# Bounded awareness and anomalies in intertemporal choice: Google Earth as metaphor and model

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# Zooming In…or… Out?

**https://www.youtube.com/watch?v=0vnA_KIojLg**

# Introduction

- Anomalies in inter-temporal choice include **hyperbolic discounting**, **magnitude effects** and **present bias**
- The logic behind the first two of these phenomena is poorly understood
  - The hyperbolic discounting model is only a descriptive model
- Cognitive limitations leading to hyperbolic discounting and magnitude effects in intertemporal choice may be described in terms of bounded awareness (unintended inconsistent behavior), and represented by phenomena familiar from visualization software such as Google Earth.

# Theory

- Given bounded cognitive resources, decision-makers must engage in both restriction and coarsening if they are to reduce even relatively simple decision problems to a manageable scale.  Moreover, there is a trade-off between the two processes: the fewer possibilities are excluded from consideration, the coarser must be the aggregation of those that remain
- Cognitive limits on visualization impose constraints on both the area being viewed and the level of detail of the view, with a trade-off between the two.
- Increasing detail at the expense of limiting the area viewed may be described as zooming

# A mental zooming theory

- In many situations the brain works as a mental zooming device and narrows in the focus on some specific issues or aspects of prospects that are compared and does not evaluate these holistically
- Narrow framing (Barberis, Huang and Thaler 2006) or choice bracketing (Read, Loewenstein and Rabin 1999) in some contexts are more specific outcomes of the zooming behavior of the brain
- This is a form of reference dependent utility
- The implication is a form of partial and variable degree of asset integration

# Google Earth as a metaphor

- Visualization software inspired by Google Earth provides a metaphor that is familiar to many.
  - As one zooms in new details appear but the frame becomes much narrower.
  - Zooming permits more focus on the details within a narrow frame but causes the user to lose sight of the larger landscape
- Can such mental zooming explain the systematic anomalies in inter-temporal choice?
- Assess it with a Field Experiment

# Credible methods for elicitation of time preferences

- **Multiple Price List** (MPL) approach introduced for elicitation of risk preferences by Holt and Laury (2002) have gained popularity and credibility (Andersen et al. 2007; 2008)
- Advantages of MPL
  - Transparency
  - With incentives; should reveal truthful responses
- Disadvantages
  - Only identifies an interval response
  - Can be sensitive to framing effects

# Time preference experiments

| Time preference series 11 | | | | |
|---|---|---|---|---|
| **Task** | Receive at far future period | Choice | Receive at near future period | Choice |
| | 3 months from now, MK | | 1 week from now, MK | |
| **111** | 10000 | | 10000 | |
| **112** | 10000 | | 9500 | |
| **113** | 10000 | | 9000 | |
| **114** | 10000 | | 8000 | |
| **115** | 10000 | | 7000 | |
| **116** | 10000 | | 6000 | |
| **117** | 10000 | | 5000 | |
| **118** | 10000 | | 4000 | |
| **119** | 10000 | | 3000 | |
| **120** | 10000 | | 2000 | |

# Time preference experiment treatments

- Far future point in time:
- **1 month, 3 months, 6 months, 1 year**
- Near future point in time:
  - **Today, 1 week, 1 month**
- Future amounts: 5x, 10x and 20x the basic magnitude level
  - **MK 1000, MK 5000, MK 10000, MK 20000**
- Randomized across households
- **10% probability that there will be a real payout for the households**
  - Random selection of series and game for households that win in the lottery
  - Arranged for future payment for the winning households (must have sufficient trust among respondents)

# Time preference experiments in Malawi 1

- The choices are between amounts of money to be received with certainty at different points in the future
- In each case the respondent chooses between two options and indicates the one he/she prefers
- In each price list we kept the future option constant while we vary the near future (current) option till we identify the switch point for the respondents
- Expect only one switch point per series for responses to be consistent in that specific series
- Randomized starting point in each series

# Time preference experiments in Malawi 2

- Experiments linked to a household panel survey
  - Introduced the experiments in each district/village one week after the survey
  - Experiment participation seen partly as a compensation for participation in survey (4th round panel survey of the same households)
  - Households had learnt that we are coming back
  - NMBU/University of Malawi collaboration since 2005/06
  - Recruited 4 enumerators (with MSc degree in agricultural economics) (one was replaced later)
  - Trained them for one week, including pilot testing of experimental protocol
  - One day in each village
  - Local schools as «field labs»
  - Minimize communication among respondents

# Estimation Issues

- Exponential discounting with dummies for treatments
  - Test for deviations from the standard model
- Choice of utility function versus ignoring risk aversion
  - Choice of a CEMU utility function in time preference models
  - Incentivized Holt and Laury (2002) MPL-type of risk experiments to estimate relative risk aversion (RRA=>EMU)
    - Similar correction as Andersen, Harrison et al. studies in Denmark

# Theoretical framework: structural model

- The decision problem can be framed as a two-period problem choosing between one amount at a near period time and another bigger amount at a more distant point in time:

$$U_A = \left(\left(e^{-\delta(t_1-t_0)}u(y_1+M_A)\right)+\left(e^{-\delta(t_2-t_0)}u(y_2)\right)\right)$$

$$U_B = \left(\left(e^{-\delta(t_1-t_0)}u(y_1)\right)+\left(e^{-\delta(t_2-t_0)}u(y_2+M_B)\right)\right)$$

Prospects are integrated with some background level of income ($y$): The literature is not very clear on what $y$ should be

# Our alternative model: Zooming as a form of reference-dependent partial asset integration

- We propose that the amount that respondents integrate the prospect with depends on the prospect characteristics such as time horizon and magnitude (zooming adjustment: reference dependent asset integration):

$$U_A = \left(\left(e^{-\delta(t_1-t_0)} u\left(y_1 f\left(t_2 - t_1, M_B\right) + M_A\right)\right) + \left(e^{-\delta(t_2-t_0)} u\left(y_2 f\left(t_2 - t_1, M_B\right)\right)\right)\right)$$

$$U_B = \left(\left(e^{-\delta(t_1-t_0)} u\left(y_1 f\left(t_2 - t_1, M_B\right)\right)\right) + \left(e^{-\delta(t_2-t_0)} u\left(y_2 f\left(t_2 - t_1, M_B\right) + M_B\right)\right)\right)$$

