# Two examples of scenario analysis tools:

# Long term demographics & travel

# Long distance mode choice with attitudinal variables

Mark Bradley, RSG

TRB Scenario Planning Conference, Portland, August 2016

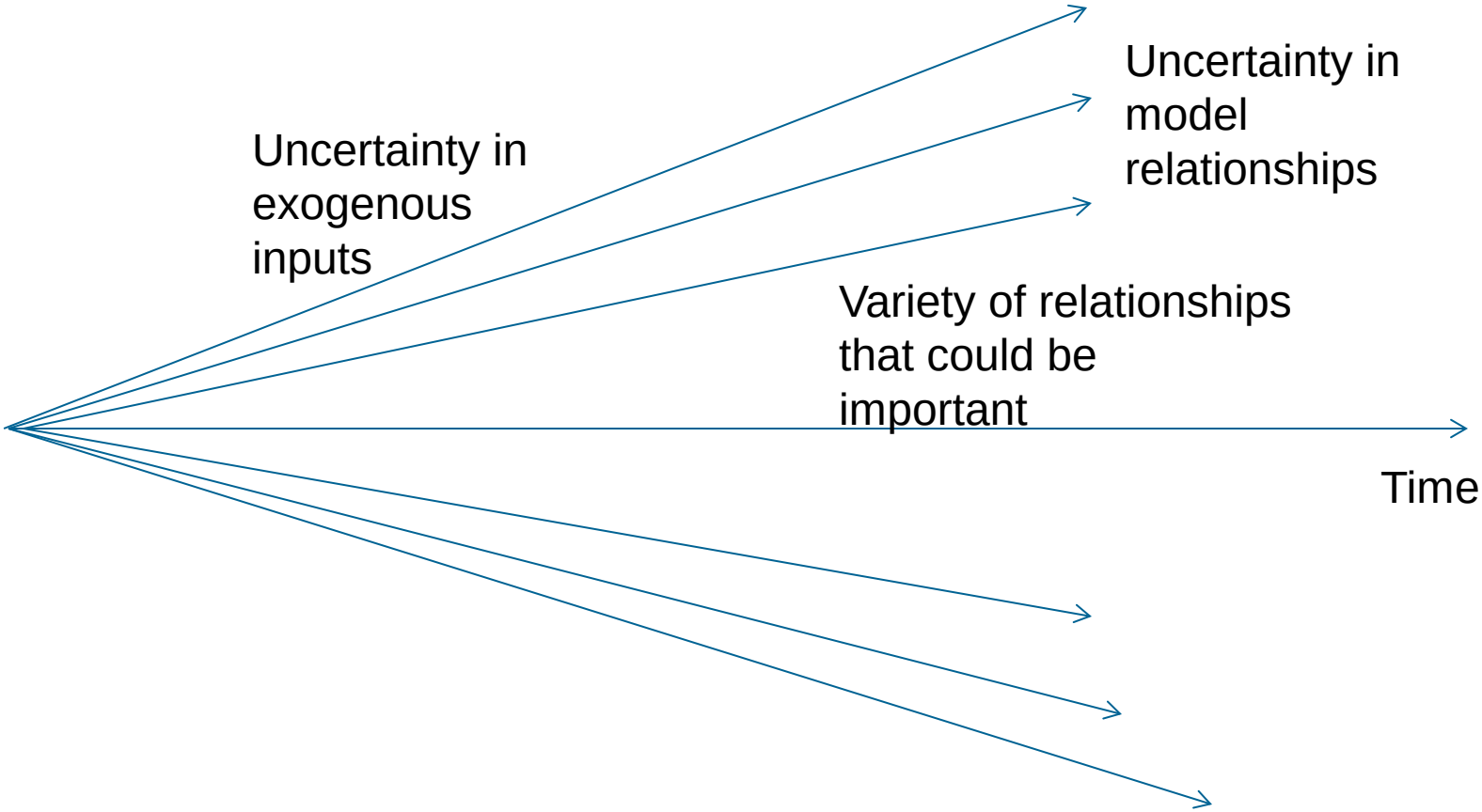
# Impact of Socio-Demographics on Travel Demand (NCHRP 20-83 (06) – TRB Report 750)

- Research focused on understanding:
  - How the composition of the population might change over time
  - How socio-demographic changes will affect ways in which people travel
  - How assumptions about changes in demographic patterns and travel behavior “play out” over time
  - Which assumptions seem to lead to the most contrast across different scenarios

# Impacts 2050 Is . . .

- A strategic scenario analysis tool
- Comprised of:
  - A Systems Dynamics model that can represent the co-evolution of population, land use, employment, transport supply and travel behavior
  - Scenarios representing divergent visions of alternative futures
- Not intended to replace existing travel demand forecast models

# As a model is run further into the future, precision in the inputs and forecasts becomes less possible, and the ability to represent a wide range of scenarios becomes more relevant



# Systems Dynamics modeling

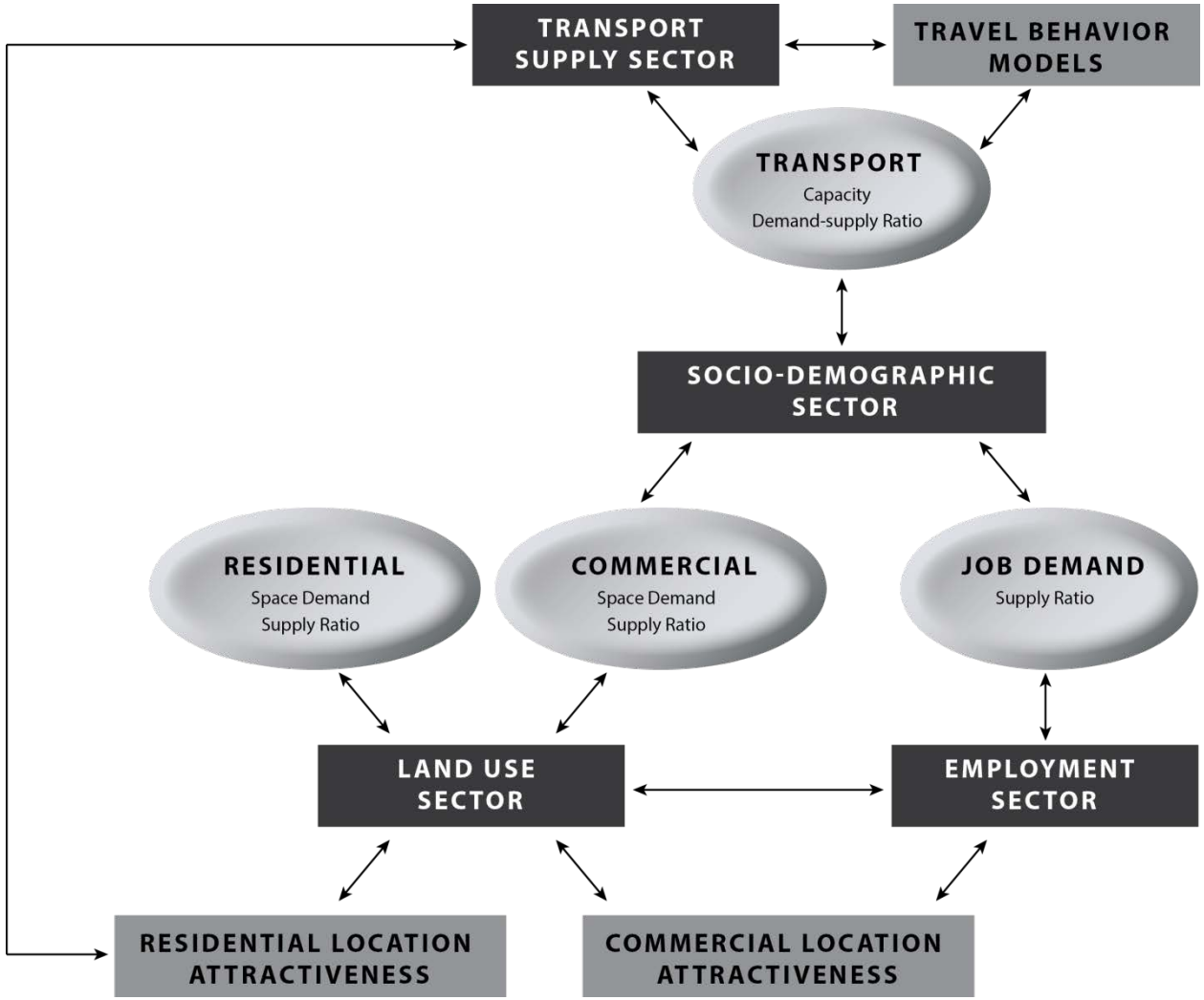
The focus is on relationships between variables **over time** *(rates of change)*

