GEOGRAPHY & RESOURCE MANAGEMENT 地理與資源管理學系

香港中文大學 The Chinese University of Hong Kong

casa

UCL University College London

Lectures on Urban Modelling January 2017

Predicting the Impact of Large Scale Urban Infrastructures

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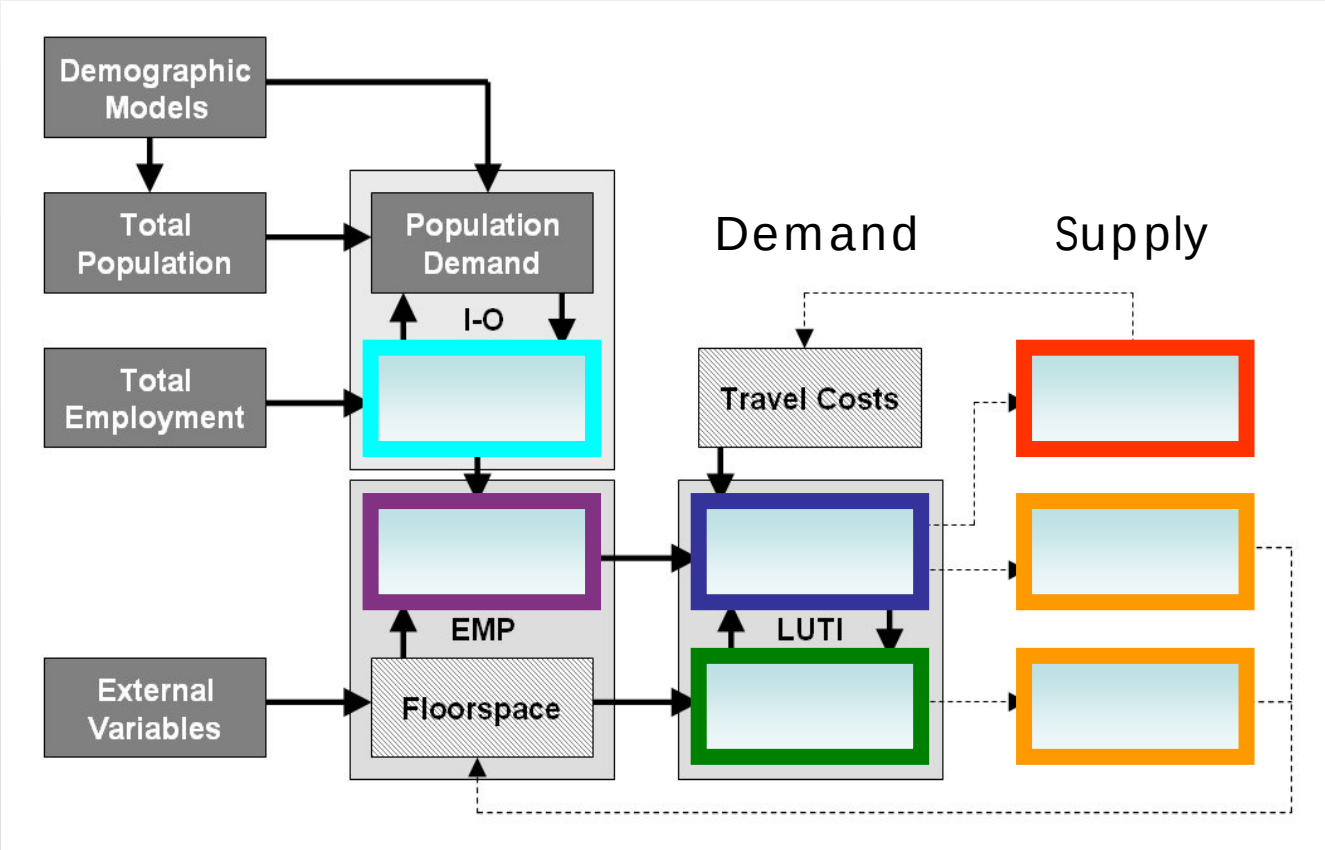
http://www.spatialcomplexity.info/

Outline

- A Demonstration of a Generic Land Use Transportation Interaction (LUTI) Model
- Scaling The Models: More Zones, More Detail
- Links to ABM (Agent-Based Models)
- A Quick Demo of QUANT
- Problems with the Models
- Setting and Testing Scenarios
- Big Infrastructure Projects: Crossrail, HS2, The Third London Airport
- Future Urban Models and Use in Planning

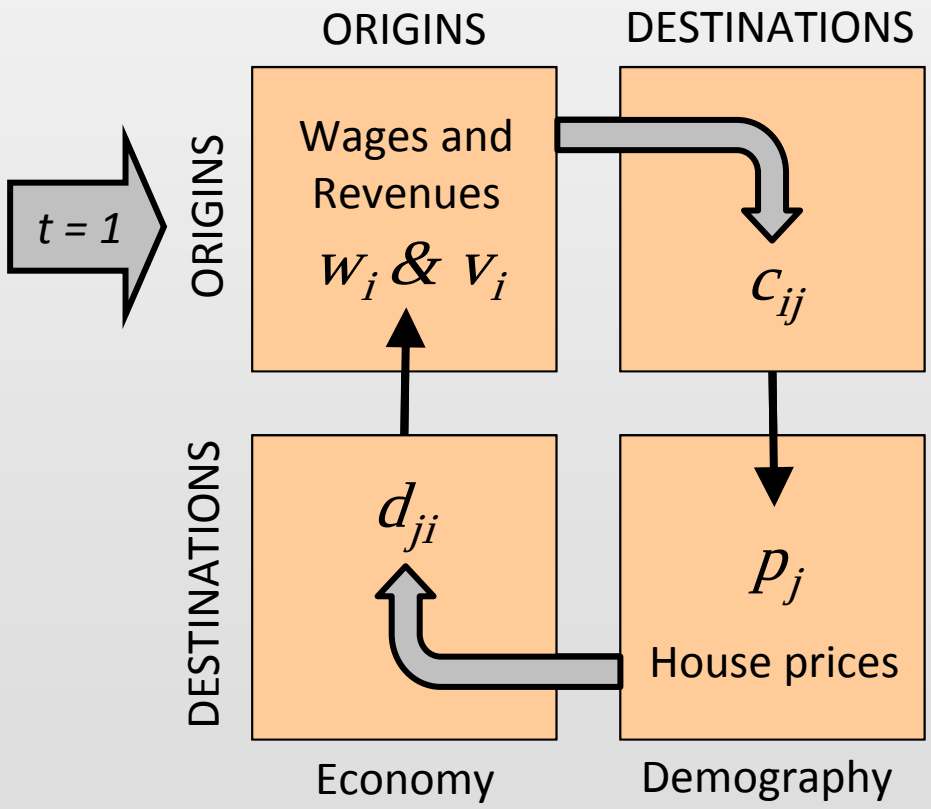
A Demonstration of a Generic Land Use Transportation Model

This is the model we have spent the lectures so far in detailing. One of our models is for Greater London and the Outer Metro Area



How They Work

Imagine two sectors – the simplest – population and employment; employment drives population and vice versa through spatial demand for labour (J-W) & spatial demand for products (J-S)



A Very Important Key Point

The demand for various products in such models is subject to capacity constraints. For example a model producing J to W flows – T_{ij} – is subject to the capacity of the network and also when we add up the number of workers getting to any place to live, this must be less than the density limit. We need to iterate. This is the killer – it has been like this since the beginning of these models

$$T_{ij} = E_i p_{ij} \sim E_i A_j \exp(-\beta c_{ij})$$

$$\text{if } T_{ij} > C_{ij} \text{ then } c_{ij} \text{ is increased, as } c_{ij} = c_{ij} \frac{T_{ij}}{C_{ij}}$$

$$P_j = \sum_i T_{ij} = \sum_i E_i p_{ij}$$

$$\text{if } P_j > Z_j \text{ then } A_j \text{ is decreased, as } A_j = A_j \frac{P_j}{Z_j}$$

ITERATE

It is made even worse by the fact that the networks are at a different (finer) scale than the aggregated zonal model. When we change c_{ij} we need to drill down and look at individual elements

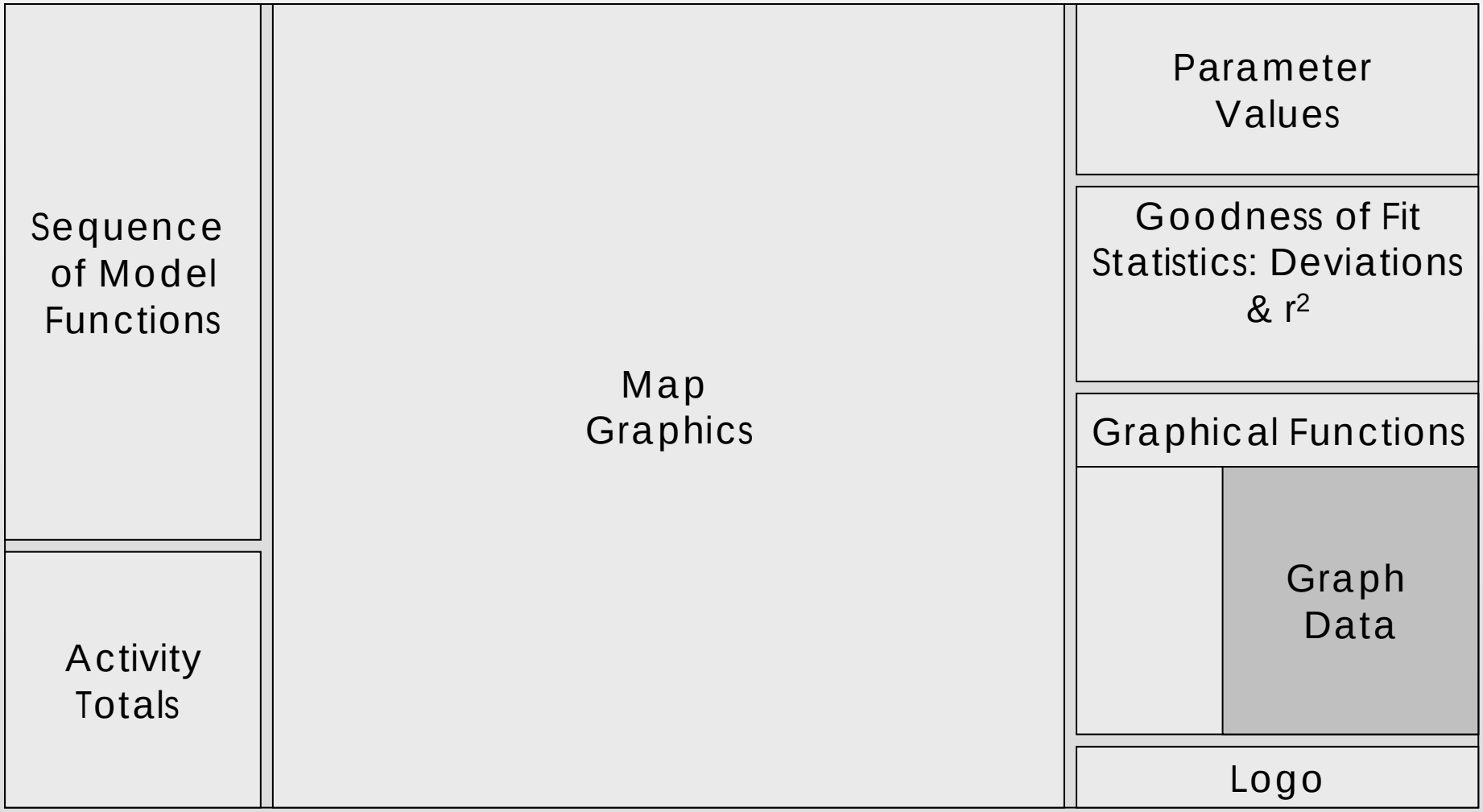
$$c_{ij} = c_{ij1} + c_{j1j2} + c_{j2j3} + \ldots\ldots + c_{jnj}$$

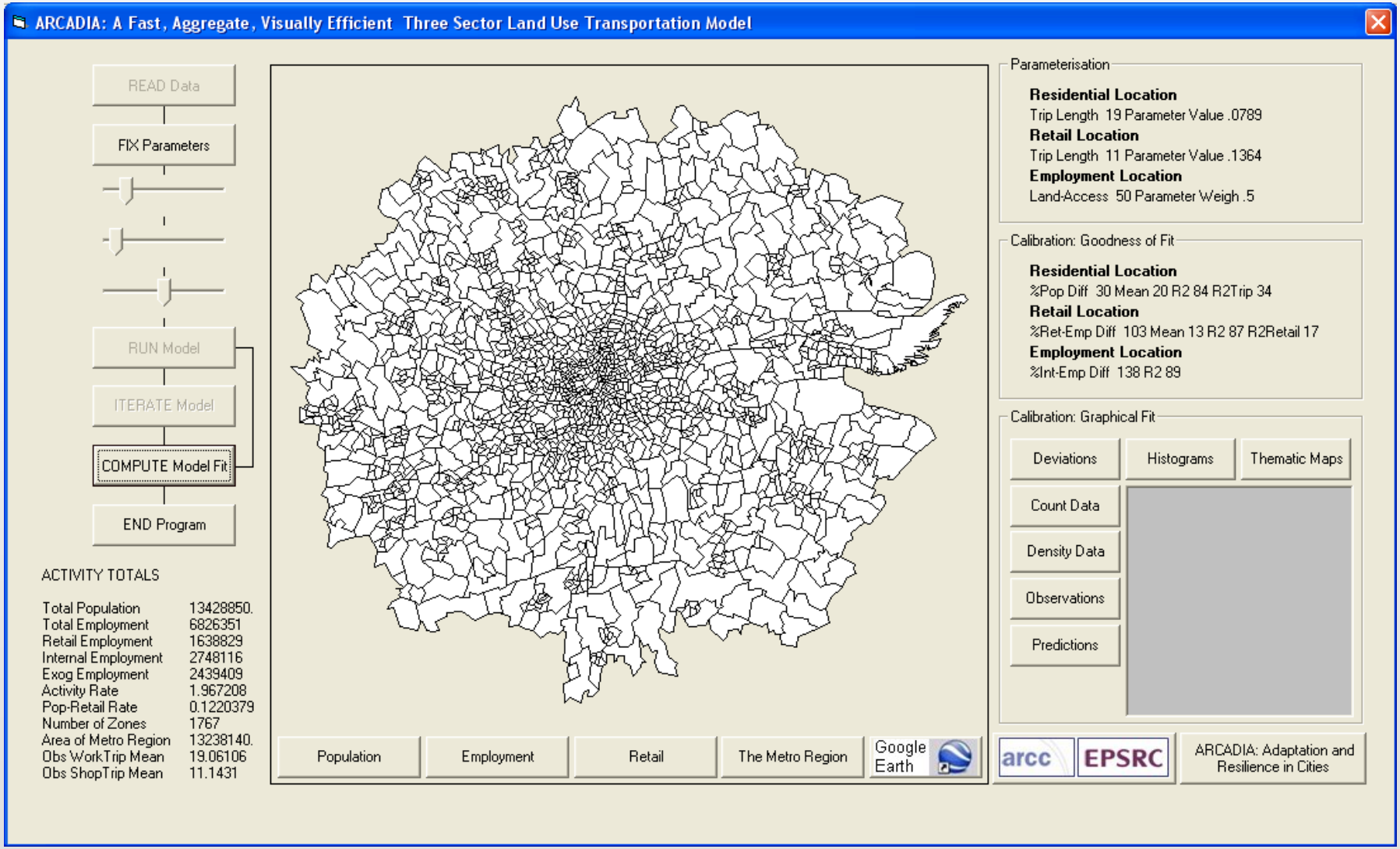
It may be that the one in the red box needs to be increased but this segment might be common to other trips and thus it is impossible to figure out which ones to increase and in what order. We thus risk setting other trips out of equilibrium, and thus no overall equilibrium can be guaranteed.

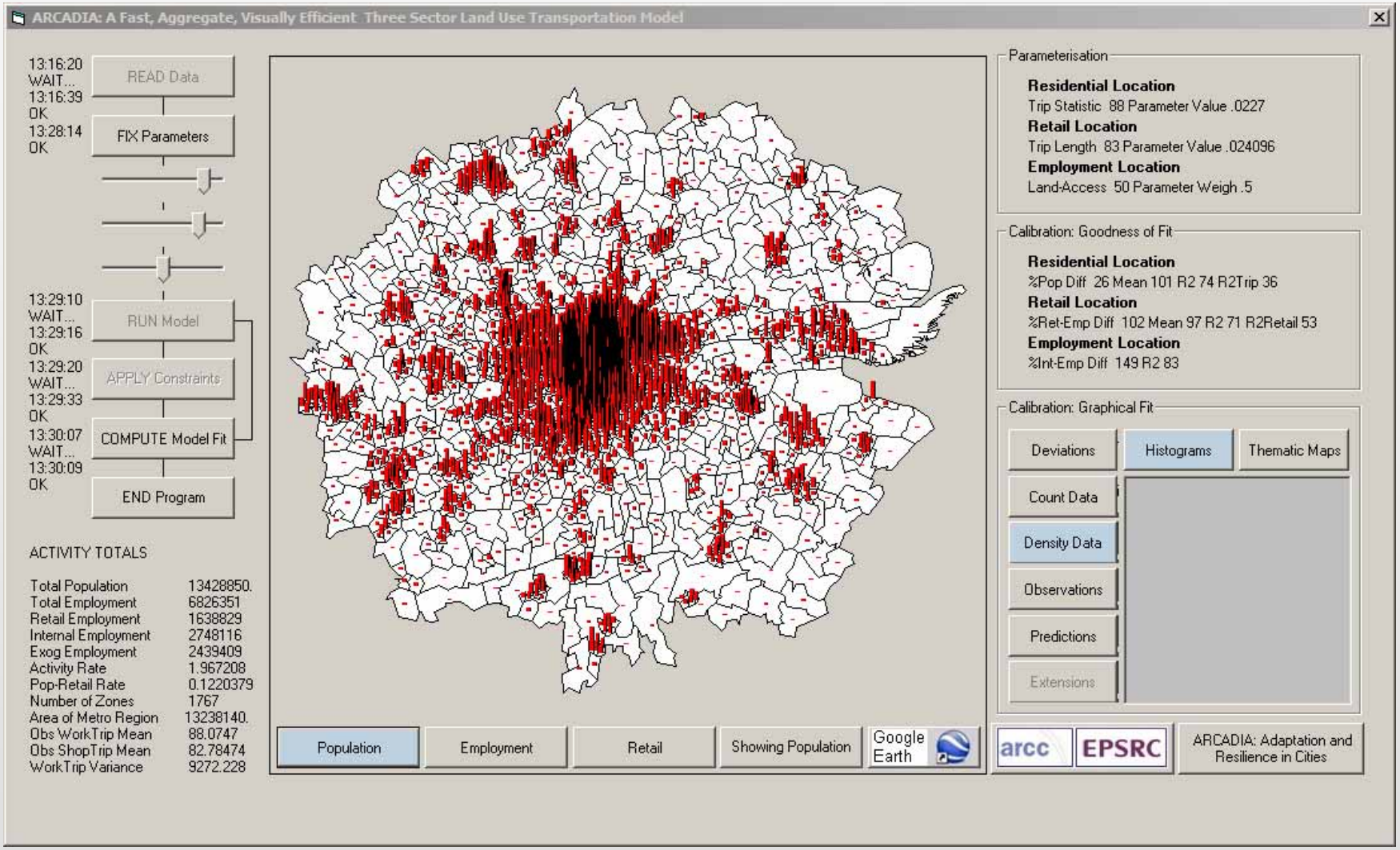
In fact if all we do is alter c_{ij} then we can be more certain that the model will converge but this may take many iterations.

