Urban Simulation 3

Spatial Interaction 2: The Family of Spatial Interaction Models Again, General Urban Models

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Monday, 23 January 2023

CASA0002: Urban Simulation 22/23

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Module Outline

Course term2	Urban Simulation: CASA0002
Lectures	Mondays 9am-11am
Practical sessions	Fridays 9-11am
Location:	Birkbeck Malet Street B35

	dates	lecturer	Theme
lecture 1	09-Jan	Michael Batty	Introduction: About Spatial models, Gravity Models, The Model-Building Process
lecture 2	16-Jan	Michael Batty	Spatial Interaction 1: Basic Concepts
lecture 3	23-Jan	Michael Batty	Spatial Interaction 2: The Family of SI Models Again, General Urban Models
lecture 4	30-Jan	Michael Batty	Urban and Regional Models: Large Scale Comprehensive LUTI Models
lecture 5	06-Feb	Michael Batty	Cellular Automata and Agent-Based Models
reading week	13-Feb		
lecture 6	20-Feb	Elsa Arcaute	Networks introduction, notation and centrality measures
lecture 7	27-Feb	Elsa Arcaute	Networks: clustering and modularity
lecture 8	06-Mar	Elsa Arcaute	Networks: community detection
lecture 9	13-Mar	Elsa Arcaute	Networks: degree distribution, random graphs and small world
lecture 10	20-Mar	Elsa Arcaute	Networks: spatial networks, power laws and percolation

Tutors: Valentina Marin, Andrew Renninger and Fulvio Lopane

I ran out of time last week.

Now I need to present the idea of ***constraints again*** in the gravity model, then the ***family of spatial interaction models***, again, followed by a demonstration of the singly constrained ***retail model***, then the idea of building a more ***general model***. Then some ***applications***

All this if we have time of course

Outline of Today's Lecture

- The Constraints on Spatial Interaction
- The Family of Spatial Interaction Models
- An Example of the Singly Constrained Model
- Urban Models: Coupled Spatial Interaction
- Generalising the Model Adding Employment
- Building Spatial Interaction into the Economic Base
- Extending the Retail Model to Deal with Agglomeration and Scale
- Three Applications and a Fourth Next Time

Ensuring the Model Meets Basic Constraints

Now in the basic model we have two 'scaling' parameters K and β. We will distinguish between these calling K the (true) scaling parameter or constant of proportionality. This parameter can be worked out by noting it adjusts the trips to make sure that they 'add up' to the total number of trips T

$$T = \sum_{i=1}^{n} \sum_{j=1}^{m} T_{ij} = \sum_{i} \sum_{j} T_{ij}$$

Now note how we can miss off the *n* and *m* and the range of the summation is obvious by context

Now the key thing in this sort of model is that we substitute the model into the constraint equation shown above. So let us do this and simplify the substitutions and thence derive the value of the parameter K . So here we go. You can also see the working in last weeks handout for the computer program we are about to develop and demonstrate. Then substitute the model

$$T_{ij} = K O_i D_j \exp(-\beta c_{ij}) \text{ into}$$

$$T = \sum_{i=1}^{n} \sum_{j=1}^{m} T_{ij}$$

And we then get the following working

$$T = \sum_{i=1}^{n} \sum_{j=1}^{m} T_{ij} = K \sum \sum O_i D_j \exp(-\beta c_{ij})$$

and we get $K = \frac{T}{\sum \sum O_i D_j \exp(-\beta c_{ij})}$

The model can be written out in full a

$$T_{ij} = T \frac{O_i D_j \exp(-\beta c_{ij})}{\sum \sum O_i D_j \exp(-\beta c_{ij})}$$

and we can think of this as defining probabilities of trips between $i \ and \ j$

$$T_{ij} = T p_{ij}; \text{where } \ p_{ij} = \frac{O_i D_j \exp(-\beta c_{ij})}{\sum \sum O_i D_j \exp(-\beta c_{ij})}; \ \sum_{i=1}^{n} \sum_{j=1}^{m} p_{ij} = 1$$

- I have checked the program from last week and I think it works – does it?
- You have the program that is on Moodle and it is in **ipynb** so that you can simply drag and drop it into the relevant folder that your Jupyter notebook points to **BasicGravityModel.ipynb**
- We are going to develop a more comprehensive suite of all four models in the family – so before we demo this we will re-introduce the family as it is so important to being able to develop a model of the right kind
- The think about spatial interaction models is that you can adapt them to different situations

The Family of Spatial Interaction Models

We have seen how we can constrain the model to produce specific types that meet various constraints on the amount of trips attracted to different locations. Our first and most basic model is unconstrained in that we ensure that the only constraints the model meets re on the total trips which are predetermined, already known, that is $T = \sum_{i=1}^{n} \sum_{j=1}^{m} T_{ij}$.

Now if we know the trips attracted to the origin, or to the destination, or to both, then these gives rise to different models. Including the basic model there are four in all that meet the following. This is the family.

1. The Unconstrained Model

$T_{ij} = KO_iD_j \exp(-\beta c_{ij})$ subject to $\sum_{i=1}^{n}\sum_{j=1}^{m} T_{ij} = T$

2. The Singly-Constrained Models

2a: The Origin- Constrained Model

$T_{ij} = A_iO_iD_j \exp(-\beta c_{ij})$ subject to $\sum_{j=1}^{m} T_{ij} = O_i$

2b: The Destination-Constrained Model

$T_{ij} = O_iB_jD_j \exp(-\beta c_{ij})$ subject to $\sum_{i=1}^{n} T_{ij} = D_j$

3. The Doubly Constrained Model

$T_{ij} = A_iO_iB_jD_j \exp(-\beta c_{ij})\ st\ \sum_{j=1}^{m} T_{ij} = O_i\ \&\ \sum_{i=1}^{n} T_{ij} = D_j$

We can work out the full models by substituting the model on the left into the constraint on the right

Now these models not only distribute trips but if we add their flows over origins or destinations or both, the different models give us predictions of what happens at origins and destinations. These are then **location models** and their predictions are in red

The Models

$T'_{ij} = KO_iD_j \exp(-\beta c_{ij})$;

$T'_{ij} = A_iO_iD_j \exp(-\beta c_{ij})$;

$T'_{ij} = O_iB_jD_j \exp(-\beta c_{ij})$;

$T'_{ij} = A_iO_iB_jD_j \exp(-\beta c_{ij})$;

The Predictions

$\sum_{j=1}^{m} T'_{ij} = O'_i$; $\sum_{i=1}^{n} T'_{ij} = D'_j$

$\sum_{j=1}^{m} T'_{ij} = O_i$; $\sum_{i=1}^{n} T'_{ij} = D'_j$

$\sum_{j=1}^{m} T'_{ij} = O'_i$; $\sum_{i=1}^{n} T'_{ij} = D_j$

$\sum_{j=1}^{m} T'_{ij} = O_i$; $\sum_{i=1}^{n} T'_{ij} = D_j$

An Example of the Singly Constrained Model

We can pick one of these models and show how we can unpack it and work out the scaling constants. We will take the origin-constrained model and adapt it to a retailing example. Here is the model

$$T'_{ij} = A_i O_i D_j \exp(-\beta c_{ij}) \ \textit{subject to} \ \sum_{j=1}^{m} T'_{ij} = O_i$$

and this model predicts what we want to know about where people will locate at the destination – in this sense it is a location

$$\sum_{i=1}^{n} T'_{ij} = D'_j$$

Now we need to figure out the scaling constant A_i

and we substitute the model into $\sum_{j=1}^{m} T'_{ij} = O_i$ and then re-arrange as $\sum_{j=1}^{m} T'_{ij} = A_i O_i \sum_j D_j \exp(-\beta c_{ij}) = O_i$

and then by cancelling O_i from both sides we get

$$A_i = 1/\sum_j D_j \exp(-\beta c_{ij})$$

This then lets us predict the amount of activity attracted to destination j

$$D'_j = \sum_{i=1}^{n} T'_{ij}$$

If the origin activity is expenditure on retailing where the population lives and the destination is some measure of the size of activity such as retail floorspace. Then the predicted activity is sales at shopping centres

Now the new computer program on the web site

Spatial-Interaction-Models.ipynb

Lets you choose one of these four models and using the same hypothetical data set we used earlier , it runs the model and presents the input and output data and the correlations of predicted v observed trips, origins and destinations.

```
Enter the Grid Size: The Number of Squares Along One Side of a Square Grid, 5 or 10, say ---  5
The Size of the Hypothetical Spatial System is 5 Zones by 5 Zones, Making 25 in All

Enter the Parameter Value on Distance - beta - that You Think Best Fits the Data: It should be greater than 0 and less than 1 ----  0.5

You now have to input one of the Four Model Variants that you want to run

We will number these as

1 The Unconstrained Model as in the Basic Gravity Model Program
2 The Singly-Constrained (Origin-Constrained) Model
3 The Singly-Constrained (Destination-Constrained) Model
4 The Doubly-Constrained (Origin-and-Destination Constrained) Model

Type in the Relevant Number from 1 to 4 3
You have chosen the Destination-Constrained Model
Zone     ObsO    ObsD    PredO   PredD

1        28.93   34.57   22.18   34.57
2        45.28   32.50   41.04   32.50
3        39.63   39.23   37.97   39.23
```

I think we should have a go at running this model. I note that you are working through a similar program for your assignment which is different.
We now need to load our model

Spatial-Interaction-Models.ipynb

And work through a couple of applications – let us look at the shopping type model – singly constrained and then the doubly constrained model. For reading have a look at Chapter 2 of my book **Urban Modelling**

https://moodle.ucl.ac.uk/pluginfile.php/3824504/mod_resource/content/1/UrbanModelling.pdf

and Alan Wilson's book **Urban and Regional Models**

Urban Models: Coupled Spatial Interaction

Ok – we have the building blocks of more comprehensive urban models now. Imagine we want to build a model of where people work, where they live and where they shop.

We first define where people work as employment at origins E_i and where they live as population at destinations P_j. This can be modelled as singly constrained model where we predict P_j from E_i and then we predict where these people will shop which relates to the number of workers or size of the shopping centre S_i at the origins.

We thus start with journey to work model defined as

Employment at Workplace

$$E_i (= B_i + S_i')$$

Journey from Work to Home

$$T_{ij}' = A_i E_i P_j \exp(-\beta c_{ij})$$

Population at Residence

$$P_j' = \sum_{i=1}^{n} T_{ij}'$$

Demand for Services from Home to Retailing

$$S_{ji}' = B_j P_j F_j \exp(-\eta c_{ji})$$

Services at Retail Centres

$$S_i' = \sum_{j=1}^{m} S_{ji}'$$

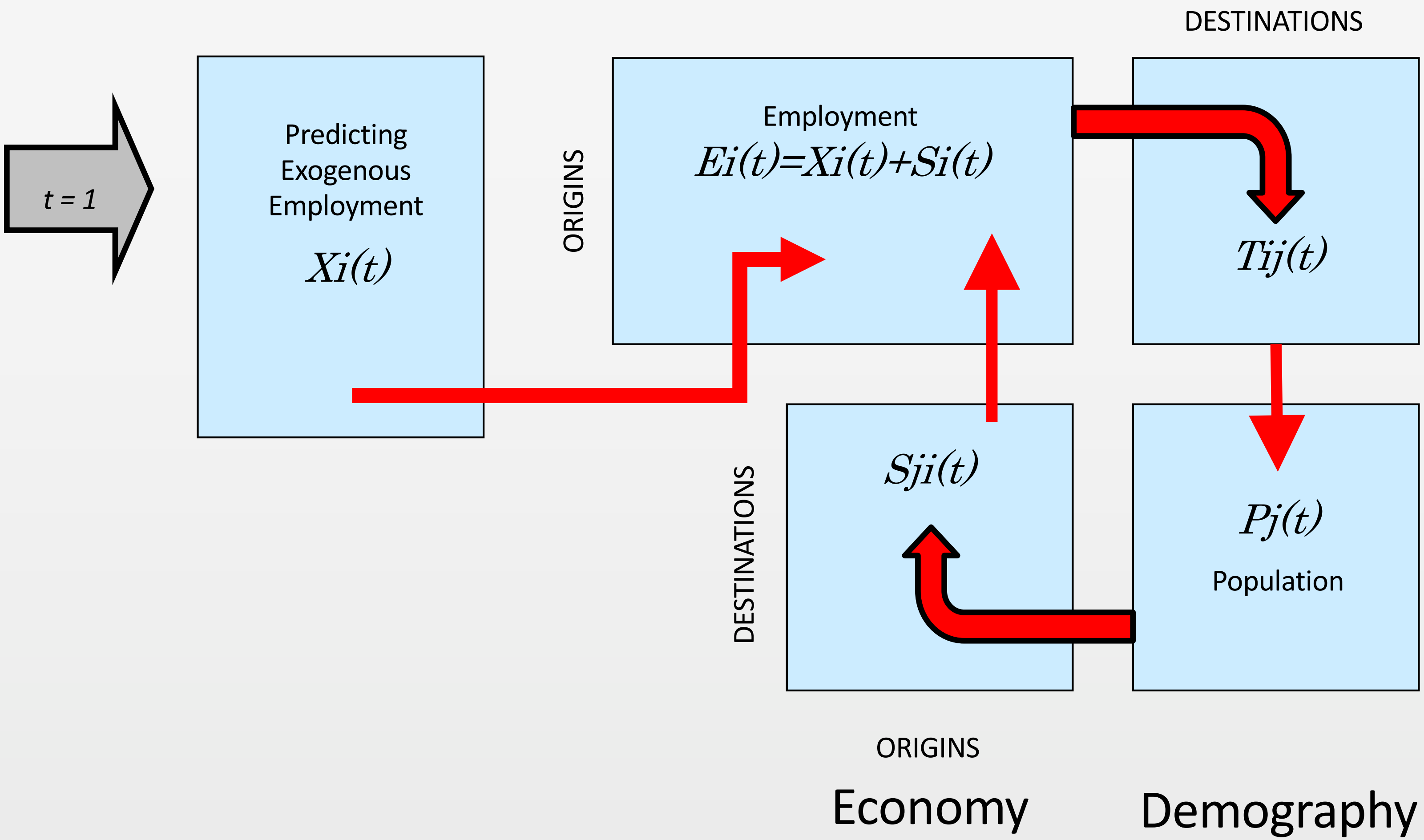
Generalising the Model Adding Employment

I am going to add a third sector – other employment to our model – sometimes it is called ‘basic employment’ and we are going to model this using a potential function. So we have two kinds of employment –

- manufacturing and public service X_i
- retail and commerce S_i

where $E_i = X_i + S_i$ and we have of course population P_j.

So we can now extend our model as follows – were we have other employment, population and retail employment in that order – our model equations begin with employment



We can keep on extending the model in this way with different sectors but let us look at a simple application for the London region bur before this let us demo the extensions

Building Spatial Interaction into an Economic Base

Ok, we will now examine the sequence of operations from with respect to employment. Let us first divide our employment into two types; $E = X + S$

- external or exogenous employment we call **basic** X
- endogenous employment called **non-basic** S

Basic is employment that drives the system, non-basic is dependent employment like retail and services, sometimes called service employment

Our general model reflects this already

Now let us first restate the identity that total employment is equal to basic and non basic as

$$E = X + S$$

And then we scale total employment to population using an activity rate α to get

$$P = \alpha E = \alpha(X + S)$$

Note that $\alpha = P/E$

Now service or non-basic employment is a function of population – it depends on population and this ratio is called the population serving ratio defined as β

Now we can generate this services or non-basic from

$$S = \beta P = \beta\alpha(X + S)$$

Multiplying this out we get

$$S = \beta\alpha X + \beta\alpha S$$

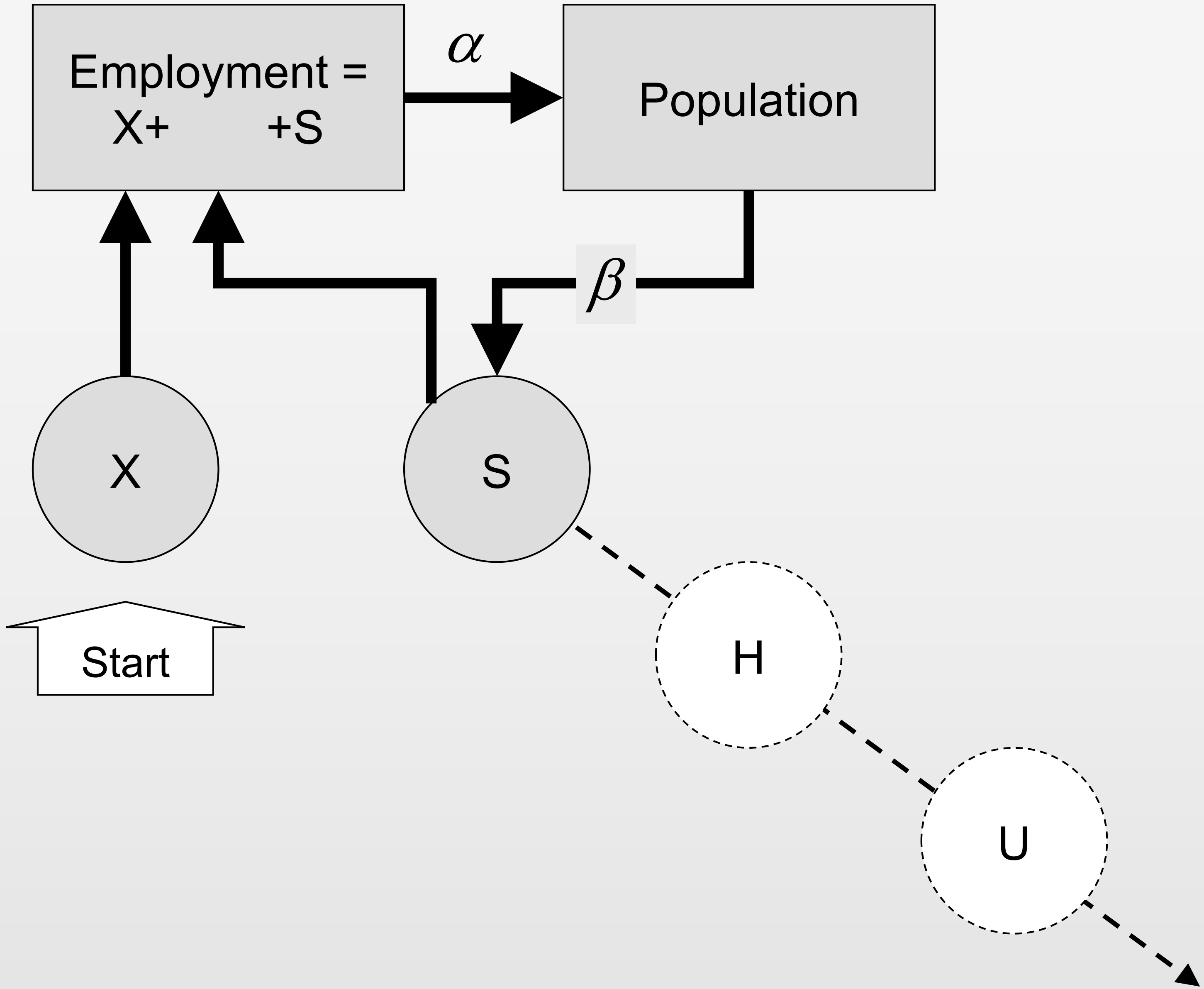
And we can then simplify this by bringing terms to the LHS of the equation as

$$\left.\begin{aligned} &S(1-\beta\alpha) = S - \beta\alpha S = \beta\alpha X, \quad and \\ &S = \beta\alpha X(1-\beta\alpha)^{-1} \end{aligned}\right\}$$

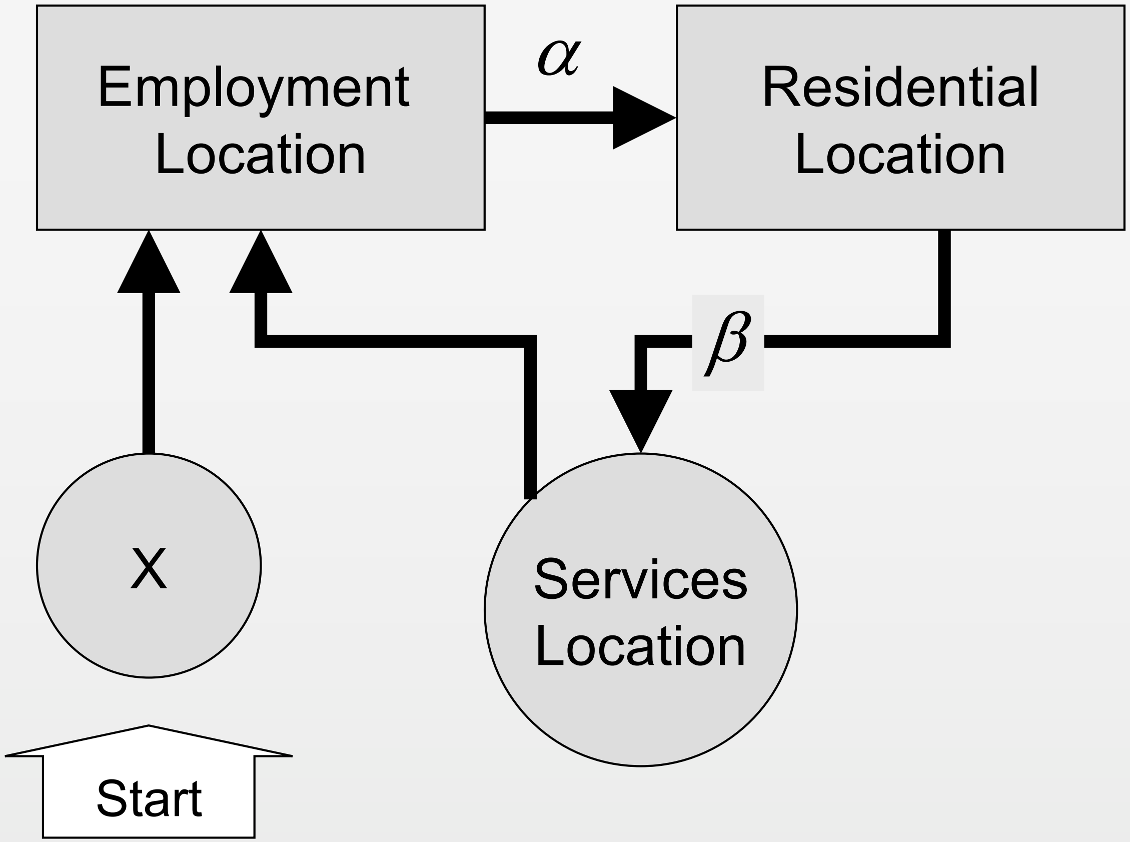
So given basic we can get non-basic and these are related by the multiplier

$$(1-\beta\alpha)^{-1}$$

Now we can draw a block diagram of this so we can see how we can generate it in sequence



Employment: X=Exogenous; S=Service;



I am not going to detail all these previous models and elaborate the equations but you can see that this is the structure they can fit into – this essentially is the Lowry model framework

Extending the Retail Model to Deal with Agglomeration and Scale

Here is the shopping model that we stated last time:

$$S_{ij} = A_i e P_i F_j \exp(-\beta c_{ij}) = eP_i \frac{F_j \exp(-\beta c_{ij})}{\sum_j F_j \exp(-\beta c_{ij})}$$

Now we can extend it in two ways – first we can add a scaling factor to the attraction on the assumption that as a centre gets bigger, then it has economies of scale. The assumption in economics is that as things get bigger other quantities grow more than proportionately – superlinearly. Thus we can replace

$$F_j \rightarrow\rightarrow\rightarrow\rightarrow F_j^{\alpha}$$

The model thus becomes

$$S_{ij} = eP_i \frac{F_j^{\alpha} \exp(-\beta c_{ij})}{\sum_j F_j^{\alpha} \exp(-\beta c_{ij})}$$

And in fact I think that your assignment exercise has this kind of scaling factor but to estimate it you would need multiple regression because there are two parameters – in fact three including the intercept,

Now we don't calibrate it this way as we will show in a minute but first we need to add an even more appropriate agglomerative effect by taking account of local economies of scales inside a retail centre

We can argue that local shops in a centre exert a positive effect on agglomeration by assuming that the attraction of the centre takes account of these local shops. If we now think of F_j^α as a shop not a set of shops and note that there are other shops F_k^α in the centre j then we can add up the effect of these shops on the attraction using a similar deterrence effect as

$$A_j = F_j^\alpha + \sum_{k \in \Omega_j} F_k^\alpha \exp(-\phi c_{jk})$$

Note we are summing over all the k located shops in the centre j and assuming a deterrent effect – i.e. closer shops exert of a positive effect

Putting this into the model, we get an augmented retail model with three scaling parameter and of course some sort of constants to ensure normalisation. The model now looks like this F_j^{α}

$$S_{ij} = \eta P_i \frac{A_j \exp(-\beta c_{ij})}{\sum_j A_j \exp(-\beta c_{ij})} = \eta P_i \frac{\left[F_j^{\alpha} + \sum_{k \in \Omega_j} F_k^{\alpha} \exp(-\phi c_{jk}) \right] \exp(-\beta c_{ij})}{\sum_j \left[F_j^{\alpha} + \sum_{k \in \Omega_j} F_k^{\alpha} \exp(-\phi c_{jk}) \right] \exp(-\beta c_{ij})}$$

