Lecture 2: Private Sector –Market dynamics and competition (ch. 8 of the book)

- Theory: conventional market theory-oligopolized markets….
- Theory: Evolutionary and Schumpeterian theory (Acemoglu, et al 2012, Aghion et al 2019, 2023….
- Theory: Game theory
- Theory: cross dual dynamics Bielefeld school…
- Theory: dual dynamics)

=> We consider drivers as well as obstacles for decarbonization

I. Private sector=>Phasing out fossil fuel, phasing in new technology; but there are barriers to entry (Ch. 8 of the book)

Can renewable energy firms enter the energy market? => Entry and competition barriers (Obstacles)

- There are dominant fossil firms (subsidized oligopolies) dominating the energy markets
- They set up entry barriers and undertake entry deterrent investments
- A limit pricing model of model of Gaskins and Judd et al. can be used, see also Semmler et al.
- There are new entrants, success or failure of new entrants can be explained in 4 model versions (I. defensive incumbents, II. evolutionary and III.game theoretic setups) ,IV,classical market dynamics

Oil companies	Fracking companies
China Petroleum & Chemical Corp. (SNP)	Chevron Corp. (CVX)
PetroChina Co. Ltd. (PTR)	Exxon Mobil Corp. (XOM)
Saudi Arabian Oil Co. (Saudi Aramco)	ConocoPhillips Co. (COP)
Royal Dutch Shell PLC (RDS. A)	Halliburton (HAL)
BP PLC (BP)	
Exxon Mobil Corp. (XOM)	
Total SE (TOT)	
Chevron Corp. (CVX)	

II. Private sector =>Inventions and Innovations: Death Valley

=> Nordhaus; Climate Casino..ch. 23, There is technological, market and financial risks

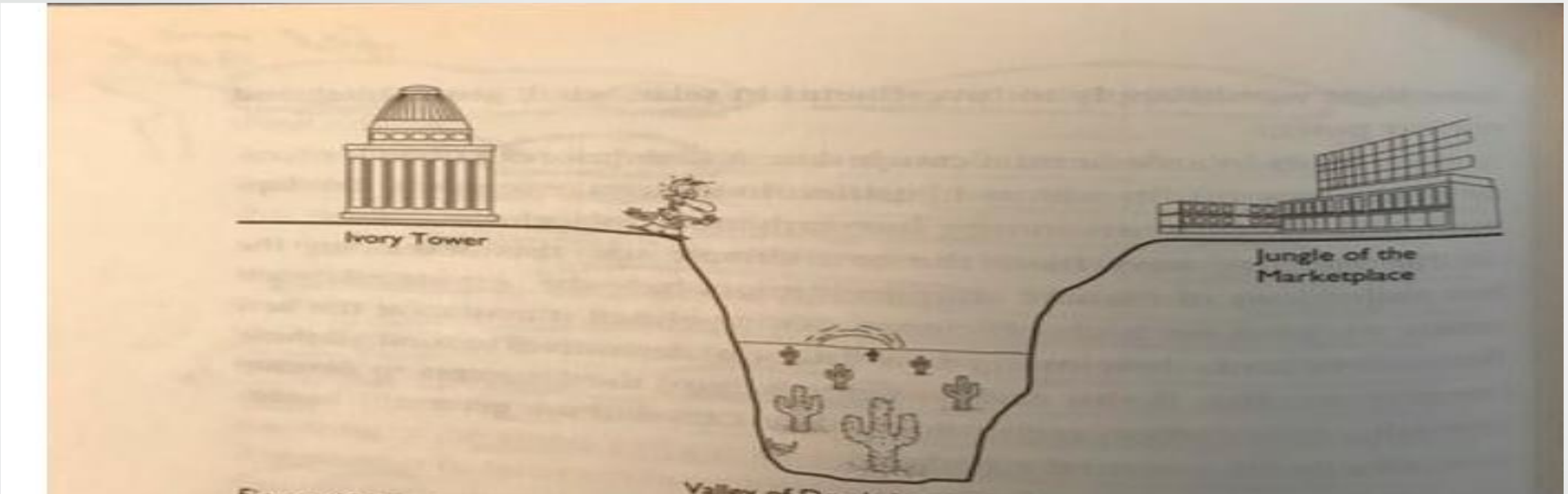


Figure 40. Few innovations survive the transition from scientific laboratories to the marketplace.