If we have the simpler model where there is only one c_{ij}, then this is more likely to converge but for a very large model it might take many iterations

Now let us show one of these models where this is the desktop order of operations that take place with the inputs and outputs




ARCADIA: A Fast, Aggregate, Visually Efficient Three Sector Land Use Transportation Model
READ Data
FIX Parameters
RUN Model
ITERATE Model
COMPUTE Model Fit
END Program
ACTIVITY TOTALS
Total Population 13428850.
Total Employment 6826351
Retail Employment 1638829
Internal Employment 2748116
Exog Employment 2439409
Activity Rate 1.967208
Pop-Retail Rate 0.1220379
Number of Zones 1767
Area of Metro Region 13238140.
Obs WorkTrip Mean 19.06106
Obs ShopTrip Mean 11.1431
Population
Employment
Retail
The Metro Region
Google Earth
Parameterisation
Residential Location
Trip Length 19 Parameter Value .0789
Retail Location
Trip Length 11 Parameter Value .1364
Employment Location
Land-Access 50 Parameter Weigh .5
Calibration: Goodness of Fit
Residential Location
%Pop Diff 30 Mean 20 R2 84 R2Trip 34
Retail Location
%Ret-Emp Diff 103 Mean 13 R2 87 R2Retail 17
Employment Location
%Int-Emp Diff 138 R2 89
Calibration: Graphical Fit
Deviations
Histograms
Thematic Maps
Count Data
Density Data
Observations
Predictions
arcc
EPSRC
ARCADIA: Adaptation and Resilience in Cities


ARCADIA: A Fast, Aggregate, Visually Efficient Three Sector Land Use Transportation Model
13:16:20
WAIT...
13:16:39
OK
READ Data
13:28:14
OK
FIX Parameters
13:29:10
WAIT...
13:29:16
OK
RUN Model
13:29:20
WAIT...
13:29:33
OK
APPLY Constraints
13:30:07
WAIT...
13:30:09
OK
COMPUTE Model Fit
END Program
ACTIVITY TOTALS
Total Population 13428850.
Total Employment 6826351
Retail Employment 1638829
Internal Employment 2748116
Exog Employment 2439409
Activity Rate 1.967208
Pop-Retail Rate 0.1220379
Number of Zones 1767
Area of Metro Region 13238140.
Obs WorkTrip Mean 88.0747
Obs ShopTrip Mean 82.78474
WorkTrip Variance 9272.228
Population
Employment
Retail
Showing Population
Google Earth
Parameterisation
Residential Location
Trip Statistic 88 Parameter Value .0227
Retail Location
Trip Length 83 Parameter Value .024096
Employment Location
Land-Access 50 Parameter Weigh .5
Calibration: Goodness of Fit
Residential Location
%Pop Diff 26 Mean 101 R2 74 R2Trip 36
Retail Location
%Ret-Emp Diff 102 Mean 97 R2 71 R2Retail 53
Employment Location
%Int-Emp Diff 149 R2 83
Calibration: Graphical Fit
Deviations
Histograms
Thematic Maps
Count Data
Density Data
Observations
Predictions
Extensions
arcc
EPSRC
ARCADIA: Adaptation and Resilience in Cities

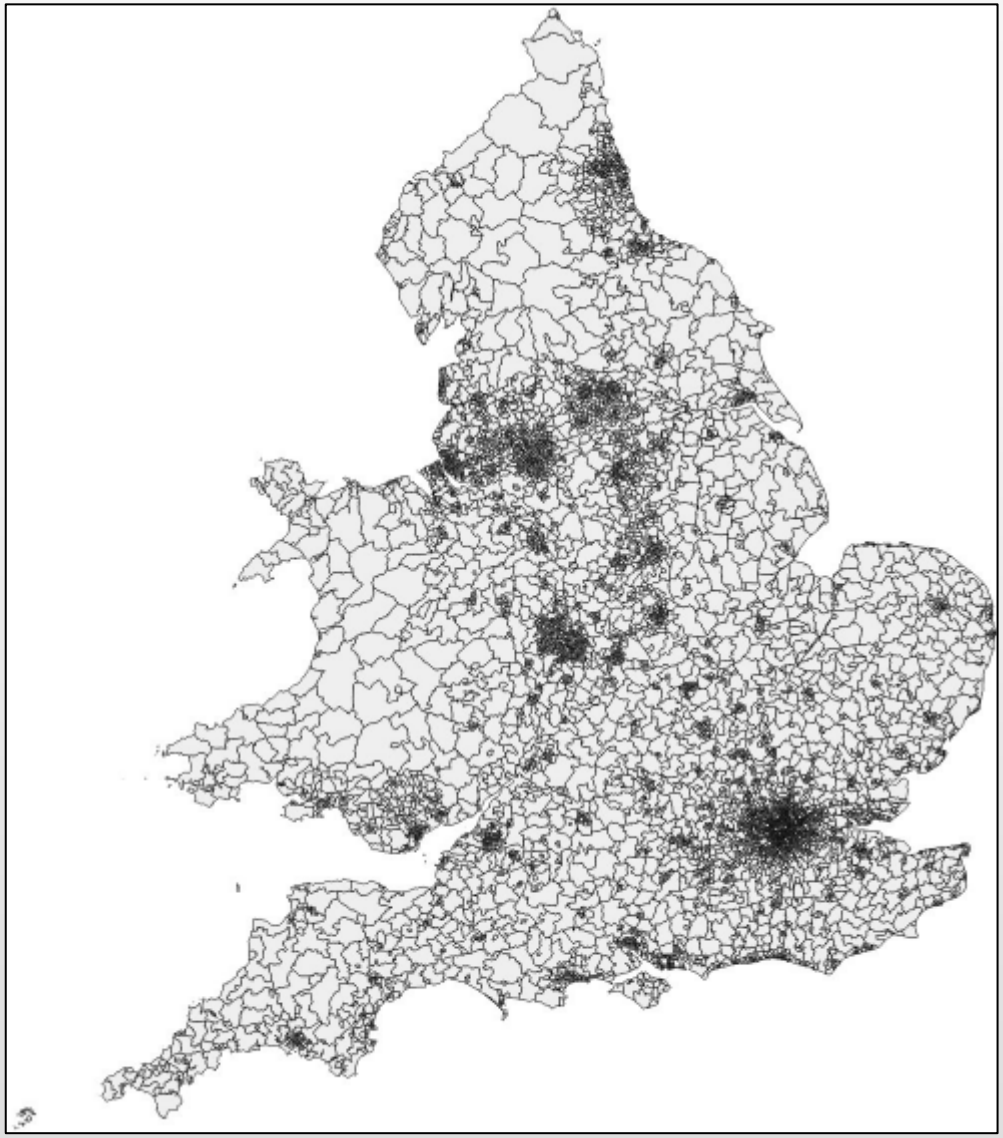
Scaling The Models

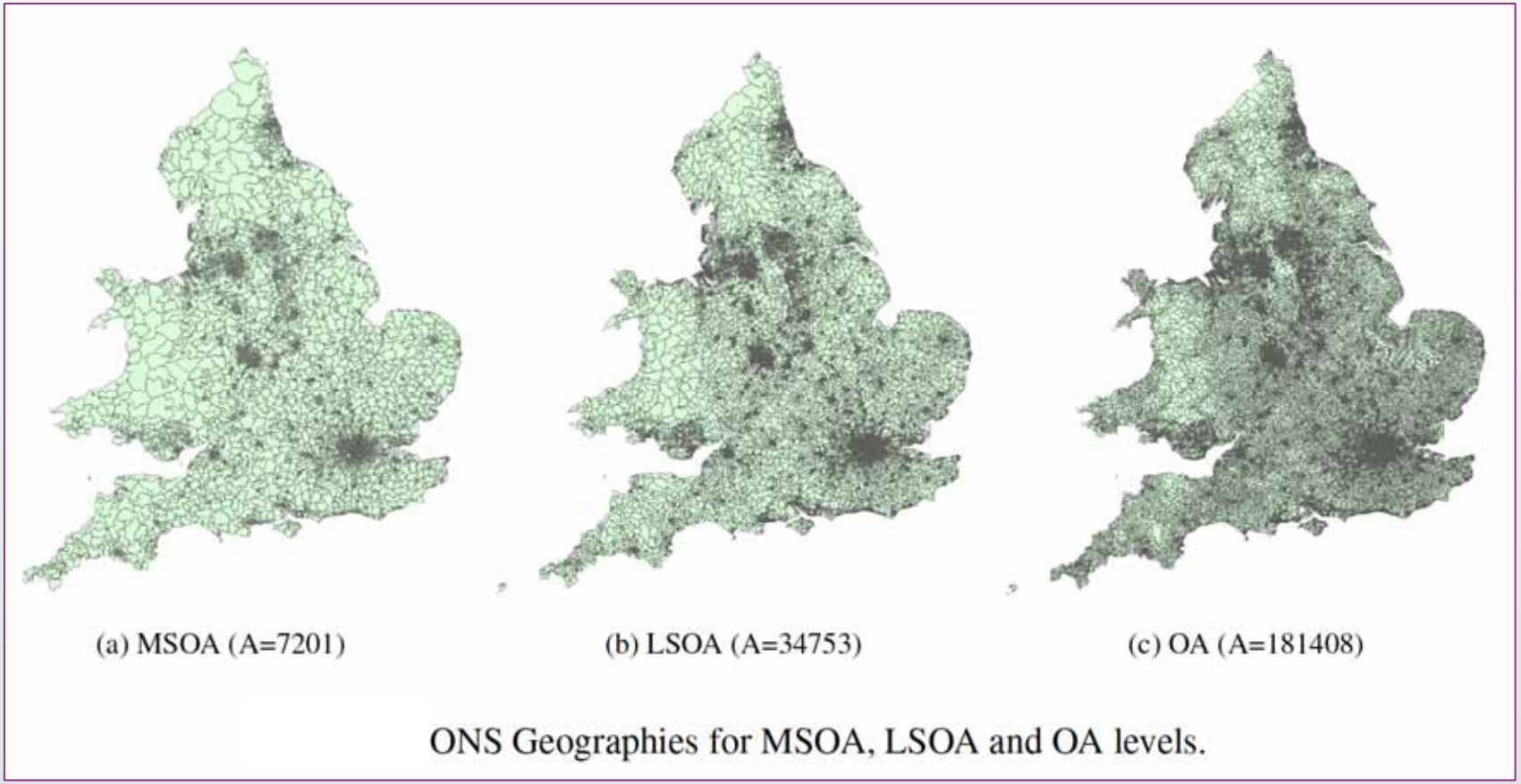
- We are building a model which is for the UK – currently England and Wales – at the same level as our current urban models. Absolutely essential to do this because of wider interaction effects – the 'where does London begin and end' problem
- The model is web based – any user can access it from anywhere – and in this sense, it has multiple users.
- It is fast to run – many problems of map delivery from server to client and so on but these are being sorted. Biggest issue is with transport networks and their updating at a very fine scale
- The model is called **QUANT** - a not very original title but easy on the eye so to speak – it means **Q**uantitative **U**rban **AN**alytics forecas**T**ing, or some variant thereof
- It grew out of a version of the model just demoed
- It is designed to let any informed expert develop scenarios

Let me show you the spatial representation first – what we call middle layer super output areas – MSOAs – which have around 7000 persons per unit on average

There are some 52 million persons in E and W in 2011; there are some 27 million jobs; there are 7201 MSOAs

Why E and W and not Scotland or NI





ONS Geographies for MSOA, LSOA and OA levels.

We could build this at the finest geographical scale – it would take ages to run because our matrices would be of the order 181K^2 and then we would have to move to ABM ~ 150 p p zone

Links to ABM: Where Are We

- Its looks like as we spatially disaggregate to the kind of data we are now getting we can begin to think about ABM – modelling every individual – so our equations might look more like this

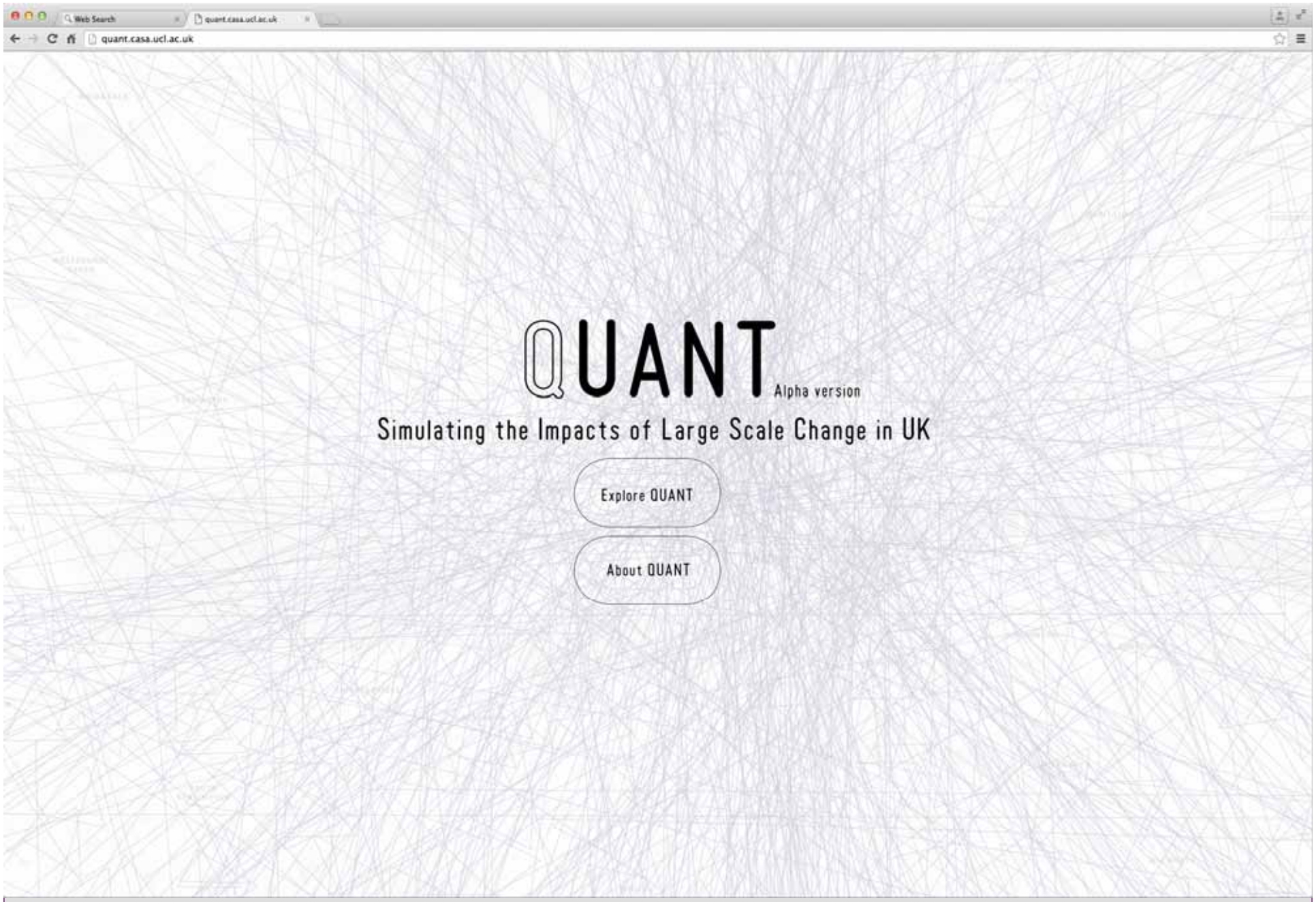
$$p_{ij} \sim E_i A_j \exp(-\beta c_{ij}) \text{ is the probability that an individual working in } i \text{ will reside in } j$$

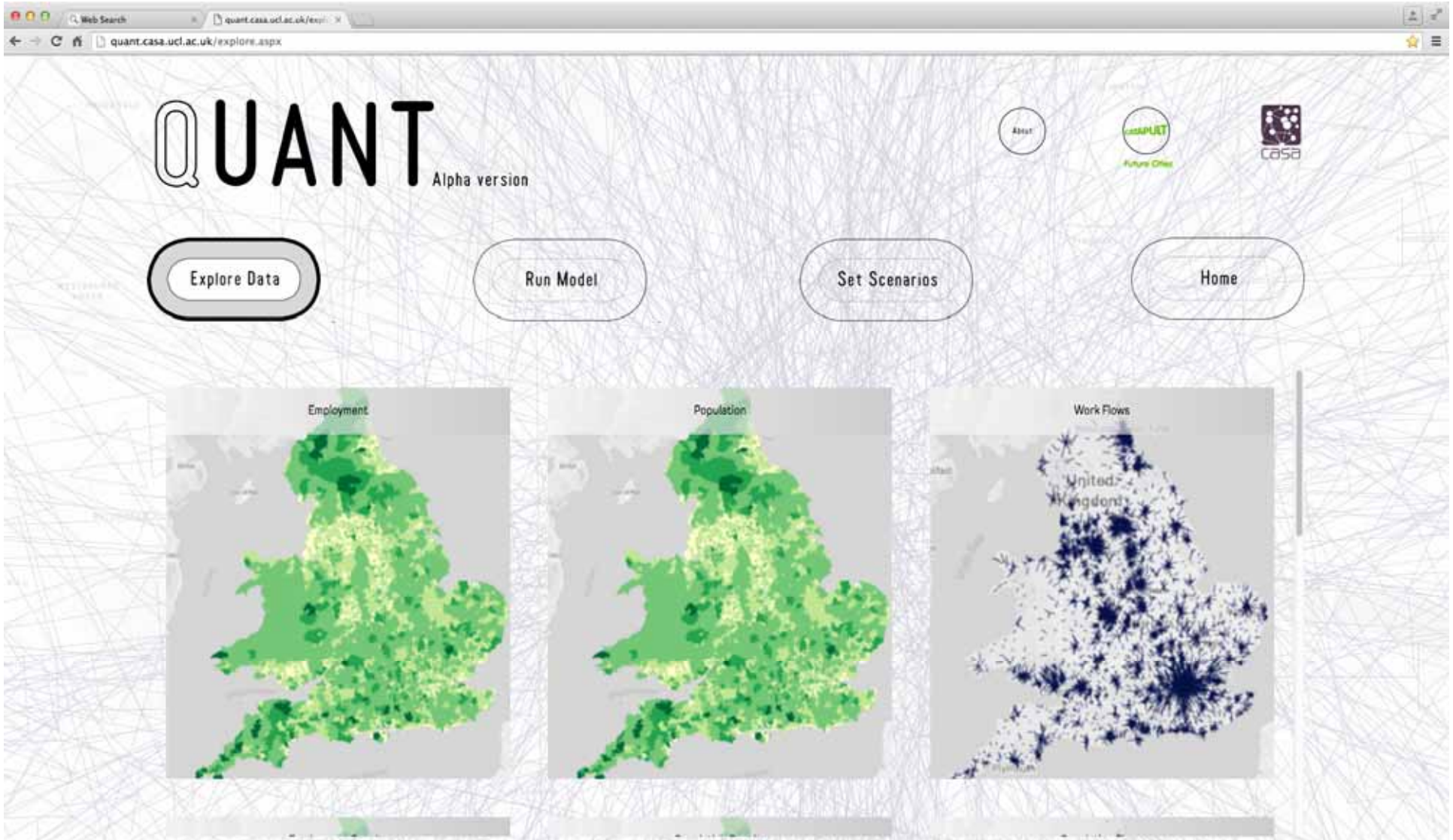
- We could simply take the maximum probability for each individual travelling to 7200 other zones and if each of the individuals was in a slightly different place in the zone – which we might know from address point data – we would get a variation around the aggregate solution.
- If more variables were different and we knew their mode of travel etc and income and so on we would have a much richer set of probabilities to work with. In QUANT and our previous models we do have three modes of travel in fact – rail, road, bus

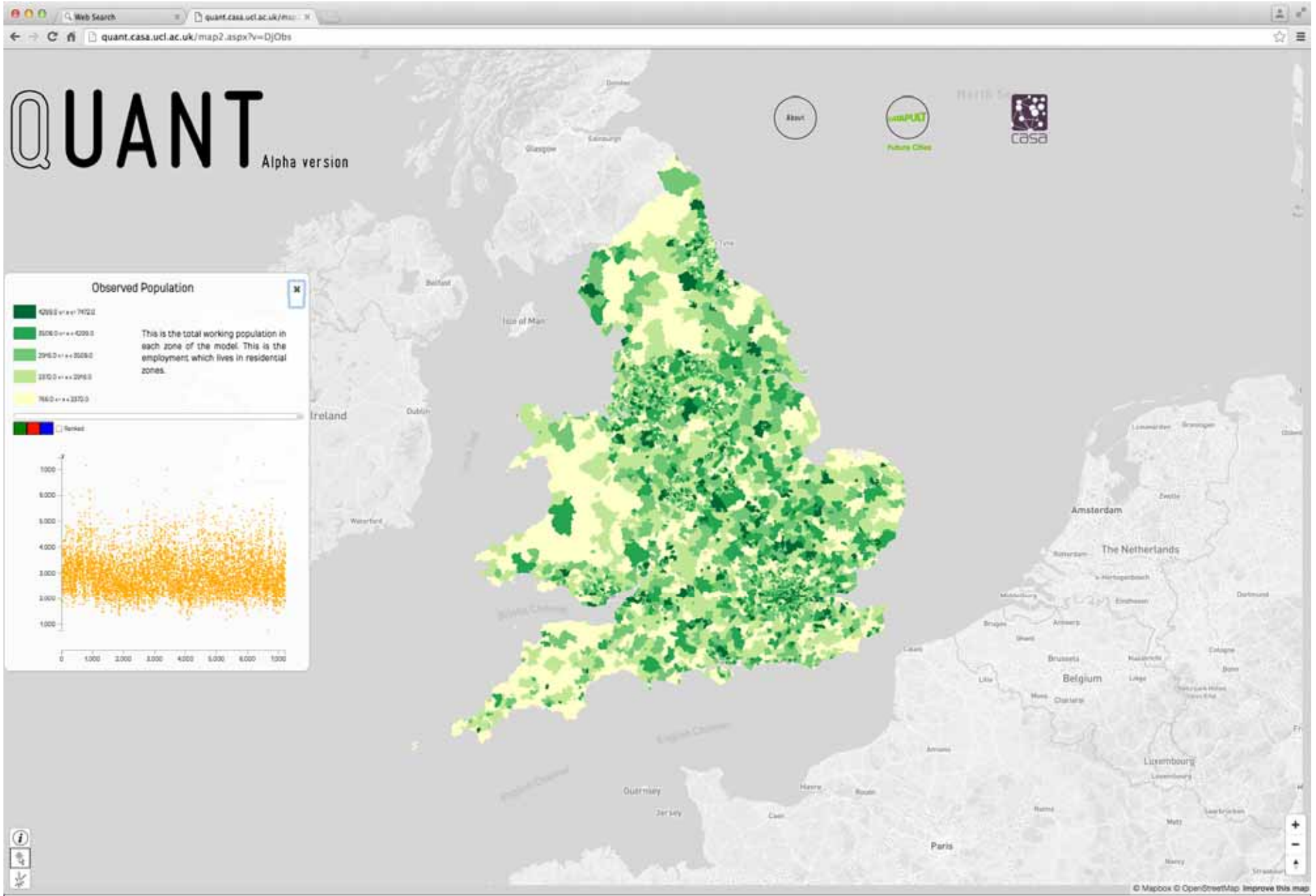
- In fact this is the way to thinking of the model in individual terms and using Monte Carlo simulation we can generate an individual from an aggregate model very easily if we had a big enough computer which we don't have yet and cannot justify.
- The model would be pretty simple anyway and it is only 'just about' agent-based in that the individuals are not influenced by the behaviour of other individuals other than through the aggregate variables that pertain to other agents
- However it is when we begin to iterate a large model such as the one we have that things get really complicated and we need to formulate the way the model allocates activity in an agent-based sense.
- So to summarise, the way to building an agent-based version which is much richer is clear but the computation is horrendous. We also have a sense in which the model users are agents and this opens up an entirely different Pandora's box which I wont discuss here but it is of great interest. But before all this, let me give you a quick run of what the model does.

