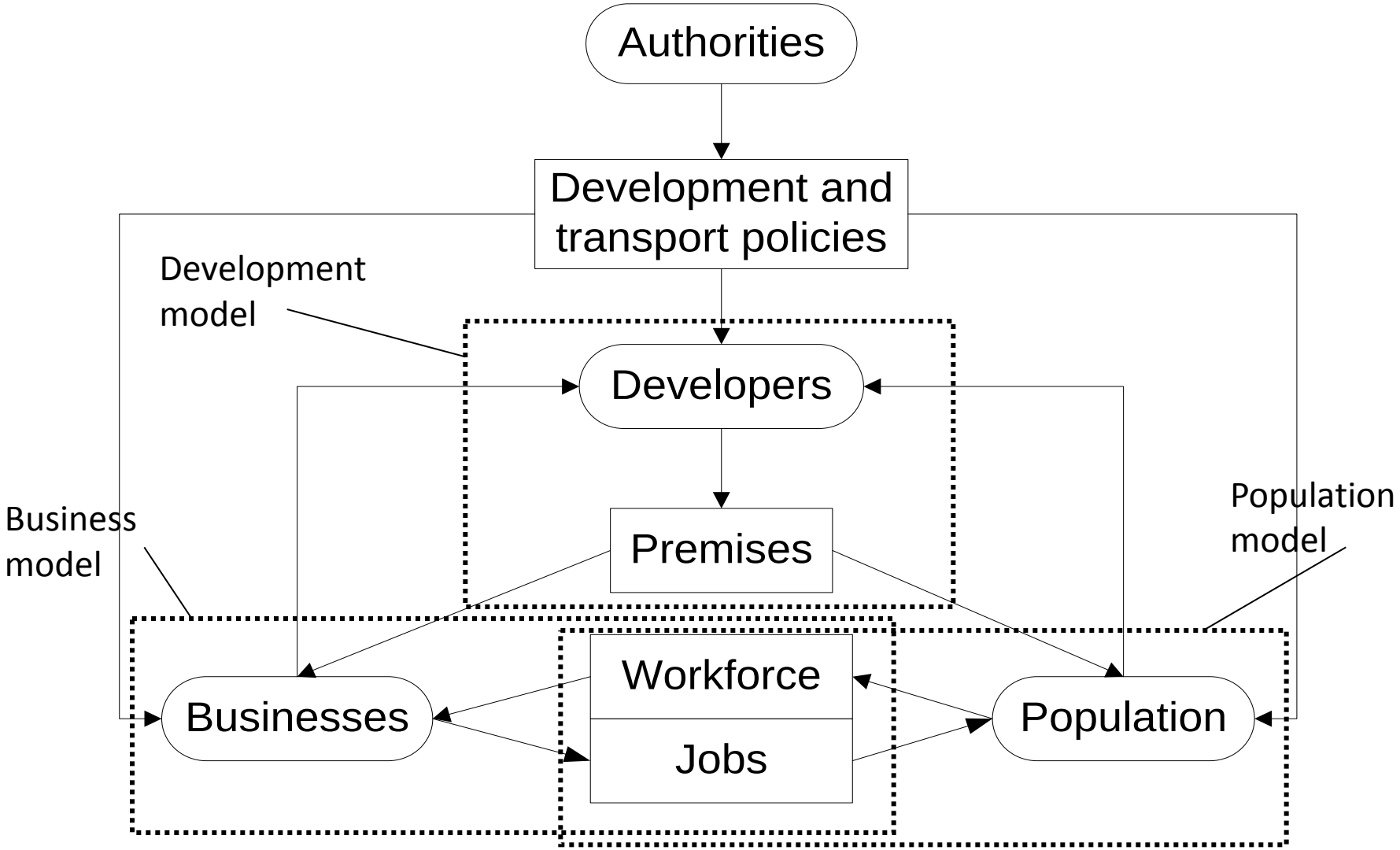
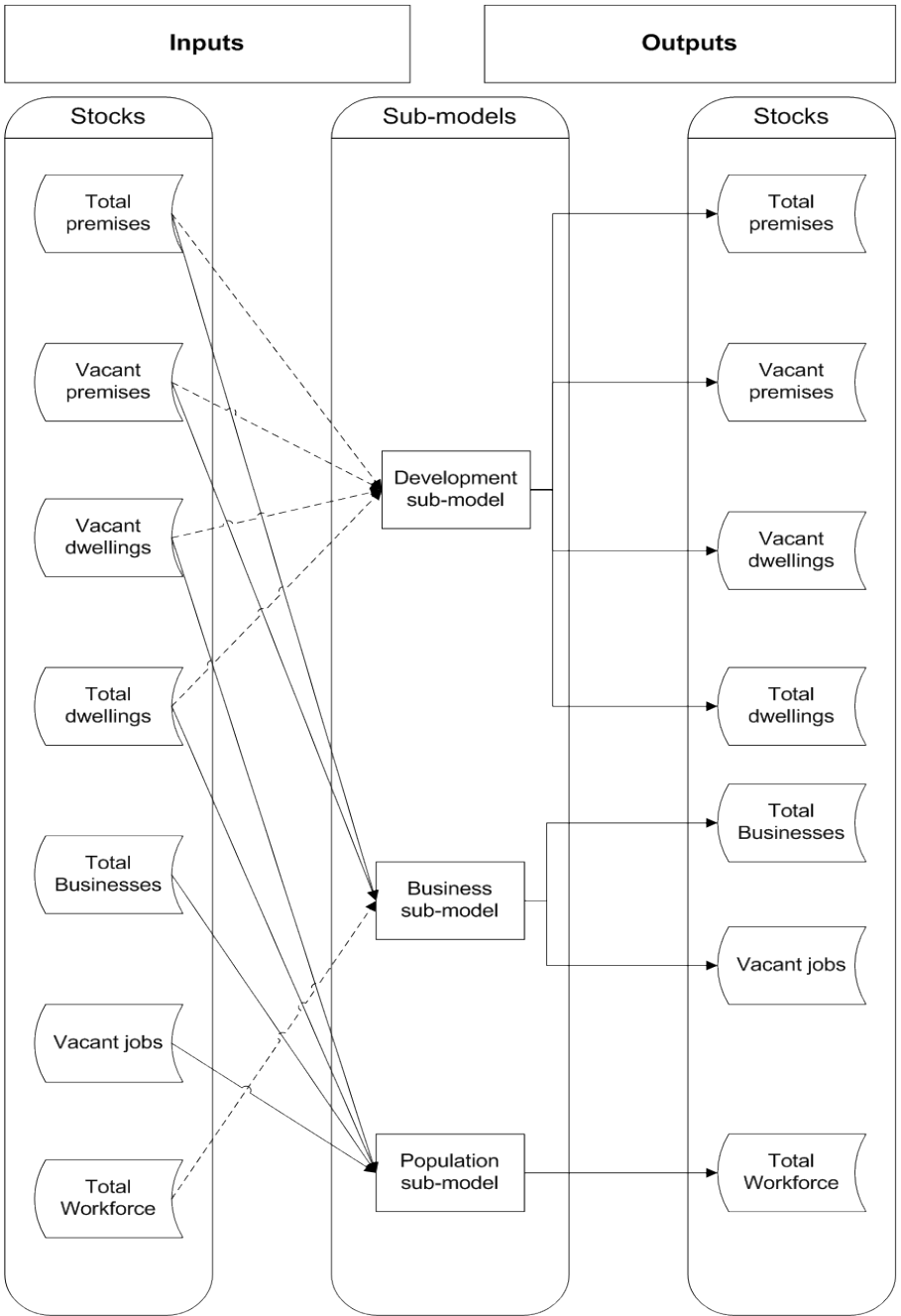
Objective - Rationale

- Develop a model to investigate the impacts of new underground lines beyond the direct transport impacts by simulating the interactions between transport and urban development.
- Desirable model characteristics
  - Comprehensiveness.
  - Dynamics of change.
  - Choice modelling at disaggregate level.
  - Operationality.
- Main product: STUDI (Simulation of Transport and Urban Development Interactions)

Agents of urban development



Agents of urban development



Development sub-model

- Residential development

$$D_{iT}^{new} = f(t_{iT}, D_{iT-1}^{total}, L_{iT-1})$$

- Variables:
  - Travel time to the city centre
  - Total dwellings
  - Land available for development

Development sub-model

- Commercial development

$$p_{iT}^{new} = f(t_{iT}, P_{iT-1}^{total}, P_{iT-1}^{vacant})$$

- Variables:
  - Travel time to the city centre
  - Total commercial premises
  - Vacant commercial premises

Business sub-model

- Microsimulation
- Synthesize database with individual business records

Processes modelled:

- Business start-ups
- Business closures
- Business location

Business sub-model

- New businesses:
  - The number of new businesses is determined exogenously based on VAT data **and** forecasted according to growth of GDP:

$$GDP_T = f(GDP_{T-1}, C_T)$$

$$B_T^{total} = f(GDP_T)$$

  - The zone allocation of new businesses is based on the last year's spatial distribution of new businesses.

Business sub-model

- Business relocation
- Zone attractiveness

$$A_{iT} = f(P_{iT}^{vacant}, W_{iT}^{accessible})$$

  – Vacant commercial premises
  – Accessible workforce:

$$W_{iT}^{accessible} = \sum_{j=1}^{33} \frac{W_{jT}}{t_{jiT}}$$

Population sub-model

- Microsimulation
- Sample population

Processes modelled:

- Demographics
- Migration
- Employment status
- Employment location
- Residential location

Population sub-model

- Demographics
  - Ageing, births, deaths, household formation and dissolution.
- Migration
  - The number of migrants is based on the number of new businesses.
  - The employment location choice is based on the spatial distribution of new businesses.
  - The residential location choice is based on job location.

Population sub-model

- Residential relocation
- Attractiveness of zone as residential location

$$A_{iT} = f(D_{iT}^{vacant}, B_{iT}^{accessible})$$

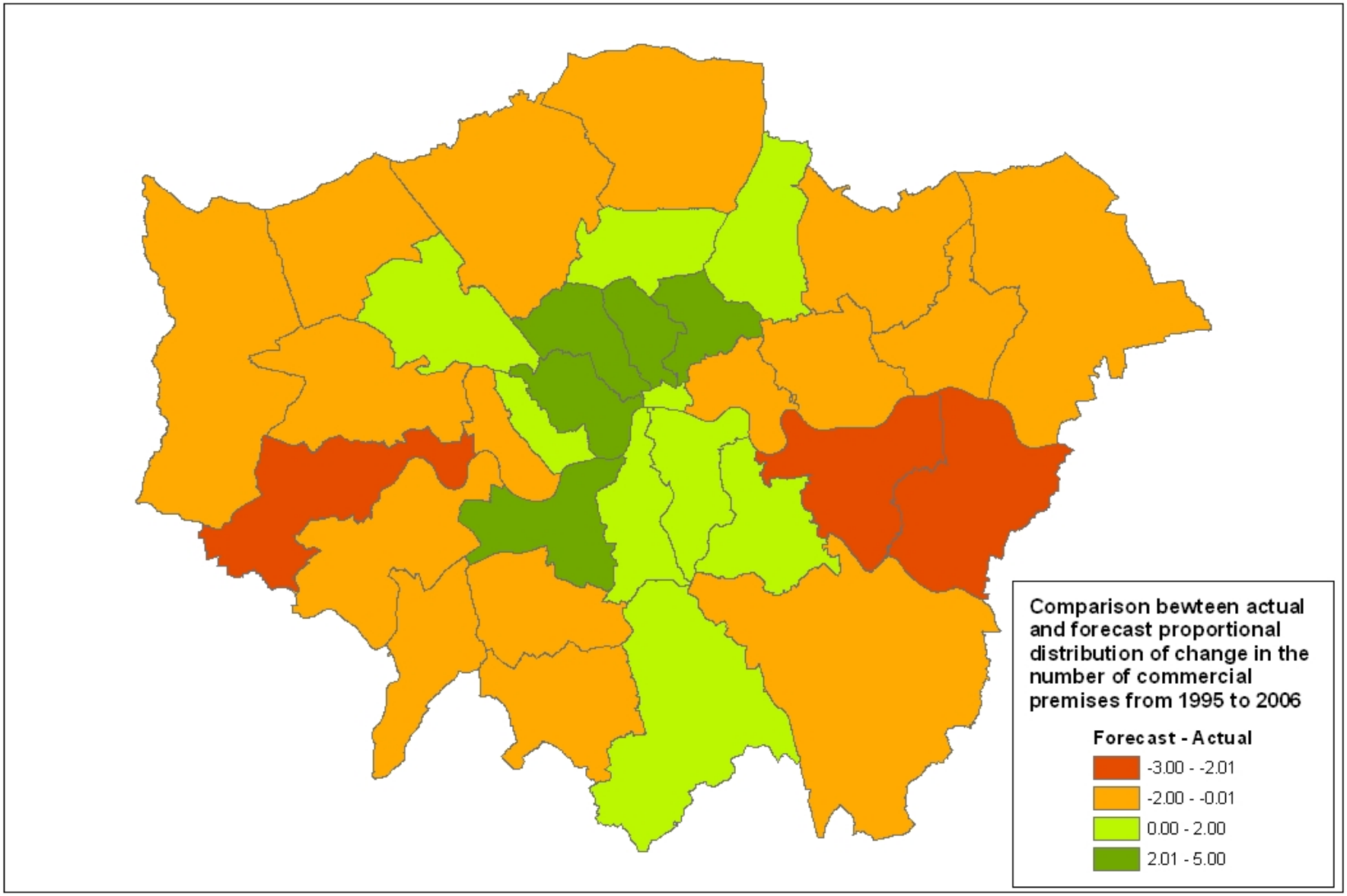
  – Vacant dwellings
  – Accessible businesses:

$$B_{iT}^{accessible} = \sum_{j=1}^{33} \frac{B_{jT}}{t_{jiT}}$$

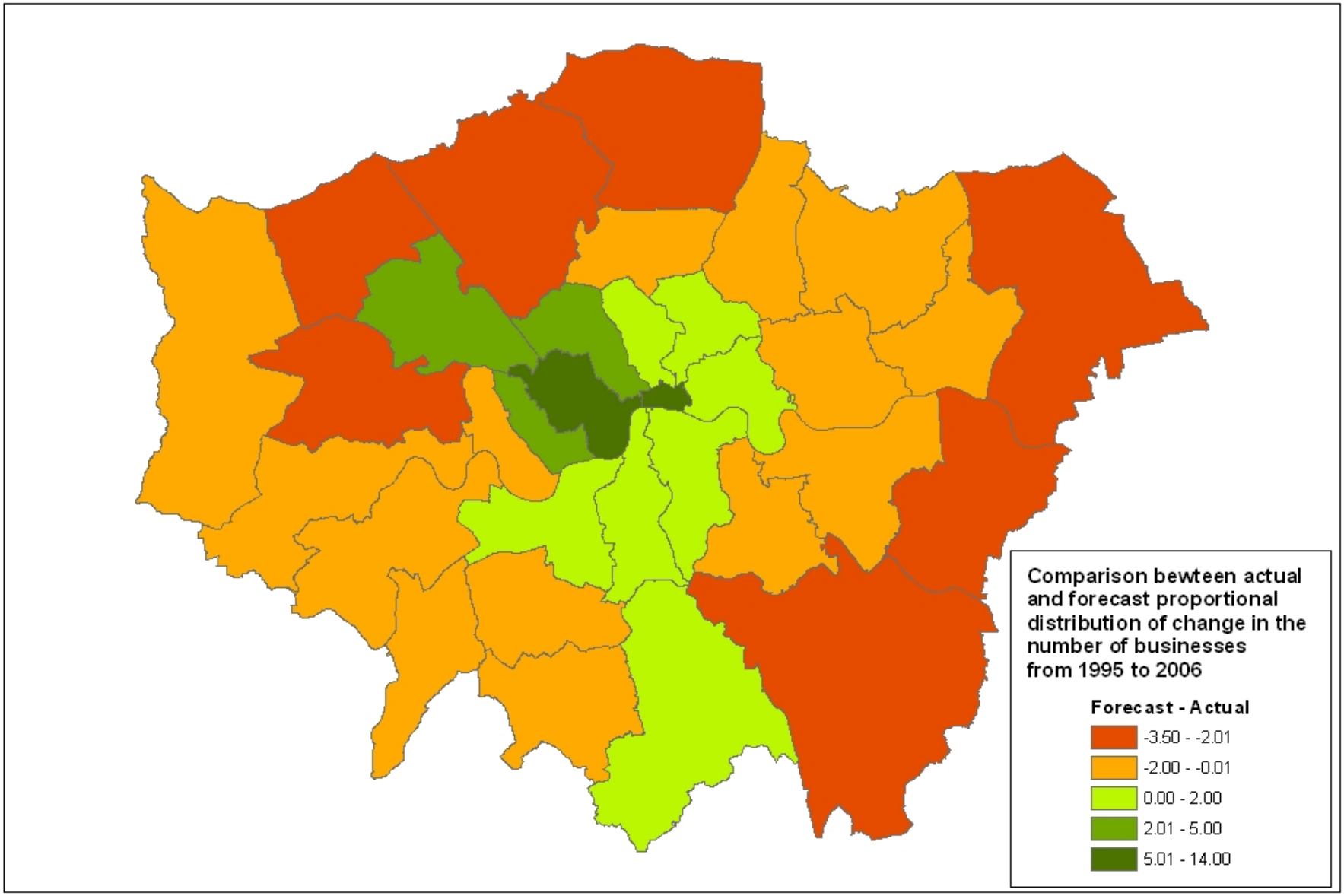
Validation

- Deviation of estimates
- Distribution of a quantity
- Change of a quantity
- Distribution of the change of a quantity in one zone over the total change of the quantity in London
  - Used to represent the spatial distribution of changes eliminating any overestimation or underestimation of the totals.

Validation – Com. Dev.



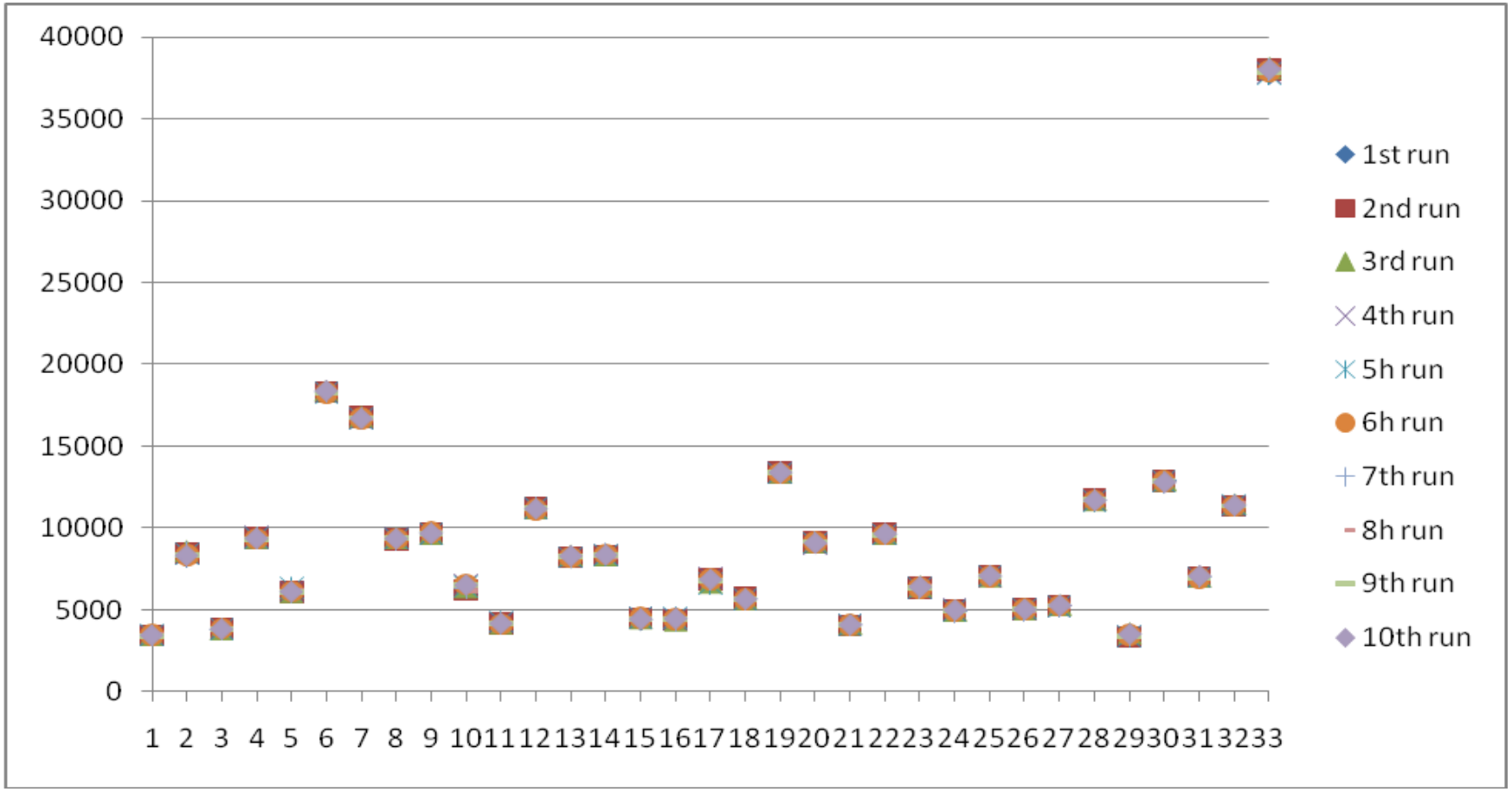
Validation – Businesses



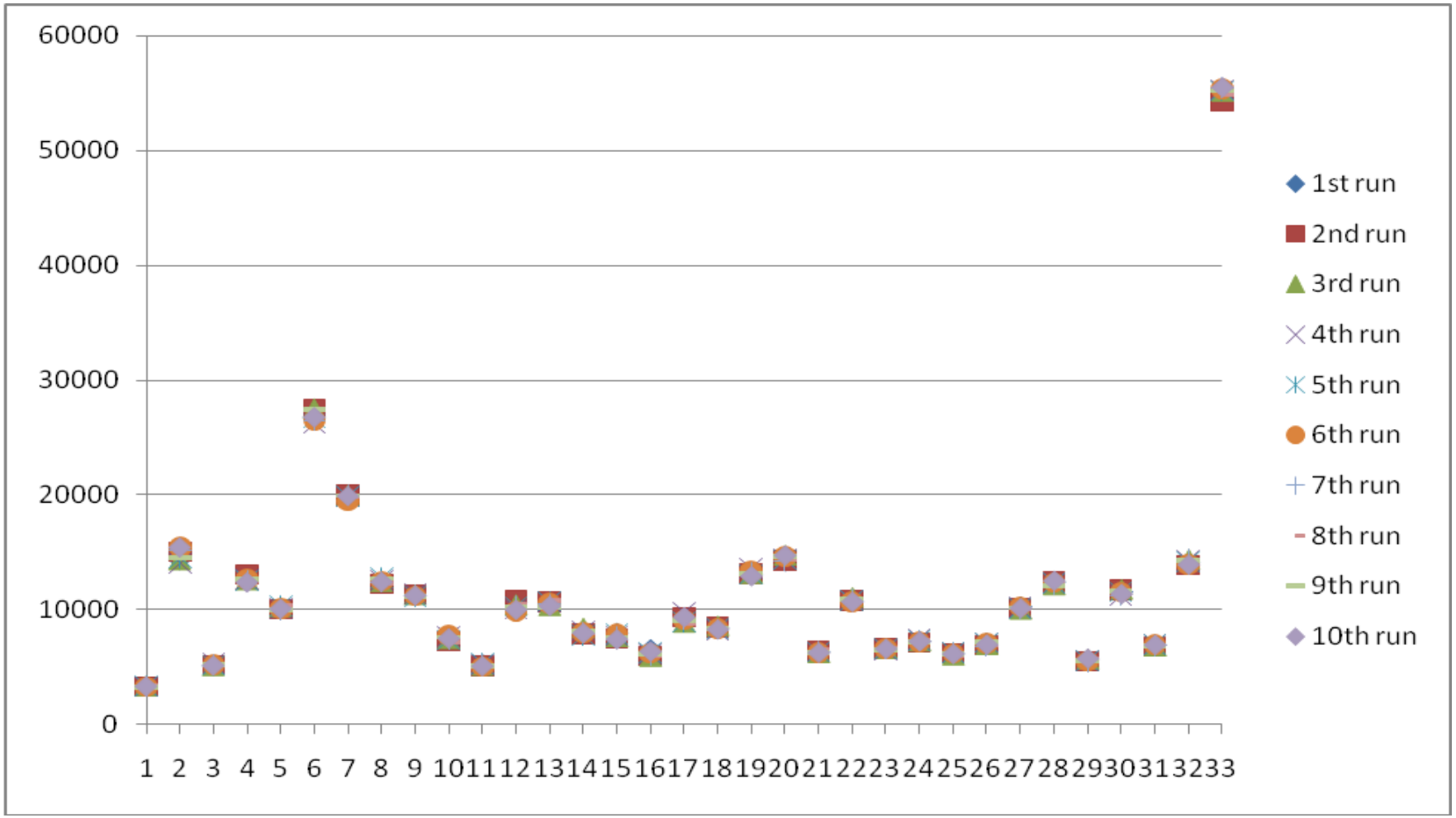
Stochastic variation

- Business and population sub-models use Monte Carlo simulation in various processes: stochastic variation
- Residential development sub-model: not affected by stochastic variation
- Commercial development sub-model: stochastic variation occurs indirectly as a result of the stochastic variation in the business sub-model
- Ten runs of STUDI from 1995 to 2006, using different random number sequences

