
Conducting experiments, recording output and analysing results of agent-based modelling for social scientists

Dr. J. Kasmire
UK Data Service



13 February 2020

UK Data Service



ABM for social scientists – webinar series

- ABM: An Intro
 - – Jan 16, 2020, recording available
- ABM: Adding Data
 - – Jan 30, 2020
- **ABM: Experiments and Output**
 - – **Feb 13, 2020**

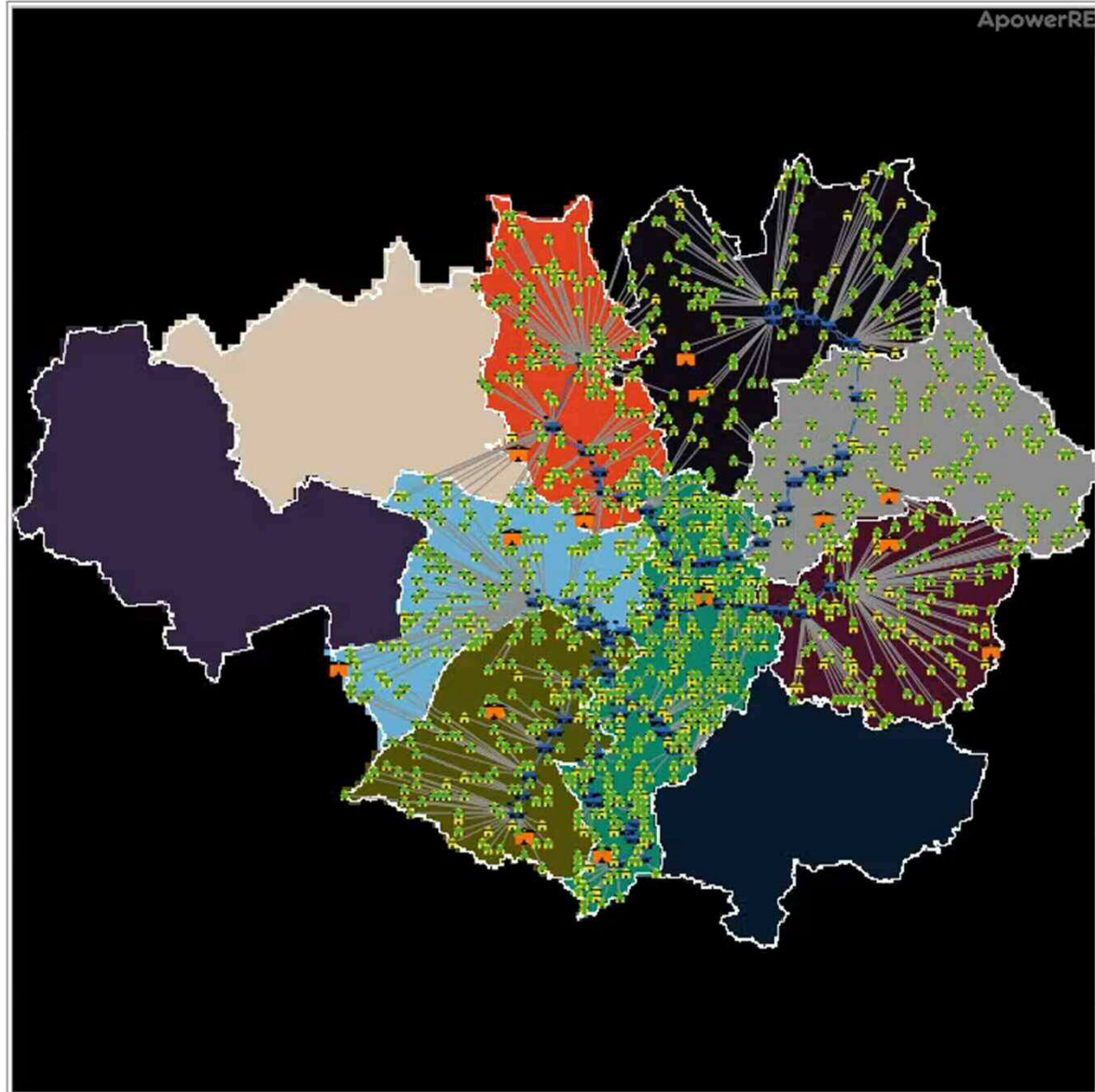


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- Behaviour Space
- Experimentation!
- Getting the right output
- Working with output
- Summary
- Questions



A moment to revisit the "Tram commute" model



Revisit the "Tram commute model"

projection
GM_LAs

setup

Go Go Once

On
 Off Garrulous?

On
 Off Label_Tramstops?

On
 Off Label_LAs?

On
 Off Reduce_Pop_For_Display?

On
 Off Tram_Commute_Only?

Output_File
Test

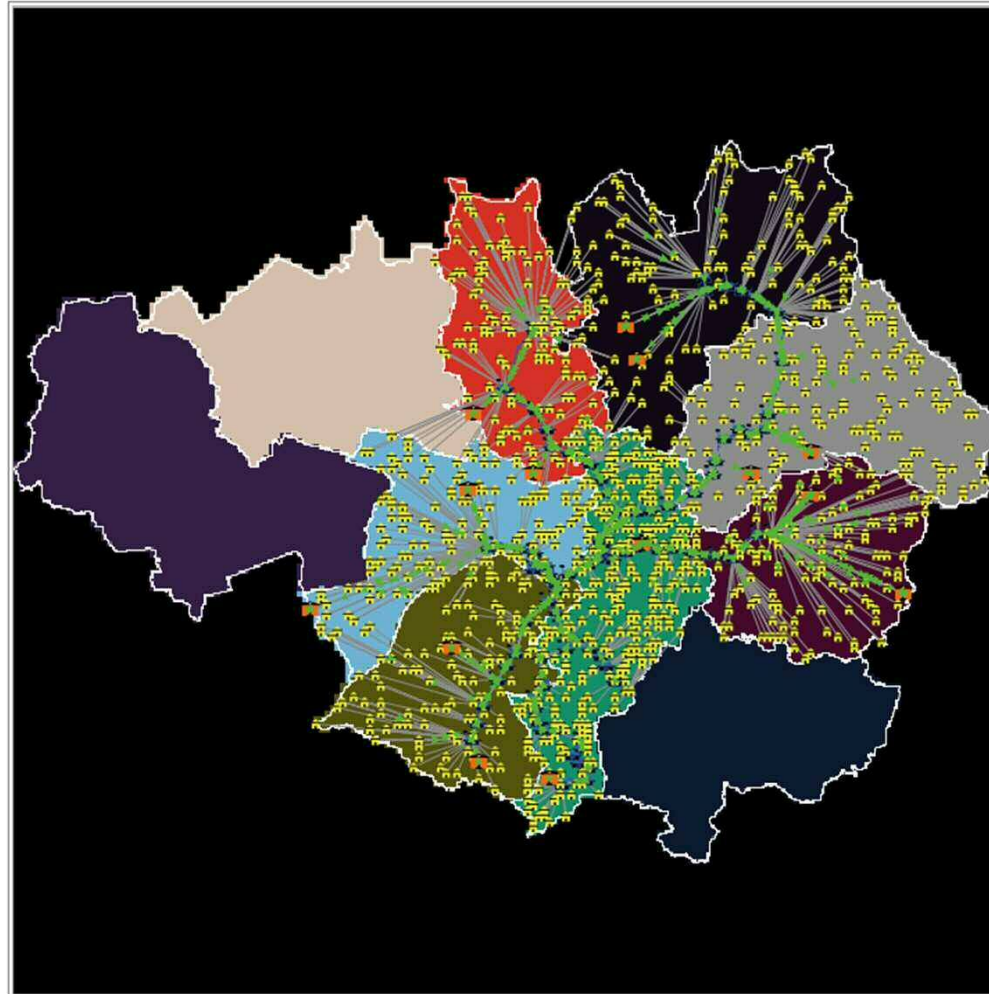
On
 Off Export_Data?