Behavior results from **feedback** between system components *(can be limiting effects or reinforcing cycles)*

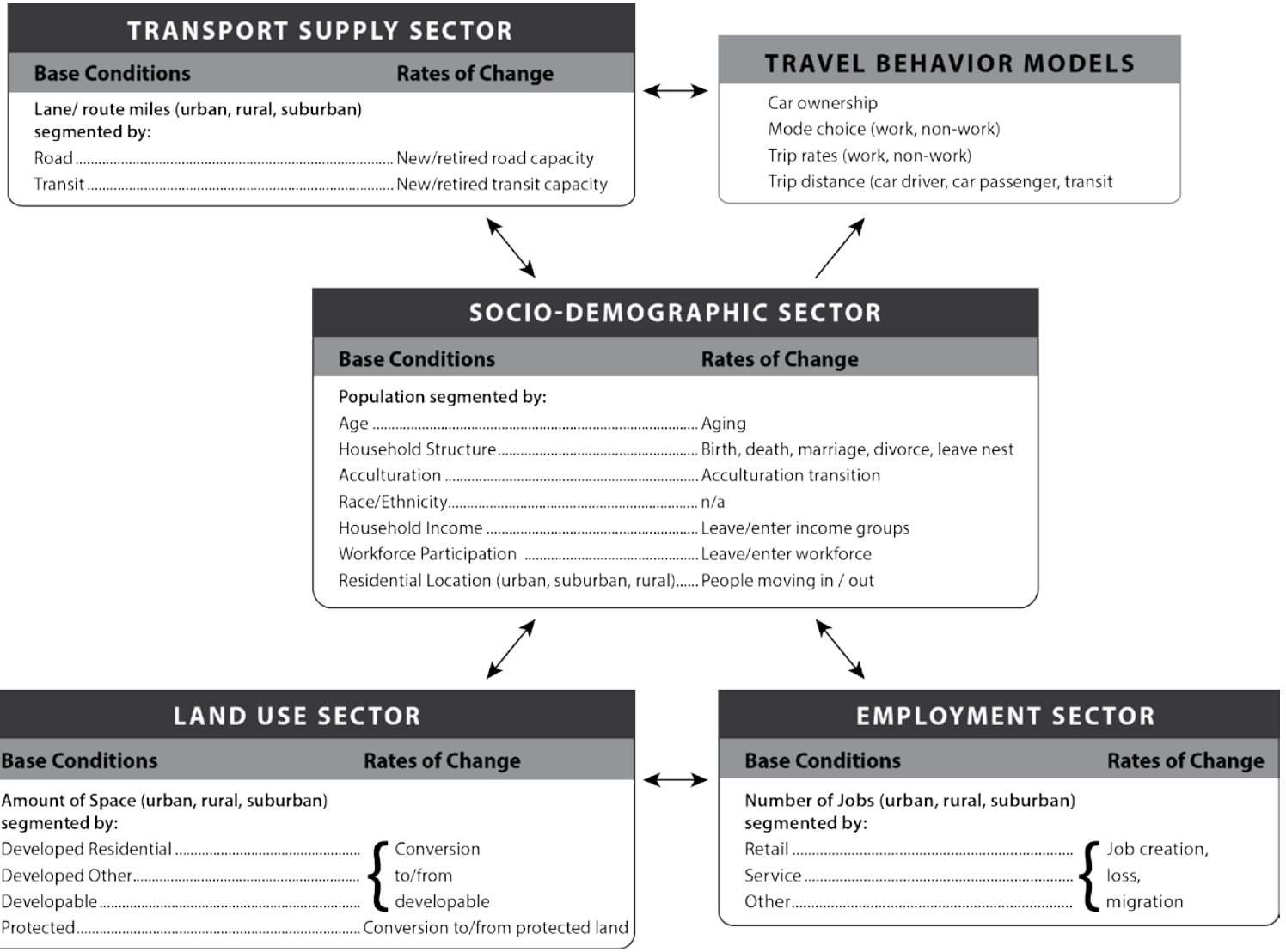
Developed at MIT in 1960's for industrial systems (Forrester).

- "Limits to Growth" Club of Rome study (Meadows, *et al.* 1970's)
- Urban Dynamics (Forrester, 1970's)
- Many applications since in many different fields.

# System Dynamics Model



# Model Structure



# Demographic transition rates

- Basic rates derived from analysis of the Panel Survey on Income Dynamics (PSID) 2003-2009
- Rates for:
  - Birth
  - Death
  - “Marriage”
  - “Divorce”
  - Leave nest/empty nest
  - Enter/leave workforce
  - Enter/leave income group
- The user can apply scenario-specific multipliers on these rates

Rates vary by combination of:
- Age group
- Household type
- Race/acculturation

# Demographic migration rates

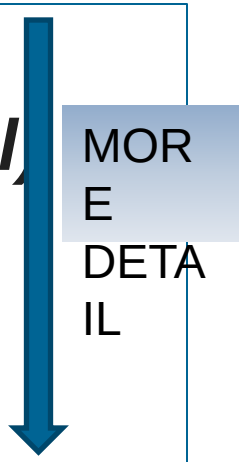
- Three types of migration:
  - Foreign (from / to other countries)
  - Domestic (from / to other regions of the US)
  - Regional (from / to other area types in the region)
- Base rates are derived from Census data, and modified by:
  - Residential attractiveness – function of demand vs. supply of jobs, housing, road capacity
  - User-defined scenario effects

# Other feedbacks…

- *The Employment Sector*
  - A very simple model of job creation, loss & migration
- *The Land Use Sector*
  - A very simple model of transition of land between residential, non-residential, undeveloped & protected
- *The Transportation Supply Sector*
  - A very simple model of capacity addition and retirement for roads and transit
- These feedbacks can be turned “on” or “off to investigate the difference between unconstrained and constrained demand, and between responsive and unresponsive supply