A Quick Demo of QUANT

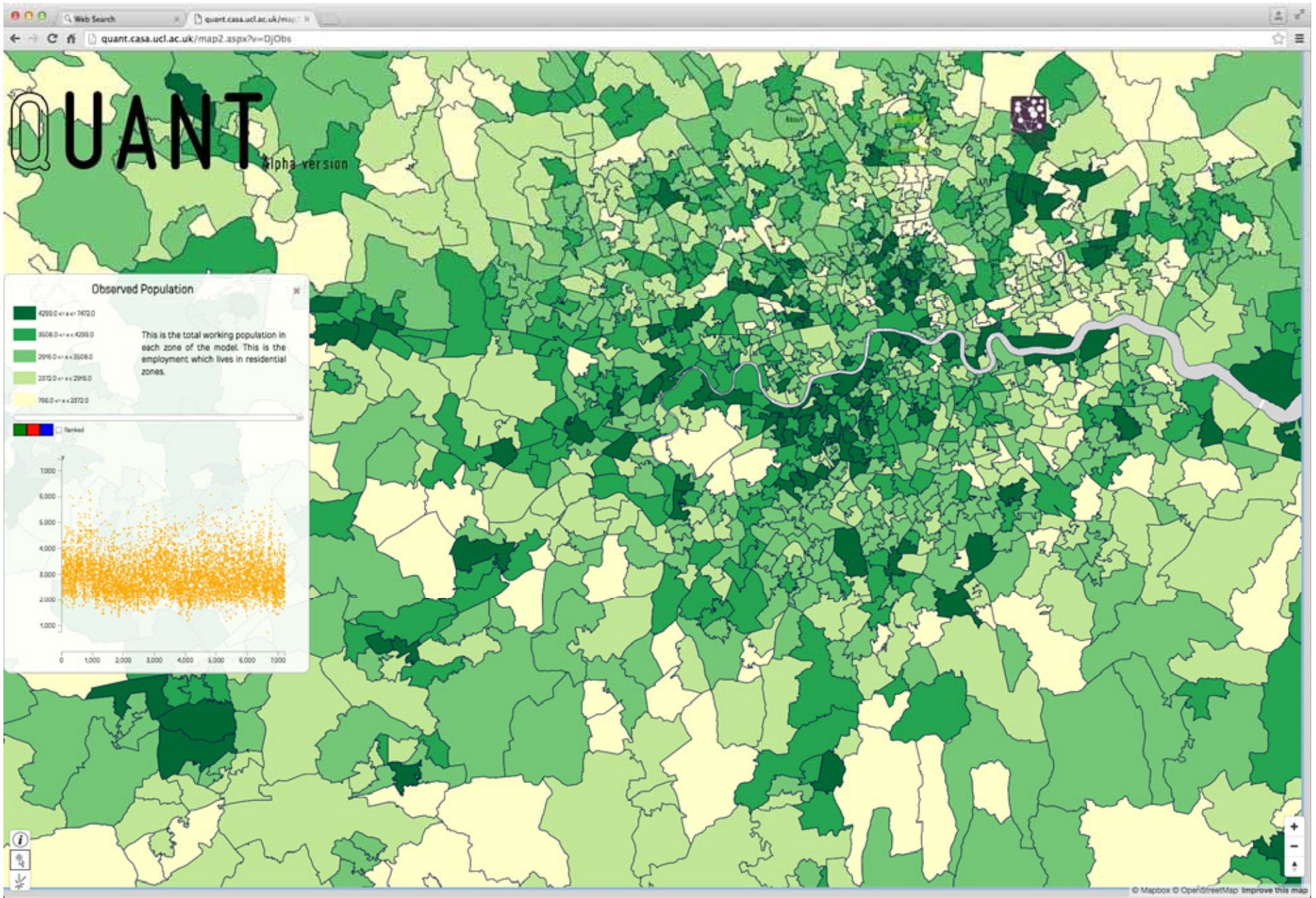
- Here is the web site that you can explore – caveat emptor – it's a prototype, its free, it is an alpha version not even beta
- **http://quant.casa.ucl.ac.uk**
- Its is based on a simple structure of letting the user explore the data, then run the model (and calibrate it although as this happens every time it like an initiation of variables), then the user can look at the model outputs (predictions of the observed cross section) and finally set up scenarios – currently changes in employment and changes in rail lines – due to our (the UK Govts) current obsession with infrastructure projects
- Many issues here that are not reported to do with computational and programming considerations
- Visualisation to date is quite primitive.

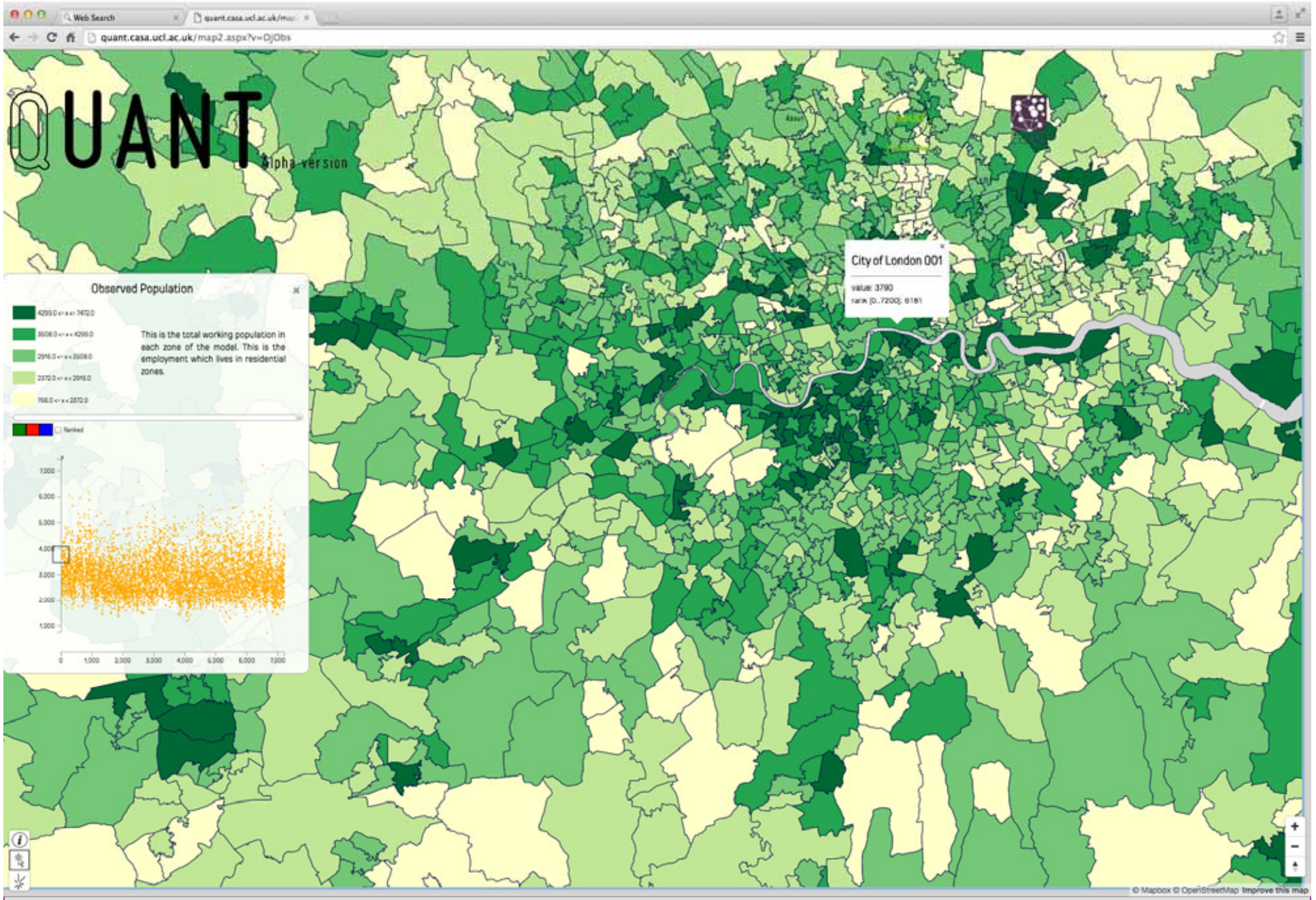

quant.casa.ucl.ac.uk
QUANT
Alpha version
Simulating the Impacts of Large Scale Change in UK
Explore QUANT
About QUANT

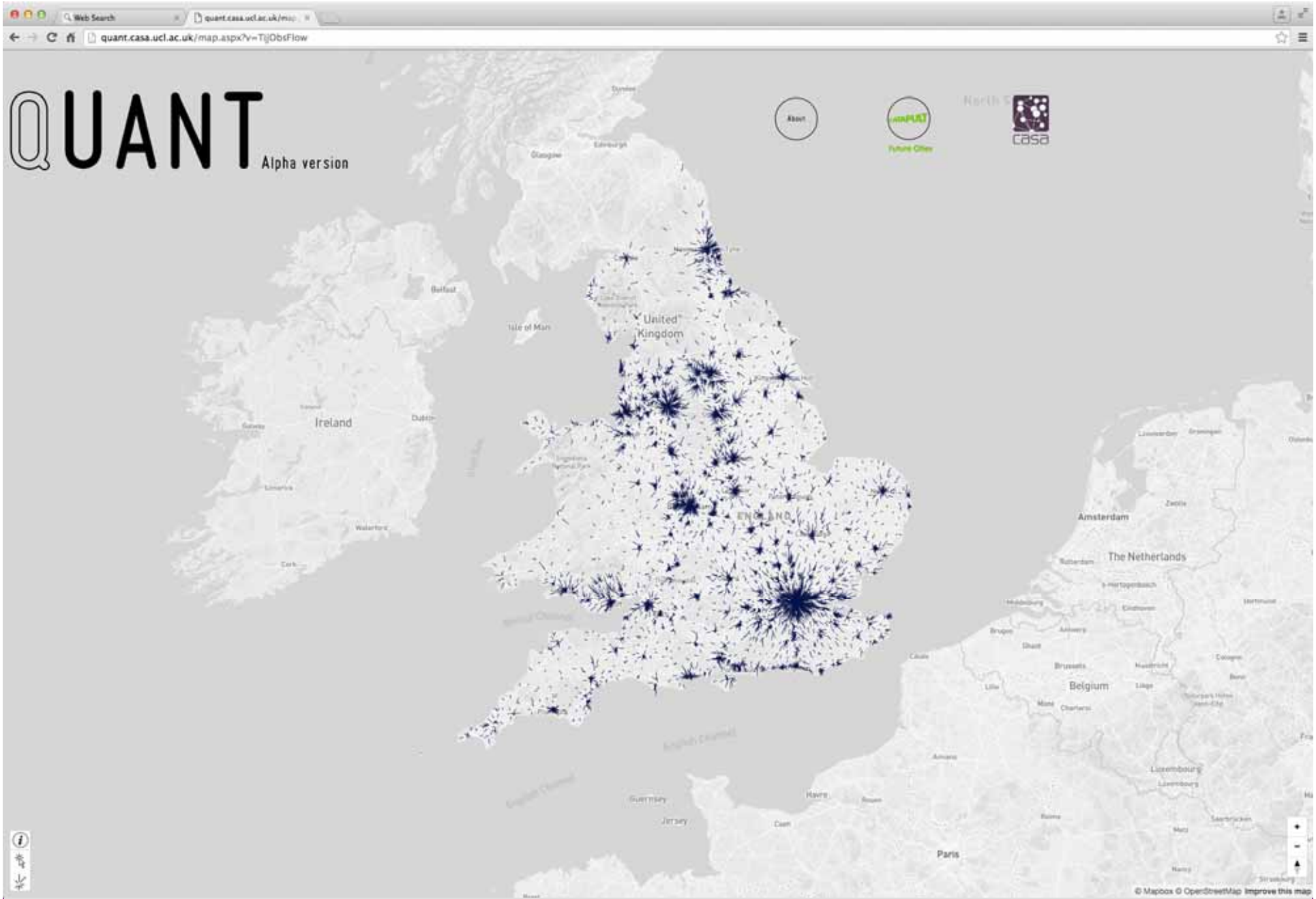

quant.casa.ucl.ac.uk/explore.aspx
QUANT
Alpha version
Explore Data
Run Model
Set Scenarios
Home
Employment
Population
Work Flows

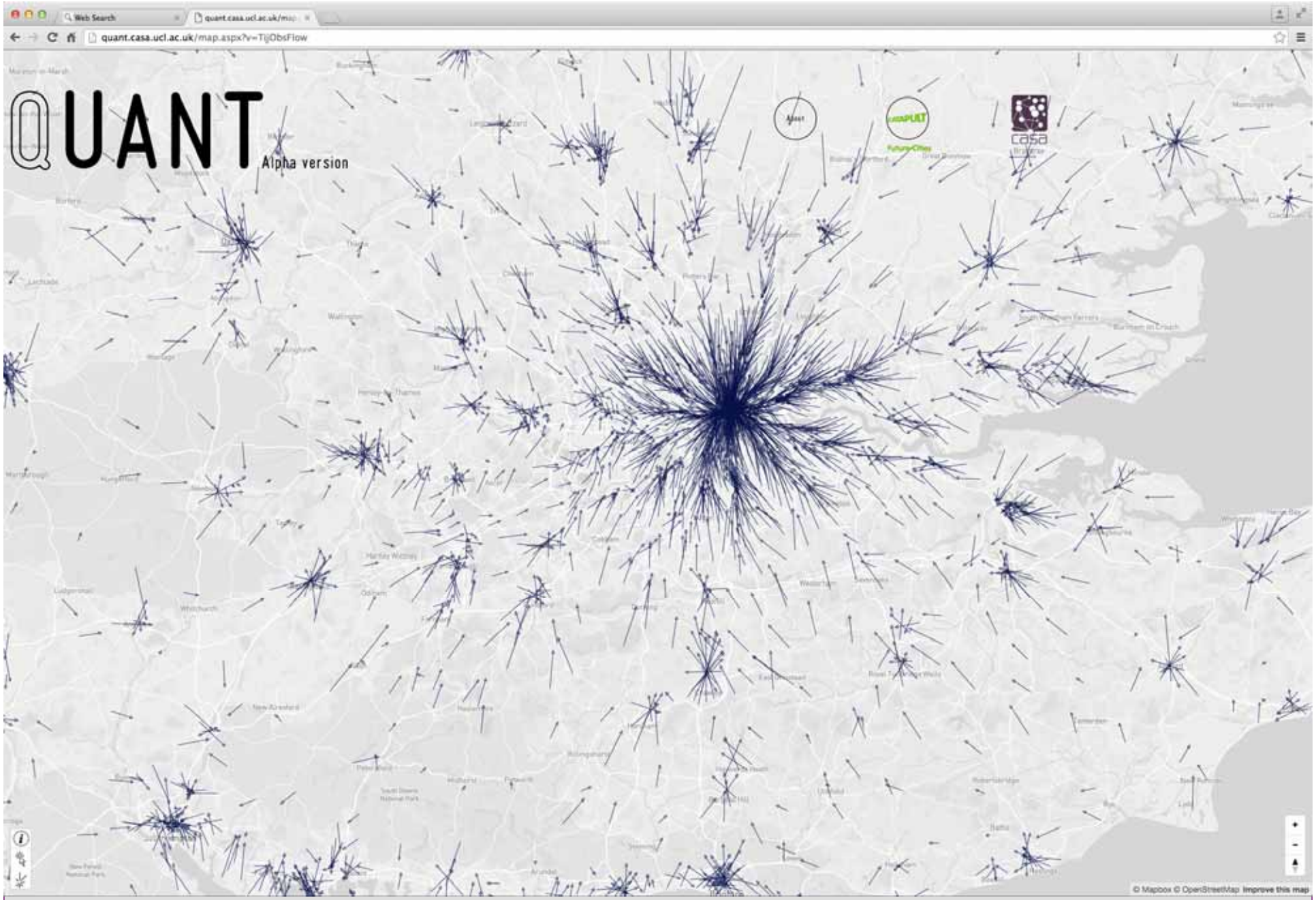

quant.casa.ucl.ac.uk/map2.aspx?v=DjObs
QUANT
Alpha version
About
casa
Observed Population
This is the total working population in each zone of the model. This is the employment which lives in residential zones.
Ireland
Dublin
Belfast
Isle of Man
Amsterdam
The Netherlands
Belgium
Luxembourg
Paris
Guernsey
Jersey
© Mapbox © OpenStreetMap Improve this map

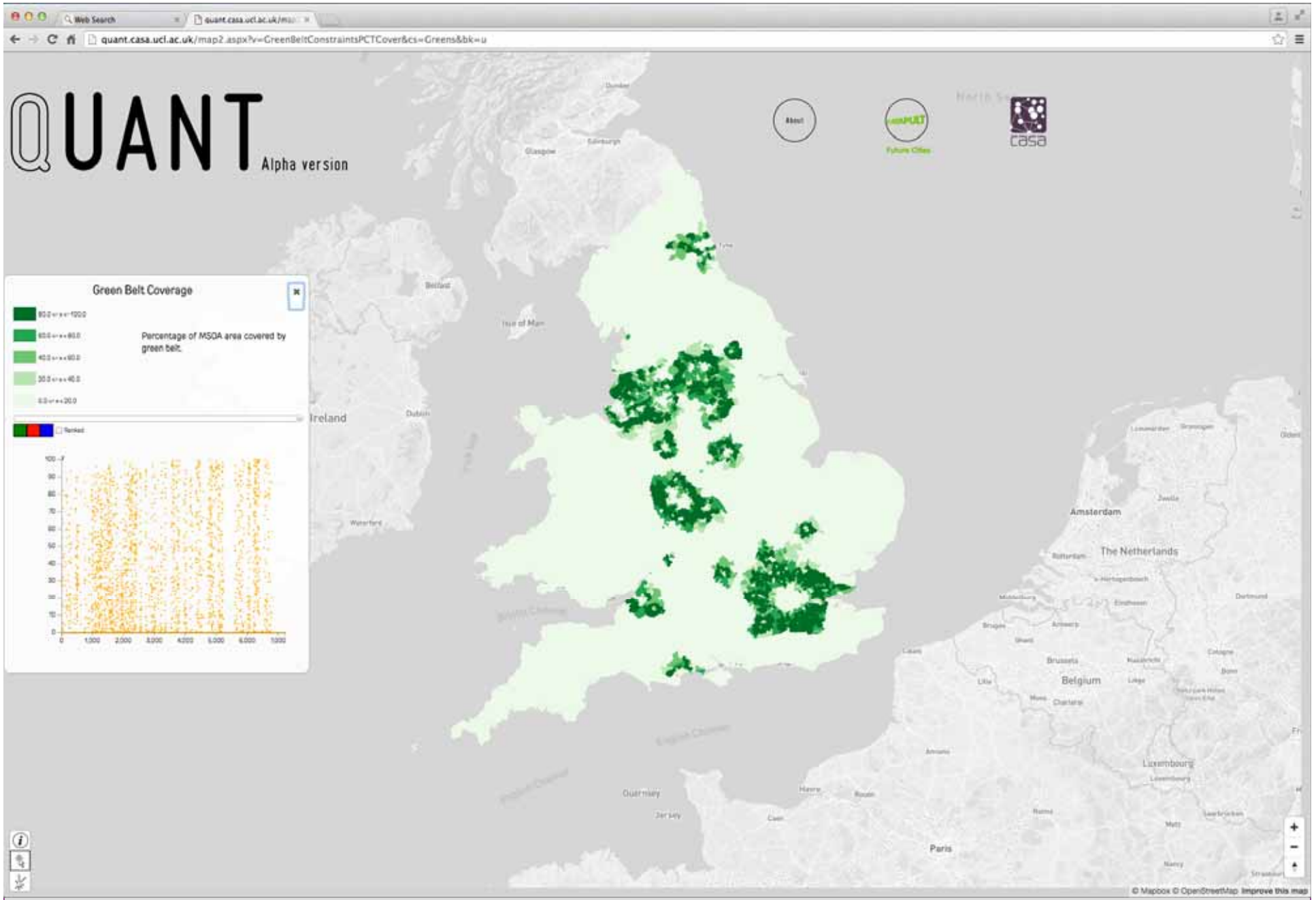

QUANT
Alpha version
Observed Population
This is the total working population in each zone of the model. This is the employment which lives in residential zones.
casa

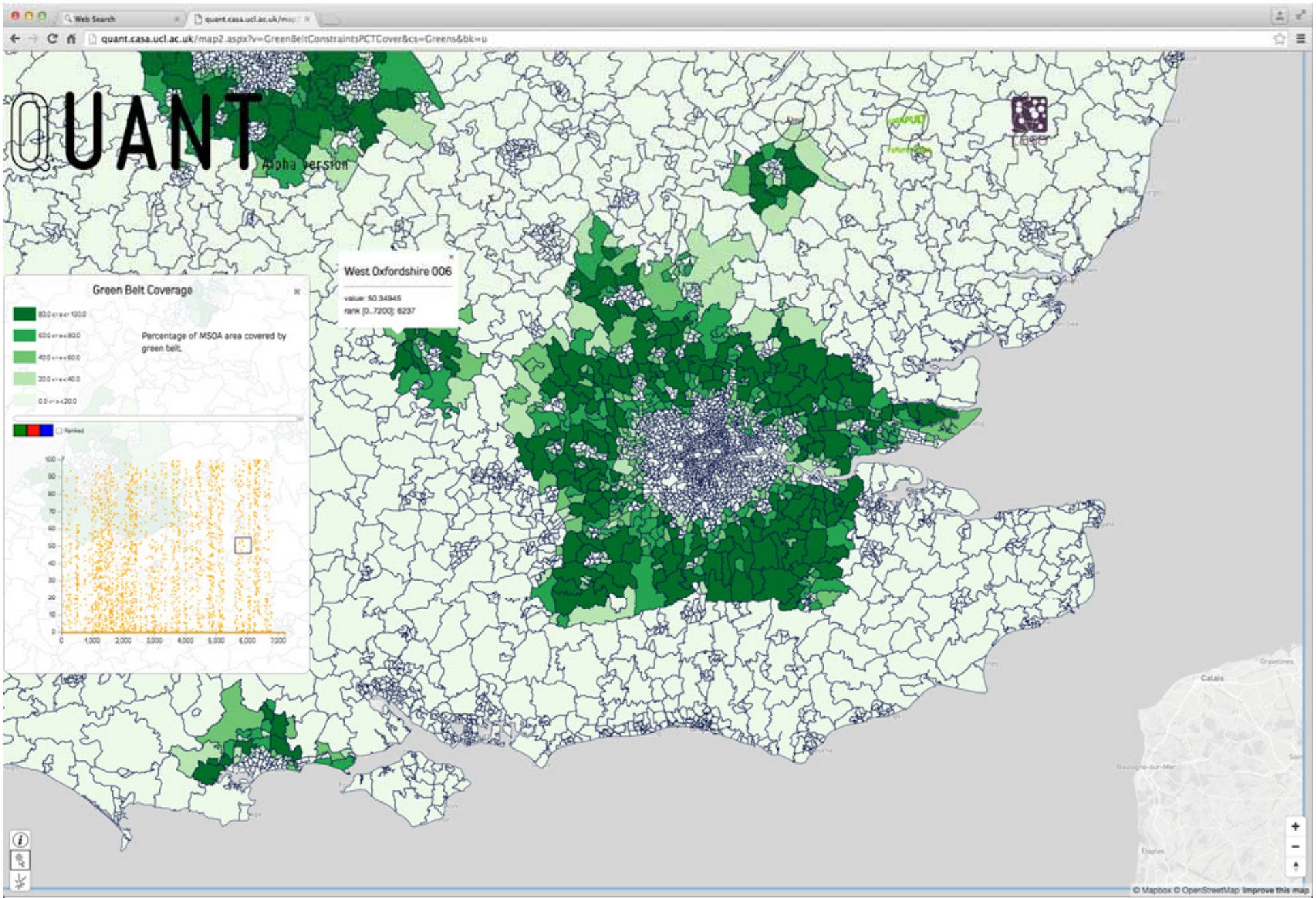

quant.casa.ucl.ac.uk/map2.aspx?v=DjObs
QUANT
alpha version
Observed Population
This is the total working population in each zone of the model. This is the employment which lives in residential zones.
Ranked
© Mapbox © OpenStreetMap Improve this map