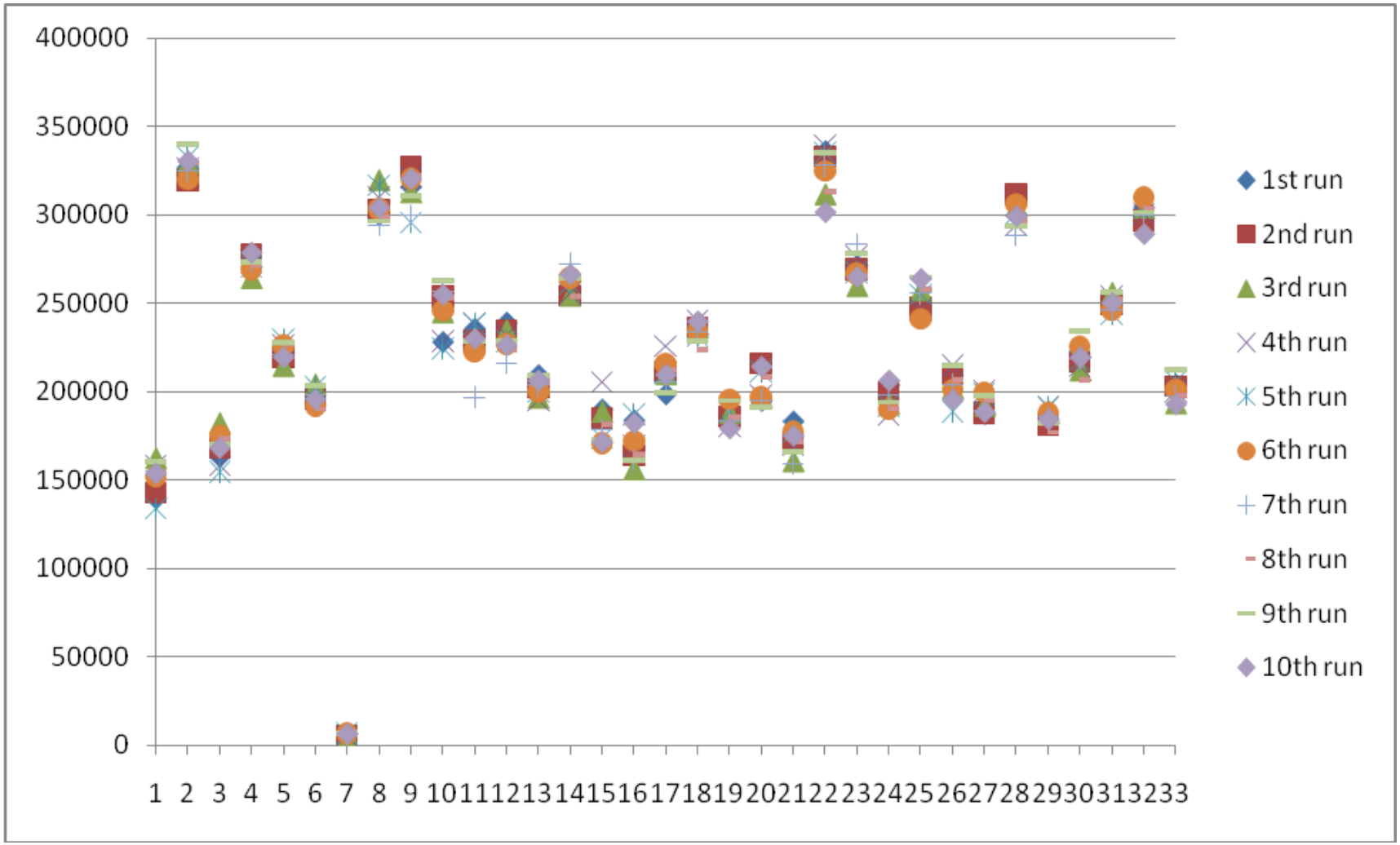
Stochastic variation – Com. Dev.