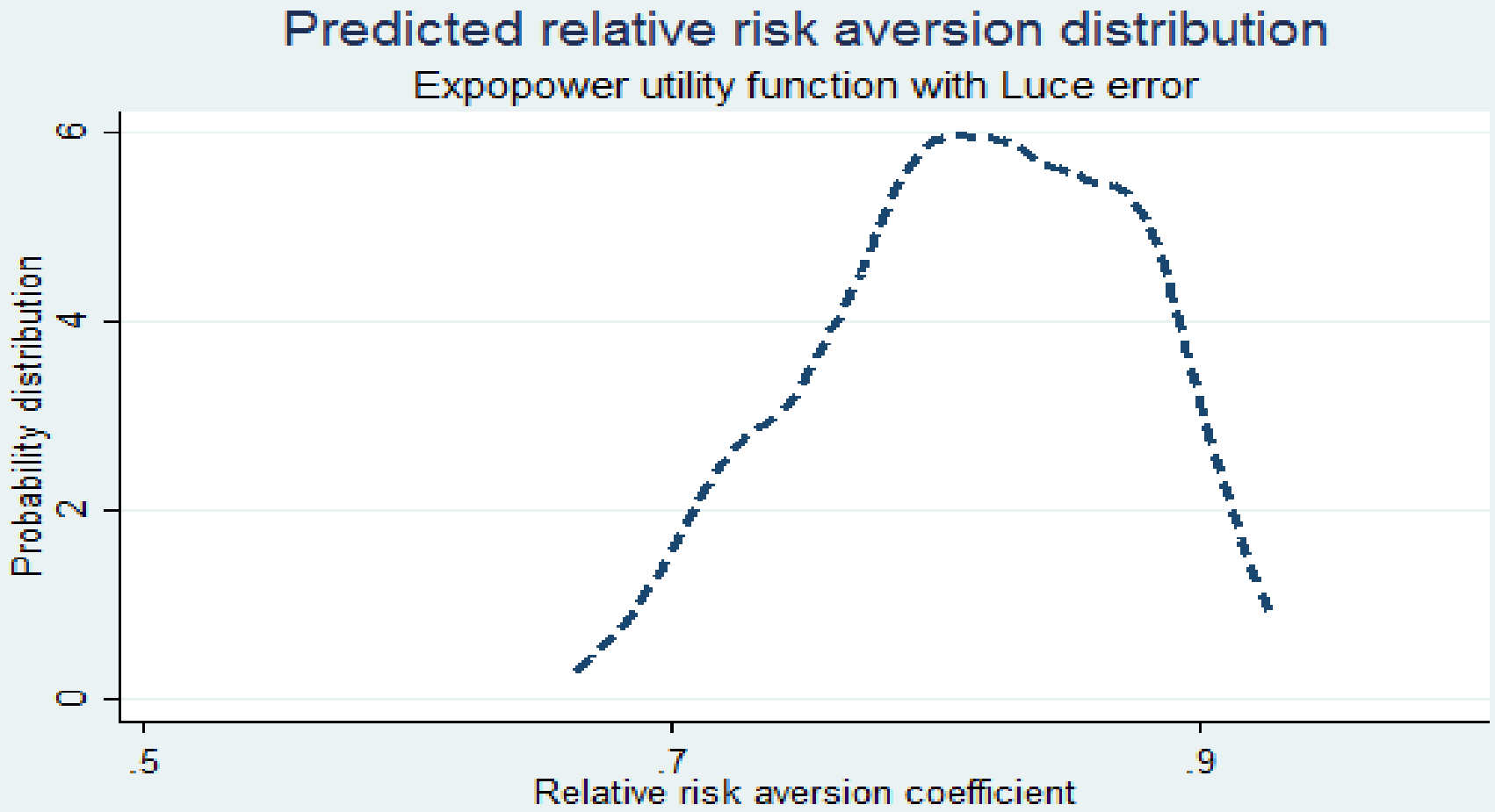
# Structural model specification

- The latent index may also be written in ratio form;
- 2) $\nabla U = U_A / (U_A + U_B)$
- A further extension of the estimation of the above models is to include stochastic errors. We applied the Luce specification
- 3) $\nabla U = U_A^{1/\mu} / \left(U_A^{1/\mu} + U_B^{1/\mu}\right)$
- With the following likelihood function used for estimation:

$$\ln L\left(\delta, \mu; Choice_{ij}, Z_i, X_j\right) = \sum_j ((\ln \Phi(\nabla U) \mid Choice_{ij} = 1) + (\ln \Phi(1 - \nabla U) \mid Choice_{ij} = 0))$$

- relevant parameters and variables such as the discount rate (δ), the noise parameter (μ), treatment (prospect) characteristics (*Z*) and respondent characteristics (*X* );