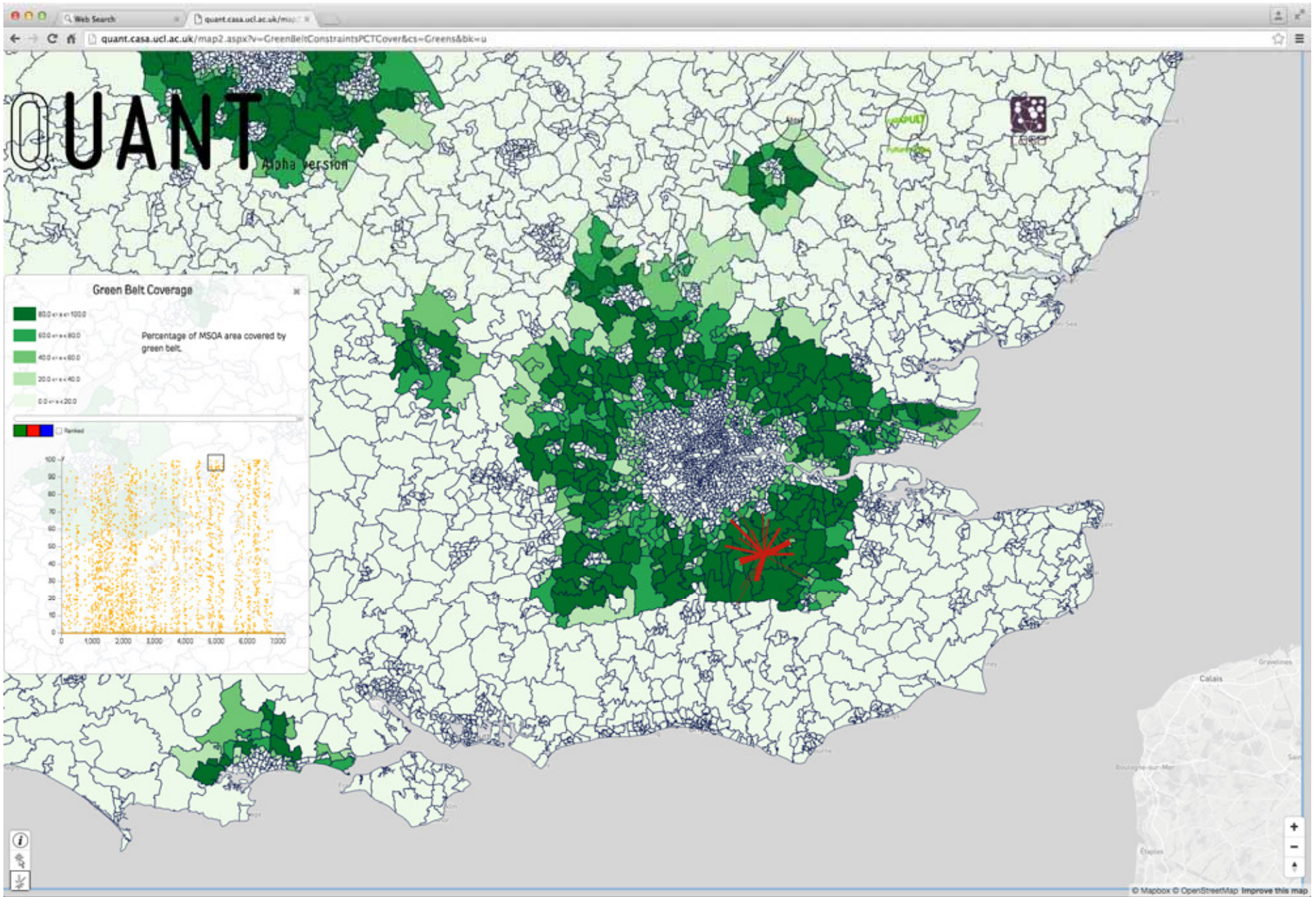

Web Search
quant.casa.ucl.ac.uk/map2.aspx?v=DjObs
QUANT
alpha version
Observed Population
This is the total working population in each zone of the model. This is the employment which lives in residential zones.
Ranked
City of London 001
value: 3790
rank [0..7200]: 6181
© Mapbox © OpenStreetMap Improve this map

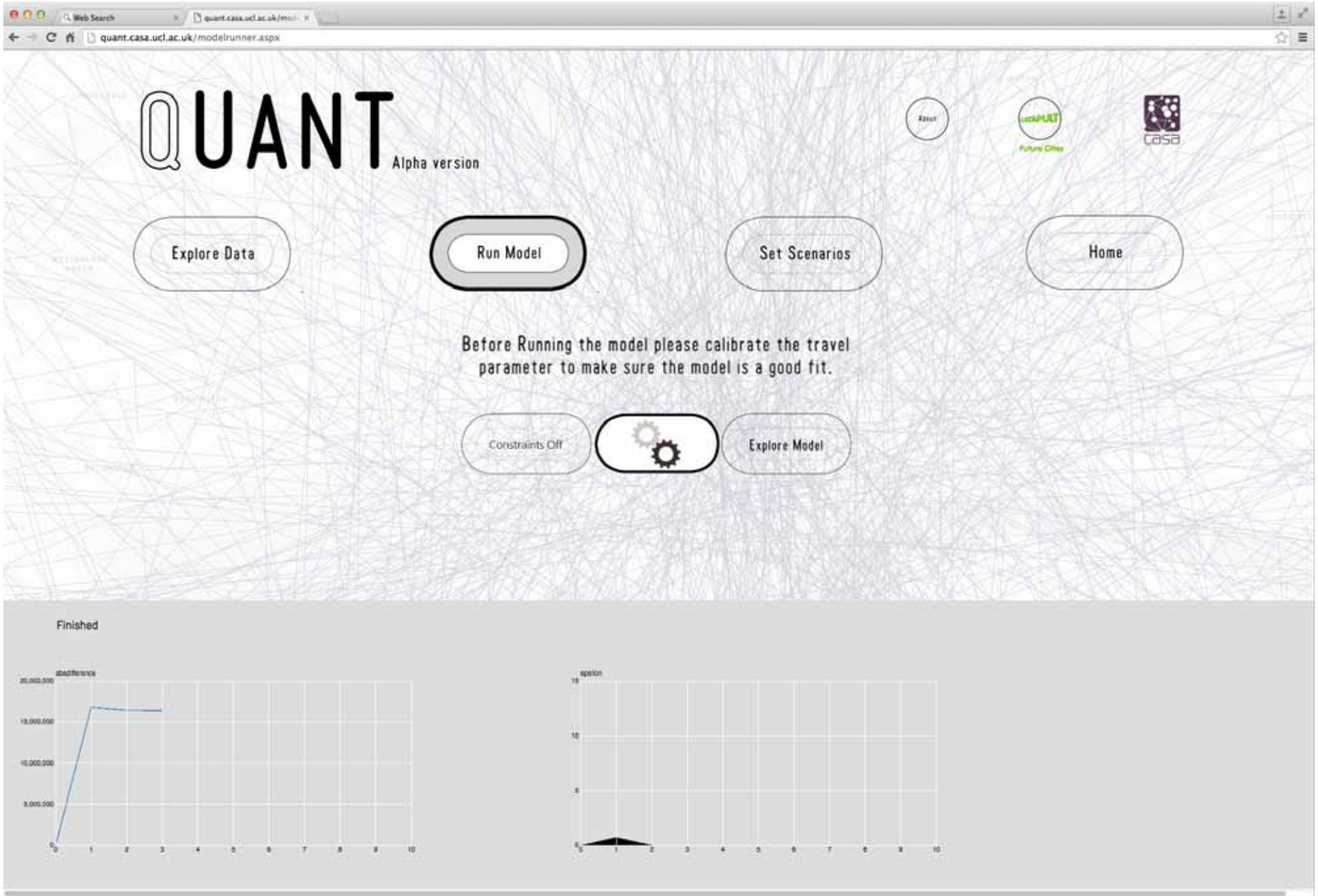

QUANT
Alpha version
About
casa
United Kingdom
Ireland
Belfast
Dublin
Galway
Limerick
Waterford
Cork
Isle of Man
Glasgow
Edinburgh
Amsterdam
The Netherlands
Belgium
Brussels
Luxembourg
Paris
Guernsey
Jersey
Havre
Caen
© Mapbox © OpenStreetMap Improve this map

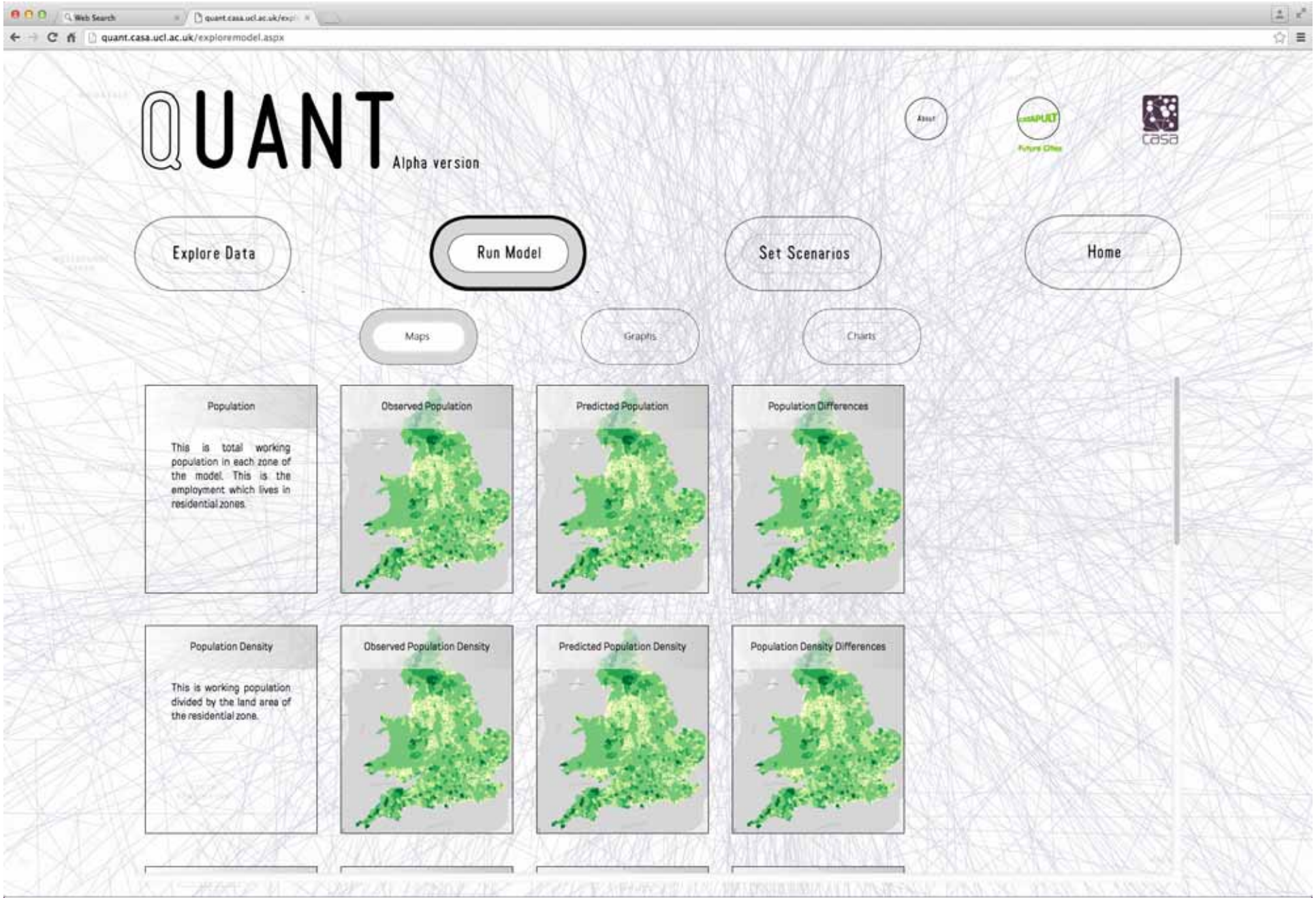

QUANT
Alpha version
quant.casa.ucl.ac.uk/map.aspx?v=TijObsFlow
casa
© Mapbox © OpenStreetMap Improve this map

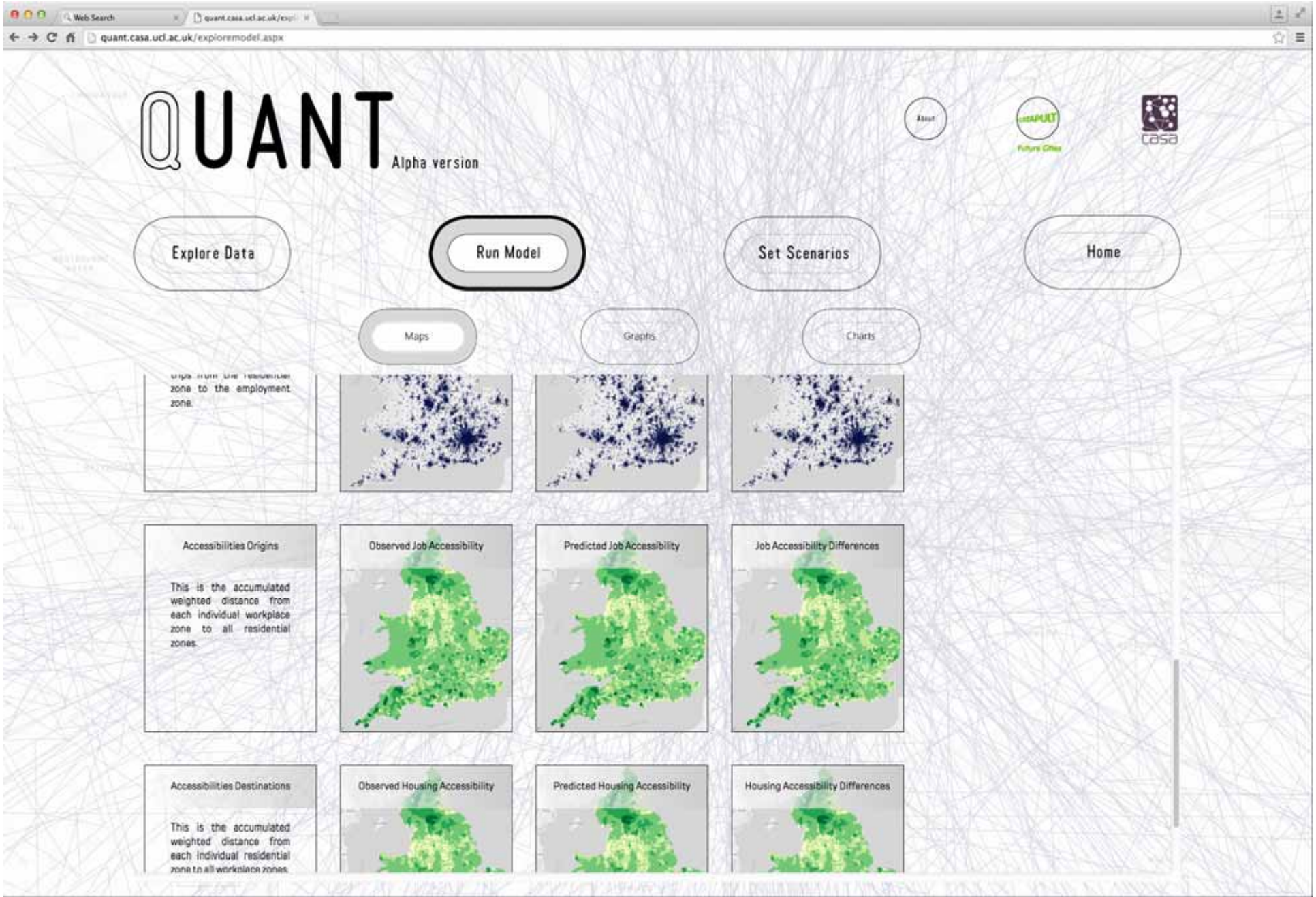

quant.casa.ucl.ac.uk/map2.aspx?v=GreenBeltConstraintsPCTCover&cs=Greens&bk=u
QUANT
Alpha version
casa
Green Belt Coverage
Percentage of MSOA area covered by green belt.
Ireland
Amsterdam
The Netherlands
Belgium
Luxembourg
Paris
© Mapbox © OpenStreetMap Improve this map


QUANT
Alpha version
West Oxfordshire 006
value: 50.34845
rank [0..7200]: 6237
Green Belt Coverage
Percentage of MSOA area covered by green belt.
Ranked
Calais
© Mapbox © OpenStreetMap Improve this map


QUANT
Alpha version
quant.casa.ucl.ac.uk/map2.aspx?v=GreenBeltConstraintsPCTCover&cs=Greens&bk=u
Green Belt Coverage
Percentage of MSOA area covered by green belt.
Calais
© Mapbox © OpenStreetMap Improve this map


quant.casa.ucl.ac.uk/modelrunner.aspx
QUANT
Alpha version
About
Explore Data
Run Model
Set Scenarios
Home
Before Running the model please calibrate the travel parameter to make sure the model is a good fit.
Constraints Off
Explore Model
Finished


quant.casa.ucl.ac.uk/exploremodel.aspx
QUANT
Alpha version
About
Future Cities
casa
Explore Data
Run Model
Set Scenarios
Home
Maps
Graphs
Charts
Population
This is total working population in each zone of the model. This is the employment which lives in residential zones.
Observed Population
Predicted Population
Population Differences
Population Density
This is working population divided by the land area of the residential zone.
Observed Population Density
Predicted Population Density
Population Density Differences