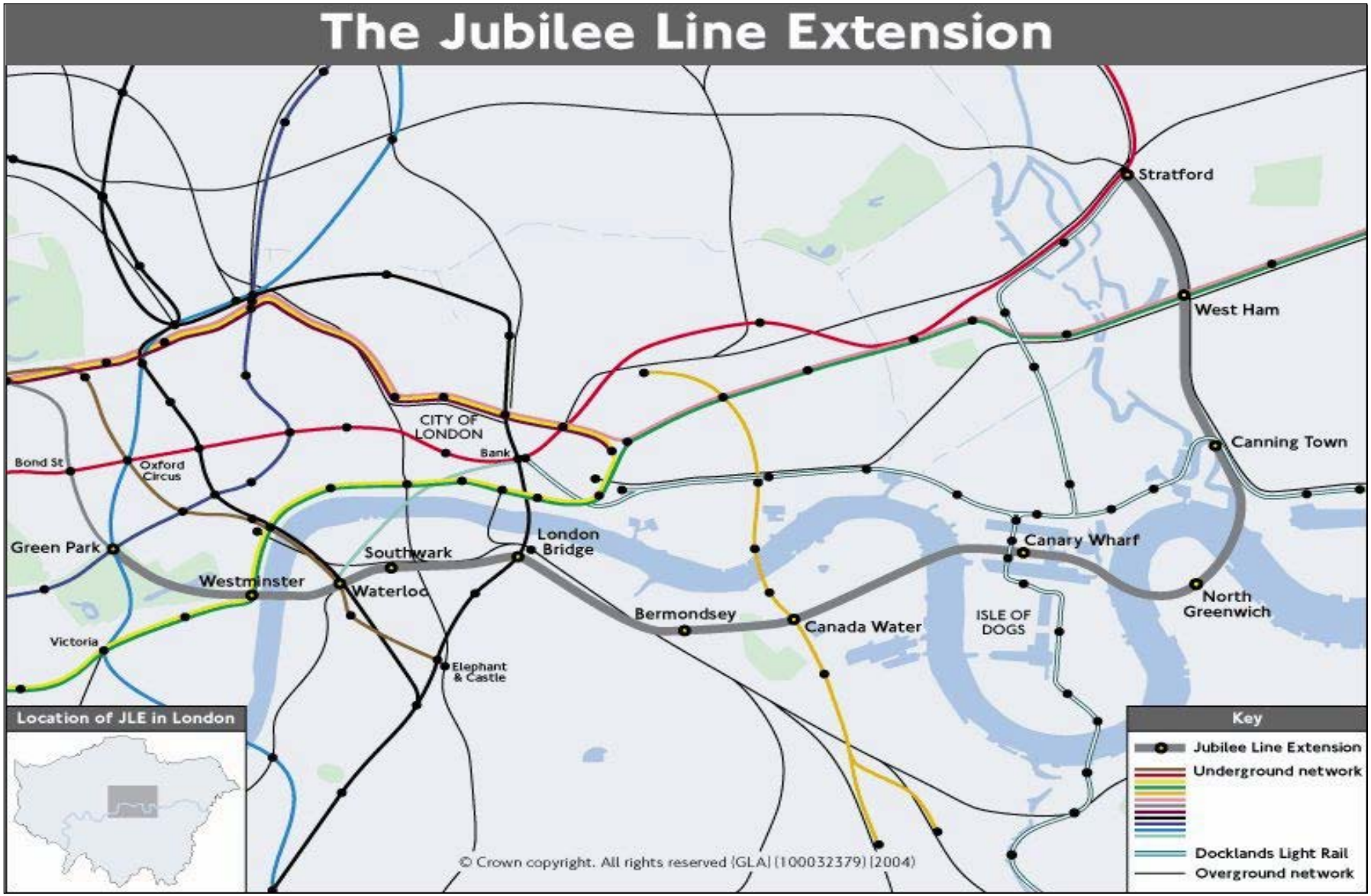


Stochastic variation – Businesses



Stochastic variation – Population

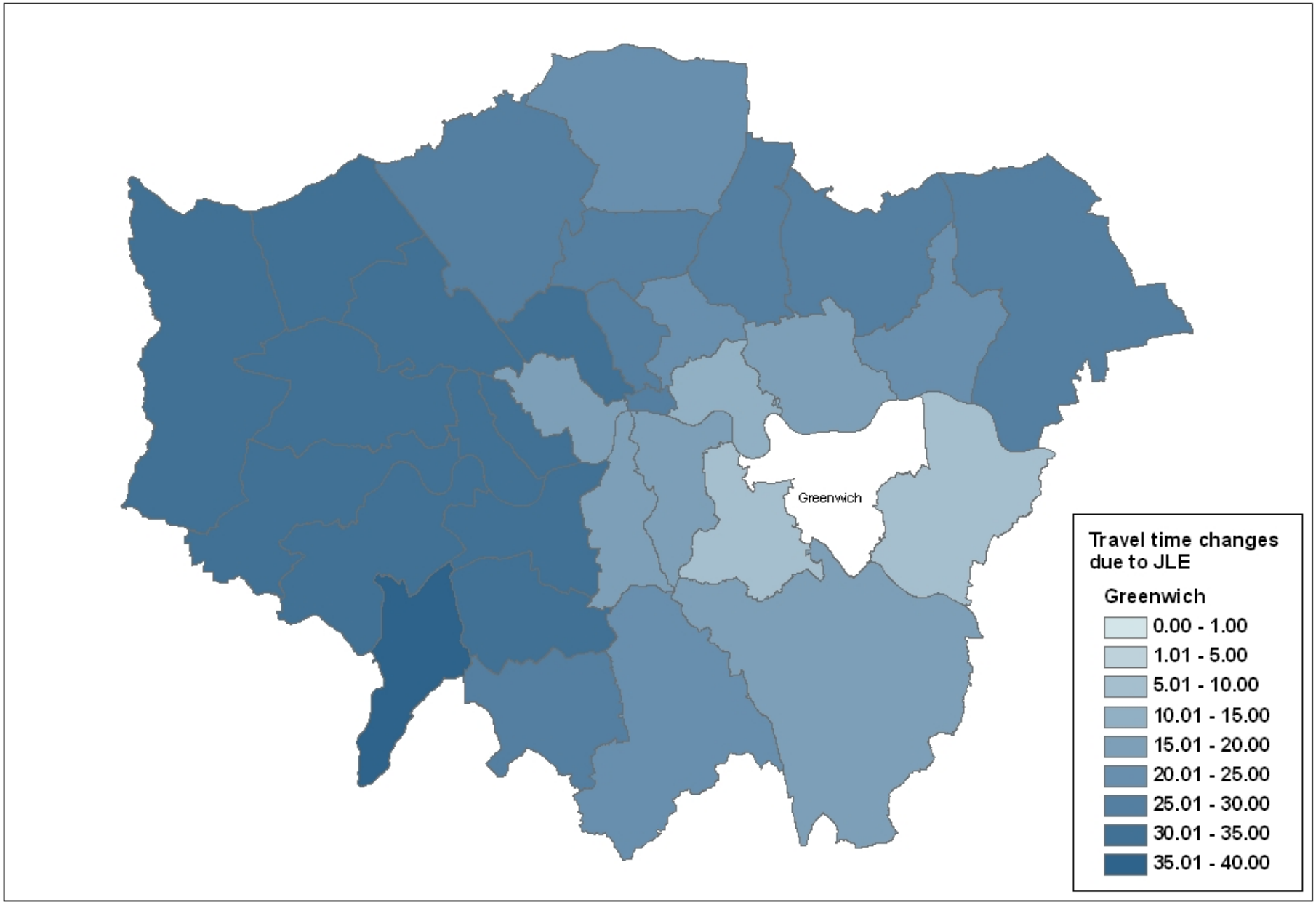




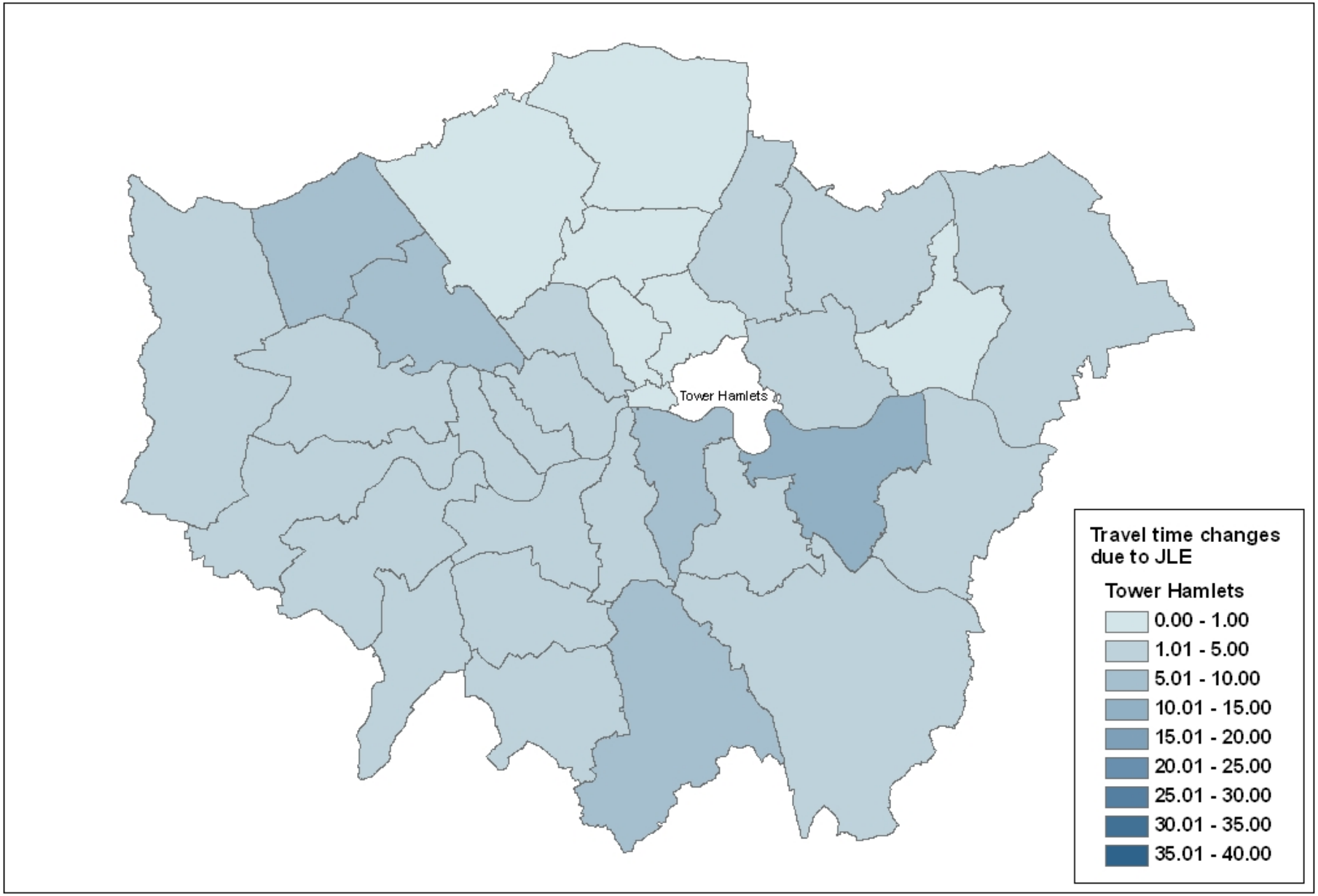
(Transport Studies Group, 2004)

London boroughs - JLE

Travel time changes due to JLE



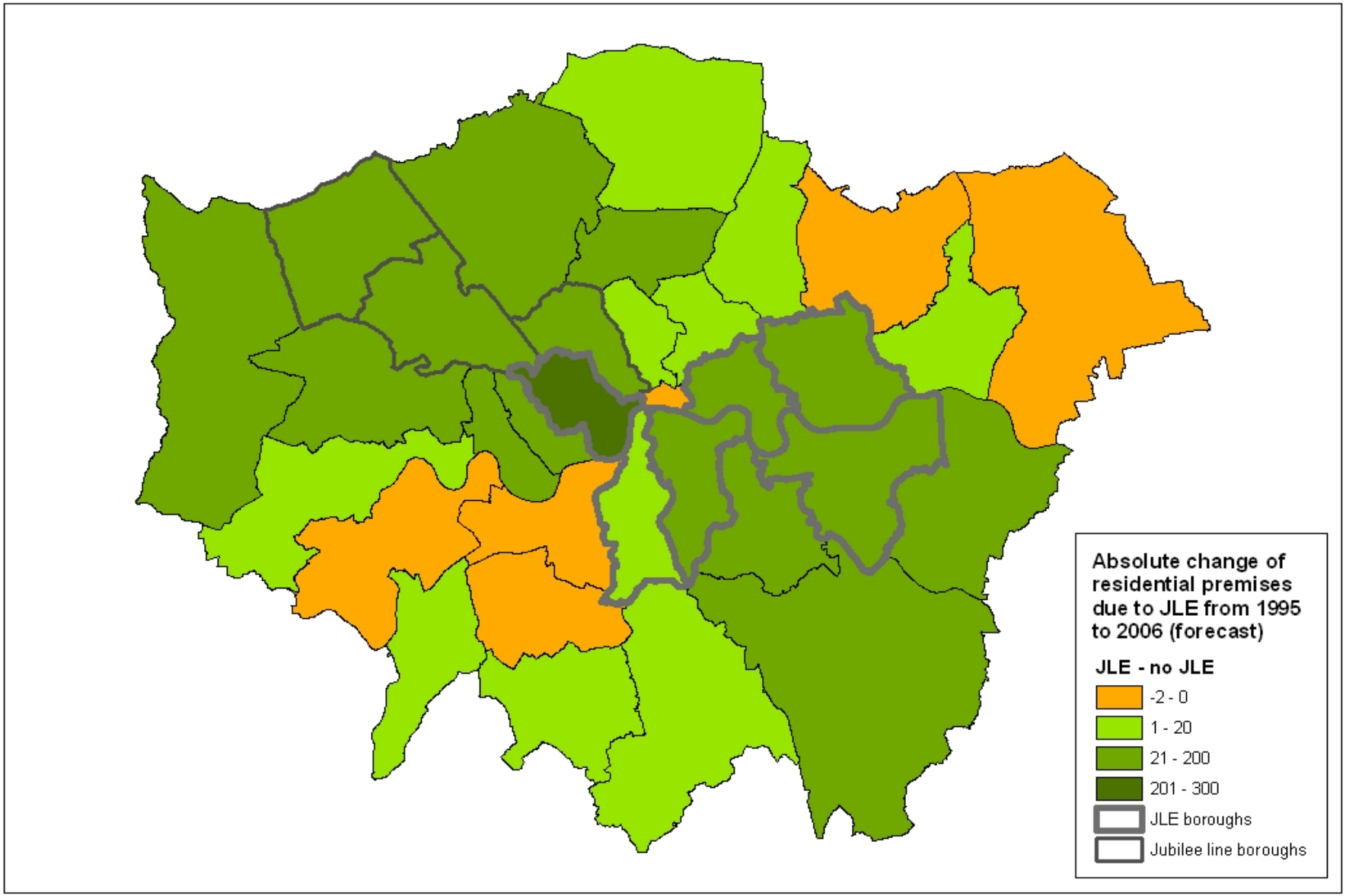
Travel time changes due to JLE



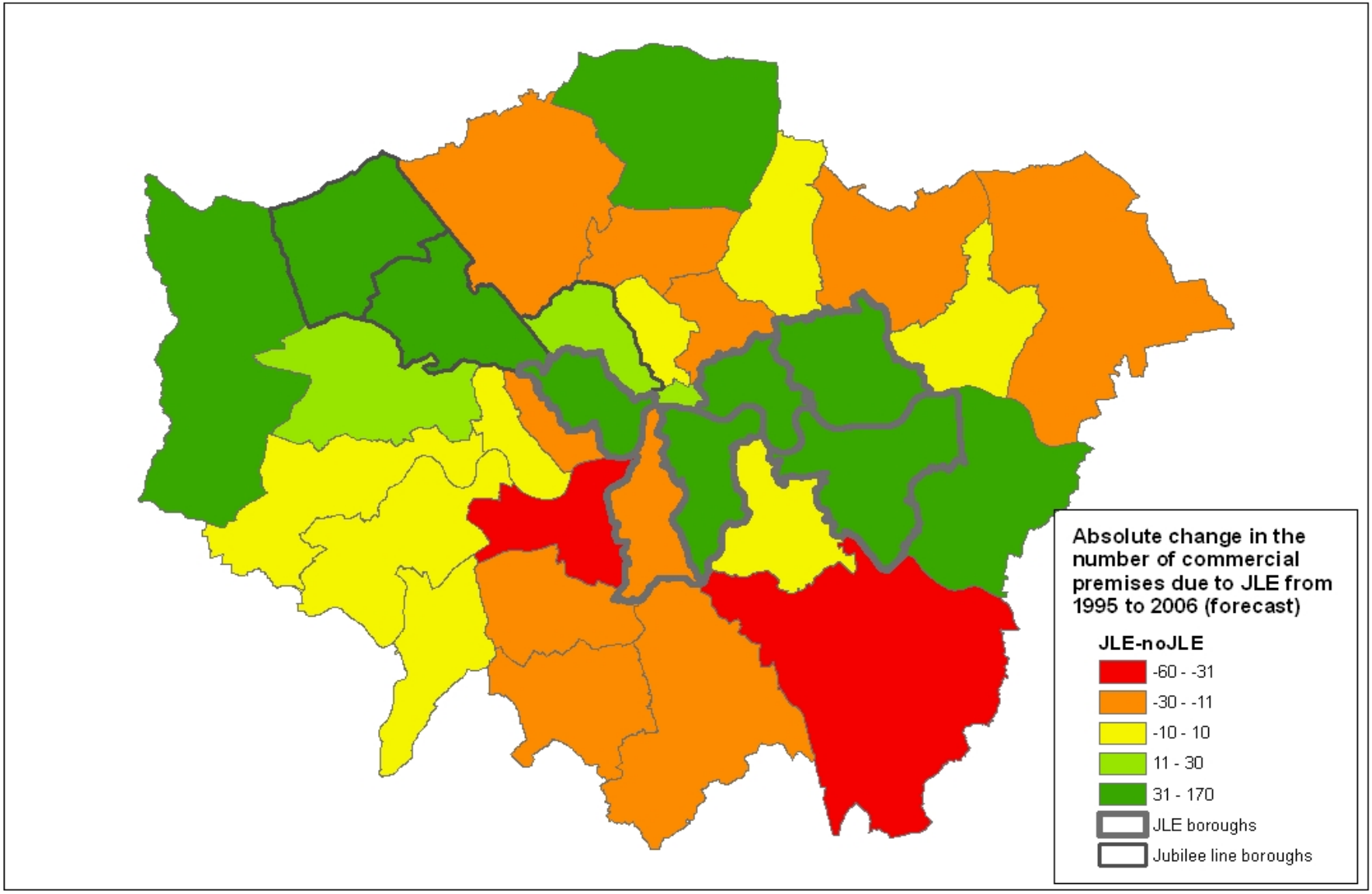
The JLE application

- STUDI with and without the JLE from 1995 to 2006
- JLE is added to the London Underground network at the beginning of 2000 (it actually opened at the end of 1999).
- 30 runs using 15 different pseudo-random number sequences:15 times with and 15 without the JLE.
- Results: differences between the average of the results of the 15 runs with the JLE and the average of the results of the 15 runs without the JLE.