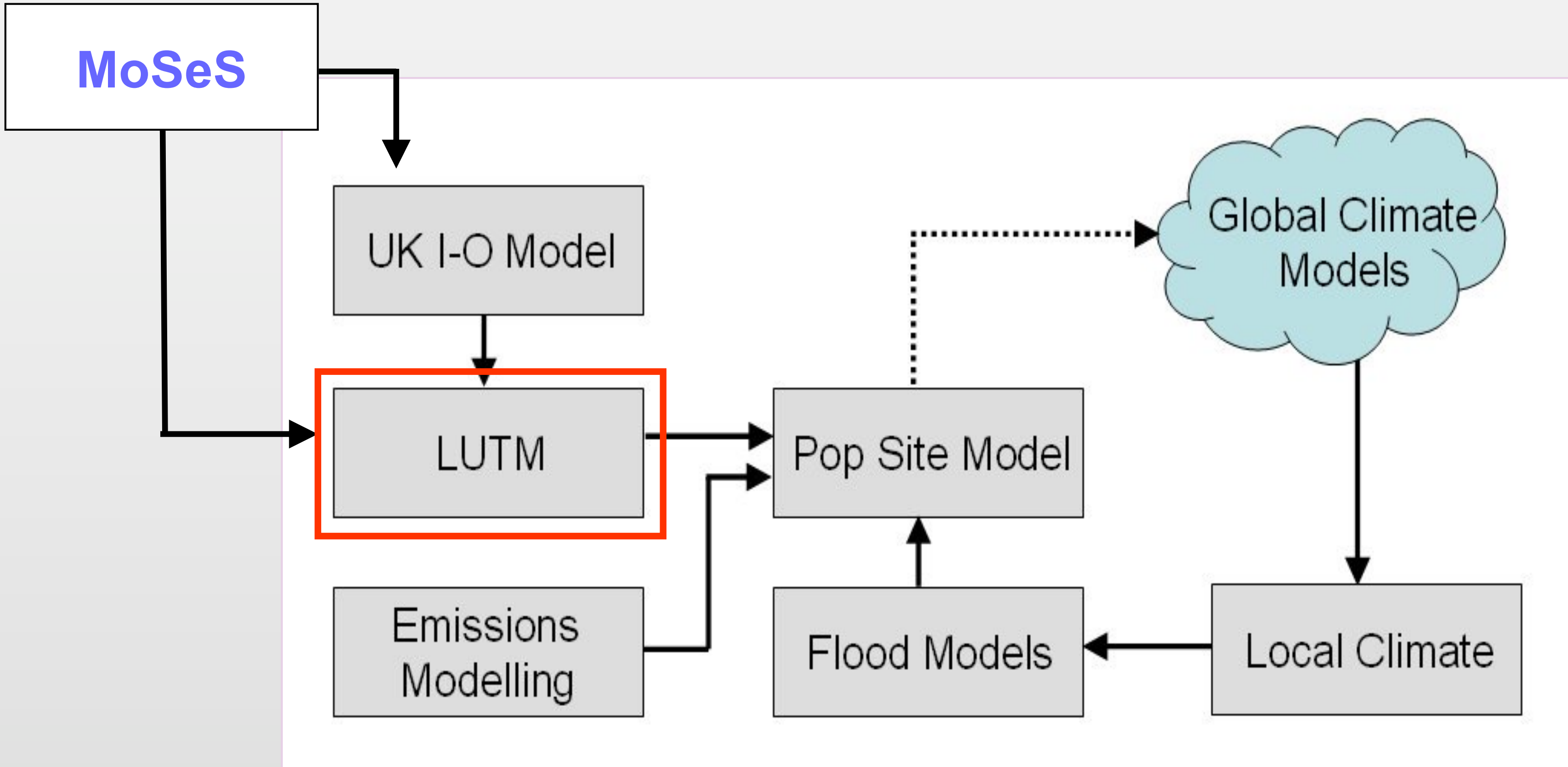
Of course we don't know what sign these parameters can take and it may be that the local effect is truly agglomerative and the parameter is positive

Three Applications and a Fourth Next Time

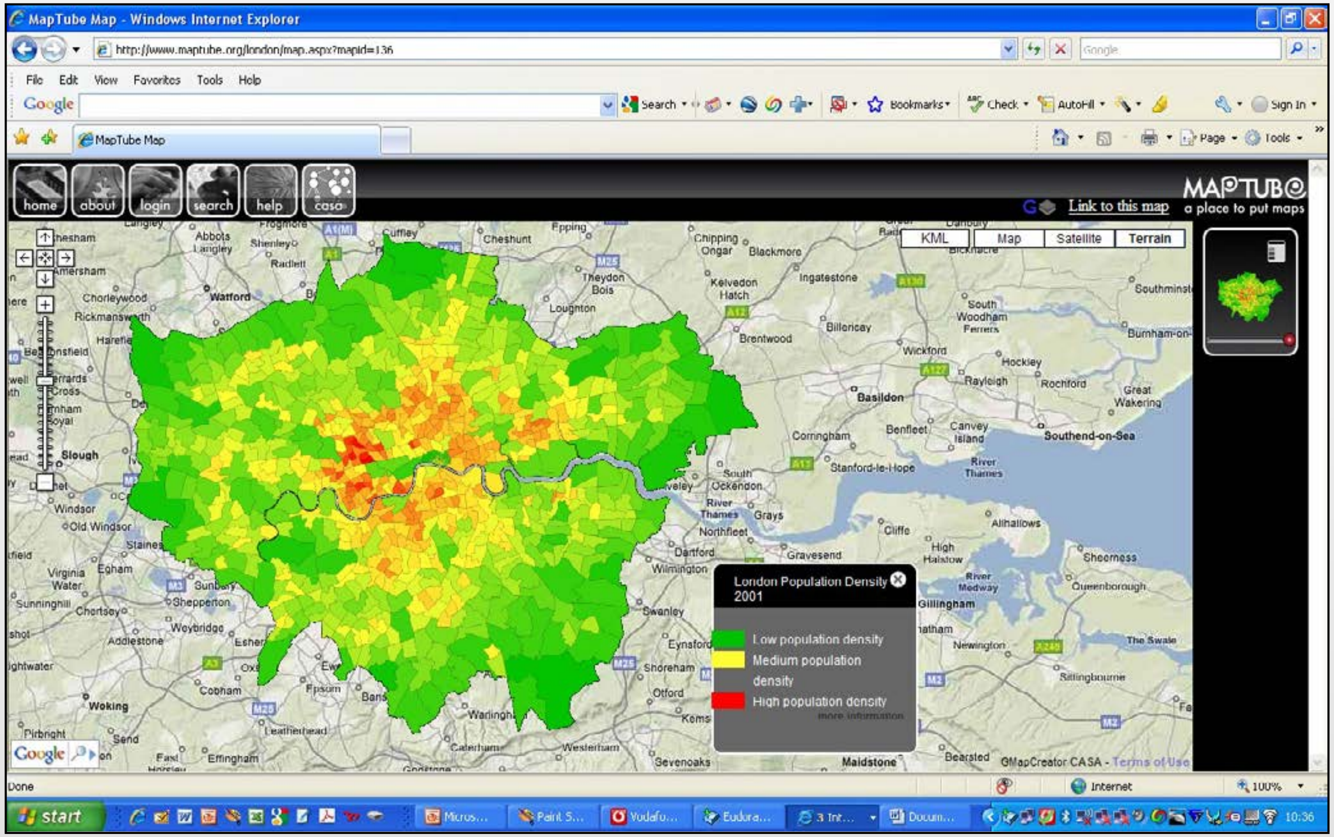
1. A simple gravitational model for Greater London – linked to other models focussed on integrating different infrastructure and economic models
2. The extended model for Greater London and the outer metropolitan area – three sector urban model called SIMULACRA
3. A simple model built rapidly in a two days - a demo for Dubai based on data extracted from the web
4. A large scale LUTI land use transportation interaction model for the UK called QUANT – we will talk about this next time in our fourth lecture

1. The London Tyndall Model Applications

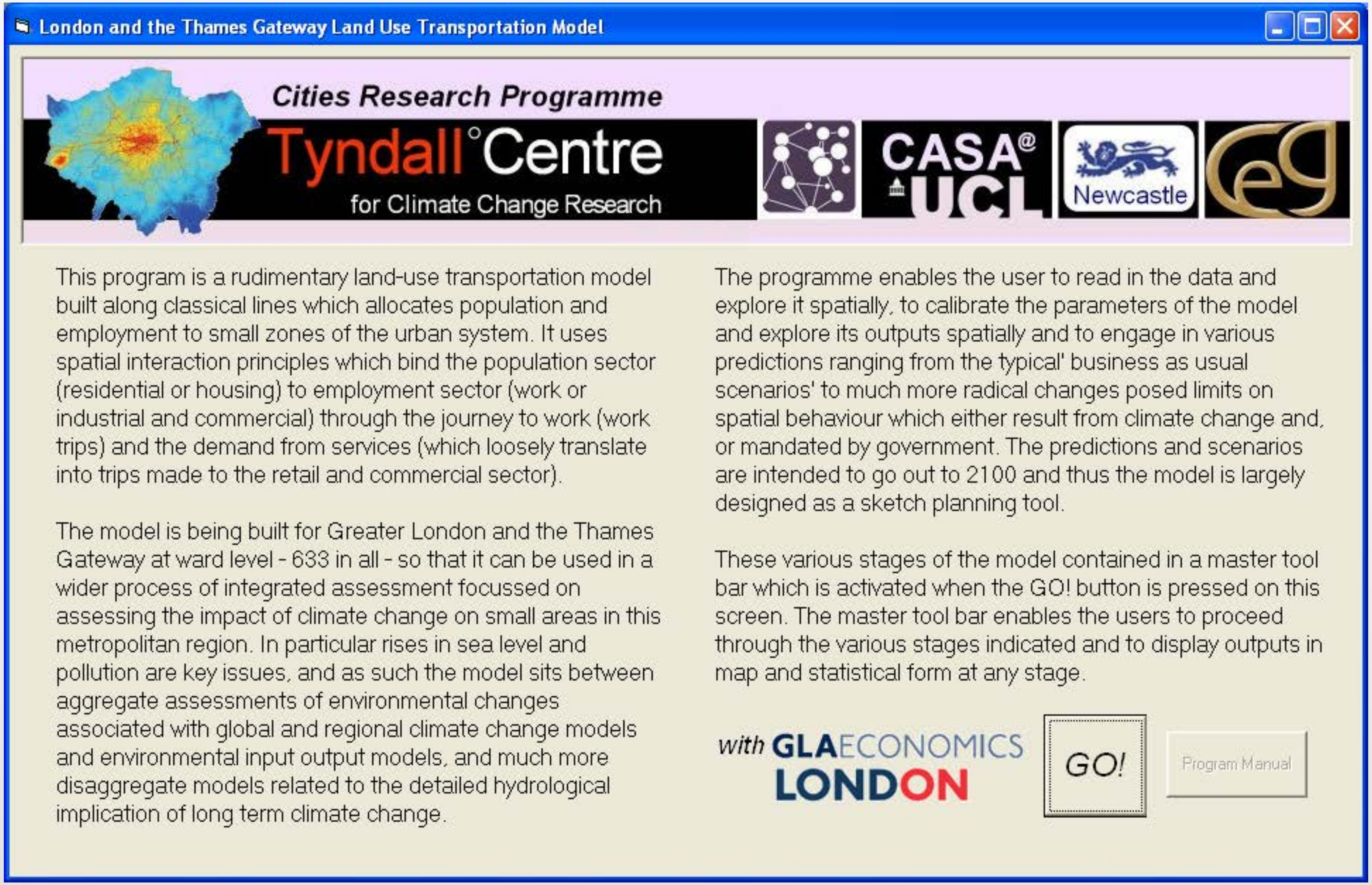
This is an integrated model as shown in the block diagram below. Our focus is on integrating a singly constrained residential local models into the framework.

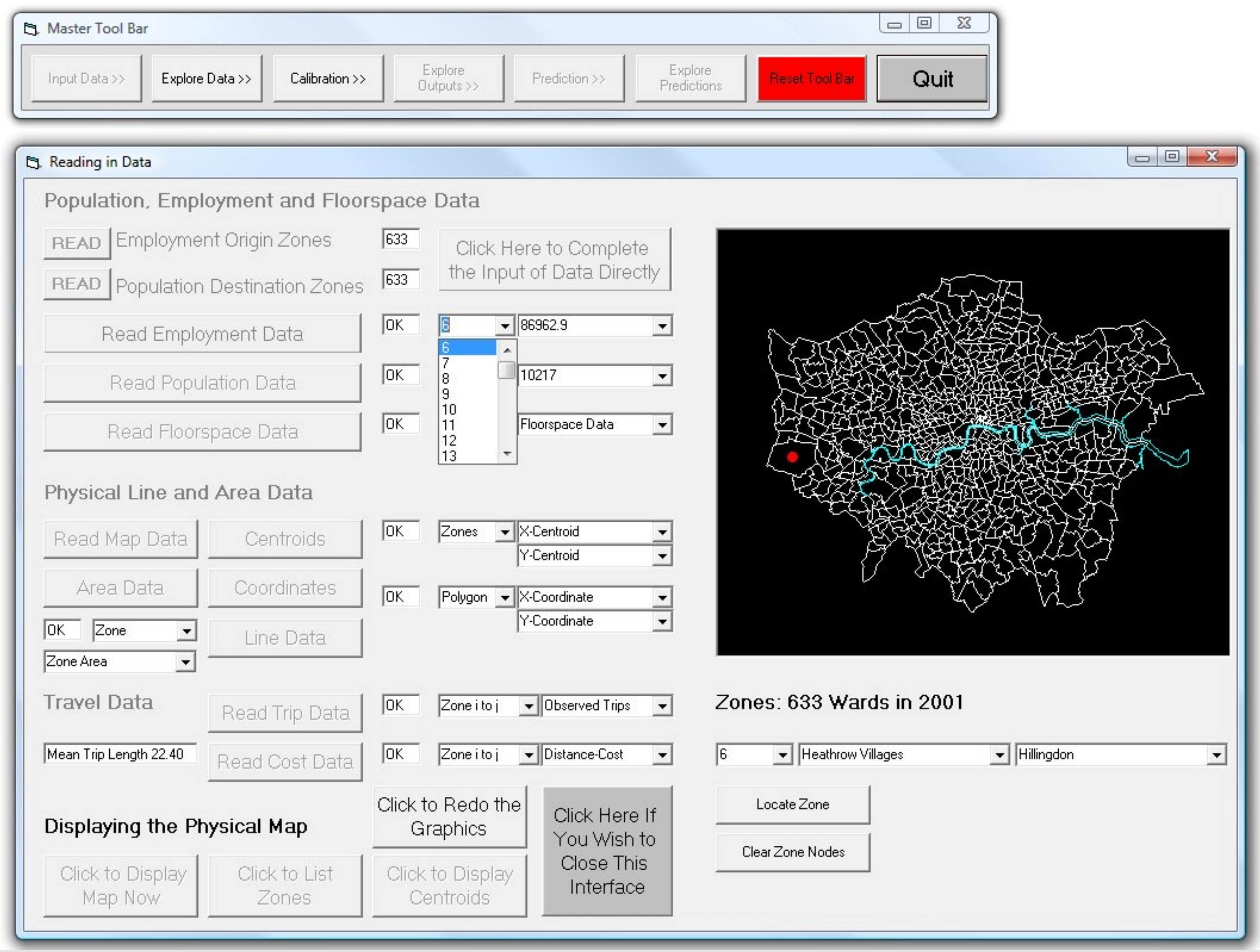


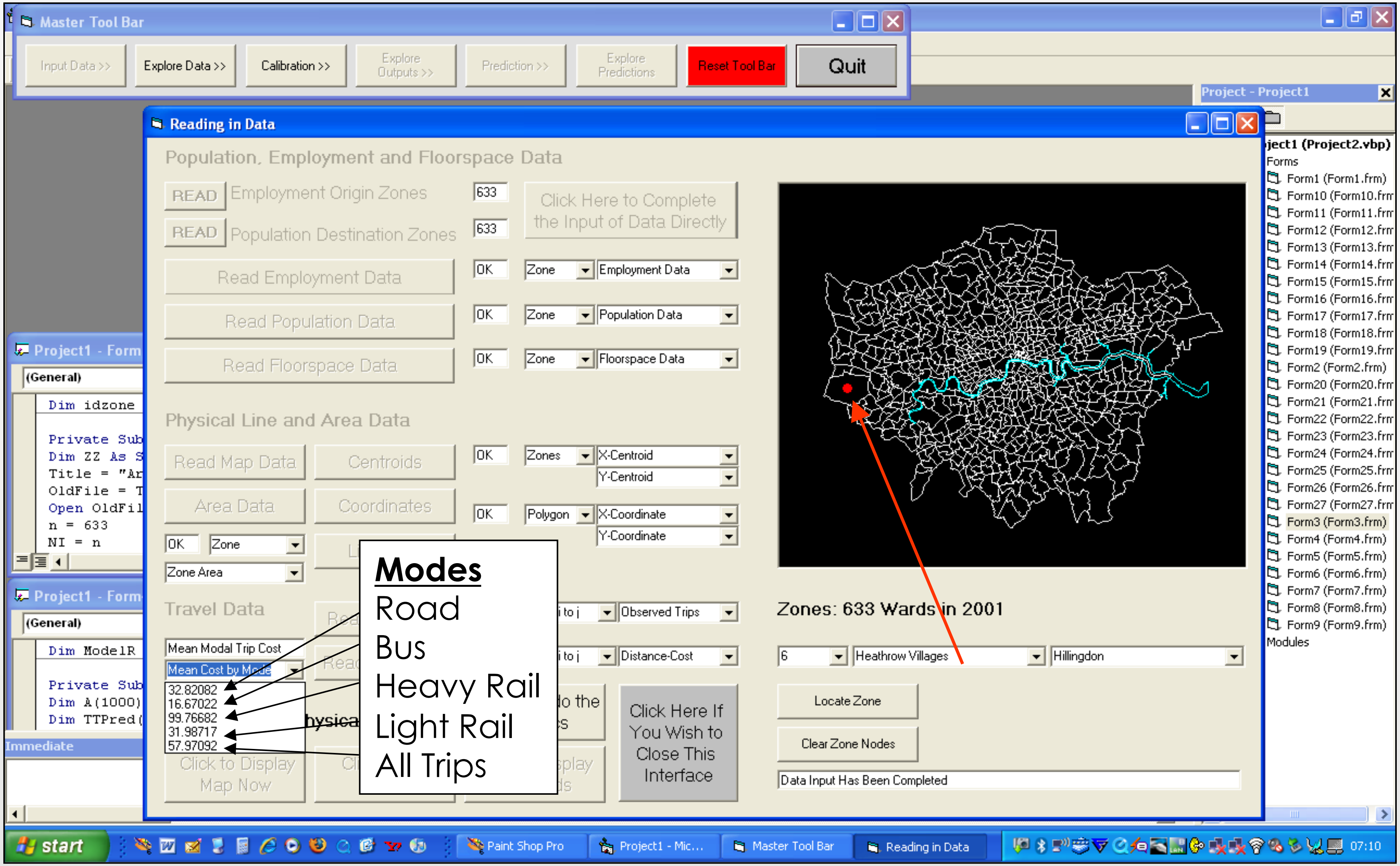
- essentially we have built this model for Greater London which is divided into 633 zones – the area has 7.7m population and about 4.3m jobs –
- we have four modes – road (car), heavy rail, light rail and tube, and bus – walk/bike is a residual mode. First the extent of the area



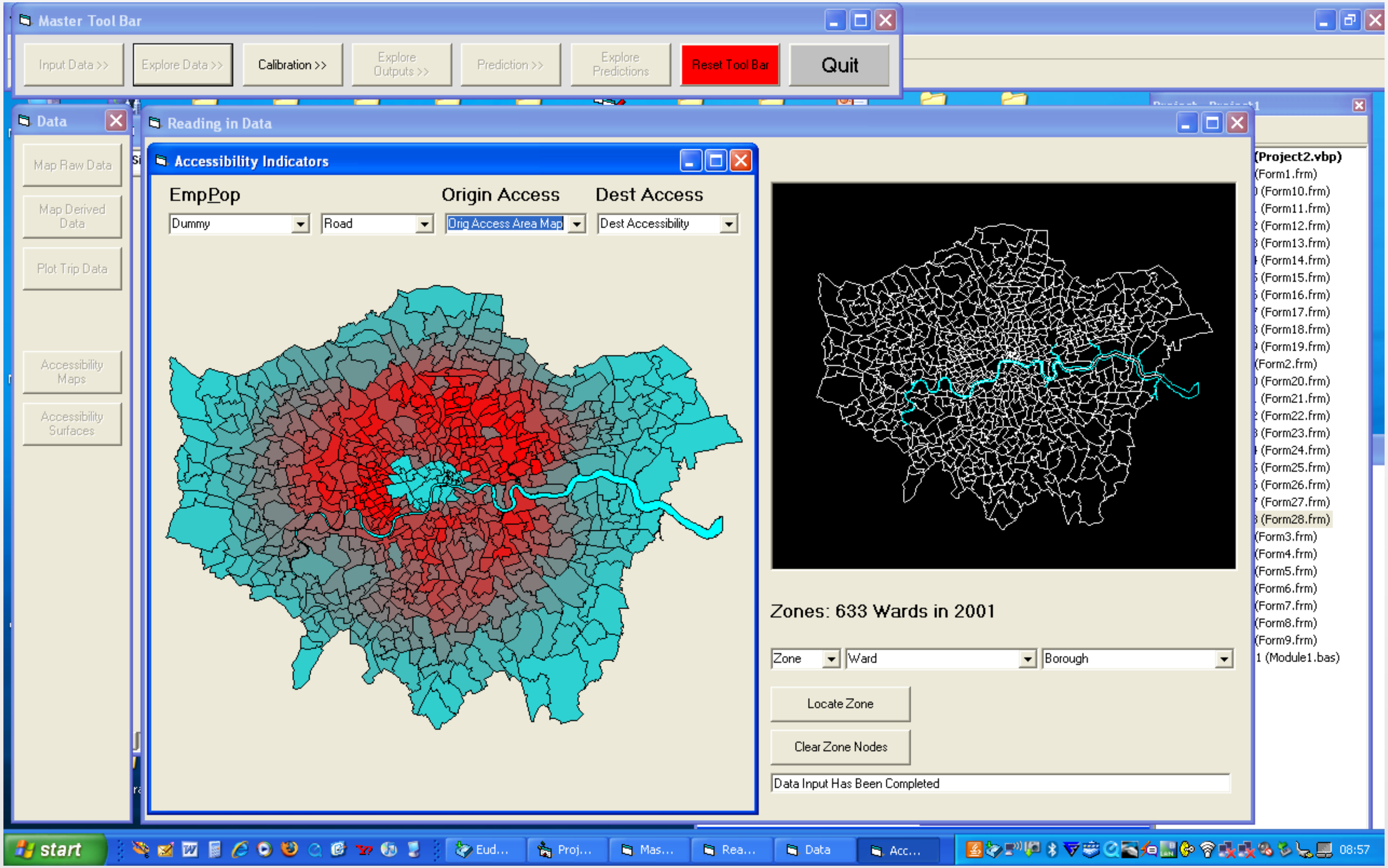
To give a flavour of the LUTI/LUTM model, I will show some screen shots first




Master Tool Bar
Input Data >>
Explore Data >>
Calibration >>
Explore Outputs >>
Prediction >>
Explore Predictions
Reset Tool Bar
Quit
Reading in Data
Population, Employment and Floorspace Data
READ Employment Origin Zones
633
READ Population Destination Zones
633
Click Here to Complete the Input of Data Directly
Read Employment Data
OK
86962.9
Read Population Data
OK
10217
Read Floorspace Data
OK
Floorspace Data
Physical Line and Area Data
Read Map Data
Centroids
OK
Zones
X-Centroid
Y-Centroid
Area Data
Coordinates
OK
Polygon
X-Coordinate
Y-Coordinate
OK
Zone
Zone Area
Line Data
Travel Data
Read Trip Data
OK
Zone i to j
Observed Trips
Mean Trip Length 22.40
Read Cost Data
OK
Zone i to j
Distance-Cost
Displaying the Physical Map
Click to Redo the Graphics
Click Here If You Wish to Close This Interface
Click to Display Map Now
Click to List Zones
Click to Display Centroids
Zones: 633 Wards in 2001
6
Heathrow Villages
Hillingdon
Locate Zone
Clear Zone Nodes



