

Intertemporal Choice in Vaccination Timing

Evidence from a Discrete Choice Experiment in Wuhan

Final Defense for the Ph.D. in Public Policy and Political Economy

Yichao Jin

Candidate for PhD in Public Policy and Political Economy

April 2026

Dissertation Committee:

Dohyeong Kim

Richard Scotch

Soyoung Kwon

Khai Chiong

(Chair)

Research Problem: Uptake vs. Timing

Traditional Focus: Uptake

- Binary: Yes / No
- Static coverage
- Ignores **delay**

Critical Gap: Timing

- Temporal: *When?*
- **Behavioral Delay**
- Prolongs infection risk

*Main Takeaway: **Timing matters** as much as uptake for epidemic control.*

Research Questions

RQ1 (Essay 1) — Time Discounting

Do individuals exhibit time discounting (present bias) in valuing delayed vaccine protection?

RQ2 (Essay 2) — Monetary Valuation

What is the monetary value individuals assign to vaccination delay (MWTA)?

RQ3 (Essay 3) — Policy Design

How can time preferences and monetary valuation inform vaccination policy design?

Gap in Literature

- Vaccination typically modeled as a **binary decision** (Yes/No)
- Limited focus on **timing** and **delay**
- Little evidence on the **behavioral cost** of delayed protection
- Weak link between **estimation** and **policy design**

Contributions

1. Measurement (Essay 1)

- Estimate intertemporal preferences and delay sensitivity via DCE

2. Valuation (Essay 2)

- Monetize delay using **MWTA** (shadow price of waiting)

3. Policy Design (Essay 3)

- Derive rules for **speed-up** vs. **compensation** strategies

Conceptual Framework



Takeaway

Present bias leads to **overweighting immediate costs** relative to **delayed protection**.

Why Wuhan?

- High-salience epidemic context
- Timing is behaviorally meaningful
- Delay implies **real exposure window**
- Ideal for **time-sensitive** decisions

Data Overview

- Discrete Choice Experiment (DCE)
- Final sample: **1,027 adults**
- **6 choice tasks** per respondent
- Attributes varied:
 - Delay (0, 1, 3, 6 months)
 - Vaccine efficacy
 - Side-effect severity
 - Monetary incentives
 - Vaccine origin

Roadmap of the Presentation

- 1 Motivation and Research Questions
- 2 Data and Methods
- 3 Essay 1: Time Discounting
- 4 Essay 2: Monetary Valuation
- 5 Essay 3: Policy Design
- 6 Conclusion

Data Collection and Sampling

Data Collection

- Online survey conducted in Wuhan
- Designed as a discrete choice experiment (DCE)
- Focus on vaccination timing decisions
- Evaluation of hypothetical vaccine scenarios

Sampling

- Final sample: **1,027** adult respondents
- Broad urban adult population in Wuhan
- Each respondent completed 6 choice tasks
- Total observations: **6,162** choice observations

Discrete Choice Experiment (DCE) Design

- Each respondent completed **6 choice tasks**
- Each task included **2 hypothetical vaccine alternatives** and an **opt-out option**
- Alternatives varied across key vaccine attributes to identify trade-offs
- Design captures stated preferences between waiting time and other features

Attribute	Vaccine A	Vaccine B	Opt-out
Waiting time	1 month	3 months	
Efficacy	95%	70%	
Side effects	Mild	Moderate	<i>Choose neither /</i>
Incentive	50 RMB	200 RMB	<i>Wait</i>
Origin	Imported	Domestic	
Your Choice	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Attributes and Levels

Attribute	Levels
Waiting Time to Protection	0, 1, 3, 6 months
Vaccine Efficacy	50%, 70%, 95%
Side Effects	Mild, Moderate, Severe
Monetary Incentive	0, 50, 200 RMB
Vaccine Origin	Domestic, Imported

Random Utility Framework

The choice process follows a standard **Random Utility Model (RUM)**:

$$U_{ijt} = V_{ijt} + \varepsilon_{ijt}$$

Systematic Utility: $V_{ijt} = \beta_1 \text{Delay}_{ijt} + \beta_2 \text{Efficacy}_{ijt} + \beta_3 \text{SideEffects}_{ijt} + \dots + \text{ASC}_{\text{optout}}$
Decision Rule: Choose alternative j if $U_{ijt} > U_{ikt}$ for all $k \neq j$

