



Tolling in Cities: to compete or share the welfare gain?

Andrew Koh (a.koh@its.leeds.ac.uk)

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SATURN UGM 18-10-2012

- Transportation crosses boundaries and the influence of transport policy in one jurisdiction has an impact elsewhere in neighbouring jurisdictions at least.

(if Leeds had implemented pricing, York might be affected.)

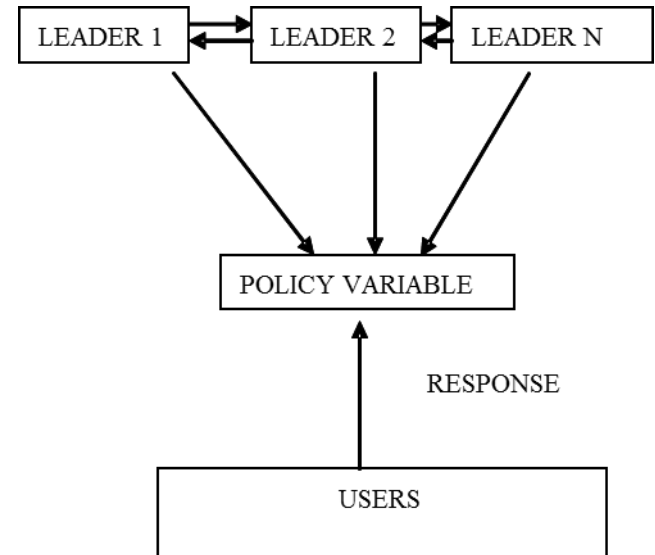
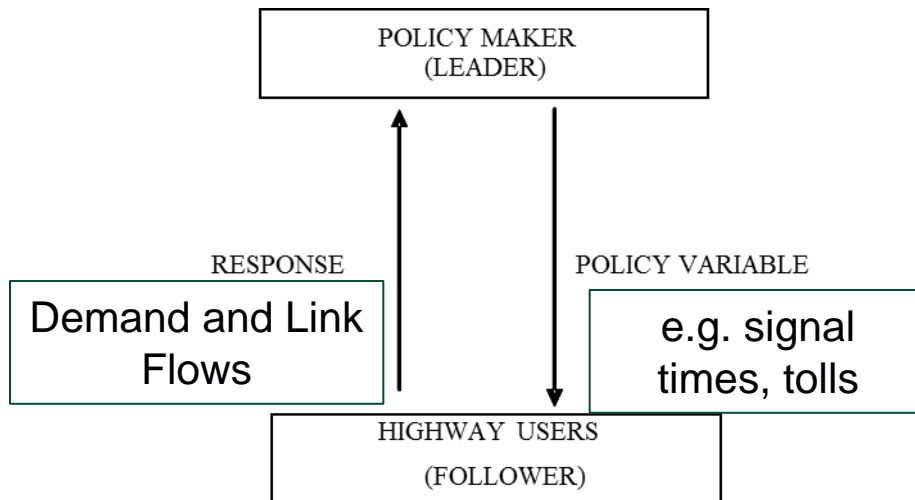
- Traffic route according to Wardrop's user Equilibrium principle (and even considering SUE) it is still an "equilibrium principle" underlying assignment.

SUZIE=T

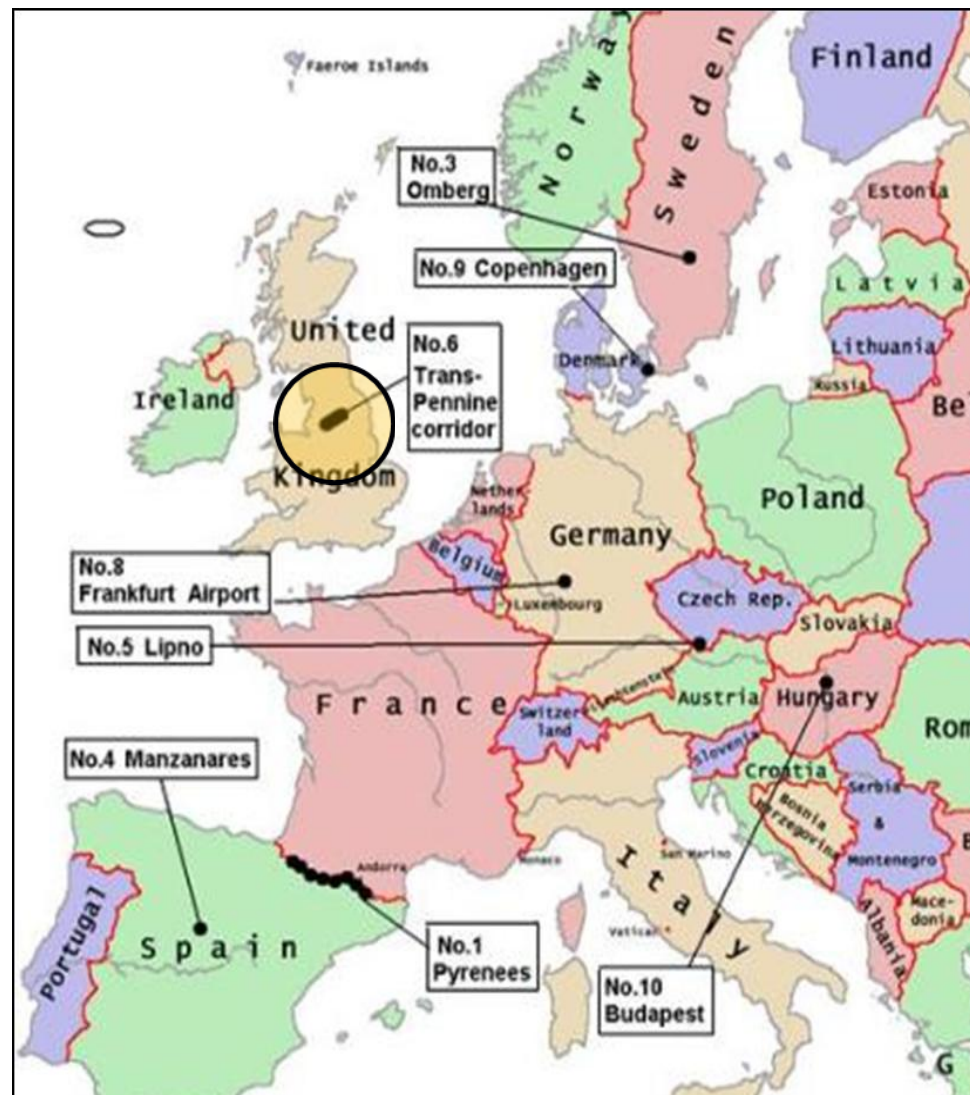
Equilibrium occurs when no user between each and every single OD pair is able to reduce **Perceived** generalized costs by switching routes

Under UE or SUE, this is an "equilibrium" constraint.