Web Search
quant.casa.ucl.ac.uk/exploremodel.aspx
QUANT
Alpha version
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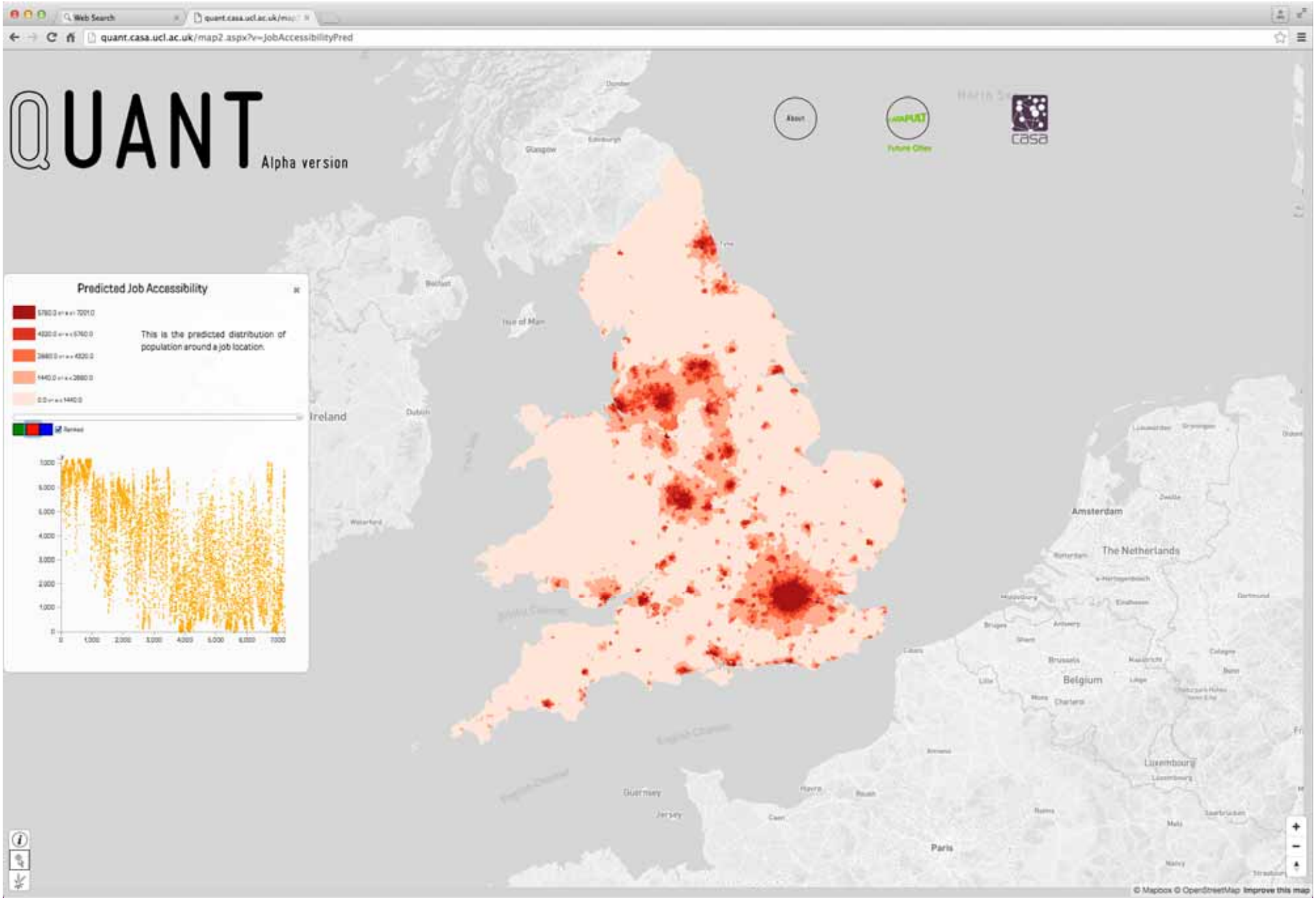
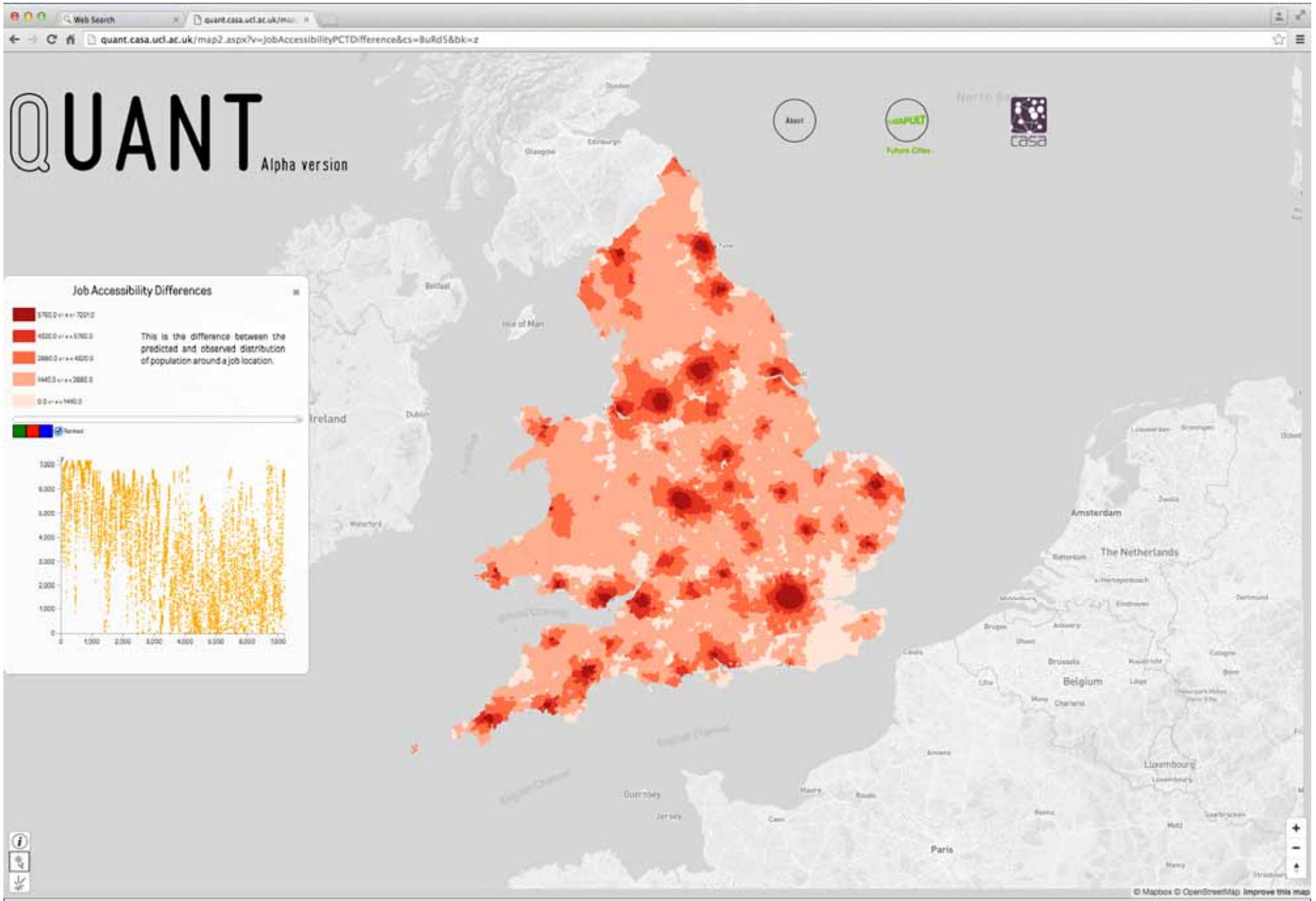
Future Cities
casa
Explore Data
Run Model
Set Scenarios
Home
Maps
Graphs
Charts
zone to the employment zone.
Accessibilities Origins
This is the accumulated weighted distance from each individual workplace zone to all residential zones.
Observed Job Accessibility
Predicted Job Accessibility
Job Accessibility Differences
Accessibilities Destinations
This is the accumulated weighted distance from each individual residential zone to all workplace zones.
Observed Housing Accessibility
Predicted Housing Accessibility
Housing Accessibility Differences


QUANT
Alpha version
quant.casa.ucl.ac.uk/map2.aspx?v=JobAccessibilityPred
About
casa
Predicted Job Accessibility
This is the predicted distribution of population around a job location.
Amsterdam
The Netherlands
Belgium
Luxembourg
Paris
Ireland
Dublin
Glasgow
Edinburgh
Belfast
Guernsey
Jersey
© Mapbox © OpenStreetMap Improve this map

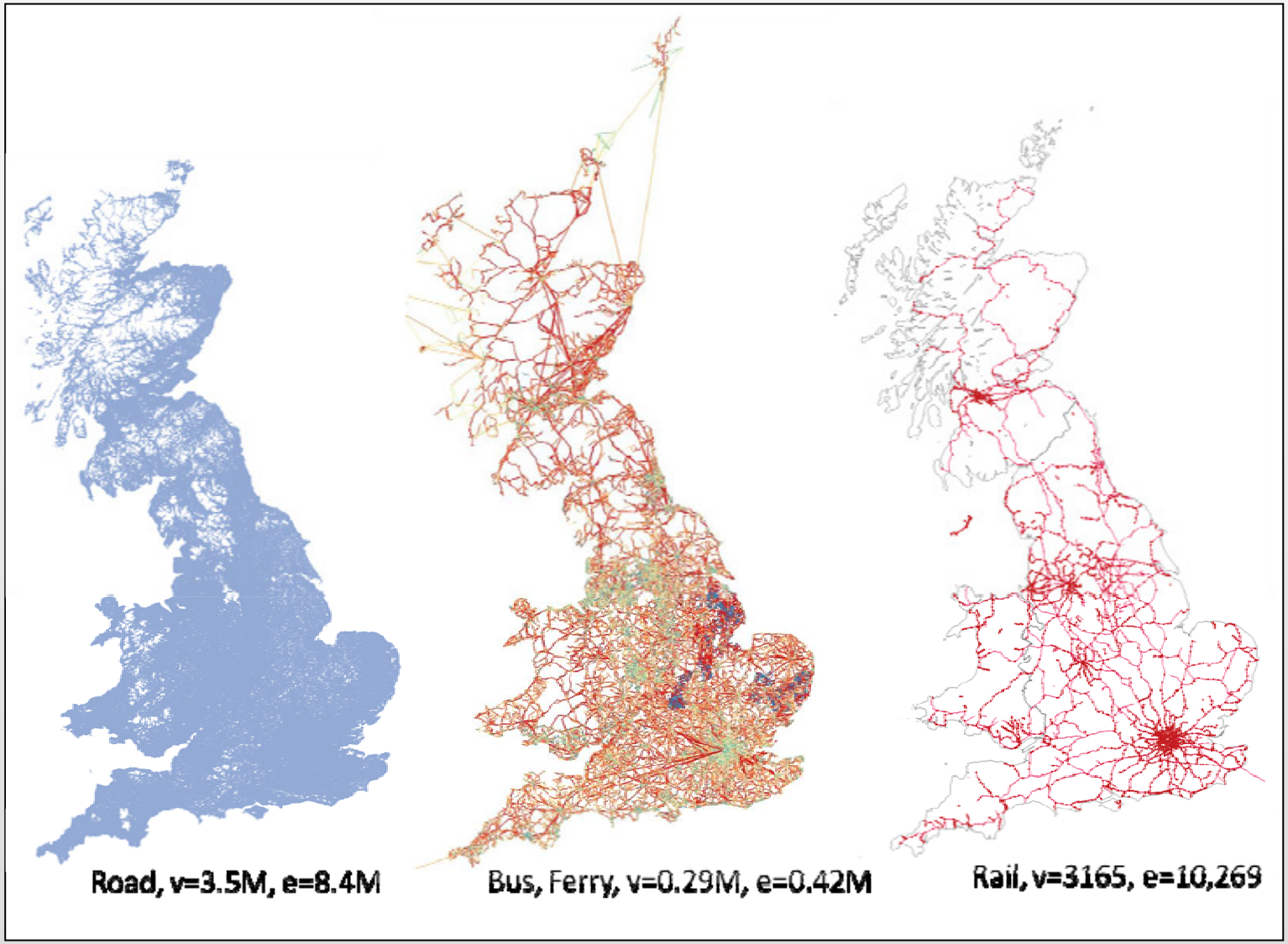

QUANT
Alpha version
Job Accessibility Differences
This is the difference between the predicted and observed distribution of population around a job location.
Amsterdam
The Netherlands
Belgium
Luxembourg
Paris
Ireland
Dublin
Belfast
Glasgow
Edinburgh
Brussels
© Mapbox © OpenStreetMap Improve this map

Problems with the Models

The problem we have with getting the model to reach an equilibrium with respect to the supply of transport through the capacity of the network is that such an equilibrium is continually disturbed by the fact that the networks are at much more detailed scale

We need to assign trips to the networks and due the fact that they compete for network space, we cannot change travel costs in a simple way. To an extent this is the problem faced in MATSIMs – the ABM/Microsimulation model developed out of TRANSIMs which we are running also for London. It take four days to converge as the trips keep on disturbing those that have been predicted.

Some versions of these models have simply developed a separate transport model alongside and accepted that the urban model produces generic interactions not trips. But this is a fudge. Let me show the complexity of the networks underlying the model


Road, v=3.5M, e=8.4M
Bus, Ferry, v=0.29M, e=0.42M
Rail, v=3165, e=10,269

If we work out the surplus trips that cannot be loaded onto the network which are

$$S_{ij} = (T_{ij} - C_{ij})$$

we can then allocate them differently, one at time as though they are agents.

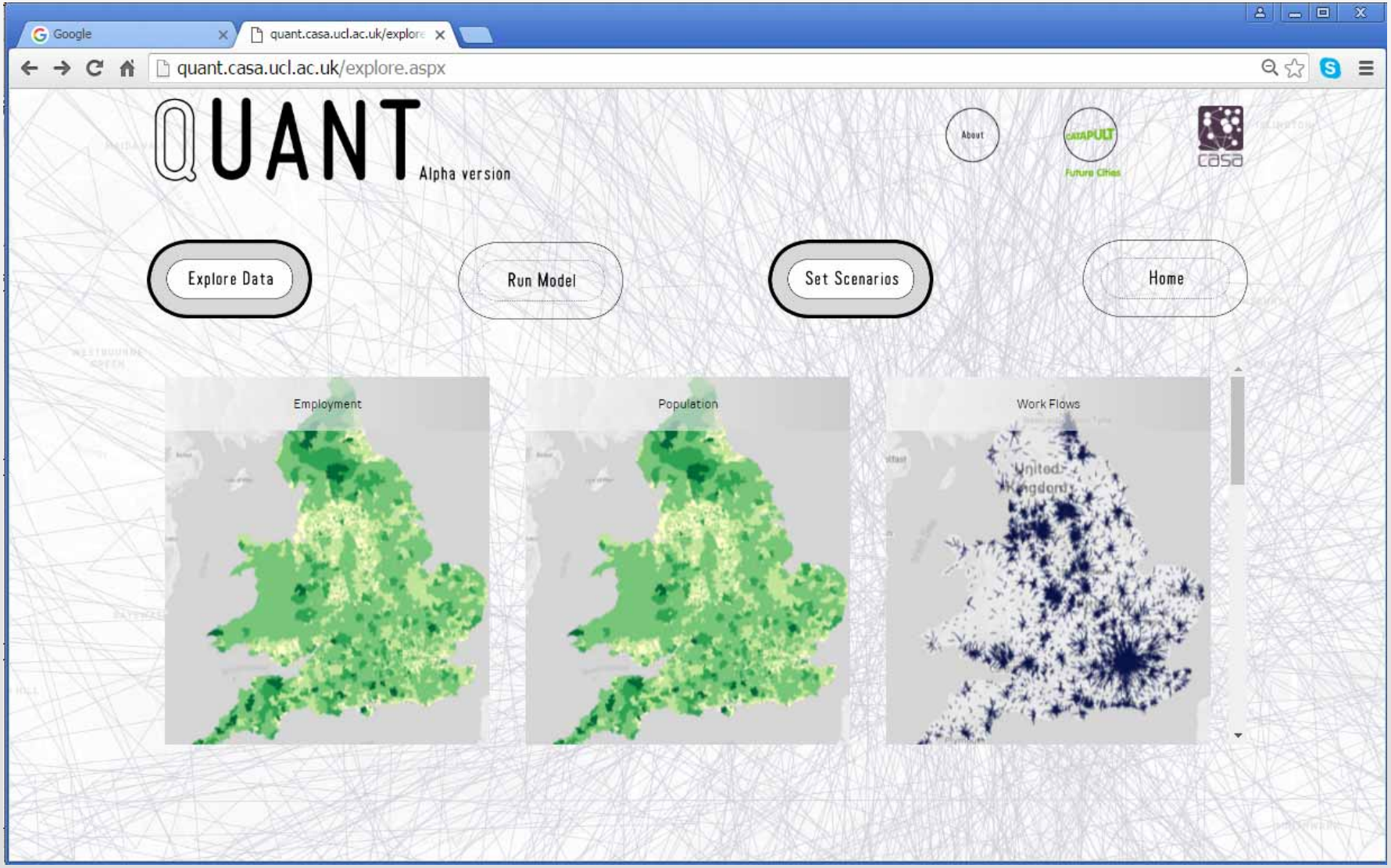
We are experimenting with doing this – and so in essence we are making use of the aggregate model to allocate demand to meet supply and the surplus demand is then allocated using an ABM – or rather it is allocated for disaggregates – to the individual level where the supply constraints are reached incrementally

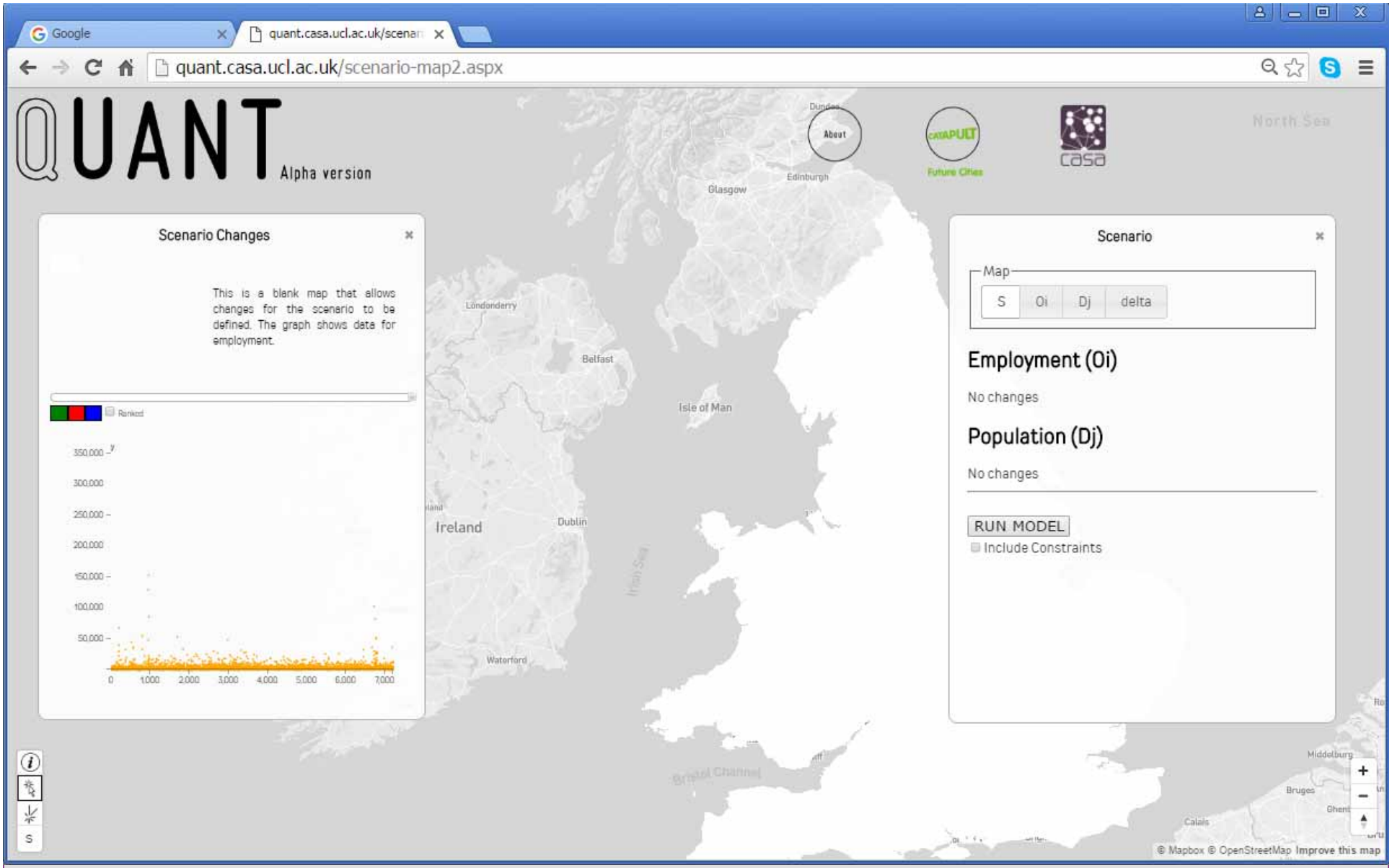
Yes it is a fudge, No it isn't an agent based model I hear you say.

But it is on the way and the logical outcome of proceeding in this direction is an ABM and probably like in our MATSIM model, would be based on a sample of employment – a 10% sample would be some 2.7 million employees

We think this is currently feasible. Ok let me show you some runs of the model and the I will wrap up

