Is Regret a suitable basis for large-scale travel demand modelling?

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Introduction

- Regret has a long history…
  - Savage (1951), Loomes & Sugden (1982), etc.
  - 'minimax' Regret covering uncertain futures
  - gives the idea that the attractiveness of an alternative depends on its competitive position, not only on its own merits
- but recent work has generalised and extended Regret to model choice under certainty of outcome
  - random Regret
  - multiple dimensions of Regret
  - RRM, with various specifications
- ..and has shown that the concept is useful for choice modelling
  - competing with RUM
  - maybe not quite as good, but certainly adding something to choice modelling
- large-scale travel demand models are an important choice modelling application: can Regret help?

Overview

- what are the properties of Regret?
  - and do these make it suitable for large-scale modelling
- Regret ≠ Utility
  - we can't get Regret results by finding a cleverer formulation of utility
  - in particular, Regret eliminates preference consistency
- preference consistency has many implications
  - without it, willingness to pay cannot be defined unequivocally
  - transport forecasting and appraisal also become difficult
- large-scale transport modelling requires several integrated steps
  - travel demand forecasting
    - conventionally, assignment is separated from other components
  - appraisal
 - consistency of numéraire across components is highly desirable

What is Regret anyway?

- it defines a choice model paradigm emphasising the position of each alternative relative to other alternatives
  - i.e. it's a specific form of reference dependence
- in particular, how much Regret there might be on each attribute
- there are several versions, some of which also give credit for better attributes, i.e. Delight
  - (Rejoice is entirely the wrong word!)
- and there are various options for non-linearity
- reference dependence relates only to other 'active' alternatives, not to any long-term or past situations
- i.e. it does not relate to history, which is known to be important
- Regret needs to be seen as a step towards a better understanding and a better model, not the whole solution

Regret is not Utility
.. preference is inconsistent
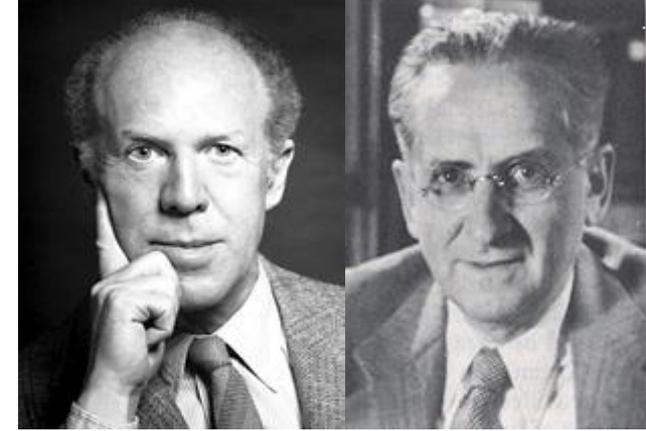
- key point: Regret implies preference reversal
  - A preferred to B, but the Regret of A and B can be changed by C so that B preferred to A
  - this is inevitable with Regret
    - part of its charm perhaps and maybe realistic as a representation of behaviour
- Debreu or Marschak & co show that Utility ⟺ Transitivity + Consistency
- this means that we can't find a 'different' Utility function that would emulate Regret
  - Regret is truly different
- but there are reference-dependent Utility functions
  - with reference to a specific base, as-now, perhaps
- the key point follows from the fact that Regret for one alternative depends on other alternatives whose attributes may change

Utility-based transport models still have many issues

- how many of these are solved by Regret?
  - what kind of non-linearity is necessary or acceptable
  - what linkages do we need between the stages
  - can we make the models run faster
  - can we link the models to land-use
  - should we use expected demand or simulate
  - can we make cross-nested or mixed logit practical
  - how do we estimate error measures for forecasts
  - do we need to model activities
  - how can we use aggregate data on elasticity or value of time
- looks like all these problems would also exist for Regret
  - and some might be more difficult to solve
- so we need to make progress in other directions as well as considering the implementation of Regret

Large-scale models have several components

at least the following

- assignment

- travel frequency

- mode-destination choice
  - including sub-modes (park & ride)
  - toll roads
  - etc.

- appraisal

- and these need to be linked to each other

Assignment with Regret is not easy

traffic intensity
(vehicles per day)
0 - 500
500 - 1000
1000 - 2500
2500 - 5000
5000 - 10000
10000 - 25000
25000 - 50000
> 50000

- intuitively, it seems Regret might be a good basis for route choice
  - comparison of routes seems to involve Regret-type thinking
- but there are issues, starting with the size of the choice set
- e.g. Bekhor et al. find they need many iterations to converge in quite small networks (2.5k links)
  - variational inequality needed to get convergence
- Prato tests different Regret approaches
  - changes to choice set, e.g. changes to network, seem to pose problems
- Chorus considers risky networks
  - interesting but goes beyond usual requirements

- these papers suggest that Regret assignment is not ready for large-scale use
- need to remember that efficiency is central and networks can be very large

Can we use Regret as the basis for travel frequency?

- what are the alternatives?
- mainly, it's staying at home!

- this seems like it's going to be difficult
  - comparable attributes are difficult/impossible to define
- the impact of (changing) accessibility on travel frequency is (in principle) an important component of the model
  - and we don't know how to define this for Regret

- this will probably have to be done on a utility basis for a while longer
  - the important extension of linking tour frequency for different purposes is difficult to imagine in a Regret context

There is progress in mode-destination-time-period choice

- seems to be the most researched area in large-scale Regret modelling
  - thorough very recent paper by van Cranenburgh and Chorus
- Utility models give an o * n process, Regret is o * n^2
  - and in mode-destination-time period models, can easily have n ~ 10^5 with o (origins, purposes, person types) larger still
  - there are ways of reducing processing, but underlying problem remains
- further, Regret doesn't seem to address any of the current issues of mode-destination modelling
  - tour and kilometre elasticities, trip length, cross-nesting, cost allocation
  - e.g. does nesting have the expected impact on elasticity?
- so results are interesting but don't seem to offer immediate gains
- remember also that we need efficiency to iterate mode-destination-time-period models with assignment
- ..and deal with subordinate choices like access modes & toll roads

Can appraisal be done at all using Regret?