MPEC vs EPEC



- **Aim:**
- Test indicators and policies
- Support Action: EU directive (its in the rules for m/way tolling in Europe)
- **10 Case Studies**
 - 2 mountainous
 - 4 urban/metropolitan
 - 3 natural
 - 1 maritime



Characteristics of the Trans-Pennine Corridor



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- **Agglomeration area**
(total of 13 Mio. Inhabitants)
- **High quality natural capital**
- **Unique cultural heritage**
(e.g UNESCO heritage sites)
- **Recreational areas**
(e.g. National Parks)
- **Extensive transport infrastructure**
including TEN-T corridors
- **Area of economic regeneration**



Trans-Pennine Corridor Case Study Approach



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- “**Competition**” between **densely populated** and **areas of high natural significance**



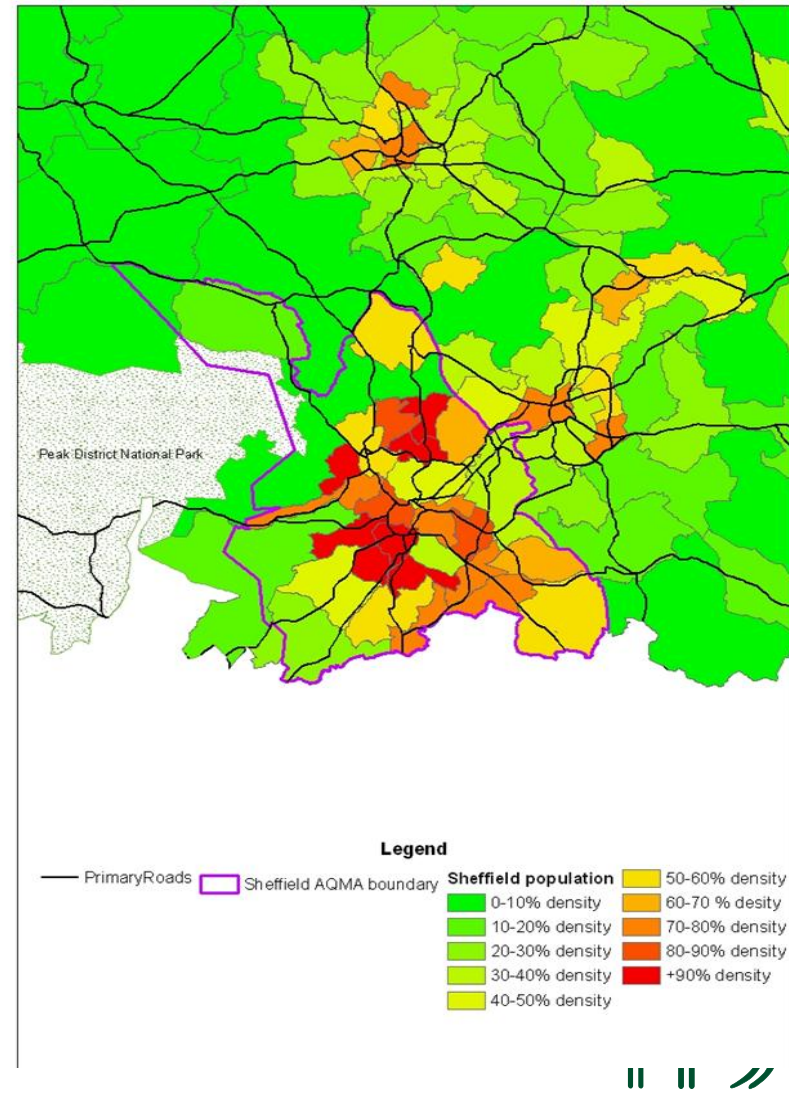
APPROACH:

1. Identification of **Transport Sensitive Areas**
 - Peak District National Park & Sheffield AQMA
2. Quantification of **Pressures** to TSAs
3. Selection of policies: **Pricing Strategies**
 - Global regulator (Whole region)
 - Myopic Regulator (TSA 1 + TSA 2)
 - Nash Competition
4. **Modelling** the **reduction potential** of policies
5. **Assessing** the **cost-effectiveness** of policies



Air Quality Management Areas

- Implemented in UK at problem areas
- Already management necessity
- Environment Act Chapter 24 of 1995:Part 4 Section 83 places statutory duty on Local Authority to devise Air Quality Management Strategy at areas where targets are not being met
- Sheffield is next to M1 motorway approx 100,000 AADT



Selection of TSAs for Policy Application



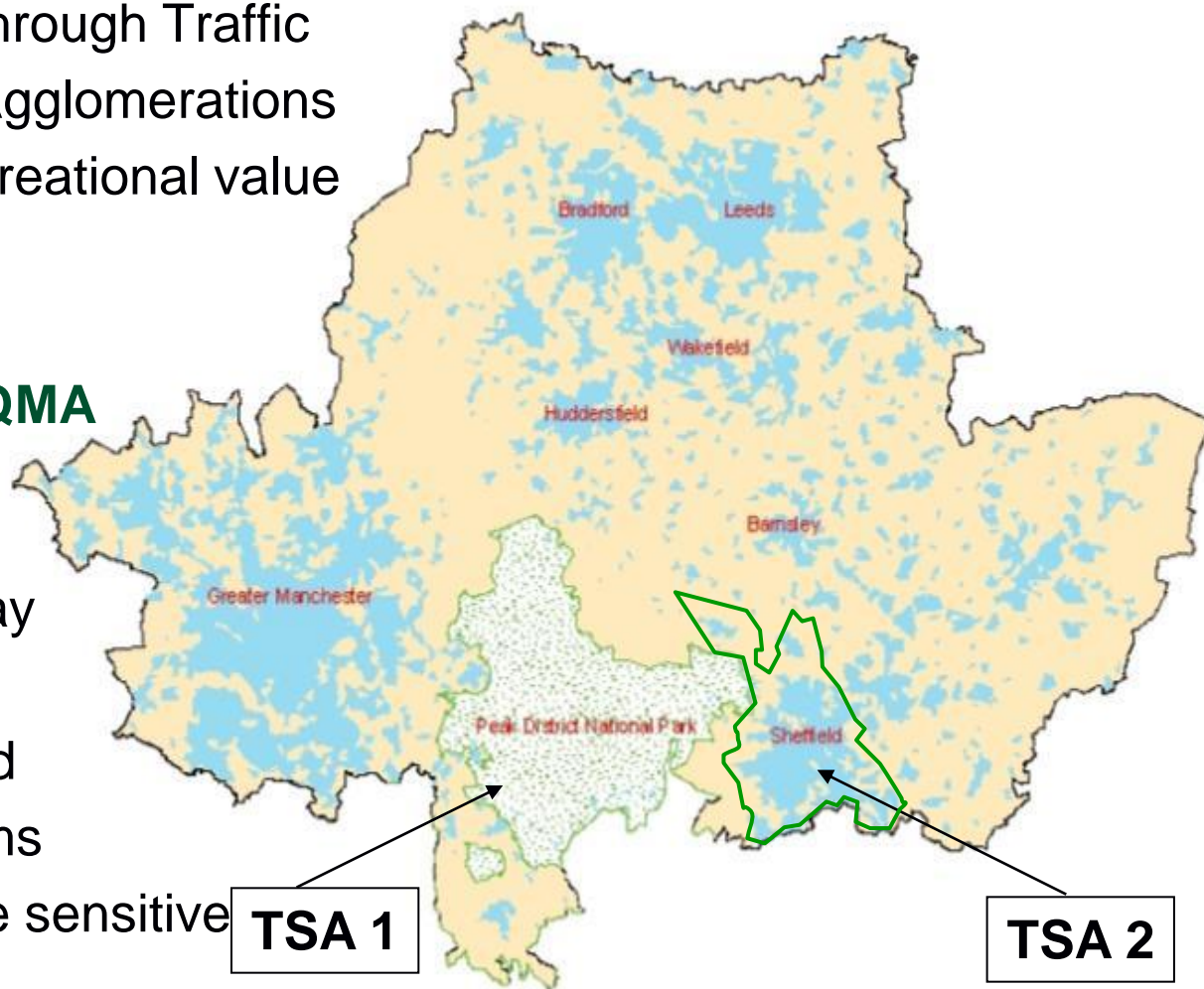
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TSA 1: **Peak District National Park**