⇒ Innovation and diffusion dynamics (of CO_2 reducing technologies) need to be supported by de-risking by public innovation policies (Arrow) (but there could be an issue of lock-in, B. Arthur)

⇒ But when it is developed and phased in, there are usually innovation and entry barriers

⇒ Entry barriers/barriers to competition:

- 1) Entry barriers (IO literature, see Bain), capital requirements,
- credit cost, economies of scale, advertisement, customer loyalty…
- 2) Competition deterring barriers by oligopolies (lawyers, political lobbying, patents…)

III. Private sector => Entrants and Incumbents- - Entry/Competition Barriers Brock (1980s), Gevorkyan/Semmler (2016)

Model Version I: Defensive Incumbents; Entry and competition deterring barriers 1) **Entry** barriers (IO literature, see Bain): capital requirements, credit cost, economies of scale, advertisement, customer loyalty; 2) **Competition** barriers (lawyers, political lobbying, patents ..)

$$\max_{x} \int_0^T e^{-rt} [pq - C(q) - x - \varphi(x)] \, dt$$

$$\dot{E} = x - \delta_E E$$

where E is the competition-deterring capital,[3] x is the investment in it, and δ_E is the depreciation rate of that capital. In Eq. (2), competition-deterring capital can be represented by the dominant energy firms' efforts to restrict competition, for example, by political lobbying, investment into entry deterring capital, protection of innovations through patents, advertising efforts, and coalition formation.[4] We conveniently assume that the price is a function of the market share of the dominant firms:

$p = p(s)$ for $0 \leq s \leq$

$q = sd(p)$.

$C(q)$ is the cost of production

$R(s) = p(s)sd(p)$

$$p(s) = p^c + (p^m - p^c)$$

$$d = b - ap$$

III. Private sector=> Entrants and Incumbents- - Entry Barriers

Gevorkyan/Semmler (2016)

multiple equilibria

Table 1
Parameters and steady states.

	SS1 (attractor)	SS2 (repellor)	SS3 (attractor)
Entry-deterring capital $E(0)(p^m = 8)$	0	30.05	37.4
Entry-deterring capital $E(0)(p^m = 7)$	0	32.5	35.5
Entry-deterring capital $E(0)(p^m = 6)$	0	0	0

Example: $r = .02, \delta_E = .15, \rho = 5, \chi = 10, c = .001, \alpha = .5, p^m = 8, 7, 6 p^c = 2, b = 10, a = .5.$