Residential development



Commercial development

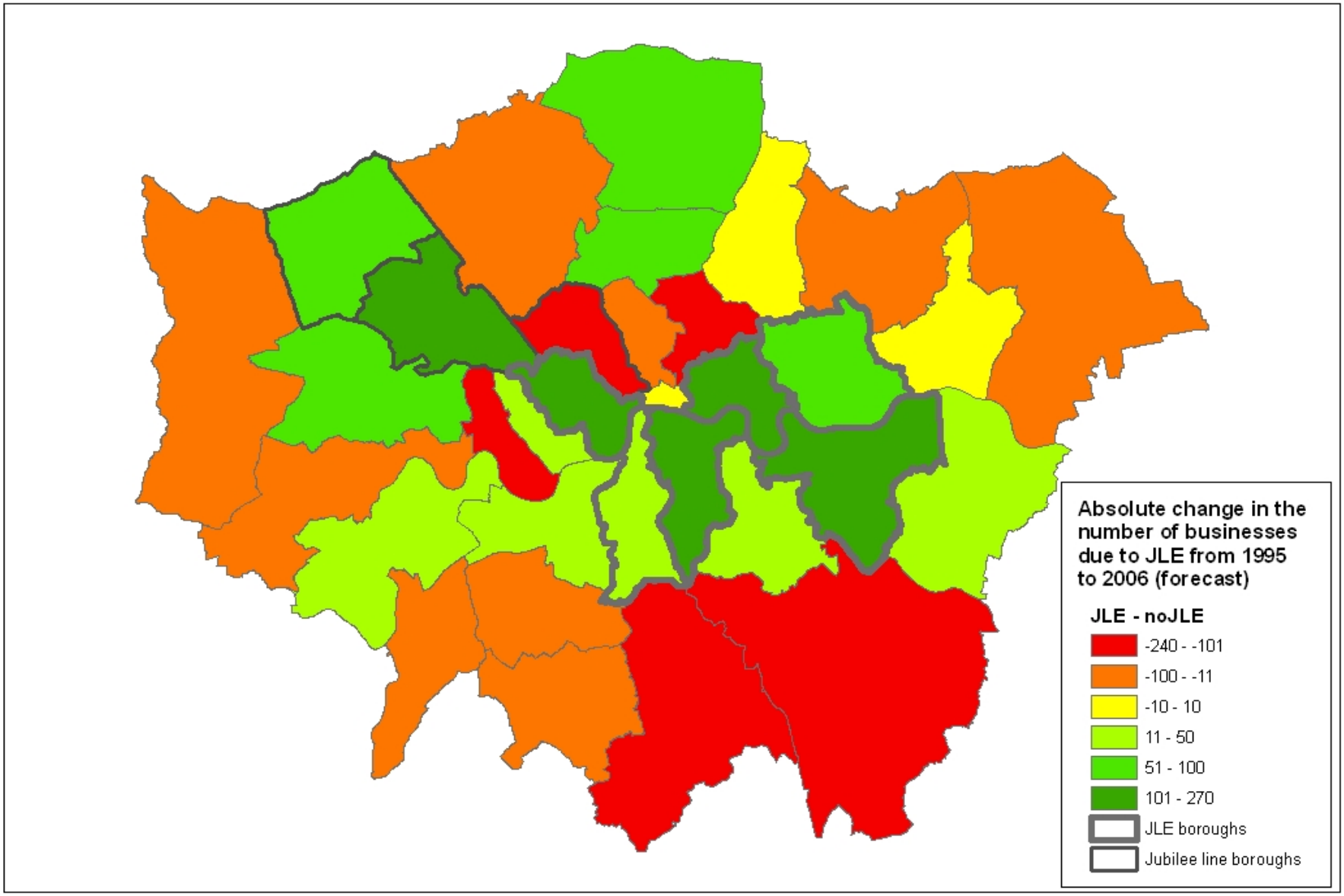


JLE impacts – aggregate areas

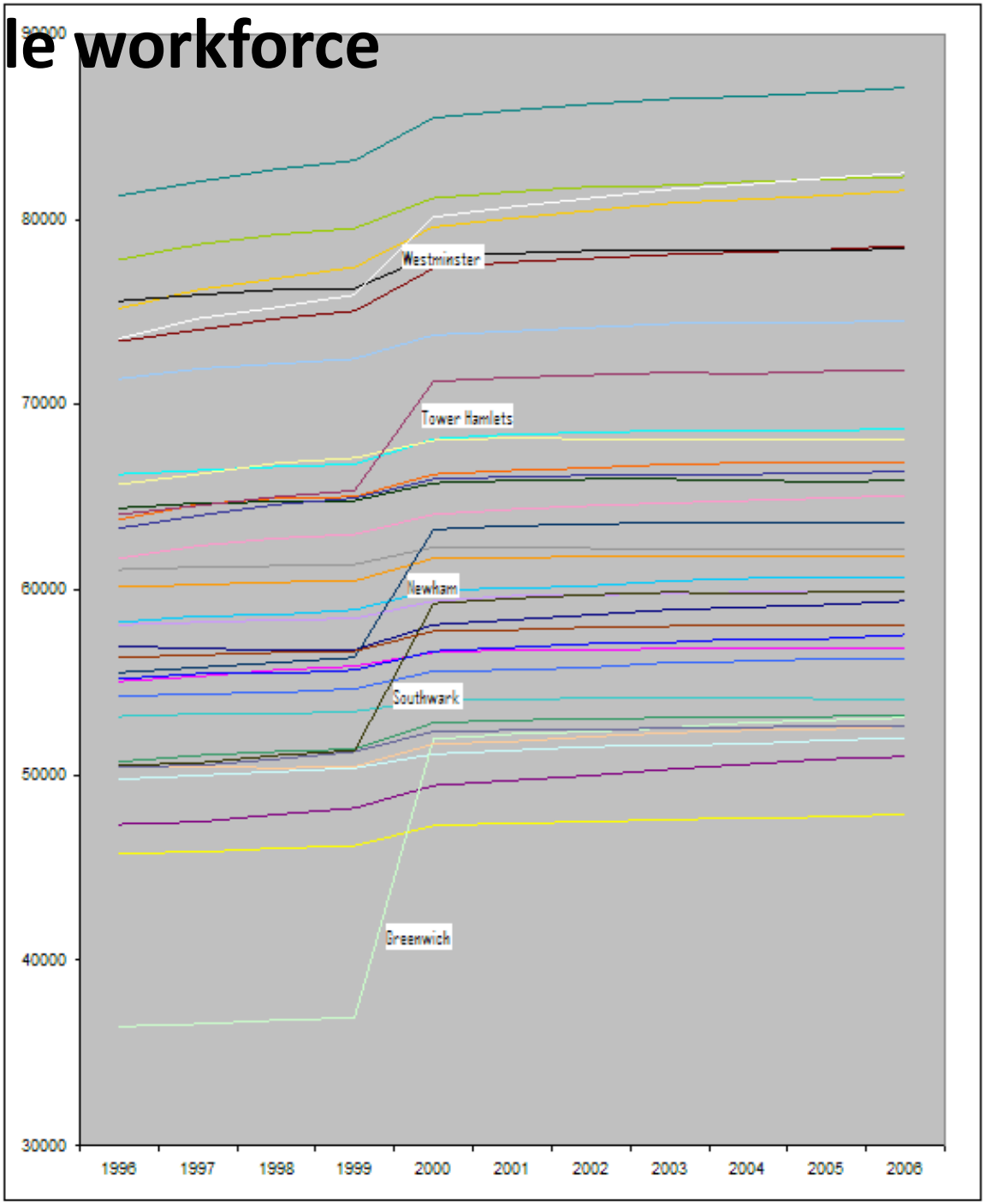
	Total number of residential premises in 2006			
Areas	**Without JLE**	**With JLE**	**Dif. JLE - no JLE**	**% Diff. JLE - no JLE**
JLE boroughs	605,798	606,382	584	0.10
Jubilee Line boroughs	277,763	278,138	375	0.14
Rest of London	2,199,874	2,200,413	539	0.02

	Total number of commercial premises in 2006			
Areas	**Without JLE**	**With JLE**	**Dif. JLE - no JLE**	**% Diff. JLE - no JLE**
JLE boroughs	76,851	77,245	394	0.51
Jubilee Line boroughs	29,526	29,712	186	0.63
Rest of London	164,061	163,971	-91	-0.06

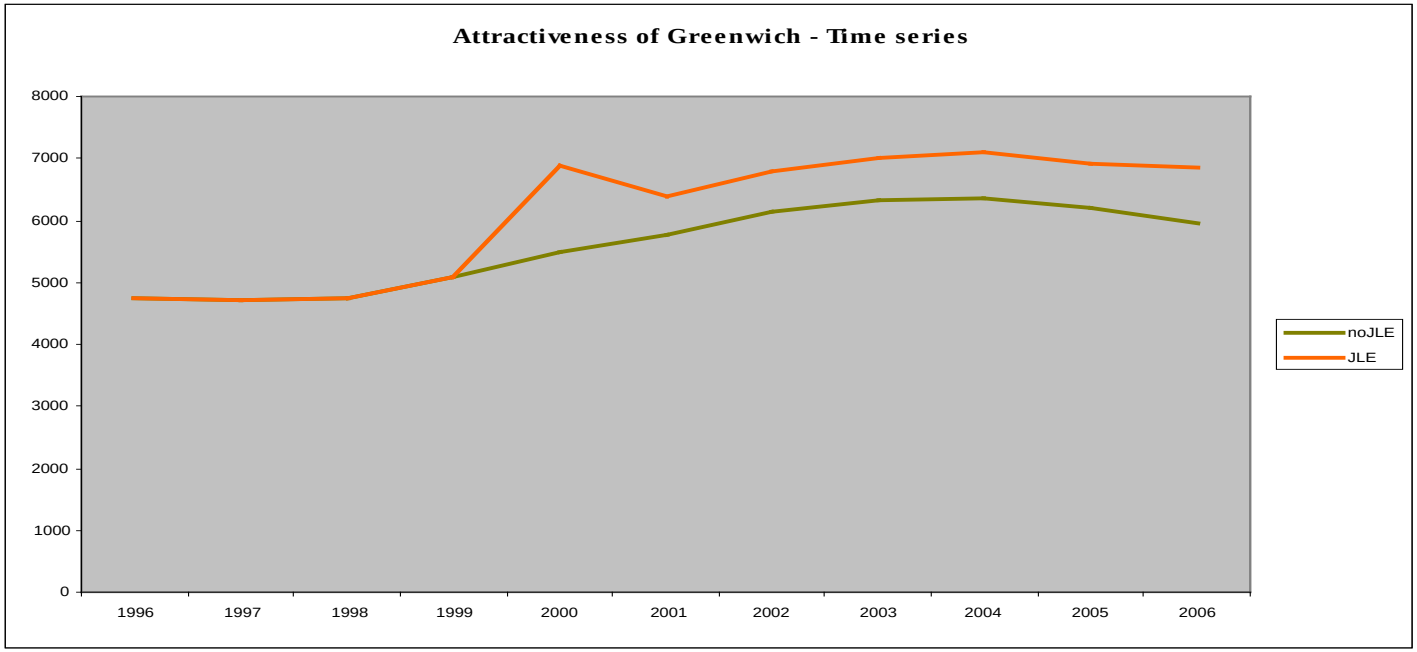
Businesses

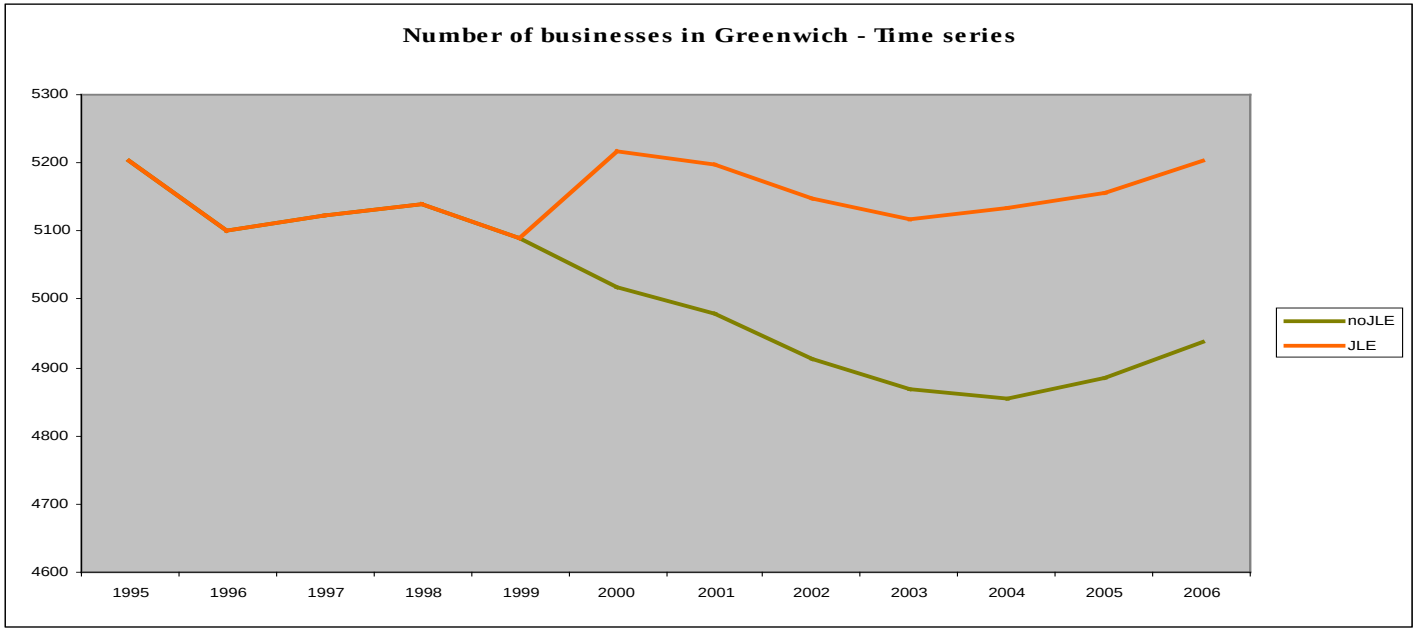

Absolute change in the number of businesses due to JLE from 1995 to 2006 (forecast)
JLE - noJLE
-240 - -101
-100 - -11
-10 - 10
11 - 50
51 - 100
101 - 270
JLE boroughs
Jubilee line boroughs