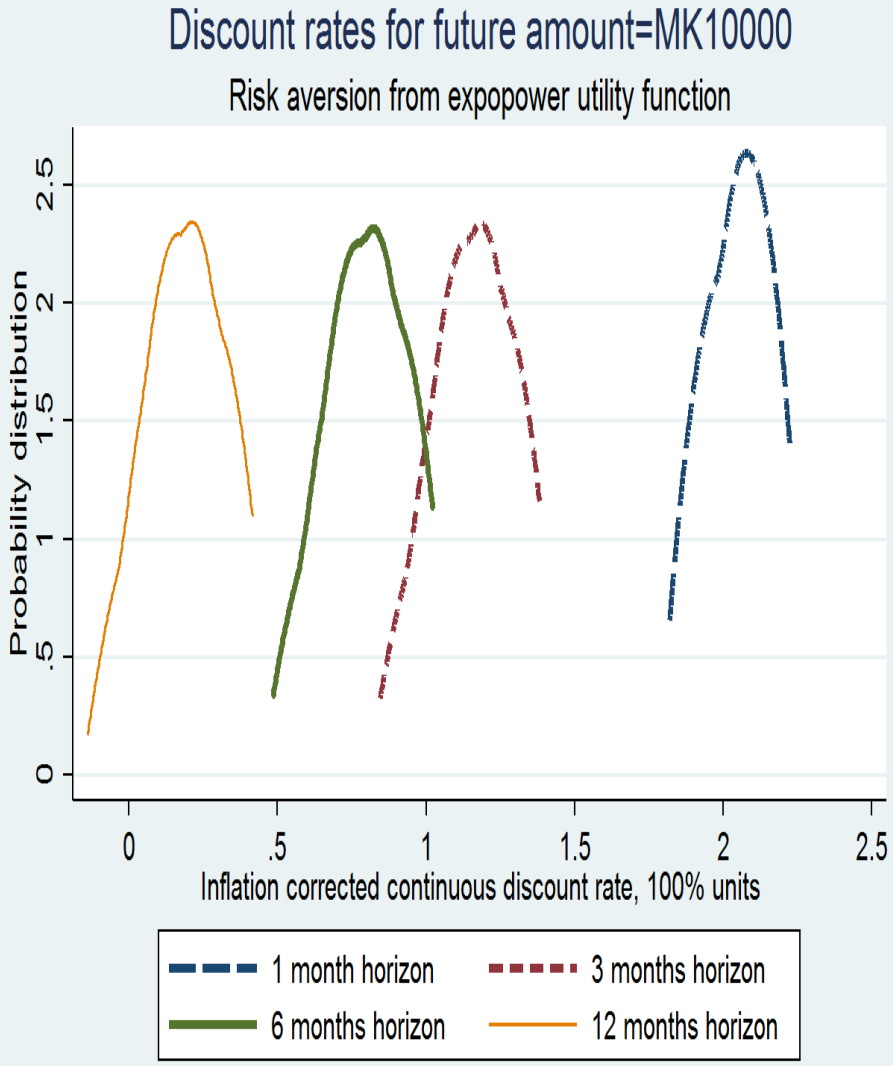
# Relative risk aversion coefficient estimates from Holt & Laury MPLs