Setting Up and Testing Scenarios




Google
quant.casa.ucl.ac.uk/scenar
quant.casa.ucl.ac.uk/scenario-map2.aspx
QUANT
Alpha version
About
Future Cities
casa
Scenario Changes
This is a blank map that allows changes for the scenario to be defined. The graph shows data for employment.
Ranked
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
Scenario
Map
S
Oi
Dj
delta
Employment (Oi)
No changes
Population (Dj)
No changes
RUN MODEL
Include Constraints
Dundee
Edinburgh
Glasgow
North Sea
Londonderry
Belfast
Isle of Man
Ireland
Dublin
Irish Sea
Waterford
Bristol Channel
Middelburg
Bruges
Ghent
Calais
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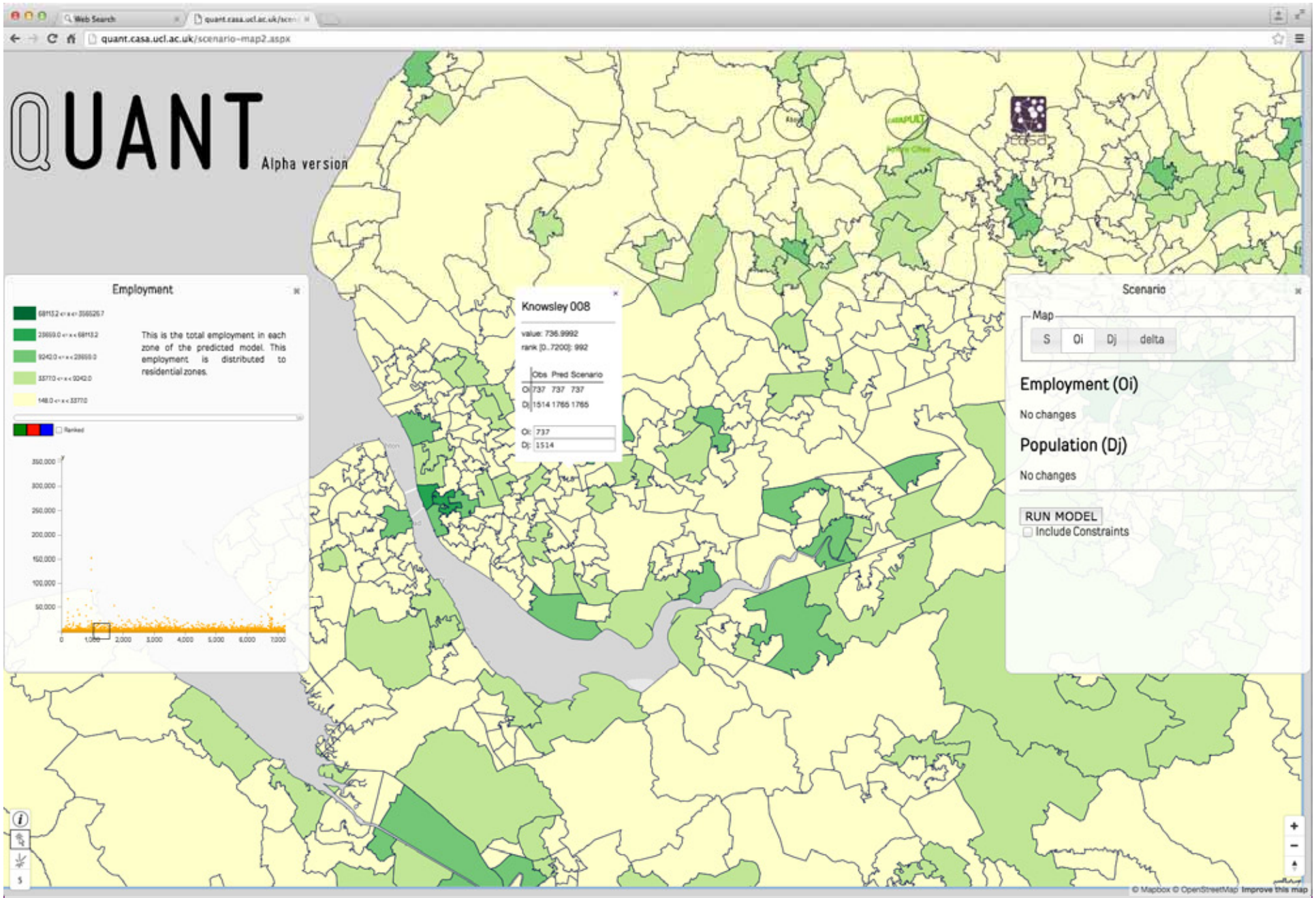
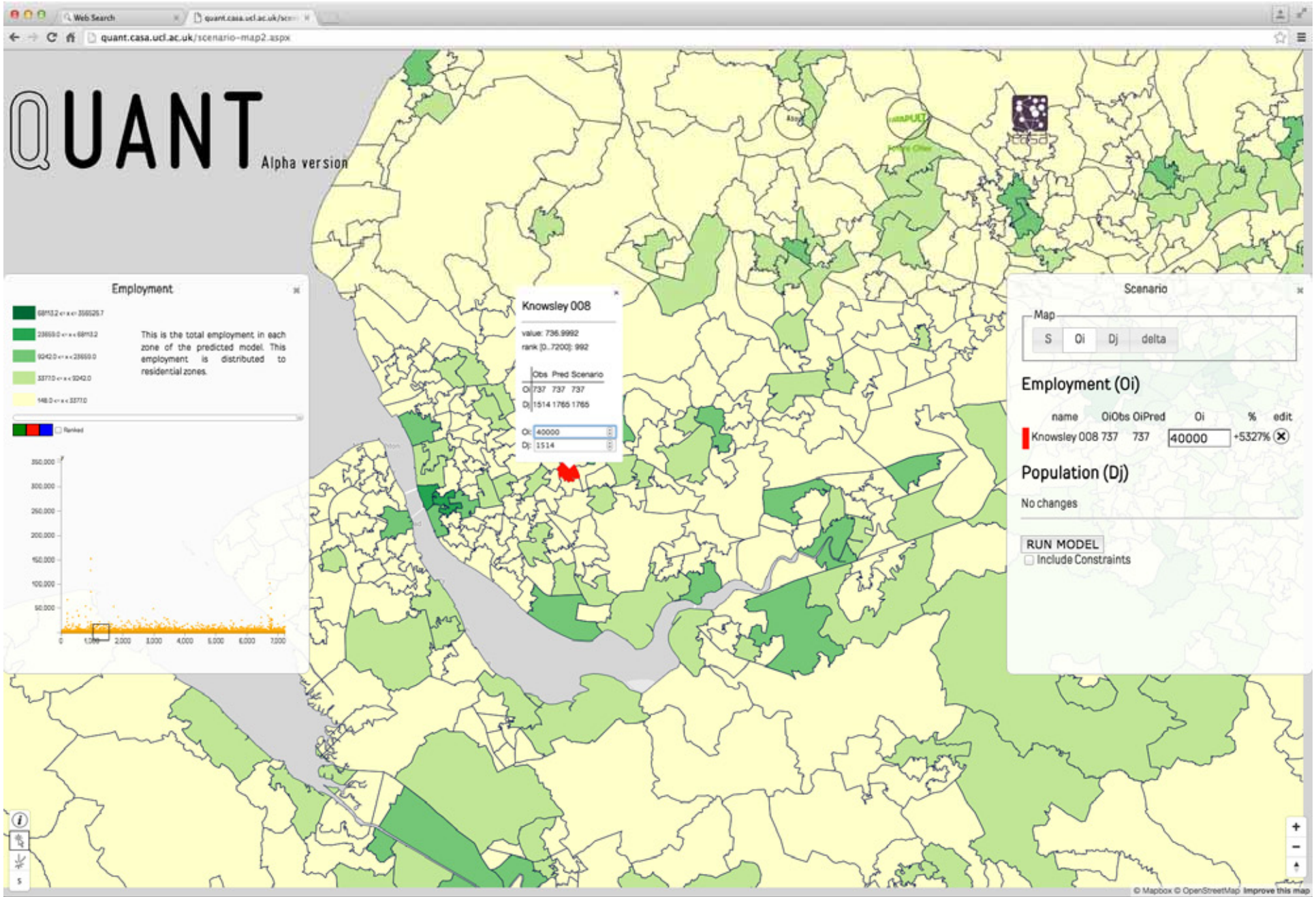

QUANT
Alpha version
quant.casa.ucl.ac.uk/scenario-map2.aspx
Employment
This is the total employment in each zone of the predicted model. This employment is distributed to residential zones.
Knowsley 008
value: 736.9992
rank [0..7200]: 992
Obs Pred Scenario
Oi 737 737 737
Dj 1514 1765 1765
Oi: 737
Dj: 1514
Scenario
Map
S
Oi
Dj
delta
Employment (Oi)
No changes
Population (Dj)
No changes
RUN MODEL
Include Constraints
© Mapbox © OpenStreetMap Improve this map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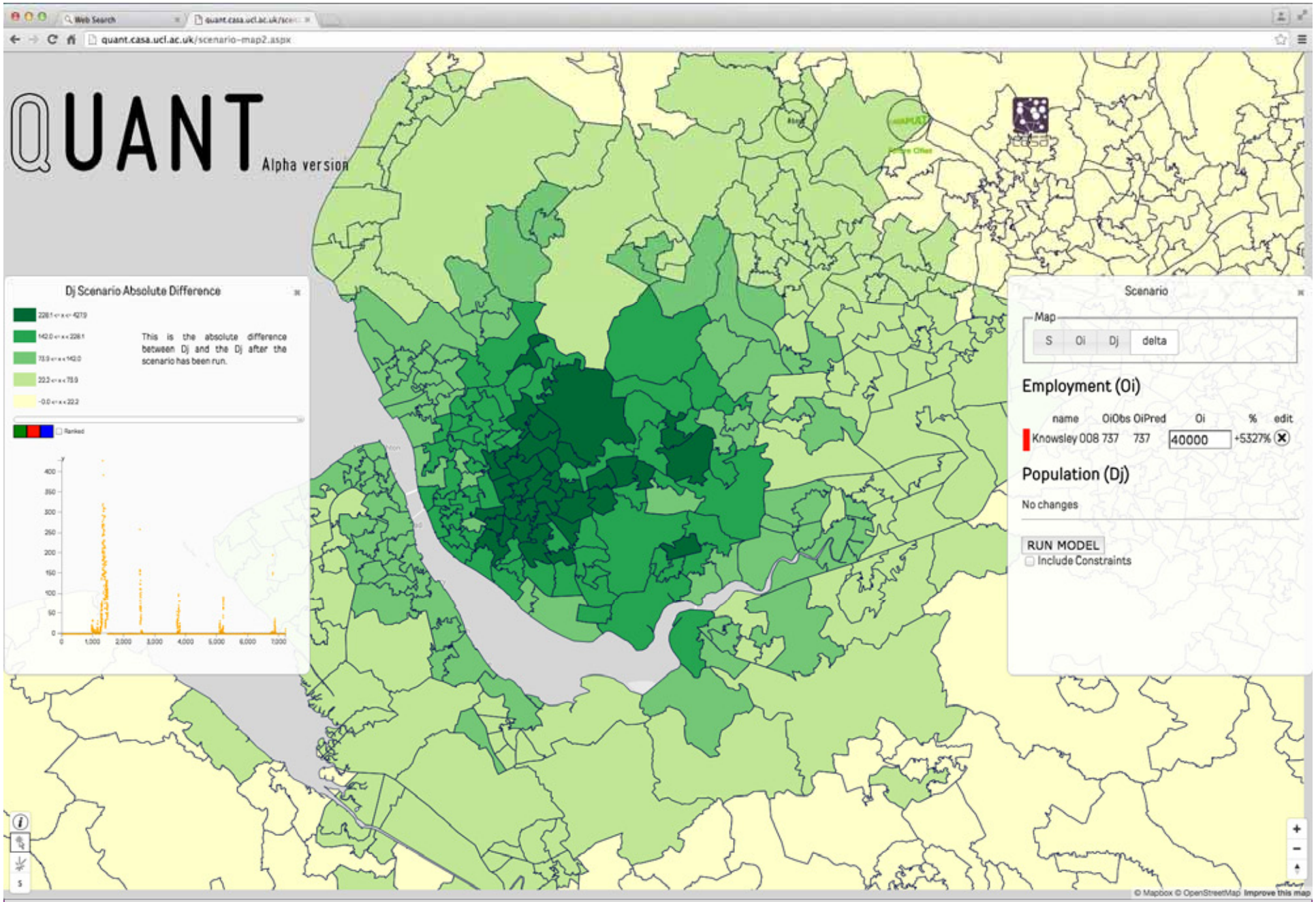
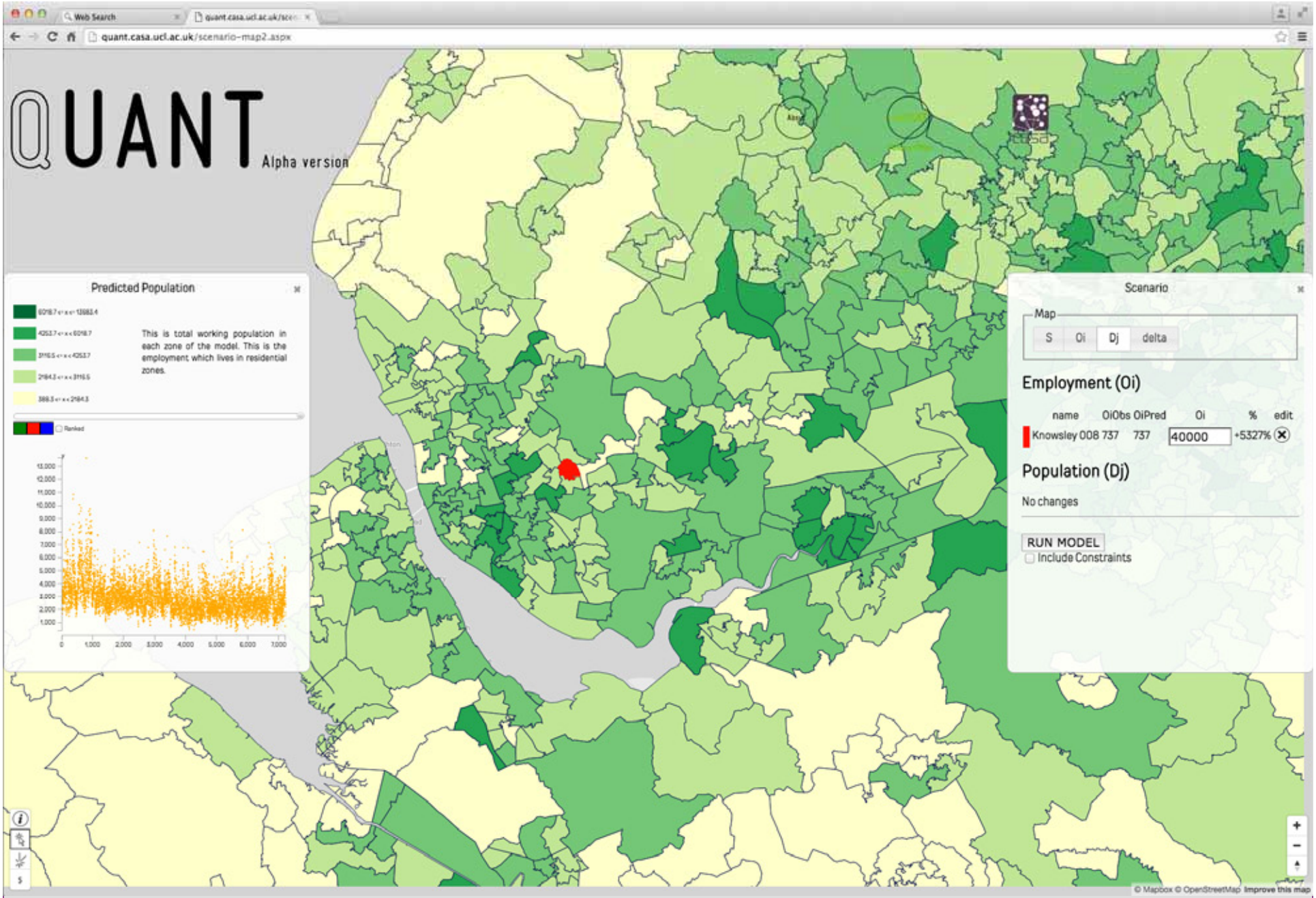
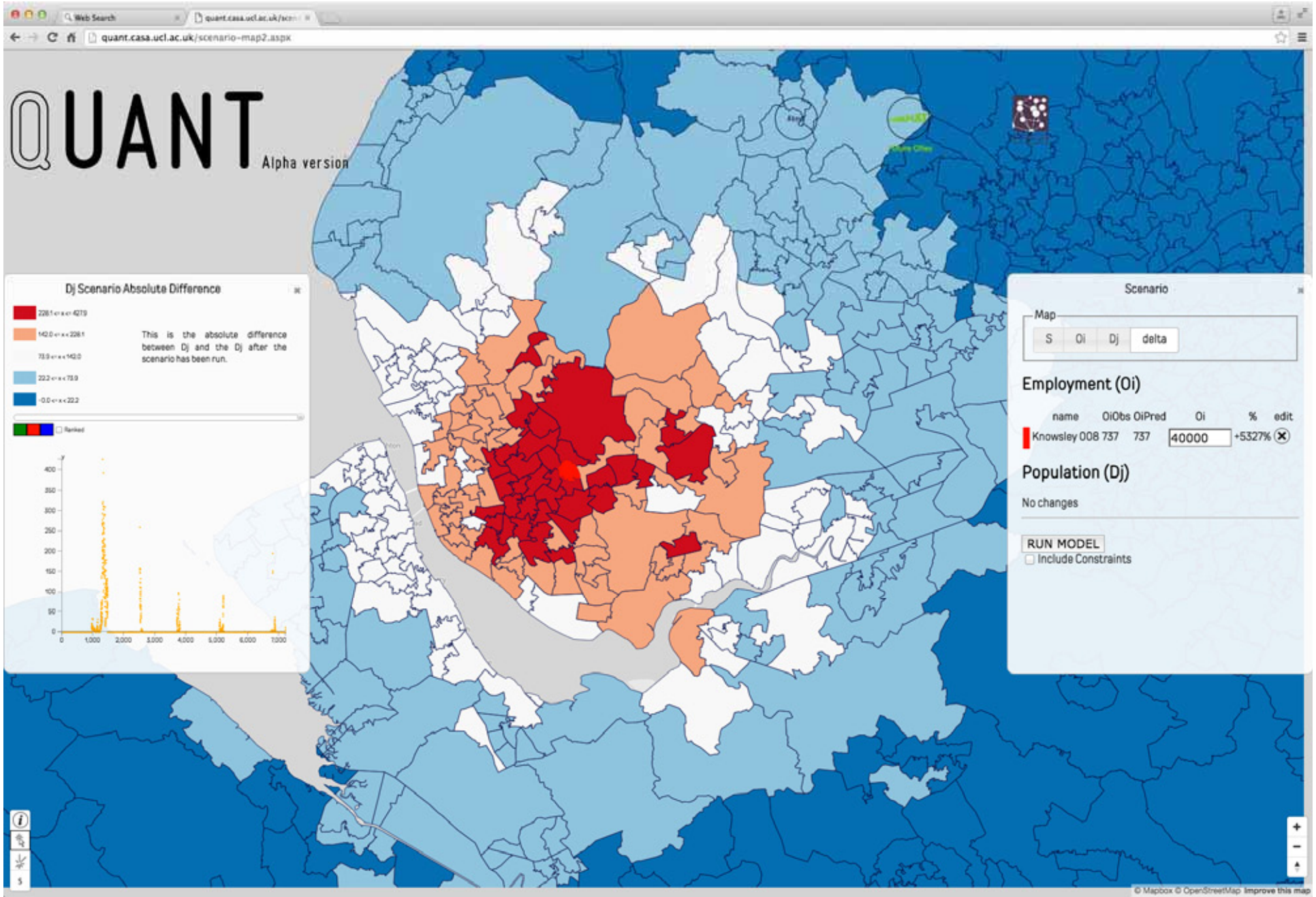
Alpha version
quant.casa.ucl.ac.uk/scenario-map2.aspx
Employment
This is the total employment in each zone of the predicted model. This employment is distributed to residential zones.
Knowsley 008
value: 736.9992
rank [0..7200]: 992
Obs Pred Scenario
Oi 737 737 737
Dj 1514 1765 1765
Oi: 40000
Dj: 1514
Scenario
Map
S
Oi
Dj
delta
Employment (Oi)
name OiObs OiPred Oi % edit
Knowsley 008 737 737 40000 +5327%
Population (Dj)
No changes
RUN MODEL
Include Constraints
© Mapbox © OpenStreetMap Improve this map


quant.casa.ucl.ac.uk/scenario-map2.aspx
QUANT
Alpha version
Dj Scenario Absolute Difference
This is the absolute difference between Dj and the Dj after the scenario has been run.
Scenario
Map
S
Oi
Dj
delta
Employment (Oi)
name
OiObs
OiPred
Oi
%
edit
Knowsley 008
737
737
40000
+5327%
Population (Dj)
No changes
RUN MODEL
Include Constraints
© Mapbox © OpenStreetMap Improve this map


quant.casa.ucl.ac.uk/scenario-map2.aspx
QUANT
Alpha version
Predicted Population
This is total working population in each zone of the model. This is the employment which lives in residential zones.
Scenario
Map
S
Oi
Dj
delta
Employment (Oi)
name
OiObs
OiPred
Oi
%
edit
Knowsley 008
737
737
40000
+5327%
Population (Dj)
No changes
RUN MODEL
Include Constraints
© Mapbox © OpenStreetMap Improve this map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Alpha version
quant.casa.ucl.ac.uk/scenario-map2.aspx
Dj Scenario Absolute Difference
This is the absolute difference between Dj and the Dj after the scenario has been run.
Scenario
Map
S
Oi
Dj
delta
Employment (Oi)
name
OiObs
OiPred
Oi
%
edit
Knowsley 008
737
737
40000
+5327%
Population (Dj)
No changes
RUN MODEL
Include Constraints
© Mapbox © OpenStreetMap Improve this map

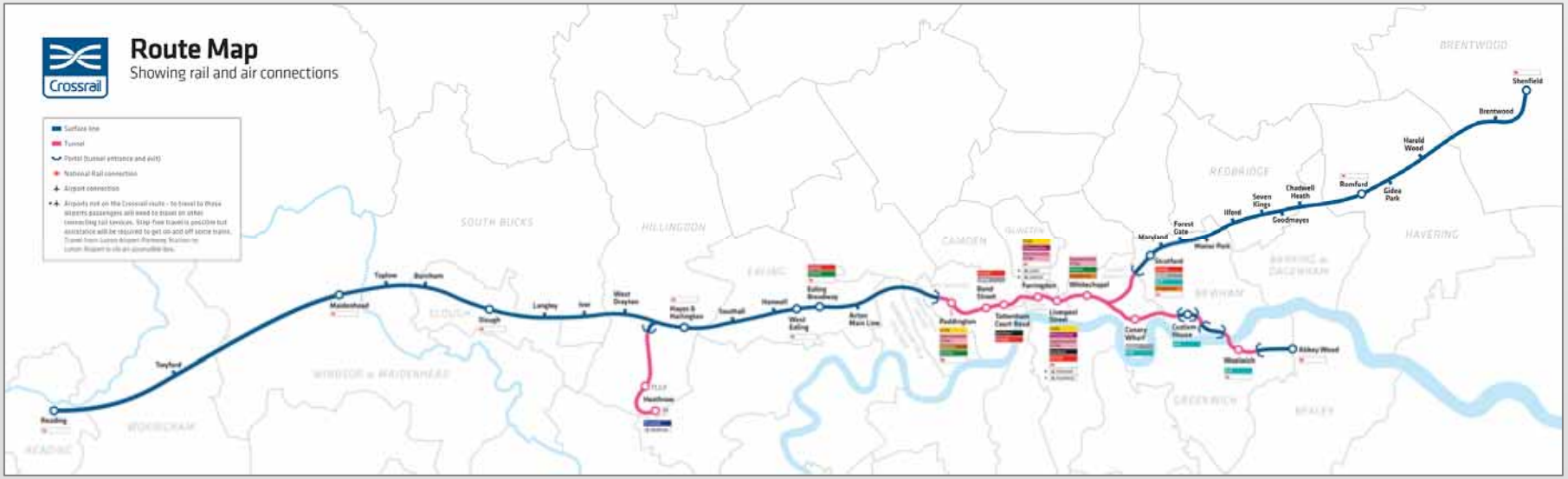
Big Infrastructure Projects: Crossrail, HS2, The Third London Airport:

Again I could spend a long time on these applications and all I can do here is show what is now possible – it is possible to test different alternatives over and over again. And any of us can do it – all you need a bit of training in the models – I suppose planning education should do this – but that is another story and not one for this evening

I will first show Crossrail and the HS2 because the impacts are much much wider than many of models can show. This reveals how important it is to make our model bigger spatial and to capture the widest economic benefits we can identify. And lastly I will deal with the Third Runway

