ON THE MAGNITUDE OF BOUNDED RATIONALITY IN BUSINESS MANAGEMENT GAMES
– a behavioural economic analysis of complex decision making

Philipp Hengel

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Outline of the Presentation

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   2.3. Normative Benchmarks

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4. Summary
Problem Description and Objectives

Problem:
• agricultural policies often do not have the desired effects
• traditional rational choice models applied by policy consultants do not allow for bounded rationality
• How much of an effect does bounded rationality have on the success of a business?

Objectives:
• quantify the amount of bounded rationality in complex decision-making
  – in more than one entrepreneurial domain
  – subject to dynamics
• separate the components of bounded rationality
  – inadequate information
  – limited computational abilities of decision-makers
Problem Description and Objectives

• business games provide very useful data for this approach
  – same initial situation and framework for all participants
  – comparability of decisions
  – applicability of benchmarks
  – incentive compatibility (i.e. through prices)

• properties of the business game
  – decisions in the entrepreneurial domains “investment“, “production“, “financing“
  – entrepreneurial goal: maximisation of terminal wealth
  – incentive compatibility
  – success depends on product prices, which, in turn, depend on the production activities of all players
  – benchmarks, that show the possible terminal wealth with no (less) bounded rationality are applicable for each player
Study Design – Research Approach

Benchmark 3: optimal information processing of subjective price prognoses
Benchmark 2: optimal information processing of naive price prognosis
Benchmark 1: hypothetical optimal behaviour

actual behaviour of players

total amount of bounded rationality

bounded rationality caused by inadequate computational abilities
bounded rationality caused by imperfect information

amount of bounded rationality avoidable by formal planning

terminal wealth
Study Design – The Business Game “SPOT”

- multi-period game (8 periods) with the goal to gain the highest terminal wealth

- participants have to decide on
  - investments (5 different production facilities)
  - production (2 different products: sparrows and pigeons)
  - financing (annuity loan, open credit)

- framework conditions:
  - seed capital of 2,000 MU (monetary units)
  - periodic fixed costs of 300 MU
  - price for sparrows is fixed and known:
    - periods 1-4: 13.5 MU
    - periods 5-8: 12.0 MU
  - price for pigeons:
    \[ P = 25 - 0.14 \times \frac{total \ amount \ of \ production}{number \ of \ players} \]
**Study Design – The Business Game „Spatz oder Taube“**

<table>
<thead>
<tr>
<th>Investment</th>
<th>Costs of Acquisition (MU)</th>
<th>Production Capacity</th>
<th>Useful Life</th>
<th>Production Costs (MU/unit)</th>
<th>Lending Limit (%)</th>
<th>Internal Rate of Return (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>70</td>
<td>20 of both together</td>
<td>2</td>
<td>9</td>
<td>0</td>
<td>10.7</td>
</tr>
<tr>
<td>B</td>
<td>195</td>
<td>25</td>
<td>3</td>
<td>8</td>
<td>80</td>
<td>10.5</td>
</tr>
<tr>
<td>C</td>
<td>340</td>
<td>-</td>
<td>3</td>
<td>-</td>
<td>80</td>
<td>9.6</td>
</tr>
<tr>
<td>D</td>
<td>1,560</td>
<td>75</td>
<td>3</td>
<td>3</td>
<td>50</td>
<td>11.9</td>
</tr>
<tr>
<td>E</td>
<td>1,760</td>
<td>-</td>
<td>3</td>
<td>-</td>
<td>50</td>
<td>11.9</td>
</tr>
</tbody>
</table>

- **Annuity Loan:**
  - Bound to investments, maximum uptake = lending limit
  - Interest rate: 10%, duration: 3 years
- **Open Credit:**
  - Maximum 2,000 MU, interest rate: 15%, duration: 1 year
- Unused capital yields interest at a rate of 4%
Study Design – The Business Game „Spatz oder Taube“

• participants had to enter their price predictions for the next 3 periods

• to ensure incentive compatibility:
  – money prices for the best 5 participants
  – 50 € for the player with the best price predictions

• SPOT was played in winter term 2008/09 (group 1) and summer term 2009 (group 2)

