SEEMINGLY EQUIVALENT FIRM DECISION HEURISTICS

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Context

My vision is to build bigger, better, and more versatile economic models by leveraging modern software engineering and by betting on agent-based modeling. Today, most economic models consist of a system of equations. They are fundamentally mathematical and solved analytically or numerically. In contrast, agent-based models are fundamentally algorithmic. Their buildings blocks are stateful, encapsulated agents that interact with each other through open markets. They are solved by running them. While the cleanest way of specifying equation-based models is to use mathematical terms, the cleanest way of specifying agent-based models is source code. Accepting this view, the code becomes the model and all the tools of modern software engineering can be leveraged to work on it and to manage its complexity.

Summary

- In order to reach their optimal size, firms in agent-based models must be allow to grow and shrink
- Firm size is controlled by dividend payments
  Firm shrinks if dividends > profits
  Firm grows if proifts > dividends
- Common sense! But still often violated in existing models… also, there are some hairy details.

The Model

- Sequence of daily spot markets
- 100 zero-intelligence consumers with Log-Utility
- 10 firms with Cobb-Douglas production (labor share λ, profit share 1- λ, no capital formation)
- Firms adjust their price beliefs over night
- Goal: converge towards efficient equilibrium

Sequence of Events

1. Consumers are endowed with 24 man-hours each.
2. Firms distribute dividends as calculated by their dividend heuristics.
3. Firms post asks to the market, offering yesterday's production in accordance with their individual price beliefs; for example ”we sell 79 pizzas for 7.30$ each”.
4. Firms calculate their budget using their spending heuristic and post bids in the form of limit-orders to the market, for example ”we buy up to 50 man-hours for 13$ each”.
5. In random order, consumers enter the market and optimize their utility given the offers they find, selling man-hours and buying output goods.
6. The market closes and each firm updates its price beliefs based on whether the relevant orders were filled or not.
7. Firms use all acquired man-hours to produce the outputs to be sold tomorrow. In equilibrium, all money resides with the firms again at this point in time, although not necessarily equally distributed.