Road: 38%; Bus: 12%: Heavy Rail: 12%: Light Rail 19%; Other (Walk, Bike): 19%


Master Tool Bar
Input Data >>
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Prediction >>
Explore Predictions
Reset Tool Bar
Quit
Data
Map Raw Data
Map Derived Data
Plot Trip Data
Accessibility Maps
Accessibility Surfaces
Reading in Data
Accessibility Indicators
EmpPop
Origin Access
Dest Access
Dummy
Road
Orig Access Area Map
Dest Accessibility
Zones: 633 Wards in 2001
Zone
Ward
Borough
Locate Zone
Clear Zone Nodes
Data Input Has Been Completed
(Project2.vbp)
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1 (Module1.bas)
start
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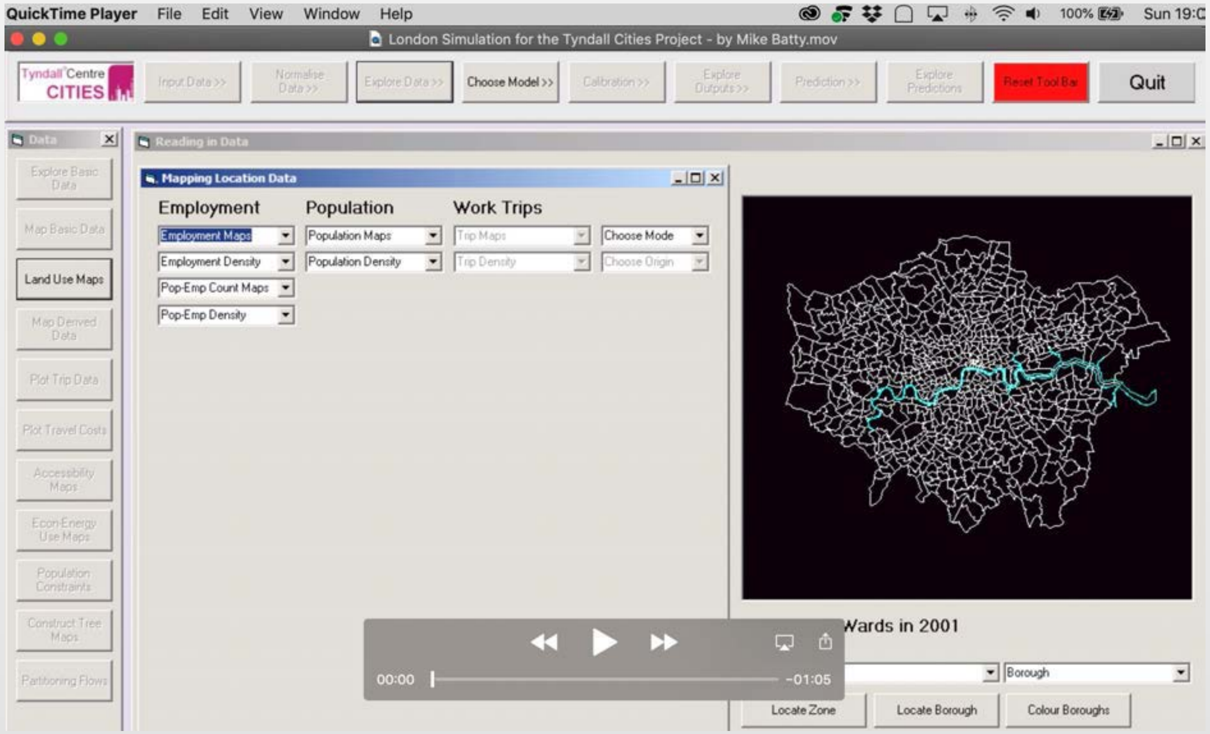
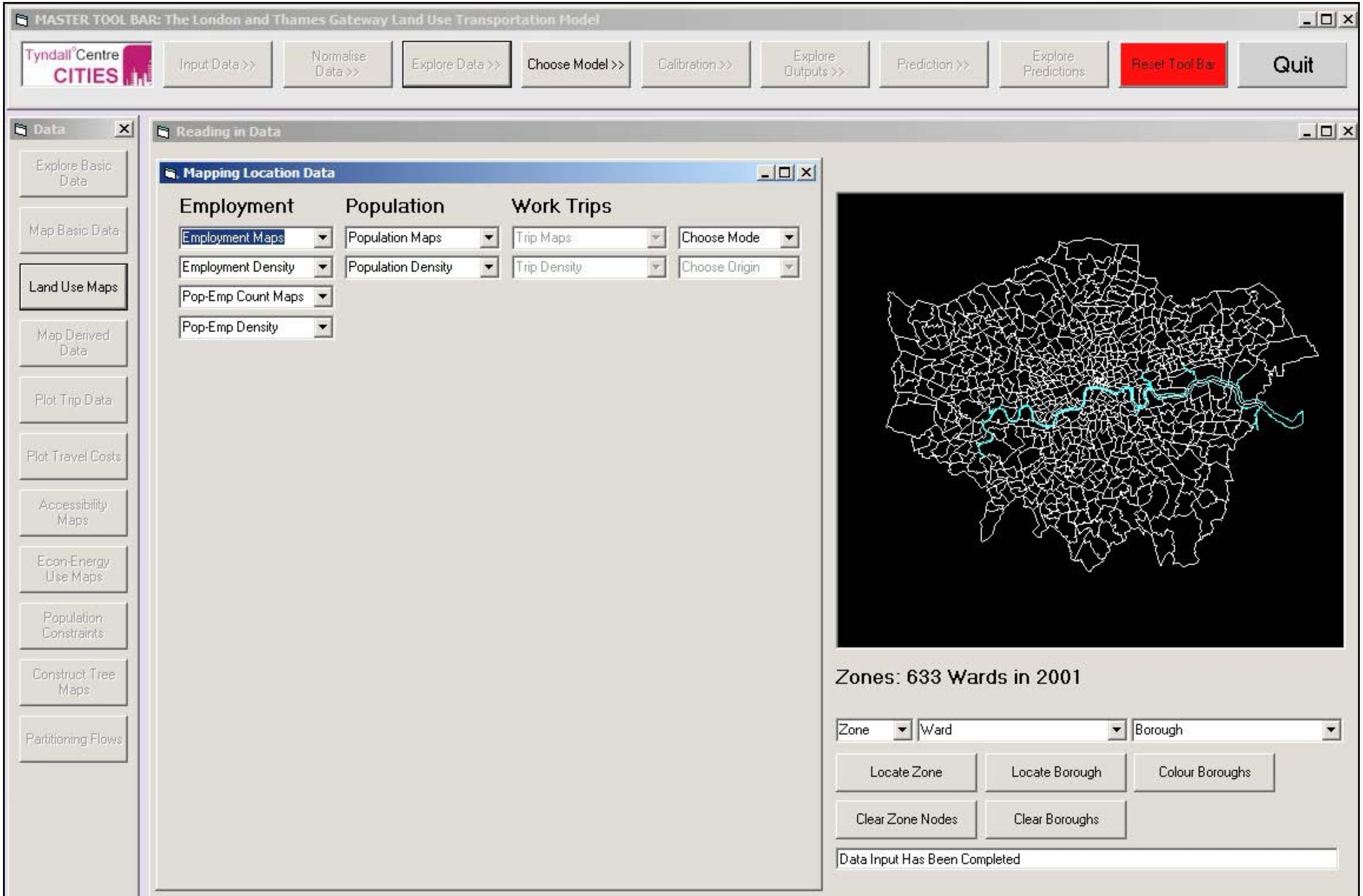
Ok let me load a movie

I may need to leave powerpoint but let us try from within first




MASTER TOOL BAR: The London and Thames Gateway Land Use Transportation Model
Tyndall Centre
CITIES
Input Data >>
Normalise Data >>
Explore Data >>
Choose Model >>
Calibration >>
Explore Outputs >>
Prediction >>
Explore Predictions
Reset Tool Bar
Quit
Data
Explore Basic Data
Map Basic Data
Land Use Maps
Map Derived Data
Plot Trip Data
Plot Travel Costs
Accessibility Maps
Econ-Energy Use Maps
Population Constraints
Construct Tree Maps
Partitioning Flows
Reading in Data
Mapping Location Data
Employment
Population
Work Trips
Employment Maps
Population Maps
Trip Maps
Choose Mode
Employment Density
Population Density
Trip Density
Choose Origin
Pop-Emp Count Maps
Pop-Emp Density
Zones: 633 Wards in 2001
Zone
Ward
Borough
Locate Zone
Locate Borough
Colour Boroughs
Clear Zone Nodes
Clear Boroughs
Data Input Has Been Completed

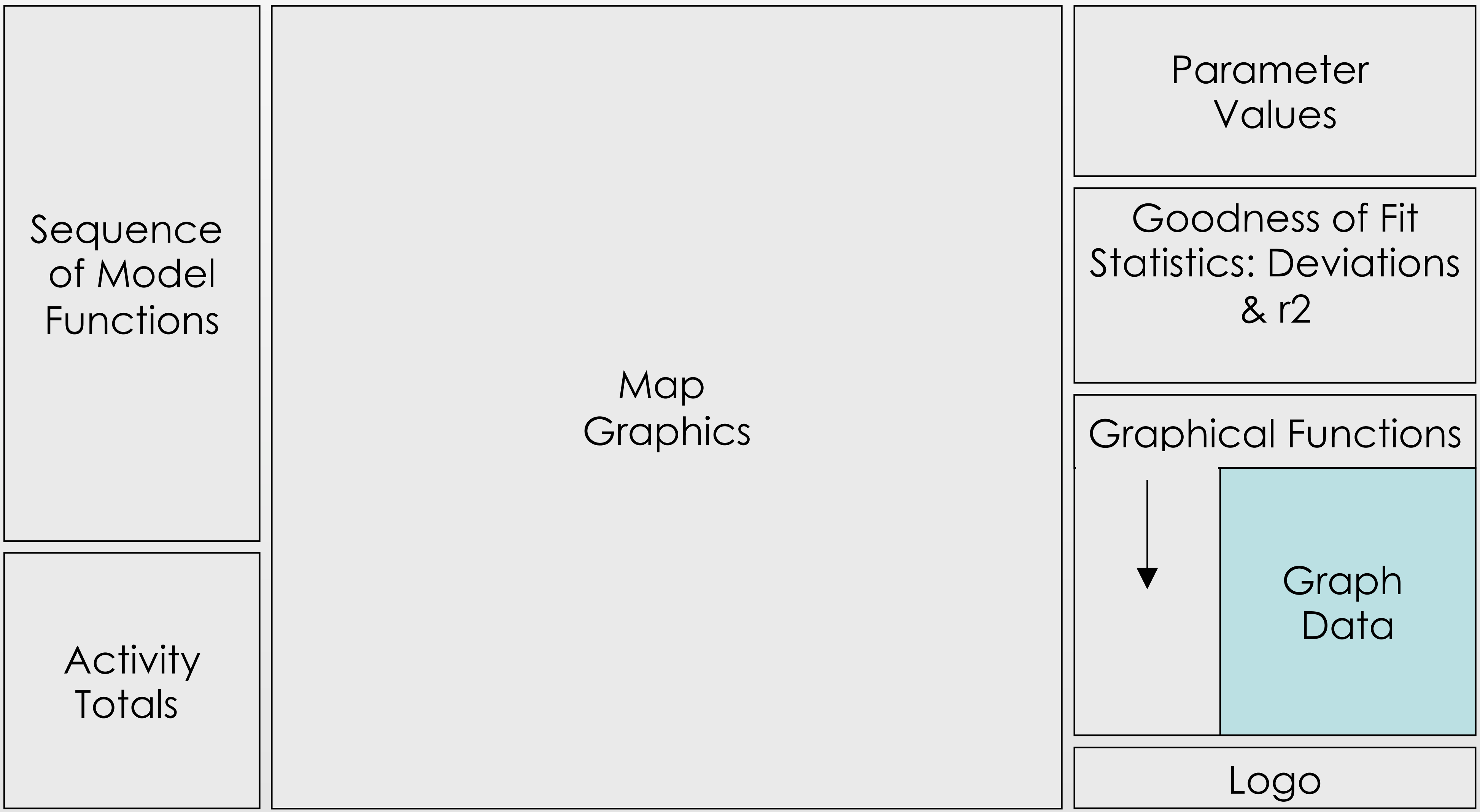
Modular Modelling: Coupled Spatial Interaction

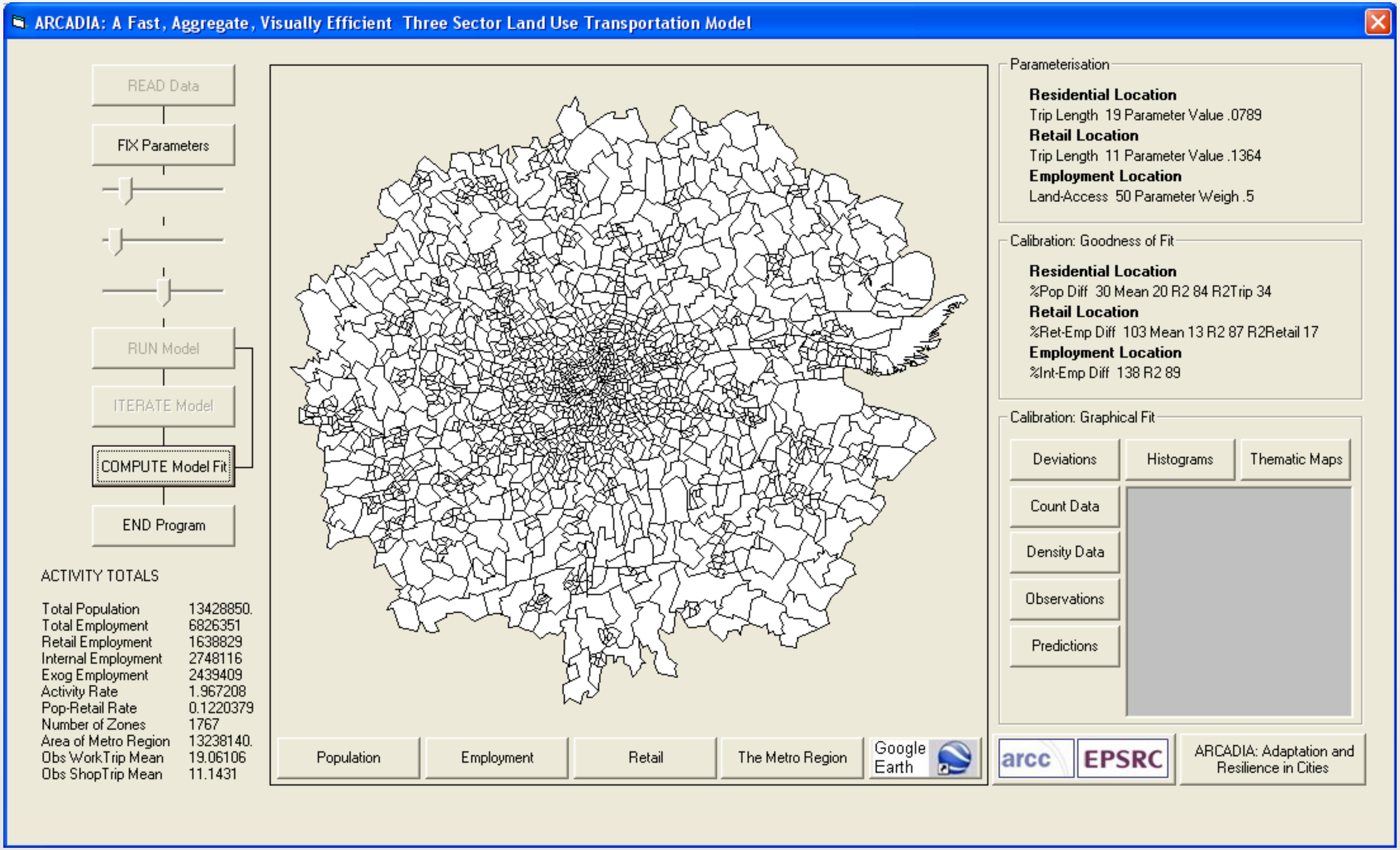
So far we have just singled out a module for one kind of interaction – based on a variant of the gravity model - consider stringing these together as more than one kind of spatial interaction: Model 1 ⇨ Model 2 ⇨ Model 3 ⇨ …..

Classically we might model flows from home to work and home to shop but there are many more and in this sense, we can use these as building blocks for wider models. This is for next time too

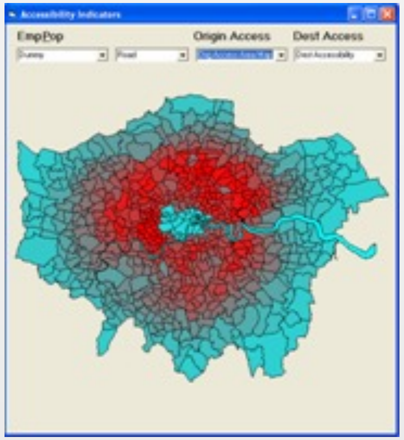
What we will now do is illustrate how we might build such a structure taking a journey to work model from Employment to Population and then to Shopping which we structure as --

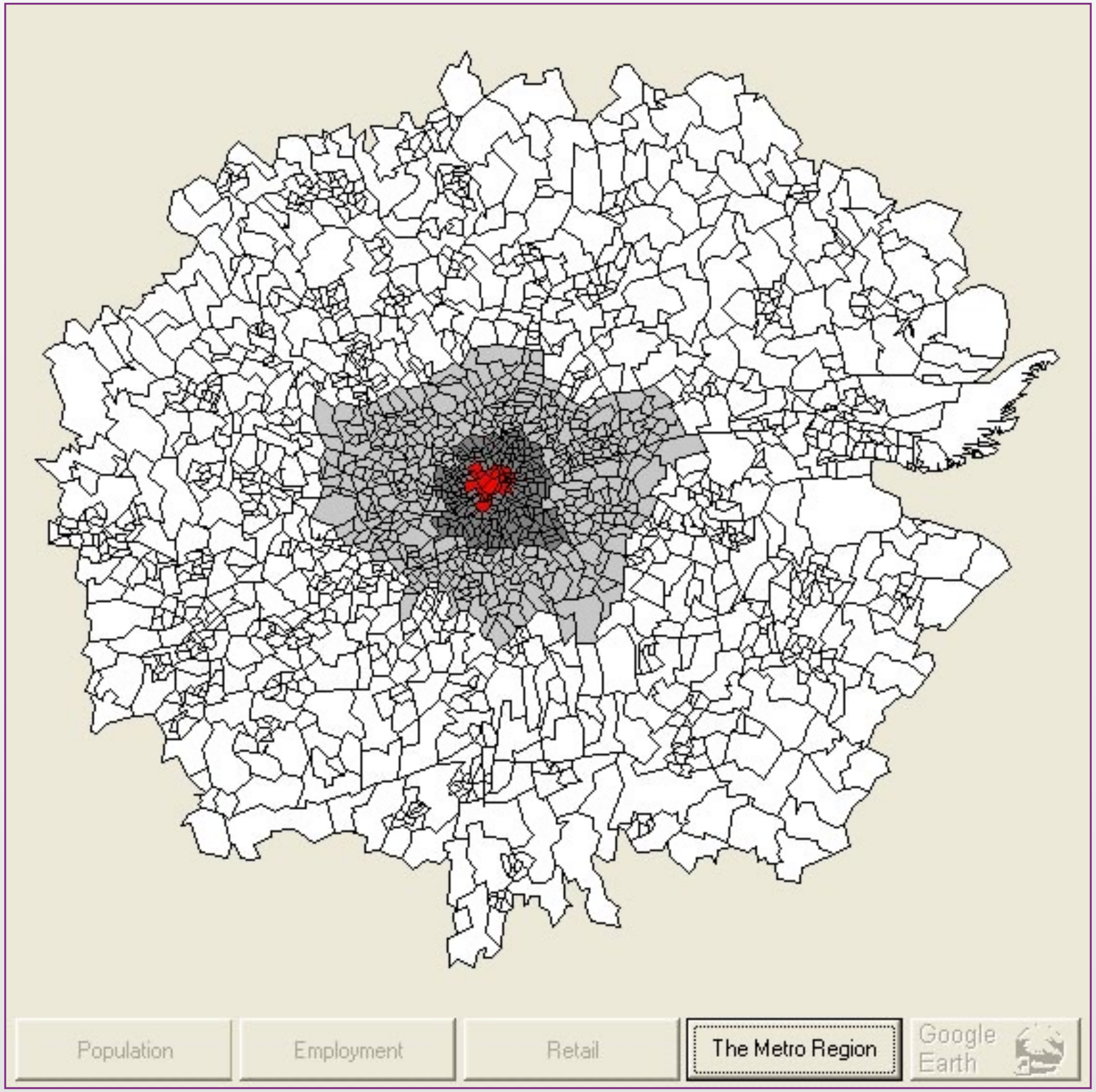
This is the order in which the operations take place

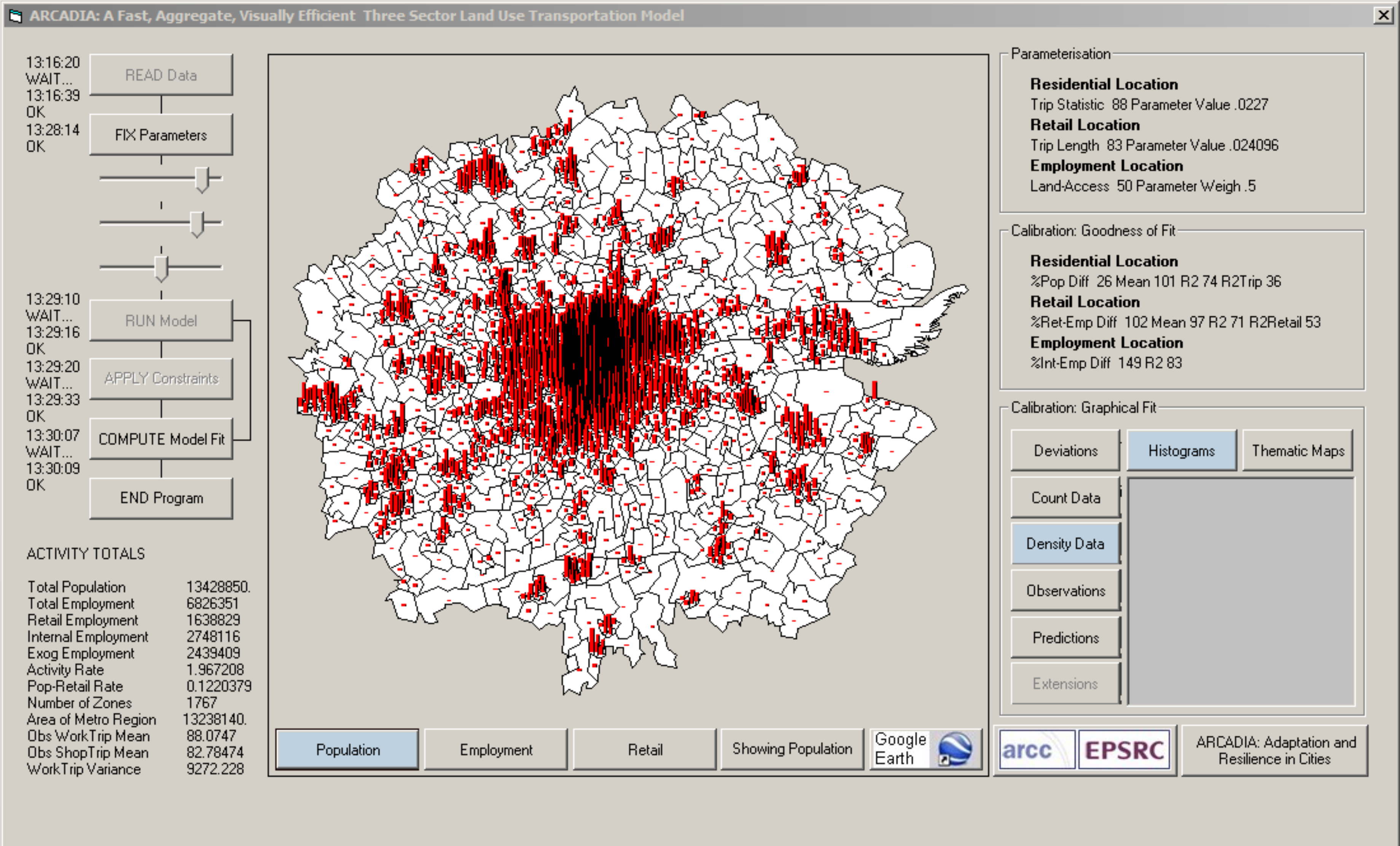


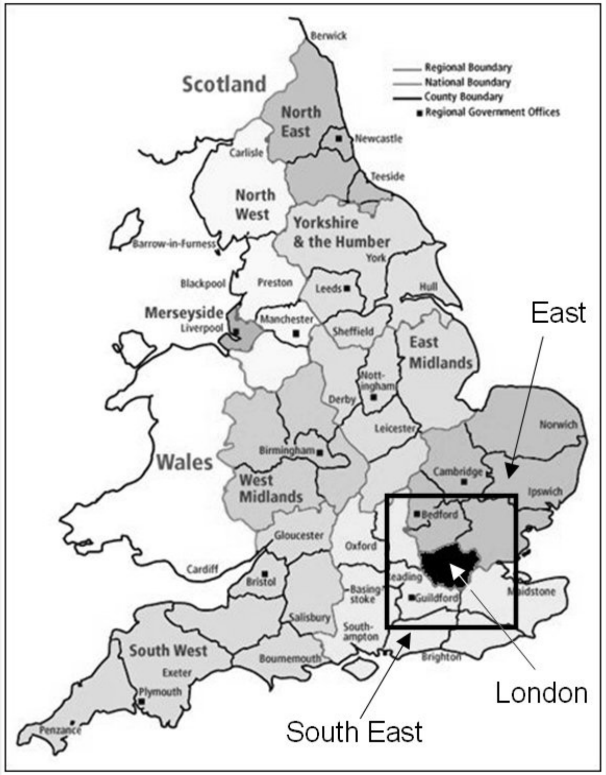

ARCADIA: A Fast, Aggregate, Visually Efficient Three Sector Land Use Transportation Model
READ Data
FIX Parameters
RUN Model
ITERATE Model
COMPUTE Model Fit
END Program
ACTIVITY TOTALS
Total Population 13428850.
Total Employment 6826351
Retail Employment 1638829
Internal Employment 2748116
Exog Employment 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

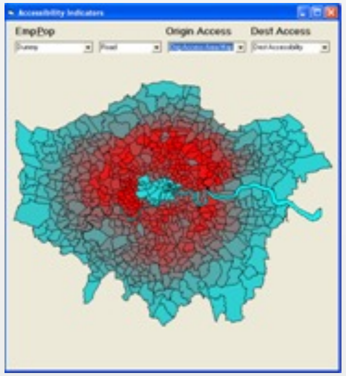

Employment
Population
Work Trips

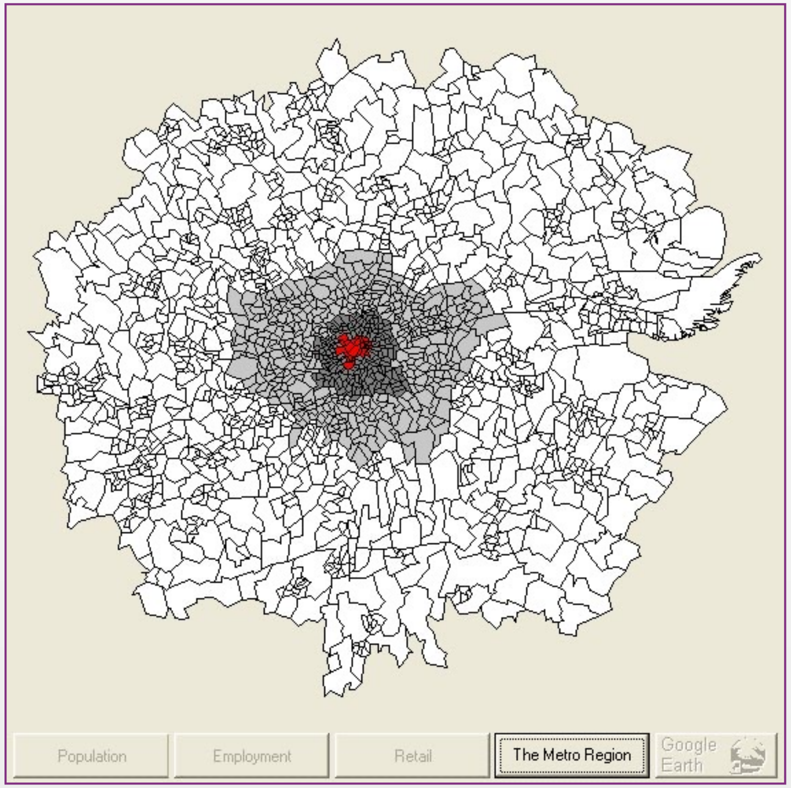

EmpPop
Origin Access
Dest Access

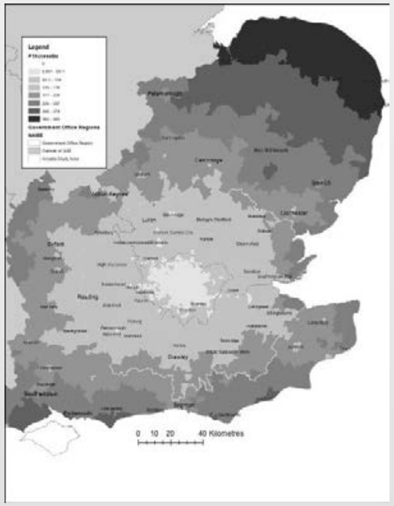

Population
Employment
Retail
The Metro Region
Google Earth

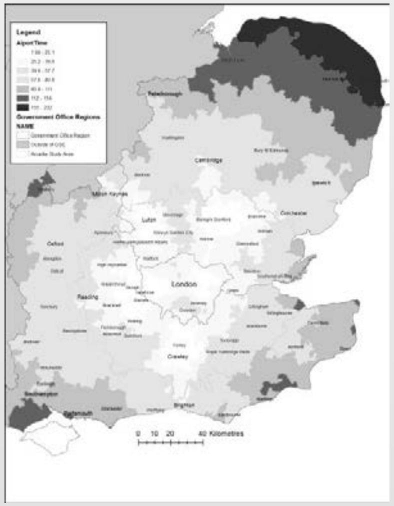

ARCADIA: A Fast, Aggregate, Visually Efficient Three Sector Land Use Transportation Model
13:16:20
WAIT...
13:16:39
OK
13:28:14
OK
READ Data
FIX Parameters
13:29:10
WAIT...
13:29:16
OK
13:29:20
WAIT...
13:29:33
OK
13:30:07
WAIT...
13:30:09
OK
RUN Model
APPLY Constraints
COMPUTE Model Fit
END Program
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
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
Population
Employment
Retail
Showing Population
Google Earth
arcc
EPSRC
ARCADIA: Adaptation and Resilience in Cities