Accessible workforce

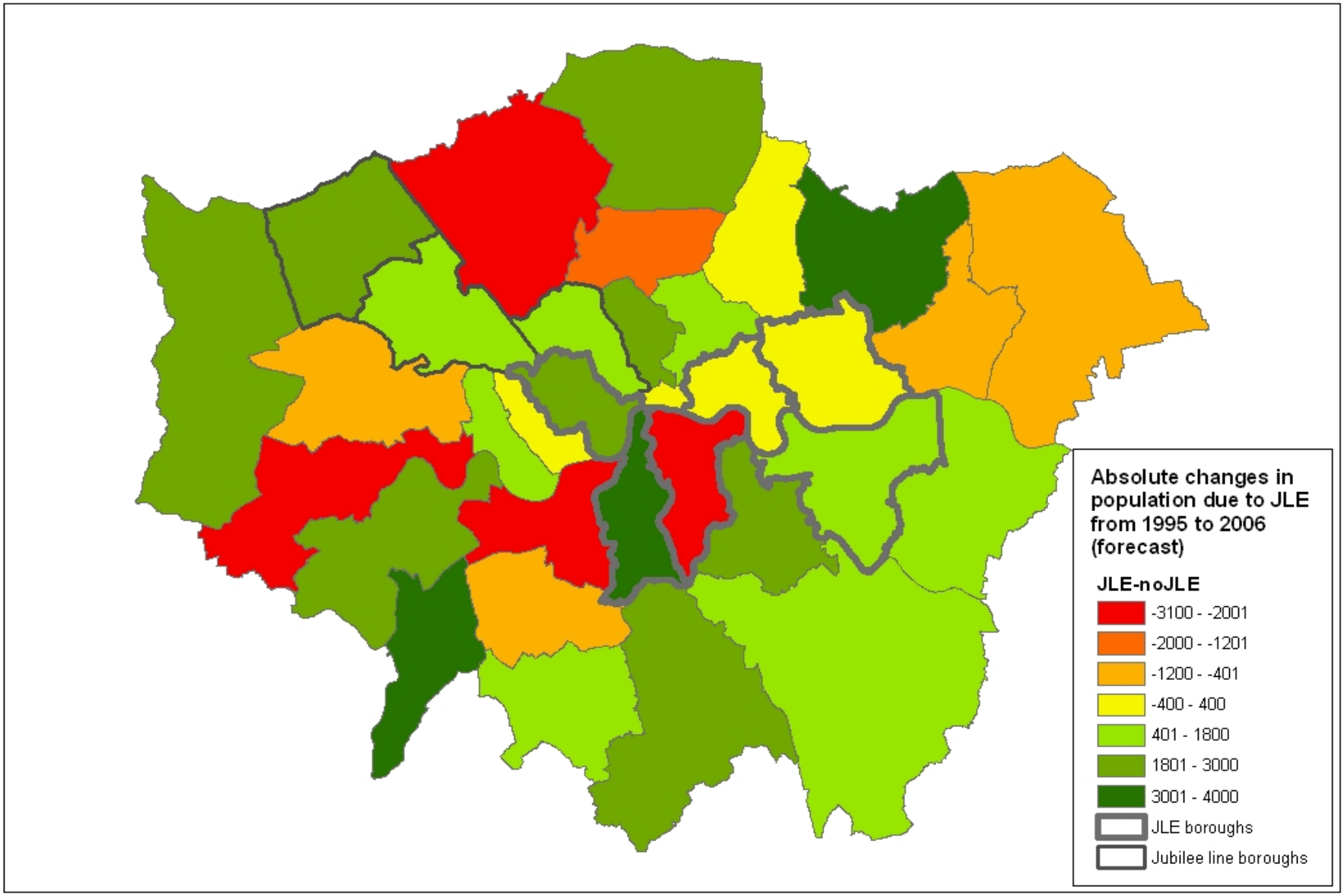


Businesses

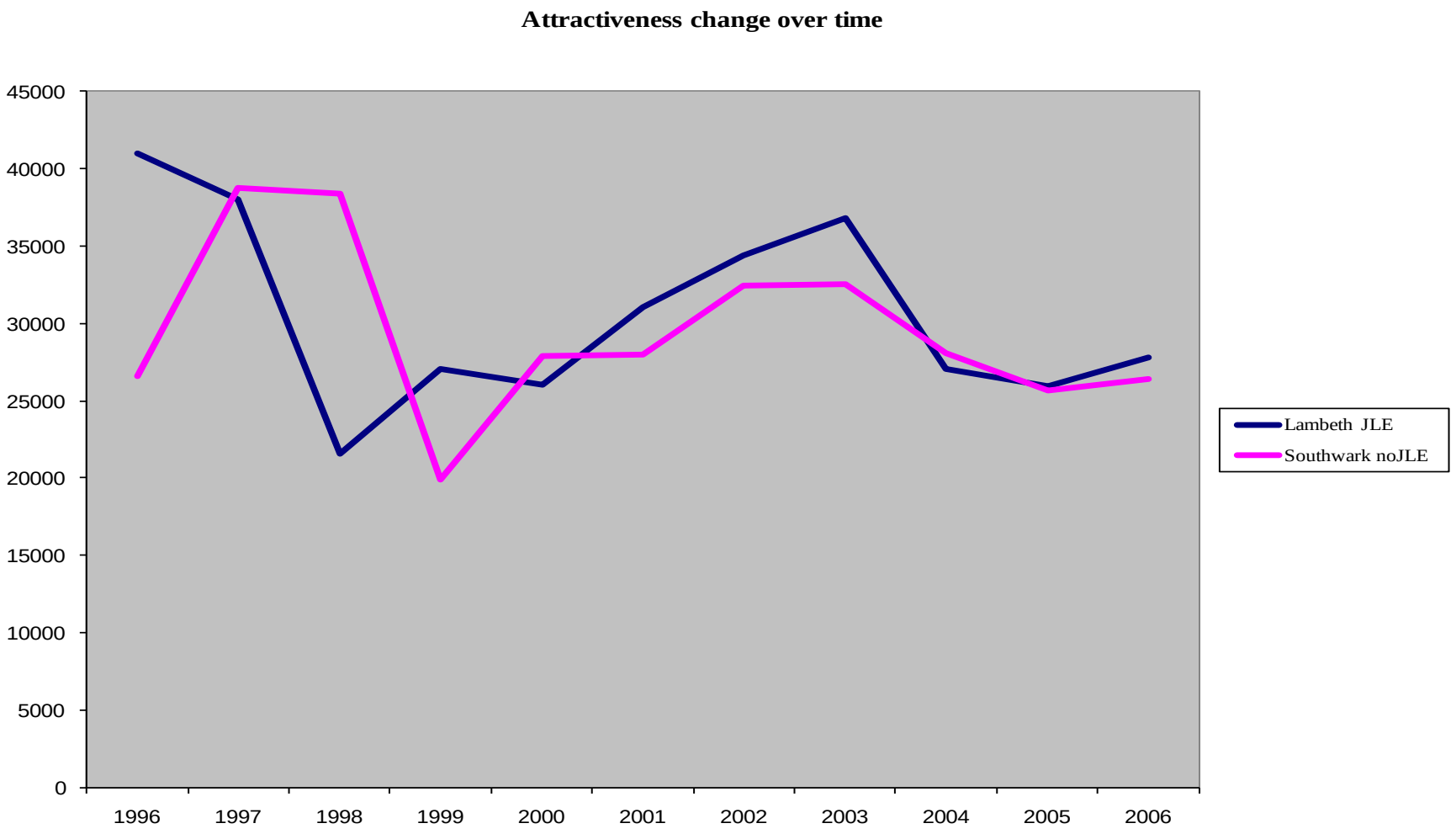

Attractiveness of Greenwich - Time series
8000
7000
6000
5000
4000
3000
2000
1000
0
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
noJLE
JLE


Number of businesses in Greenwich - Time series
5300
5200
5100
5000
4900
4800
4700
4600
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
noJLE
JLE

Population


Absolute changes in population due to JLE from 1995 to 2006 (forecast)
JLE-noJLE
-3100 - -2001
-2000 - -1201
-1200 - -401
-400 - 400
401 - 1800
1801 - 3000
3001 - 4000
JLE boroughs
Jubilee line boroughs

Population

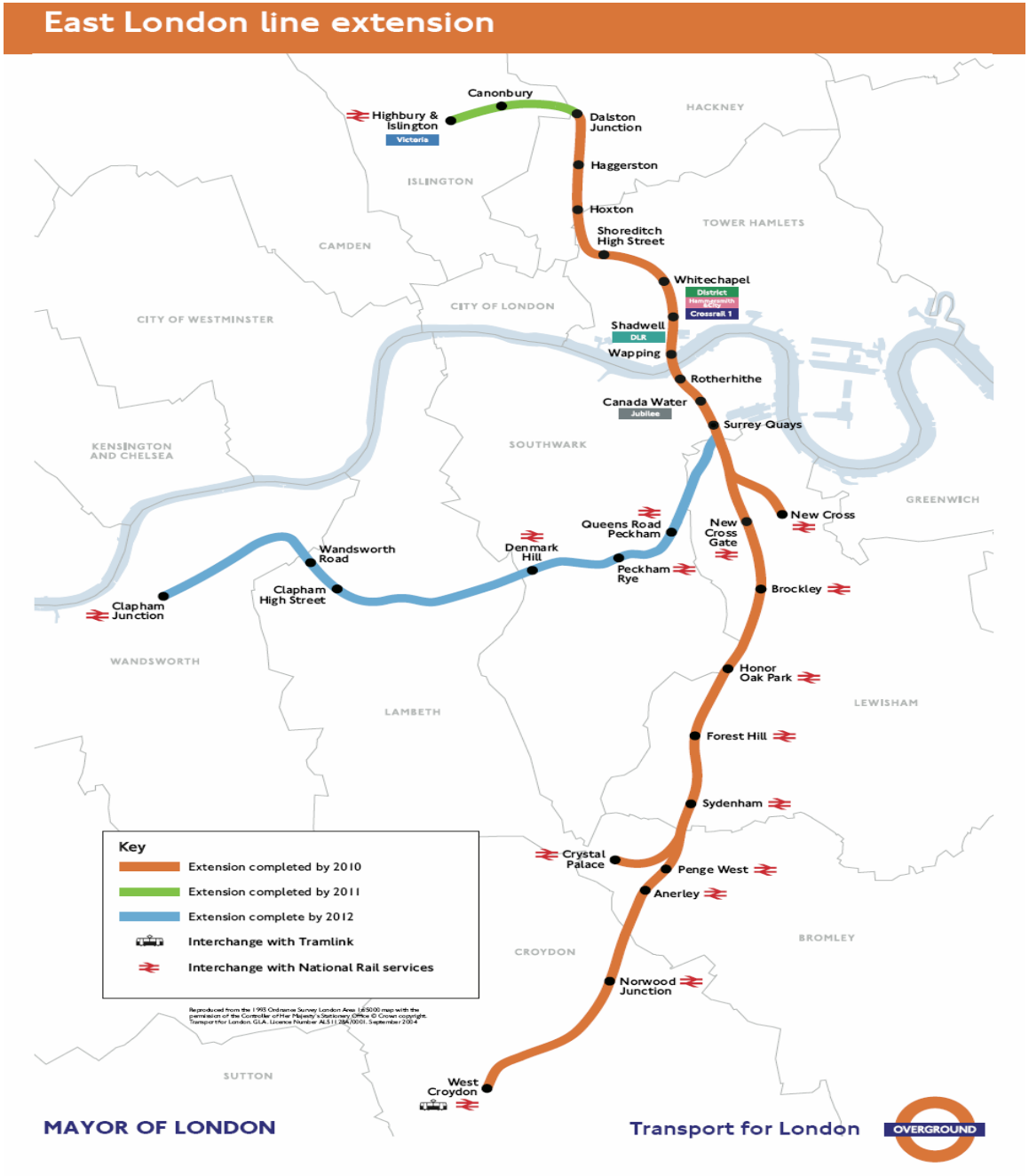

Attractiveness change over time
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Lambeth JLE
Southwark noJLE

JLE impacts – aggregate areas

	Total number of businesses in 2006			
Areas	**Without JLE**	**With JLE**	**Dif. JLE - no JLE**	**% Diff. JLE - no JLE**
JLE boroughs	100,401	101,339	937	0.93
Jubilee Line boroughs	47,205	47,185	-19	-0.04
Rest of London	229,166	228,554	-613	-0.27