Max_Random_Population
150

Number_Generated_LAs 5

Number_Generated_Tramstops 25

Number_Generated_Places 17



A couple of changes ...

```
TramCommute - NetLogo (\\nask.man.ac.uk\home5\Desktop\ABM)
File Edit Tools Zoom Tabs Help
Interface Info Code
Find... Check Procedures Indent automatically
; extensions [ gis ; GIS extension for NetLogo, needed if using imported shapefiles
; nw ; NW extension for NetLogo, needed to create the network shapes for houses, destinations, etc.
; csv ] ; CSV extension for NetLogo, needed to read in the file of which tramstops are connected
;
; globals [ tramstops-dataset ; These are declared here to make it easier to switch between the Random and GM projections
; tramlines-dataset
; LAs-dataset
; Tramstop_Connections
; output-filename
; run-seed ]
;
; breed [tramstops tramstop] ; Breeds allows the modeller to easily ask some sets of agents to run commands or otherwise take actions
; breed [houses house]
; breed [places place]
; breed [denizens denizen]
; breed [ LAs LA ]
;
; turtles-own [LAs-name-t ; These are (in addition to primitive features like size or color) the features that every agent in this mod
; LAs-population-t]
;
; tramstops-own [myneighbors
; Tramstop_Name]
;
; patches-own [ centroid ; Like turtles-own, these are the features that all patches in this model have (also, primitive patch featur
; LAs-population
; LAs-name]
;
; LAs-own [centroid-x] ; These are the features that only the subset of LA agents have. No other turtle will have these.
;
; links-own [Speed ; Like turtles-own and patches-own, links can be assigned model specific features here.
; Capacity]
;
; denizens-own [My_Places ; Denizens have the most features as these are the only agents that move around when the model runs.
; current-location
; current-path
; next-location
; current-speed
; destination
; starting-place
; travel-timer]
```



Import a .csv file ...

```
* TramCommuter - NetLogo (\nask.man.ac.uk\home\Desktop\ABM)
File Edit Tools Zoom Tabs Help
Interface Info Code
Find... Check Procedures Indent automatically

to setup-input
  gis:load-coordinate-system (word "Model_Data/" projection ".prj") ; The non-random projection also has several steps, many are similar to those in the random set up.
  set tramstops-dataset gis:load-dataset "Model_Data/GM_Tramstops.shp" ; 1- Set the coordinate system or 'projection'. This is optional as long as all of the datasets use
  set tramlines-dataset gis:load-dataset "Model_Data/GM_Tramlines.shp" ; - Load all of your non-random datasets (as many as you need), assigning them to the globals crea
  set LAs-dataset gis:load-dataset "Model_Data/GM_LAs_R.shp"
  gis:set-world-envelope (gis:envelope-union-of (gis:envelope-of tramstops-dataset) ; 2- Set the world envelope to the union of all of the datasets' envelopes. This ensures they line
    (gis:envelope-of tramlines-dataset)
    (gis:envelope-of LAs-dataset))
  set Tramstop_Connections (csv:from-file "Model_Data/Tramstop_Connections.csv" ",") ; Load the .csv file of which tramstops are connected
ask LAs [ die ] ; 3- As with the Random projection, clear any agents that may be around.
gis:set-drawing-color white ; 4- Set the drawing color to white.
gis:draw LAs-dataset 1 ; - Draw the polygon data from the shapefile.
let i 1 ; 5- Technical processes of identifying features from the shapefile and loading them into temporary
foreach gis:feature-list-of LAs-dataset [ vector-feature ->
  let centroid-y gis:location-of gis:centroid-of vector-feature ; - The middle of each polygon is identified and added to a list (but not if it lies outside the w
  if not empty? centroid-y ; 6- If the centroid list is not empty,
  [ create-LAs 1 ; - Then create an LA agent and ...
  [ set xcor item 0 centroid-y ; - Move it to the right position (right/left)
    set ycor item 1 centroid-y ; - Move it to the right position (up/down)
    set size 0 ; - Set their size to 0 so as to be invisible ...
    set label-color yellow ; - Set their label color to yellow to increase visibility ...
    if label-LAs? [set label gis:property-value vector-feature "name"] ; - Set their label color to yellow to increase visibility ...
    set LAs-population-t gis:property-value vector-feature "population" ; - Set their label to be their name, which is drawn from the imported shapefile ...
    set LAs-name-t gis:property-value vector-feature "name" ; - And copy that name to turtles-own feature.
    ask patch-here [set LAs-population [LAs-population-t] of LAs-here ; 7- Then the LA agents talks to the patch underneath themselves.
      set LAs-name [LAs-name-t] of LAs-here ; - The LA agent asks the patch to copy details like population and name from the LA agent to itse
    set pcolor red ] ] ; - And also asks the patches to set their color to red.
  set i i + 1 ]

gis:apply-coverage LAs-dataset "POPULATION" LAs-population ; 8- Pass the population feature from the LA to the patches within the LA
gis:apply-coverage LAs-dataset "NAME" LAs-name ; - Also pass the name feature from LA to patches.
let min-pop min [read-from-string LAs-population ] of patches with [is-string? LAs-population] ; 9- The patches then set their color relative to their population to improve visibilit
ask patches with [is-string? LAs-population] [
  set pcolor red + ((read-from-string LAs-population - min-pop) * .1 )
  if pcolor = black [set pcolor pcolor + 5 ]
end
```

With a list of tram stops and their next stops...

```
Tramstop_Connections - Notepad
File Edit Format View Help
"Abraham Moss", "Crumpsall", "Queen's Road"
"Manchester Airport", "Shadowmoss"
"Altrincham", "Navigation Road"
"Ashton Moss", "Ashton West", "Audenshaw"
"Anchorage", "Harbour City", "Salford Quay"
"Audenshaw", "Droylsden", "Ashton Moss"
"Ashton-Under-Lyne", "Ashton West"
"Ashton West", "Ashton Moss", "Ashton-Under-Lyne"
"Baguley", "Roundthorn", "Moor Road"
"Barlow Moor Road", "St Werburgh's Road", "Sale Water Park"
"Brooklands", "Timperley", "Sale"
"Benchill", "Crossacres", "Martinscroft"
"Burton Road", "West Didsbury", "Withington"
"Besses o'th' Barn", "Prestwich", "Whitefield"
"Bowker Vale", "Crumpsall", "Heaton Park"
"Bury", "Radcliffe"
"Broadway", "Langworthy", "MediaCityUK", "Harbour City"
"Cemetery Road", "Edge Lane", "Droylsden"
"Chorlton", "St Werburgh's Road", "Firswood"
"Clayton Hall", "Edge Lane", "Velopark"
"Cornebrook", "Pomona", "Trafford Bar", "Deansgate-Castlefield"
"Crumpsall", "Bowker Vale", "Abraham Moss"
"Crossacres", "Wythenshawe Town Centre", "Benchill"
"Central Park", "Monsall", "Newton Heath and Moston"
"Derker", "Oldham Mumps", "Shaw and Compton"
"Didsbury Village", "East Didsbury", "West Didsbury"
"Dane Road", "Sale", "Stretford"
"Droylsden", "Cemetery Road", "Audenshaw"
"Eccles", "Ladywell"
"Etihad Campus", "Holt Town", "Velopark"
"East Didsbury", "Didsbury Village"
"Edge Lane", "Cemetery Road", "Clayton Hall"
"Exchange Quay", "Salford Quays", "Pomona"
"Exchange Square", "St Peter's Square", "Victoria"
"Firswood", "Trafford Bar", "Chorlton"
"Freehold", "South Chadderton", "Westwood"
"Failsworth", "Hollinwood", "Newton Heath and Moston"
"Deansgate - Castlefield", "St Peter's Square", "Cornebrook"
"Harbour City", "Anchorage", "MediaCityUK", "Broadway"
"Heaton Park", "Bowker Vale", "Prestwich"
"Hollinwood", "Failsworth", "South Chadderton"
"Holt Town", "New Traction", "Etihad Campus"
```



Model now opens .csv to link tram stop-agents

```

TramCommute - NetLogo (\\nask.man.ac.uk\home$\Desktop\ABM)
File Edit Tools Zoom Tabs Help
Interface Info Code
Find... Check Procedures Indent automatically

to setup-trams
  ask tramstops [ die ]
  set-default-shape tramstops "building store"
  ifelse projection = "Random"
  [ nw:generate-preferential-attachment tramstops links Number_Generated_Tramstops 1 [
  move-to one-of patches with [pcolor != black]
  if Label_Tramstops? [set label (word LAs-name-t who) ] ]
  repeat 50 [ layout-spring tramstops links 0.2 11 1 ] ]
  [gis:set-drawing-color blue
  gis:draw tramlines-dataset 1
  gis:set-drawing-color cyan
  foreach gis:feature-list-of tramstops-dataset [ vector-feature ->
  let centroid-stops gis:location-of gis:centroid-of vector-feature
  if not empty? centroid-stops
  [ create-tramstops 1
  [ set xcor item 0 centroid-stops
  set ycor item 1 centroid-stops
  set Tramstop_Name gis:property-value vector-feature "RSTNAM"
  if Label_Tramstops? [set label gis:property-value vector-feature "RSTNAM" ] ] ] ] ]

  ask tramstops [
  set LAs-name-t [LAs-name] of patch-here
  set LAs-population-t [LAs-population] of patch-here
  set color blue
  set size 3
  if projection != "Random" [
  foreach Tramstop_Connections [
  [ LinkedStops ] -> ask tramstops with [Tramstop_Name = (item 0 LinkedStops)]
  [set myneighbors but-first LinkedStops] ] ]
  foreach myneighbors [
  [ next_stop ] -> ask tramstops with [Tramstop_Name = next_stop]
  [create-link-with myself] ] ] ]
  ask tramstops [ set myneighbors link-neighbors ]
  ask links [set Speed 10
  set Capacity 100]
end