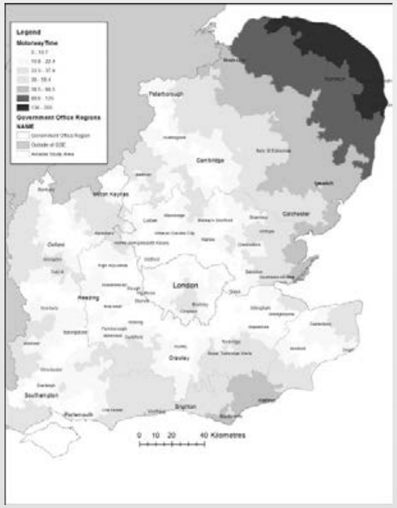


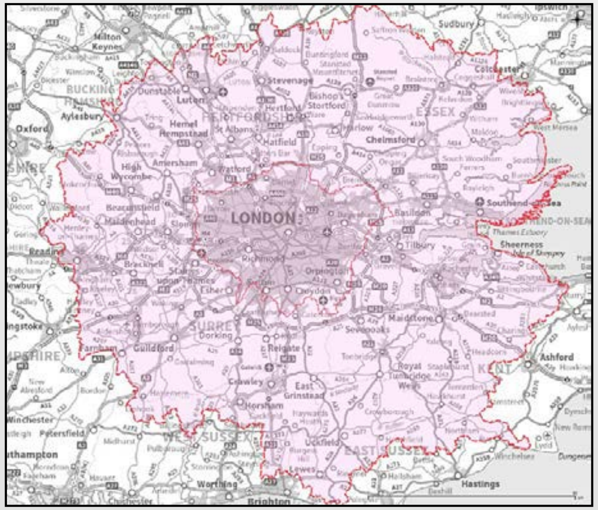








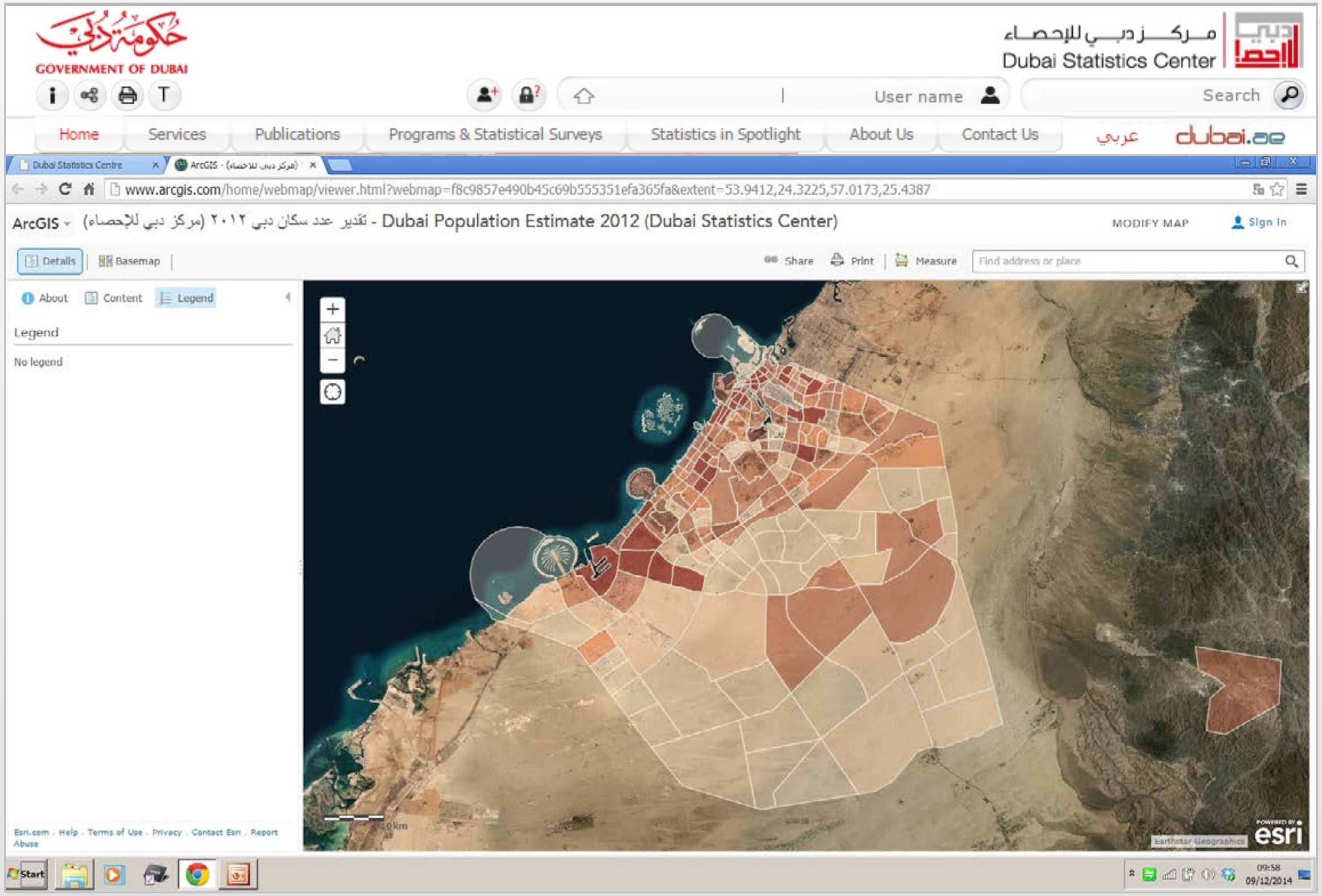




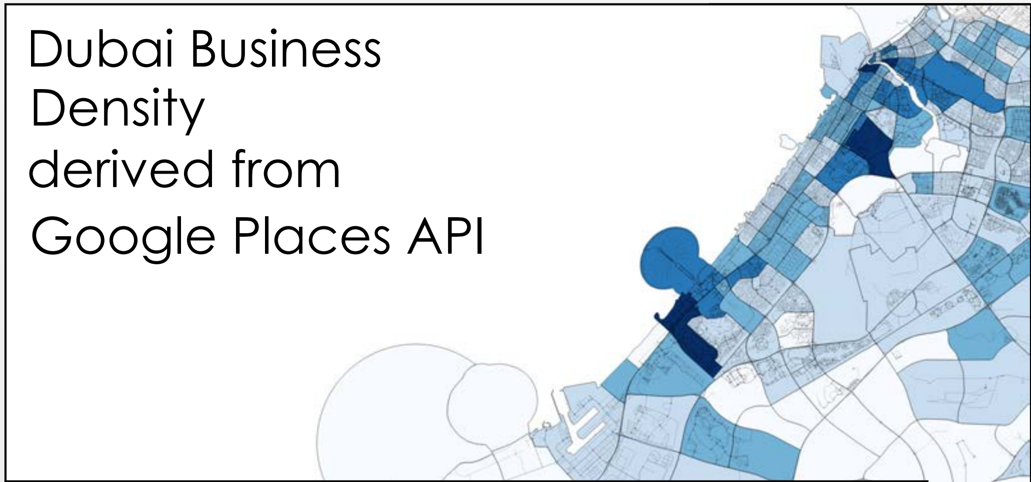
Spatial Interaction 2: The Family of Spatial Interaction Models Again, General Urban Models

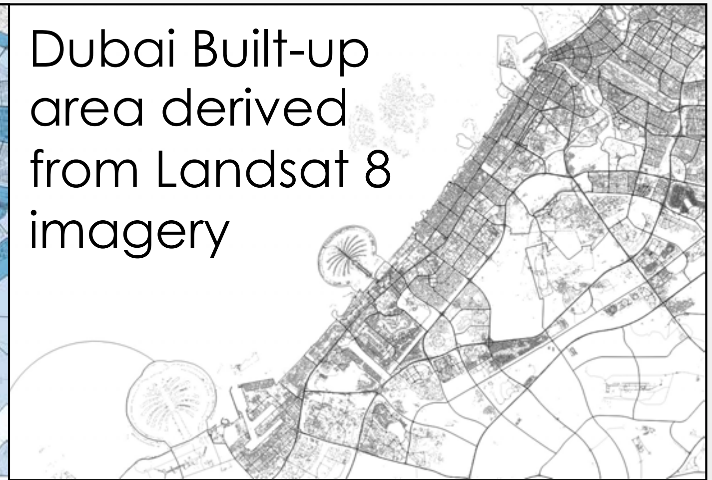
Quick and Dirty Models

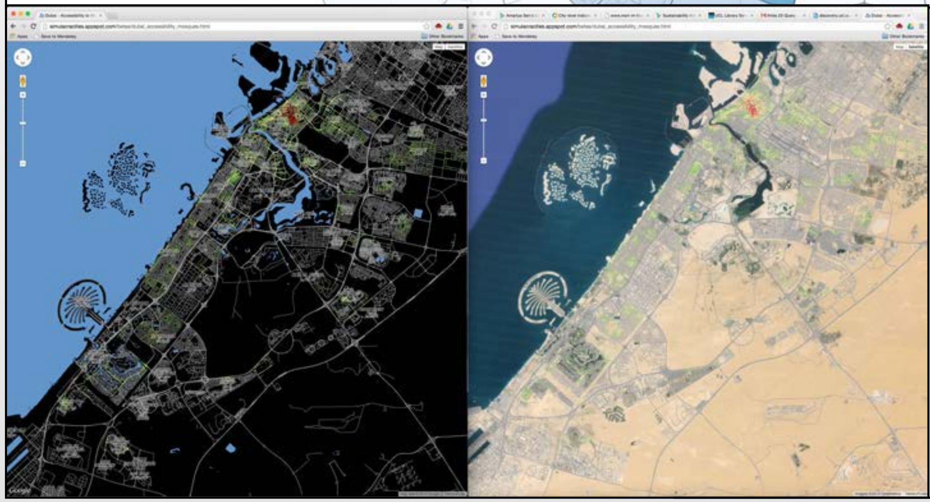
A New Retail Centre in Dubai

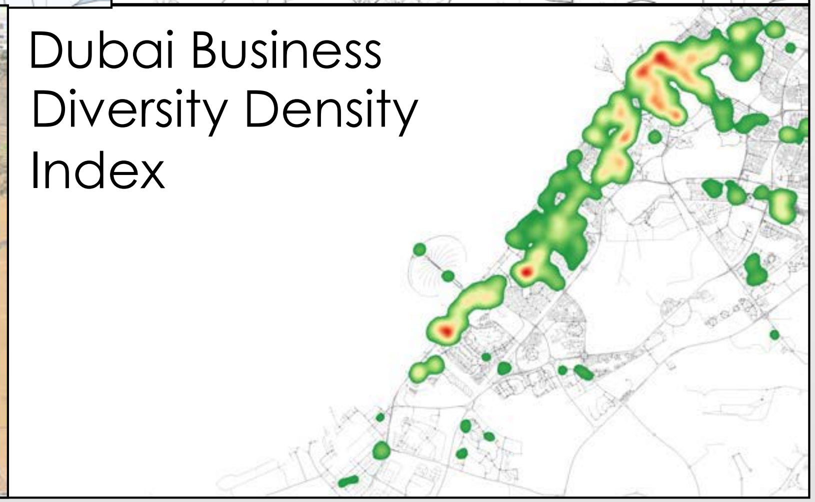


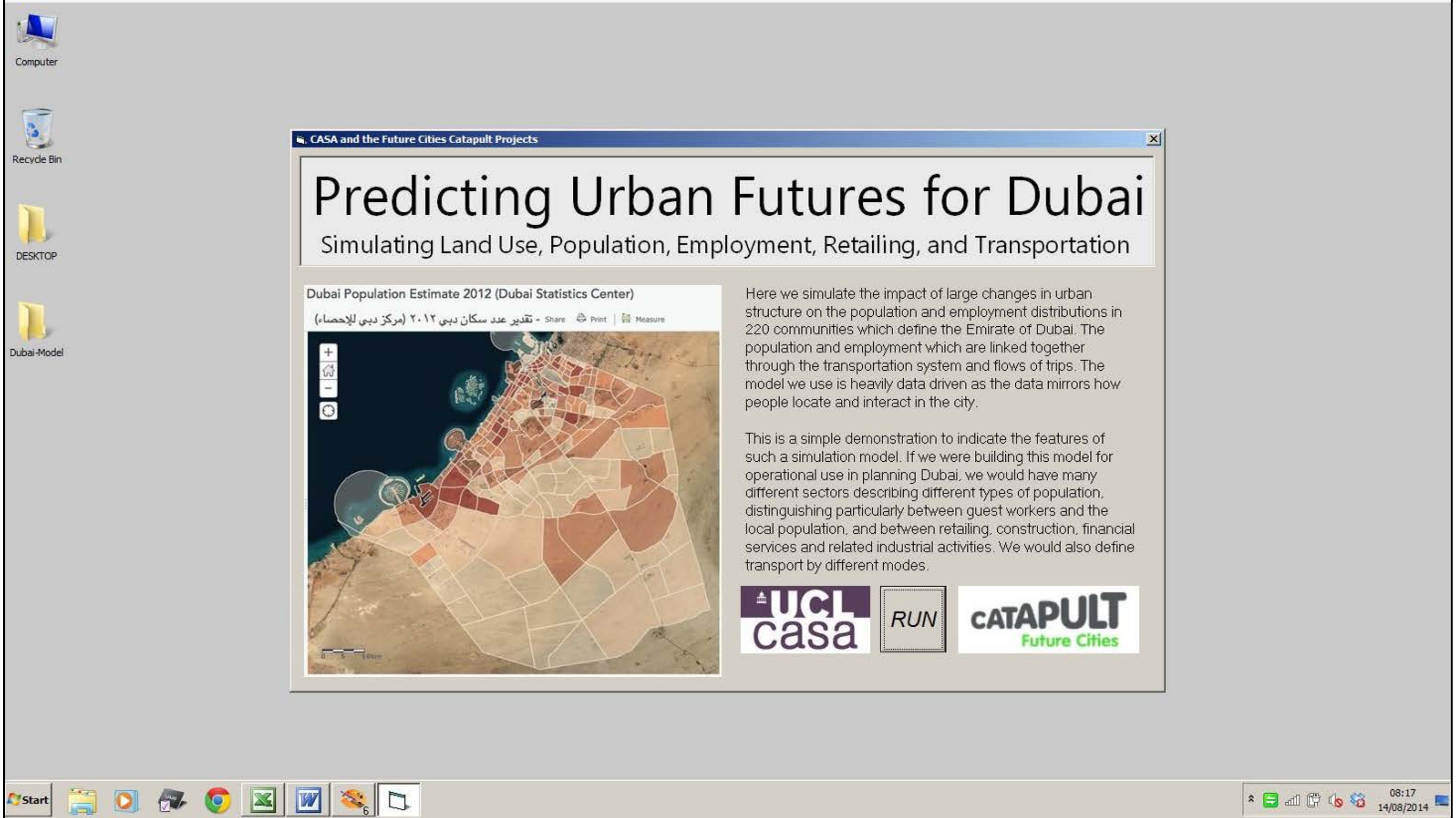
Where did we get the data – in a data poor environment?

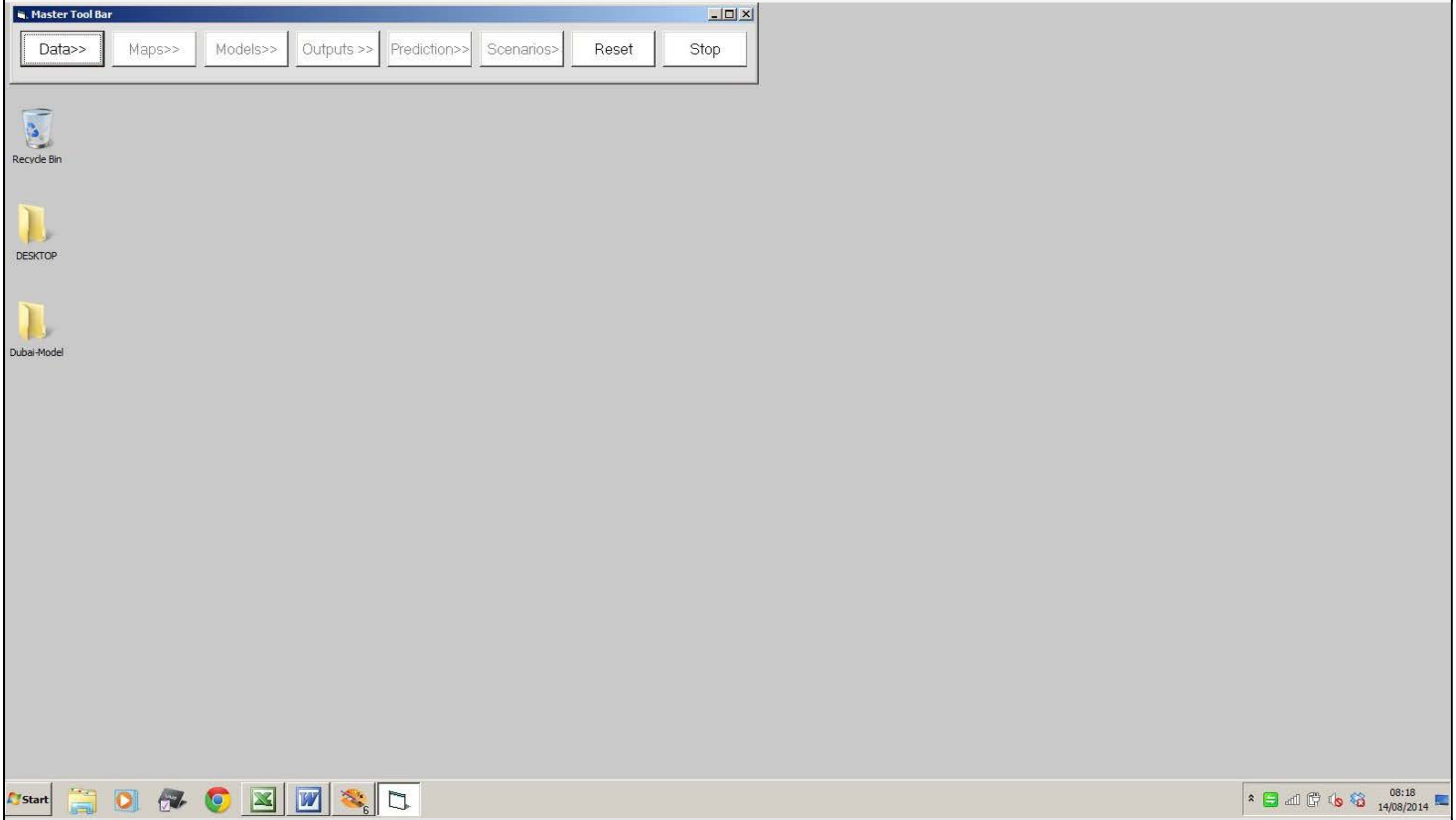









Computer
Recycle Bin
DESKTOP
Dubai-Model
CASA and the Future Cities Catapult Projects
Predicting Urban Futures for Dubai
Simulating Land Use, Population, Employment, Retailing, and Transportation
Dubai Population Estimate 2012 (Dubai Statistics Center)
تقدير عدد سكان دبي ٢٠١٢ (مركز دبي للإحصاء) - Share Print Measure
Here we simulate the impact of large changes in urban structure on the population and employment distributions in 220 communities which define the Emirate of Dubai. The population and employment which are linked together through the transportation system and flows of trips. The model we use is heavily data driven as the data mirrors how people locate and interact in the city.
This is a simple demonstration to indicate the features of such a simulation model. If we were building this model for operational use in planning Dubai, we would have many different sectors describing different types of population, distinguishing particularly between guest workers and the local population, and between retailing, construction, financial services and related industrial activities. We would also define transport by different modes.
UCL casa
RUN
CATAPULT Future Cities
Start
08:17
14/08/2014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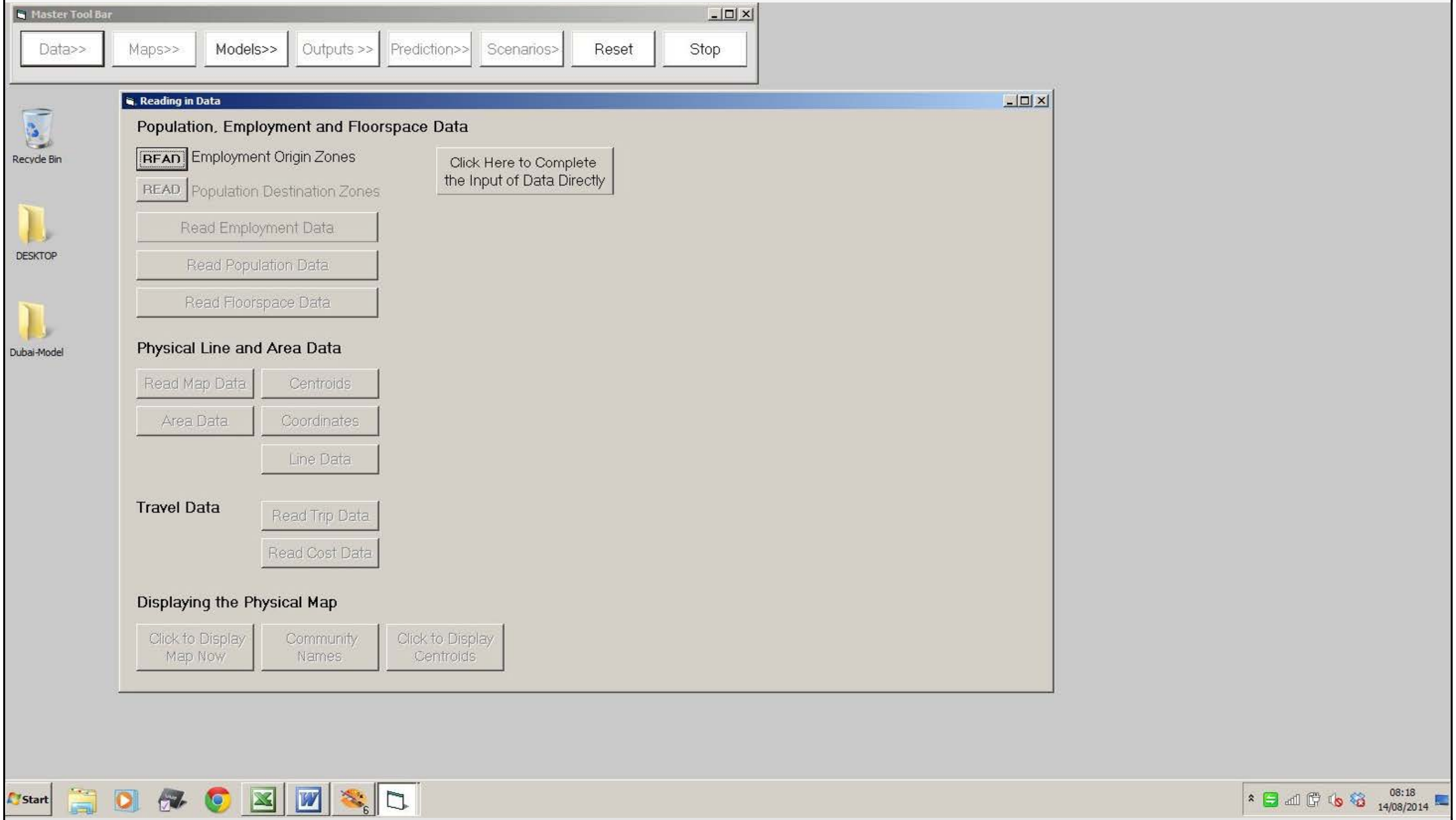
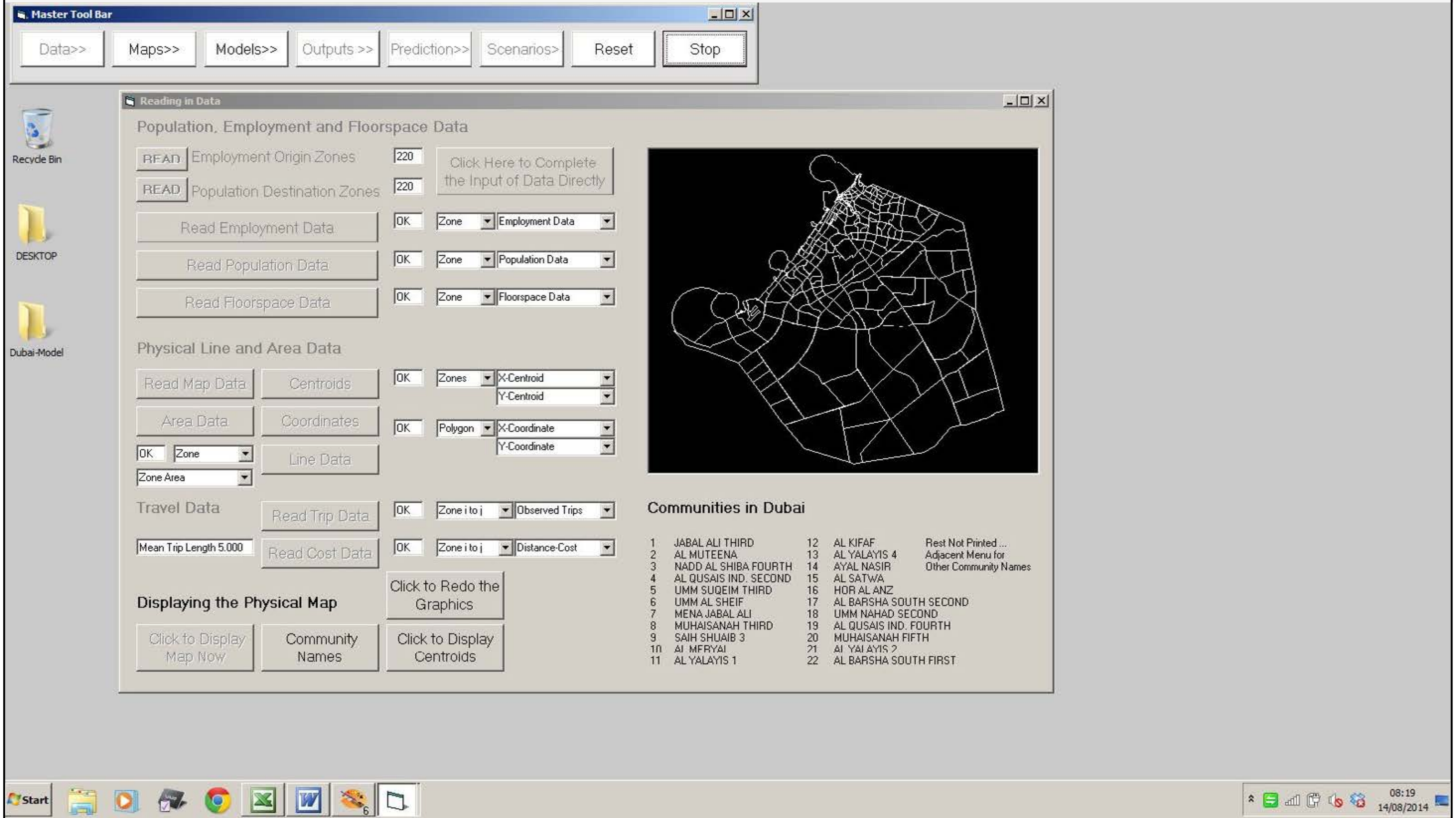
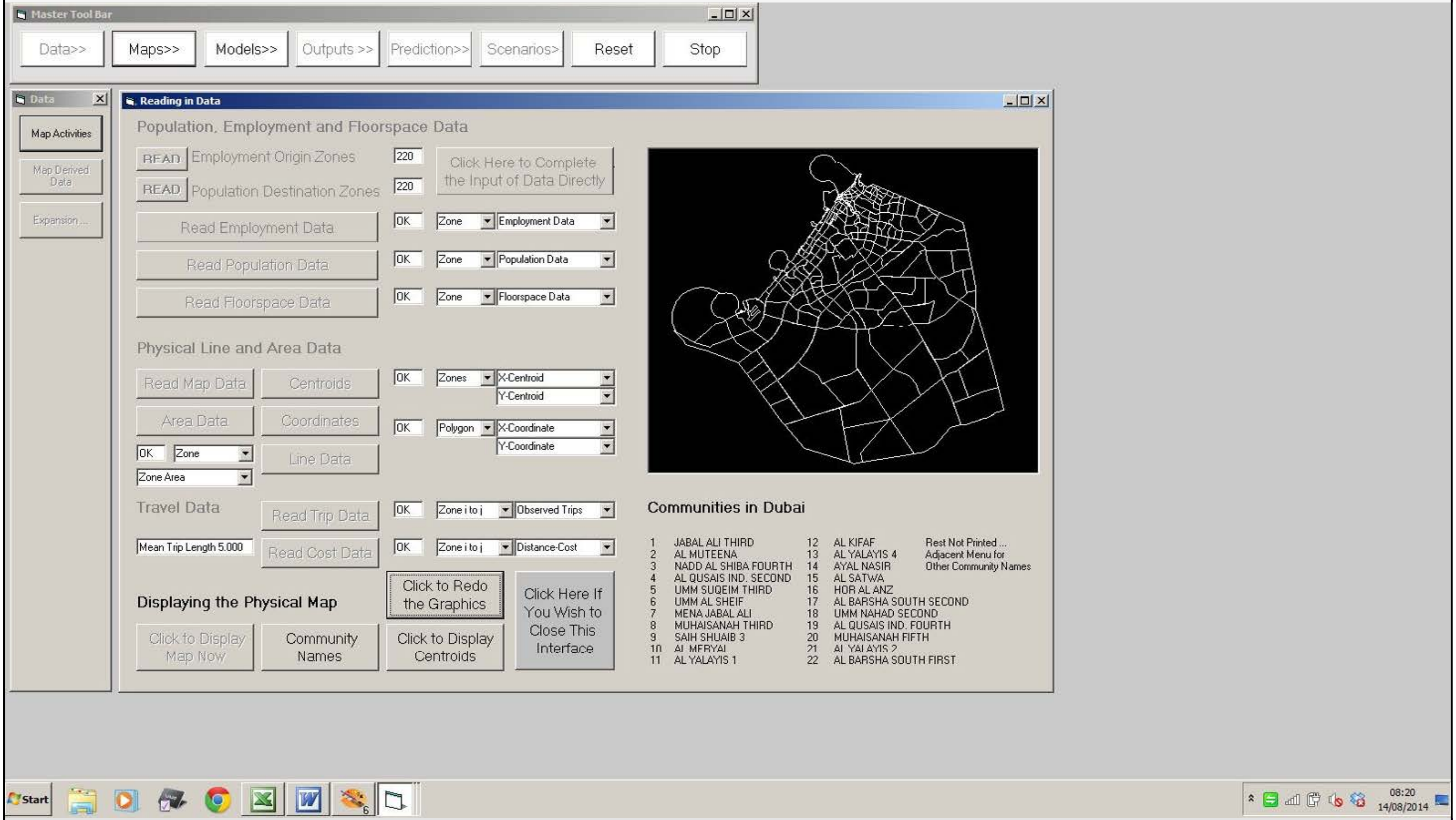
Outputs >>
Prediction>>
Scenarios>
Reset
Stop
Recycle Bin
DESKTOP
Dubai-Model
Start
08:18
14/08/2014