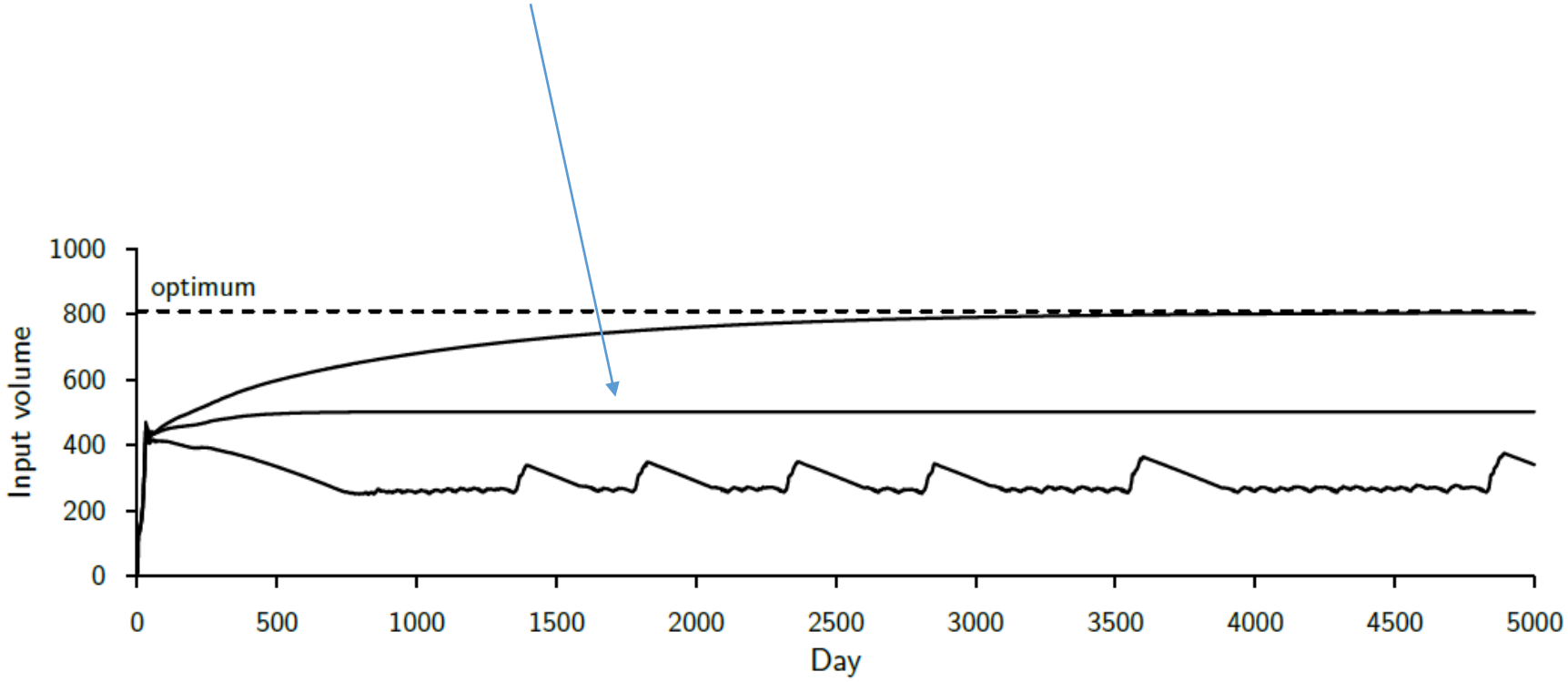
Dividend Decision

- In equilibrium, dividends d = profits π
- Three equivalent ways to calculate equilibrium profits under Cobb-Douglas production:

$$\pi = R - C = (1 - \lambda)R = \frac{1 - \lambda}{\lambda}C$$

- Using them off equilibrium leads to varying results.

Example: d = π = R-C



Systematic Variation

- Three equivalent ways

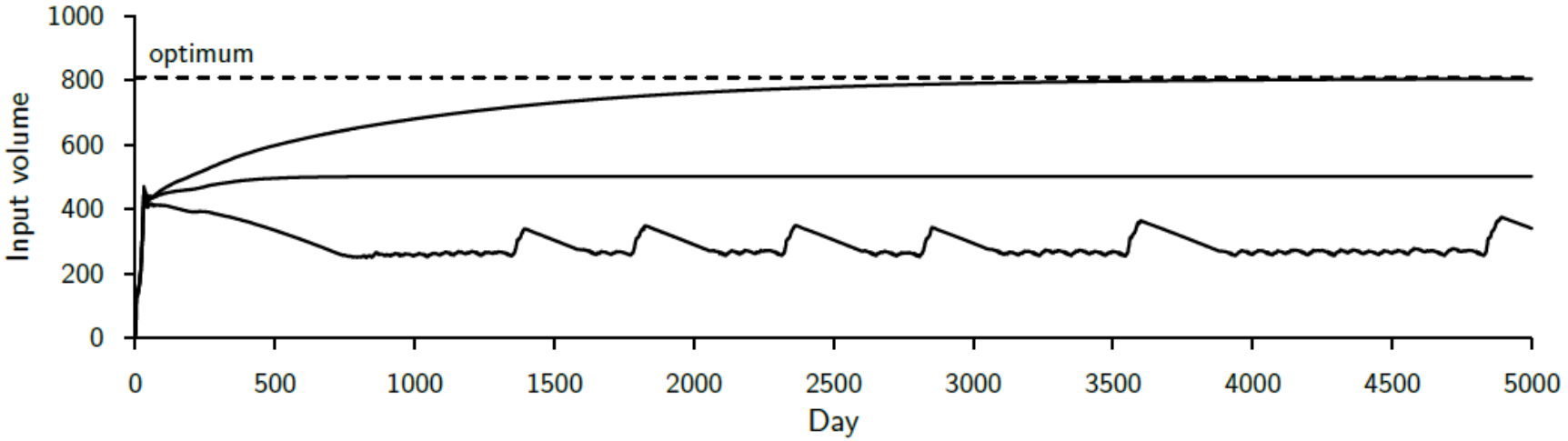
$$\pi = R - C = (1-\lambda)R = \frac{1-\lambda}{\lambda}C$$

- Can be linearly combined:

$$\pi = (1 - a_C - a_R)(R - C) + a_R(1-\lambda)R + a_C\frac{1-\lambda}{\lambda}C$$

- Which is reducible to:

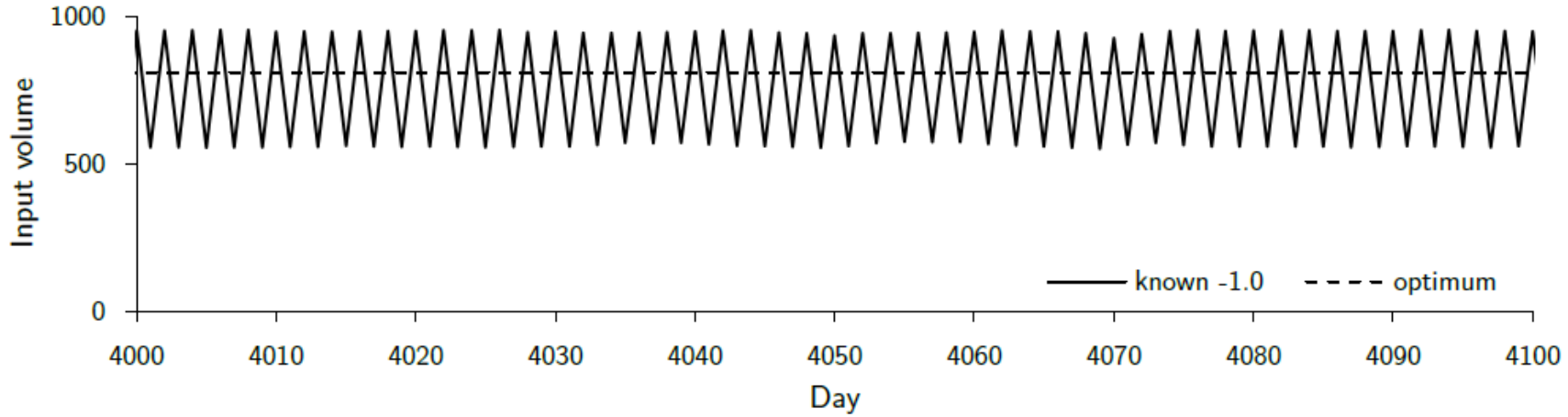
$$\pi = b_R R + b_C C \qquad\qquad \lambda(b_C + 1) = 1 - b_R$$



$b_R = 0.999 \quad \rightarrow \quad d = \pi = 0.999\ R - (1 - 0.001 / \lambda)\ C$

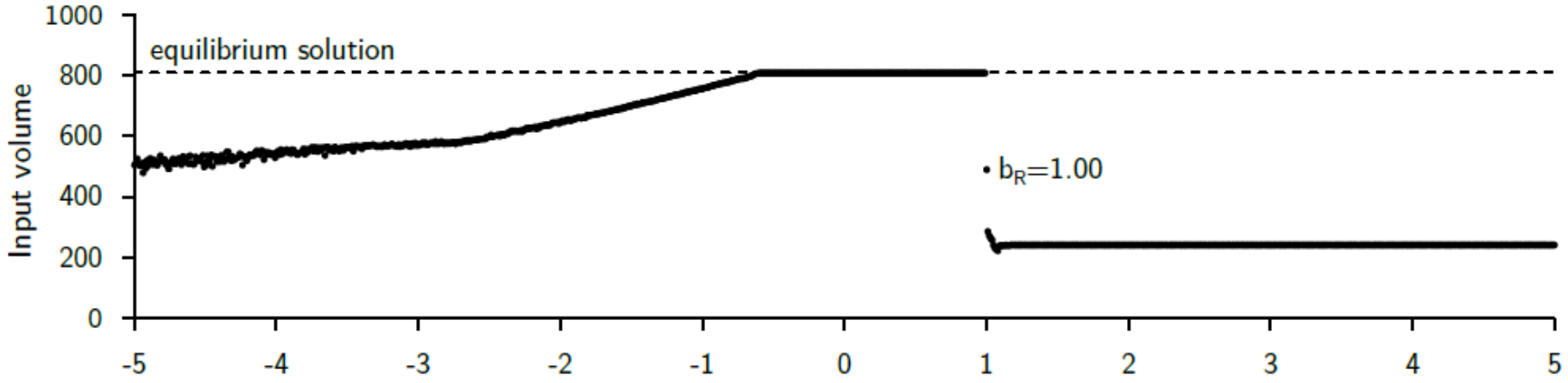
$b_R = 1.000 \quad \rightarrow \quad d = \pi = R - C$