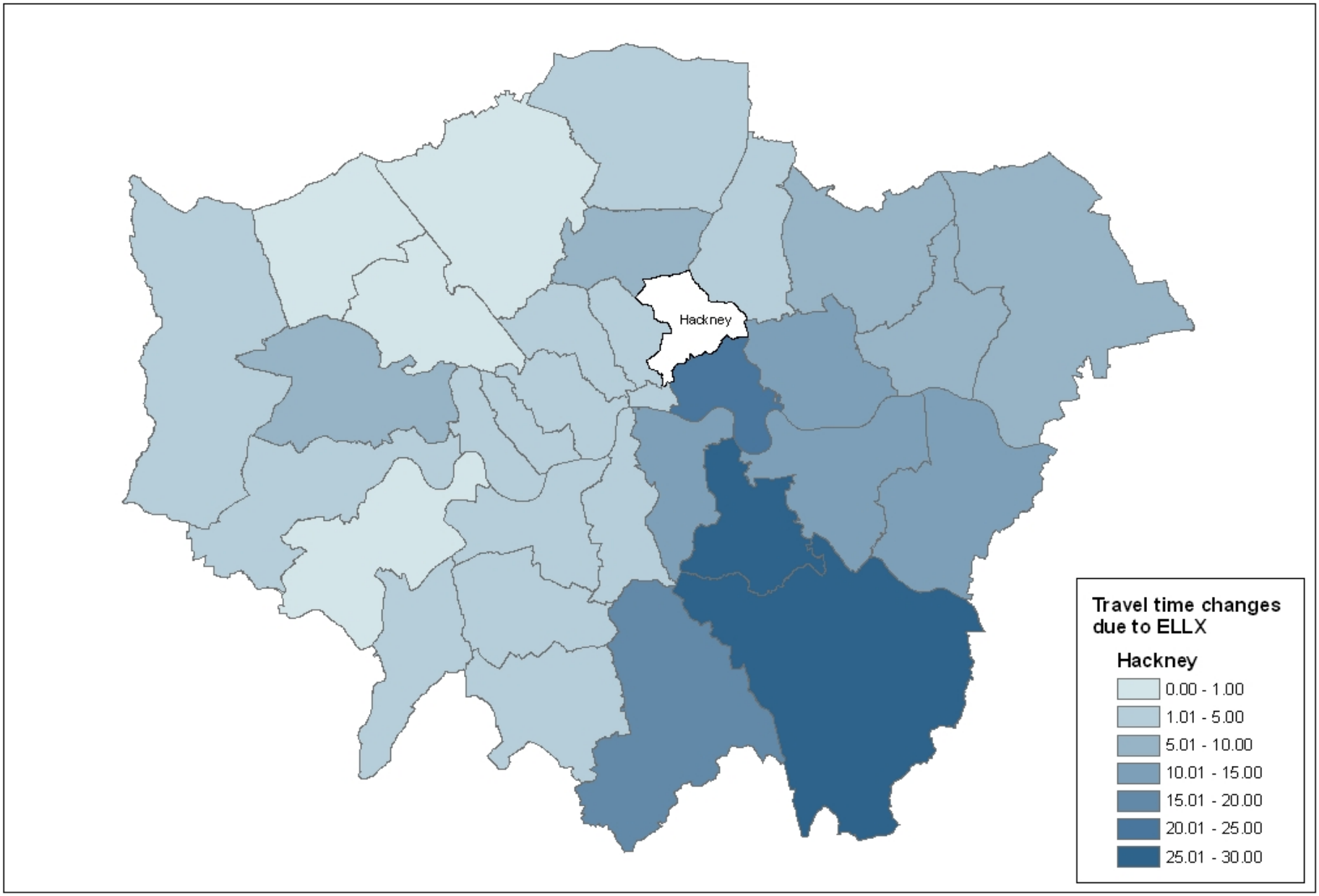
	Total population in 2006			
Areas	**Without JLE**	**With JLE**	**Dif. JLE - no JLE**	**% Diff. JLE - no JLE**
JLE boroughs	1,525,432	1,530,410	4,978	0.33
Jubilee Line boroughs	618,126	622,161	4,036	0.65
Rest of London	4,939,942	4,954,226	14,284	0.29