Notation Guide

i = individual

j = alternative

t = choice task

V_{ijt} = observed utility

ε_{ijt} = unobserved component

*Mixed logit is the preferred specification for capturing **heterogeneity** in vaccination timing preferences.*

Multinomial Logit (MNL)

- Assumes **homogeneous** preferences across individuals
- Coefficients are fixed
- Imposes Independence of Irrelevant Alternatives (IIA)

Mixed Logit (MXL)

- Allows random coefficients (**heterogeneity**)
- Captures variation in time preferences across individuals
- Relaxes IIA assumption
- Estimated via simulated maximum likelihood

Essay 1: Time Discounting in Vaccination Timing

Identifying present bias in delayed vaccine protection

Objective

- Estimate **intertemporal preference** parameters governing vaccination timing
- Test whether individuals exhibit **present bias** in valuing delayed protection
- Compare exponential and hyperbolic **discounting** models

Key Idea

- Vaccination involves immediate costs and delayed benefits
- Individuals may overweight short-term costs relative to future protection
- This mechanism contributes to **delayed vaccination** behavior

We now unpack this behavioral mechanism step by step.

This section quantifies how individuals discount delayed vaccine protection.

Exponential vs. Hyperbolic Discounting

Exponential Discounting

- **Time-consistent** preferences
- Constant discount rate: $D(t) = \delta^t$
- Smooth decline over time

Hyperbolic Discounting

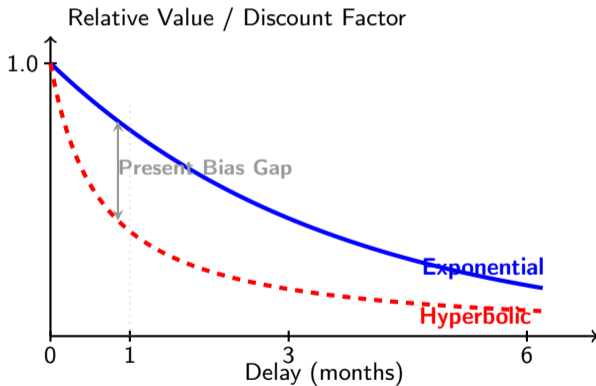
- **Present-biased** preferences
- Declining discount rate
- Strong short-run discounting

The key difference is what happens at short delays.

Hyperbolic discounting places disproportionately high weight on immediate protection.

Present Bias Visualization

Individuals disproportionately discount short delays.



Short waiting times impose disproportionately large behavioral costs.

From Present Bias to Measurement: Behavioral Delay Multiplier

BDM translates present bias into a measurable time distortion.

$$\text{BDM}(t) = \frac{\text{Perceived Delay}}{\text{Actual Delay}}$$

Intuition

- Individuals **overweight** short delays
- Waiting feels **longer** than it actually is

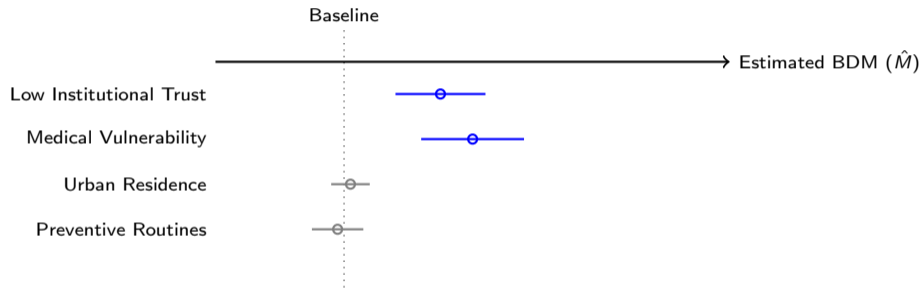
Interpretation

- **BDM > 1**: delay is perceived as longer than actual
- Larger BDM at short delays indicates **present bias**

This converts behavioral intuition into an interpretable metric for comparing delay burdens.