$b_R = 1.001 \quad \rightarrow \quad d = \pi = 1.001\ R - (1 + 0.001 / \lambda)\ C$



$b_R = -1 \quad \rightarrow \quad d = \pi = -R - (1 - 2 / \lambda)\ C$

Exploring the Parameter Space

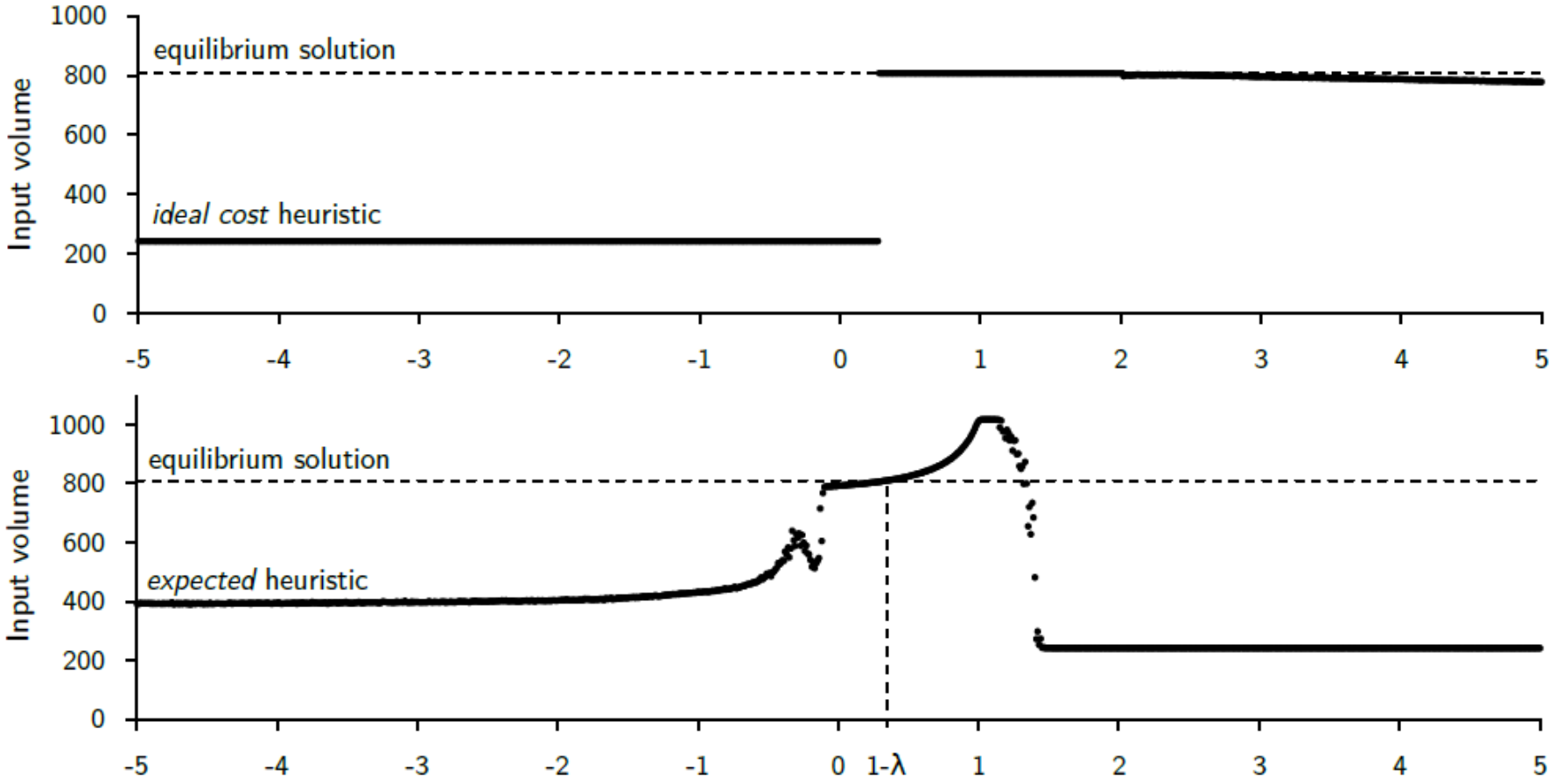


How to measure C and R?