```

- ; - Start by ensuring that there are no tramstops already present
- ; - Set the default shape for a tram stop to the building shape that looks most approp
- ; - Set up locations for tramstops (and create links between them) based on random gen
- ; - Create tramstops in a random preferential attachment network for the random projec
- ; - The newly created tramstops move to coloured areas (just in case there are any non
- ; - Label the tramstops if modeller input says to do so (in a random model, this will
- ; - This pushes the tramstops away from each other to spread out the network and is th
- ; - The GIS set up begins by setting the color with which to draw the tramlines
- ; - Draw in all the tramlines according to the tramlines dataset
- ; - Reset drawing color for the tramstops
- ; - This step looks into the tramstop dataset and pulls out the features of each trams
- ; - Centroid will be an empty list if not within the current NetLogo world, as defined
- ; - If centroid is NOT an empty list
- ; - Create one tramstop for each tramstop on the Centroid list (all tramstops from the
- ; - Position the newly created tramstop agent on the X coordinates
- ; - Position the newly created tramstop agent on the Y coordinates
- ; - Copy the tramstop name from the tramstop dataset
- ; - Show the tramstop name as a label if the modeller input says to do so
- ; - Set of commands for the newly created tramstops to perform
- ; - Copy the LAs-name from the patch on which it now finds itself
- ; - Also copy the LAs-population from the patch
- ; - Become blue
- ; - And also become a visible size
- ; - These steps are needed to create the correct non-random tram network
- ; - For each tramstop listed in the imported .csv file of which tramstops are connecte
- ; - Create a temporary row and ask the tramstop whose name matches the first name list
- ; - to copy the rest of the tramstops in that temporary row to a tramstop variable cal
- ; - Then, ask the tramstop to review the items stored in its "myneighbors" variable ..
- ; - Asking the tramstop that matches those names, each in turn, ...
- ; - to create a link back to the original tramstop agent that is doing the asking.
- ; - With all tramstops correctly linked, tramstops overwrite "myneighbors" with the se
- ; - Now, the model asks all the links (which so far are only between tramstops) to set
- ; - and their capacity. As of now, capacity is not used for anything.



Moving on!

File Edit **Tools** Zoom Tabs Help

Interface Info Code

Edit Delete Add abc Button normal speed view updates ticks: 11 Settings... continuous

projection
Random

setup

Go Go Once

On
 Off Garrulous?

On
 Off Label_Tramstops?

On
 Off Label_LAs?

On
 Off Reduce_Pop_For_Display?

On
 Off Tram_Commute_Only?

Output_File
Test

On
 Off Export_Data?

Max_Random_Population
150

Number_Generated_LAs 5

Number_Generated_Tramstops 25

Number_Generated_Places 17



Behaviour Space

The screenshot shows the NetLogo software interface. The 'Tools' menu is open, listing various monitoring and editing tools. The 'BehaviorSpace' option is highlighted with a red box. Below the menu, a 'BehaviorSpace' dialog box is open, also with a 'New' button highlighted in red. The main window displays a map with a network of agents and connections.

Tools menu items:

- Preferences...
- Extensions...
- Halt
- Globals Monitor
- Turtle Monitor
- Patch Monitor
- Link Monitor
- Close All Agent Monitors
- Close Monitors for Dead Agents
- Hide Command Center (Ctrl+Slash)
- Jump to Command Center (Ctrl+Shift+C)
- Switch to 3D View (Ctrl+Shift+T)
- Color Swatches
- Turtle Shapes Editor
- Link Shapes Editor
- System Dynamics Modeler (Ctrl+Shift+D)
- Preview Commands Editor (Ctrl+Shift+P)
- BehaviorSpace (Ctrl+Shift+B)**
- HubNet Client Editor
- HubNet Control Center (Ctrl+Shift+H)

BehaviorSpace dialog box buttons:

- New**
- Edit
- Duplicate
- Delete
- Run



Behaviour Space

Experiment

Experiment name: Tram_Commute_Random_Initial_Parameter_Sweep

Vary variables as follows (note brackets and quotation marks):

```
[ "Export_Data?" true ]
[ "Number_Generated_LAs" [ 4 1 10 ] ]
[ "Garrulous?" false ]
[ "Number_Generated_Places" [ 25 25 250 ] ]
[ "Label_Tramstops?" false ]
[ "Projection" Random ]
[ "Tram_Commute_Only?" true false ]
[ "Label_LAS?" false ]
[ "Output_File" "Random_Test" ]
[ "Max_Random_Population" [ 500 500 10000 ] ]
[ "Produce_Pop_Fore_Display?" true false ]
[ "Number_Generated_Tramstops" [ 20 10 100 ] ]
```

Either list values to use, for example:
["my-slider" 1 2 7 8]
or specify start, increment, and end, for example:
["my-slider" [0 1 10]] (note additional brackets)
to go from 0, 1 at a time, to 10.
You may also vary max-pixcor, min-pixcor, max-pycor, min-pycor, random-seed.

Repetitions: 10
run each combination this many times

Run combinations in sequential order
For example, having ["var" 1 2 3] with 2 repetitions, the experiments' "var" values will be:
sequential order: 1, 1, 2, 2, 3, 3
alternating order: 1, 2, 3, 1, 2, 3

Measure runs using these reporters:

```
count turtles
```

one reporter per line; you may not split a reporter across multiple lines

Measure runs at every step
if unchecked, runs are measured only when they are over

Setup commands: setup
Go commands: go

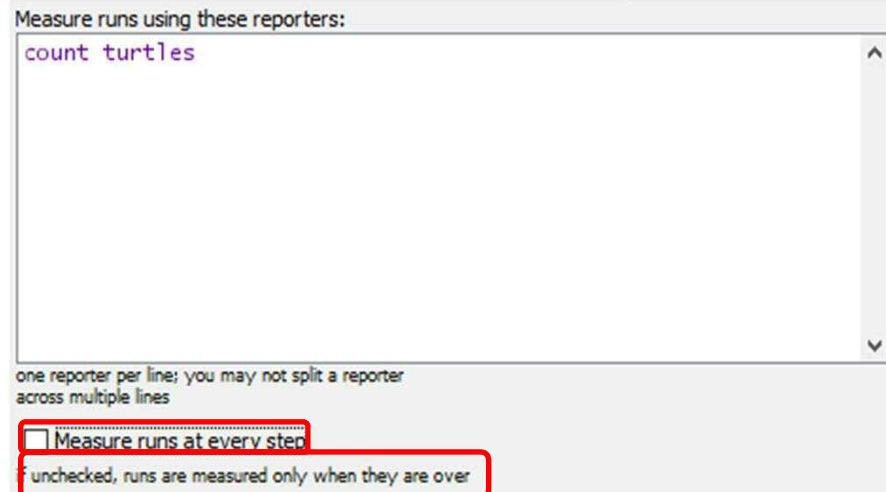
Stop condition: the run stops if this reporter becomes true
Final commands: run at the end of each run

Time limit: 0
stop after this many steps (0 = no limit)



Basic Behaviour Space output

- Output options are built-in to the behaviour space interface.



- **BUT!**

- Choice to measure selected commands at every step or
- Measure selected commands at end of run.
- Swap out the above "if" command for a very basic "count tramstop-agents"

Behaviour Space

Experiment

Experiment name

Vary variables as follows (note brackets and quotation marks):

```
[!Export_Data?" true]
[!Number_Generated_LAs" [4 1 10]]
[!Garrulous?" false]
[!Number_Generated_Places" [25 25 250]]
[!Label_Tramstops?" false]
[!projection" "Random"]
[!Tram_Commute_Only?" true false]
[!Label_LAs?" false]
[!Output_File" "Random_Test"]
[!Max_Random_Population" [500 500 10000]]
[!Reduce_Pop_For_Display?" true false]
[!Number_Generated_Tramstops" [20 10 100]]
```

Either list values to use, for example:
[!my-slider" 1 2 7 8]
or specify start, increment, and end, for example:
[!my-slider" [0 1 10]] (note additional brackets)
to go from 0, 1 at a time, to 10.
You may also vary max-pycor, min-pycor, max-pycor, min-pycor, random-seed.