Master Tool Bar
Data>>
Maps>>
Models>>
Outputs >>
Prediction>>
Scenarios>
Reset
Stop
Reading in Data
Population, Employment and Floorspace Data
READ Employment Origin Zones
READ Population Destination Zones
Click Here to Complete the Input of Data Directly
Read Employment Data
Read Population Data
Read Floorspace Data
Physical Line and Area Data
Read Map Data
Centroids
Area Data
Coordinates
Line Data
Travel Data
Read Trip Data
Read Cost Data
Displaying the Physical Map
Click to Display Map Now
Community Names
Click to Display Centroids
Recycle Bin
DESKTOP
Dubai-Model
Start
08:18
14/08/2014



Spatial Interaction 2: The Family of Spatial Interaction Models Again, General Urban Models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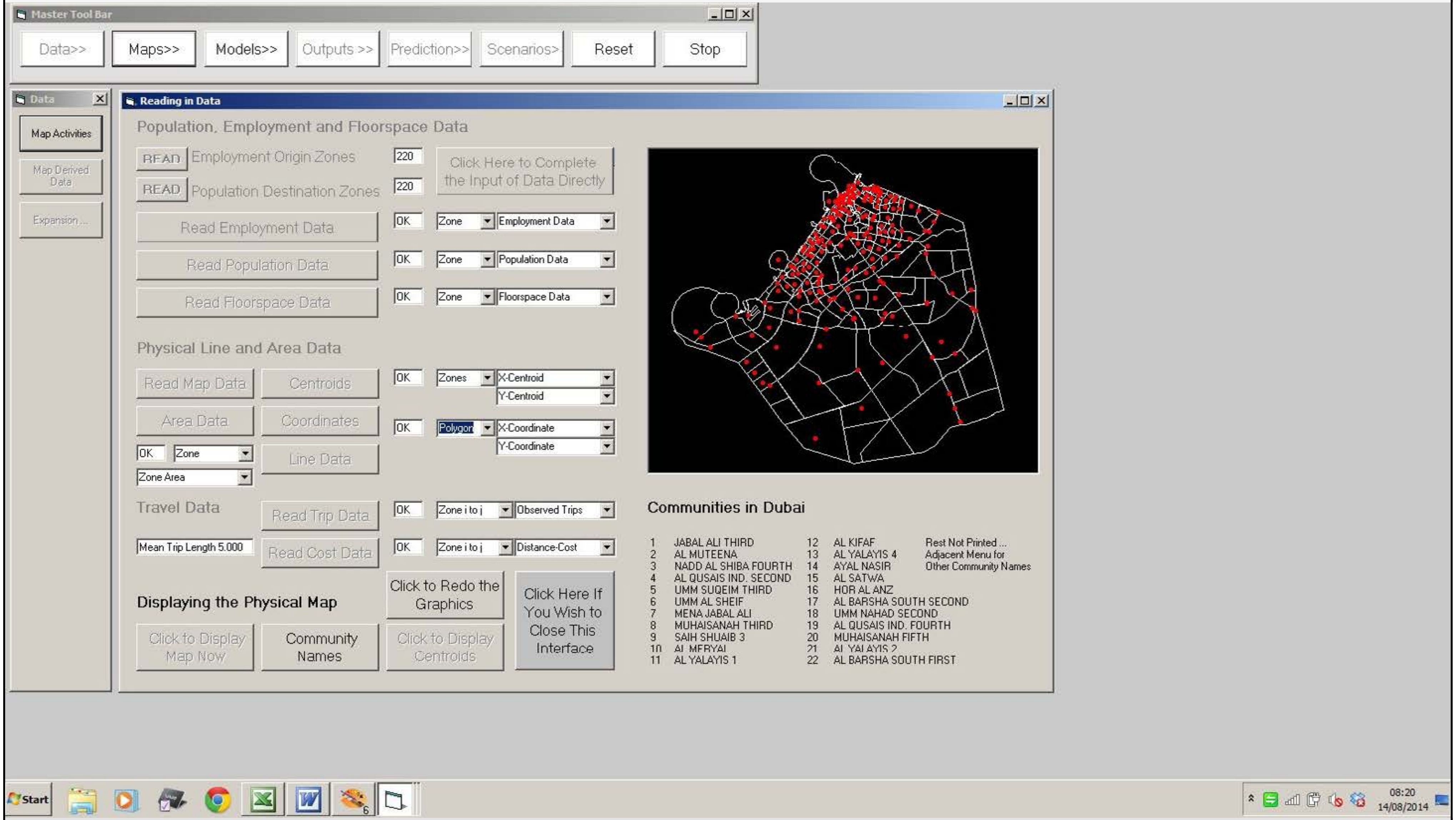
Data>>
Maps>>
Models>>
Outputs >>
Prediction>>
Scenarios>
Reset
Stop
Data
Map Activities
Map Derived Data
Expansion ...
Reading in Data
Population, Employment and Floorspace Data
READ Employment Origin Zones 220
READ Population Destination Zones 220
Click Here to Complete the Input of Data Directly
Read Employment Data OK Zone Employment Data
Read Population Data OK Zone Population Data
Read Floorspace Data OK Zone Floorspace Data
Physical Line and Area Data
Read Map Data
Centroids
OK Zones X-Centroid Y-Centroid
Area Data
Coordinates
OK Polygon X-Coordinate Y-Coordinate
OK Zone
Zone Area
Line Data
Travel Data
Read Trip Data OK Zone i to j Observed Trips
Mean Trip Length 5.000
Read Cost Data OK Zone i to j Distance-Cost
Displaying the Physical Map
Click to Redo the Graphics
Click Here If You Wish to Close This Interface
Click to Display Map Now
Community Names
Click to Display Centroids
Communities in Dubai
1 JABAL ALI THIRD
2 AL MUTEENA
3 NADD AL SHIBA FOURTH
4 AL QUSAIS IND. SECOND
5 UMM SUQEIM THIRD
6 UMM AL SHEIF
7 MENA JABAL ALI
8 MUHAISANAH THIRD
9 SAIH SHUAIB 3
10 AL MERYAL
11 AL YALAYIS 1
12 AL KIFAF
13 AL YALAYIS 4
14 AYAL NASIR
15 AL SATWA
16 HOR AL ANZ
17 AL BARSHA SOUTH SECOND
18 UMM NAHAD SECOND
19 AL QUSAIS IND. FOURTH
20 MUHAISANAH FIFTH
21 AL YALAYIS 2
22 AL BARSHA SOUTH FIRST
Rest Not Printed ... Adjacent Menu for Other Community Names
Start
08:20
14/08/2014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Maps>>
Models>>
Outputs >>
Prediction>>
Scenarios>
Reset
Stop
Data
Map Activities
Map Derived Data
Expansion ...
Reading in Data
Population, Employment and Floorspace Data
READ Employment Origin Zones
220
READ Population Destination Zones
220
Click Here to Complete the Input of Data Directly
Read Employment Data
OK
Zone
Employment Data
Read Population Data
OK
Zone
Population Data
Read Floorspace Data
OK
Zone
Floorspace Data
Physical Line and Area Data
Read Map Data
Centroids
OK
Zones
X-Centroid
Y-Centroid
Area Data
Coordinates
OK
Polygon
X-Coordinate
Y-Coordinate
OK
Zone
Zone Area
Line Data
Travel Data
Read Trip Data
OK
Zone i to j
Observed Trips
Mean Trip Length 5.000
Read Cost Data
OK
Zone i to j
Distance-Cost
Displaying the Physical Map
Click to Redo the Graphics
Click Here If You Wish to Close This Interface
Click to Display Map Now
Community Names
Click to Display Centroids
Communities in Dubai
1 JABAL ALI THIRD
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15 AL SATWA
16 HOR AL ANZ
17 AL BARSHA SOUTH SECOND
18 UMM NAHAD SECOND
19 AL QUSAIS IND. FOURTH
20 MUHAISANAH FIFTH
21 AL YALAYIS 2
22 AL BARSHA SOUTH FIRST
Rest Not Printed ...
Adjacent Menu for
Other Community Names
Start
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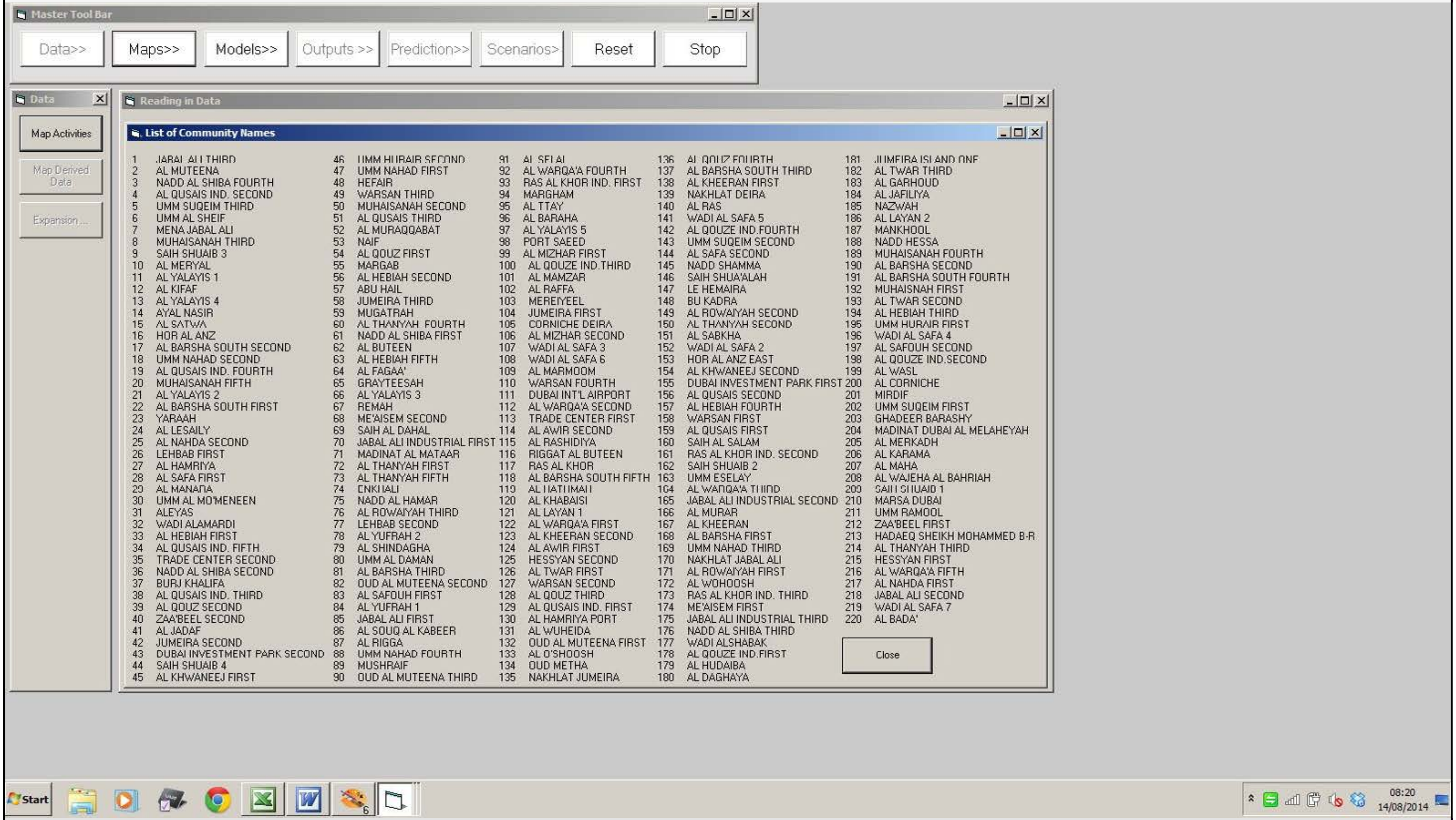
14/08/2014