Choose A from {A, B, C1}
Choose B from {A, B, C2}
What if these are policy options?

- Dekker & Chorus (2016?) give a thoughtful analysis
  - can't do Hicksian appraisal, i.e. income effect impossible
  - generally remains difficult to make appraisals
  - e.g. restricted to changes in one alternative, but in many (all?) transport scenarios many alternatives change
  - "more work needed"
- for Utility models individual preference consistency implies aggregate
  - although preferences can and do shift across population groups
- but for Regret we haven't even got individual consistency, so we can't rely on it at aggregate level
- choosing between two policies may depend on what other policies are included in the mix
  - though these will never be chosen

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Can appraisal be done at all using Regret? (2)

- governments may insist of rule-of-a-half appraisal, which seems to be (even) more inconsistent with Regret than with Utility
    - as it's founded on generalised cost = negative utility
    - even though Regret models behave properly with cost changes
- conclude that appraisal may remain a difficult area for Regret

- maybe not unreasonable behaviourally but impossible politically

Choose Heathrow from {Heathrow, Gatwick, Boris Island}
Choose Gatwick from {Heathrow, Gatwick, no expansion}

We need clear links between model components

in Utility models:
- the link could be overall Utility, i.e. some form of logsum, or an average
  - usually this is done as a generalised cost
- but logsum > average (sometimes logsum >> average)
- specifically, in MNL, logsum = average + entropy
- entropy ($\frac{1}{\lambda}\sum_j p_j . \log p_j > 0$) is a measure of diversity at lower level
  - $\lambda < 0$ is the coefficient of the numéraire (e.g. time or cost) in the logit utility function
- the more choice, the worse the average as an overall measure
  - this remains a problem in Utility models, particularly for changes in choice set size
  - the derivative of the average can have the wrong sign!
  - can be a large problem when λ is small

what does this imply for Regret?
- we can't use Regret, or a logsum, because the overall level is not defined
- doesn't seem to have been studied for assignment → demand
- some consideration for demand → appraisal, but not yet solved
- and the problems of Utility models remain

Can we use inconsistent components?

- e.g. Regret for mode-destination models, Utility for the rest

- the problem here is to guarantee intuitive responses
  - e.g. improve a rail line $\Rightarrow$ more trips assigned and lower rail time could this mean more rail trips to competing destinations or car trips?
  - in Utility models we know how constraints need to be applied, e.g. logsum coefficients < 1 to guarantee intuitive directions of response
    - not always applied <u>between</u> major model components!
  - but what are the constraints on Regret models?

- and to guarantee intuitive appraisal
  - e.g. if a policy reduces Regret in the mode-destination model, will it always give a positive appraisal in (e.g.) a rule-of-half appraisal using Utility

- problem exists now for Utility models, seems to be worse for Regret

Have we thought enough about consideration sets?

- in a large-scale model there are many almost irrelevant alternatives
  - very distant alternatives, in particular, have very low probabilities
- in Utility models, low Utility serves to represent both low probability of consideration and low probability of choice
  - the model form may not be quite right, but we get the effect approximately
- in Regret models, we have to consider attributes in detail, even for these low-probability alternatives
  - e.g. comparing two nearby shopping centres, we have to consider attributes of many shopping centres on the other side of the country
  - can this be right?
- does the model form for Regret deal with this issue appropriately?
  - maybe a simpler 'filter' function could eliminate some low-probability choices, but there are risks of further incompatibility
- Regret has been developed in a Stated Choice context, where this issue is less important

Summary

- Regret is hard work
  - you need to look all the attributes of an alternative against those of all the other alternatives, not just a single index
    - more calculation is needed
  - it looks like algorithms may be more complicated and difficult to work with (e.g. to get convergence)
    - more calculation is needed
- it's not clear what the best Regret approach is
  - several different definitions exist for Regret, willingness-to-pay and other components of the choice/valuation system
  - this seems to need testing in every context
    - more calculation needed
- Regret doesn't address history or reference to attribute values outside the choice set
  - at least not directly, though you could consider Regret vs. status quo
  - gains and losses, learning etc. are known to be important

Summary (2)

- abandoning preference consistency is an important loss
  - makes appraisal difficult or impossible
  - (but not forgetting that people may be really inconsistent!)
- each of the other components of large-scale models presents specific challenges for Regret modelling
- putting together a complete Regret system presents further challenges
  - while inconsistency may introduce counter-intuitive results
- Regret seems more suitable for Stated Choice than RP contexts
  - having the choice/consideration sets more clearly defined is obviously a help

Conclusions

- Regret seems to capture an important aspect of behaviour
  - different from utility
  - maybe this could be captured another way?
- but there are other aspects of behaviour it doesn't capture
  - so Regret is not the whole answer, not even Regret + Utility

- don't underestimate the (painful) progress that has been made with utility models and that this would have to be repeated
  - the history goes back at least 60 years

- large-scale modelling and Regret seem simply a poor match
  - despite the excellent work that has been done
    - maybe that work even drives us to this conclusion

The Regret Challenge

- how can we use the insights generated from Regret models to improve our large-scale travel demand forecasting?