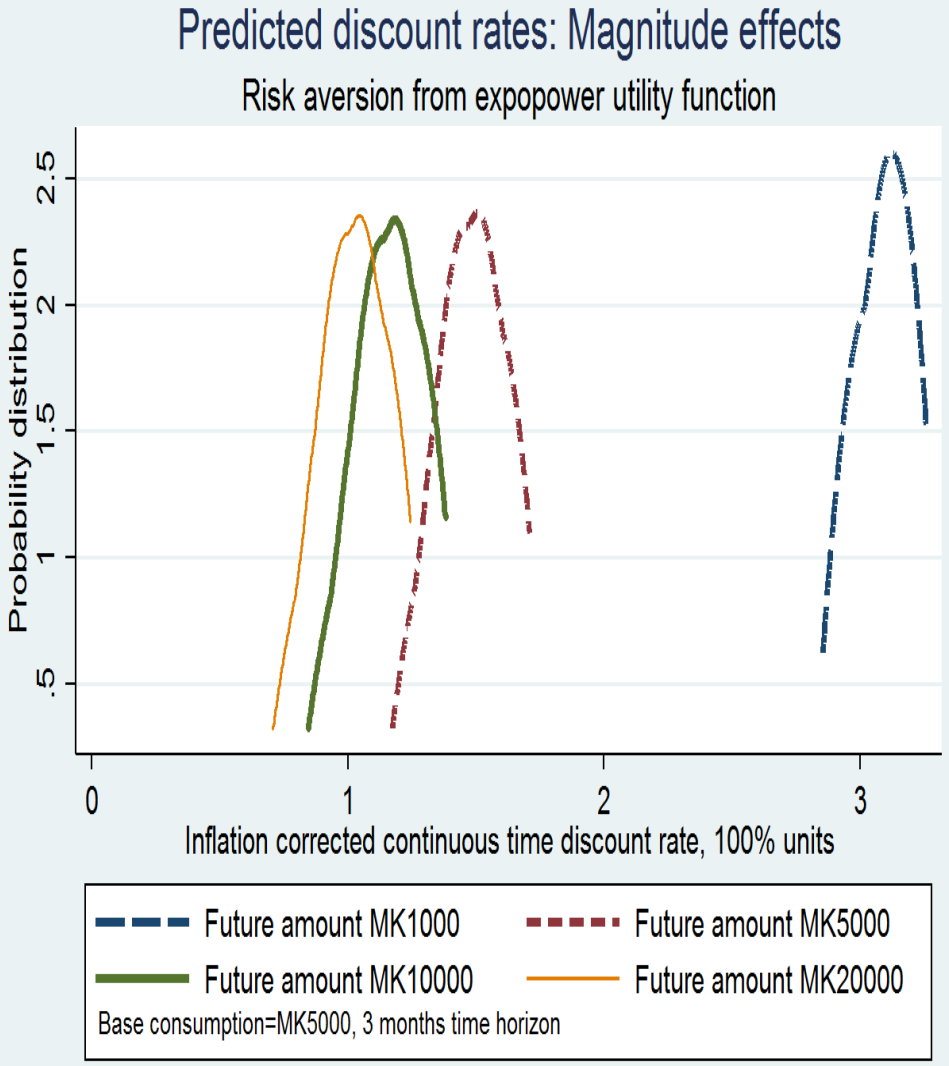


# Alternative zooming models tested

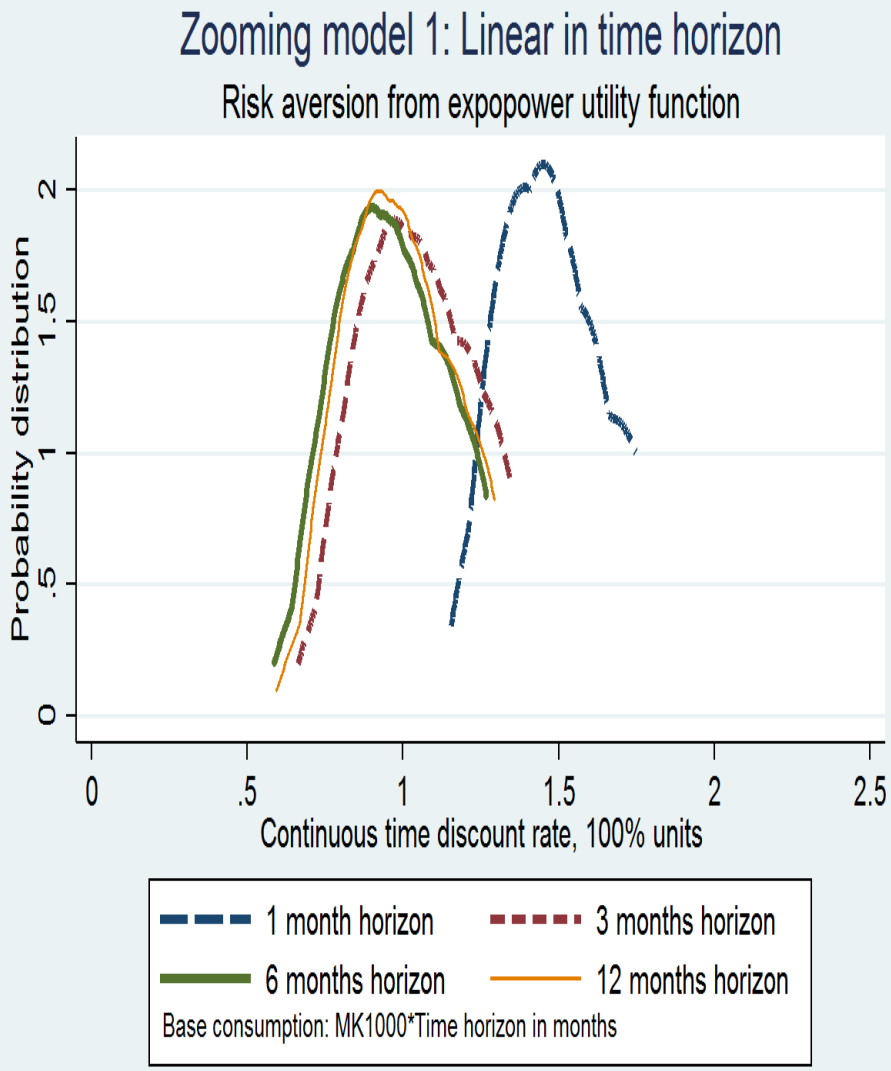
| Zooming model | Base consumption adjustment |
|---|---|
| Base model | MK5000 – calibrated to give positive discount rates for the largest amounts and longest horizons |
| Zoom Model 1 | MK 1000*Time horizon (months) |
| Zoom Model 2 | MK300*(Time horizon)*(Future amount/10000) |
| Zoom Model 3 | MK 300*(Time horizon)^2*sqrt(Future amount /10000) |

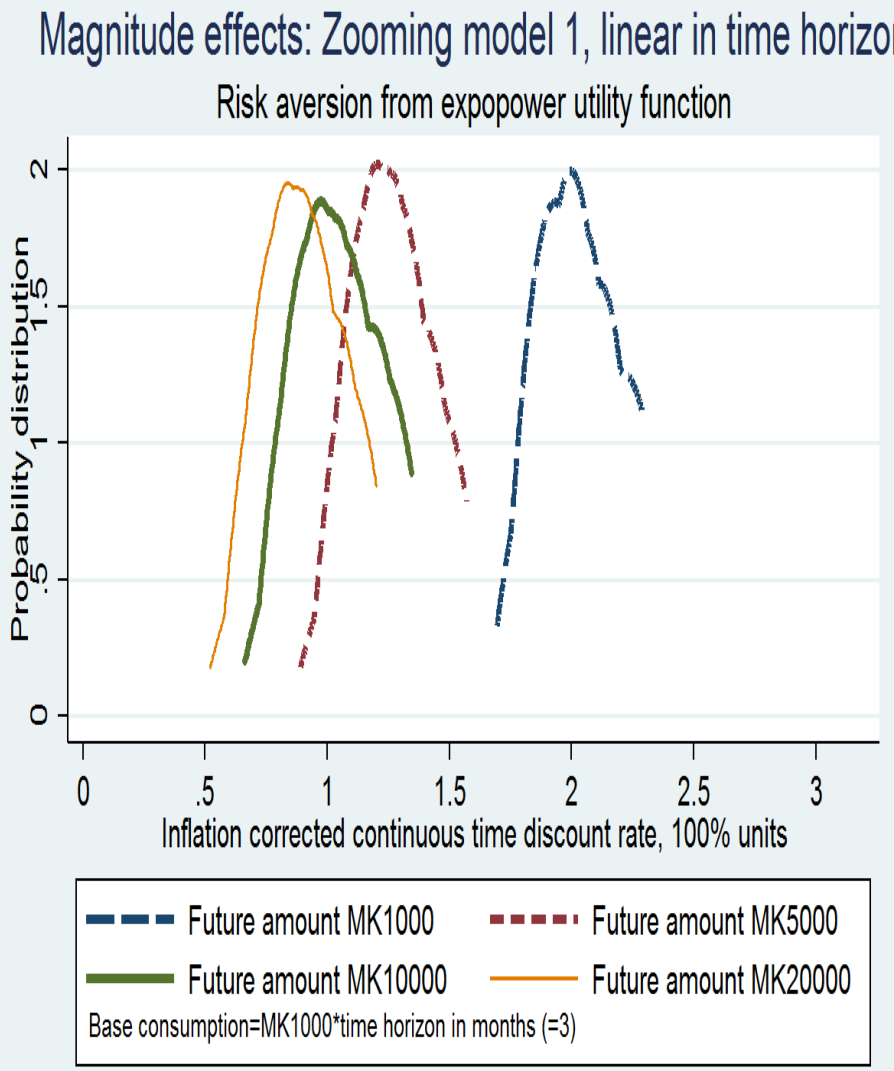
# Time horizon and magnitude effects: Predicted discount rate distribution with base model consumption=MK5000