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Prediction>>
Scenarios>
Reset
Stop
Data
Map Activities
Map Derived Data
Expansion ...
Reading in Data
List of Community Names
1 JABAL ALI THIRD
2 AL MUTEENA
3 NADD AL SHIBA FOURTH
4 AL QUSAIS IND. SECOND
5 UMM SUQEIM THIRD
6 UMM AL SHEIF
7 MENA JABAL ALI
8 MUHAISANAH THIRD
9 SAIH SHUAIB 3
10 AL MERYAL
11 AL YALAYIS 1
12 AL KIFAF
13 AL YALAYIS 4
14 AYAL NASIR
15 AL SATWA
16 HOR AL ANZ
17 AL BARSHA SOUTH SECOND
18 UMM NAHAD SECOND
19 AL QUSAIS IND. FOURTH
20 MUHAISANAH FIFTH
21 AL YALAYIS 2
22 AL BARSHA SOUTH FIRST
23 YARAAH
24 AL LESAILY
25 AL NAHDA SECOND
26 LEHBAB FIRST
27 AL HAMRIYA
28 AL SAFA FIRST
29 AL MANARA
30 UMM AL MO'MENEEN
31 ALEYAS
32 WADI ALAMARDI
33 AL HEBIAH FIRST
34 AL QUSAIS IND. FIFTH
35 TRADE CENTER SECOND
36 NADD AL SHIBA SECOND
37 BURJ KHALIFA
38 AL QUSAIS IND. THIRD
39 AL QOUZ SECOND
40 ZAA'BEEL SECOND
41 AL JADAF
42 JUMEIRA SECOND
43 DUBAI INVESTMENT PARK SECOND
44 SAIH SHUAIB 4
45 AL KHWANEEJ FIRST
46 UMM HURAIR SECOND
47 UMM NAHAD FIRST
48 HEFAIR
49 WARSAN THIRD
50 MUHAISANAH SECOND
51 AL QUSAIS THIRD
52 AL MURAQQABAT
53 NAIF
54 AL QOUZ FIRST
55 MARGAB
56 AL HEBIAH SECOND
57 ABU HAIL
58 JUMEIRA THIRD
59 MUGATRAH
60 AL THANYAH FOURTH
61 NADD AL SHIBA FIRST
62 AL BUTEEN
63 AL HEBIAH FIFTH
64 AL FAGAA'
65 GRAYTEESAH
66 AL YALAYIS 3
67 REMAH
68 ME'AISEM SECOND
69 SAIH AL DAHAL
70 JABAL ALI INDUSTRIAL FIRST
71 MADINAT AL MATAAR
72 AL THANYAH FIRST
73 AL THANYAH FIFTH
74 ENKHALI
75 NADD AL HAMAR
76 AL ROWAIYAH THIRD
77 LEHBAB SECOND
78 AL YUFRAH 2
79 AL SHINDAGHA
80 UMM AL DAMAN
81 AL BARSHA THIRD
82 OUD AL MUTEENA SECOND
83 AL SAFOUH FIRST
84 AL YUFRAH 1
85 JABAL ALI FIRST
86 AL SOUQ AL KABEER
87 AL RIGGA
88 UMM NAHAD FOURTH
89 MUSHRAIF
90 OUD AL MUTEENA THIRD
91 AL SELAL
92 AL WARQA'A FOURTH
93 RAS AL KHOR IND. FIRST
94 MARGHAM
95 AL TTAY
96 AL BARAHA
97 AL YALAYIS 5
98 PORT SAEED
99 AL MIZHAR FIRST
100 AL QOUZE IND.THIRD
101 AL MAMZAR
102 AL RAFFA
103 MEREIYEEL
104 JUMEIRA FIRST
105 CORNICHE DEIRA
106 AL MIZHAR SECOND
107 WADI AL SAFA 3
108 WADI AL SAFA 6
109 AL MARMOOM
110 WARSAN FOURTH
111 DUBAI INT'L AIRPORT
112 AL WARQA'A SECOND
113 TRADE CENTER FIRST
114 AL AWIR SECOND
115 AL RASHIDIYA
116 RIGGAT AL BUTEEN
117 RAS AL KHOR
118 AL BARSHA SOUTH FIFTH
119 AL HATUMALI
120 AL KHABAISI
121 AL LAYAN 1
122 AL WARQA'A FIRST
123 AL KHEERAN SECOND
124 AL AWIR FIRST
125 HESSYAN SECOND
126 AL TWAR FIRST
127 WARSAN SECOND
128 AL QOUZ THIRD
129 AL QUSAIS IND. FIRST
130 AL HAMRIYA PORT
131 AL WUHEIDA
132 OUD AL MUTEENA FIRST
133 AL O'SHOOSH
134 OUD METHA
135 NAKHLAT JUMEIRA
136 AL QOUZ FOURTH
137 AL BARSHA SOUTH THIRD
138 AL KHEERAN FIRST
139 NAKHLAT DEIRA
140 AL RAS
141 WADI AL SAFA 5
142 AL QOUZE IND.FOURTH
143 UMM SUQEIM SECOND
144 AL SAFA SECOND
145 NADD SHAMMA
146 SAIH SHUA'ALAH
147 LE HEMAIRA
148 BU KADRA
149 AL ROWAIYAH SECOND
150 AL THANYAH SECOND
151 AL SABKHA
152 WADI AL SAFA 2
153 HOR AL ANZ EAST
154 AL KHWANEEJ SECOND
155 DUBAI INVESTMENT PARK FIRST
156 AL QUSAIS SECOND
157 AL HEBIAH FOURTH
158 WARSAN FIRST
159 AL QUSAIS FIRST
160 SAIH AL SALAM
161 RAS AL KHOR IND. SECOND
162 SAIH SHUAIB 2
163 UMM ESELAY
164 AL WARQA'A THIRD
165 JABAL ALI INDUSTRIAL SECOND
166 AL MURAR
167 AL KHEERAN
168 AL BARSHA FIRST
169 UMM NAHAD THIRD
170 NAKHLAT JABAL ALI
171 AL ROWAIYAH FIRST
172 AL WOHOOSH
173 RAS AL KHOR IND. THIRD
174 ME'AISEM FIRST
175 JABAL ALI INDUSTRIAL THIRD
176 NADD AL SHIBA THIRD
177 WADI ALSHABAK
178 AL QOUZE IND.FIRST
179 AL HUDAIBA
180 AL DAGHAYA
181 JUMEIRA ISLAND ONE
182 AL TWAR THIRD
183 AL GARHOUD
184 AL JAFILIYA
185 NAZWAH
186 AL LAYAN 2
187 MANKHOOL
188 NADD HESSA
189 MUHAISANAH FOURTH
190 AL BARSHA SECOND
191 AL BARSHA SOUTH FOURTH
192 MUHAISNAH FIRST
193 AL TWAR SECOND
194 AL HEBIAH THIRD
195 UMM HURAIR FIRST
196 WADI AL SAFA 4
197 AL SAFOUH SECOND
198 AL QOUZE IND.SECOND
199 AL WASL
200 AL CORNICHE
201 MIRDIF
202 UMM SUQEIM FIRST
203 GHADEER BARASHY
204 MADINAT DUBAI AL MELAHEYAH
205 AL MERKADH
206 AL KARAMA
207 AL MAHA
208 AL WAJEHA AL BAHRIAH
209 SAIH SHUAIB 1
210 MARSA DUBAI
211 UMM RAMOOL
212 ZAA'BEEL FIRST
213 HADAEQ SHEIKH MOHAMMED B-R
214 AL THANYAH THIRD
215 HESSYAN FIRST
216 AL WARQA'A FIFTH
217 AL NAHDA FIRST
218 JABAL ALI SECOND
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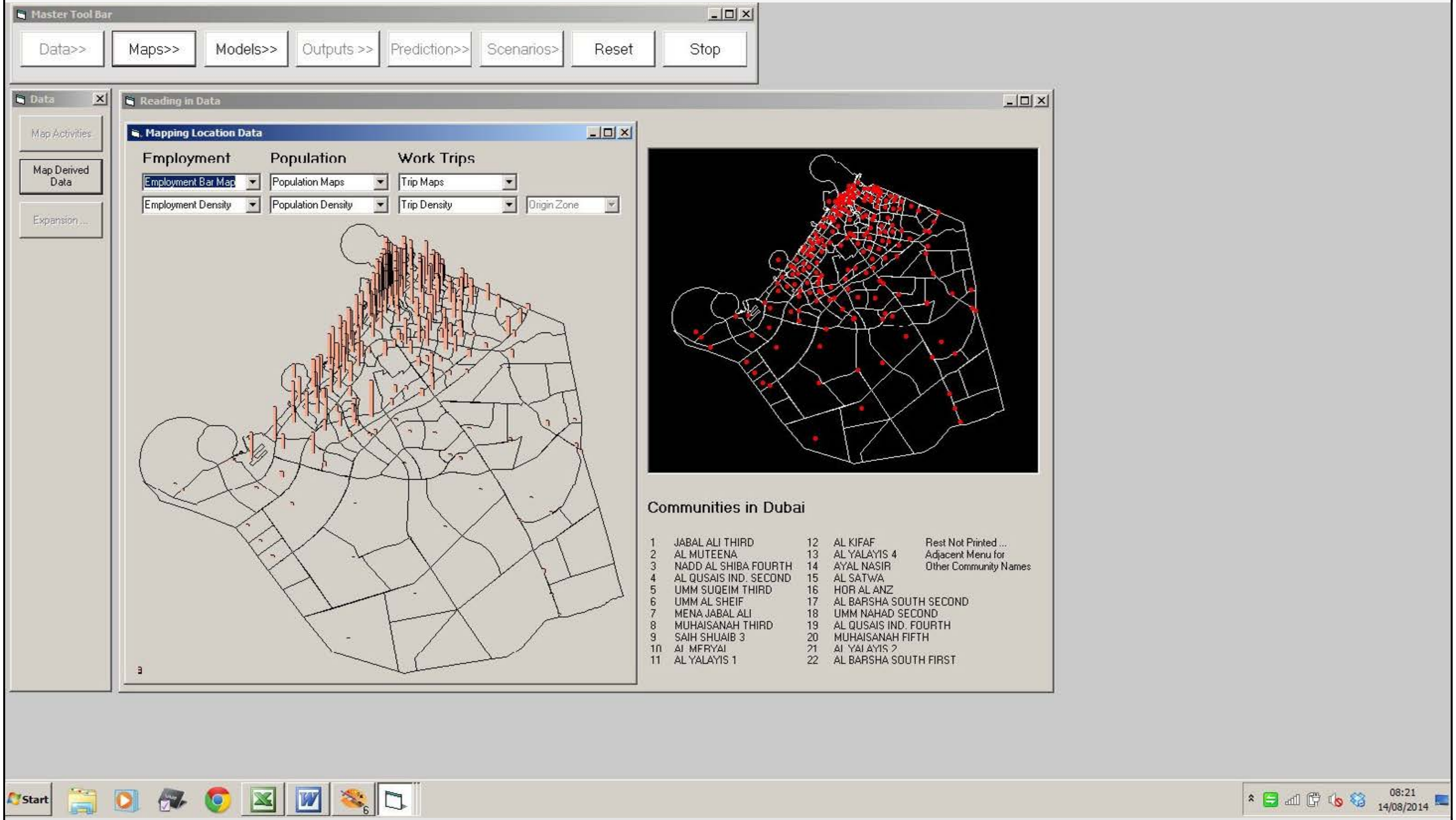
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Mapping Location Data
Employment
Population
Work Trips
Employment Bar Map
Population Maps
Trip Maps
Employment Density
Population Density
Trip Density
Origin Zone
Communities in Dubai
1 JABAL ALI THIRD
2 AL MUTEENA
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13 AL YALAYIS 4
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15 AL SATWA
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18 UMM NAHAD SECOND
19 AL QUSAIS IND. FOURTH
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21 AL YALAYIS 2
22 AL BARSHA SOUTH FIRST
Rest Not Printed ...
Adjacent Menu for
Other Community Names
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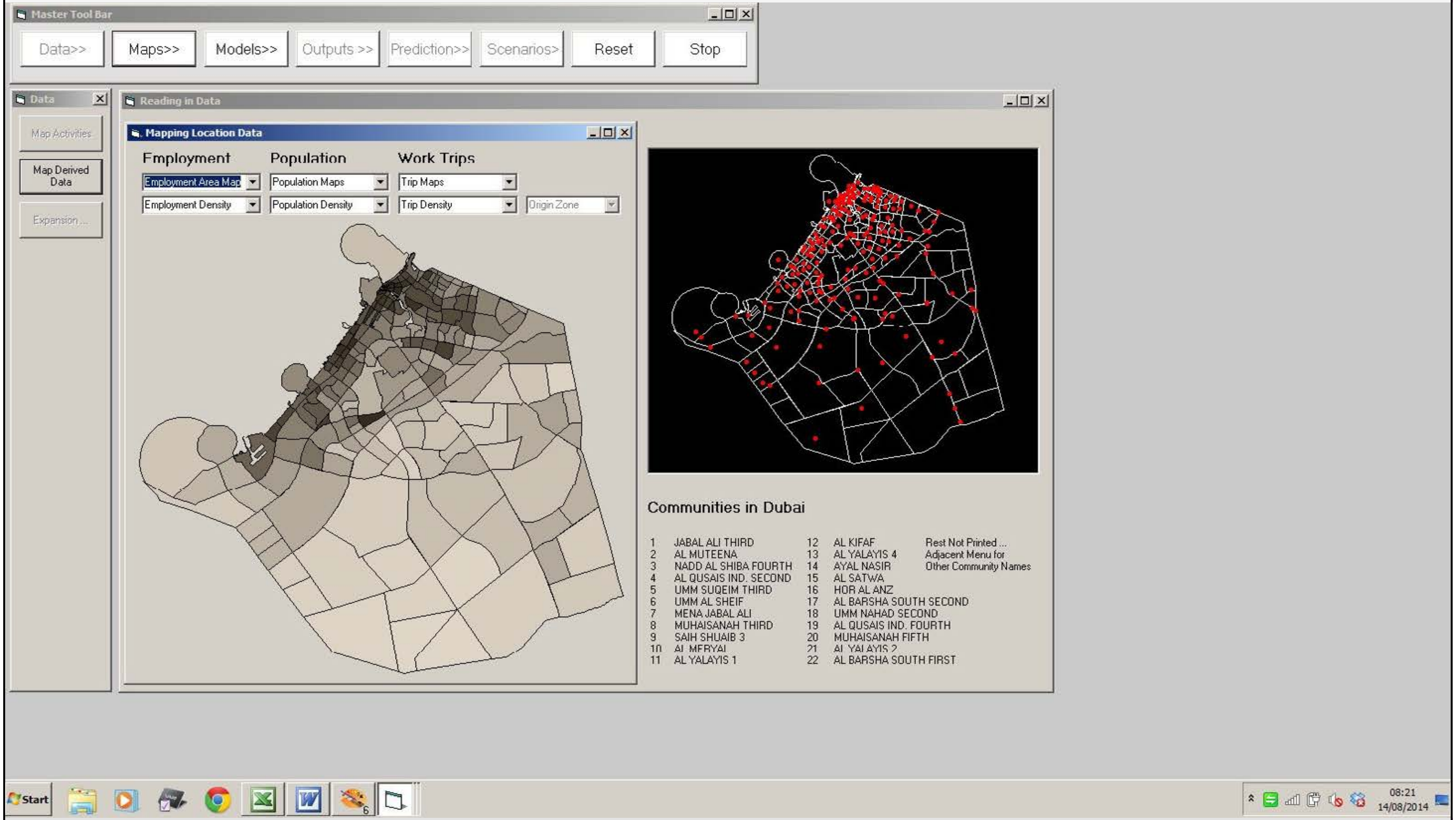
14/08/2014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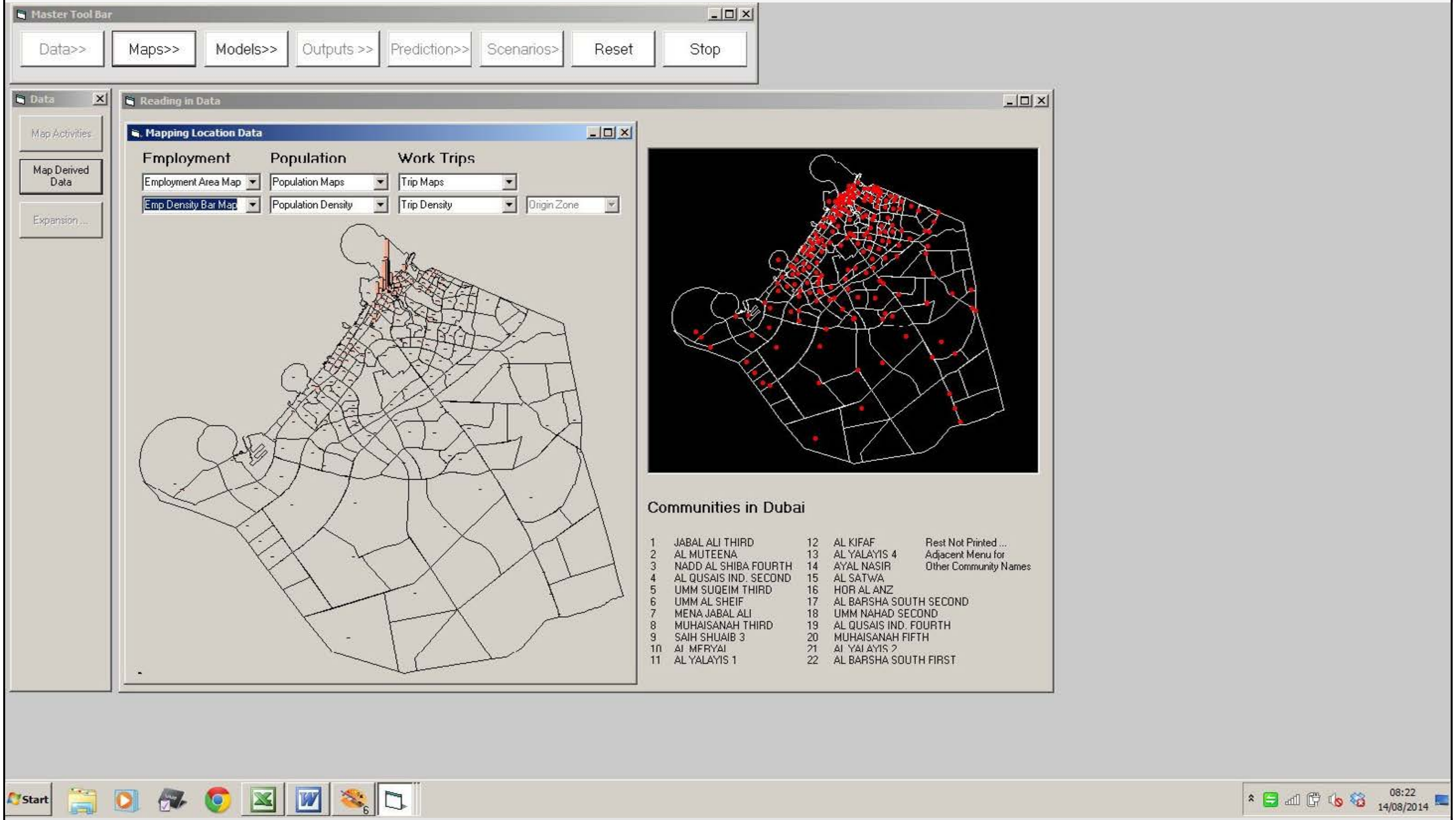
14/08/2014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Trip Maps
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Population Density
Trip Density
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Adjacent Menu for
Other Community Names
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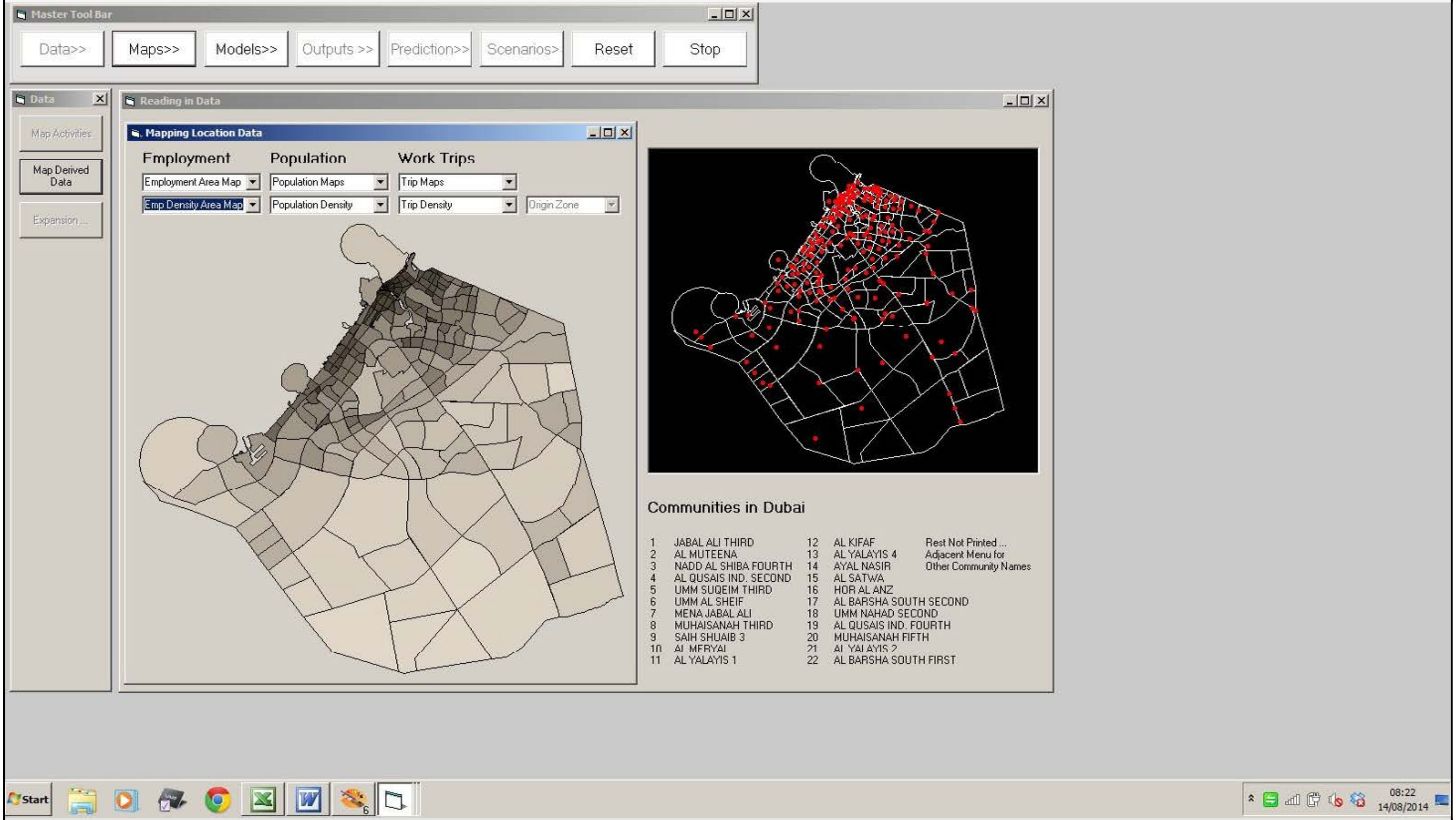
14/08/2014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Scenarios>
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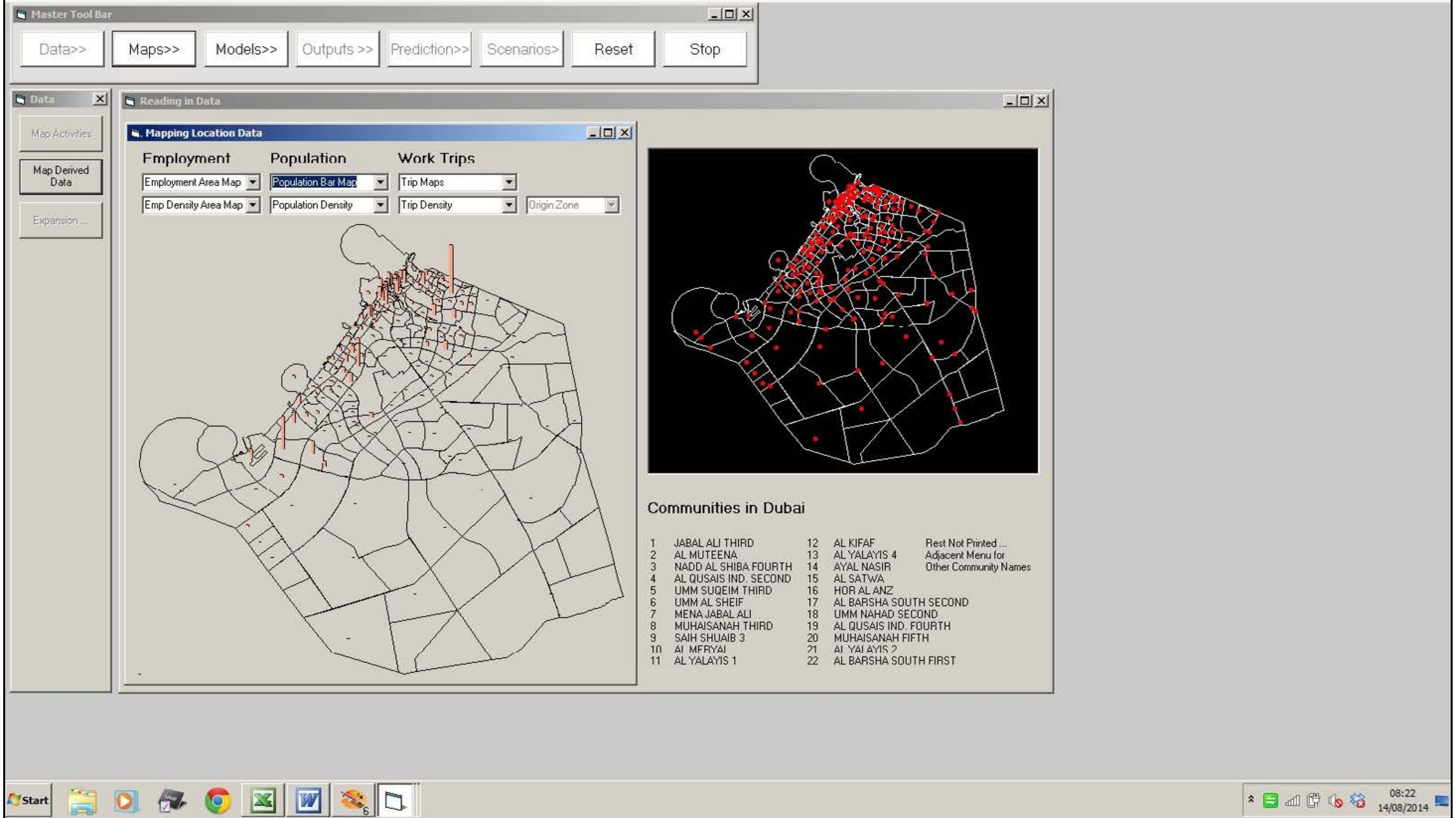
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2 AL MUTEENA
3 NADD AL SHIBA FOURTH
4 AL QUSAIS IND. SECOND
5 UMM SUQEIM THIRD
6 UMM AL SHEIF
7 MENA JABAL ALI
8 MUHAISANAH THIRD
9 SAIH SHUAIB 3
10 AL MERYAL
11 AL YALAYIS 1
12 AL KIFAF
13 AL YALAYIS 4
14 AYAL NASIR
15 AL SATWA
16 HOR AL ANZ
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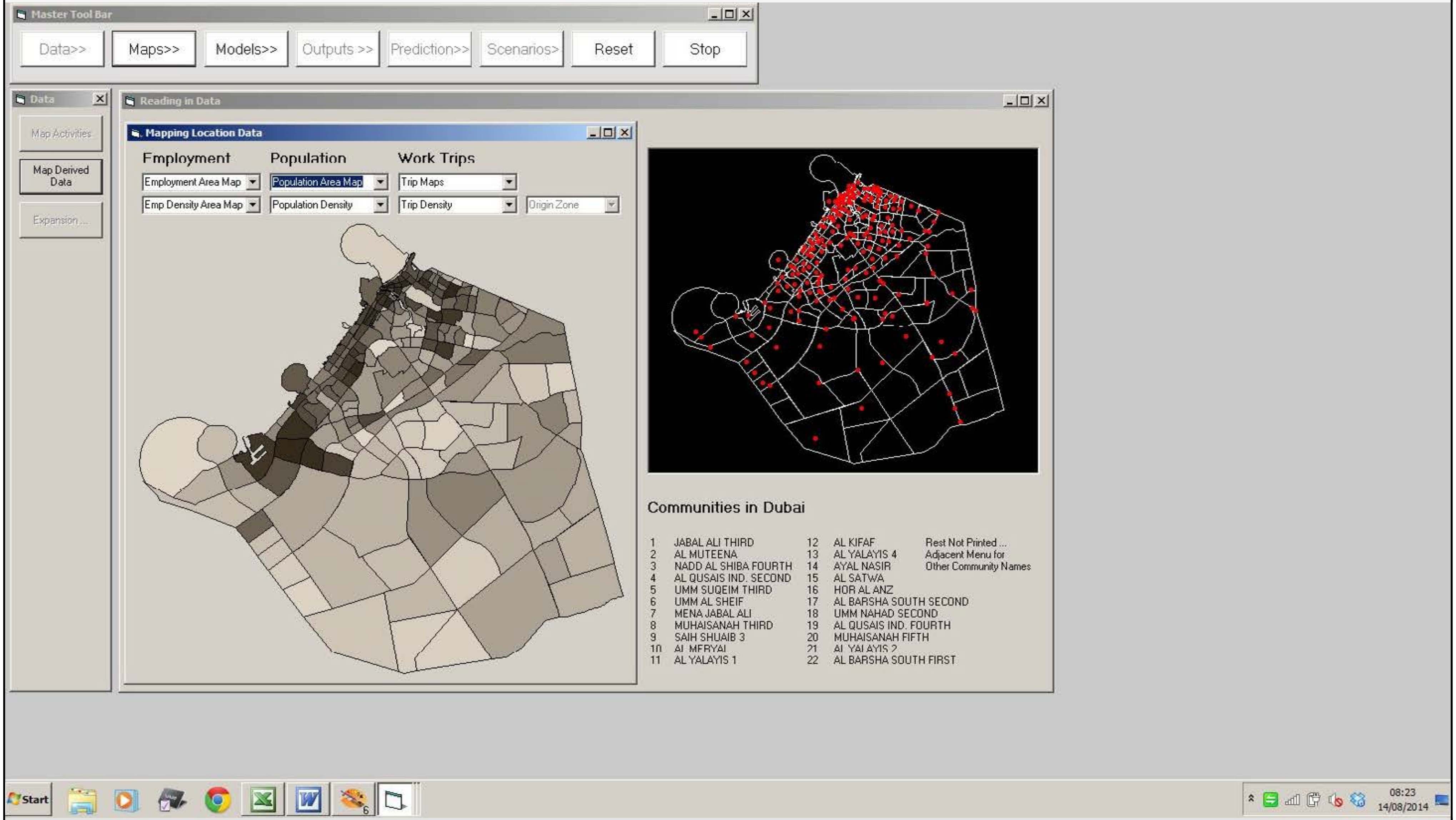
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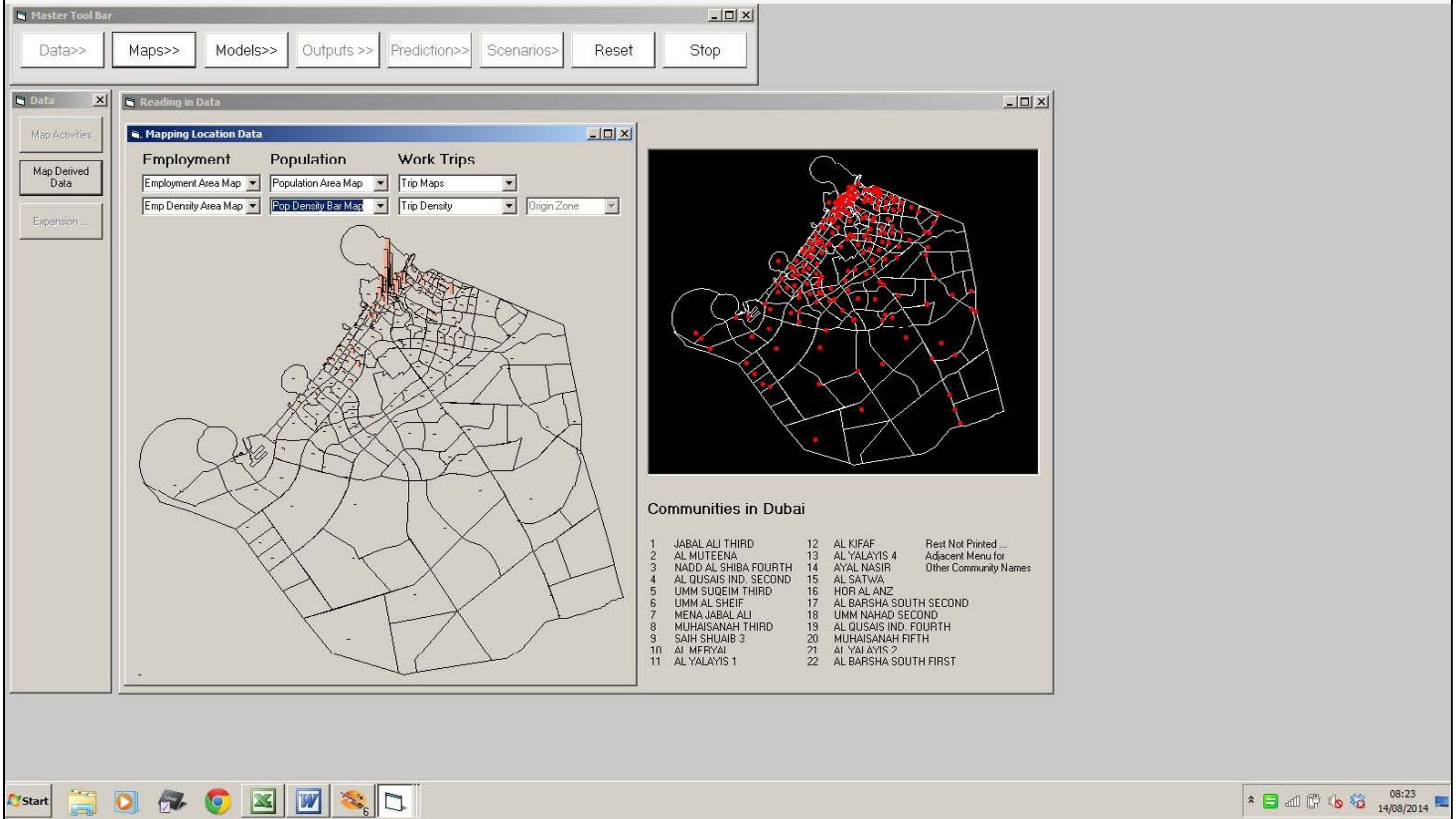
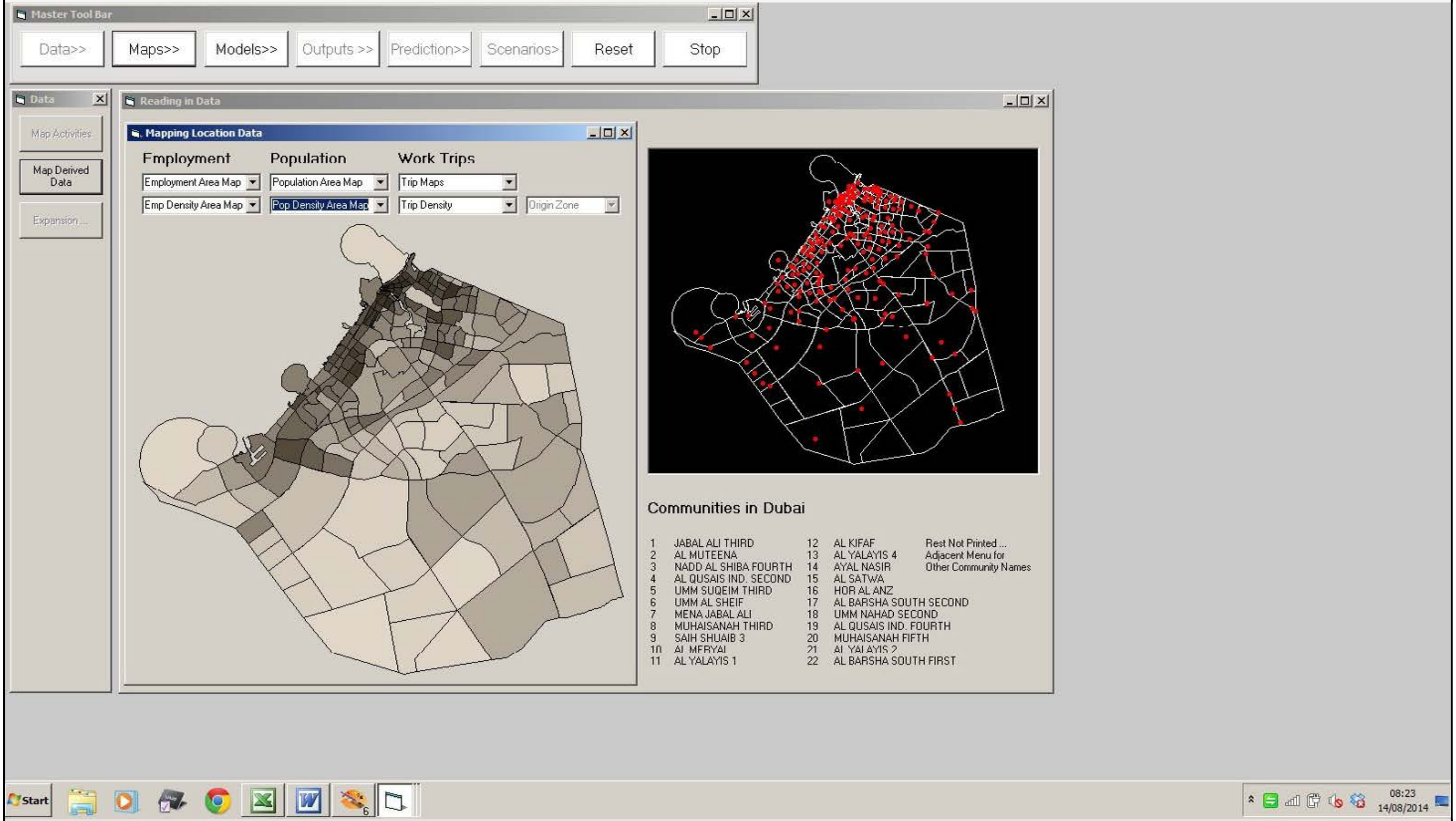