III. Private sector=> Entrants and Incumbents: Market Dynamics; Thresholds – entry barriers and regulations

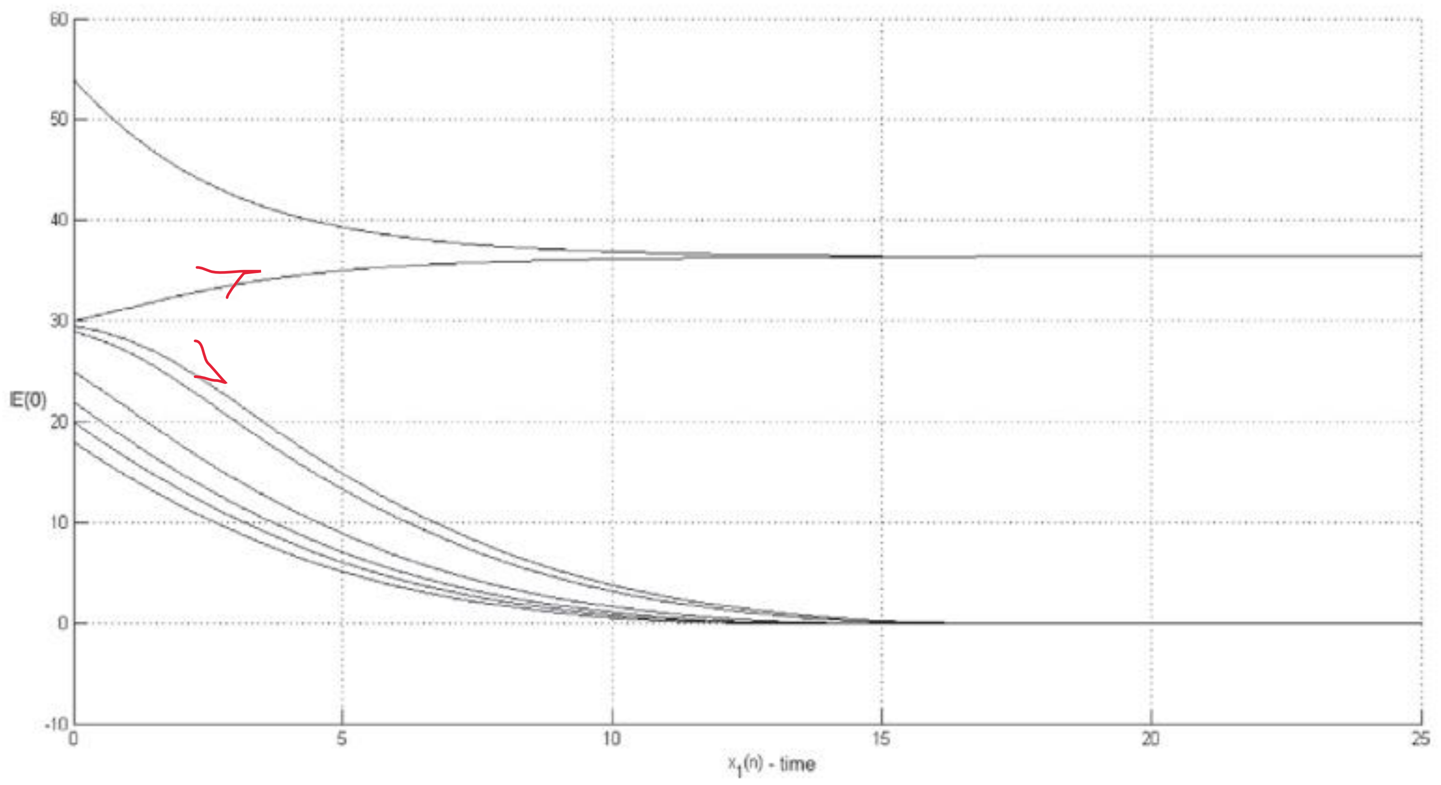


Fig. 1. Multiple equilibria; upper two trajectories, convergence to dominant firms' market share, higher markup, high attracting market share, reached from initial condition E(0)=30.05; declining trajectories represent declining market share due to competition below threshold E(0)=30.05, $p^m = 8$.