- Protection from Through Traffic
- Centre of Urban Agglomerations
- High natural + recreational value
- Noise sensitive

TSA 2: **Sheffield AQMA**

- Through and area wide traffic
- next to major Mway (J 32 and 33 of M1)
- Densely populated
- Air quality problems
- Air pollution, noise sensitive





BAU Quantification and Valuation of Impacts

Effect	Description	Quantification of Effect				Costs [1000 Euro]	
		Units	Base Year (2005)	BAU (2020)	% Change	Base Year (2005)	BAU (2020)
Air Pollution	NMVOC	Tonnes per Peak Hour per annum	142	204	43.66	168	330
Air Pollution	NO _x	Tonnes per Peak Hour per annum	754	1032	36.87	6545	12263
Air Pollution	PM 2.5	Tonnes per Peak Hour per annum	463	633	36.72	137213	258935
Noise	Total Number Affected > 50 dBA	Population Affected	508225	567672	11.70	26538	29210
Accidents	Total Number of Accidents	Accidents per Peak Hour Per Annum with Casualty Costs	136	178	30.88	14026	21683

Choice of Policy Measures

- Main issues: noise and air pollution → pricing measures (internalization)
- Strong interest in demand management measures, in particular road user charging instruments in region, e.g.
 - Action 3 , Section 6 **Peak District National Park Management Plan 2006-11:**



“Research an environmental levy in partnership with key stakeholders as a means of securing resources for conserving and enhancing the National Park, promoting its understanding and enjoyment, as well as constraining the proliferation of traffic.”

- **Northern Way Transport Strategy** on local fiscal restraint measures:

“The Northern Way fully endorses these City Regional and local initiatives but it is also clear that approaches based on individual local authority areas are hard to adopt in practice.”

- ⇒ **Cordon Charging**



Pricing Strategies (Policy Packages)



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- Predefined Cordon in each TSA

- **Level of Charge** for TSAs:

- Determine the cordon charge (for all UC)

- Difference is the **definition** of the objective function

- **Global regulator PP1**

- concerned with welfare of all travellers over the entire network

- **Myopic Regulator PP2**

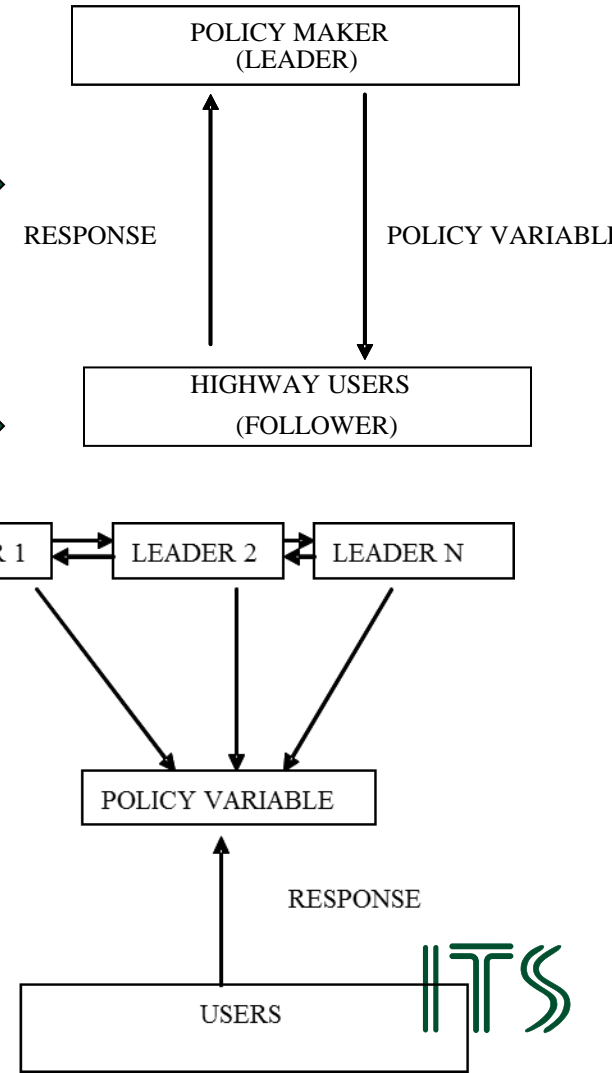
- concerned with welfare of all travellers in TSAs only