Spatial Interaction 2: The Family of Spatial Interaction Models Again, General Urban Models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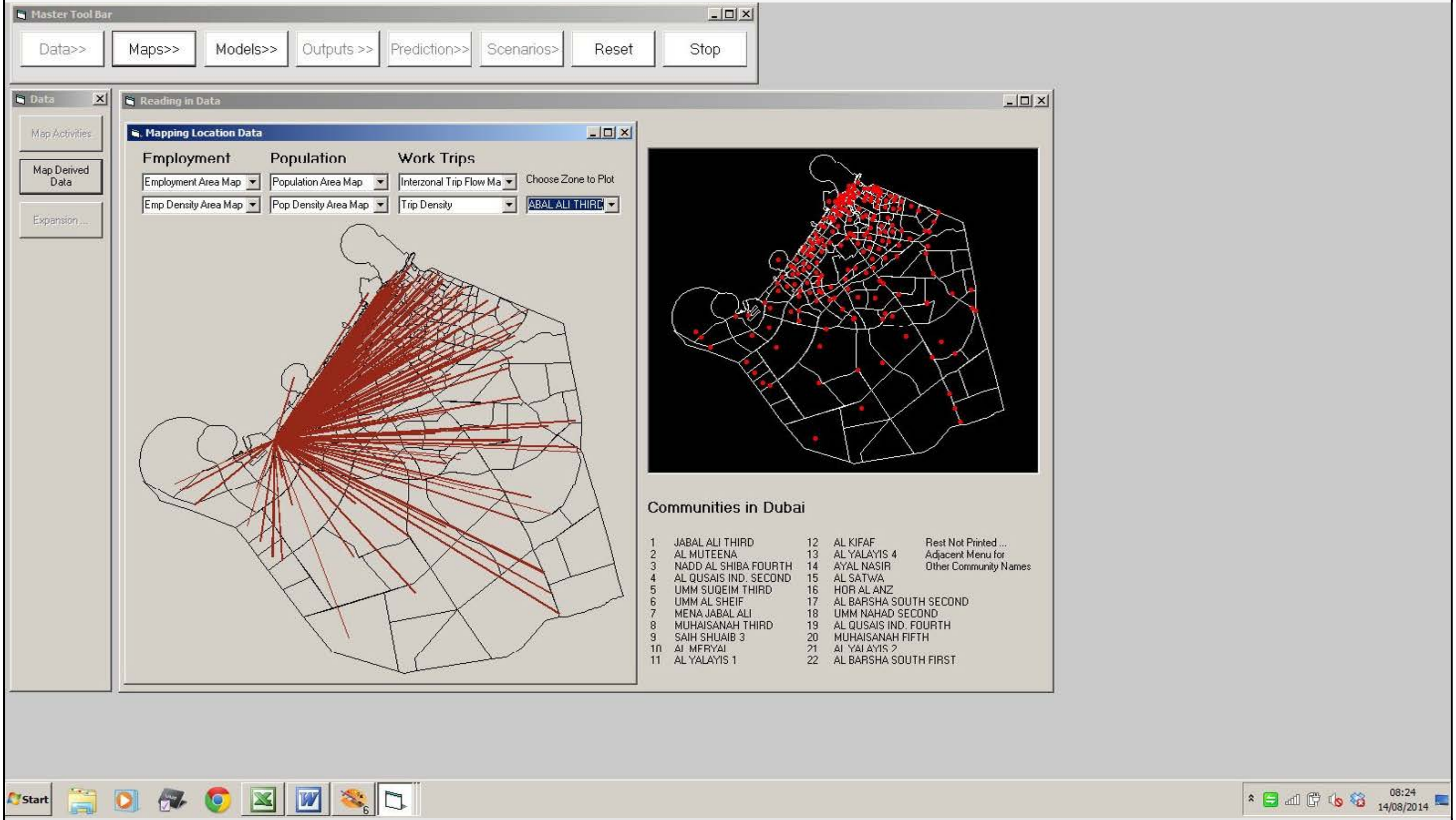
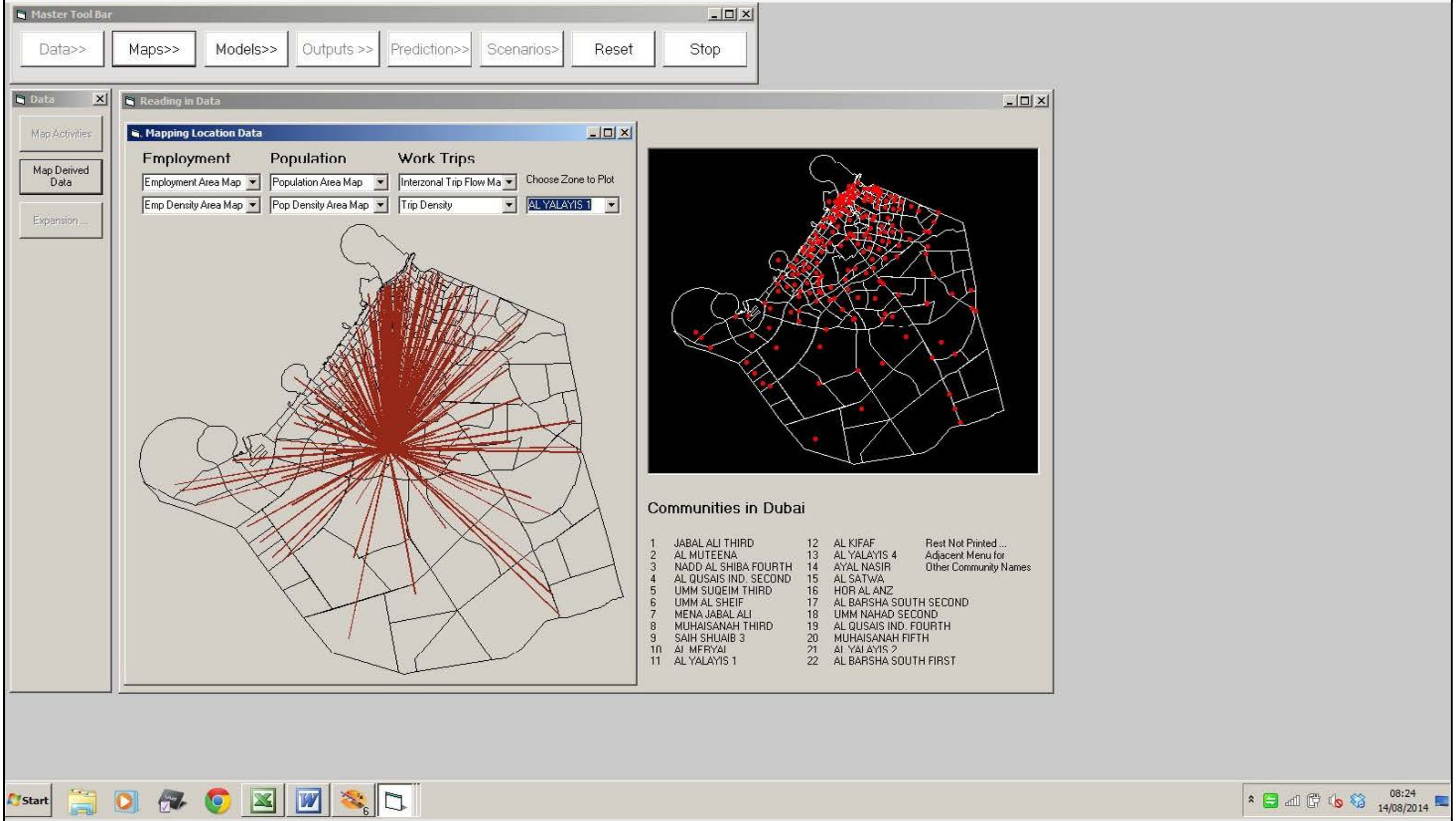
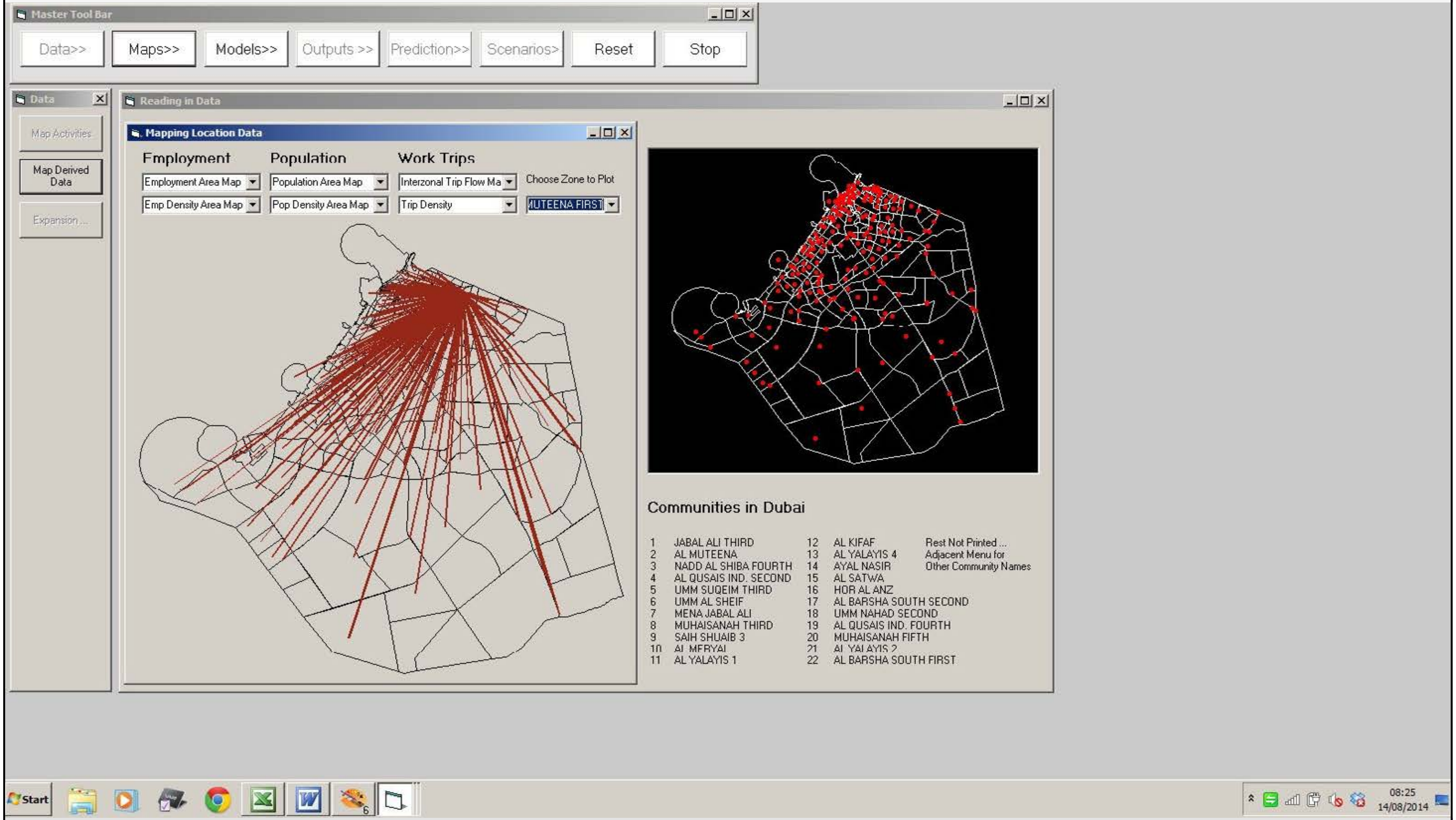


Spatial Interaction 2: The Family of Spatial Interaction Models Again, General Urban Models



Spatial Interaction 2: The Family of Spatial Interaction Models Again, General Urban Models



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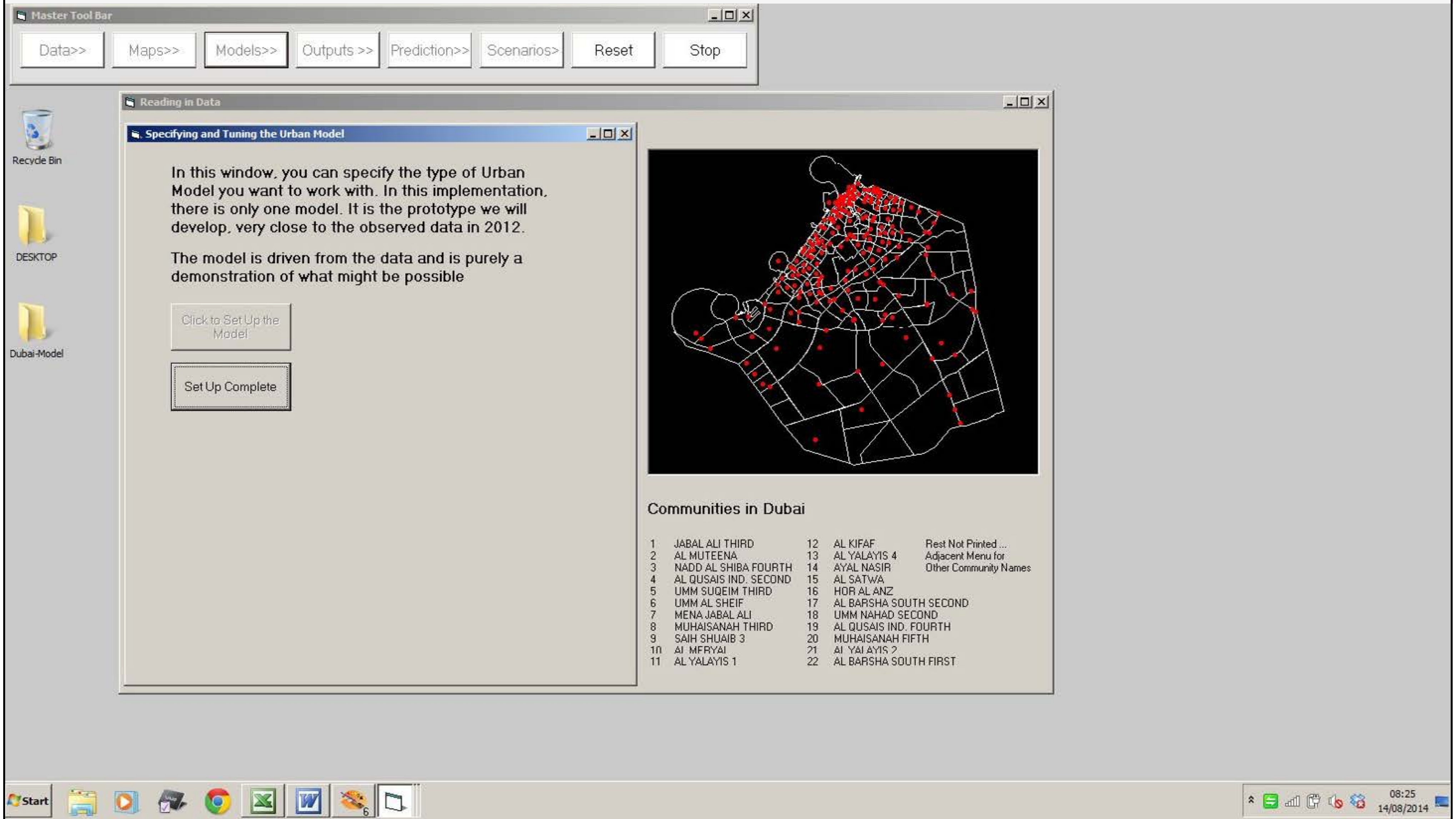
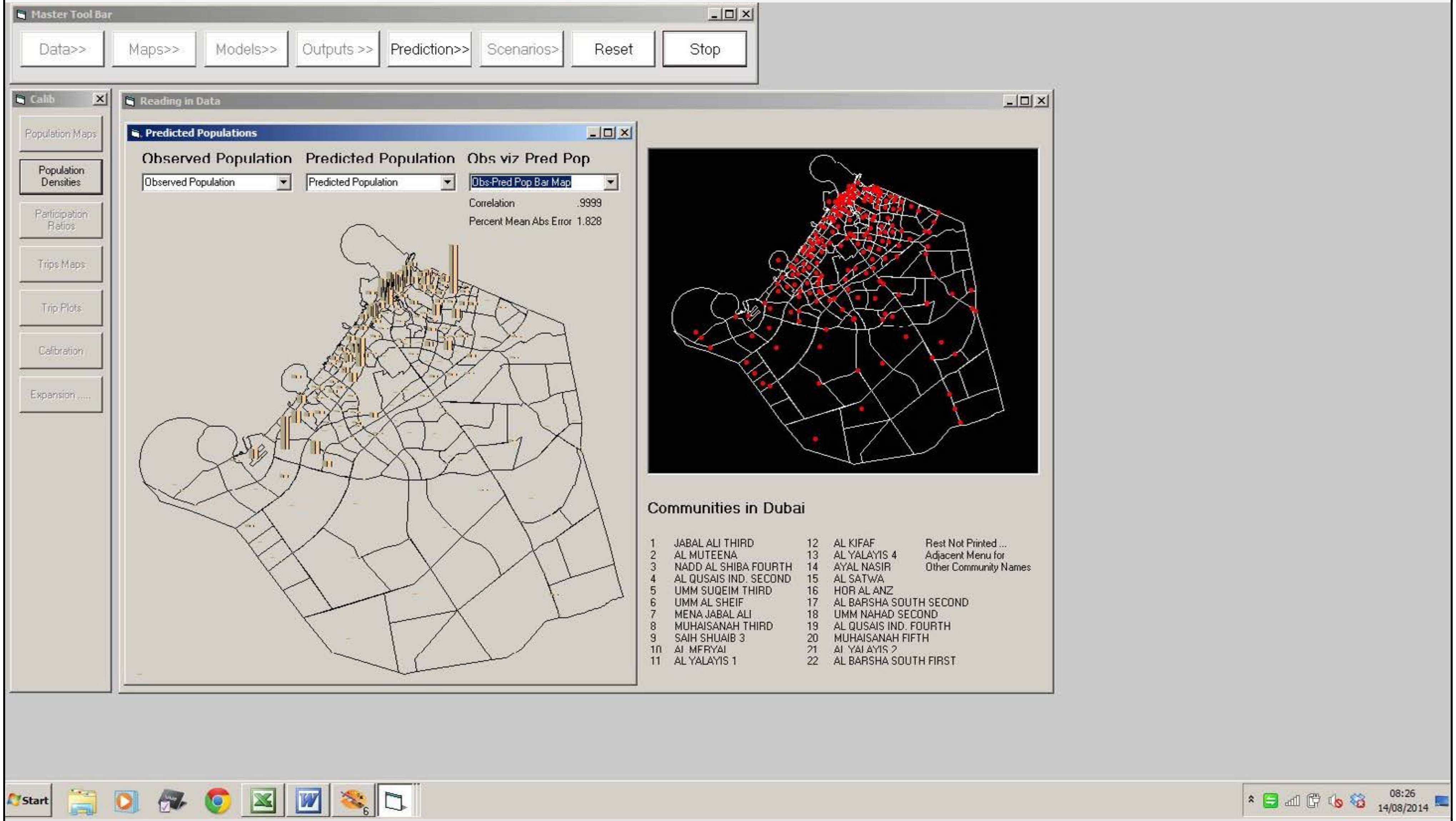


Spatial Interaction 2: The Family of Spatial Interaction Models Again, General Urban Models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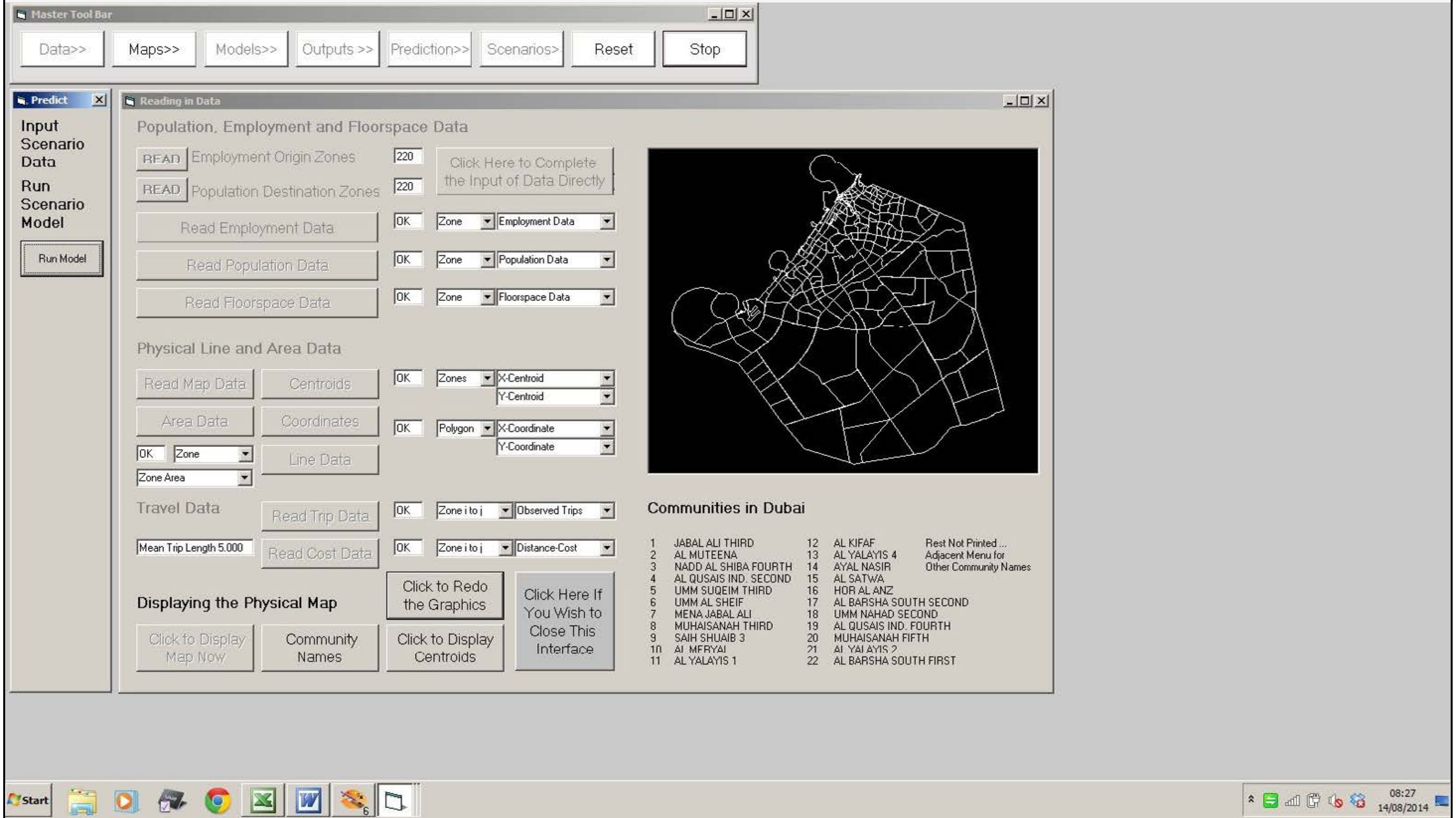
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Run Model
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Population, Employment and Floorspace Data
READ Employment Origin Zones
220
READ Population Destination Zones
220
Click Here to Complete the Input of Data Directly
Read Employment Data
OK
Zone
Employment Data
Read Population Data
OK
Zone
Population Data
Read Floorspace Data
OK
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Floorspace Data
Physical Line and Area Data
Read Map Data
Centroids
OK
Zones
X-Centroid
Y-Centroid
Area Data
Coordinates
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Polygon
X-Coordinate
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Zone Area
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Displaying the Physical Map
Click to Redo the Graphics
Click Here If You Wish to Close This Interface
Click to Display Map Now
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Click to Display Centroids
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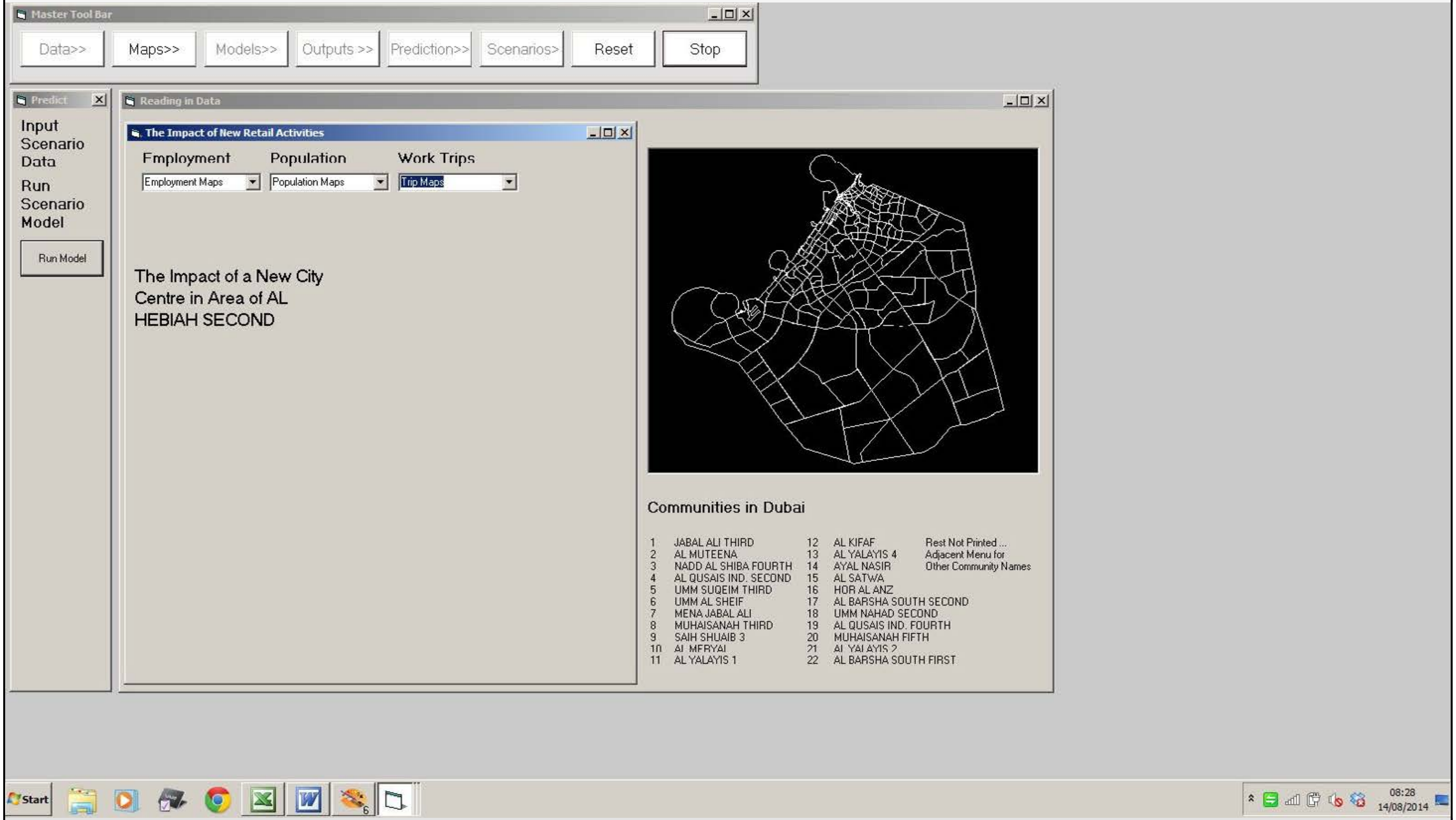