II. Private sector=> Entrants and Incumbents; Phasing in of new energy firms

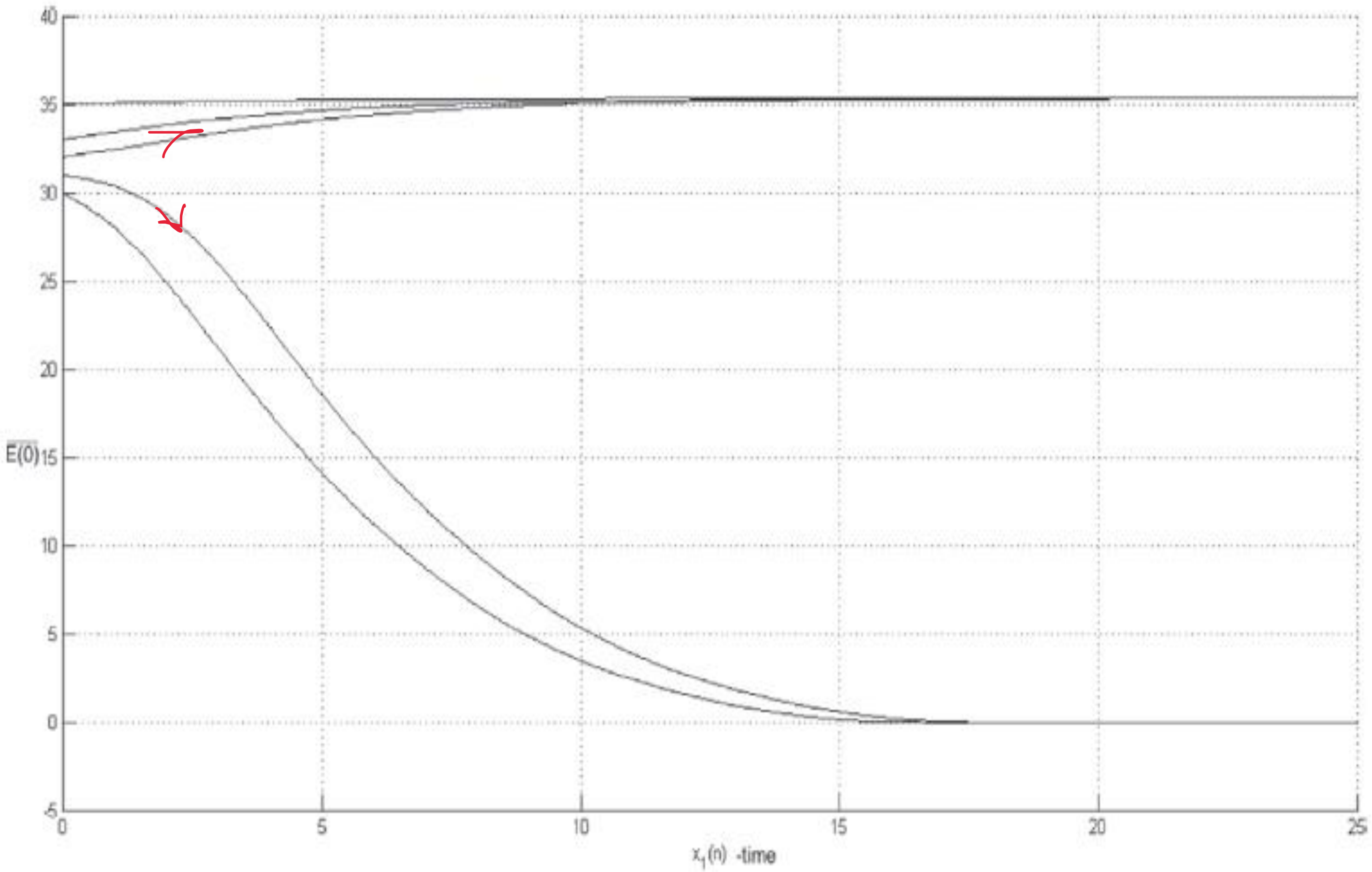


Fig. 2. Loss of dominance, market share shrinking, even with large initial capital and market share, loss of dominance due to lower markup, E(0)=32.5, p^m = 7.

IV. Private sector => Dynamic evolutionary models, see ch. 8 of the book

=> **Model version II: Evolutionary theory;** non-innovating (incumbents) and innovating firms (active entrants):
u= numbers of engineers, x_2:Innovators (active), x_1: Incumbents (passive); x_3 debt evolution

- Dynamic evolutionary models, see Brian Arthur (1989), see Braga, Semmler, and Grass (JEDC 2022)

- Technology (Pistorius & Utterback, 1996) - *entrants and incumbents:* simultaneously compete, cooperate, and have a predator-prey relationship, see also Utterback et al. (2018)
- Lotka-Volterra system, such as those applied to the bioeconomic literature (e.g.: fishery model in Clark (1976) and Semmler & Sieveking (1994)
- Heterogeneous Firm Model but with dynamic limit pricing - Judd & Petersen (1985), Gaskins (1971), Kato & Semmler (2011) with:

✓ Entrants (Innovator – Renewable Energy), with pay-off function

✓ Incumbents (Fossil Fuel Energy), but passively responding

✓ Competition among them

✓ Evolution of debt

- For conventional climate models, see also Kotlikoff et al. (2019); Acemoglu et al. (2012);

IV. Private sector => Phasing in Renewable Energy: Market Dynamics with Entrants and Incumbents,

Semmler (1994), Kato/Semmler (2011), Arthur (1989), Nordhaus, Climate Casino, ch 23, Braga and Semmler (2020); evolutionary model of Lotka-Volterra type

Model version II: non-innovating (incumbents) and innovating firms: u= numbers of engineers, x_1=incumbents, x_2=entrants, x_3 debt of x_2

Multi-period Payoff function of the Entrant; Model solved through

$$\max_u V = \int_0^T e^{-\gamma t} g(x_2, x_3, u)\,dt$$

s.t.