- **Nash Competition PP3**

- local regulators concerned with welfare of travellers in each TSA

- Each TSA plays a “game” to determine charge

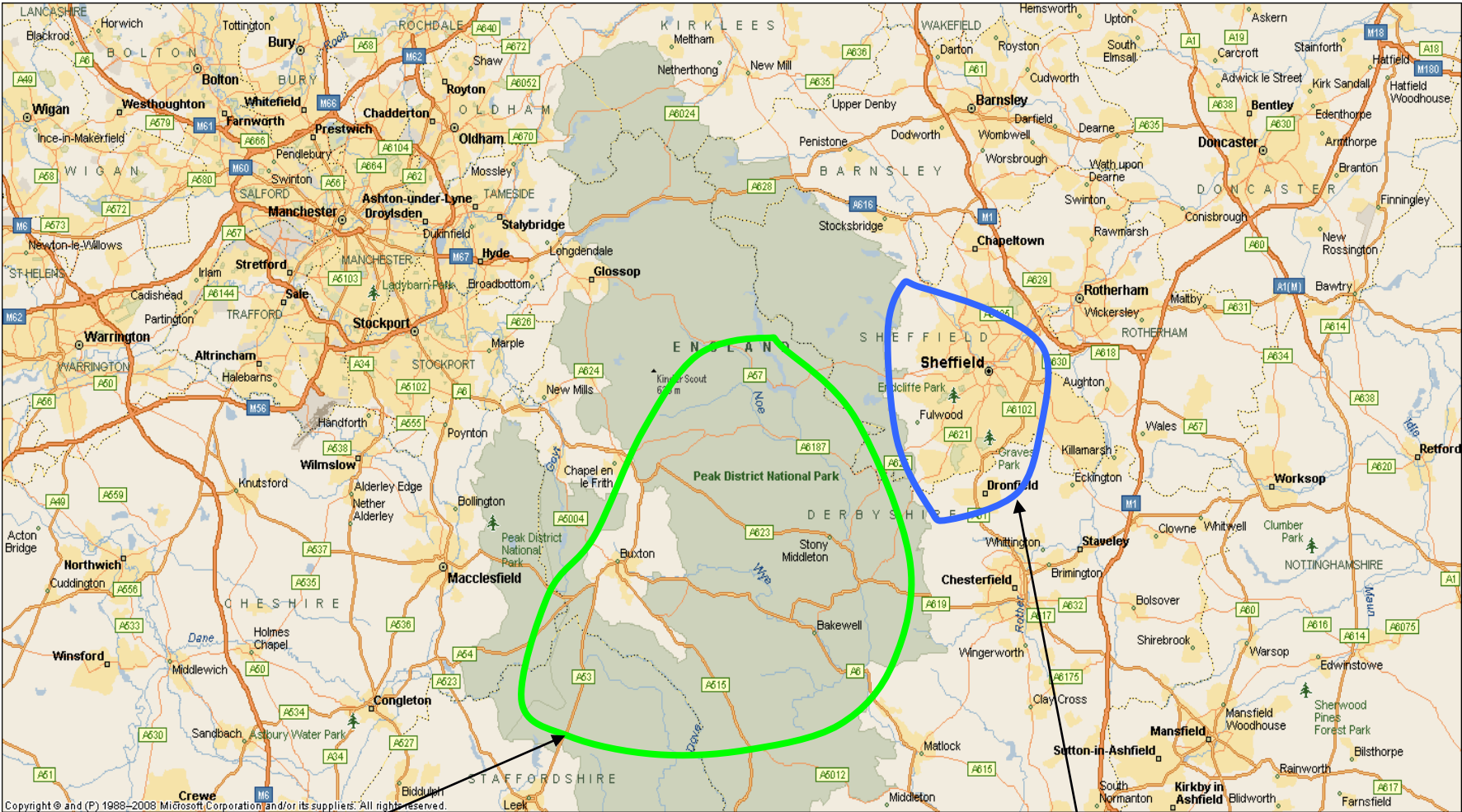
- **incentive to extract revenue from non-residents**



Charging Cords around TSAs



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Cordon TSA 1

Cordon TSA 2

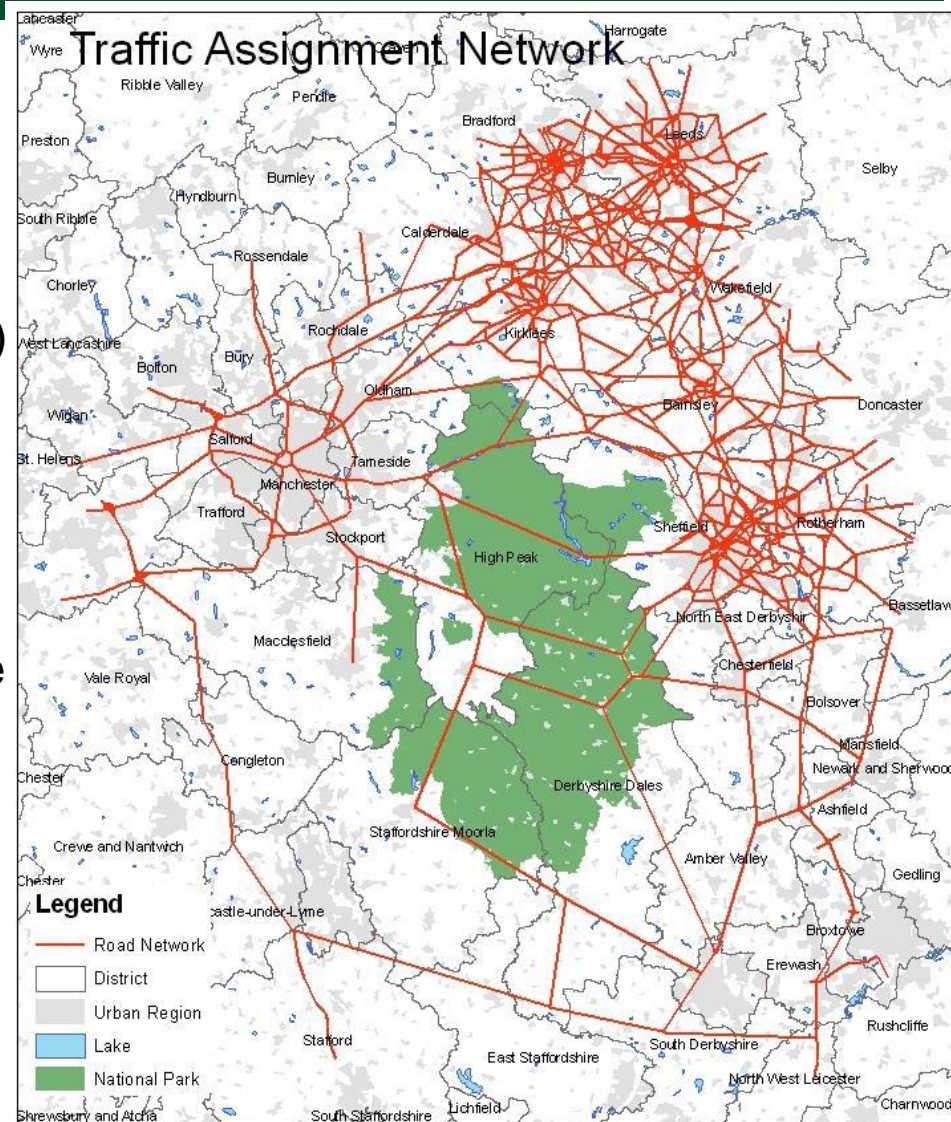


Modelling Approach



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- Welfare function - sum of:
 - User benefits (generalised costs)
 - Revenues
 - Pollution costs (NMVOC, NO_x , PM_{10})
- Modelling Framework
 - SWYMBUS transport data
 - Base case 2005 and BAU scenario
 - SATURN traffic assignment software
 - Local Environmental models
- Valuation
 - Pollution: HEATCO (Impact pathway approach)
 - User benefits: Rule of Half