Repetitions

Run combinations in sequential order
For example, having [!var" 1 2 3] with 2 repetitions, the experiments' "var" values will be:
sequential order: 1, 1, 2, 2, 3, 3
alternating order: 1, 2, 3, 1, 2, 3

Measure runs using these reporters:

```
count turtles
```

one reporter per line; you may not split a reporter across multiple lines

Measure runs at every step
if unchecked, runs are measured only when they are over

Setup commands:

Go commands:

Stop condition: the run stops if this reporter becomes true

Final commands: run at the end of each run

Time limit
stop after this many steps (0 = no limit)



Experiments on random projection



projection
Random

setup

Go Go Once

On
 Off Garrulous?

On
 Off Label_Tramstops?

On
 Off Label_LAs?

On
 Off Reduce_Pop_For_Display?

On
 Off Tram_Commute_Only?

Output_File
Test

On
 Off Export_Data?

Max_Random_Population
150

Number_Generated_LAs 5

Number_Generated_Tramstops 25

Number_Generated_Places 17

First experiments will be parameter sweeps:

- All parameters vary
- Wide ranges, big increments
- Fewer repetitions

Then, use the results to run targeted sweeps with:

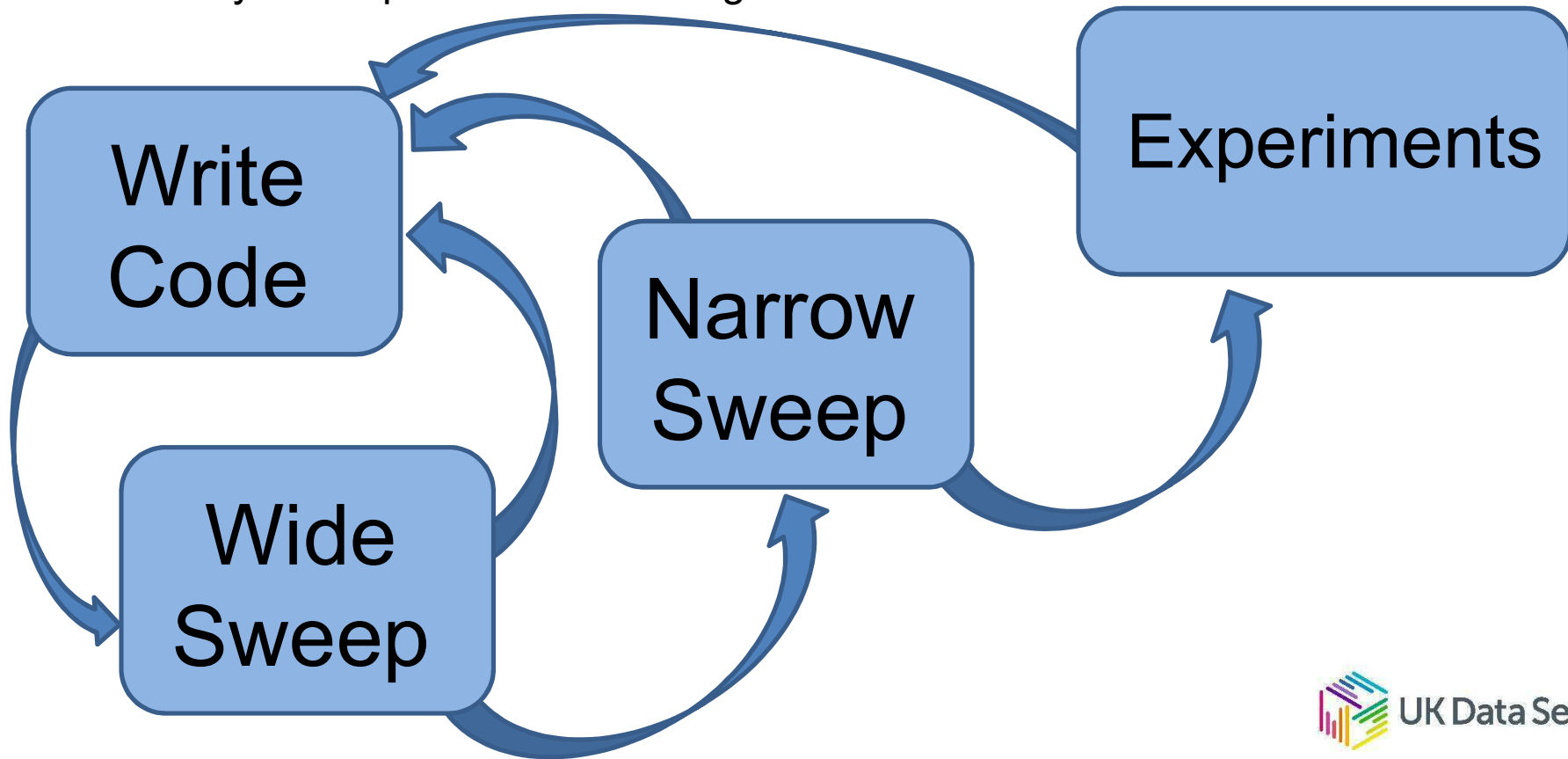
- Maybe not all parameters
- Narrower ranges and/or smaller increments
- More repetitions

Or experiments

- MANY repetitions on single/few settings
- Changes to model code
 - Generate more tram stops, houses, or places
 - Generate more commuters
 - After some trigger or at a fixed point in time
- Etc.

Random projection experiments needed to:

- Verify model logic
- Test model changes
- Identify interactions of various parameters
- Identify break points / critical ranges



Behaviour Space

Experiment

Experiment name **Tram_Commute_Random_Initial_Parameter_Sweep**

Vary variables as follows (note brackets and quotation marks):

```
[ "Export_Data?" true ]  
[ "Number_Generated_LAs" 5 ]  
[ "Garrulous?" false ]  
[ "Number_Generated_Places" 5 ]  
[ "Label_Tramstops?" false ]  
[ "projection" "GM_LAs" ]  
[ "Tram_Commute_Only?" true false ]  
[ "Label_LAs?" false ]  
[ "Output_File" "GM_LAs_Test" ]  
[ "Max_Random_Population" 5 ]  
[ "Reduce_Pop_For_Display?" true false ]  
[ "Number_Generated_Tramstops" 5 ]
```

Either list values to use, for example:
["my-slider" 1 2 7 8]
or specify start, increment, and end, for example:
["my-slider" [0 1 10]] (note additional brackets)
to go from 0, 1 at a time, to 10.
You may also vary max-pixcor, min-pixcor, max-pycor, min-pycor, random-seed.

Repetitions 10
run each combination this many times

Run combinations in sequential order
For example, having ["var" 1 2 3] with 2 repetitions, the experiments' "var" values will be:
sequential order: 1, 1, 2, 2, 3, 3
alternating order: 1, 2, 3, 1, 2, 3

Measure runs using these reporters:

```
if current-location = destination [  
  print who  
  print starting-place  
  print [LAs-name-t] of starting-place  
  print destination  
  print [LAs-name-t] of destination  
  print travel-timer]
```

one reporter per line; you may not split a reporter across multiple lines

Measure runs at every step
if unchecked, runs are measured only when they are over

Setup commands:

Go commands:

Stop condition: the run stops if this reporter becomes true
Time limit 10000
stop after this many steps (0 = no limit)

Final commands: run at the end of each run



Experiments on GM_LAs projection

The screenshot shows a software interface for running experiments. It includes a dropdown menu for 'projection' set to 'GM_LAs', a 'setup' button, and 'Go' and 'Go Once' buttons. Below these are several toggle switches for 'Garrulous?', 'Label_Tramstops?', 'Label_LAs?', 'Reduce_Pop_For_Display?', and 'Tram_Commute_Only?'. There is an 'Output_File' text box containing 'Test' and an 'Export_Data?' toggle switch. At the bottom, there are three sliders for 'Number_Generated_LAs' (set to 5), 'Number_Generated_Tramstops' (set to 25), and 'Number_Generated_Places' (set to 17).