$$\dot{x}_1 = k - a x_1 x_2^2 + b x_2 - x_1 e/\mu \quad (1)$$

$$\dot{x}_2 = x_2(a x_1 x_2 + v g(x_2, x_3, u) - \beta) \quad (2)$$

$$\dot{x}_3 = -g(x_2, x_3, u) - \tau x_3^2 \quad (3)$$

$$g(x_2, u) = \mu(x_2, u) x_2 u - cu - c_0 x_2 - r x_3$$

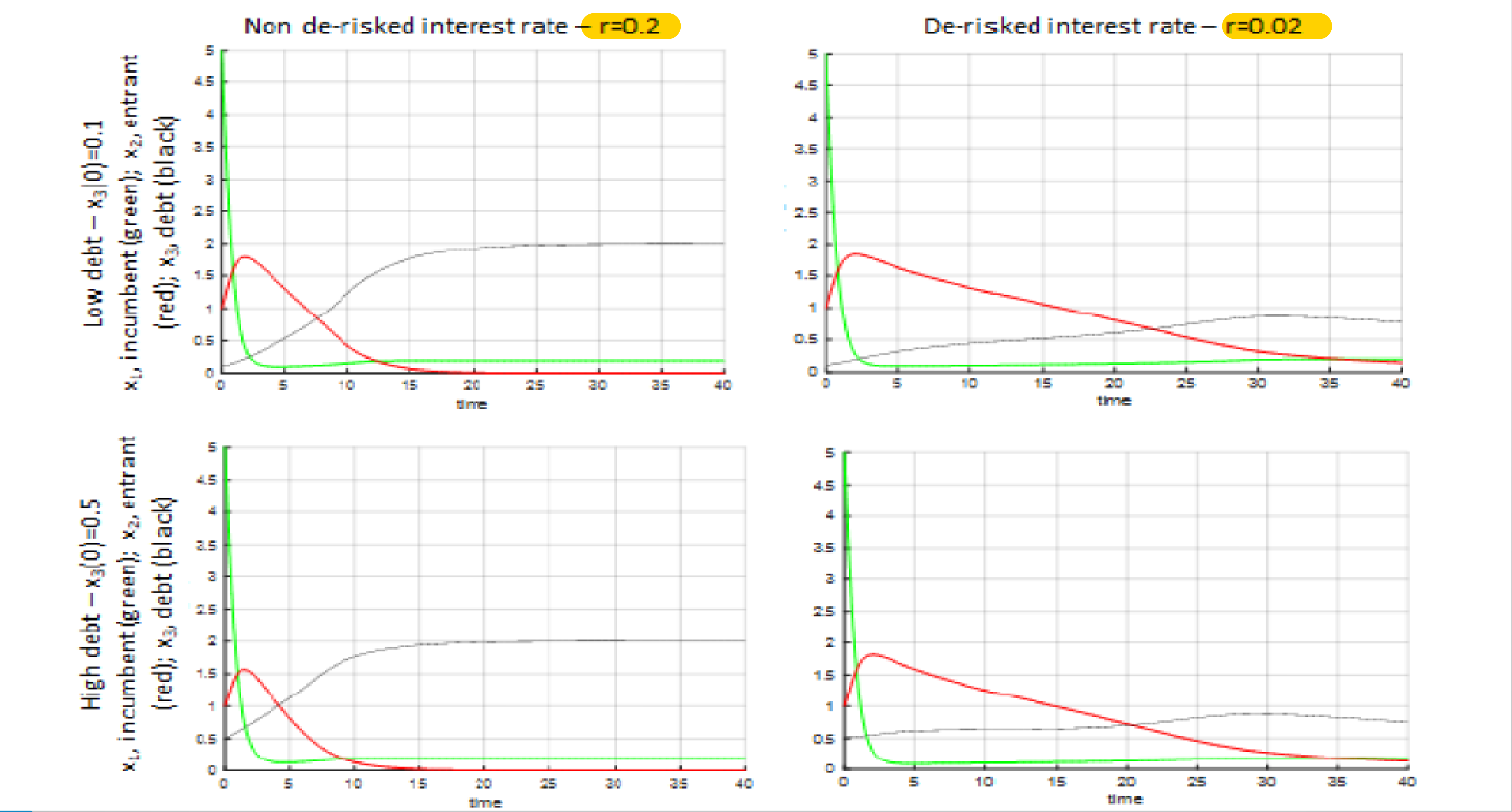
$$\mu = \alpha / (\Phi + x_2 u)$$

- x1: number of incumbent firms
- x2: number of innovator firms
- x3: external finance
- u: cooperative innovative effort
- Mu: Mark-up

IV. Private sector => Phasing in Renewable Energy: Market Dynamics

Entrants, Incumbents, and Debt; Braga and Semmler, JEDC (2020); evolutionary model;

Model version II: non-innovating (incumbents) and innovating firms (entrants)



V. Private sector: R&D, innovations and entry game;

Model Version III: Game theory; Limit pricing and renewable energy firms into the energy sector: Game theoretical model: Semmler et al. (2022, SCED), Cournot oligopoly model and entrants; strategic interactions

Driver: => Renewable energy technology is key, but how to phase it in?

