EIOBook-9: Dynamic Games (Applications)

Fast, intuitive, and highly coherent review notes (with inner connections)

Coherence spine (read this first)

Chapter 9 is Chapter 8 in action: once sunk/adjustment costs make today's decisions affect tomorrow, the correct object is a **dynamic game in MPE**. Every application follows the same logic: (i) identify the key **state variable** that creates persistence, (ii) identify the key **dynamic cost** (entry, capacity, network, innovation) that makes the state matter, (iii) nest a **static competition model** inside each period to generate variable profits, (iv) estimate primitives using CCP/NPL/inequalities or other feasible methods, and (v) run counterfactual equilibria. The chapter moves from simpler to harder environments because each step adds a new complication: from policy with entry/investment (cement), to multi-location networks (stores), to cross-market network externalities (airlines), to innovation where strategic forces (preemption vs cannibalization) dominate and often interact with durability.

Master pipeline (use everywhere)

$$\textbf{Static competition} \Rightarrow VP(x) \quad + \quad \textbf{Dynamic costs} \Rightarrow \text{state dependence} \Rightarrow \text{dynamic game (MPE)}$$
$$\Rightarrow \text{estimate primitives} \Rightarrow \text{counterfactual equilibria.}$$

Rule of thumb: applications differ mainly in (a) the choice of *state* and (b) the source of *sunk/adjustment cost*.

A 6-line template for any application

For each paper/case study, write:

1. **State x_t:** what carries the past forward?
2. **Actions a_{it}:** what can firms change today?
3. **Within-period game:** how is $VP(x_t)$ generated (Bertrand/Cournot)?
4. **Dynamic costs:** what creates persistence (entry, investment, adjustment)?
5. **Equilibrium & estimation:** MPE + CCP/NPL/inequalities/etc.
6. **Counterfactual:** what primitive changes, and what equilibrium outcome is reported?

1) Cement regulation (Ryan): policy evaluation must be dynamic

Connection tag: regulation changes dynamic costs $\Rightarrow$ entry/investment adjust $\Rightarrow$ long-run structure and welfare change.

What problem it solves. Static policy evaluation can treat regulation as a marginal-cost shifter and miss the long-run response of entry, exit, and capacity investment.

Pipeline mapping.

- **State:** market structure/capacity (plants, kilns, utilization).
- **Actions:** invest in capacity, enter/exit, produce.
- **Within-period game:** Cournot (variable profits depend on demand and capacity constraints).
- **Dynamic costs:** entry/investment adjustment costs (policy may raise sunk components).
- **Counterfactual:** pre- vs post-regulation MPE; welfare evaluated including structure changes.

Why it appears first. It is the cleanest illustration that policy effects operate through *dynamic costs* and *market structure*, not only through marginal costs.

Why the next section is needed. Once "enter/invest" is understood as dynamic, the next natural step is to generalize entry from a scalar count to a *network/location* decision: where to operate.

2) Store location / retail networks: entry becomes a dynamic network choice

Connection tag: location choices are sunk/adjustment decisions $\Rightarrow$ networks become the state $\Rightarrow$ action space explodes.

What problem it solves. Opening/closing stores is forward-looking because costs are partially sunk; current networks affect future competition and expansion.

Pipeline mapping.

- **State:** store network (which locations are active).
- **Actions:** open/close locations (possibly multi-store).
- **Within-period game:** price competition given networks $\Rightarrow VP^*$(networks).
- **Dynamic costs:** sunk/adjustment costs of changing the network.
- **Estimation challenge:** network action spaces scale quickly, motivating CCP/NPL or inequality methods.

Why it comes after cement. It uses the same "static competition nested in a dynamic decision" structure, but the state is now a *vector/network* rather than a scalar.

Why the next section is needed. Networks introduce dimensionality; the airline case adds the deeper complication that network decisions create *cross-market strategic links* (one action affects many markets).