First experiments are still parameter sweeps:

- Still important to check model function
- May not need as many rounds

Experiments

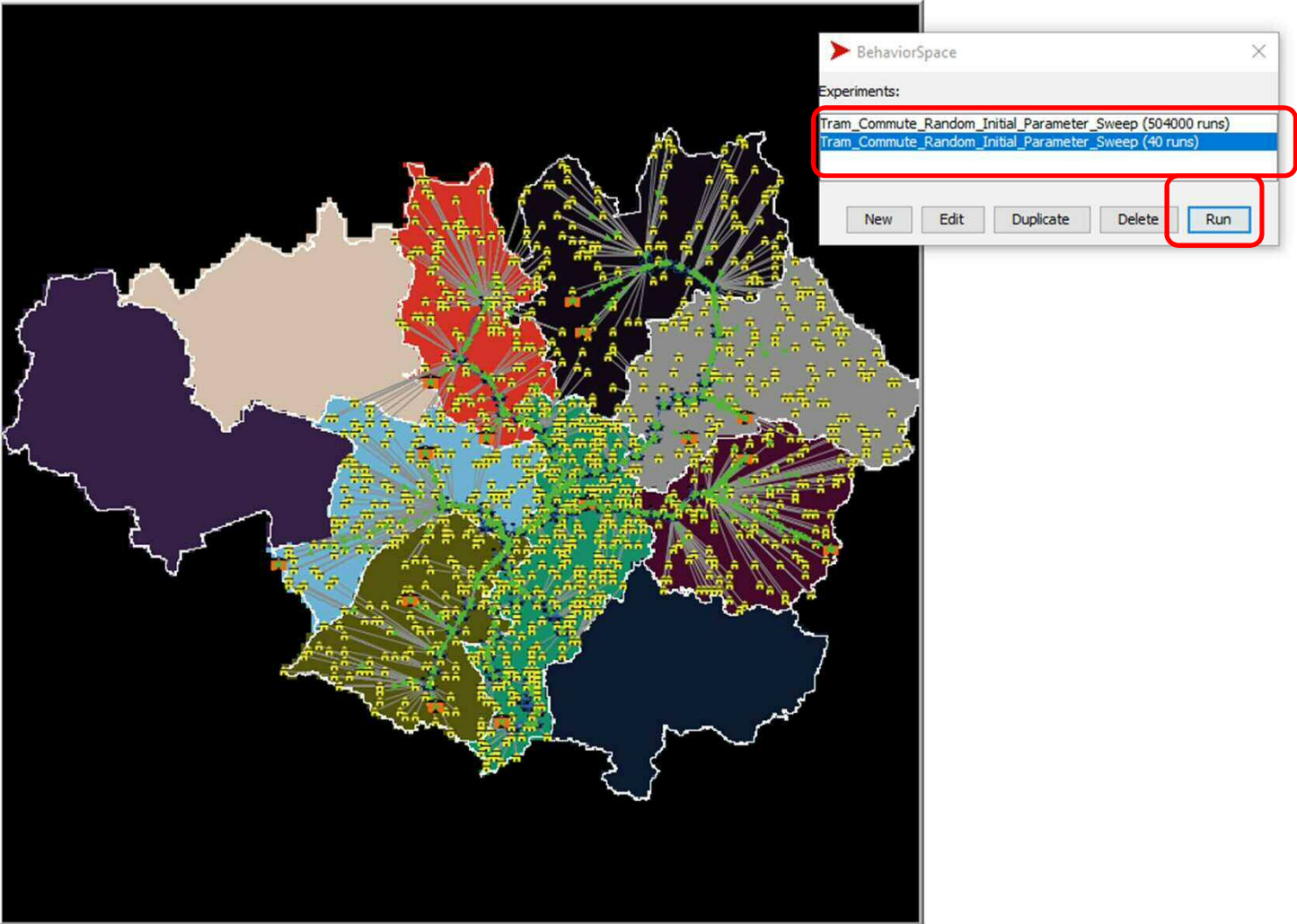
- Can still repeat on large scale
- Can change projection and/or model code
 - Start with oldest tramlines and add extensions at specified points in model run
 - Include currently agreed extensions (from beginning or at specified point in model run)
 - Include currently considered lines, rejected lines, totally imaginary lines, etc.
- Others?

GM_LAs projection experiments needed to:

- Compare model behaviour to real-world observations
- Test projection-specific model changes
- Identify interactions of various parameters under realistic layout
- Identify break points / critical ranges
- Model possible outcomes of making changes
- Answer specific research questions



Parameter sweeps are part of model testing

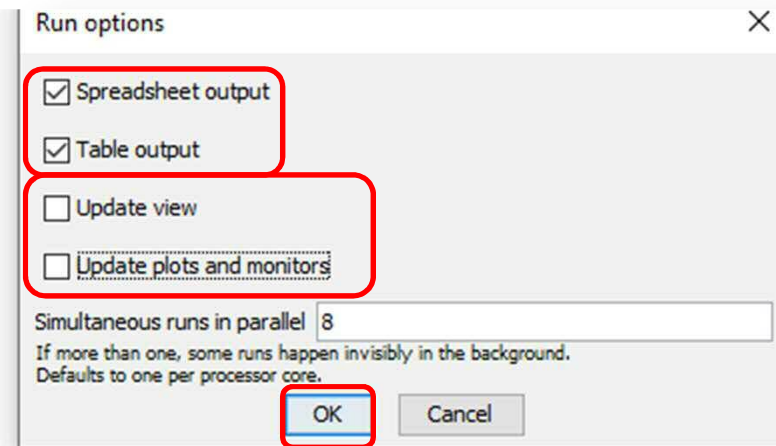
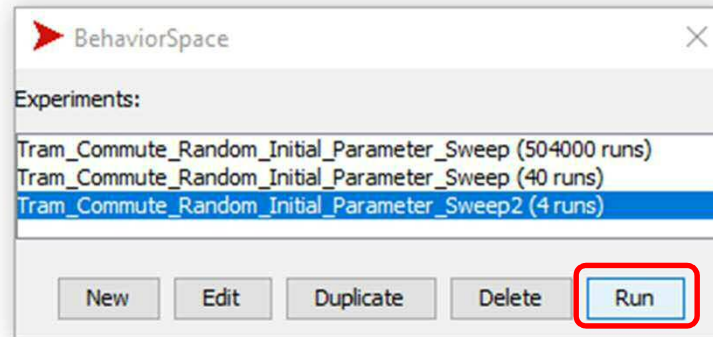


But first...

- Ideal output is well-motivated by:
 - Research questions
 - Model design
 - Iterative developments
- In this model, as it stands, I decided to look at output related to:
 - How long does it take to travel between one LA and another?
 - How common are trips within each LA and between LAs?
- With fairly minor changes we could also get output related to:
 - Most popular places to visit
 - Most used tram stops
 - More?



Hitting the Run button



Experiments need output!

Running Experiment: Tram_Commute_Random_Initial_Parameter_Sw... X

normal speed

```
Run #1 of 4, step #0
Total elapsed time: 0:00:09
Export_Data? = true
Number_Generated_LAs = 5
Garrulous? = false
Number_Generated_Places = 5
Label_Tramstops? = false
projection = GM_LAs
Tram_Commute_Only? = true
Label_LAs? = false
```

Update view
 Update plots and monitors



Behaviour Space standard output - spreadsheet



BehaviorSpace results (NetLogo 6.1.1)				
TramCommute.nlogo				
Tram_Commute_Initial_Parameter_Sweep				
02/11/2020 17:05:56:445 +0000				
min-pxcor	max-pxcor	min-pycor	max-pycor	
	-90	90	-90	90
[run number]		1	2	
Export_Data?	TRUE	TRUE	TRUE	
Number_Generated_LAs		5	5	
Garrulous?	FALSE	FALSE	FALSE	
Number_Generated_Places		17	17	
Label_Tramstops?	FALSE	FALSE	FALSE	
projection	GM_LAs	GM_LAs		
Tram_Commute_Only?	TRUE	FALSE	FALSE	
Label_LAs?	FALSE	FALSE	FALSE	
Output_File	Test	Test		
Max_Random_Population		150	150	
Reduce_Pop_For_Display?	TRUE	TRUE	TRUE	
Number_Generated_Tramstops		25	25	
[steps]		1000	1000	
[initial & final values]	count tramstops	count tramstops		
		93	93	

Behaviour Space standard output - table



BehaviorSpace results (NetLogo 6.1.1)																
TramCommute.nlogo																
Tram_Commute_Initial_Parameter_Sweep																
02/11/2020 17:05:26:223 +0000																
min-pxcor	max-pxcor	min-pycor	max-pycor													
-90	90	-90	90													
[run number]	Export_Data?	Number_Generated_LAs	Garrulous?	Number_Generated_Places	Label_Tramstops?	projection	Tram_Commute_Only?	Label_LAs?	Output_File	Max_Random_Population	Reduce_Pop_For_Display?	Number_Generated_Tramstops	[step]	count tramstops		
1	TRUE	5	FALSE	17	FALSE	GM_LAs	TRUE	FALSE	Test	150	TRUE	25	1000	93		
2	TRUE	5	FALSE	17	FALSE	GM_LAs	FALSE	FALSE	Test	150	TRUE	25	1000	93		

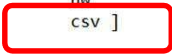
Alternate output

- Output options are built-in to the behaviour space interface.
 - Choice to measure selected commands at every step or
 - Measure selected commands at end of run.
 - Spreadsheet or table options
- Other output options can be built directly into the model code.