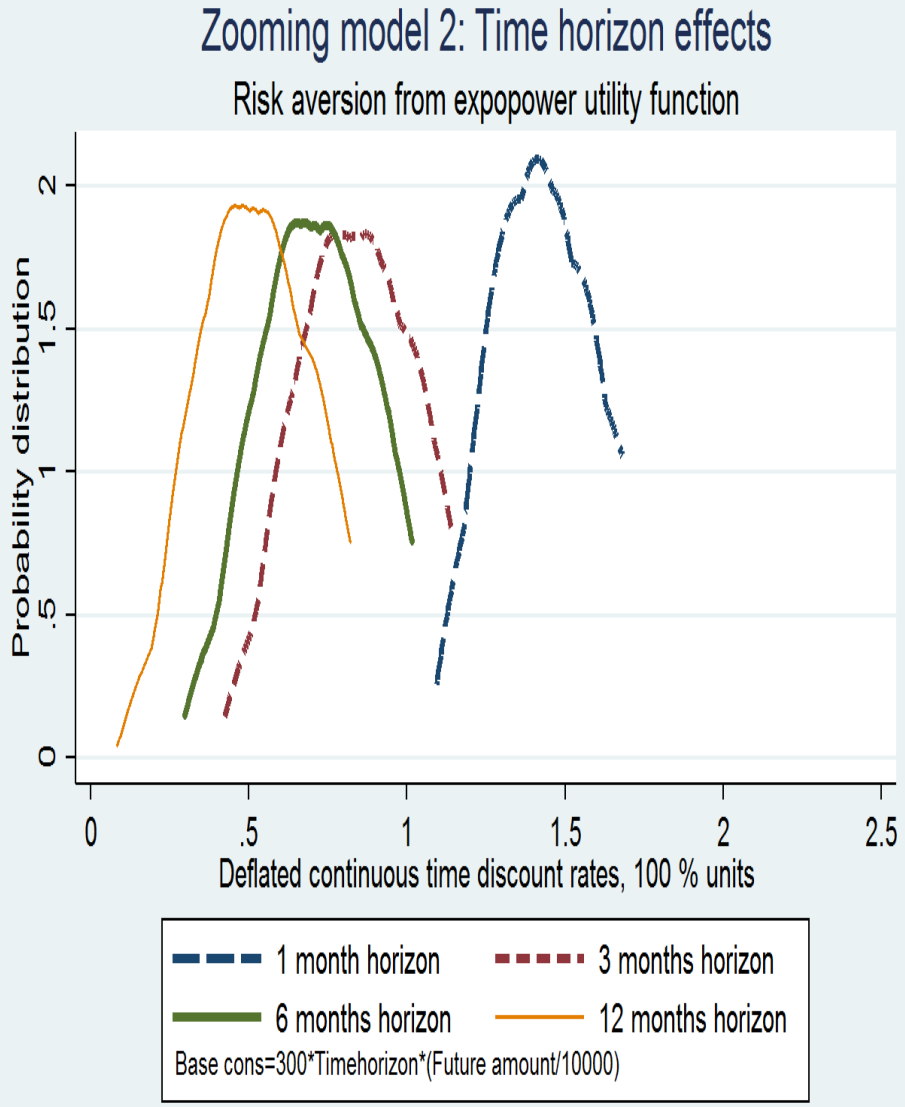



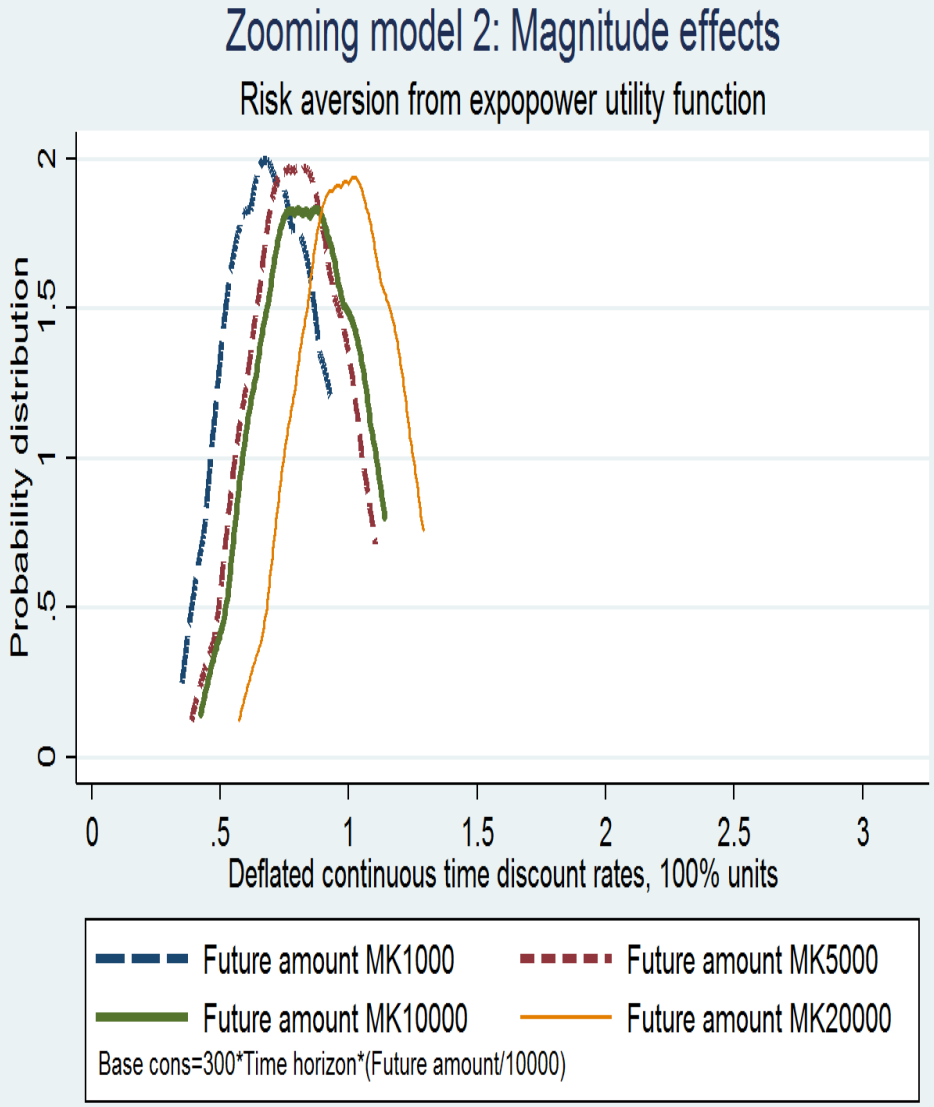
# Predicted discount rates with Zooming Model 1: Linear in time horizon