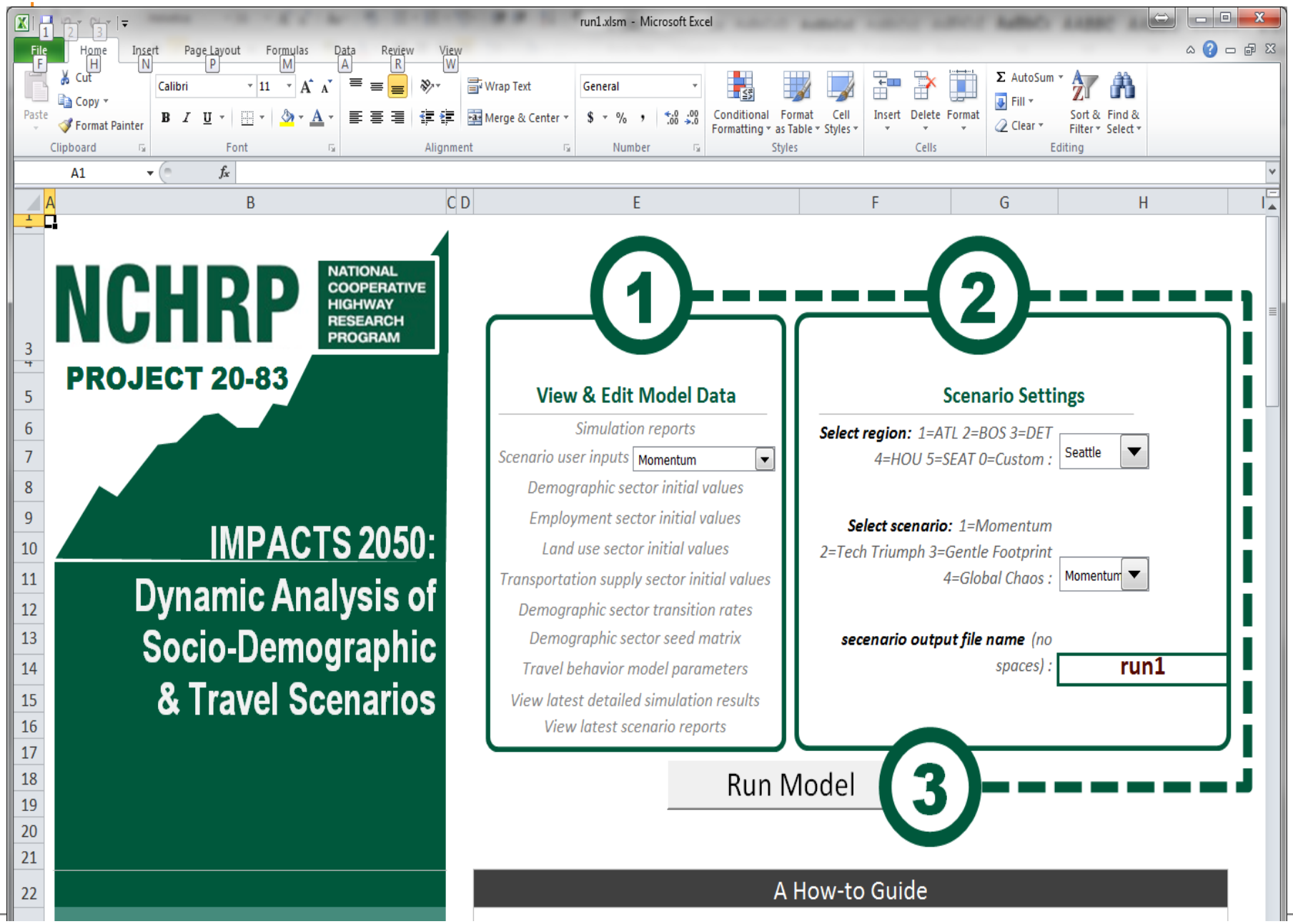
# Options for Spatial Detail

- A single area for the entire region
- ***Generic area types (urban, suburban, rural)***
- County-level zones
- Combination of County-level and area types
- Census tract level zones




Started with simple area types to ease data preparation and model useability.

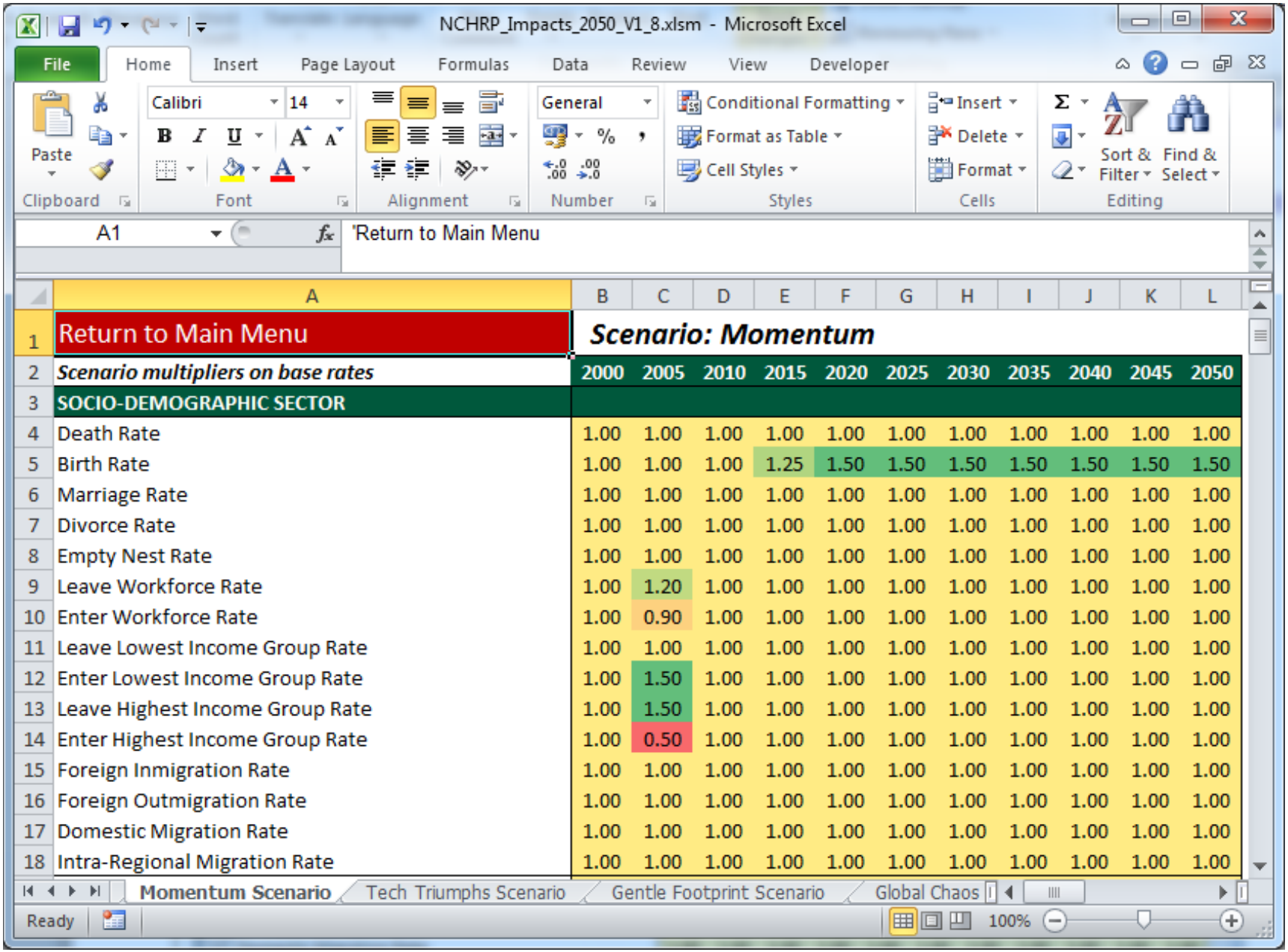
Could move to somewhat more detail in a future version


run1.xlsm - Microsoft Excel
NCHRP
NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
PROJECT 20-83
IMPACTS 2050:
Dynamic Analysis of Socio-Demographic & Travel Scenarios
1
View & Edit Model Data
Simulation reports
Scenario user inputs
Momentum
Demographic sector initial values
Employment sector initial values
Land use sector initial values
Transportation supply sector initial values
Demographic sector transition rates
Demographic sector seed matrix
Travel behavior model parameters
View latest detailed simulation results
View latest scenario reports
2
Scenario Settings
Select region: 1=ATL 2=BOS 3=DET 4=HOU 5=SEAT 0=Custom :
Seattle
Select scenario: 1=Momentum 2=Tech Triumph 3=Gentle Footprint 4=Global Chaos :
Momentum
secenario output file name (no spaces) :
run1
Run Model
3
A How-to Guide

# Pre-Programmed Scenarios

*Based on Delphi panel deliberation*

- ***Momentum***
  - Change is based on population dynamics
- ***Technology Triumphs***
  - Innovations mitigate difficult challenges
- ***Gentle Footprint***
  - Public consciousness and political shifting toward taking serious action to curb climate change
- ***Global Chaos***
  - Distressing new normal – financial instability, climate change impacts, isolationism



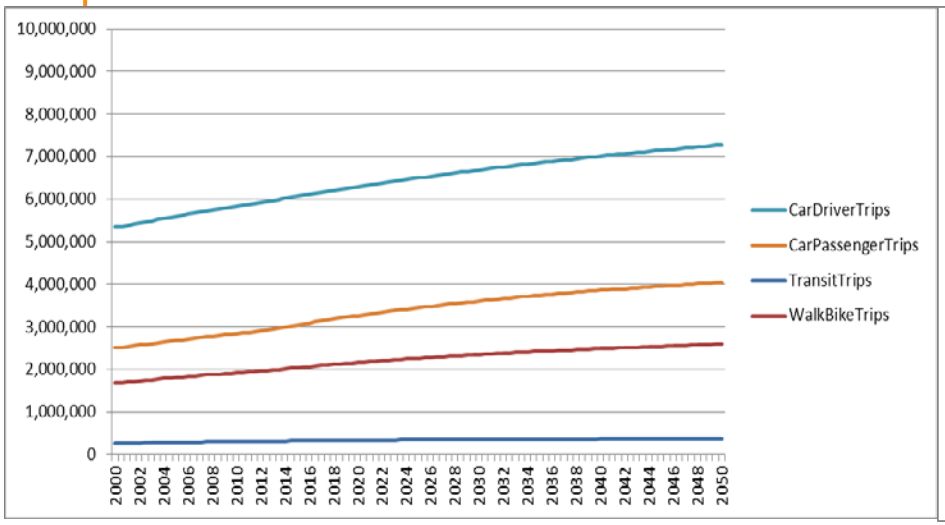

| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Return to Main Menu | *Scenario: Momentum* | | | | | | | | | | |
| 2 | *Scenario multipliers on base rates* | 2000 | 2005 | 2010 | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
| 3 | SOCIO-DEMOGRAPHIC SECTOR | | | | | | | | | | | |
| 4 | Death Rate | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 5 | Birth Rate | 1.00 | 1.00 | 1.00 | 1.25 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 |
| 6 | Marriage Rate | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 7 | Divorce Rate | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 8 | Empty Nest Rate | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 9 | Leave Workforce Rate | 1.00 | 1.20 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 10 | Enter Workforce Rate | 1.00 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 11 | Leave Lowest Income Group Rate | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 12 | Enter Lowest Income Group Rate | 1.00 | 1.50 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 13 | Leave Highest Income Group Rate | 1.00 | 1.50 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 14 | Enter Highest Income Group Rate | 1.00 | 0.50 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 15 | Foreign Inmigration Rate | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 16 | Foreign Outmigration Rate | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 17 | Domestic Migration Rate | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 18 | Intra-Regional Migration Rate | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