Exports in setup

```
3 extensions [ gis ; GIS extension for NetLogo, needed if using imported shapefiles  
nw ; NW extension for NetLogo, needed to create the network shapes for houses, destinations, etc.  
csv ] ; CSV extension for NetLogo, needed to read in the file of which tramstops are connected
```



Exports in setup

```

to setup
  clear-all
  set run-seed new-seed
  random-seed run-seed
  set output-filename (word projection "_" Output_File "_" run-seed )
  ifelse projection = "Random"
    [ setup-random ]
    [ setup-input ]
  setup-trams
  if Garrulous? [ask links [print end]]
  setup-houses-and-places
  setup-denizens
  check-speed
  initial-exports
  reset-ticks
end

to initial-exports
  if Export_Data?
    [file-open (word output-filename ".csv" )
     file-print (word "Commuter,Origen,Origin_LA,Destination,Destination_LA,Travel_time")
    ;
     file-print (word " , , , , ,")
    file-close]
end

to when-at-destination
  set current-location next-location
  set travel-timer travel-timer + 1
  if Export_Data?
    [file-open (word output-filename ".csv" )
     file-print
     (word who "," starting-place "," [LAS-name-t] of starting-place "," destination "," [LAS-name-t] of starting-place "," travel-timer)
     file-close]
  set starting-place destination
  set destination one-of My_Places
  set travel-timer 0
  if any? places-here
    [create-link-with one-of places-here]
  if any? houses-here
    [create-link-with one-of houses-here]
  set current-path []
  set current-path nw:turtles-on-path-to destination
  set next-location first current-path
  face next-location
  set current-path but-first current-path
end

```

; Always start by clearing everything.
 ; Creates a "seed" to use as a unique identifier for the run (also, allows the run to be re-run e
 ; Initiates this run using the just created seed
 ; Creates an output file to record the model run based on the projection selected, a user input v
 ; The model diverges significantly depending on whether you want to use randomly generated or imp
 ; This initiates the procedures to set up a random world, drawing on the various "Random_Generate
 ; This initiates the procedures to set up a world based on imported shapefiles. This too draws on
 ; the Random projection models, such as "Random_Generated_Tramstops".

; Creates a file named with the output-filename created earlier. Wrapping it
 ; Set up the headers that should appear in the output file
 ; Currently not needed - but you could use row (or more like it) to write ou
 ; Closes the file - necessary to save the input just added and also prepare

; They copy over their next proximal destination to their current location
 ; They add one to their travel time
 ; Check to see if the modeller wants data exports
 ; If so, they open the appropriate file. The "," enables it to be formatted for .i
 ; Adds their who number, origen, origen LA, destination, destination LA, and trav
 ; And closes the file - still important.
 ; They copy over their current destination to be the starting-place for the next
 ; Pick a new destination is head to...
 ; Reset the counter that tracks time elapsed for travel back to zero
 ; Checks to see if they are currently at a Place and...
 ; If so, creates a link with that place.



; If they are currently at a House and...
 ; link with that house.
 ; ent-path to their new destination back to an empty list
 ; Identifies the path to that new destination and fills in the recently reset cur
 ; Sets next proximal destination
 ; Turns to face that proximal destination
 ; And removes the proximal destination from the current-path

One file per run

```

GM_LAs_Test_-85998618 - Notepad
File Edit Format View Help
Commuter,Origen,Origin_LA,Destination,Destination_LA,Travel_time
2867,(house 177),Trafford,(place 1238),Trafford,3
2838,(house 205),Trafford,(place 1238),Trafford,3
3136,(house 1047),Tameside,(place 1234),Tameside,4
3029,(house 205),Trafford,(place 1238),Trafford,4
3313,(house 1085),Tameside,(place 1234),Tameside,4
3355,(house 1047),Tameside,(place 1234),Tameside,4
3033,(house 234),Trafford,(place 1238),Trafford,4
2481,(house 630),Bury,(place 1232),Bury,4
3093,(house 103),Trafford,(place 1237),Trafford,4
1370,(house 716),Rochdale,(place 1232),Rochdale,4
3359,(house 962),Tameside,(place 1233),Tameside,4
3145,(house 1063),Tameside,(place 1233),Tameside,4
2455,(house 572),Bury,(place 1231),Bury,4
2304,(house 678),Bury,(place 1231),Bury,4
3066,(house 169),Trafford,(place 1238),Trafford,4
2588,(house 1196),Oldham,(place 1236),Oldham,4
3367,(house 1030),Tameside,(place 1234),Tameside,4
2552,(house 1171),Oldham,(place 1236),Oldham,4
2532,(house 576),Bury,(place 1232),Bury,4
2724,(house 1201),Oldham,(place 1236),Oldham,4
3388,(house 1085),Tameside,(place 1234),Tameside,4
2838,(place 1238),Trafford,(place 1238),Trafford,2
2857,(house 104),Trafford,(place 1227),Trafford,5
3136,(place 1234),Tameside,(place 1234),Tameside,2
2534,(house 665),Bury,(place 1232),Bury,5
2309,(house 610),Bury,(place 1231),Bury,5
3405,(house 992),Tameside,(place 1234),Tameside,5
2854,(house 237),Trafford,(place 1238),Trafford,5
3029,(place 1238),Trafford,(place 1238),Trafford,2
2471,(house 598),Bury,(place 1231),Bury,5
3367,(place 1234),Tameside,(place 1234),Tameside,2
2685,(house 1112),Oldham,(place 1233),Oldham,5
1370,(place 1232),Bury,(place 1232),Bury,2
3375,(house 959),Tameside,(place 1233),Tameside,5
3321,(house 1011),Tameside,(place 1233),Tameside,5
1287,(house 768),Rochdale,(place 1229),Rochdale,5
3156,(house 959),Tameside,(place 1234),Tameside,5
2234,(house 427),Manchester,(place 1236),Manchester,5
2727,(house 1112),Oldham,(place 1233),Oldham,5
3354,(house 1011),Tameside,(place 1233),Tameside,5
3134,(house 959),Tameside,(place 1234),Tameside,5
3258,(house 988),Tameside,(place 1233),Tameside,5
3026,(house 127),Trafford,(place 1237),Trafford,5
2992,(house 232),Trafford,(place 1237),Trafford,5
2231,(house 494),Manchester,(place 1234),Manchester,5
2814,(house 1217),Oldham,(place 1235),Oldham,5
3207,(house 993),Tameside,(place 1234),Tameside,5
3319,(house 975),Tameside,(place 1233),Tameside,5
2433,(house 671),Bury,(place 1232),Bury,5
3388,(place 1234),Tameside,(place 1234),Tameside,2
3030,(house 112),Trafford,(place 1238),Trafford,5
1746,(house 935),Salford,(place 1228),Salford,6
    
```