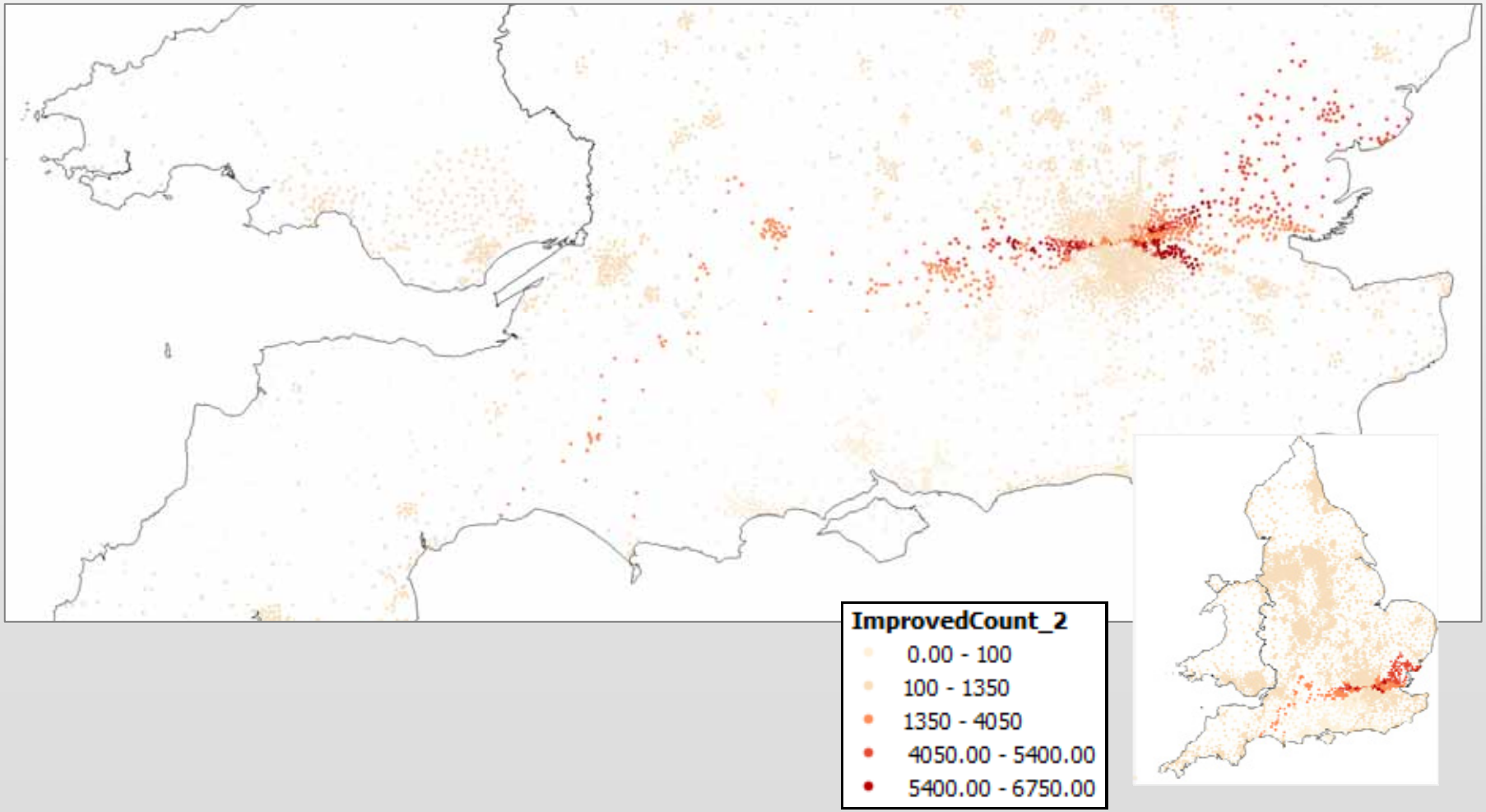
Crossrail

Reading, Heathrow, Shenfield, Abbey Wood



Crossrail

Number of Improved Journeys (n_i)

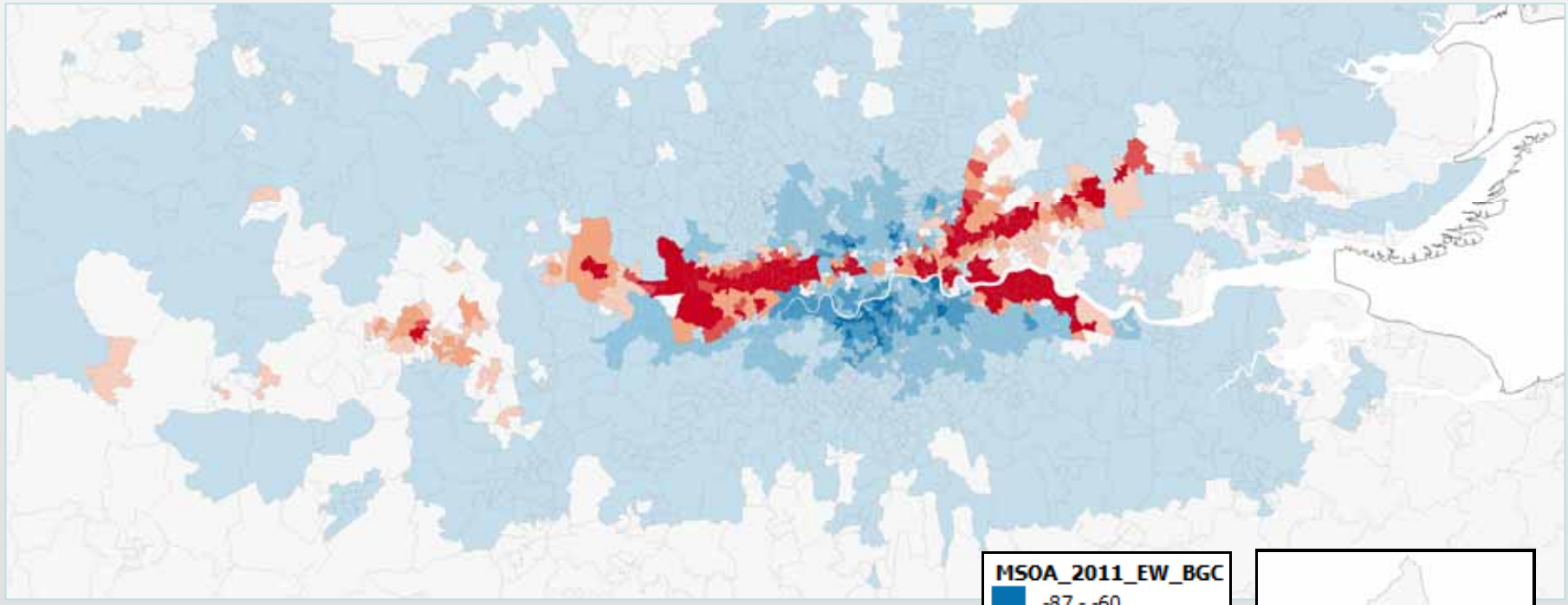


Crossrail

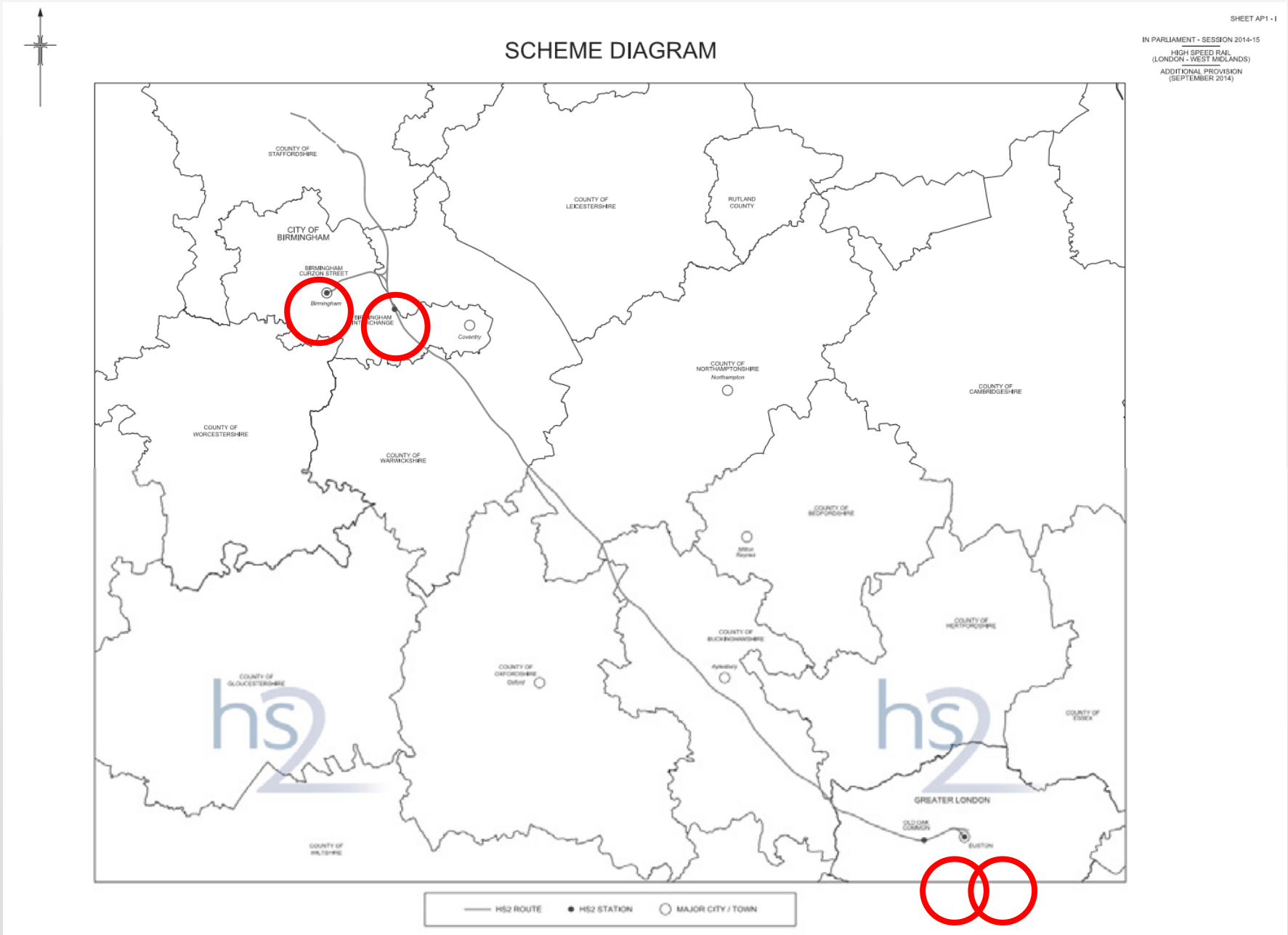
Population change (rail mode only)

Crossrail

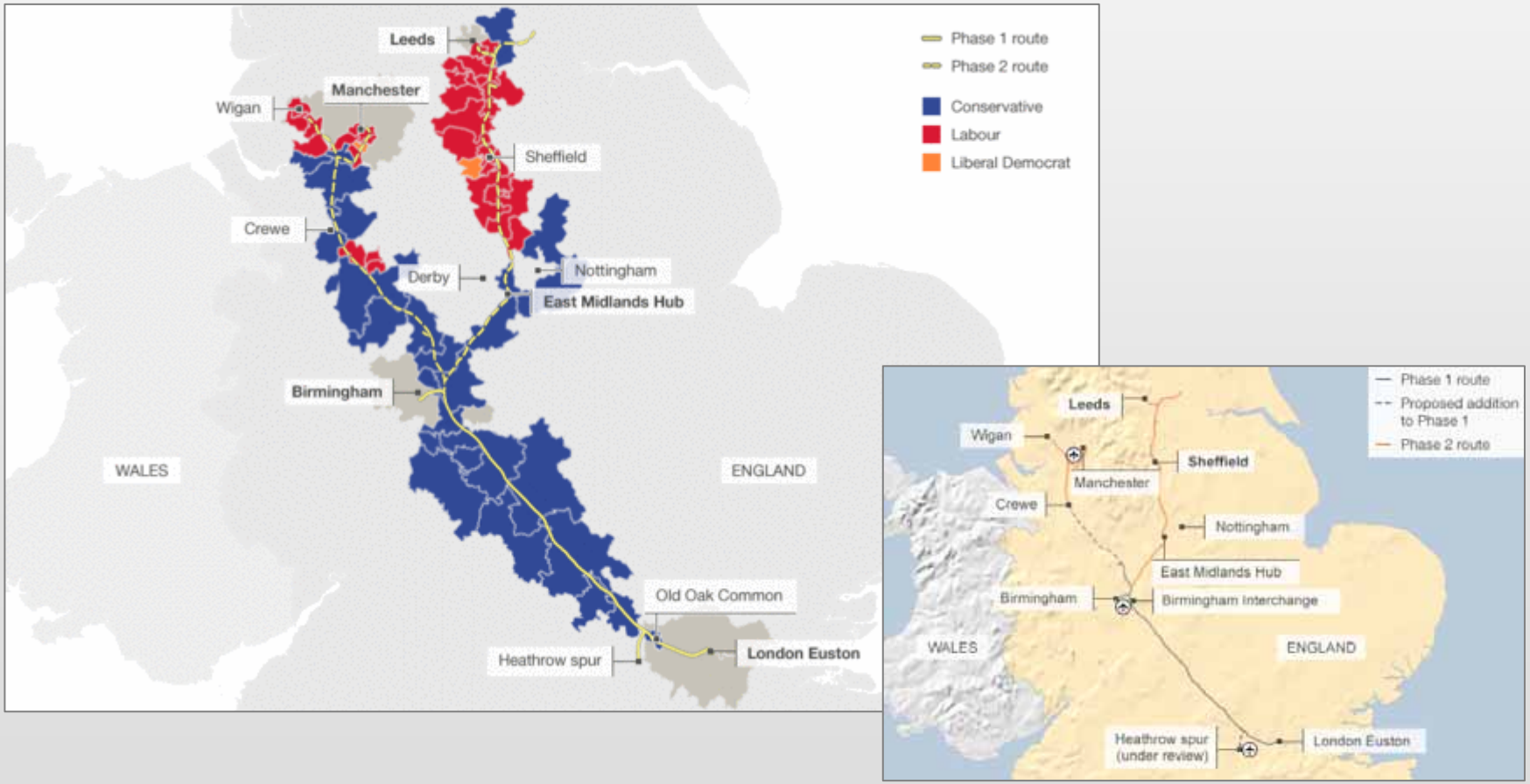
Population Change (all modes)



High Speed Rail

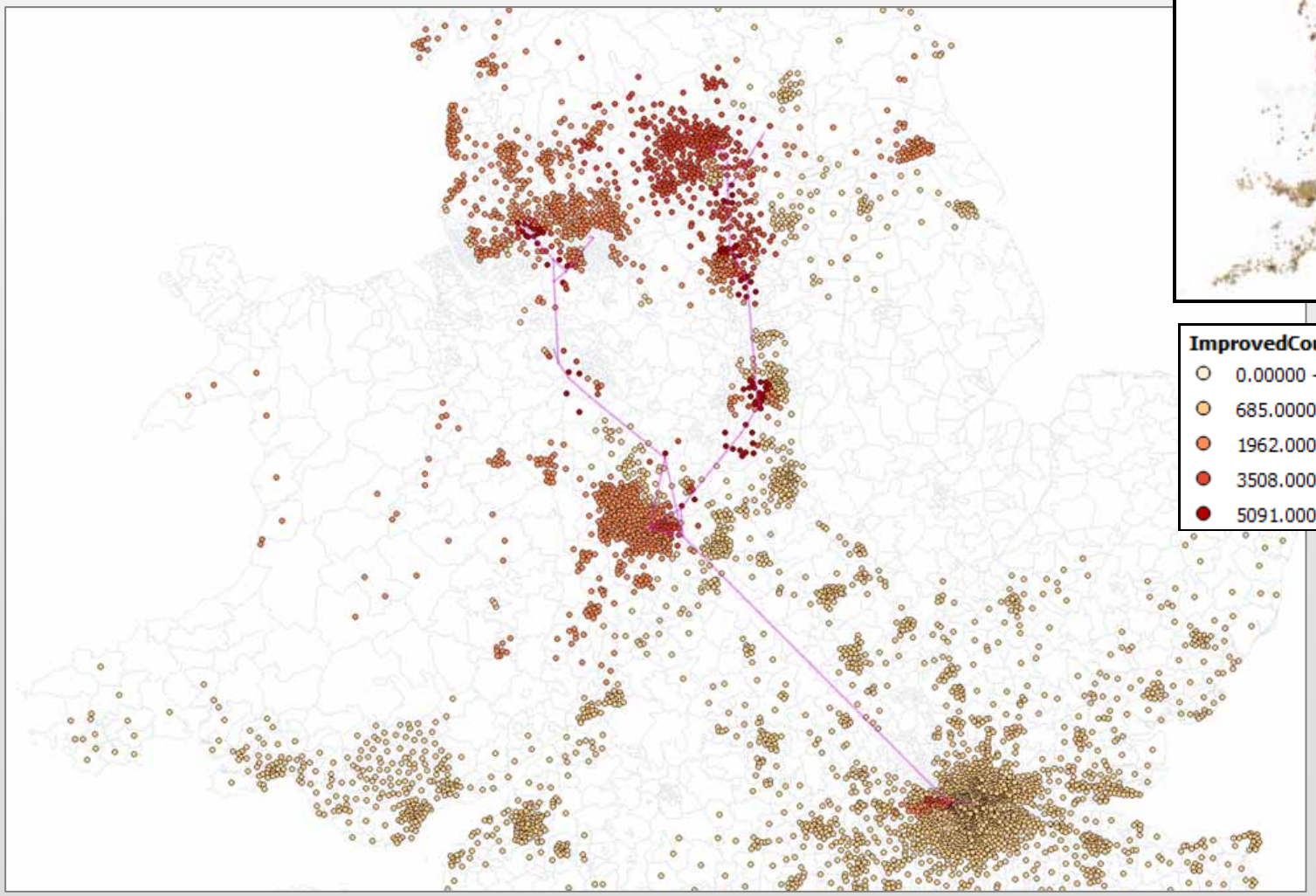

SCHEME DIAGRAM
SHEET AP1 - I
IN PARLIAMENT - SESSION 2014-15
HIGH SPEED RAIL
(LONDON - WEST MIDLANDS)
ADDITIONAL PROVISION
(SEPTEMBER 2014)
COUNTY OF STAFFORDSHIRE
CITY OF BIRMINGHAM
BIRMINGHAM CURZON STREET
Birmingham
BIRMINGHAM INTERCHANGE
Coventry
COUNTY OF LEICESTERSHIRE
RUTLAND COUNTY
COUNTY OF NORTHAMPTONSHIRE
Northampton
COUNTY OF CAMBRIDGESHIRE
COUNTY OF WORCESTERSHIRE
COUNTY OF WARWICKSHIRE
COUNTY OF BEDFORDSHIRE
Milton Keynes
COUNTY OF BUCKINGHAMSHIRE
Aylesbury
COUNTY OF HERTFORDSHIRE
COUNTY OF GLOUCESTERSHIRE
COUNTY OF OXFORDSHIRE
Oxford
COUNTY OF ESSEX
GREATER LONDON
OLD OAK COMMON
EUSTON
COUNTY OF WILTSHIRE
HS2 ROUTE
HS2 STATION
MAJOR CITY / TOWN

HS2 Route Maps



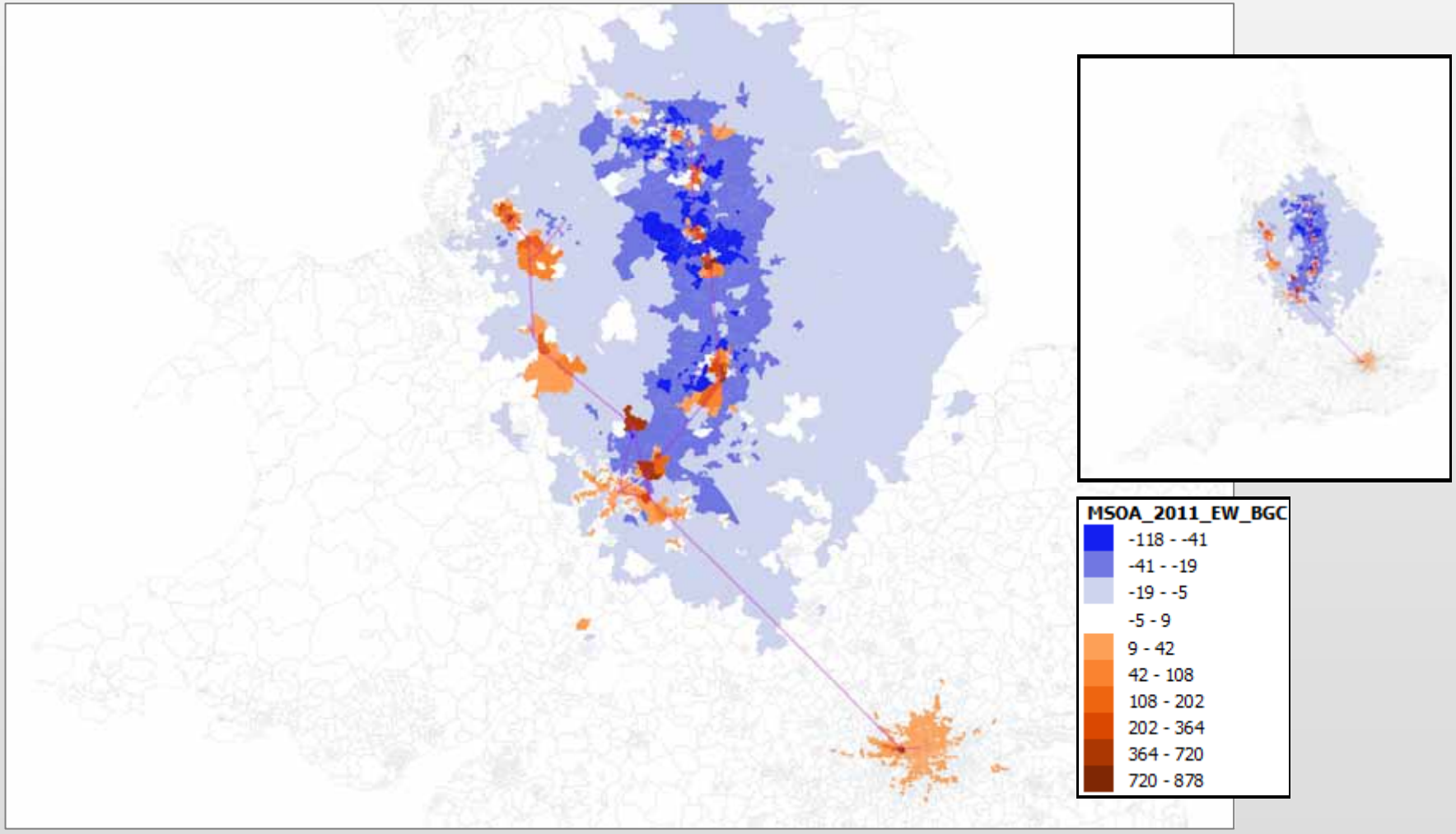
High Speed 2

Number of improved trips (n_i>685)



High Speed 2

Population change (all modes)



CHAPTER 11

A Major Project: Third London Airport

(June 1968–December 1970)

The deliberations of the Roskill Commission on the Third London Airport were distinguished by the very clear and logical process by which recommendations were arrived at. The Commission adopted five cycles, from the definition of a "universe" of possibilities to a short-list of four sites, and then directly to a recommended alternative. One particularly important feature was that the evaluation criteria were determined at the outset of the process and were then used consistently throughout.