3) Airline networks (Aguirregabiria–Ho): cross-market network externalities

Connection tag: routes are interconnected ⇒ state is an industry network ⇒ requires demand+cost recovery and state reduction.

What problem it solves. Hub-and-spoke arises from a mix of demand, cost, and strategic effects; a structural dynamic model is needed to separate these channels.

Pipeline mapping.

- **State:** industry network (which airlines serve which routes).
- **Actions:** add/drop routes (time-to-build) ⇒ next-period network.
- **Within-period game:** Bertrand pricing on served routes; demand estimation + pricing FOCs recover markups and marginal costs.
- **Dynamic costs:** fixed and entry costs that depend on hub/network measures.
- **Computation:** state space is enormous ⇒ decentralization and state compression (inclusive-value style aggregation).
- **Counterfactual:** remove/alter hub effects in demand vs fixed costs vs entry costs to decompose the hub-and-spoke mechanism.

Why it comes after stores. It takes the "network as state" idea and adds *cross-market linkage*: one route decision affects many other route profits through hub size and connectivity.

Why the next section is needed. Once the state is a network, the hardest remaining setting is when the state is *technology* (innovation), where strategic forces like preemption and cannibalization dominate.

4) Innovation block: dynamics is essential (preemption vs cannibalization)

Connection tag: innovation changes future states ⇒ strategic timing matters ⇒ reduced-form "competition–innovation" signs are unstable.

4.1 Competition is not a scalar (conceptual motivation)

Connection: different ways of "increasing competition" (entry costs, substitutability, market size, policy) change innovation incentives differently; this motivates structural dynamic games.

4.2 Creative destruction (e.g., HDD): incumbents vs entrants

Connection tag: incumbents face cannibalization + preemption ⇒ innovation timing requires a dynamic game.

- **State:** technology frontier and firm types (old/new/both; incumbents vs potential entrants).

- **Actions:** adopt/innovate and enter/exit.
- **Key forces: cannibalization** (new product steals old profits) vs **preemption** (innovate early to deter entry).
- **Counterfactuals:** "remove cannibalization" or "remove preemption" to isolate mechanisms.

4.3 CPU (Intel vs AMD): durability makes the consumer state central

Connection tag: durability implies an installed-base state $\Rightarrow$ innovation can trigger upgrades $\Rightarrow$ dynamic demand + dynamic competition interact.

- **State (demand side):** installed base / what consumers currently own.
- **State (supply side):** quality frontier/technology.
- **Actions:** prices and R&D/innovation that shift future quality.
- **Counterfactuals:** monopoly vs duopoly, foreclosure/substitutability changes, and welfare under alternative innovation incentives.

Why innovation is last. It combines all earlier complications: forward-looking behavior, state dependence, strategic interaction, very high-dimensional states (technology + installed base), and delicate counterfactual equilibrium selection.

One-line connection tags (paste under headers)

- **Cement regulation** $\rightarrow$ policy changes dynamic costs $\rightarrow$ structure adjusts $\rightarrow$ welfare changes.
- **Store networks** $\rightarrow$ entry becomes "where" $\rightarrow$ networks are the state $\rightarrow$ action space explodes.
- **Airline networks** $\rightarrow$ cross-market links $\rightarrow$ need state reduction/decentralization.
- **Innovation** $\rightarrow$ tech/installed-base states + preemption/cannibalization $\rightarrow$ dynamics is essential.

Five-minute self-test

1. In the cement setting, why can regulation have large effects through entry/investment even if short-run prices appear unchanged?
2. In store location, why is the store network a payoff-relevant state and why is price competition nested inside the dynamic problem?
3. In airline networks, why does entering one route affect profits in other routes, and what modeling steps address the resulting state explosion?
4. Define cannibalization and preemption in one sentence each; why do they make innovation inherently dynamic?
5. In durable-goods innovation (CPU), why does installed base make demand and innovation incentives state-dependent?