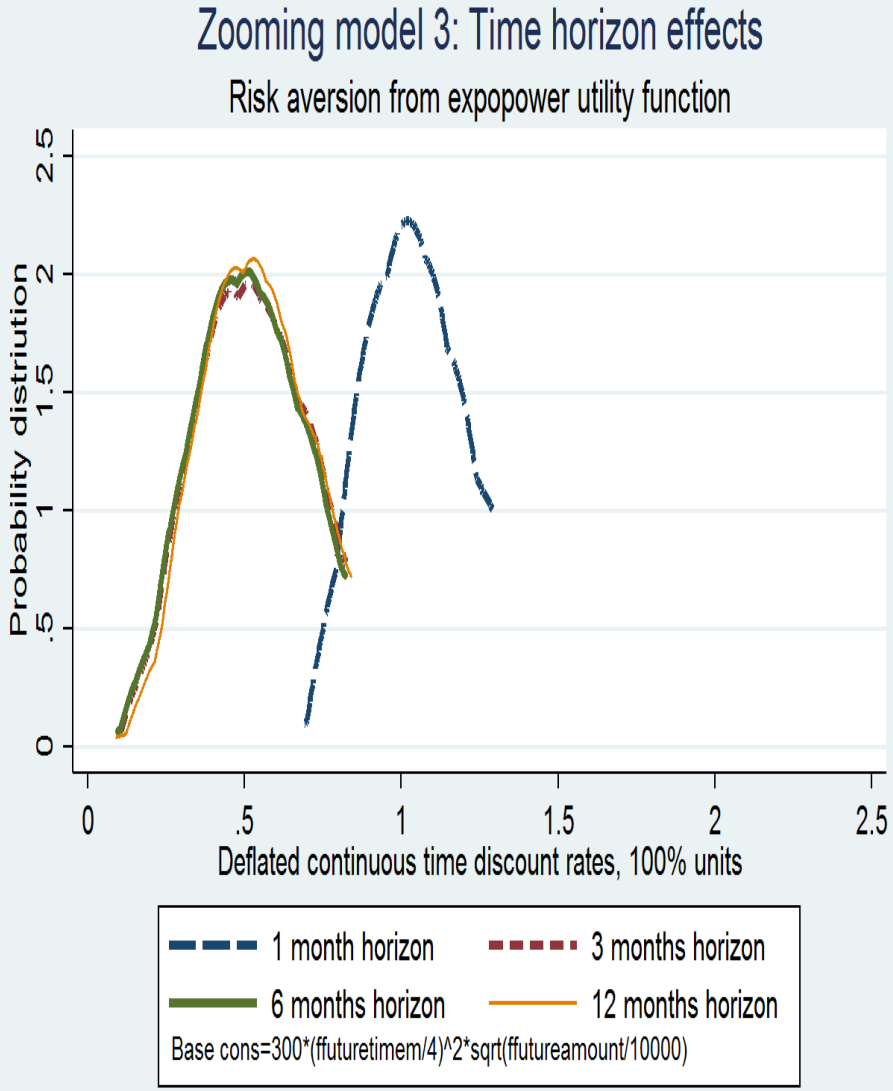



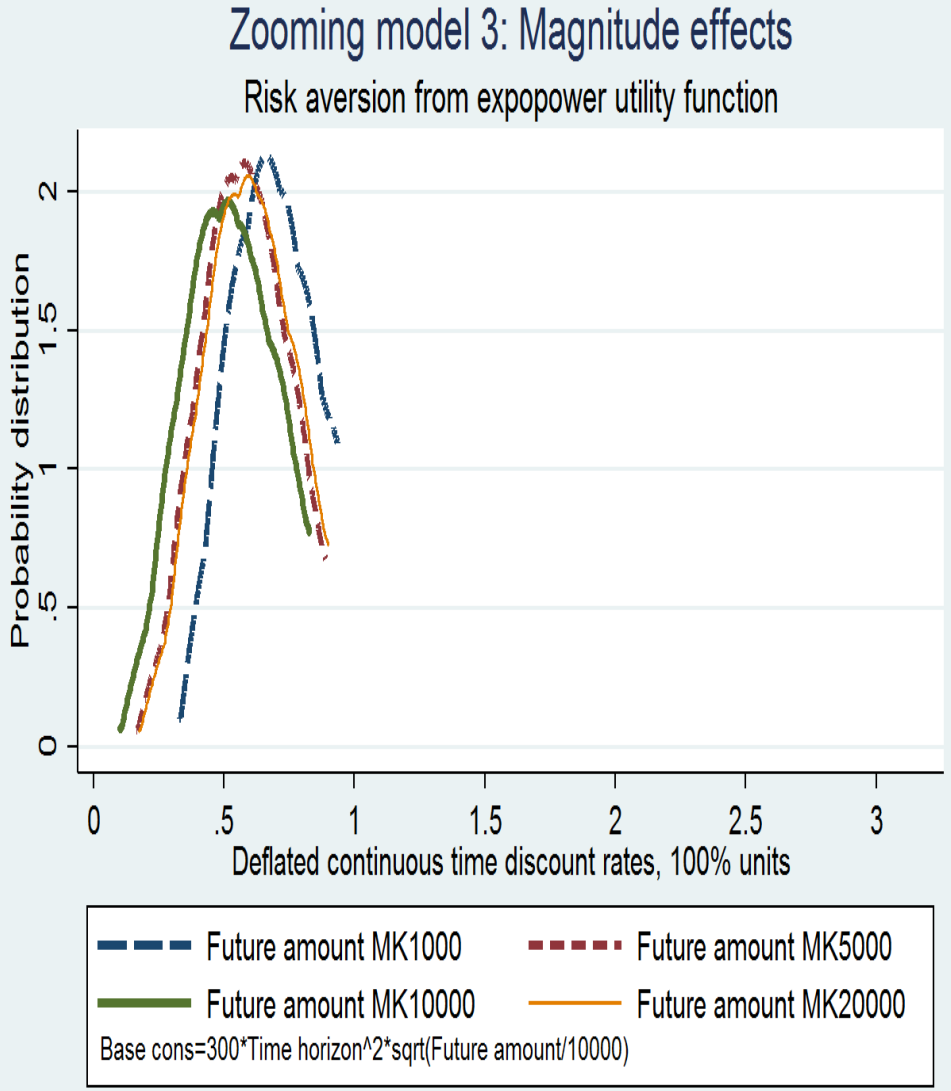
# Predicted discount rates with Zooming Model 2: Linear in time horizon and magnitude