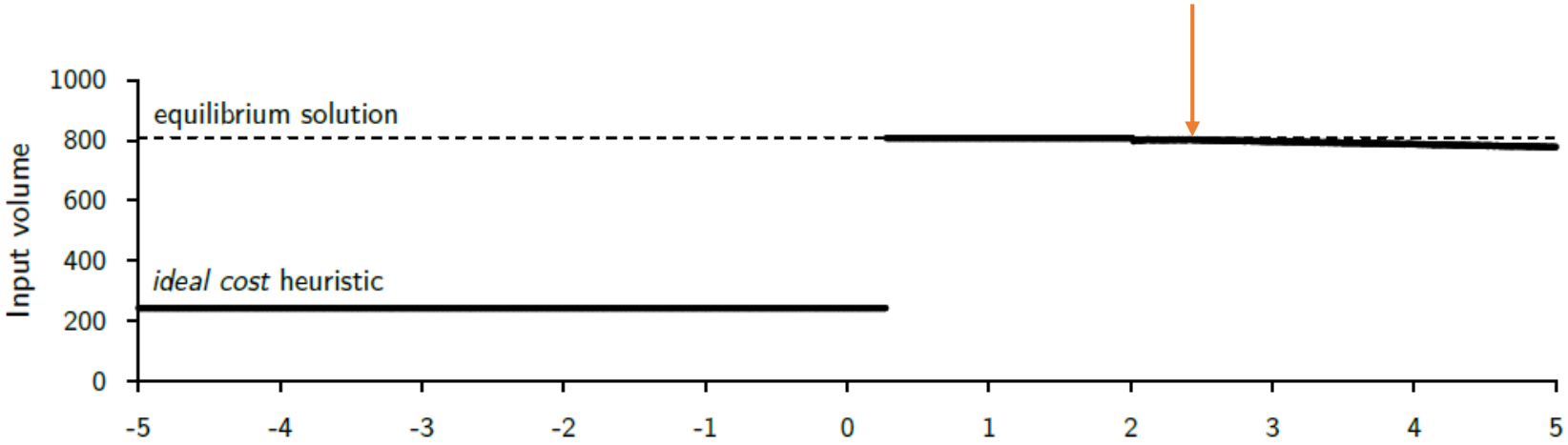
- R_t not known yet when d_t is calculated
- So far, we have just used yesterday's R_{t-1} instead
- But what if we used $E[R_t] = p_t x_t$?
  (price belief * inventory to sell)
- Same holds for C_t, where C_{t-1} was used so far
- "expected heuristic": $E[R_t]$ and planned cost E[C_t]
- "ideal cost heuristic": $E[R_t]$ and optimal C given price beliefs

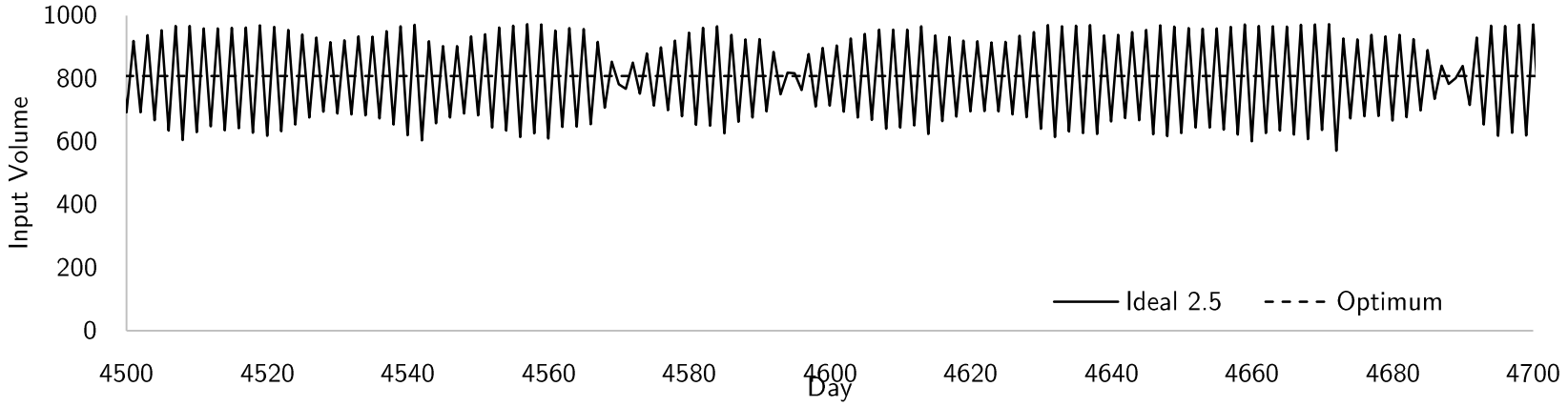
→ All alternatives equivalent in equilibrium

