Assignment 3 — EV Adoption, Coordination, and Policy Intervention

Model-Based Decision Making (2025)

University of Amsterdam

Overview

In this assignment you will work **in pairs** to analyse the transition to electric vehicles (EVs) using a networked agent-based model. The provided Mesa implementation combines a **Stag Hunt coordination game** with **positive feedback** from charging infrastructure.

Your goal is to:

1. Understand the baseline dynamics of the system, including tipping behaviour.
2. Evaluate how network structure affects diffusion and coordination.
3. Design, implement, and test a **policy intervention** motivated by the vulnerabilities you identify in (1) and (2).

You will find an implementation of the model, some example interventions and functions for plotting. The model is implemented in `Mesa` and `NetworkX`. You will also find two implementations for the strategy update rules (either imitation or best-response (using logit)). There is a readme inside the assignment 3 folder that explains how to use the model and the example interventions, read that and ask the TAs for help if your stuck.

The assignment has 3 parts, the first two are common that all groups should do. The third part is designing an intervention and you can choose, a few examples are:

- Increasing the infrastructure feedback strength β_I.
- Increasing the infrastructure growth rate g_I.
- Increasing the initial infrastructure I_0.

You are also free to implement your own policy, irrespective you should explain the policy design in your report and presentations.

Learning Goals

This assignment emphasises:

- Experimental design for simulation studies.

- Identifying leverage points in complex systems.
- Evaluating policies under uncertainty.
- Communicating model-based policy advice.

Model Summary

Agents occupy a network environment and choose between:

$$C = \text{EV adoption}, \qquad D = \text{conventional car}.$$

Pairwise interactions follow a Stag Hunt game. The payoff for mutual adoption increases with a global infrastructure variable $I(t)$:

$$a(I) = a_0 + \beta_I I(t).$$

Infrastructure evolves as a function of current adoption $X(t)$:

$$I(t+1) = I(t) + g_I(X(t) - I(t)).$$

There are two Agents imitate successful neighbours, generating spatial diffusion patterns, clusters, and potential tipping transitions between low and high adoption equilibria.

Assignment Structure

Your project consists of three mandatory components.

Part 1: Baseline System Analysis (All Groups Must Do This)

Conduct a systematic investigation of the system's unforced dynamics. You should examine:

- how initial adoption X_0 affects long-term outcomes,
- how initial infrastructure I_0 influences tipping,
- the effect of the infrastructure feedback strength β_I,
- evidence of tipping points, path dependence, or bistability.

You should run parameter sweeps and produce clear visualisations, such as:

- heatmaps of final adoption vs. (X_0, I_0),
- phase plots $(I(t), X(t))$,
- sensitivity curves for varying β_I.

Goal: Identify the natural dynamics of the system, the conditions under which it transitions, and its intrinsic vulnerabilities.

Part 2: Network Structure Analysis (All Groups Must Do This)

Next, investigate how the underlying topology affects adoption dynamics. Explore at least three structures:

- grid (local interactions),
- small-world network,
- scale-free network,
- or Erdős–Rényi random network.

Evaluate:

- speed of adoption,
- probability of reaching the high-adoption equilibrium,
- cluster formation,
- network-specific sensitivity to tipping.

Goal: Identify how structure shapes diffusion processes and where the system is most/least resilient.

Part 3: Policy Intervention Design and Evaluation

Using what you discovered in Parts 1 and 2, you must now design a **targeted intervention**. This is not chosen from a predefined list but should follow logically from your earlier results.

Possible interventions include:

- **Infrastructure shocks**: one-time increase in $I(t)$ for selected nodes or globally.
- **Subsidies**: temporary boost to a_0 or reduction of b.
- **Targeted seeding**: convert specific high-centrality agents to EVs.

- **Timed interventions**: apply only during early, mid, or late periods.
- **Spatial policies**: invest in selected regions or critical clusters.

Your intervention must be:

- **targeted** (to chosen nodes/regions), or
- **timed** (e.g., early vs. late intervention), or preferably both.

Experiments should compare:

- no-intervention baseline,
- multiple intervention intensities,
- different timing windows,
- variations under different network structures.

Goal: Provide policy-relevant insight into *which interventions work, when they work, and under which structural conditions they succeed or fail*.

Deliverables

1. Research Report (1500 words)

Your report should contain:

1. **Introduction and policy relevance**. Describe the transition challenge and the role of modelling.
2. **Methods and experimental design**. Clearly explain the experiments in Parts 1–3.
3. **Results**. Include plots, tables, sensitivity studies.
4. **Policy interpretation**. Translate simulation findings into actionable recommendations.
5. **Limitations and uncertainty**. Discuss robustness, randomness, scalability, model assumptions.
6. **Reproducibility**. Reference your code, parameter settings, and seeds.

2. Policy Presentation (10–12 minutes)

Prepare a presentation aimed at non-technical policy-makers. Focus on:

- the problem you identified,
- the interventions you tested,
- risks, tipping points, and timing,
- clear policy recommendations.

Avoid technical detail; emphasise clarity, narrative, and policy relevance.

3. Git Repository

Submit:

- all simulation code,
- configuration files or parameter scripts,
- analysis scripts and notebooks,
- a short README explaining how to reproduce your results.

Assessment Criteria

Your project will be assessed on:

- **Experimental design** (rigour, justification, clarity)
- **Interpretation** (quality of policy insight)
- **Complex-systems reasoning** (feedbacks, tipping points, structural effects)
- **Reproducibility** (transparent and well-documented code)
- **Communication** (clarity of writing and effectiveness of the policy presentation)

Working in Pairs

Both partners must collaborate in:

- designing experiments,
- running simulations,
- analysing results,
- writing the report,
- preparing and delivering the presentation.

Submission

Submit via Canvas:

- PDF report,
- presentation slides (PDF),
- Git repository link.

Good luck!

Focus on thoughtful modelling, careful experimentation, and clear policy interpretation.