# Tabular output from one scenario

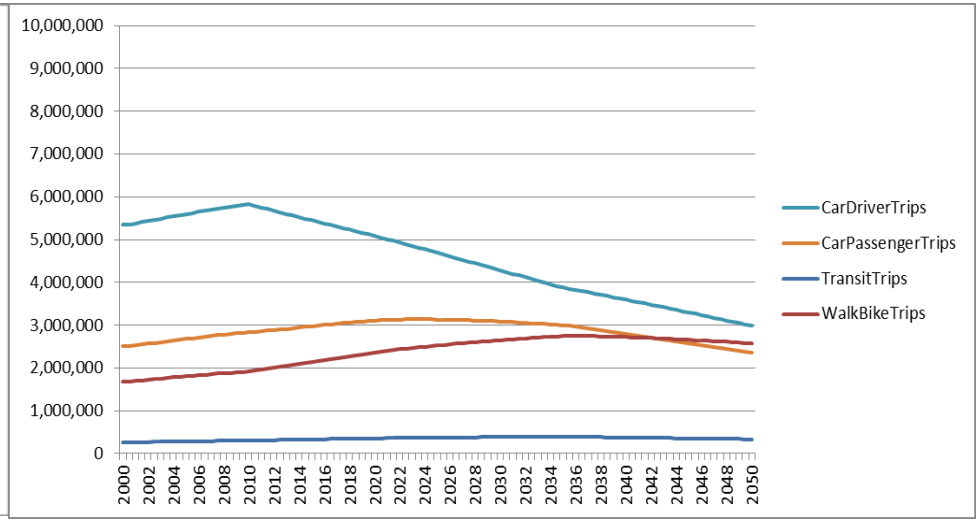
| Year | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|---|---|
| Population | 4,247,982 | 5,262,023 | 6,300,547 | 7,076,865 | 7,691,863 | 8,225,550 |
| Percent under age 16 | 23% | 22% | 22% | 23% | 23% | 23% |
| Percent over age 60 | 11% | 14% | 16% | 18% | 19% | 19% |
| Percent in single household | 13% | 19% | 21% | 23% | 24% | 24% |
| Percent in HH w/ children | 63% | 64% | 62% | 61% | 61% | 61% |
| Percent Immigrants>20 yrs in US | 2% | 5% | 9% | 10% | 10% | 9% |
| Percent Immigrants<20 yrs in US | 8% | 10% | 9% | 7% | 5% | 4% |
| Percent White/other | 61% | 59% | 57% | 56% | 55% | 55% |
| Percent Hispanic | 6% | 8% | 10% | 11% | 12% | 12% |
| Percent Black | 29% | 26% | 25% | 25% | 24% | 24% |
| Percent Asian | 3% | 6% | 8% | 9% | 9% | 10% |
| Percent low income group | 31% | 32% | 34% | 34% | 33% | 33% |
| Percent in high income group | 18% | 19% | 22% | 25% | 26% | 27% |
| Percent in workforce | 51% | 47% | 43% | 41% | 40% | 39% |
| Percent non -car-owning | 2.4% | 2.5% | 2.7% | 2.8% | 2.9% | 3.0% |
| Percent car-sharing | 22.6% | 21.8% | 21.9% | 21.9% | 21.9% | 21.8% |
| Avg. car-occupancy-Work | 1.13 | 1.13 | 1.13 | 1.13 | 1.13 | 1.13 |
| Transit mode share - Work | 1.7% | 1.9% | 2.1% | 2.3% | 2.4% | 2.5% |
| Walk/bike mode share - Work | 5.2% | 5.6% | 5.9% | 6.1% | 6.2% | 6.3% |
| Avg. car-occupancy-Non-work | 1.82 | 1.76 | 1.75 | 1.75 | 1.76 | 1.76 |
| Transit mode share - Non-work | 1.5% | 1.6% | 1.7% | 1.8% | 1.9% | 1.9% |
| Walk/bike mode share - Non-work | 11.2% | 11.5% | 11.7% | 11.8% | 11.9% | 12.0% |
| Work trips/capita per day | 0.61 | 0.55 | 0.51 | 0.48 | 0.47 | 0.46 |
| Other trips/capita per day | 2.82 | 2.86 | 2.93 | 2.96 | 2.98 | 2.99 |
| Auto VMT/capita per year | 11,726 | 11,115 | 10,714 | 10,472 | 10,336 | 10,251 |