Heuristics Comparison

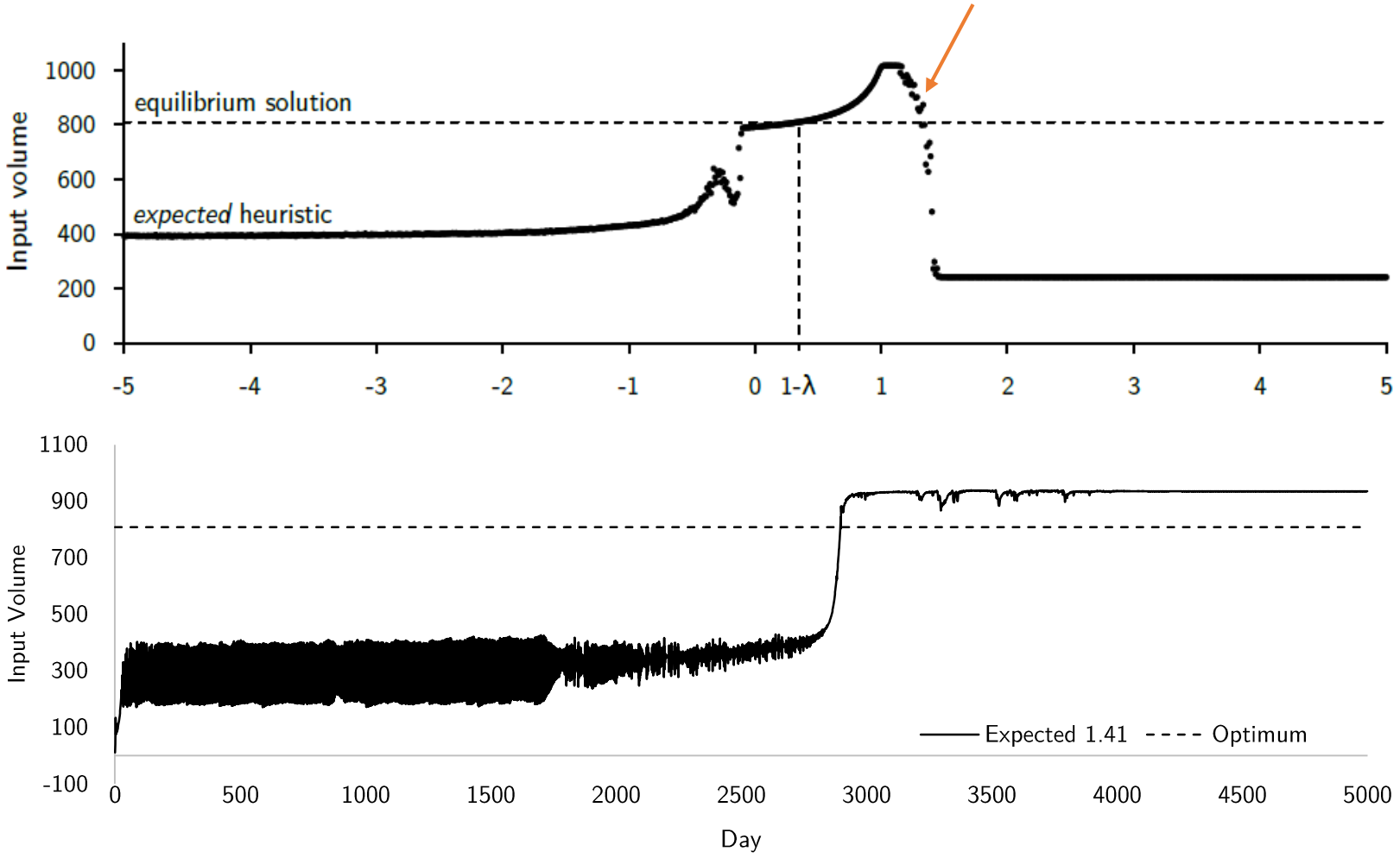


“Ideal Cost Heuristic” with $b_R = 2.5$

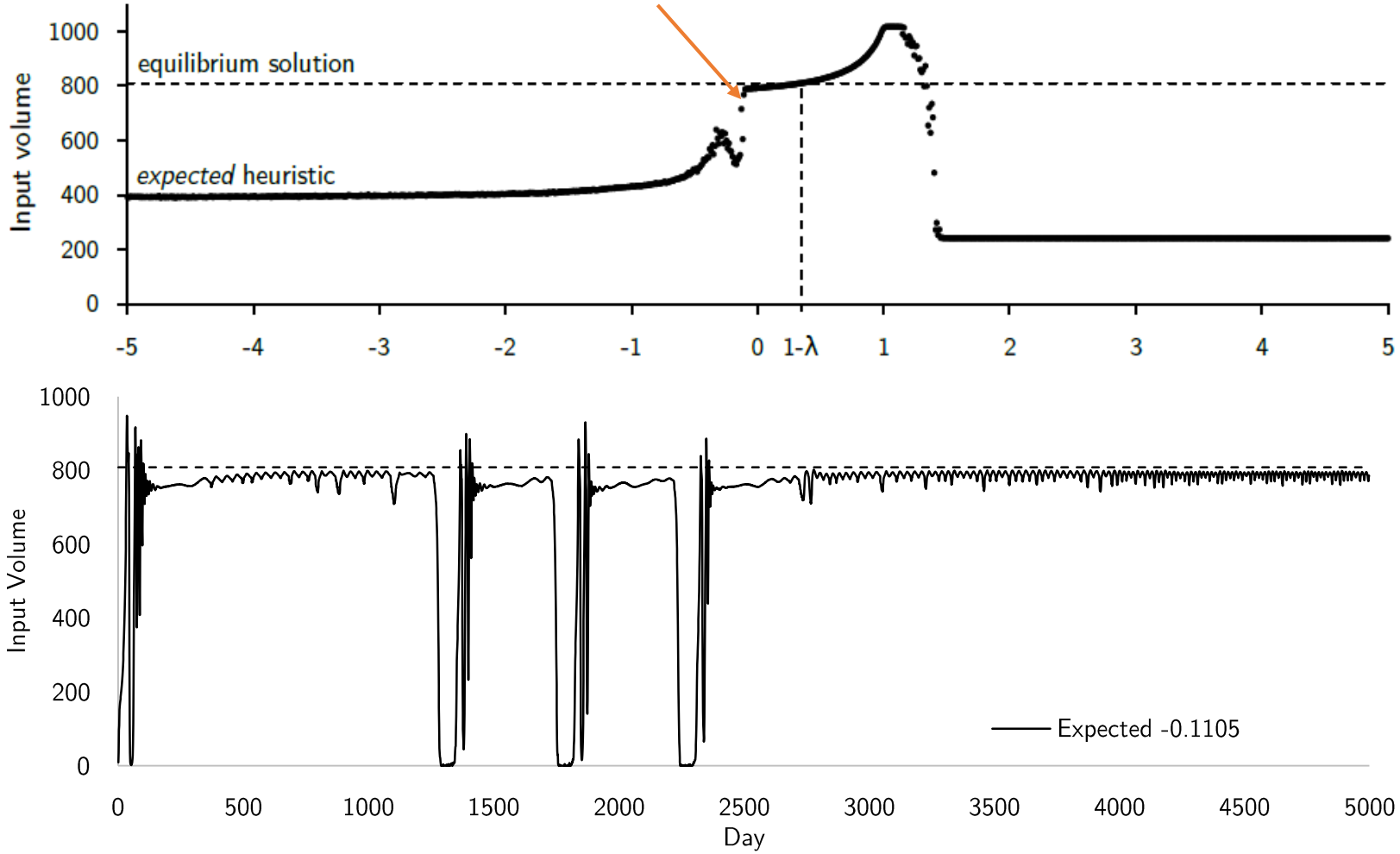




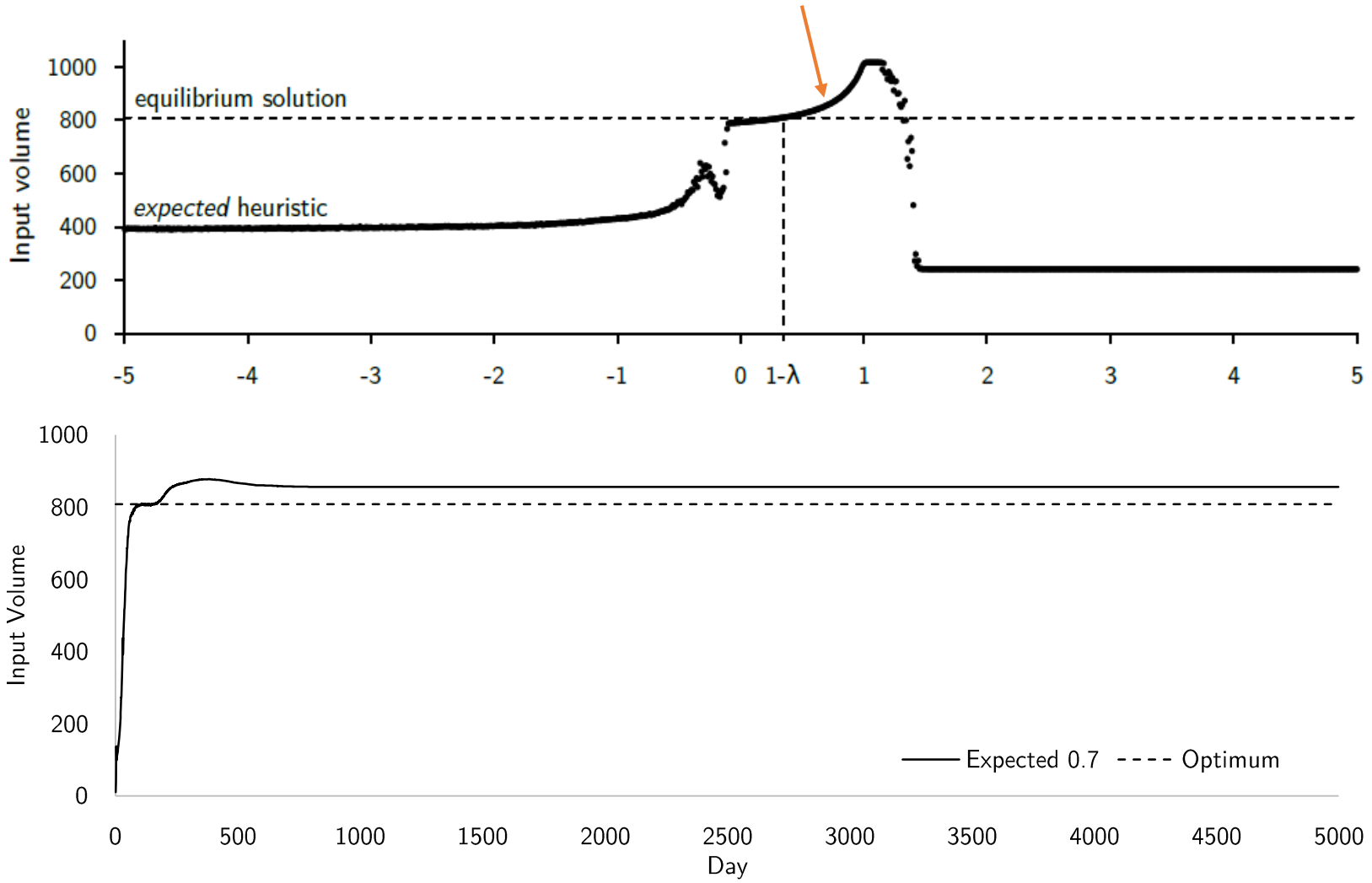
"Expected Heuristic" with $b_R = 1.41$



"Expected Heuristic" with $b_R = -0.1105$



"Expected Heuristic" with $b_R = 0.7$



Conclusion

- Details matter
- Testing is essential (equilibrium benchmark)
- Micro-decisions should be better documented (no other paper found that discusses the dividend heuristic)

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