Results



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Policy Package		Toll [£]	Welfare [£ per hour]	
PP1: Global	Peak Welfare	0.50	-936	
	Sheffield Welfare	2	5,723	
	Global Welfare = Regulator			1,577
PP 2: Myopic	Peak Welfare	1.50	3,037	
	Sheffield Welfare	2	3,809	
	Regulator (Peak + Sheffield)			6,910
	Global Welfare			936
PP3: Nash Game between TSAs	Peak Welfare	4.00	4,317	
	Sheffield Welfare	5.50	1,433	
	Global Welfare			-4,667



Observations

		Toll [£]	Welfare [£ per hour]
<ul style="list-style-type: none"> Global welfare and for Sheffield highest under global regulator (PP1) and lowest in Nash Game (PP3) 	Peak	0.50	-936
	Sheffield	2	5,723
<ul style="list-style-type: none"> Welfare for Peak District highest under PP3 “Beggars my neighbour” in Nash Game i.e. Peak has incentive to make Sheffield worse off so as to make own welfare better 	Global = Regulator	1.50	1,577
	Peak		3,037
	Sheffield		3,809
	Regulator (Peak + Sheffield)		6,910
<ul style="list-style-type: none"> PP2: Myopic 	Global		936
	Peak	4.00	4,317
	Sheffield	5.50	1,433
<ul style="list-style-type: none"> PP3: Nash Game between authorities 	Global		-4,667

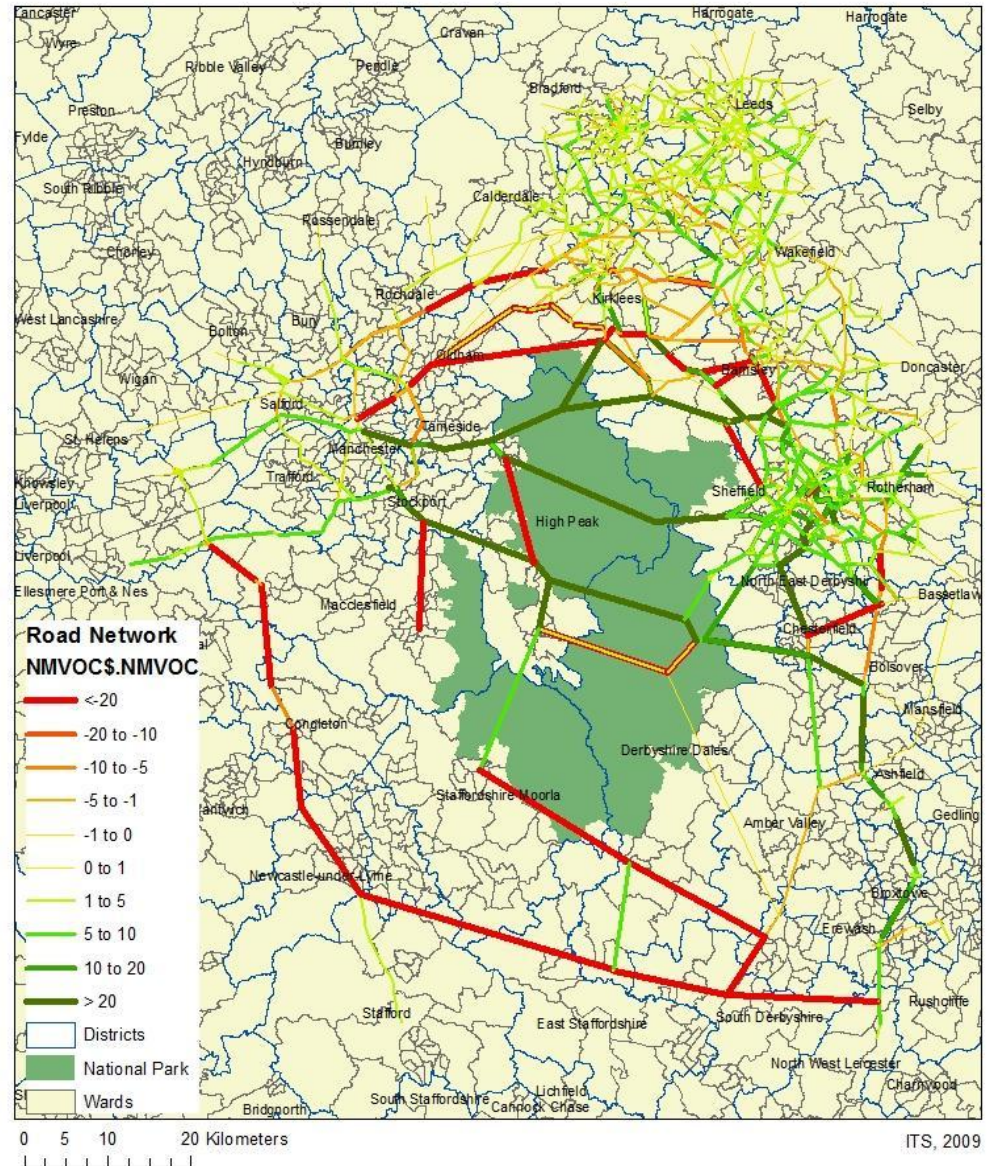
Rerouting Impacts

- Relocation of environmental burden due to **long distance rerouting**, most obvious under Nash game due to toll level

➔ Environmental Justice of pricing policies (Dobson, 1998)

Env Justice: spatial inequities due to *relocation* of pollution

Change in NMVOC Emissions BAU - Nash [ton/peak h annual]



Example Results PP 3 (Nash Game)



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Entire Network	BAU (2020)	Policy Package 3	% Change
NM VOC	808.22	805.82	-0.30%
NO _x	4081.52	4065.81	-0.39%
PM2.5	2503.12	2493.41	-0.39%