Heterogeneity in Time Preferences

*Time preferences are not uniform across individuals; **heterogeneity** drives policy effectiveness.*



- Lower **institutional trust** is associated with steeper short-run discounting.
- More vulnerable groups face higher behavioral costs of delay (higher BDM).
- Understanding variation is critical for **targeting** vaccination policy.

Essay 1 Summary: Behavioral Mechanism of Delay

*Individuals exhibit **present-biased** preferences in valuing delayed vaccine protection.*

1. Present Bias Identified

Hyperbolic discounting fits the data better than exponential models, confirming stronger short-run discounting and **present bias**.

2. Quantifying Delay Distortion

The **BDM** shows that short delays are perceived as disproportionately longer, imposing significant behavioral costs.

3. Policy Implication

Reducing short waiting times can significantly boost uptake; behavioral bias **amplifies** the impact of small delays.

Essay 2: Monetary Valuation of Vaccination Delay

Estimating the economic cost of waiting (MWTA)

Objective

- Estimate marginal willingness-to-accept (**MWTA**) for delay
- Quantify the economic **cost of waiting** time
- Translate behavioral preferences into **monetary value**

Key Idea

- Waiting time imposes a behavioral cost
- Individuals require compensation to accept delay
- **MWTA** represents the shadow price of waiting

This section monetizes the behavioral cost of delayed vaccine protection.

Estimating MWTA: Logic and Interpretation

MWTA translates delay sensitivity into a monetary value.

$$\text{MWTA} = - \frac{\beta_{\text{delay}}}{\beta_{\text{monetary incentive}}}$$

Derived from the marginal rate of substitution between delay and money.

Intuition

- Delay reduces utility
- Monetary incentives increase utility
- **MWTA** measures compensation needed to offset delay

Interpretation

- Higher **MWTA** → higher **cost of waiting**
- Captures the shadow price of delay
- Allows comparison across individuals and groups

Core Result: Mean MWTA

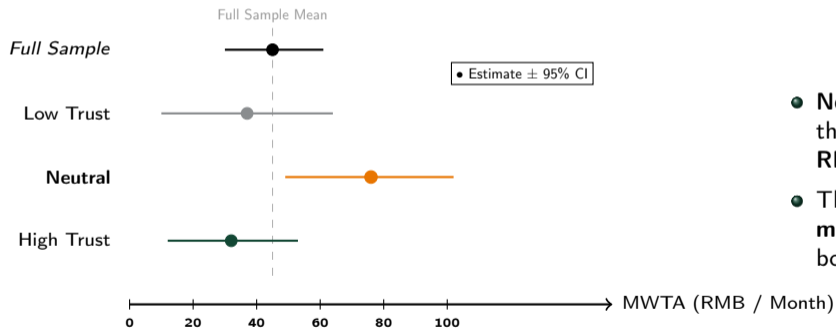
Vaccination delay has a measurable and economically meaningful cost.

Mean MWTA = 44.8 RMB per
month

Individuals require approximately **44.8 RMB** compensation
to accept one additional month of delay.

MWTA by Institutional Trust

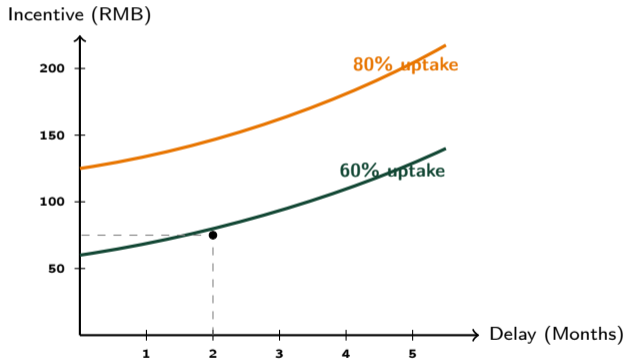
Institutional trust shapes how costly delay is.



- **Neutral trust** respondents show the highest MWTA (~**76 RMB/month**).
- The relationship is **not monotonic**: neutral trust exceeds both high- and low-trust groups.

Iso-acceptance Curves

Higher **delay** requires higher **compensation** to sustain the same uptake level.