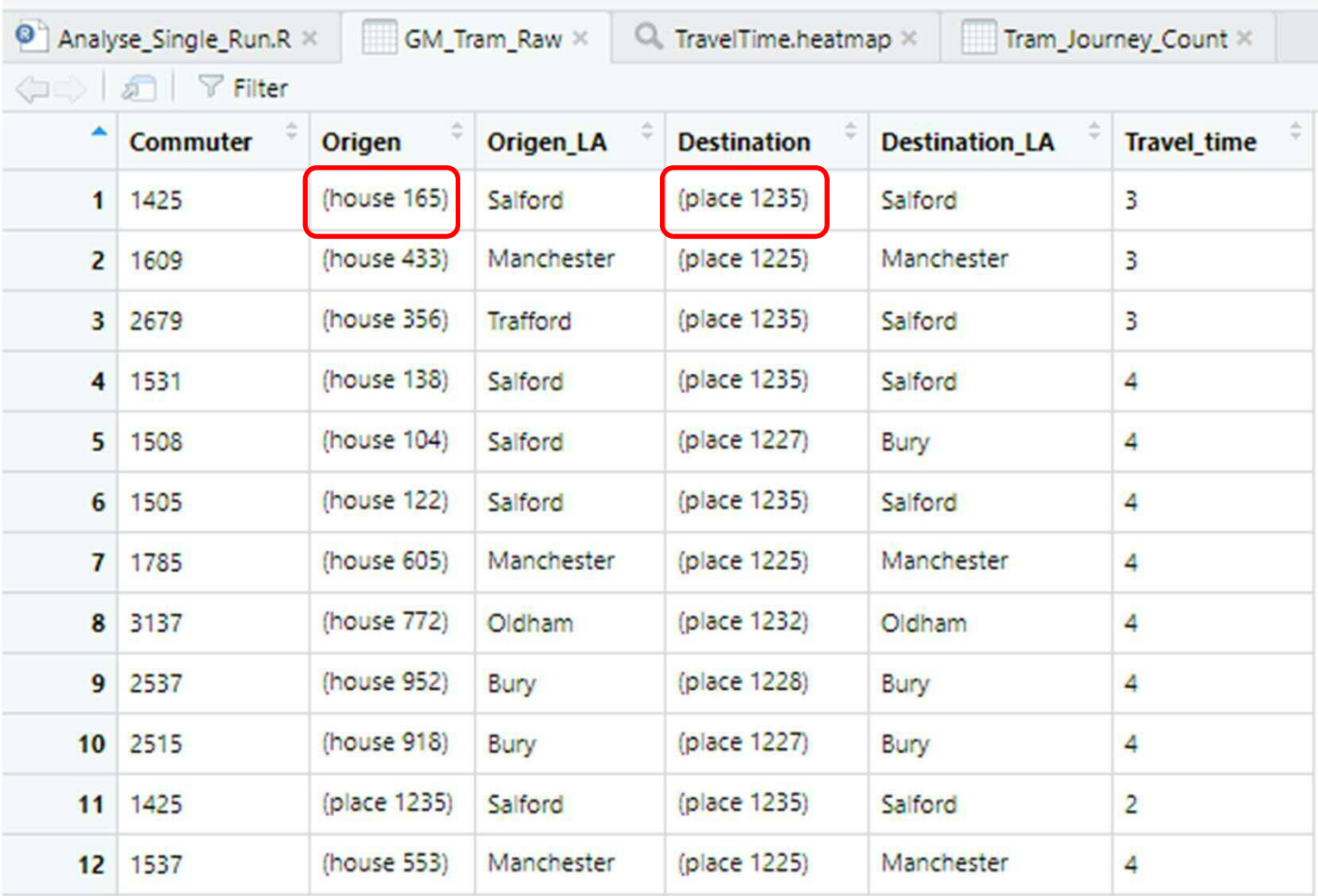
	A	B	C	D	E	F
1	Commuter	Origen	Origin_LA	Destination	Destination_LA	Travel_time
2		2381 (house 473)	Manchester	(place 1229)	Manchester	3
3		3305 (house 201)	Trafford	(place 1237)	Trafford	3
4		2491 (house 439)	Manchester	(place 1229)	Manchester	3
5		2218 (house 556)	Manchester	(place 1230)	Manchester	4
6		2345 (house 458)	Manchester	(place 1230)	Manchester	4
7		3361 (house 146)	Trafford	(place 1233)	Trafford	4
8		2451 (house 697)	Manchester	(place 1229)	Manchester	4
9		2788 (house 1195)	Oldham	(place 1235)	Oldham	4
10		3052 (house 931)	Bury	(place 1225)	Bury	4
11		3043 (house 860)	Bury	(place 1225)	Bury	4
12		3234 (house 239)	Trafford	(place 1237)	Trafford	4
13		2092 (house 1017)	Tameside	(place 1227)	Tameside	4
14		2563 (house 458)	Manchester	(place 1230)	Manchester	4
15		2326 (house 614)	Manchester	(place 1230)	Manchester	4
16		1707 (house 371)	Salford	(place 1233)	Salford	4
17		2903 (house 860)	Bury	(place 1225)	Bury	4
18		3340 (house 116)	Trafford	(place 1229)	Trafford	4
19		3385 (house 126)	Trafford	(place 1233)	Trafford	4
20		1841 (house 977)	Tameside	(place 1227)	Tameside	4
21		1794 (house 346)	Salford	(place 1225)	Salford	4
22		1650 (house 248)	Salford	(place 1225)	Salford	4
23		2525 (house 600)	Manchester	(place 1229)	Manchester	4
24		2546 (house 423)	Manchester	(place 1229)	Manchester	4
25		1819 (house 960)	Tameside	(place 1227)	Tameside	4
26		2783 (house 1144)	Oldham	(place 1235)	Oldham	4
27		3301 (house 146)	Trafford	(place 1233)	Trafford	4
28		1945 (house 1036)	Tameside	(place 1227)	Tameside	4
29		1501 (house 835)	Rochdale	(place 1232)	Rochdale	5
30		3259 (house 218)	Trafford	(place 1237)	Trafford	5
31		1891 (house 961)	Tameside	(place 1227)	Tameside	5
32		2169 (house 389)	Manchester	(place 1230)	Manchester	5
33		2396 (house 664)	Manchester	(place 1230)	Manchester	5
34		1916 (house 1073)	Tameside	(place 1227)	Tameside	5
35		2021 (house 1047)	Tameside	(place 1227)	Tameside	5
36		2009 (house 1047)	Tameside	(place 1227)	Tameside	5
37		1925 (house 1086)	Tameside	(place 1227)	Tameside	5
38		3215 (house 109)	Trafford	(place 1238)	Trafford	5

Open in RStudio

```
Analyse_Single_Run.R* x Tram_Journey_Count x TravelTime.heatmap x
Source on Save Run Source
1 ## Global options, necessary libraries, etc.
2 ## Take time to install if needed.
3
4 options(stringsAsFactors = FALSE)
5 library(ggplot2)
6 library(sqldf)
7 library(tidyverse)
8 detach("package:RPostgreSQL", unload=TRUE)
9
10 ## Always good to start off by checking and/or setting your working directory
11 getwd()
12 setwd("//nask.man.ac.uk/home$/Desktop/ABM/Experimental_Results")
13
14 ## Read in csv files
15 GM_Tram_Raw <- (read.csv("//nask.man.ac.uk/home$/Desktop/ABM/Experimental_Results/GM_LAs_CodeTest_-473979832.csv",
16                        header = TRUE))
17
```



Look at raw file



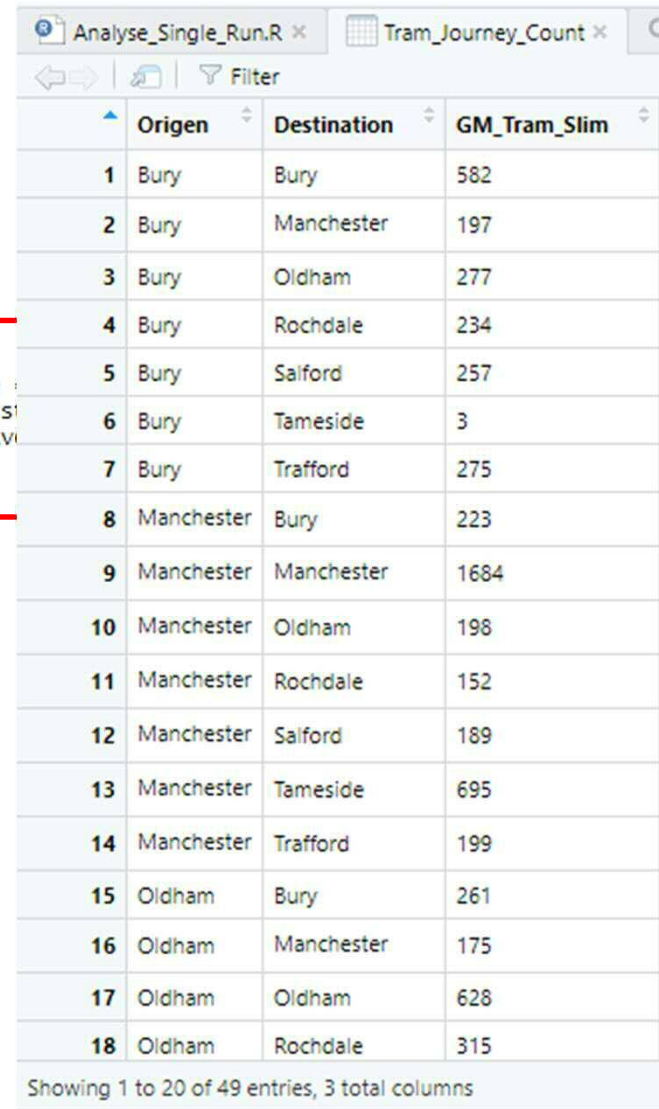
	Commuter	Origen	Origen_LA	Destination	Destination_LA	Travel_time
1	1425	(house 165)	Salford	(place 1235)	Salford	3
2	1609	(house 433)	Manchester	(place 1225)	Manchester	3
3	2679	(house 356)	Trafford	(place 1235)	Salford	3
4	1531	(house 138)	Salford	(place 1235)	Salford	4
5	1508	(house 104)	Salford	(place 1227)	Bury	4
6	1505	(house 122)	Salford	(place 1235)	Salford	4
7	1785	(house 605)	Manchester	(place 1225)	Manchester	4
8	3137	(house 772)	Oldham	(place 1232)	Oldham	4
9	2537	(house 952)	Bury	(place 1228)	Bury	4
10	2515	(house 918)	Bury	(place 1227)	Bury	4
11	1425	(place 1235)	Salford	(place 1235)	Salford	2
12	1537	(house 553)	Manchester	(place 1225)	Manchester	4