11.1. BACKGROUND

The eventual recommendation by the Roskill Commission of Cublington as the site for the Third London Airport in preference to Foulness led to considerable controversy. This controversy, coupled with the fact that the Government eventually decided in favour of Foulness against the Commission's recommendation, has obscured many interesting and original features of the process by which the Commission reached its recommendation. In this chapter we discuss some of the main features of this process. It does not cover the ground of the many critiques of the Commission's work which have mainly concentrated on the treatment of measured items in the Commission's Research Team's evaluation; intangibles in the decision; important issues affected by the decision but outside the Study terms of reference, and on the validity of the Commission's conclusion. In this chapter any reference to these topics is restricted to those cases illustrating a feature of the site selection process itself.

One might say that the setting up of the Commission was a result of public outcry over an inadequate process of site selection. The arguments against the decision to locate the airport at Stansted were largely motivated, and strongly supported, by the fact that the Stansted decision was not shown to be in the general public interest. There was no formal evidence to suggest that the alternative possible sites to Stansted which were considered had been rigorously investigated, with all factors for and against them, in comparison with Stansted, taken into account in the decision. Much of the work behind the selection of Stansted was undertaken in

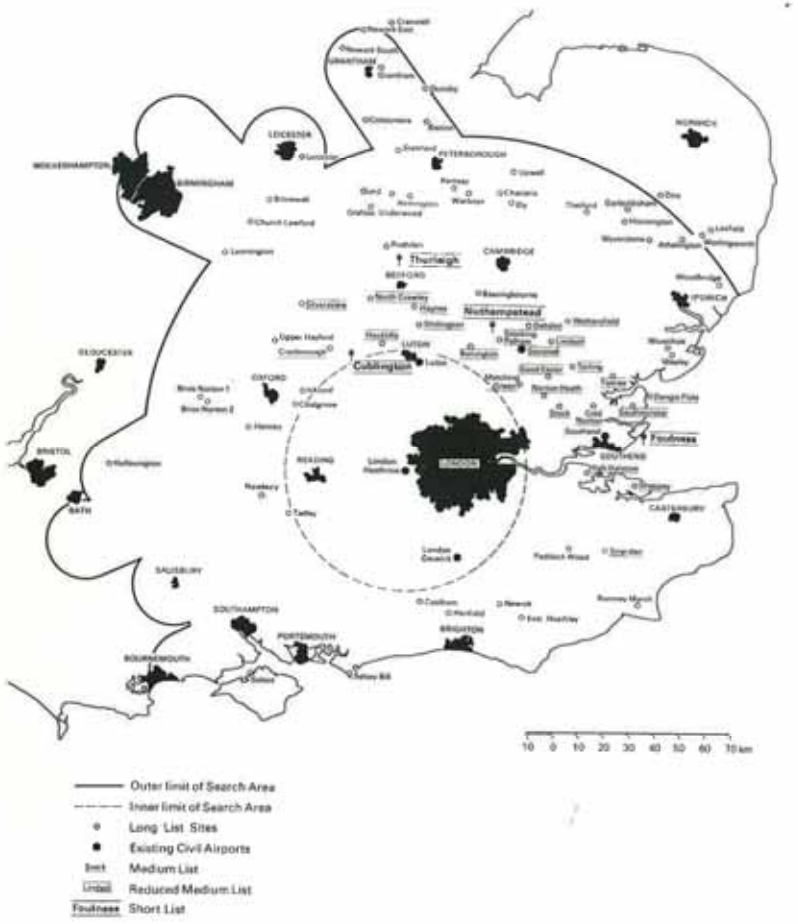


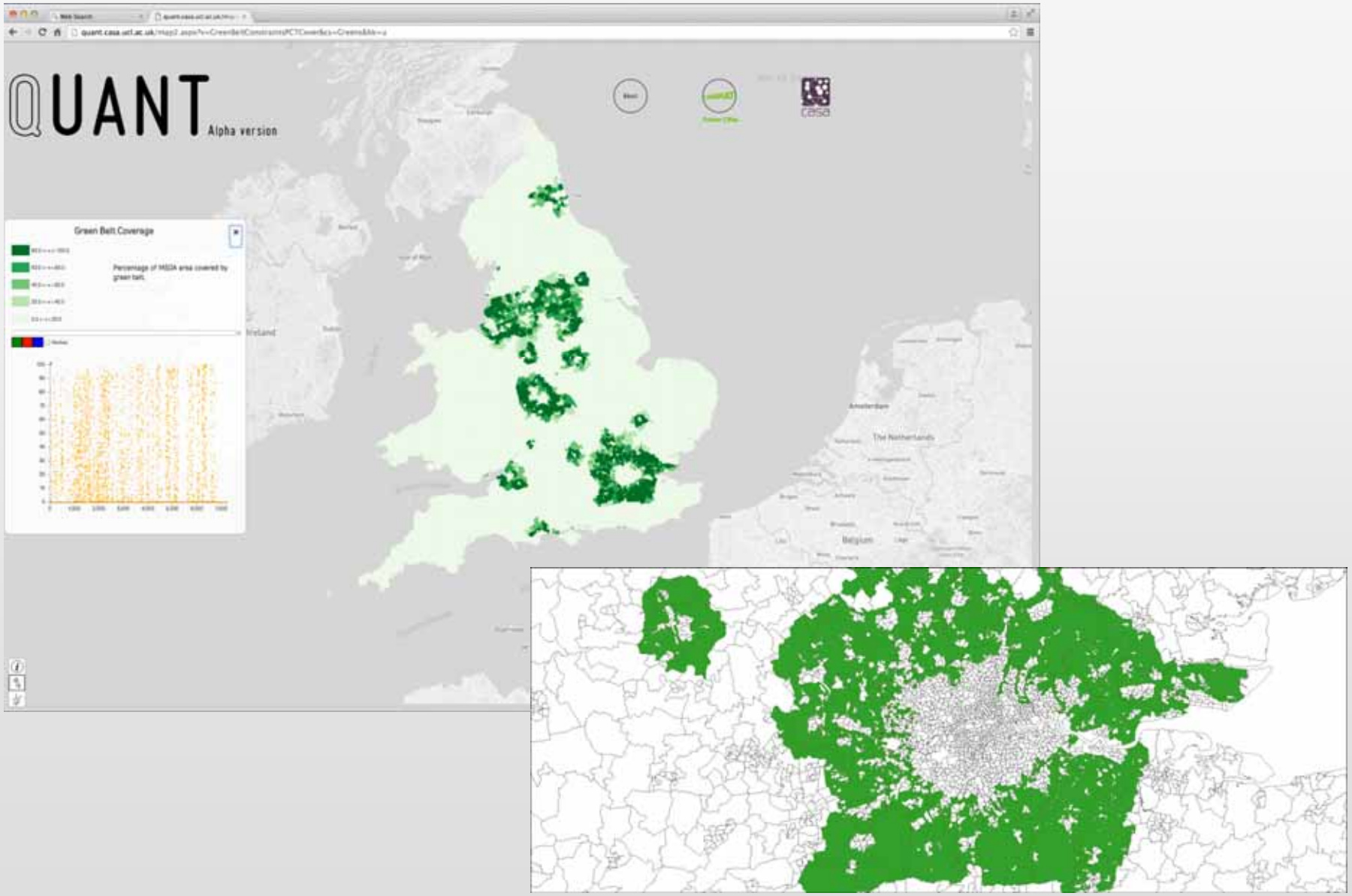
FIG. 11.1. Location of sites. (Source: Commission on the Third London Airport, *Report*, appendix 5, fig. 2, p. 184.)

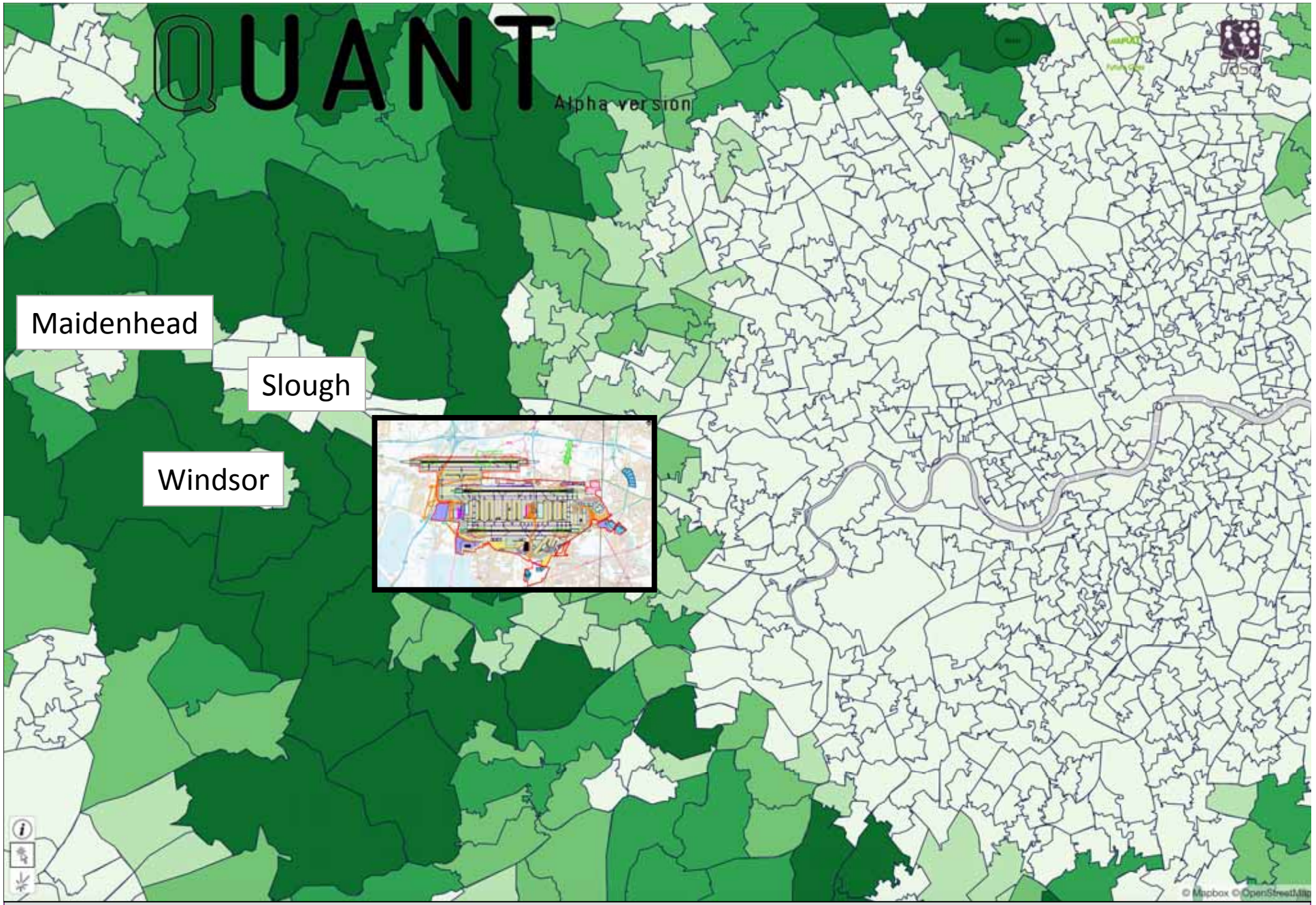
The Objectives Used by the Davies Commission in Assessing the Various Options for the Expansion of Heathrow and/or Gatwick

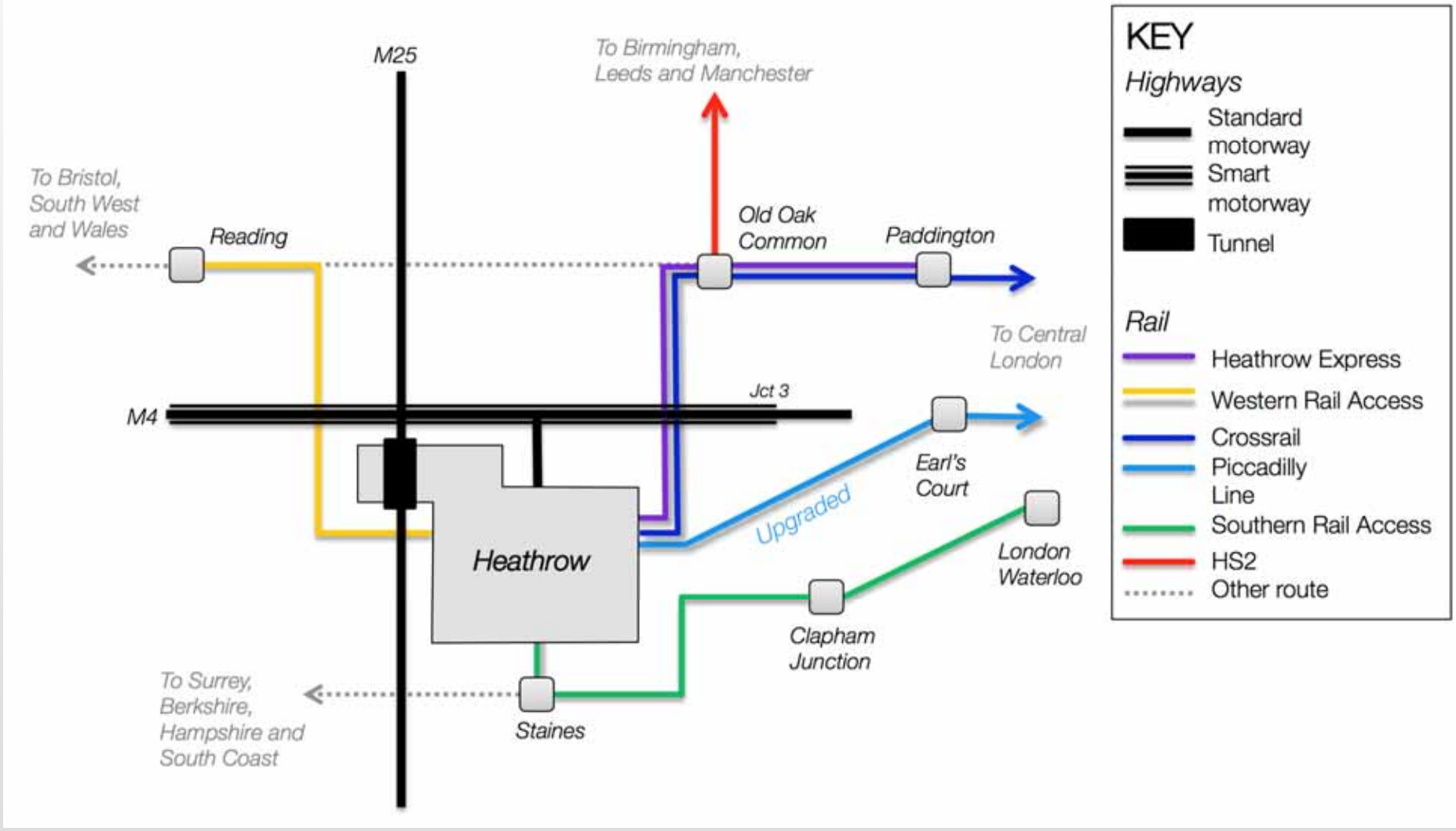
Sift criteria categories	Appraisal objective
Cost	To make efficient use of public funds, where they are required, and ensure that the benefits of schemes clearly outweigh the costs, taking account of social, environmental and economic costs and benefits.
Delivery	To be affordable and financeable, including any public expenditure that may be required and taking account of the needs of airport users.
	To have the equivalent overall capacity of one new runway operational by 2030.
	To actively engage local groups in scheme progression, design and management.
Operational Viability	To enhance individual airport and airports system resilience.

Table 4.1: The Commission's *Appraisal Framework* objectives

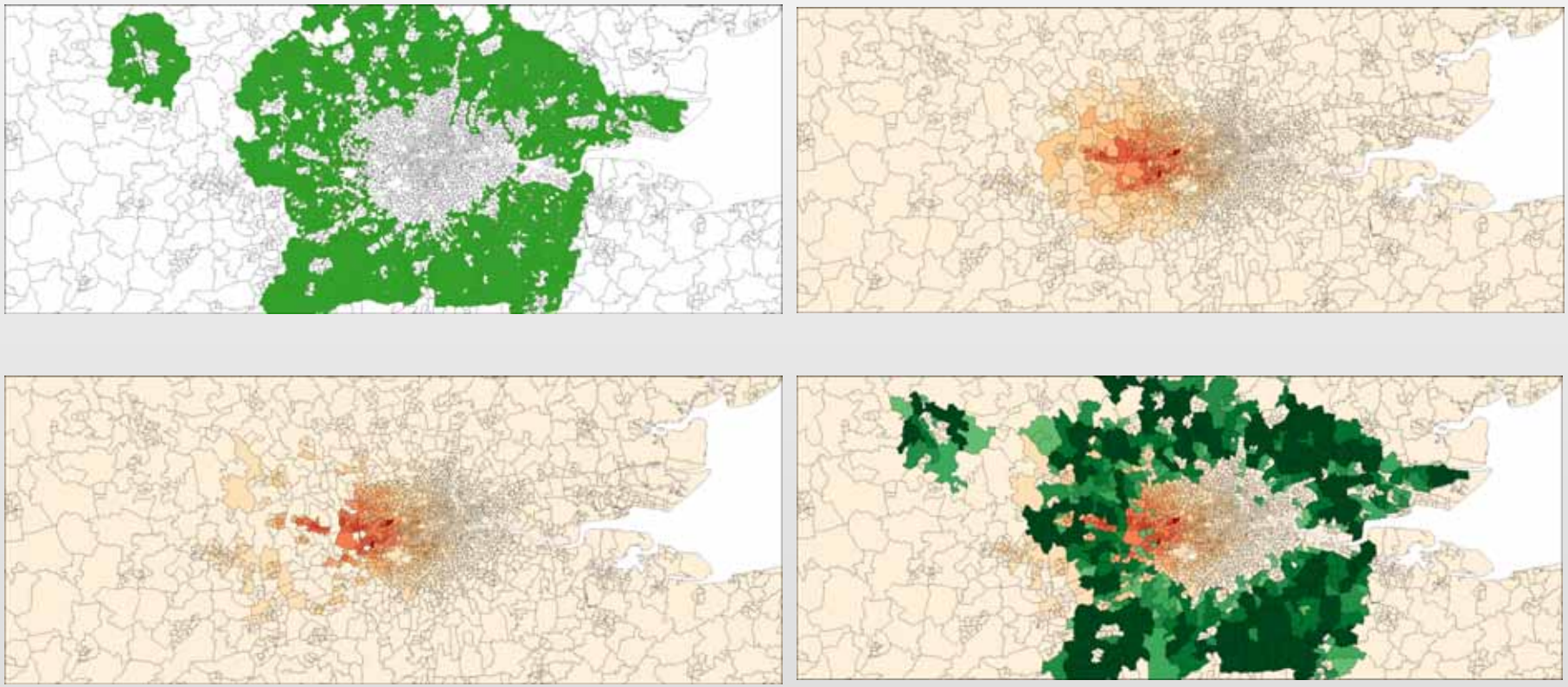
Sift criteria categories	Appraisal objective
Strategic Fit	To provide additional capacity that facilitates connectivity in line with the assessment of need.
	To improve the experience of passengers and other users of aviation.
	To maximise the benefits of competition to aviation users and the broader economy.
	To maximise benefits in line with relevant long-term strategies for economic and spatial development.
Economy	To maximise economic benefits and support the competitiveness of the UK economy.
	To promote employment and economic growth in the local area and surrounding region.
	To produce positive outcomes for local communities and the local economy from any surface access that may be required to support the proposal.
Surface Access	To maximise the number of passengers and workforce accessing the airport via sustainable modes of transport.
	To accommodate the needs of other users of transport networks, such as commuters, intercity travellers and freight.
	To enable access to the airport from a wide catchment area.
Environment	To minimise and where possible reduce noise impacts.
	To improve air quality consistent with EU standards and local planning policy requirements.
	To protect and maintain natural habitats and biodiversity.
	To minimise carbon emissions in airport construction and operation.
	To protect the quality of surface and ground waters, use water resources efficiently and minimise flood risk.
	To minimise impacts on existing landscape character and heritage assets.
	To identify and mitigate any other significant environmental impacts.
People	To maintain and where possible improve the quality of life for local residents and the wider population.
	To manage and reduce the effects of housing loss on local communities.
	To reduce or avoid disproportionate impacts on any social group.


QUANT
Alpha version
Green Belt Coverage
Percentage of MSOA area covered by green belt.
Ireland
Amsterdam
The Netherlands
Belgium


QUANT
Alpha version
Maidenhead
Slough
Windsor


M25
To Birmingham, Leeds and Manchester
To Bristol, South West and Wales
Reading
Old Oak Common
Paddington
To Central London
M4
Jct 3
Earl's Court
Upgraded
Heathrow
London Waterloo
Clapham Junction
To Surrey, Berkshire, Hampshire and South Coast
Staines
KEY
Highways
Standard motorway
Smart motorway
Tunnel
Rail
Heathrow Express
Western Rail Access
Crossrail
Piccadilly Line
Southern Rail Access
HS2
Other route

We have Tested the Impact of the Fourth Runway on E&W in terms of Where the Population from an Extra 5000 Jobs will Locate



Future Urban Models and Use in Planning

- We need a new way of thinking about science in public policy
- It needs to inform, it must be based on conditional prediction – what if scenarios
- It needs to accept the inherent unpredictability of complex systems and this suggest continual action – this is little different from what has always been preached in urban planning – continual review, but the cycles need to be faster
- We must be aware that the systems we are dealing with moving targets of increasing complexity

GEOGRAPHY & RESOURCE MANAGEMENT 地理與資源管理學系

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Lectures on Urban Modelling January 2017

That's It Thanks

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Monday, 23 January 2017

http://www.spatialcomplexity.info/