# Trips by Mode

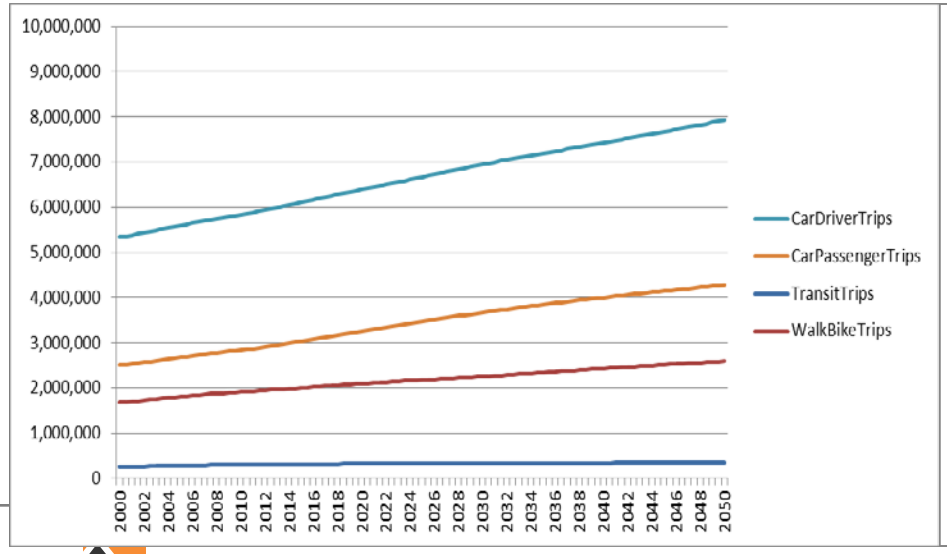
## *Momentum*



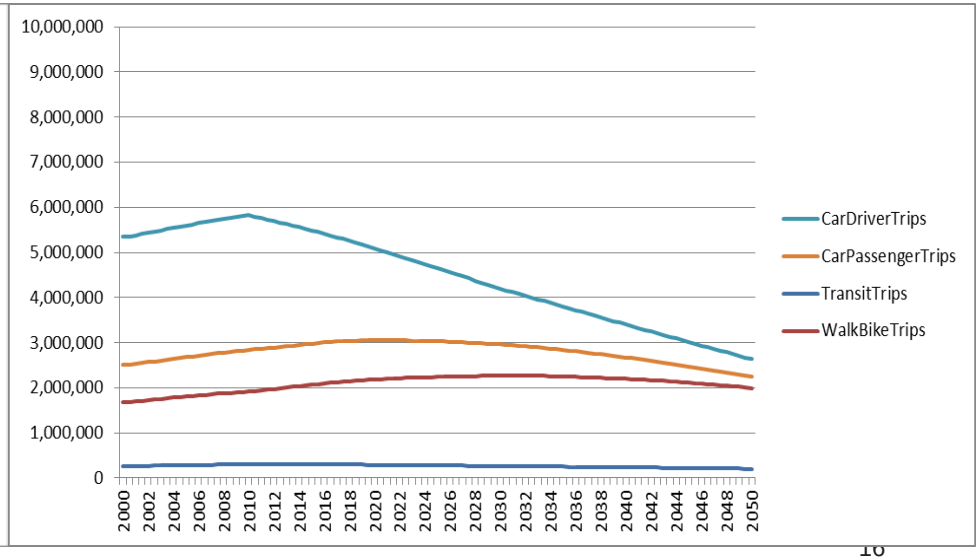

## *Gentle Footprint*




## *Tech Triumphs*

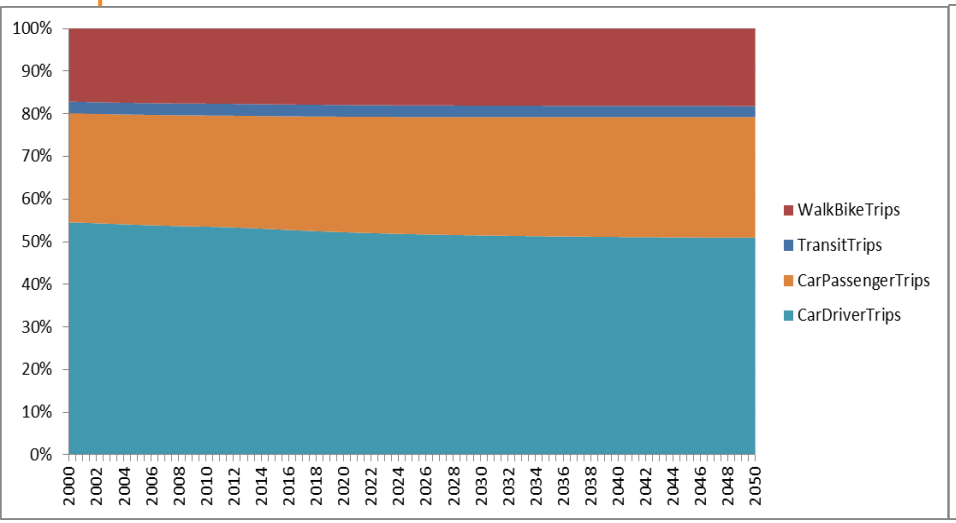



## *Global Chaos*

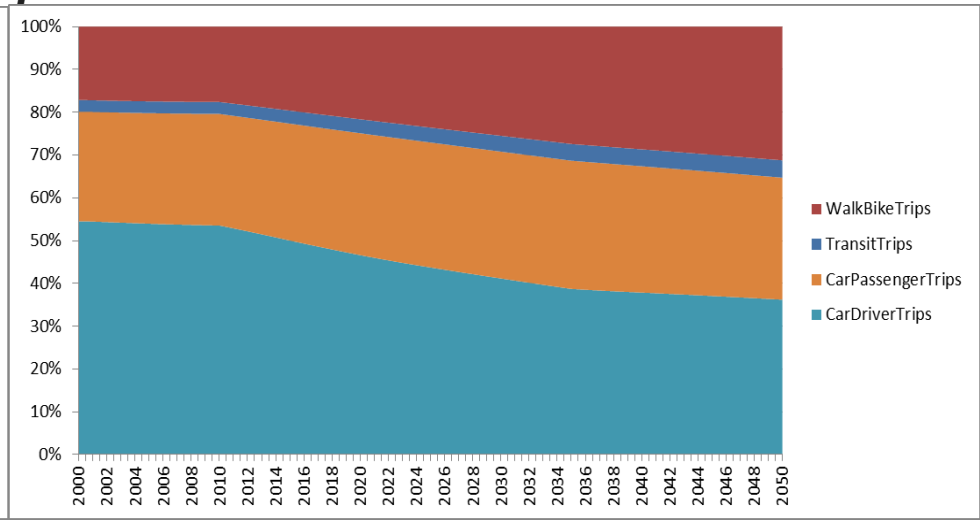


# Trip Mode Share

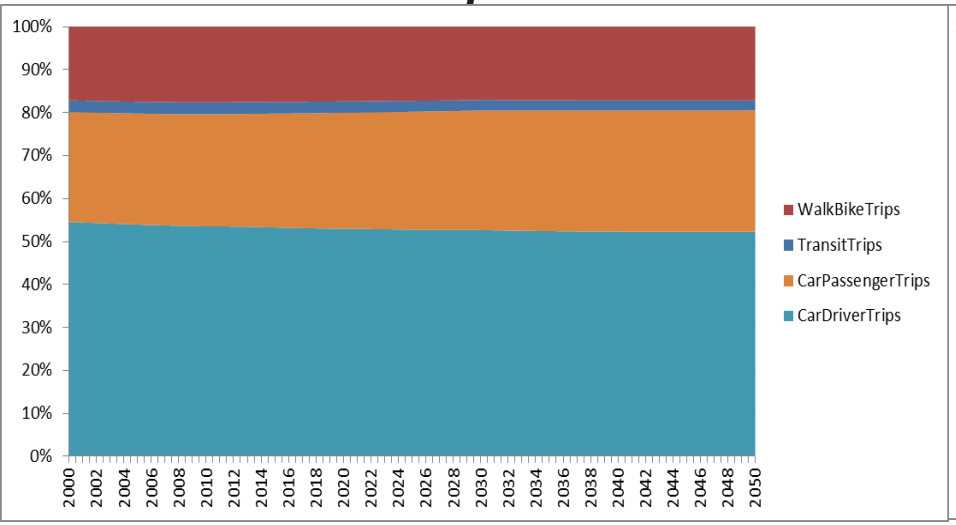
## *Momentum*



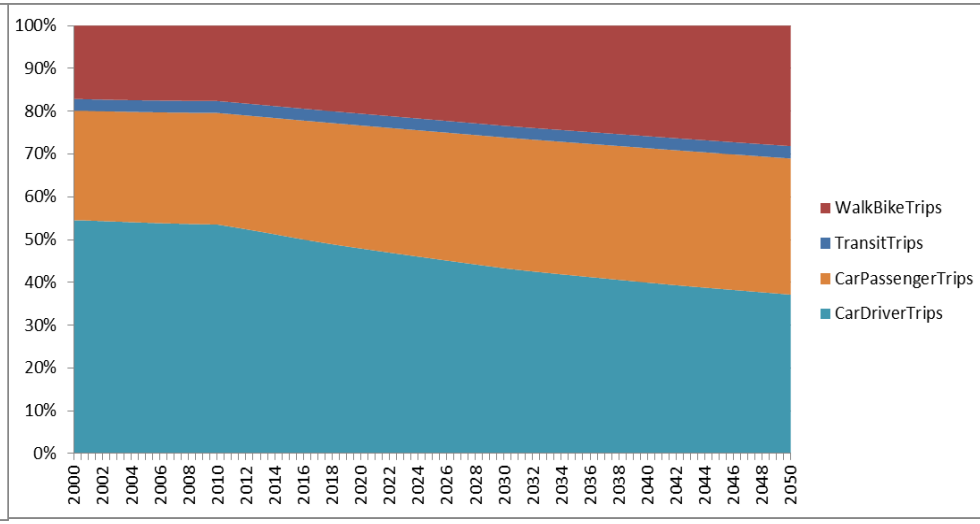

## *Gentle Footprint*




## *Tech Triumphs*




## *Global Chaos*



**NCRRP Report 4 Pre-Publication Draft—Subject to Revision**

# Intercity Passenger Rail in the Context of Dynamic Travel Markets


RSG, Inc.
White River Junction, VT

in association with

Matthew Coogan
White River Junction, VT

AECOM
New York, NY

Icek Ajzen
Amherst, MA

Chandra Bhat
Austin, TX

Brian Lee
Burlington, VT

Megan Ryerson
Philadelphia, PA

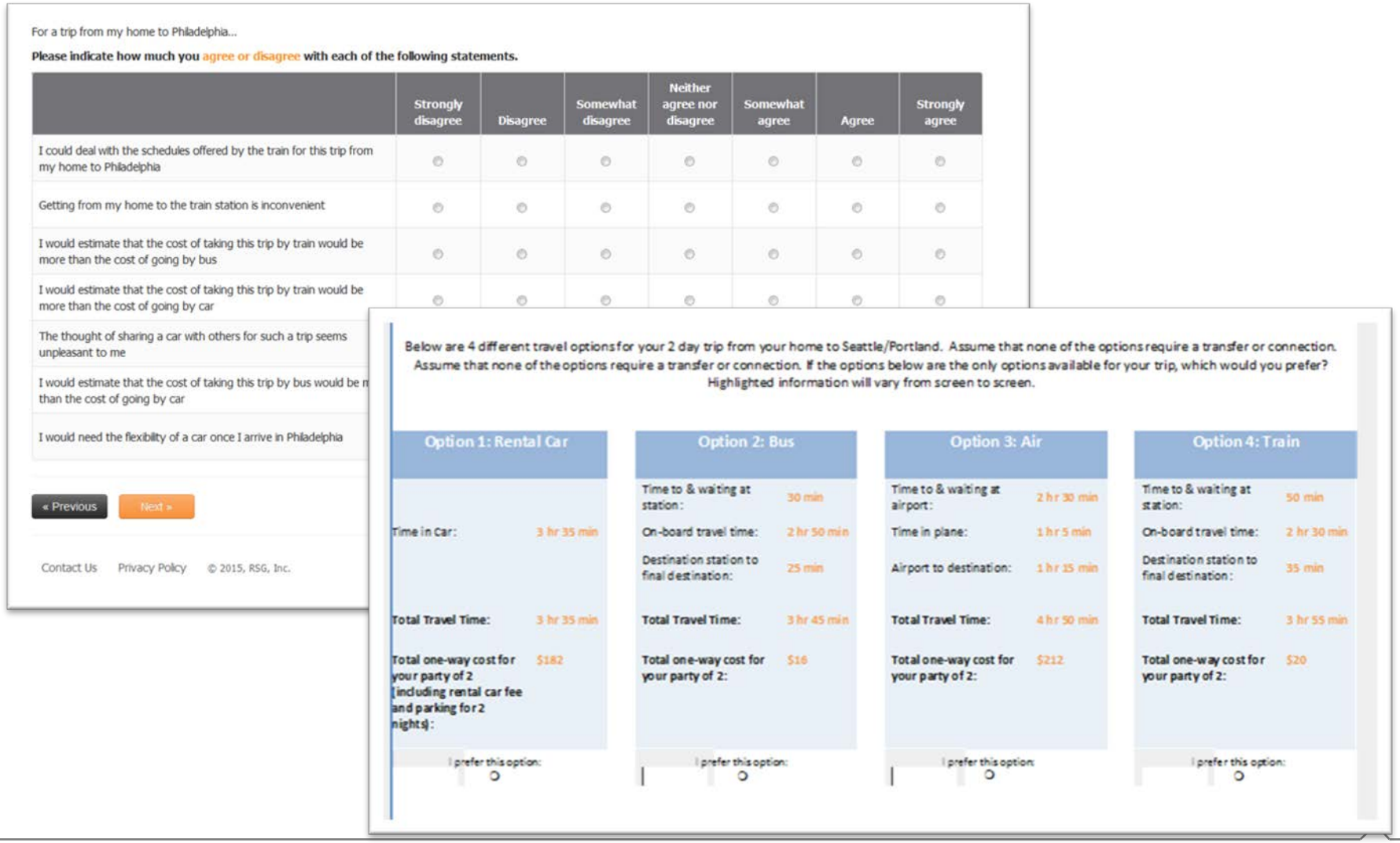
Joseph Schwieterman
Chicago, IL



Submitted November 2015

# Conducted project-specific on-line surveys in two major intercity rail corridors

# Attitudinal and Stated Preference questions



For a trip from my home to Philadelphia...

**Please indicate how much you agree or disagree with each of the following statements.**

| | Strongly disagree | Disagree | Somewhat disagree | Neither agree nor disagree | Somewhat agree | Agree | Strongly agree |
