Agents behaviour Part i

Learning outcomes

Introduction to the **four steps** to model an agent
Difference between full vs bounded rationality
Agents with **heterogeneous** beliefs

Modelling agents behaviour

Nature of agents

List of variables describing their state

List of **actions** the agents can perform

Structure of their **interaction** with other agents

Certainty (full rationality)

Objective utility function
Constraints
Perfect information
Perfect cognitive capabilities

Example - production problem

$$\text{Max } \pi = Pq - Wn$$

Maximise profit

Price and quantity

Wage and employment

Example

$$\text{Max}\ \pi = Pq - Wn$$

$$q = n^{\alpha} \qquad\qquad 0 < \alpha < 1$$

Production function

Example

Max $\pi = Pq - Wn$

$q = n^{\alpha} \qquad 0 < \alpha < 1$

Magic happens, then: $q^* = \left(\frac{\alpha P}{W}\right)^{\frac{\alpha}{1-\alpha}}$

Uncertainty

Some variables may be **unknown** or not computable

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Measurable or tractable uncertainty (risk)
Agents know all possible states
Probability distribution

Uncertainty

Some variables may be **unknown** or not computable

Measurable or tractable uncertainty (risk)

Agents know all possible states

Probability distribution

Untractable uncertainty

True uncertainty

Don’t know the states or can’t compute probability

Risk neutrality

Agents are risk neutral if in presence of measurable uncertainty they **maximise the expected value** of the uncertain payoff

Risk neutrality

Agents are risk neutral if in presence of measurable uncertainty they **maximise the expected value** of the uncertain payoff

Agents can still make optimal choice **based on available information**

Agents form **expectations**

Risk neutrality

Know all the states (eg, two states, low price, high price)
Selling price in each state P_h and P_l
Probability of each state p_h and p_l
expected selling price:

$$E(P) = p_h P_h + p_l Pl$$

Example – production problem

Max $\pi = E(P)q - Wn$

$$q = n^{\alpha} \qquad 0 < \alpha < 1$$

Magic happens, then: $q^* = \left(\frac{\alpha E(P)}{W}\right)^{\frac{\alpha}{1-\alpha}}$

Rational expectation models

Perfect **information** and **computing** capabilities

Agents will learn the **“true model”**

Representative agent

Rational expectation models

Clearly not true

Perfect **information** and **computing** capabilities

Agents will learn the **“true model”**

Representative agent

What is the true model?

Are we all the same?

Heterogeneous beliefs

No. Agents often use heuristics

Perfect **information** and **computing** capabilities

Agents will learn the **“true model”**

Representative agent

No true model, agents can switch

Agents have a variety of behaviours and beliefs

Heterogeneous beliefs

No. Agents often use heuristics

Perfect **information** and **computing** capabilities

Agents will learn the **"true model"**

Representative agent

No true model, agents can switch

Agents have a variety of behaviours and beliefs

Heterogeneous beliefs

No. Agents often use heuristics

Perfect **inf** … babilities

Agents wi

Representative agent

$$x^e_{i,t+1} = f_i(x_t, \alpha_i)$$

Bias

No true model, agents can switch

Agents have a variety of behaviours and beliefs

Nature of agents

Empirical economics

Consumer behaviour

Psychology

Data Research

Behavioural economics

Cognitive science

Psychology - theories

Case study I: Favourite-longshot bias

What is the FLB?

Outcomes with **high** probability are **underpriced**
Outcomes with **low** probability are **overpriced**

Why agents?

Problem studied since the 1940s
Economic theories only
No perfect rationality but still
representative agents

Main explanations

“Insider” trading

Misperception of probabilities

Risk-love

Main explanations

“Insider” trading

Two types of agents. Random and insiders.
Insiders know the real probability.

Main explanations

Misperception of probabilities

High values are underestimated
low values are overestimated

Main explanations

Risk attitudes

Some people are averse to risk
Some people seek risk

Prediction markets

π_i Price of ticket to bet on i

p_i True Probability of i happening

Pays **1** if i occurs, **0** if it doesn't

So you can win $1 - \pi_i$ or lose π_i

ABM

From prospect theory - our value/utility

$$v(x) = \begin{cases} x^{\alpha} & \text{if } x \geq 0 \\ -(-x)^{\alpha} & \text{if } x < 0 \end{cases}$$

$$w(p) = e^{-[-ln(p)]^{\beta}}$$

From research on probability misperception - our expected probability

ABM

$$v(x) = \begin{cases} x^{\alpha} & \text{if } x \geq 0 \end{cases}$$

$$\boxed{u(\pi_i, p_i) = w(p_i)v(1-\pi_i) + w(1-p_i)v(-\pi_i)}$$

$$w(p) = e^{-[-ln(p)]^{\beta}}$$

ABM

Random

No "function", bet on a or b randomly (50/50 chance)