Road Network within TSA1 Only	BAU (2020)	Policy Package 3	% Change
NM VOC	46.79	36.15	-29.44%
NO _x	225.92	178.17	-26.80%
PM2.5	4.57	3.56	-28.43%

Road Network within TSA2 Only	BAU (2020)	Policy Package 3	% Change
NM VOC	40.99	35.70	-14.81%
NO _x	134.30	110.48	-21.56%
PM2.5	3.84	3.37	-14.22%

- **Public acceptability**

- Strong opposition by public (eg Manchester, Edinburgh failures @ referenda)
- Current economic climate → against additional charges
- But also opposition against Environmental Zones (Sheffield)

- **Administrative / legislative powers**

- Peak District National Park Authority could not introduce charge: relies on
7 Highway Authorities and at least 6 Local Authorities

- **Funding**

- GB TIF (Transport Innovation Fund) pump priming funding uncertain (central government decides) and probably out of question now
 - Unsuccessful bid by Derbyshire county in 2005 to investigate traffic restraint measures including Environmental Levy

- **Necessity for some global regulation** of charging in ‘competitive’ situation so as to:
 - Avoid revenue extraction by regulators from non-local traffic
 - Avoid relocation of impacts
 - Myopic scenario could be **compromise**
- **Bias of results** towards **impacts on human health**
 - Valuation approaches for tranquillity + impacts on biodiversity required (concern expressed by Peak District National Park)
 - Difference between Nash (as optimum for Peak) and global could be seen as ‘opportunity cost’ / ‘mark-up’

“Overall the study is very good, and is particularly so in recognising the lack of valuation accorded to the impacts of traffic upon environmentally sensitive areas.” (*comments from Peak District Official*)

- Pricing: **blunt** and raise issues of Environmental Justice

Institute for Transport Studies

FACULTY OF ENVIRONMENT



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PART 2: IMPLEMENTATION IN SATURN

ITS

- We need to implement algorithm to do a “Grid Search” to find benefits for each level of toll

For Toll Peak = £0 to £8 step 0.5

For Toll Sheffield = £0 to £8 step 0.5

WRITE OUT A “KNOBS” FILE

RUN SATURN

CARRY OUT MX ROH

COMPUTE POLLUTION BENEFITS

Next Toll Sheffield

Next Toll Peak

need to “pause” the main program, pass control over to the batch file which does the assignment calculations before continuing

→ Launch application asynchronously

Next few slides show how we did it

Followed by a demo

Implementation in VB (Visual Studio.NET)



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```
19
20 Sub Main()
21
22     'this is the value of time..essential in the work
23     VOT(0, 0) = 14.76
24     VOT(0, 1) = 26.92
25     VOT(0, 2) = 17.99
26     VOT(0, 3) = 17.99
27
28     Dim FreeFNum As Integer = FreeFile()
29     FileOpen(FreeFNum, "summary.dat", OpenMode.Output)
30     FileClose(FreeFNum)
31     FileOpen(FreeFNum, "summary.dat", OpenMode.Append)
32
33     counter1 = 1
34     Call ReadInCordonDefn()
35     For Toll1 = 0 To 800 Step 50
36         counter2 = 1
37         For Toll2 = 0 To 800 Step 50
38             Console.WriteLine("Toll Light:" & Toll1.ToString & "Toll Heavies:" & Toll2.ToString)
39             Call WriteChargeFile(Toll1, Toll2, counter1, counter2)
40             Call WriteSATfile()
41             Call ReadRevenue(counter1, counter2)
42             Call ReadBenefits(counter1, counter2)
43             PrintLine(FreeFNum, Toll1.ToString, Toll2.ToString, UB.ToString, rev.ToString)
44             counter2 = counter2 + 1
45         Next Toll2
46         counter1 = counter1 + 1
47     Next Toll1
48
49     FileClose(FreeFNum)
50     Console.WriteLine("Done")
51 End Sub
```



The code to “start a process”



```
187 Sub WriteSATfile()  
188  
189     Dim q As Integer  
190     'open the file and close it  
191     'this makes sure that if it was already filled with data it will be killed  
192  
193     Dim FreeFNum As Integer = FreeFile()  
194     Dim xProcess As New Process  
195     FileOpen(FreeFNum, "temp.bat", OpenMode.Output)  
196     FileClose(FreeFNum)  
197     FileOpen(FreeFNum, "temp.bat", OpenMode.Append)  
198     PrintLine(FreeFNum, "PATH=" & SATPATH)  
199     PrintLine(FreeFNum, "CALL runevalDiff.bat")  
200     FileClose(FreeFNum)  
201  
202     'modified code here  
203     xProcess.StartInfo.FileName = "temp.bat"  
204     xProcess.StartInfo.UseShellExecute = False  
205     xProcess.StartInfo.CreateNoWindow = True  
206     xProcess.StartInfo.WindowStyle = ProcessWindowStyle.Hidden  
207     xProcess.Start()  
208     xProcess.WaitForExit()  
209  
210 End Sub  
211
```


Batch file that is called



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```
if exist cordonknb.dat erase cordonknb.dat
type cordonknbshef.dat >> cordonknb.dat
type cordonknbpeak.dat >> cordonknb.dat

start/w $satnet 0800_2020_ASSET_CORDON quiet
COPY 0800_2020_ASSET_CORDON.LPN 0800_2020_ASSET_CORDON.NET
start/w $satal1 0800_2020_ASSET_CORDON AMMAT_2020 KR somecon COST basecost TIJ TRIPS_CORDON QUIET

if exist temp1.ufm erase temp1.ufm
if exist temp2.ufm erase temp2.ufm
if exist temp3.ufm erase temp3.ufm
if exist temp4.ufm erase temp4.ufm
start/w $satlook 0800_2020_ASSET_CORDON key skim4uc vdu vdu
CALL MXSTACK CORDON_COST TEMP1 TEMP2 TEMP3 TEMP4
if exist temp1.ufm erase temp1.ufm
if exist temp2.ufm erase temp2.ufm
if exist temp3.ufm erase temp3.ufm
if exist temp4.ufm erase temp4.ufm

IF EXIST EVAL.TXT ERASE EVAL.TXT
REM generate a file called eval.txt for VB program to read
CALL mxroh TRIPS_DM TRIPS_CORDON DM_COST CORDON_COST EVAL
COPY EVAL.UFM EVALS.UFM

REM REVENUE FOR SHEFFIELD
if exist linkrevSHEF.dat erase linkrevSHEF.dat
if exist temp.txt erase temp.txt
START/w $SATDB 0800_2020_ASSET_CORDON KR CORDONKNBSHEF KEY getrev vdu vdu
copy temp.txt linkrevSHEF.dat
erase temp.txt

rem ENVIRONMENT INFORMATION FOR SHEFFIELD LAQM
if exist temp.txt erase temp.txt
START/w $SATDB 0800_2020_ASSET_CORDON KR env_laqm KEY getenv VDU VDU
```



```
workingshellwait.cs X
1 using System;
2 using System.Diagnostics;
3 //this is an example of a working shell and wait in VISUAL C #
4 namespace test
5 {
6 public class test
7 {
8 static void Main()
9 {
10 ProcessStartInfo myP = new ProcessStartInfo();
11 myP.FileName = "F:\\\\Projects\\CSharp\\temp.bat";
12 using(Process myp = new Process())
13 {
14 myp.StartInfo = myP;
15 try{
16 myp.Start();
17 myp.WaitForExit();
18 Console.WriteLine("alles guttes");
19 }
20 catch{
21 Console.WriteLine("fail");
22 }
23 }
24 }
25 }
26 }
27 }
```