|---|---|---|---|---|---|---|---|
| I could deal with the schedules offered by the train for this trip from my home to Philadelphia | | | | | | | |
| Getting from my home to the train station is inconvenient | | | | | | | |
| I would estimate that the cost of taking this trip by train would be more than the cost of going by bus | | | | | | | |
| I would estimate that the cost of taking this trip by train would be more than the cost of going by car | | | | | | | |
| The thought of sharing a car with others for such a trip seems unpleasant to me | | | | | | | |
| I would estimate that the cost of taking this trip by bus would be m than the cost of going by car | | | | | | | |
| I would need the flexibility of a car once I arrive in Philadelphia | | | | | | | |

« Previous  Next »

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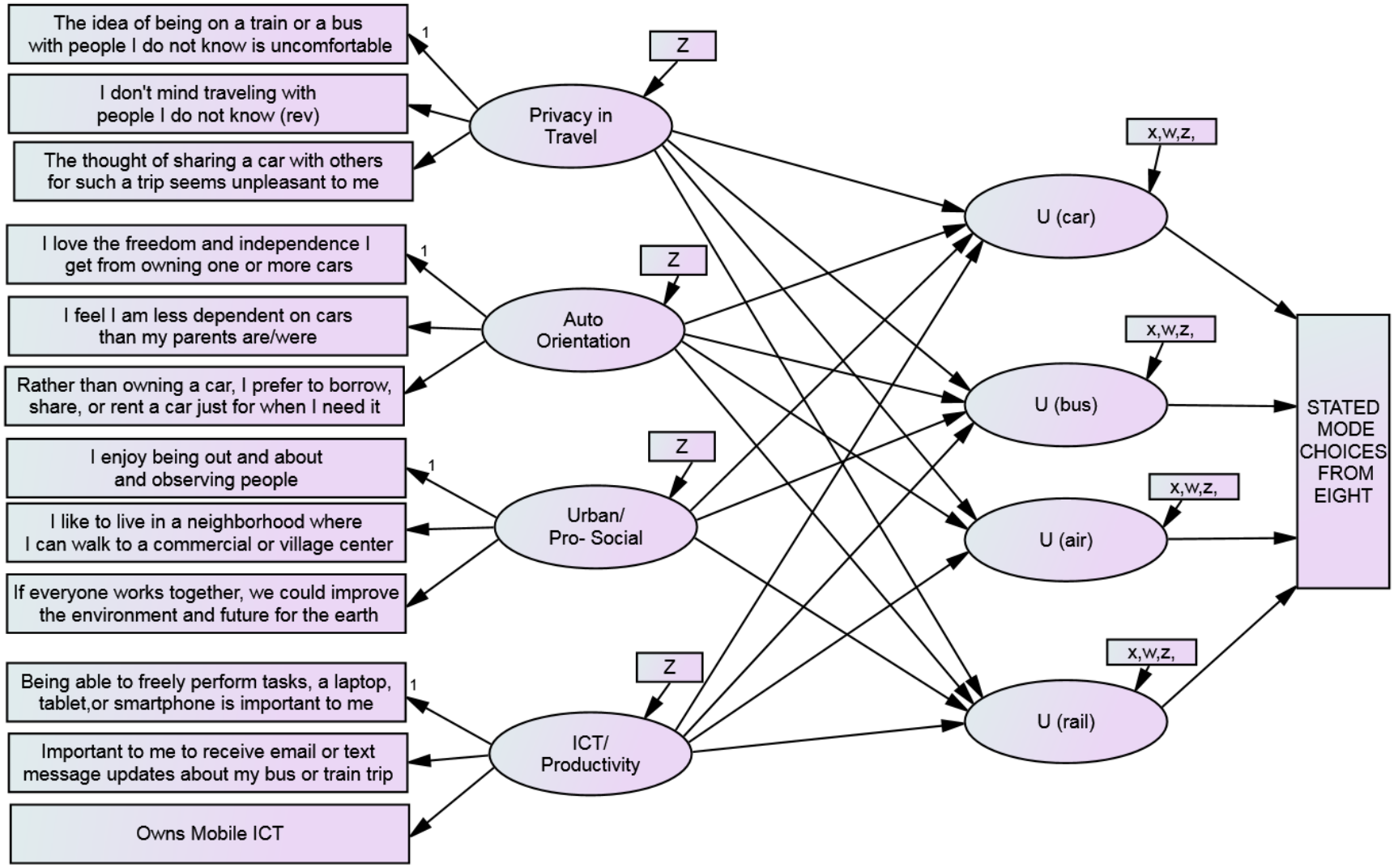
Below are 4 different travel options for your 2 day trip from your home to Seattle/Portland. Assume that none of the options require a transfer or connection. Assume that none of the options require a transfer or connection. If the options below are the only options available for your trip, which would you prefer? Highlighted information will vary from screen to screen.