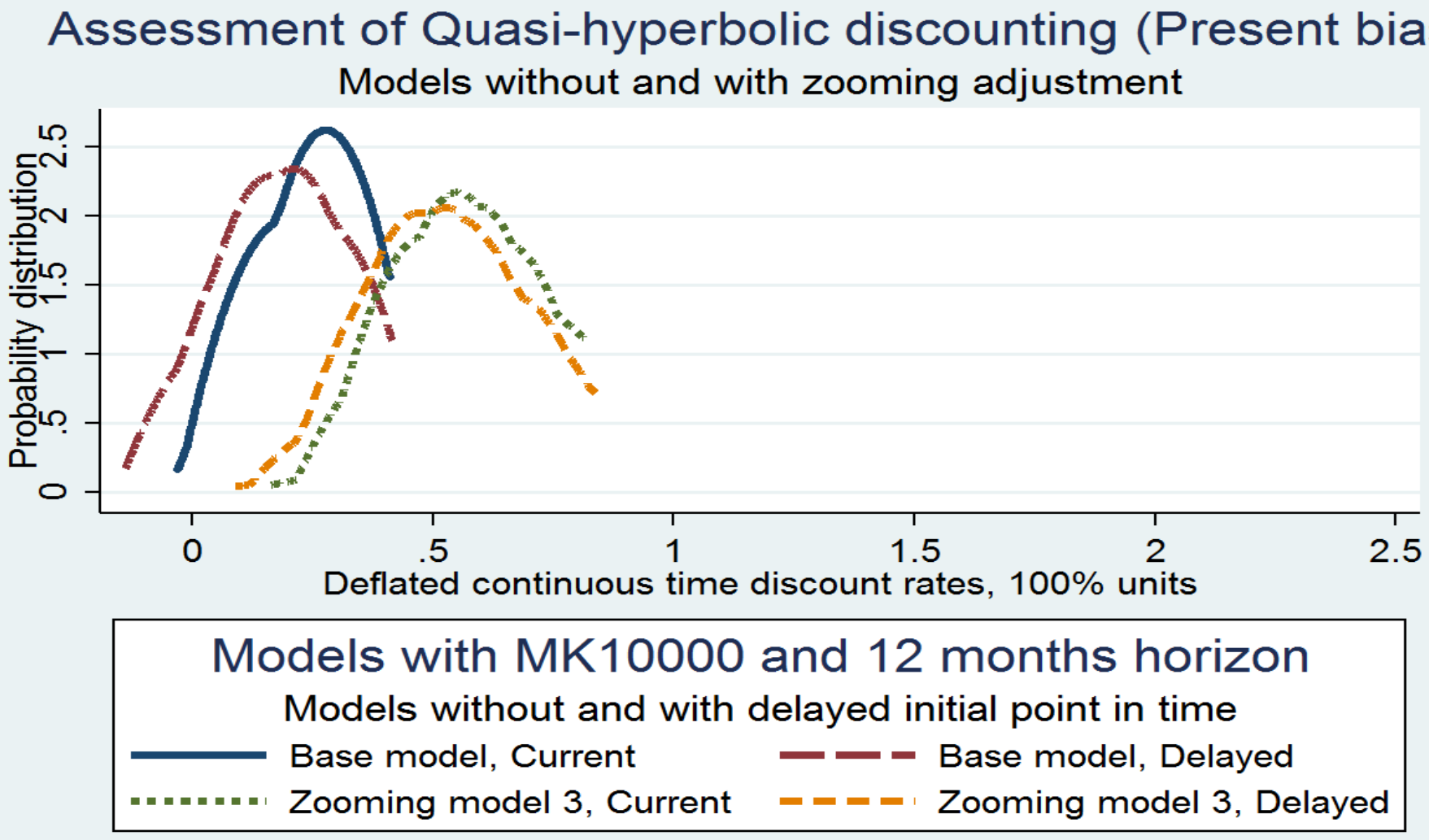



# Predicted discount rates with Zooming Model 3: Non-linear in time horizon and magnitude

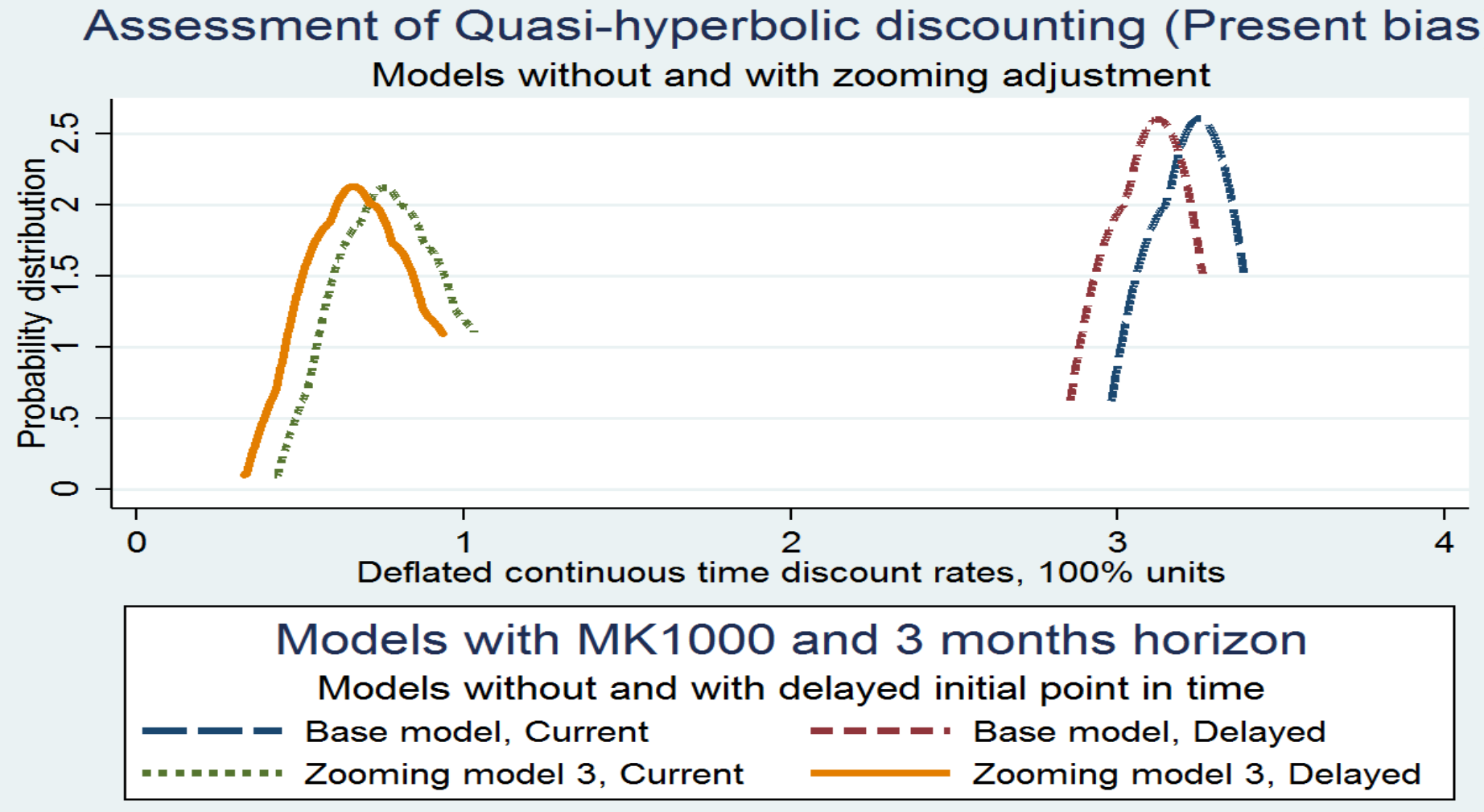


# Extent of present bias in models without and with zooming adjustment: Longer time horizon & larger amount



# Extent of present bias in models without and with zooming adjustment: Shorter time horizon & small amount



# Econometric results

| | Base model Bc: MK5000 | Zooming adjustment 1 | Zooming adjustment 2 | Zooming adjustment 3 |
|---|---|---|---|---|
| Future amount: Base: MK20000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Future amount: MK10000 | 0.137 | 0.143 | -0.150 | -0.073 |
| Future amount: MK5000 | 0.465**** | 0.370**** | -0.186* | -0.010 |
| Future amount: MK1000 | 2.146**** | 1.175**** | -0.223*** | 0.155** |
| Time horizon: Base: 12 months | 0.000 | 0.000 | 0.000 | 0.000 |
| Time horizon: 6 months | 0.606**** | -0.027 | 0.193* | -0.018 |
| Time horizon: 3 months | 0.966**** | 0.050 | 0.318*** | -0.013 |
| Time horizon: 1 month | 1.940**** | 0.542*** | 0.989**** | 0.578**** |
| Dummy for front end point=current | 0.126** | 0.073 | 0.105*** | 0.097** |
| Dummy for front end point=1 month | 0.132*** | 0.087* | 0.128*** | 0.118** |
| Random starting point*Task number | -0.018**** | -0.019**** | -0.020**** | -0.023**** |
| Enumerator dummies (5 enumerators) | n.s. | n.s. | n.s. | n.s. |
| Constant | 0.129 | 0.947**** | 0.746**** | 0.673**** |
| Luce error constant | 0.040**** | 0.043**** | 0.072**** | 0.090**** |
| Prob > F | 0.000 | 0.000 | 0.000 | 0.000 |
| Number of observations | 33586 | 33586 | 33586 | 33586 |

# Conclusions

- We have proposed a zooming model based on the idea of bounded awareness and reference dependent utility.
- We hope that the model will contribute to a deeper understanding of hyperbolic discounting and magnitude effects
- Doubt about the existence of these phenomena has arisen because they have been mostly identified in hypothetical experiments that do not meet the quality standards of experimental economics (Andersen et al. 2011)
- Based on an incentive-compatible field experiment with prospects characterized by alternative time horizons and magnitudes, we demonstrate that these phenomena are highly significant and cannot be explained by present bias/quasi-hyperbolic discounting
- They are, however, consistent with the zooming model proposed here. On the other hand, our findings indicate that small amounts and short horizons are associated with additional mark-ups of discount rates and that our zooming theory cannot explain present bias (quasi-hyperbolic discounting)