East London Line Extension

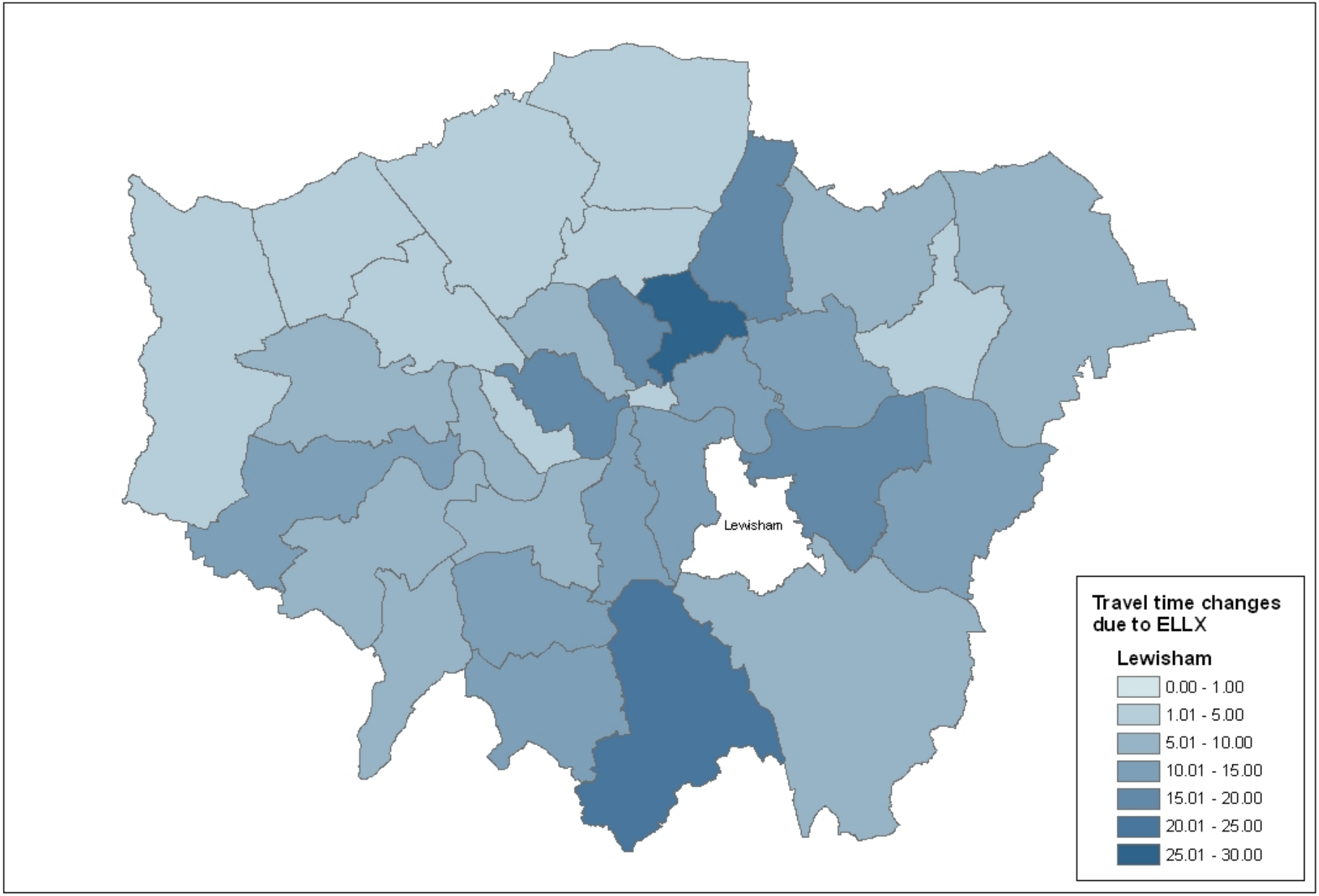


London boroughs - ELLX

Travel time changes due to ELLX



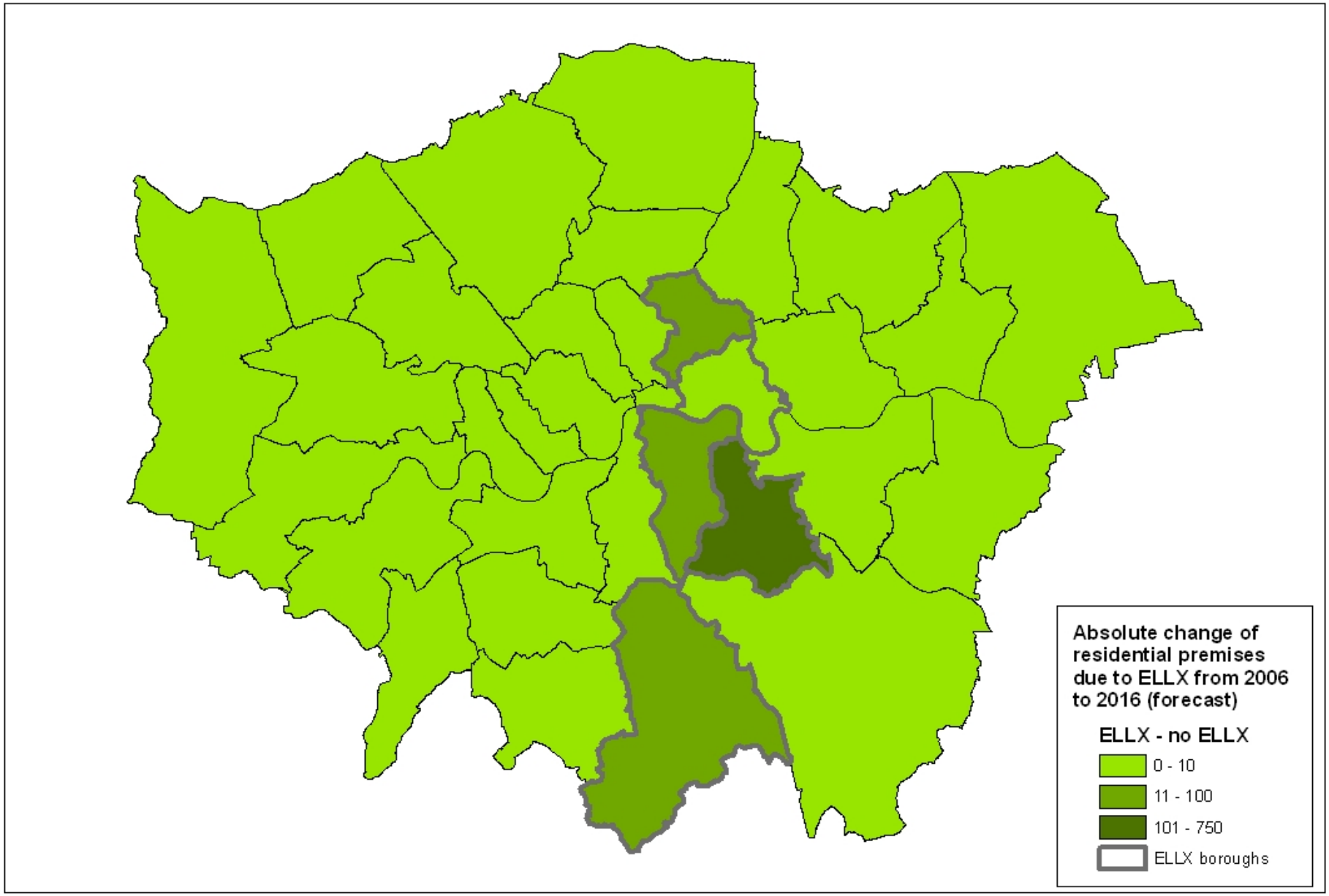
Travel time changes due to ELLX



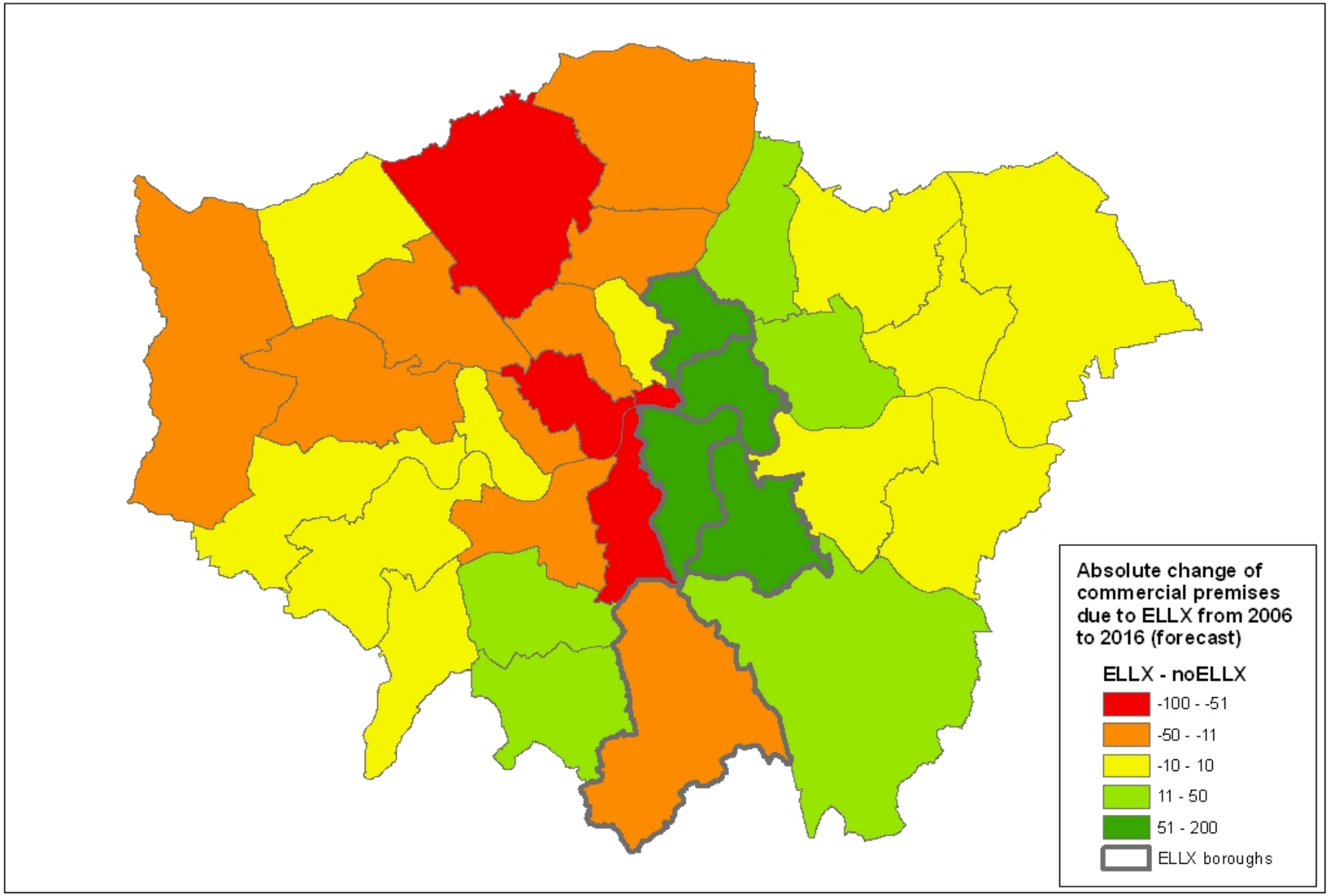
East London Line Extension

- STUDI with and without the ELLX from 1995 to 2016.
- ELLX added to the London Underground network at the beginning of 2011 (actually opened in June 2010).
- 30 runs using 15 different pseudo-random number sequences: 15 times with and 15 without the ELLX.
- The number of new businesses to be added in the future depends on economic (GDP) growth.

Residential development



Commercial development

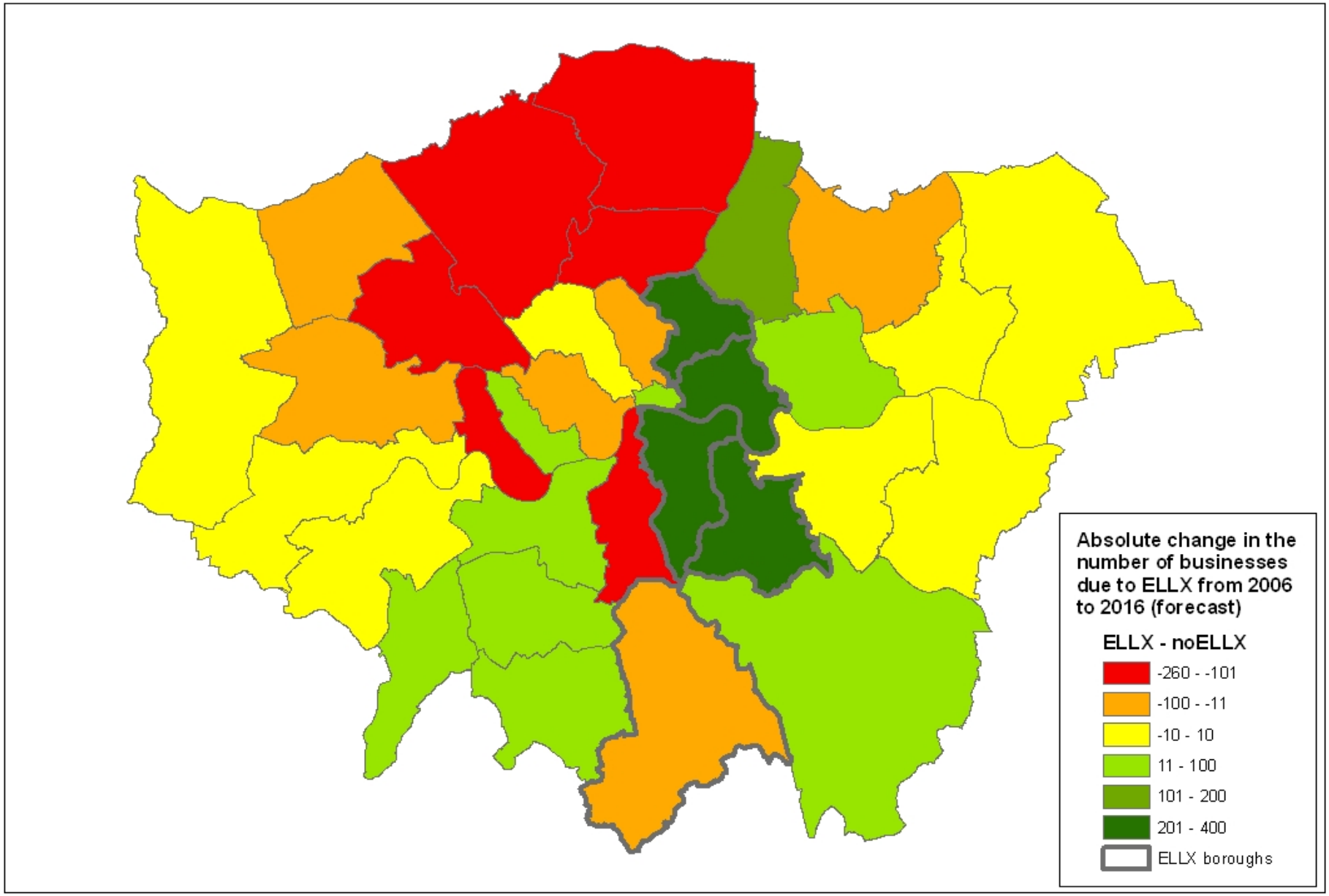


ELLX impacts on aggregate areas

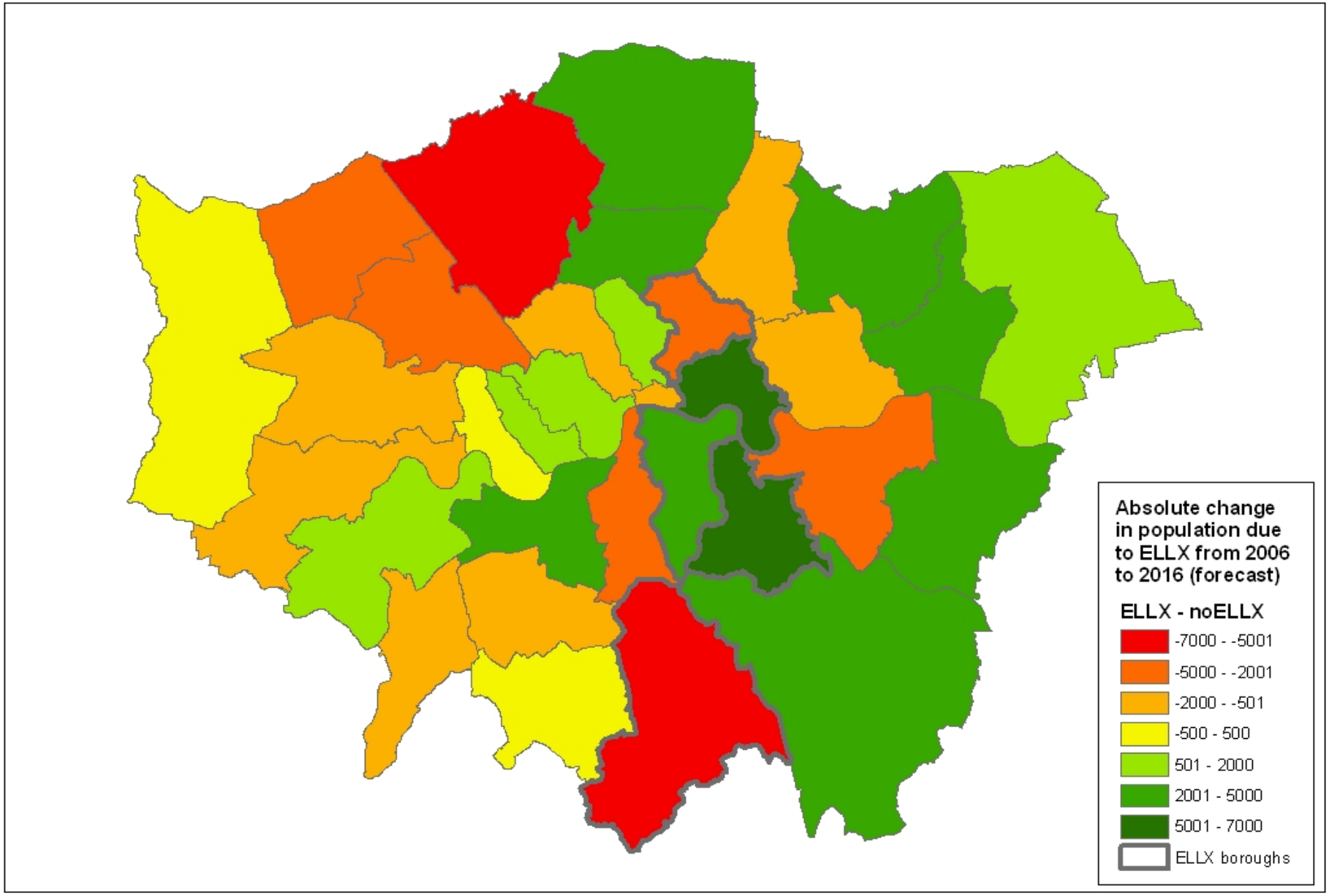
	Total number of residential premises in 2016 (forecast)			
Zones	**Without ELLX**	**With ELLX**	**Diff. ELLX - no ELLX**	**% Diff. ELLX - no ELLX**
ELLX boroughs	541,205	542,059	854	0.16
Rest of London	2,637,217	2,637,239	22	0.00

	Total number of commercial premises in 2016 (forecast)			
Areas	**Without ELLX**	**With ELLX**	**Diff. ELLX - no ELLX**	**% Diff. ELLX - no ELLX**
ELLX boroughs	68,063	68,620	558	0.82
Rest of London	315,171	314,826	-345	-0.11

Businesses


Absolute change in the number of businesses due to ELLX from 2006 to 2016 (forecast)
ELLX - noELLX
-260 - -101
-100 - -11
-10 - 10
11 - 100
101 - 200
201 - 400
ELLX boroughs

Population


Absolute change in population due to ELLX from 2006 to 2016 (forecast)
ELLX - noELLX
-7000 - -5001
-5000 - -2001
-2000 - -501
-500 - 500
501 - 2000
2001 - 5000
5001 - 7000
ELLX boroughs

ELLX impacts on aggregate areas

	Total number of businesses in 2016 (forecast)			
Areas	**Without ELLX**	**With ELLX**	**Diff. ELLX - no ELLX**	**% Diff. ELLX - no ELLX**
ELLX boroughs	69,554	70,577	1,023	1.47
Rest of London	396,701	395,861	-840	-0.21

	Population in 2016 (forecast)			
Areas	**Without ELLX**	**With ELLX**	**Diff. ELLX - no ELLX**	**% Diff. ELLX - no ELLX**
ELLX boroughs	1,544,030	1,549,356	5,326	0.34
Rest of London	6,935,345	6,938,256	2,911	0.04

STUDI

Summary

- Simulation of the processes of urban development
- Microsimulation of business and population decisions
- Application to evaluate the impacts of the JLE and ELLX on London Underground
- Results: positive impact of new metro lines on urban development

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