| Option 1: Rental Car | | Option 2: Bus | | Option 3: Air | | Option 4: Train | |
|---|---|---|---|---|---|---|---|
| | | Time to & waiting at station: | 30 min | Time to & waiting at airport: | 2 hr 30 min | Time to & waiting at station: | 50 min |
| Time in Car: | 3 hr 35 min | On-board travel time: | 2 hr 50 min | Time in plane: | 1 hr 5 min | On-board travel time: | 2 hr 30 min |
| | | Destination station to final destination: | 25 min | Airport to destination: | 1 hr 15 min | Destination station to final destination: | 35 min |
| **Total Travel Time:** | 3 hr 35 min | **Total Travel Time:** | 3 hr 45 min | **Total Travel Time:** | 4 hr 50 min | **Total Travel Time:** | 3 hr 55 min |
| **Total one-way cost for your party of 2 (including rental car fee and parking for 2 nights):** | $182 | **Total one-way cost for your party of 2:** | $16 | **Total one-way cost for your party of 2:** | $212 | **Total one-way cost for your party of 2:** | $20 |
| I prefer this option: | | I prefer this option: | | I prefer this option: | | I prefer this option: | |

# Structural diagram of the ICLV model (x=trip attributes; w=mode attributes; z=demographic characteristics)



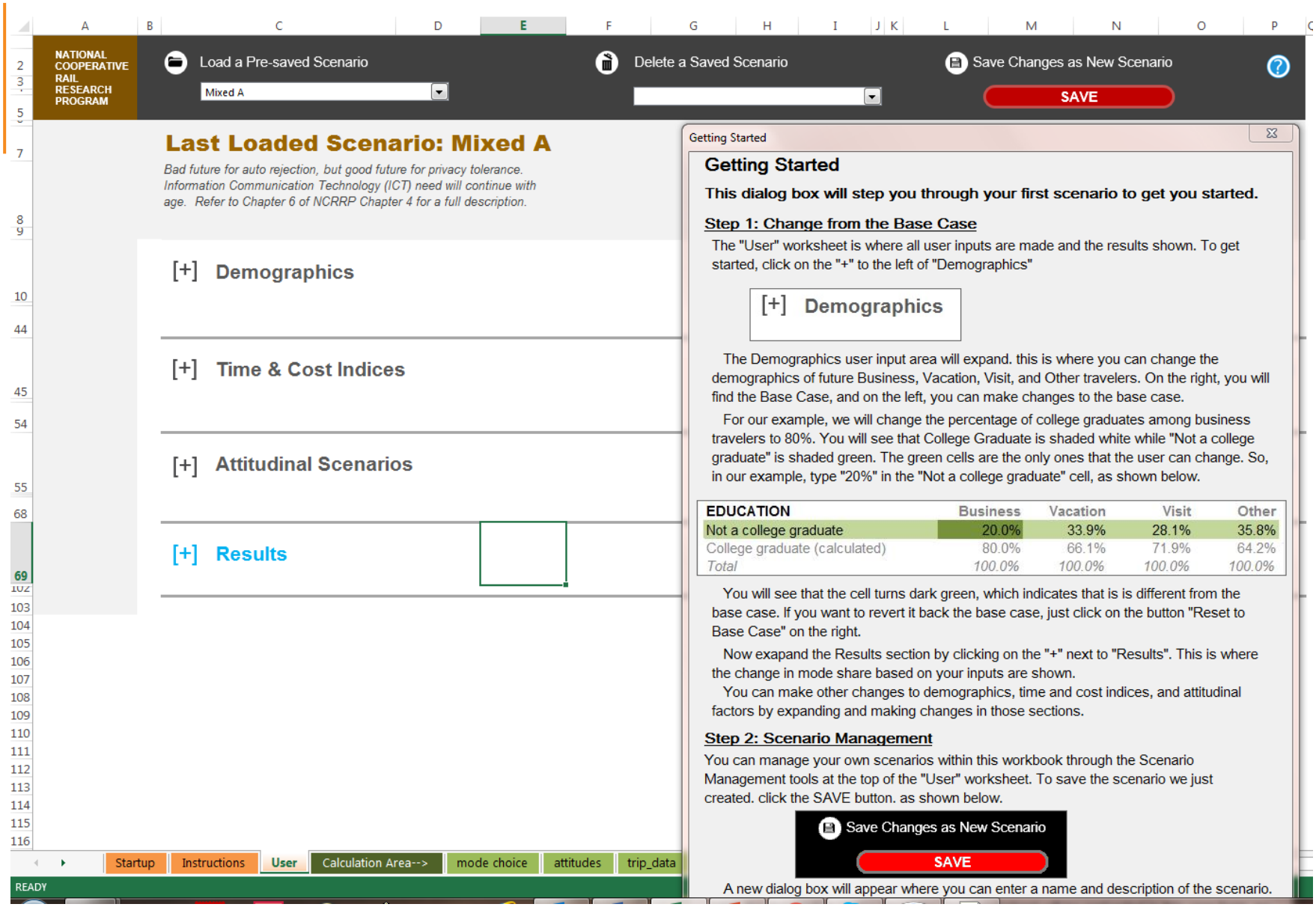
# Why do we care about “latent attitudinal variables”?

- Because the NCRRP study specifically wants to know about “Intercity Passenger Rail in the Context of Dynamic Travel Markets”

- Policy makers want to understand changing demand as completely as possible

- They already have traditional demand estimates, but they want new methods to deal with changing attitudes and preferences

# Model applied to the survey data in an Excel interface for user-friendly scenario analysis


NATIONAL COOPERATIVE RAIL RESEARCH PROGRAM
Load a Pre-saved Scenario
Mixed A
Delete a Saved Scenario
Save Changes as New Scenario
SAVE
Last Loaded Scenario: Mixed A
Bad future for auto rejection, but good future for privacy tolerance. Information Communication Technology (ICT) need will continue with age. Refer to Chapter 6 of NCRRP Chapter 4 for a full description.
[+] Demographics
[+] Time & Cost Indices
[+] Attitudinal Scenarios
[+] Results
Getting Started
Getting Started
This dialog box will step you through your first scenario to get you started.
Step 1: Change from the Base Case
The "User" worksheet is where all user inputs are made and the results shown. To get started, click on the "+" to the left of "Demographics"
[+] Demographics
The Demographics user input area will expand. this is where you can change the demographics of future Business, Vacation, Visit, and Other travelers. On the right, you will find the Base Case, and on the left, you can make changes to the base case.
For our example, we will change the percentage of college graduates among business travelers to 80%. You will see that College Graduate is shaded white while "Not a college graduate" is shaded green. The green cells are the only ones that the user can change. So, in our example, type "20%" in the "Not a college graduate" cell, as shown below.
EDUCATION Business Vacation Visit Other
Not a college graduate 20.0% 33.9% 28.1% 35.8%
College graduate (calculated) 80.0% 66.1% 71.9% 64.2%
Total 100.0% 100.0% 100.0% 100.0%
You will see that the cell turns dark green, which indicates that is is different from the base case. If you want to revert it back the base case, just click on the button "Reset to Base Case" on the right.
Now exapand the Results section by clicking on the "+" next to "Results". This is where the change in mode share based on your inputs are shown.
You can make other changes to demographics, time and cost indices, and attitudinal factors by expanding and making changes in those sections.
Step 2: Scenario Management
You can manage your own scenarios within this workbook through the Scenario Management tools at the top of the "User" worksheet. To save the scenario we just created. click the SAVE button. as shown below.
Save Changes as New Scenario
SAVE
A new dialog box will appear where you can enter a name and description of the scenario.
Startup
Instructions
User
Calculation Area-->
mode choice
attitudes
trip_data
READY

## [-] Attitudinal Scenarios

| Attitudinal scenarios | USER SCENARIO Car-lover | Technology | Urbanism | Privacy | BASE CASE Car-lover | Technology | Urbanism | Privacy |
|---|---|---|---|---|---|---|---|---|
| Shift all ages to under 35 attitude | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Shift under 35 to 35-44 attitude | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Shift all ages to over 65 attitude | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Shift all ages to previous cohort att | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Shift female to male attitude | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Shift male to female attitude | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Shift no college to college attitude | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Shift college to no college attitude | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Shift no job to employed attitude | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Shift employed to no job attitude | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Reset to Base Case

## [-] Results

USER SCENARIO

Predicted Trips (1,000/year)

| Mode | Business | Vacation | Visit | Other | *Total* |
|---|---|---|---|---|---|
| Car | 5,820 | 19,089 | 19,234 | 7,095 | *51,238* |
| Bus | 1,692 | 6,639 | 3,119 | 961 | *12,411* |
| Rail | 3,797 | 4,656 | 3,867 | 1,420 | *13,740* |
| Air | 1,796 | 2,237 | 2,207 | 568 | *6,809* |
| ***Total*** | ***13,104*** | ***32,622*** | ***28,428*** | ***10,044*** | ***84,198*** |