Insiders

$\alpha = \beta = 1$

Risk averse

$\alpha = 0.5 \quad \beta = 1$

Misperceiving agents

$\alpha = 1 \quad \beta = 0.928$

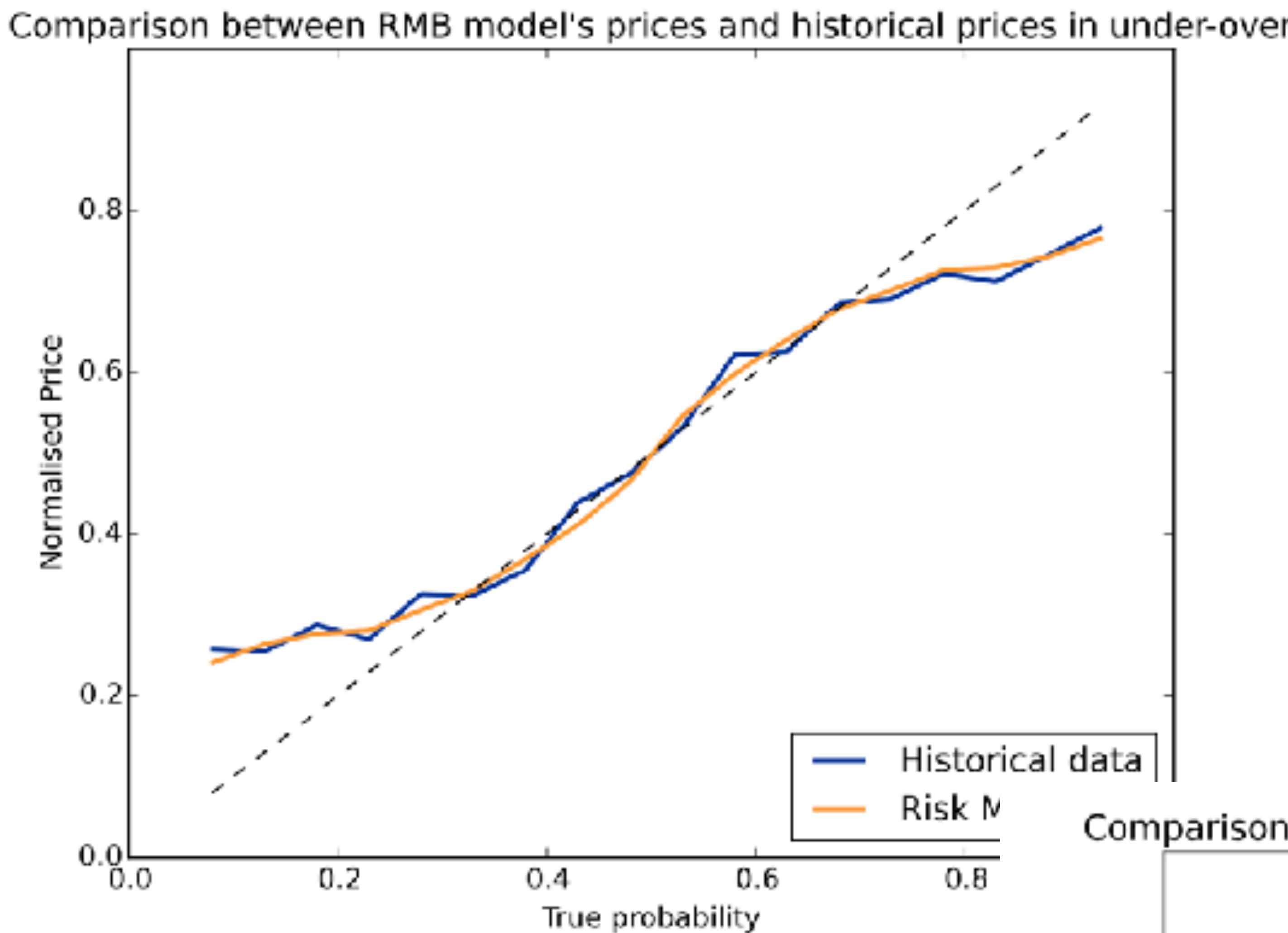
Risk lovers

$\alpha = 2 \quad \beta = 1$

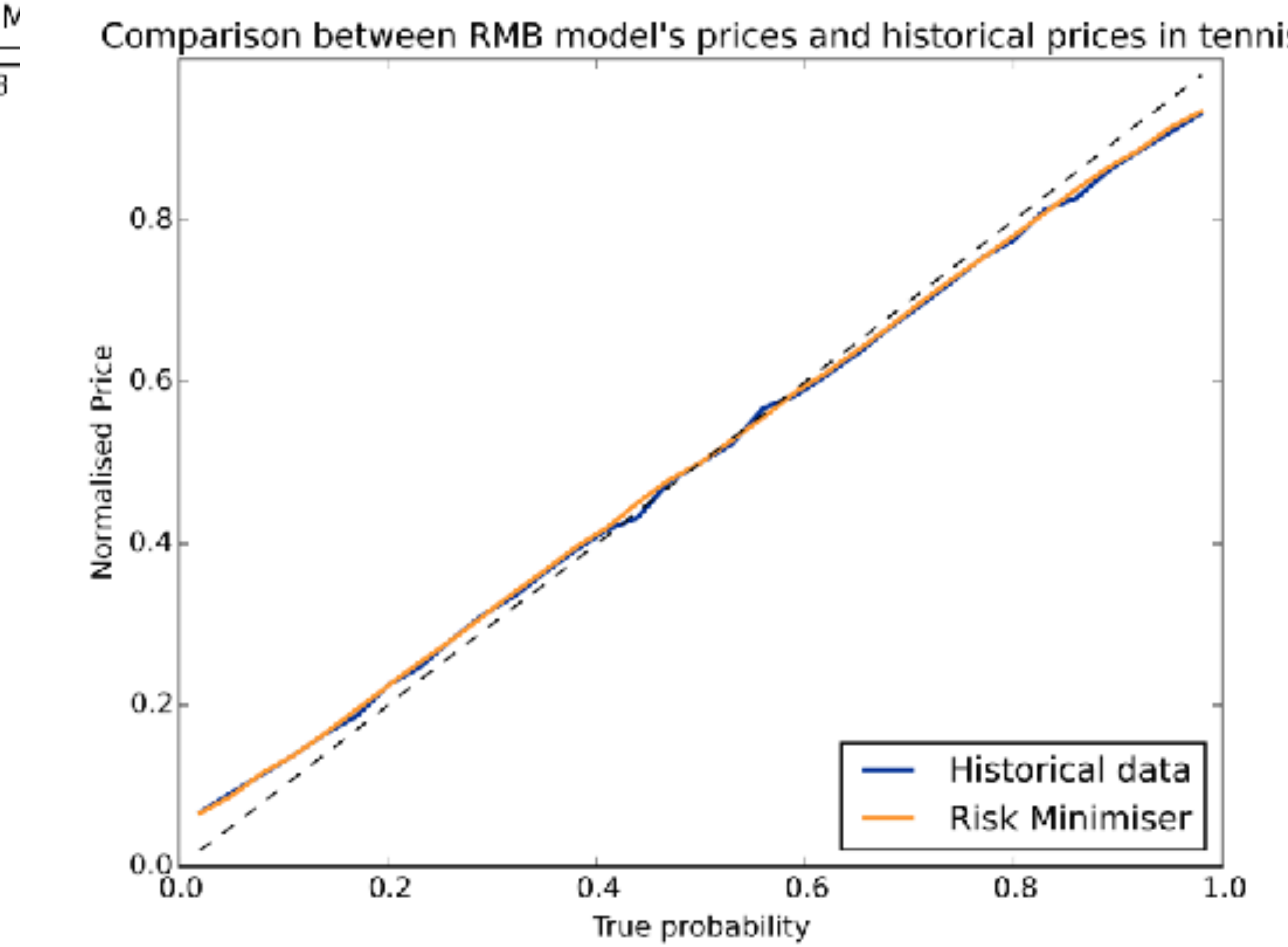
Abm

Risk averse $$\pi^s(p) = \frac{p - \sqrt{p - p^2}}{2p - 1}$$

Risk lovers $$\pi^s(p) = \frac{p^2}{1 - 2p + 2p^2}$$



Comparison between RMB model's prices and historical prices in under-over
Normalised Price
0.0
0.2
0.4
0.6
0.8
True probability
Historical data
Risk M



Comparison between RMB model's prices and historical prices in tennis
Normalised Price
0.0
0.2
0.4
0.6
0.8
1.0
True probability
Historical data
Risk Minimiser

Exercise:

Design a simple agent for financial markets

Case study ii: Financial markets

Basic financial abm

Chartists
Fundamentalists

Basic financial abm

Introduced by **Frankel and Froot**

Based on **surveys** with professionals

They found traders had **different expectations** especially with respect to long/short-term trades

Chartists

Follow the trend

Short-term investors

$$s_{t+1}^{e} = (1 - g)s_t + gs_{t-1}$$

Expected price **Price at time t** **Price at time t-1**

Chartists

Follow the trend

Short-term investors

$$\boxed{\Delta s^e_{t+1} = -g\Delta s_t}$$

$$s^e_{t+1} = (1-g)s_t + g s_{t-1}$$

Expected price **Price at time t** **Price at time t-1**

Fundamentalists

Derive the “fundamental” price
Long-term investors

$$s_{t+1}^{e} = (1 - v)s_t + v\bar{s}_t$$

Expected price **Price at time t** **Fundamental Price at time t**

Fundamentalists

Derive the "fundamental" price

Long term investors

$$\boxed{\Delta s^{e}_{t+1} = v(\bar{s}_t - s_t)}$$

Expected price

Price at time t

Fundamental Price at time t-1

Switching behaviour

Agents can compare different heuristics and choose
Agents can change their behaviour

Basic Financial ABM

Basic Financial ABM

Basic Financial ABM

Basic Financial ABM

Basic Financial ABM

Summary

Introduction to agents behaviour
Four steps to design agents
Real-world examples