About Microsoft Visual Studio

Microsoft Visual Studio 2010
Version 10.0.30319.1 RTMRel
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Installed products:

- Microsoft Office Developer Tools 01018-532-2002181-70985
- Microsoft Visual Basic 2010 01018-532-2002181-70985
- Microsoft Visual C# 2010 01018-532-2002181-70985
- Microsoft Visual C++ 2010 01018-532-2002181-70985
- Microsoft Visual F# 2010 01018-532-2002181-70985
- Microsoft Visual Studio 2010 Team Explorer 01018-532-2002181-70985
- Microsoft Visual Web Developer 2010 01018-532-2002181-70985
- Crystal Reports Templates for Microsoft Visual Studio 2010
- Microsoft Visual Studio 2010 SharePoint Developer Tools 10.0.30319



Can also be done In SALFORD FTN



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A screenshot of a Fortran IDE window titled 'Plato - DEMOSHELLWAIT.F95*'. The window has a menu bar with 'File', 'Edit', 'View', 'Project', 'Build', 'Tools', 'Window', and 'Help'. Below the menu bar is a toolbar with various icons for file operations and editing. The main text area contains the following Fortran code:

```
PROGRAM DEMOSHELLWAIT
!VERY IMPORTANT TO INCLUDE THIS AS WE USE THE LIBRARY CLEARWIN
USE MSWIN
! SEE THE DOCUMENTATION FOR START_PROCESS WHICH BASICALLY STARTS A PROCESS AND WAITS FOR IT TO TERMINATE
INTEGER START_PROCESS@,i
i=START_PROCESS@('TEMP.BAT',' ')
PRINT *,' Look at the results.'
END PROGRAM DEMOSHELLWAIT
```

- Microsoft Excel™ is available at most desktops in many offices
- Obviates need for specialised programming language
- Remark: Microsoft offers some editions of Visual Studio at no charge even for commercial use

DEMO:

#1 Run SATURN and use P1X

#2 Run SATURN and obtain link flows from base year to 2020

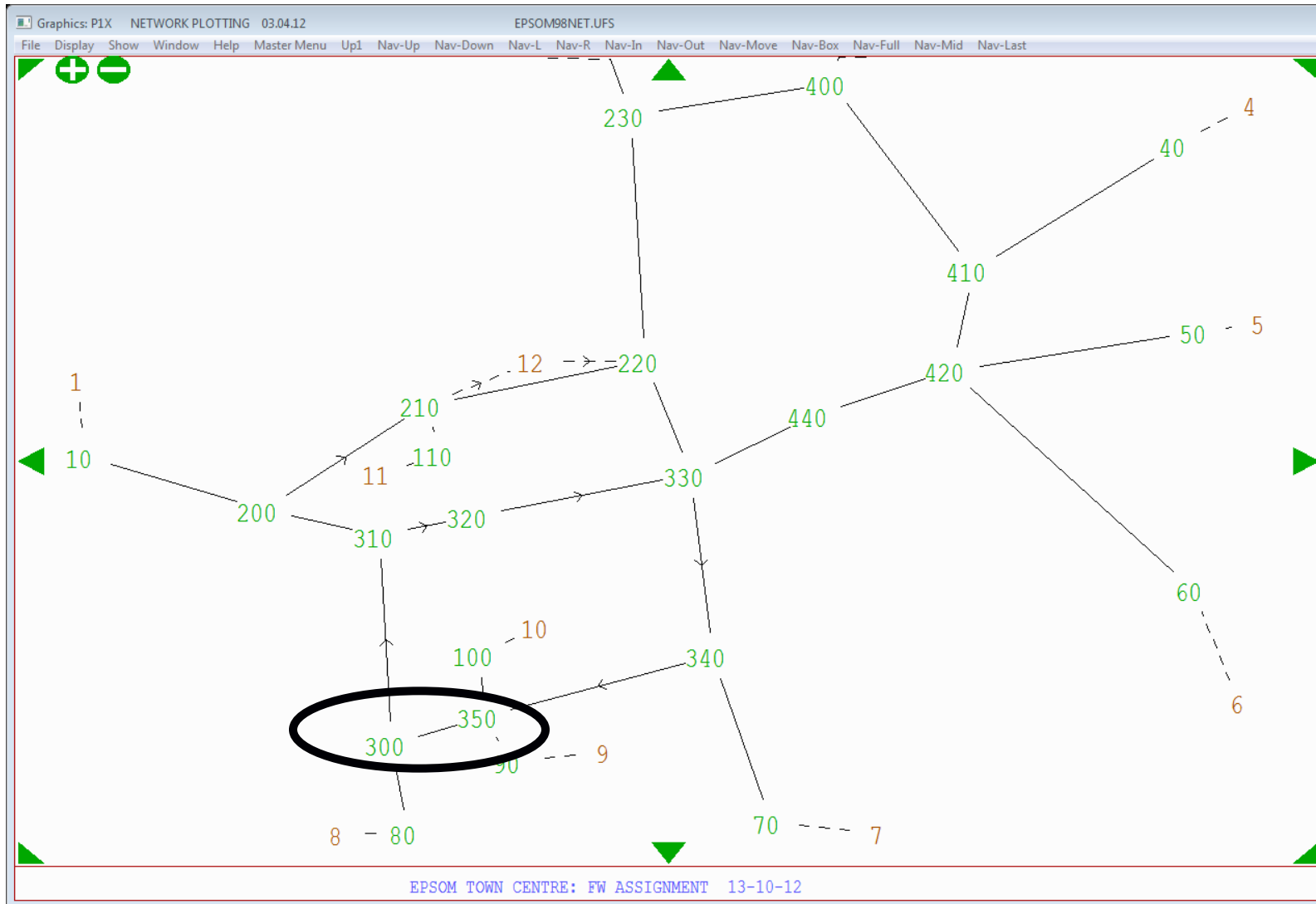
#2 requires saturn → VBA → saturn in a loop