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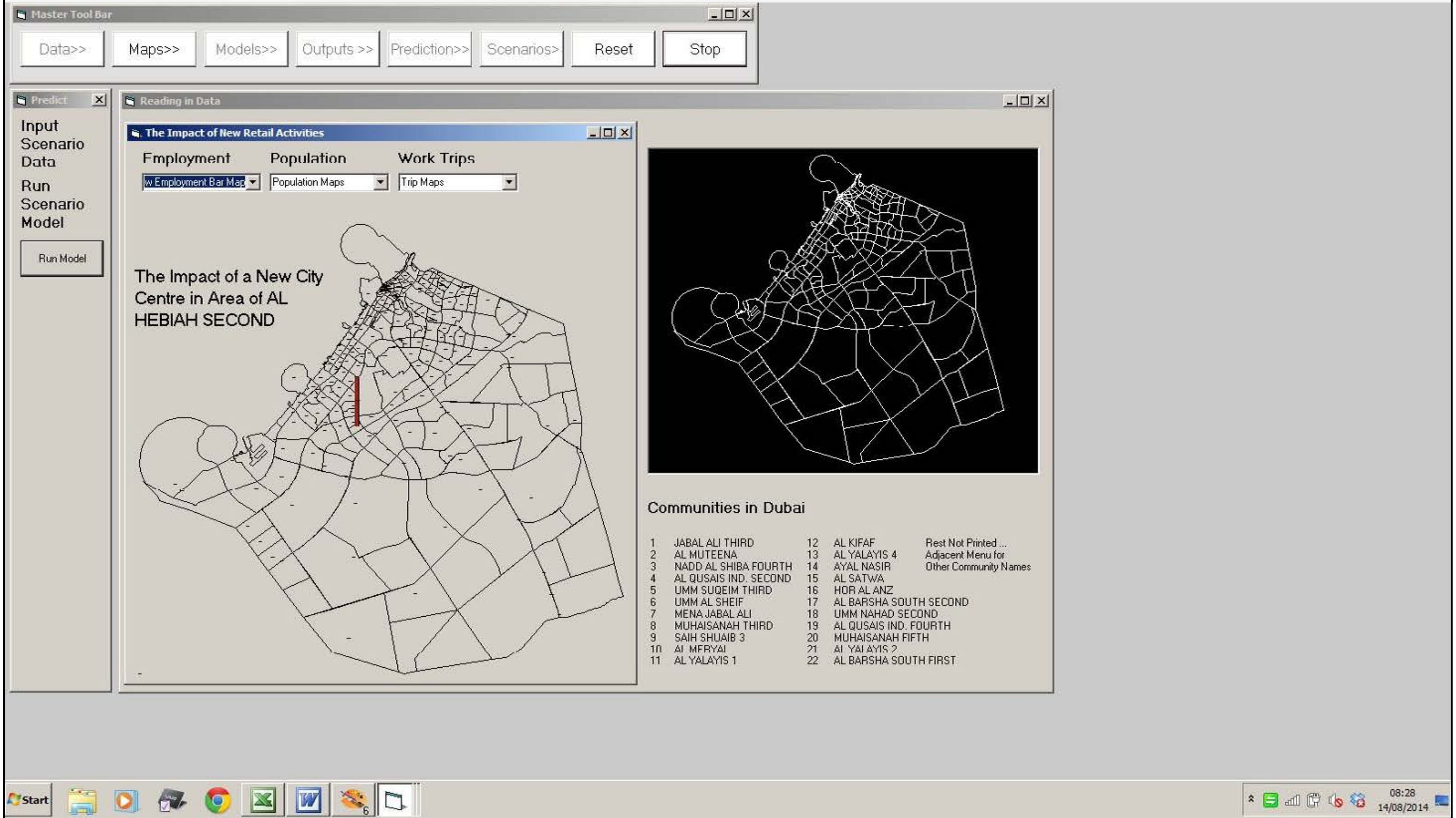
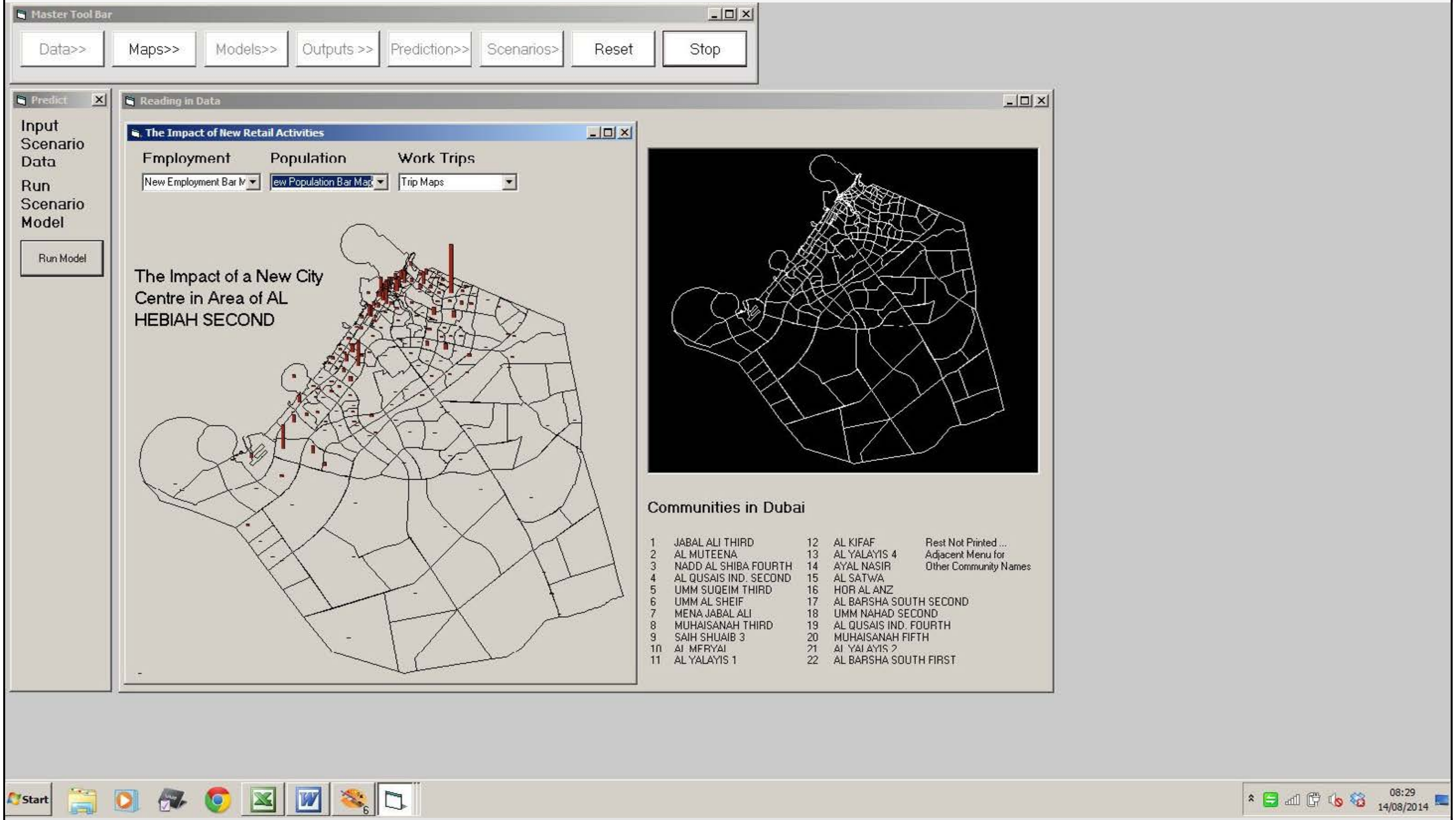


Spatial Interaction 2: The Family of Spatial Interaction Models Again, General Urban Models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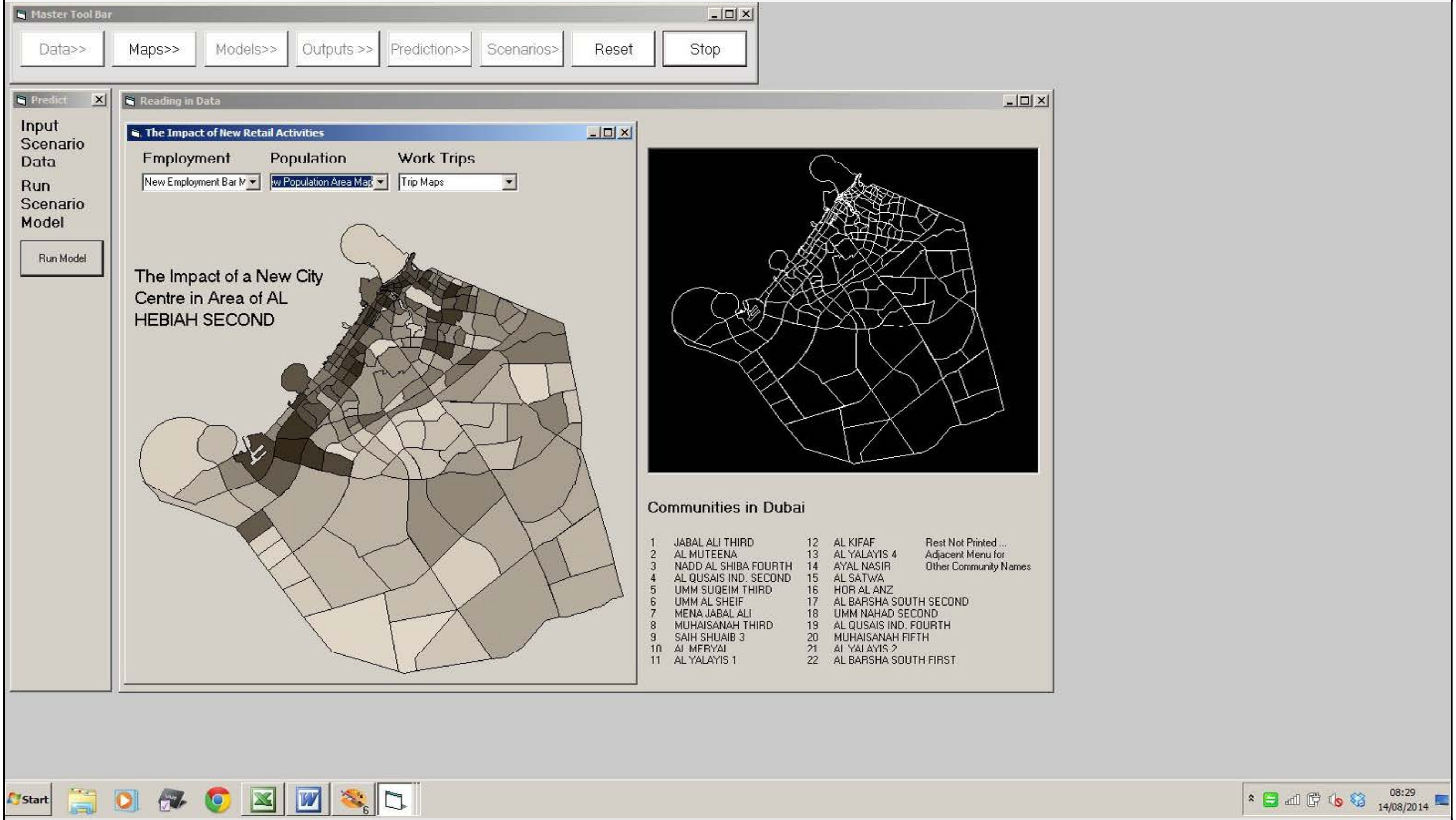
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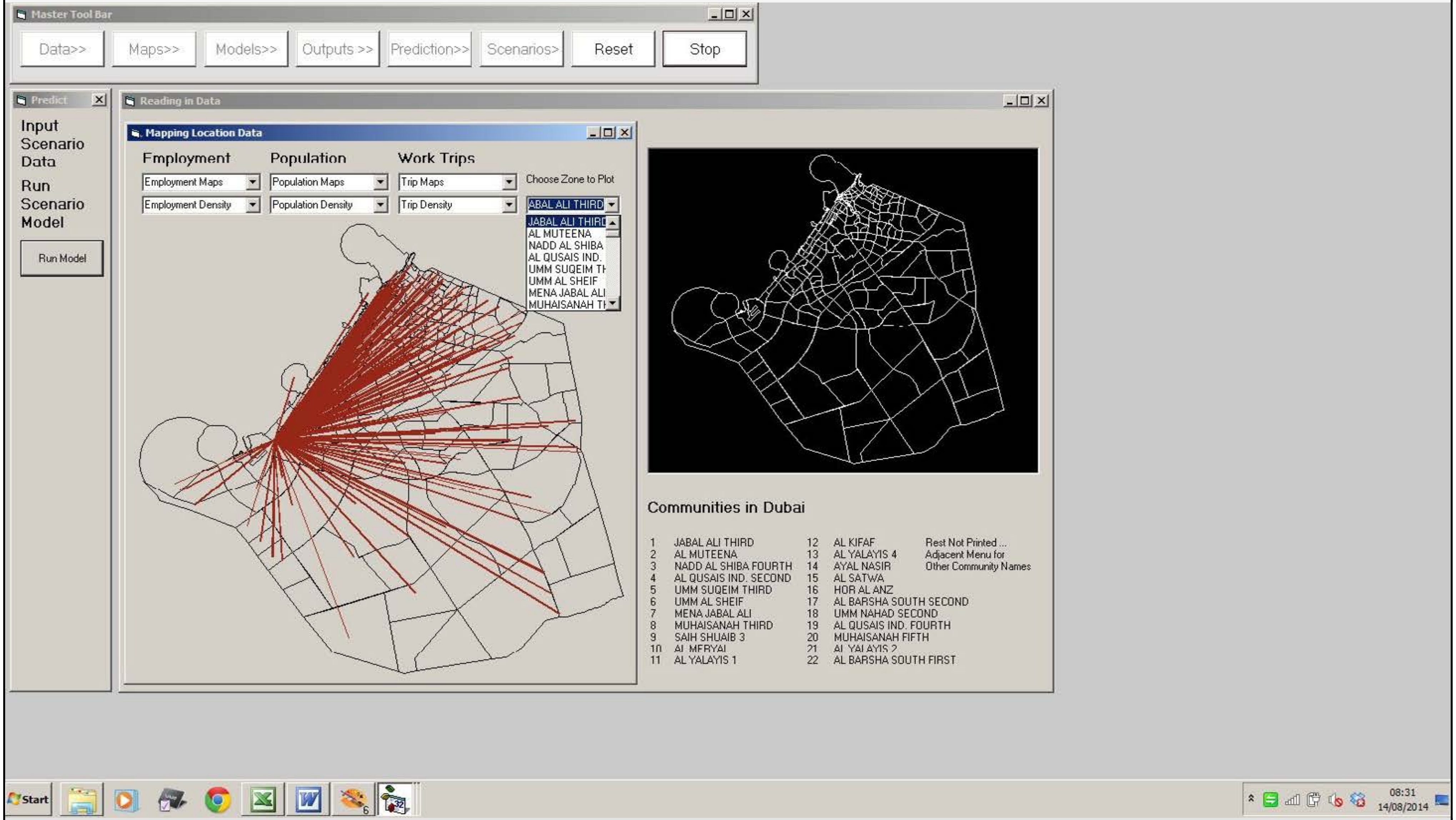
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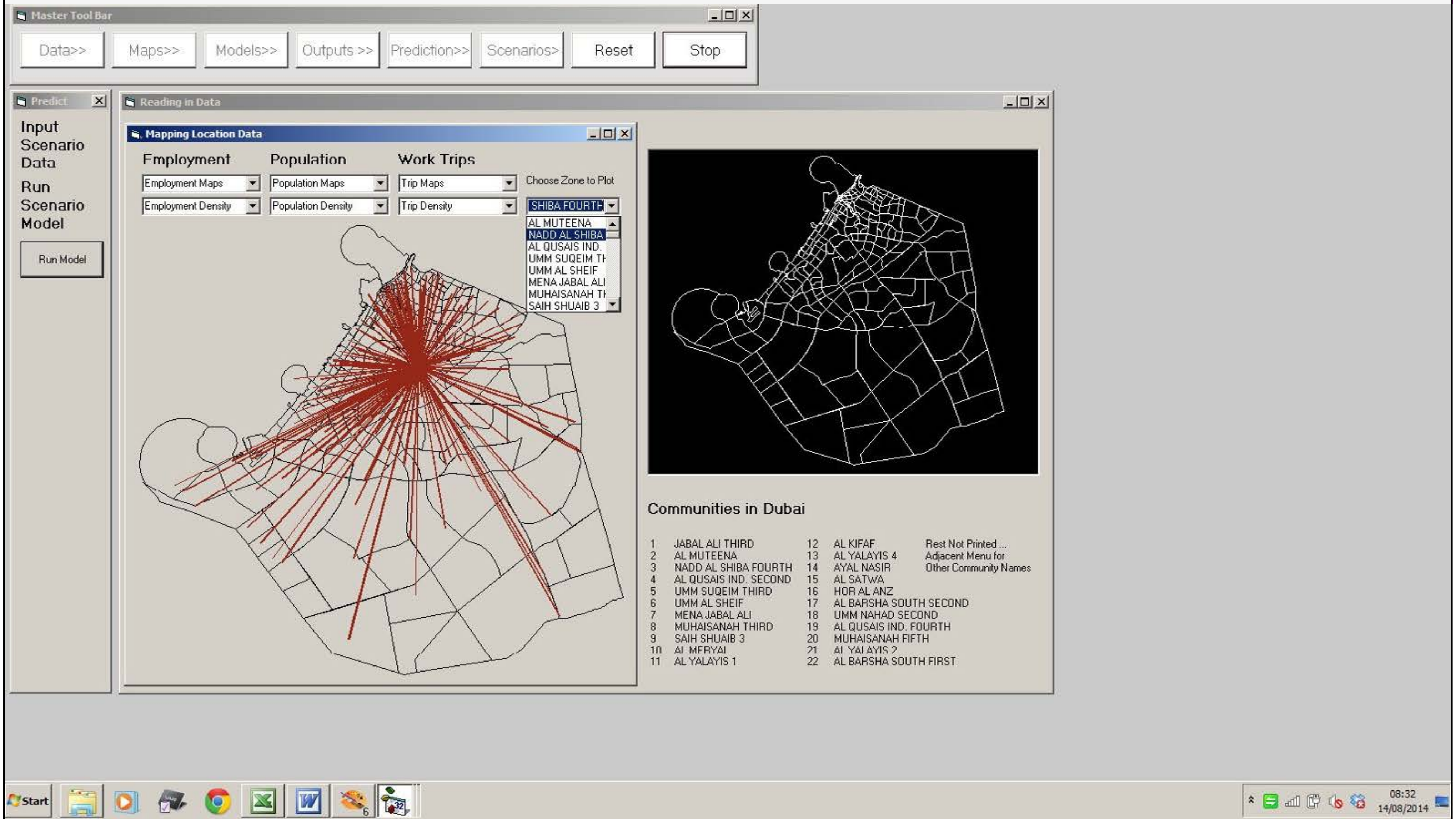
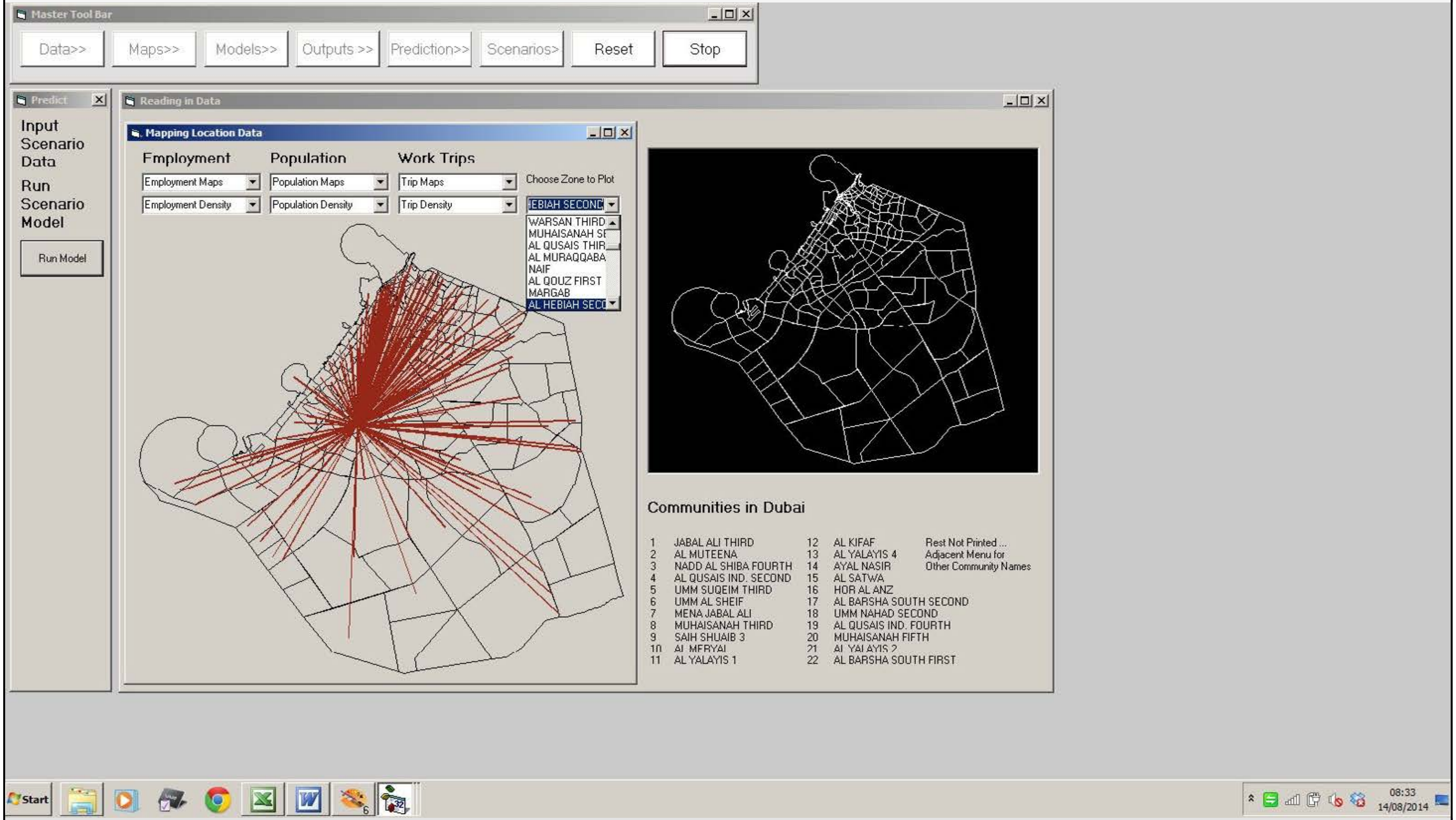


Spatial Interaction 2: The Family of Spatial Interaction Models Again, General Urban Models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Other Community Names
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08:33
14/08/2014

I am bound to have run out of time and we need some questions – which Elsa will act as host for – and anything you want to know about the ipynb programs, please ask the TAS and also post on Slack. Someone will pick them up

m.batty@ucl.ac.uk
@jmichaelbatty

Monday, 23 January 2023