Model of entry game, with

entry barriers and limit pricing

- Dominant firms (incumbents)

  (fossil fuel firms)

$$\max_{p_t} \int_t^{t+N} e^{\gamma t}\left(f(p_t) - w_t\right)(p_t - c_d)e^{-rt}dt$$

$$\text{s.t.} \quad \dot{w}_t = (p_t - c_f) \cdot w_t u_t J - \gamma w_t$$

- Fringe Firms (entrants)

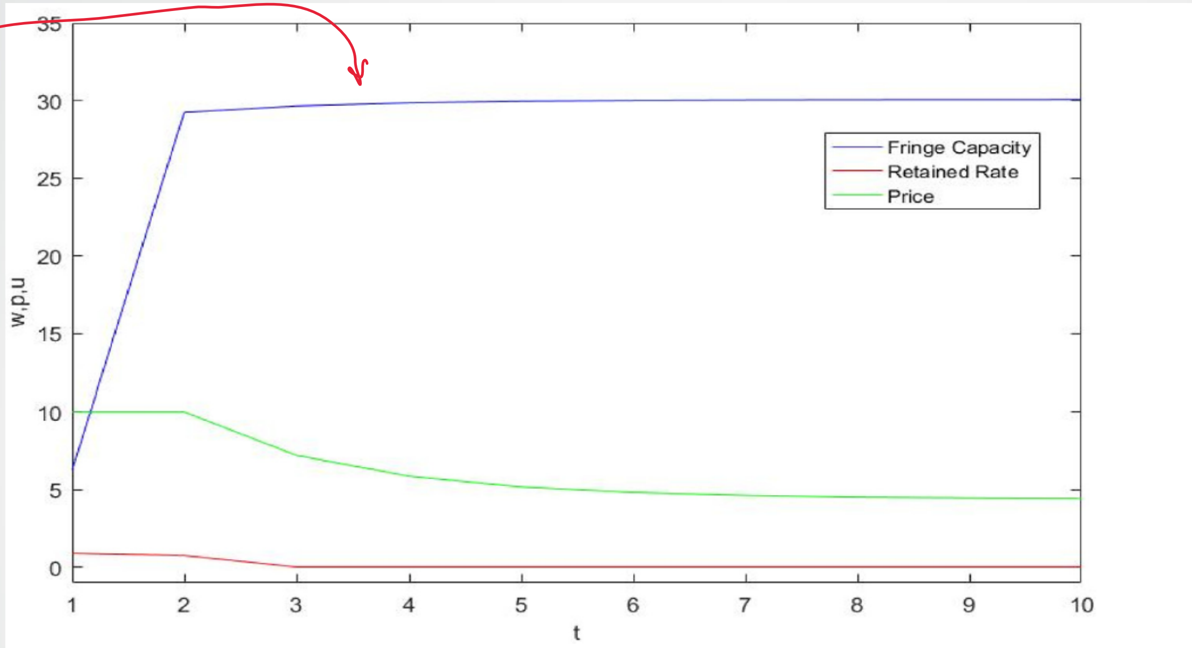
  (renewable energy entrants)

$$\max_{u_t} \int_t^{t+N} e^{\gamma t}(p_t - c_f)w_t(1 - u_t)e^{-rt}dt$$

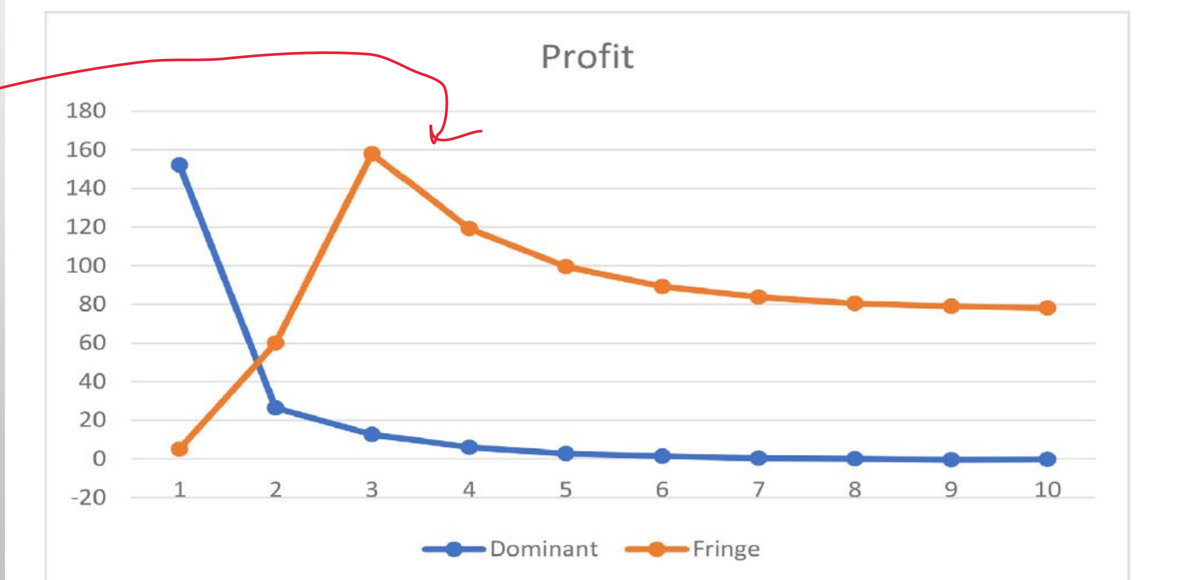
$$\text{s.t.} \dot{w}_t = (p_t - c_f)w_t u_t J - \gamma w_t$$