Open in RStudio

```
14 ## Read in csv files
15 GM_Tram_Raw <- (read.csv("//nask.man.ac.uk/home$/Desktop/ABM/Experimental_Results/GM_LAs_CodeTest_-473979832.csv",
16                          header = TRUE))
17
18 ## Basic clean up
19 ## Remove parentheses
20 GM_Tram_Raw$Origen <- (gsub("[()]", "", GM_Tram_Raw$Origen))
21
22 ## Split the Origen column into one that tracks the agent-type and another than has that agent's who number
23 GM_Tram_Adjusted <- GM_Tram_Raw %>%
24   separate(Origen, c("Journey", "OSpecifics"), 6)
25
26 ## Remove unneeded columns
27 GM_Tram_Slim <- GM_Tram_Adjusted[c("Commuter", "Journey", "Origen_LA", "Destination_LA", "Travel_time")]
28
29 ## Rename some columns to streamline interpretation
30 GM_Tram_Slim <- GM_Tram_Slim %>%
31   rename(
32     Origen = Origen_LA,
33     Destination = Destination_LA )
34
35 ## Shockingly basic analysis
36 ## Count the number of journeys taken between each pair of LAs
37 Tram_Journey_Count <- GM_Tram_Slim %>%
38   group_by (Origen, Destination) %>%
39   summarize( GM_Tram_Slim = n())
40
41
42 #Heat map of travel time between Origen LA and destination LA
43 TravelTime.heatmap <- ggplot(data = GM_Tram_Slim, mapping = aes(x = Origen,
44                                                                y = Destination,
45                                                                fill = Travel_time)) +
46   geom_tile() +
47   xlab(label = "Heatmap of Travel Time")
48
```

Open in RStudio

```
35 ## Shockingly basic analysis
36 ## Count the number of journeys taken between each pair of LAs
37 Tram_Journey_Count <- GM_Train_Slim %>%
38   group_by (Origen, Destination) %>%
39   summarize( GM_Train_Slim = n())
40
41
42 #Heat map of travel time between Origen LA and destination LA
43 TravelTime.heatmap <- ggplot(data = GM_Train_Slim, mapping = aes(x = Origen, y = Destination, fill = TravelTime))
44
45   geom_tile() +
46   xlab(label = "Heatmap of Travel Time")
47
48
```

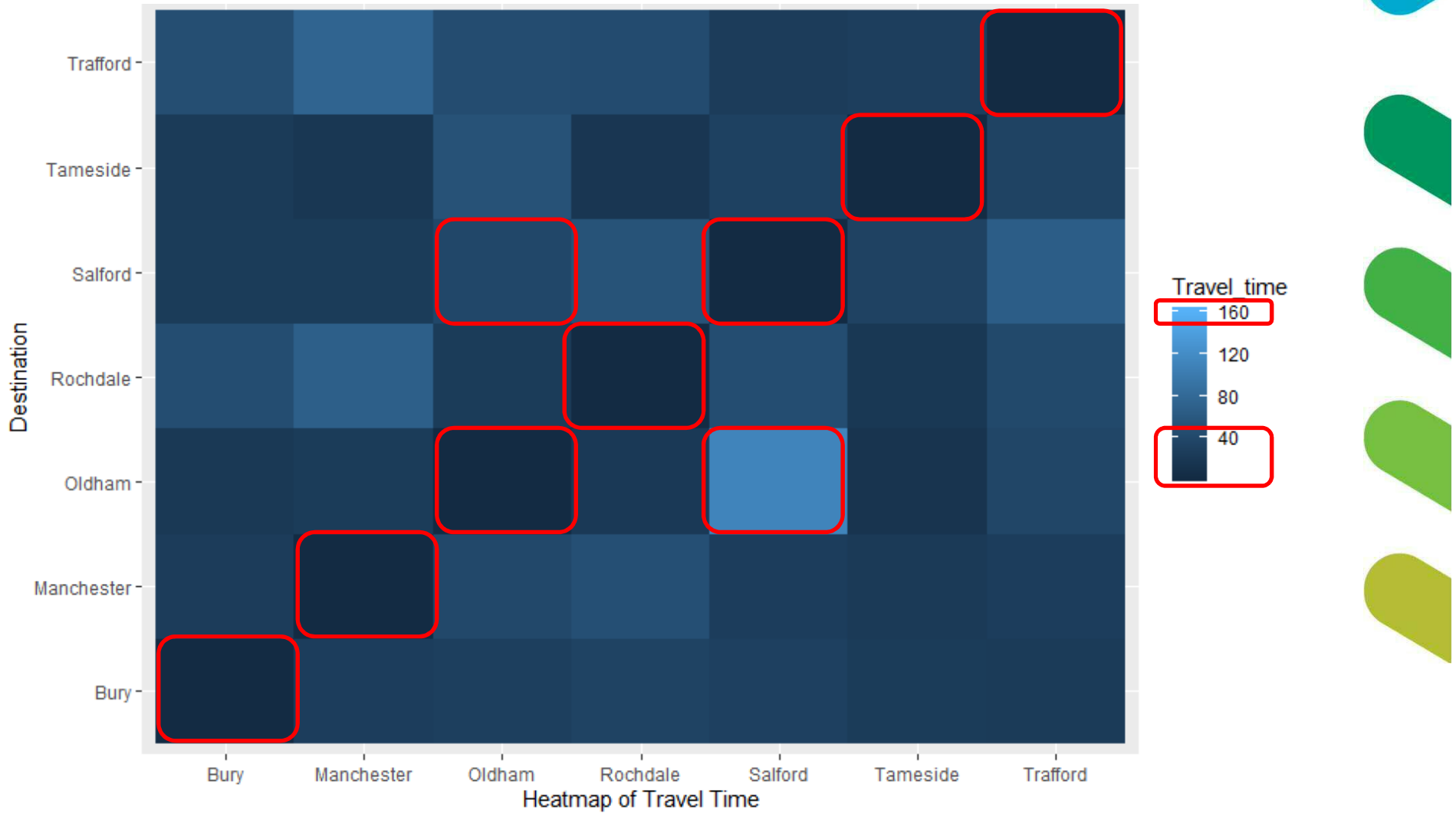


	Origen	Destination	GM_Train_Slim
1	Bury	Bury	582
2	Bury	Manchester	197
3	Bury	Oldham	277
4	Bury	Rochdale	234
5	Bury	Salford	257
6	Bury	Tameside	3
7	Bury	Trafford	275
8	Manchester	Bury	223
9	Manchester	Manchester	1684
10	Manchester	Oldham	198
11	Manchester	Rochdale	152
12	Manchester	Salford	189
13	Manchester	Tameside	695
14	Manchester	Trafford	199
15	Oldham	Bury	261
16	Oldham	Manchester	175
17	Oldham	Oldham	628
18	Oldham	Rochdale	315

Showing 1 to 20 of 49 entries, 3 total columns



Open in RStudio



Summary

- Revisit the "Tram commute model"
- Behaviour Space
- Consider what experiments to run –
 - parameter sweeps
 - targeted research questions
- Building output creation into your model code – an optional extra
- Open output
 - Process
 - Analyze
 - Visualise
- <https://www.comses.net/codebases/5ec74433-0536-4343-88fd-8385e7f5066c/releases/1.0.0/>
- Or
- <https://tinyurl.com/wagewt9>

Questions

Dr. J. Kasmire

julia.kasmire@manchester.ac.uk

 @JKasmireComplex

ukdataservice.ac.uk/help/

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