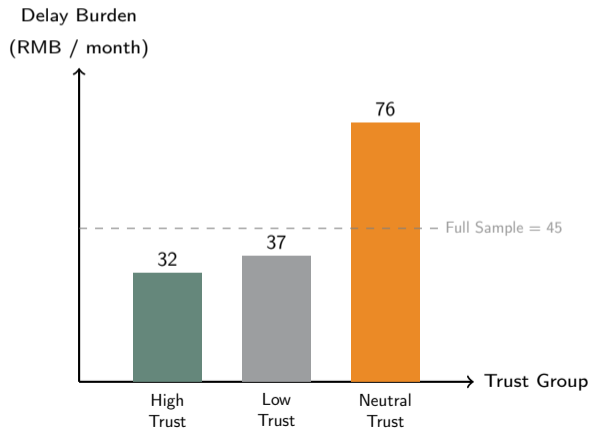


- Delay and incentives are **policy substitutes**.
- Required **compensation rises** with waiting time.

These curves provide a practical menu for balancing timeliness and incentives.

Welfare Analysis: The Time Tax

MWTA can be reinterpreted as an implicit **behavioral time tax**.



- The **same delay** does not impose the same welfare loss on everyone.
- **Neutral-trust** individuals face the largest implied delay burden.

Essay 2 Summary: Quantifying the Burden of Delay

Vaccination delay imposes a **measurable monetary-equivalent** burden.

1. Mean **MWTA**

Delay has a **meaningful monetary cost**.

2. **Trust Heterogeneity**

The **cost of waiting varies** across trust groups.

3. **Policy Relevance**

Delay and incentives can be compared for **policy design**.

Essay 2 turns delay into a policy-relevant monetary benchmark.

Essay 3: Policy Integration

From behavioral estimates to actionable vaccination policy

Objective

- Translate **MWTA** and present bias into policy metrics
- Compare **reducing delay** vs. providing incentives
- Develop rules for **efficient and equitable** allocation

Key Idea

- Policy can act on **time** or **incentives**
- Delay creates **unequal costs** across individuals
- Targeting high-burden groups improves outcomes

How should policy respond to the cost of delay?

Reduce delay — or compensate for it.

Speed-up (Reduce Delay)

- Shorten waiting time
- Reduce administrative frictions
- Increase the value of immediate protection

Compensation (Incentives)

- Provide monetary or in-kind incentives
- Offset the cost of waiting (MWTA)
- Maintain uptake despite delays

Two alternative policy responses to the same behavioral constraint.

Rule 1: Efficiency — When to Reduce Delay vs. Compensate

Choose the policy that achieves uptake at the lowest cost.

Reduce **Delay** if: **Cost** of speed-up $<$ **MWTA**

Compensate if: **Cost** of speed-up $>$ **MWTA**

Intuition

- **MWTA** measures how costly delay is
- Compensation offsets delay when speed-up is too expensive

Implication

- If delay is very costly, reducing it is more **efficient**
- Policy should compare **costs on both sides**

Efficiency links policy choice to the shadow price of delay.

Rule 2: Equity — Who Should Be Prioritized?

Prioritize groups facing the highest delay burden.

Equity Principle

- Individuals face unequal costs of delay (**MWTA**)
- Equal treatment can lead to unequal outcomes

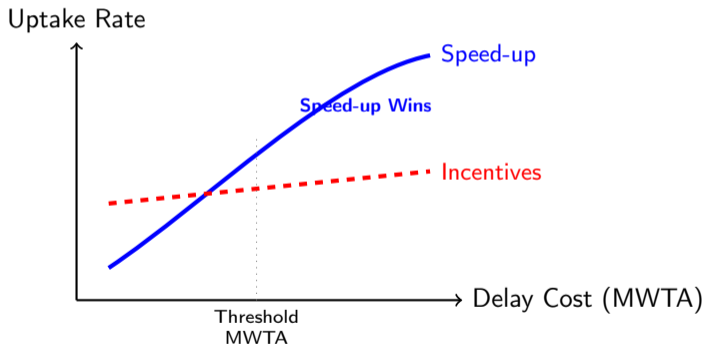
Policy Implication

- Prioritize high-**MWTA** groups
- Target interventions toward high-burden populations

Equity complements efficiency by focusing on who bears the greatest cost.

Policy Simulation 1: Speed-up vs. Compensation

Reducing delay can outperform compensation when delay costs are high.