Requires “waiting” for SATURN batch to complete before executing next line of the macro

EPSOM Network 1998 base year



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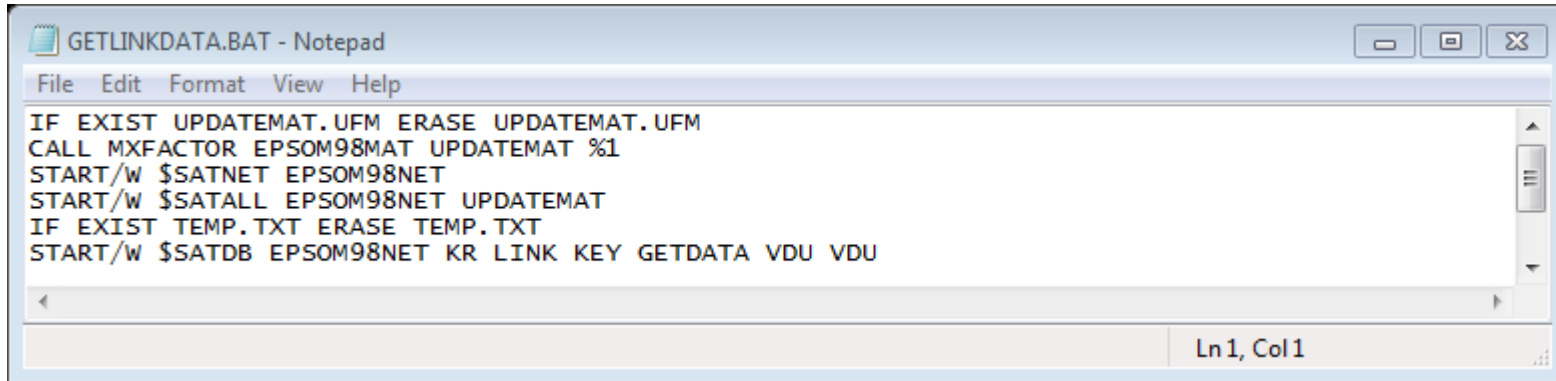
Can Ian enter the Atkins Carpark each morning?



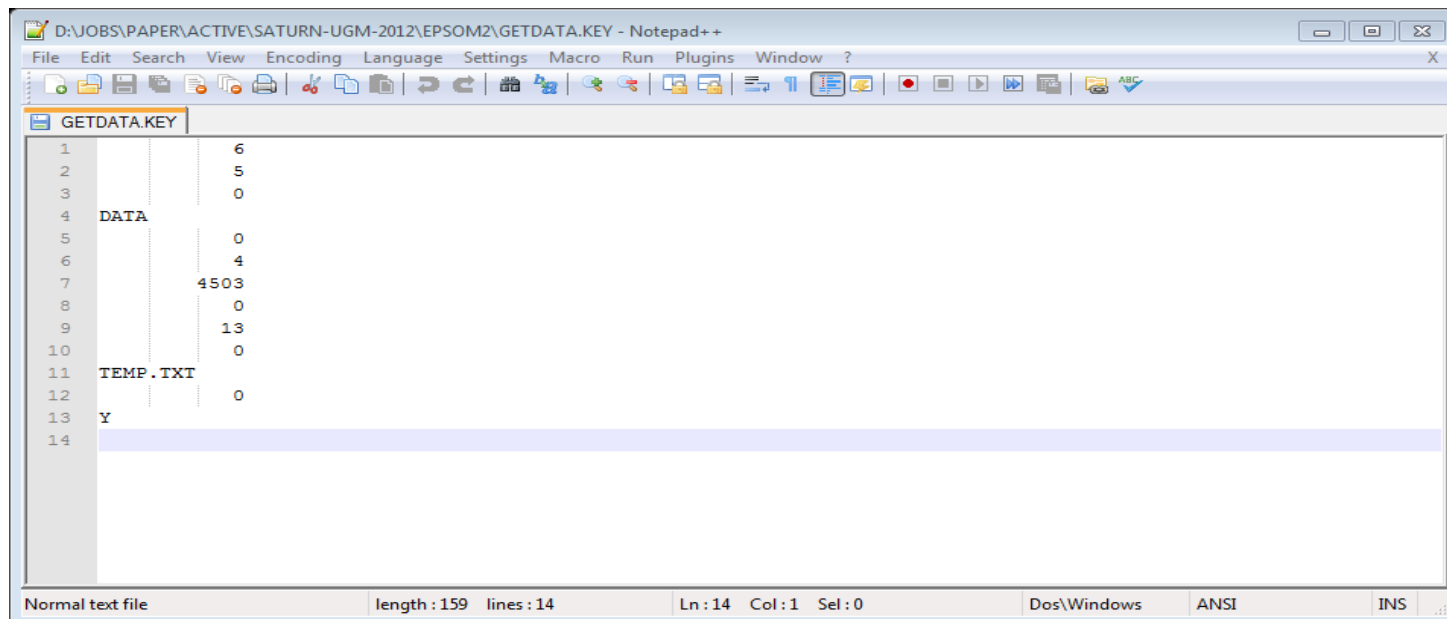
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- Ian wants to know traffic flow on Link 300-350 for 17 years from 1998 to 2015
- Let's assume Matrix Factor of 1.02 per annum but this can be changed within Excel™...we want to:
 1. Assign for each year, after growing matrix (avoiding use of GONZO parameter)
 2. extract the Link Flow for Link 300-350
 3. plot a chart of the link flow each year

- BATCH FILE LOOKS LIKE THIS



```
GETLINKDATA.BAT - Notepad
File Edit Format View Help
IF EXIST UPDTEMAT.UFM ERASE UPDTEMAT.UFM
CALL MXFACTOR EPSOM98MAT UPDTEMAT %1
START/W $SATNET EPSOM98NET
START/W $SATALL EPSOM98NET UPDTEMAT
IF EXIST TEMP.TXT ERASE TEMP.TXT
START/W $SATDB EPSOM98NET KR LINK KEY GETDATA VDU VDU
Ln 1, Col 1
```



```
D:\JOBS\PAPER\ACTIVE\SATURN-UGM-2012\EPSOM2\GETDATA.KEY - Notepad++
File Edit Search View Encoding Language Settings Macro Run Plugins Window ?
GETDATA.KEY
1      6
2      5
3      0
4  DATA
5      0
6      4
7      4503
8      0
9      13
10     0
11  TEMP.TXT
12     0
13  Y
14
Normal text file length : 159 lines : 14 Ln : 14 Col : 1 Sel : 0 Dos\Windows ANSI INS
```