<table>
<thead>
<tr>
<th></th>
<th>number of analysed players</th>
<th>average time of study (in semesters)</th>
<th>average self-assessment of economic knowledge (1 = very good, 5 = bad)</th>
</tr>
</thead>
<tbody>
<tr>
<td>group 1</td>
<td>23</td>
<td>4.6</td>
<td>2.70</td>
</tr>
<tr>
<td>group 2</td>
<td>23</td>
<td>5.8</td>
<td>2.86</td>
</tr>
<tr>
<td>total</td>
<td>46</td>
<td>5.2</td>
<td>2.78</td>
</tr>
</tbody>
</table>
Study Design – Normative Benchmarks

• to quantify bounded rationality, we need to compare actual behaviour with normative benchmarks

• all decisions by the benchmarks are met c.p. (no influence on actually observed prices)

• to determine the benchmarks, we use (mixed-integer) multi-period linear programming (MLP)

• depending on the benchmark, different prices / price predictions are used
Study Design – Normative Benchmarks

• determination of Benchmark 1:
  – use of actually observed market prices as price predictions
  – price predictions = actual prices => no need to adjust plans over time
  – can be solved in one run

• determination of Benchmarks 2 & 3:
  – use of naive price prognosis and players’ predicted prices, using the last
    price prognosis for all following periods and biasing by \(-1.5\) MU for price
    predictions in period 5 (analogue to the drop of sparrow prices)
  – price prediction ≠ actual prices
  – changes in future business organisation to adjust to different situation
    (caused by the difference between predicted and actual prices)
  – has to be solved for each period of decision-making
  – Benchmark 3 produces a different solution for each player
# Results and the Sources of Bounded Rationality

<table>
<thead>
<tr>
<th>Actual terminal wealth</th>
<th>Benchmark 1</th>
<th>Benchmark 2</th>
<th>Benchmark 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>total</td>
<td>diff to 1</td>
<td>total</td>
</tr>
<tr>
<td>Group 1 (N=23)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean</td>
<td>4,029</td>
<td>7,255</td>
<td>5,754</td>
</tr>
<tr>
<td>max</td>
<td>8,691</td>
<td>11,284</td>
<td>9,783</td>
</tr>
<tr>
<td>min</td>
<td>716</td>
<td>10,568</td>
<td>9,067</td>
</tr>
<tr>
<td>Group 2 (N=23)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean</td>
<td>3,044</td>
<td>6,414</td>
<td>1,685</td>
</tr>
<tr>
<td>max</td>
<td>5,057</td>
<td>9,458</td>
<td>4,729</td>
</tr>
<tr>
<td>min</td>
<td>1,579</td>
<td>7,879</td>
<td>3,150</td>
</tr>
<tr>
<td>total mean</td>
<td>3,537</td>
<td>10,371</td>
<td>7,256</td>
</tr>
</tbody>
</table>
Results – Price Developments

- Pigeons G1
- Pigeons G2
- Sparrows

Graph showing price developments over a period of 8 weeks.
Results and the Sources of Bounded Rationality

- Benchmark 3: optimal information processing of subjective price prognoses
  - bounded rationality caused by limited information processing abilities: 2,626
- Benchmark 2: optimal information processing of naive price prognosis
  - bounded rationality caused by imperfect information: 4,209
- Benchmark 1: hypothetical optimal behaviour
  - theoretical amount of bounded rationality: 6,835

Actual behaviour of players: 3,537
Terminal wealth: 10,371
Summary

• comparison of players’ actual behaviour with normative benchmarks (determined by formal planning)

• the improvement potential (magnitude of bounded rationality) is substantial

• realistic planning assumptions are as important as the ability to solve optimisation problems

• if inadequate assumptions are made, players can be “right for the wrong reasons“

• bounded rationality can be divided into limited information processing abilities and imperfect information.

• the impact of each component is subject to market dynamics
Summary - Implications for the Agricultural Sector

- large differences between technically equal entrepreneurs
  => formal planning paired with acquisition of good information has a great improvement potential

- policy consultants have to take into account that bounded rationality has a substantial effect on entrepreneurial decisions

  “A good policy for the wrong decision-maker is a bad policy.”

- usage of business games as a lab for better prediction of policy measures

- further questions:
  - How does attitude towards risk affect bounded rationality?
  - How does bounded rationality affect entrepreneurial behaviour when faced with changing framework conditions or a change in policies?
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Thank you very much for your attention!