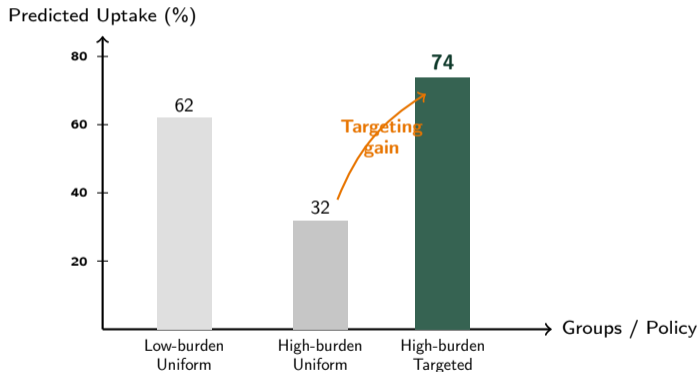


- **Speed-up** is most effective when delay costs are high
- **Incentives** preferred when speed-up is costly

Policy choice depends on the relative cost of time vs. incentives.

Policy Simulation 2: Targeted vs. Uniform Allocation

Targeted policies improve outcomes by focusing on high-burden groups.



- Uniform policies can underperform when delay costs are highly **heterogeneous**.
- Targeting **high-MWTA** groups improves both effectiveness and equity.

Targeting high-burden groups improves both effectiveness and distributional outcomes.

Essay 3 Summary: From Behavioral Estimates to Policy Design

Behavioral estimates can be translated into actionable vaccination policy.

1. Policy Levers

Vaccination policy can respond to delay by speeding up access or compensating for waiting.

2. Decision Rules

Efficiency guides what to do; equity guides who should be prioritized.

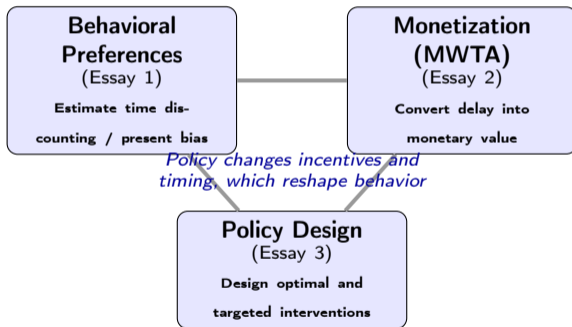
3. Policy Simulations

Targeted policies improve outcomes by focusing on high-burden groups.

Essay 3 converts behavioral heterogeneity into practical policy guidance.

Synthesis: The Scientific Loop

This research forms a closed loop from behavior to policy and back.



Behavioral insights → valuation → policy → behavioral response.

This dissertation contributes to behavioral health economics in three ways.

1. Behavioral Measurement

Identifies present-biased valuation of delayed vaccine protection using a DCE framework.

2. Economic Valuation

Converts delay into a monetary metric (MWTM) and an interpretable behavioral measure (BDM).

3. Policy Design

Develops efficiency- and equity-oriented rules for vaccination timing policy.

Together, these contributions connect behavioral estimation, valuation, and policy design.

Vaccination policy should treat time as a policy lever, not just an operational detail.

1. Reduce Short Delays

Small reductions in waiting time can generate disproportionately large behavioral gains.

2. Use Compensation

When delay cannot be avoided, incentives can offset the behavioral cost of waiting.

3. Target High-Burden

Prioritize groups with higher delay costs, especially where trust-related frictions are strongest.

Effective vaccination policy should balance speed, incentives, and targeting.

Limitations & Future Research

This dissertation provides a policy-relevant framework, but several extensions remain important.

Limitations

- Results based on stated preferences rather than realized behavior
- Setting specific to Wuhan and a COVID-like disease context
- Delay measured over limited horizon within stylized DCE design

Future Research

- Link stated preferences to observed vaccination timing behavior
- Extend framework to other settings, populations, and interventions
- Embed timing preferences in richer operational or epidemic models

These limitations point to a broader research agenda on time-sensitive health behavior.

Time matters in vaccination decisions.

Delays are not neutral — they impose real behavioral costs.

These costs can be measured, monetized, and compared.

Policy can act by reducing delay or targeting those most affected.

Thank you!

I welcome your questions and feedback.

Yichao Jin — UT Dallas