Mode Share

| Mode | Business | Vacation | Visit | Other | *Total* |
|---|---|---|---|---|---|
| Car | 44.4% | 58.5% | 67.7% | 70.6% | *60.9%* |
| Bus | 12.9% | 20.4% | 11.0% | 9.6% | *14.7%* |
| Rail | 29.0% | 14.3% | 13.6% | 14.1% | *16.3%* |
| Air | 13.7% | 6.9% | 7.8% | 5.7% | *8.1%* |

Percent Change in Trips vs. Base Case

| Mode | Business | Vacation | Visit | Other | *Total* |
|---|---|---|---|---|---|
| Car | -4.8% | -4.0% | -2.7% | -7.1% | *-4.1%* |
| Bus | -6.6% | 8.3% | 7.6% | 37.9% | *7.6%* |
| Rail | 15.4% | 9.3% | 8.9% | 19.4% | *11.8%* |
| Air | -4.9% | -4.4% | -0.2% | 9.8% | *-2.2%* |
| ***Total*** | ***0.0%*** | ***0.0%*** | ***0.0%*** | ***0.0%*** | ***0.0%*** |

Percent Change in Mode Share vs. Base Case

| Mode | Business | Vacation | Visit | Other | *Total* |
|---|---|---|---|---|---|
| Car | -4.8% | -4.0% | -2.7% | -7.1% | *-4.1%* |
| Bus | -6.6% | 8.3% | 7.6% | 37.9% | *7.6%* |
| Rail | 15.4% | 9.3% | 8.9% | 19.4% | *11.8%* |
| Air | -4.9% | -4.4% | -0.2% | 9.8% | *-2.2%* |

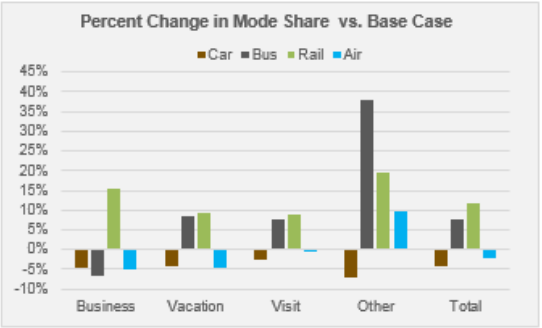
BASE CASE

Predicted Trips (1,000/year)

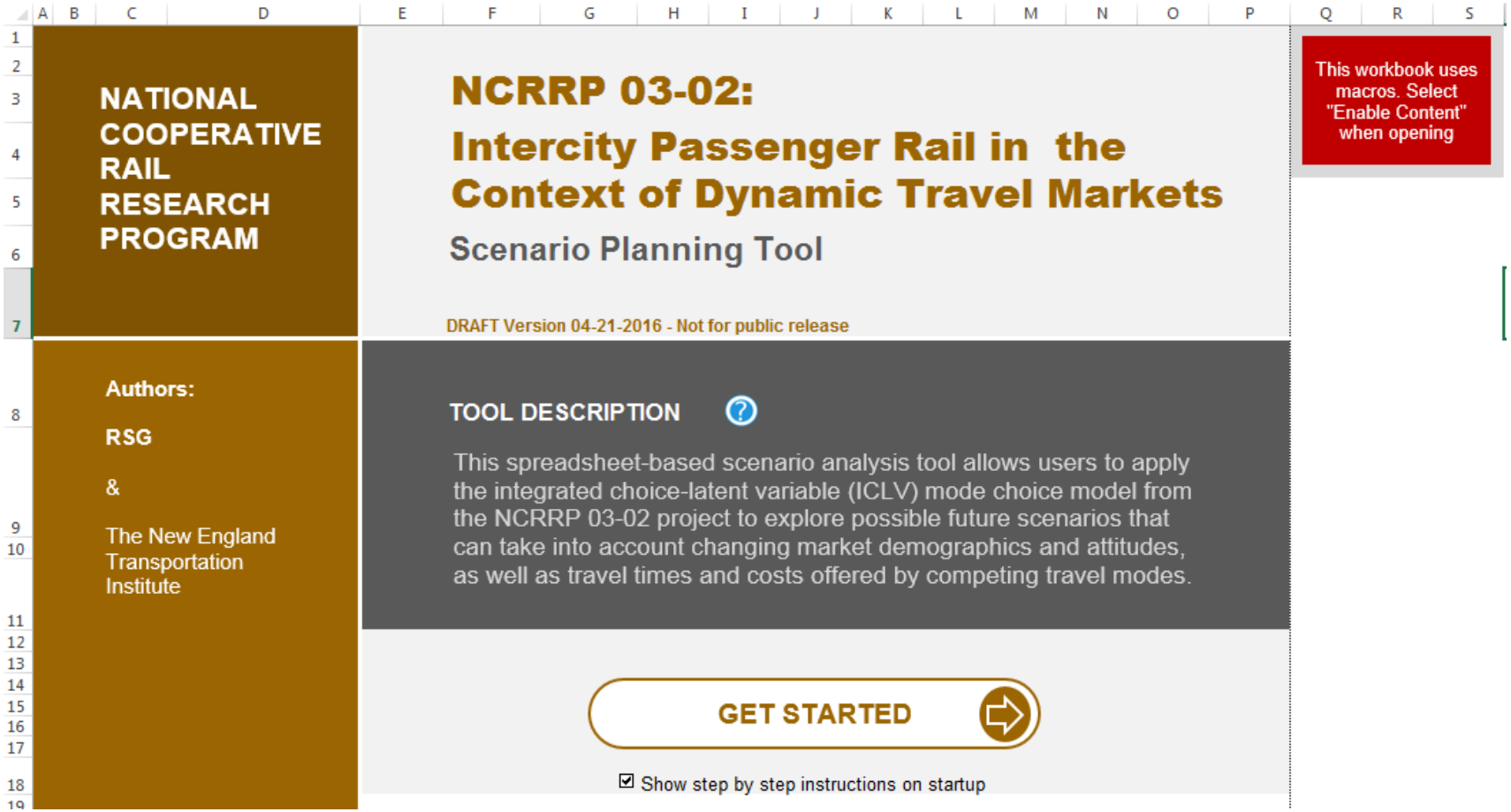
| Business | Vacation | Visit | Other | Total |
|---|---|---|---|---|
| 6,114 | 19,891 | 19,765 | 7,641 | 53,411 |
| 1,812 | 6,130 | 2,900 | 697 | 11,539 |
| 3,290 | 4,260 | 3,551 | 1,189 | 12,290 |
| 1,887 | 2,341 | 2,213 | 517 | 6,958 |
| 13,104 | 32,622 | 28,428 | 10,044 | 84,198 |

Predicted Trips (1,000/year)

| Business | Vacation | Visit | Other | Total |
|---|---|---|---|---|
| 46.7% | 61.0% | 69.5% | 76.1% | 63.4% |
| 13.8% | 18.8% | 10.2% | 6.9% | 13.7% |
| 25.1% | 13.1% | 12.5% | 11.8% | 14.6% |
| 14.4% | 7.2% | 7.8% | 5.2% | 8.3% |



# Scenarios involving shifts in attitudes: The indicated effects on rail mode share

| % change in rail trips | Orient-ation toward car | Technology during travel | Pro Urbanism | Privacy during travel | Change all 4 at once |
|---|---|---|---|---|---|
| Shift female to male attitude | 2.30% | -0.41% | -0.30% | -0.40% | 1.20% |
| Shift male to female attitude | -1.80% | 0.30% | 0.20% | 0.40% | -1.00% |
| Shift age groups to under 35 attitude | 17.95% | 2.50% | 0.00% | -3.40% | 16.40% |
| Shift under 35 to 35-44 attitude | -1.70% | 0.00% | 0.00% | 0.00% | -1.70% |
| Shift age groups to over 65 attitude | -11.90% | -3.40% | 0.00% | 10.40% | -5.70% |
| Shift no college to college attitude | 1.20% | 0.10% | 0.10% | 2.70% | 4.20% |
| Shift college to no college attitude | -3.60% | -0.30% | -0.20% | -7.50% | -11.40% |
| Shift no job to employed attitude | -0.60% | 0.20% | 0.00% | 1.30% | 0.90% |
| Shift employed to no job attitude | 1.20% | -0.40% | 0.00% | -2.50% | -1.70% |

# Tool available from NCRRP website – search for the report below….