V. Private sector; Who wins in the energy supply–demand game?

- Fringe firms (entrants)



- Dominant and
- fringe firms' profits



VI. Cross-dual dynamics and phasing in of renewables

Model version IV: Classical market dynamics (Hahn, Morishima, Goodwin, Flaschel and Semmler (1987), Oriol and Semmler (2024), Jahrbuch...

$$1 + r^* = R^* = pBx/pAx$$

$$\hat{x}_t = < d_1 > (B - R^* A)' p'_t = < d_1 > C' p'_t$$

$$\hat{p}'_t = - < d_2 > (B - R^* A) x_t = - < d_2 > C x_t$$

VI. Cross-dual dynamics and phasing in of renewables (Price effects and technical change)

Model version IV: Classical market dynamics, Codina and Semmler (2024), DIW inflation paper

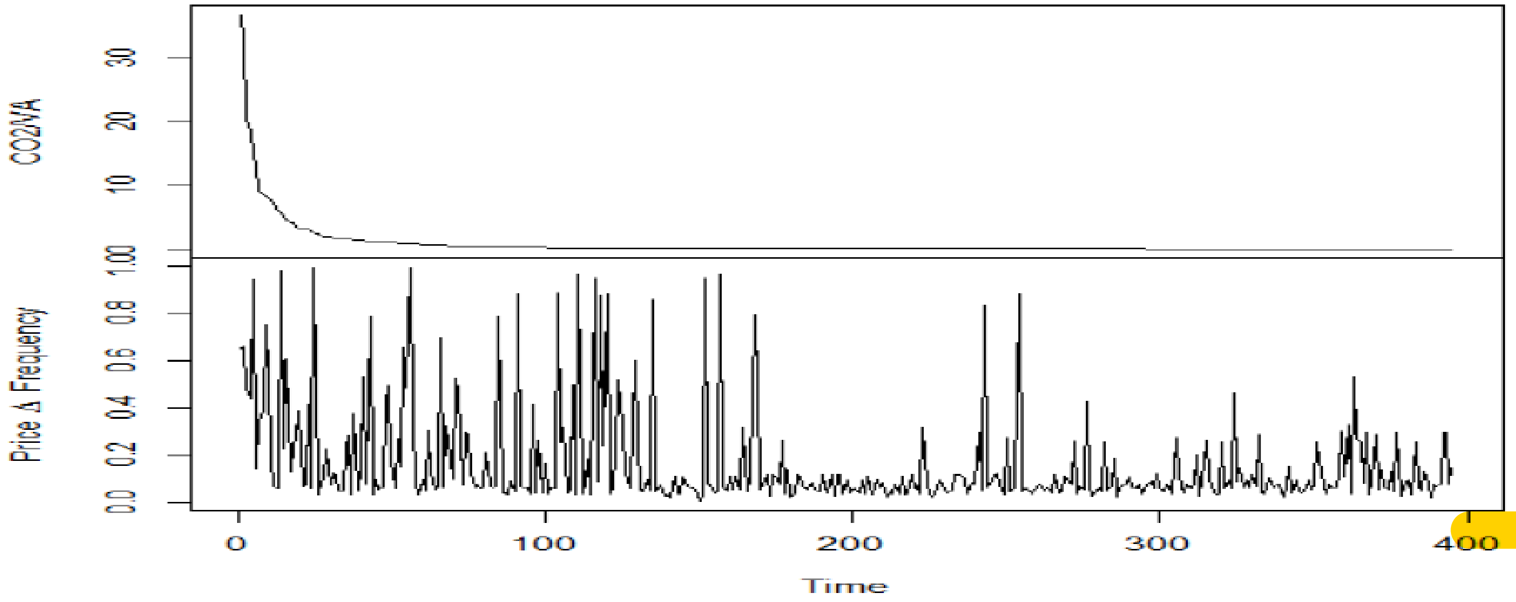
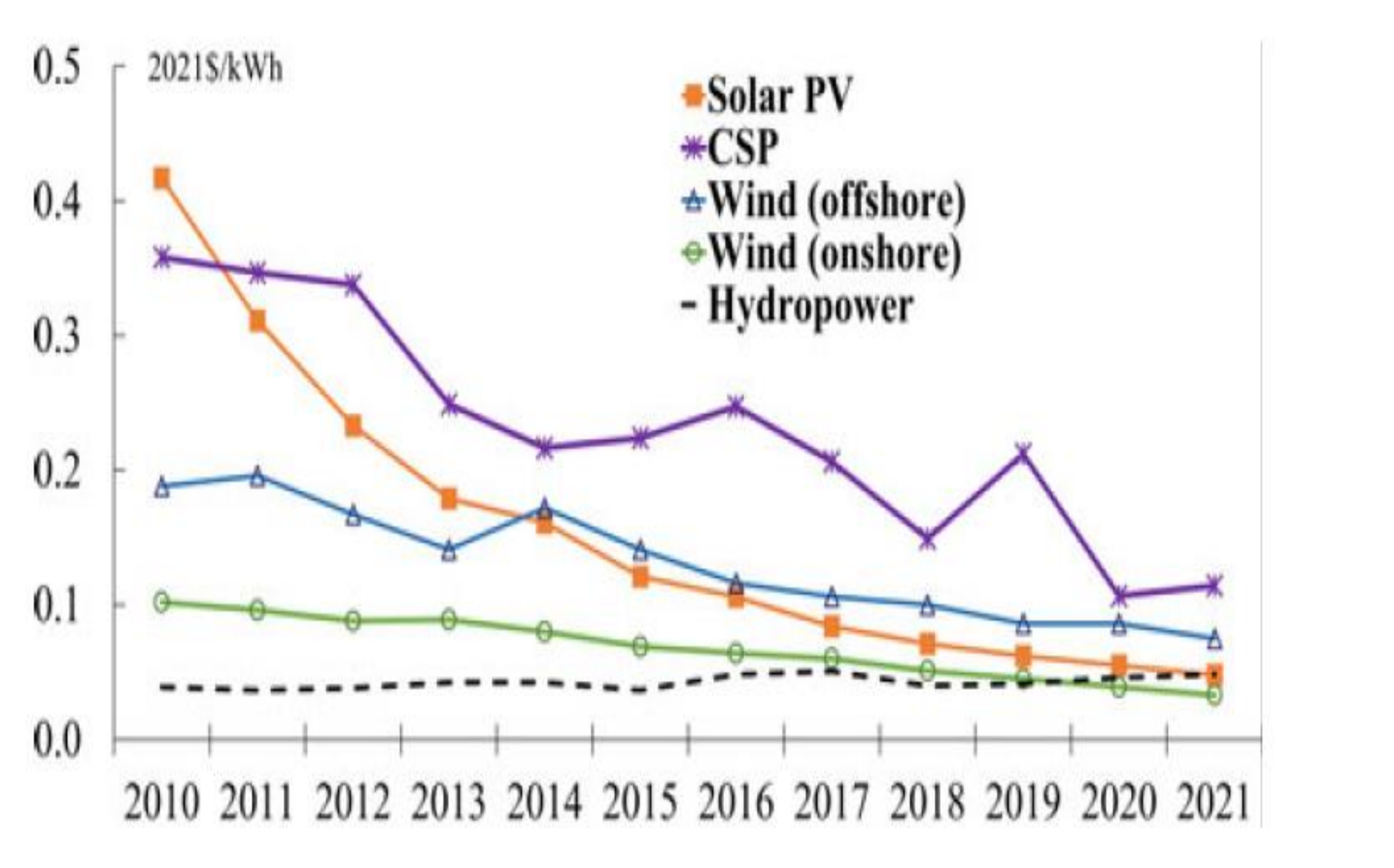


Figure 1: Price-quantity dynamics for US sectors; upper graph: carbon intensity of the sectors in declining order; lower graph: price change frequency

VII. Private Sector=> Cost advantage? Supply side: Overall, we see declining energy costs

=>Eventually declining cost of renewable energy (electricity cost)

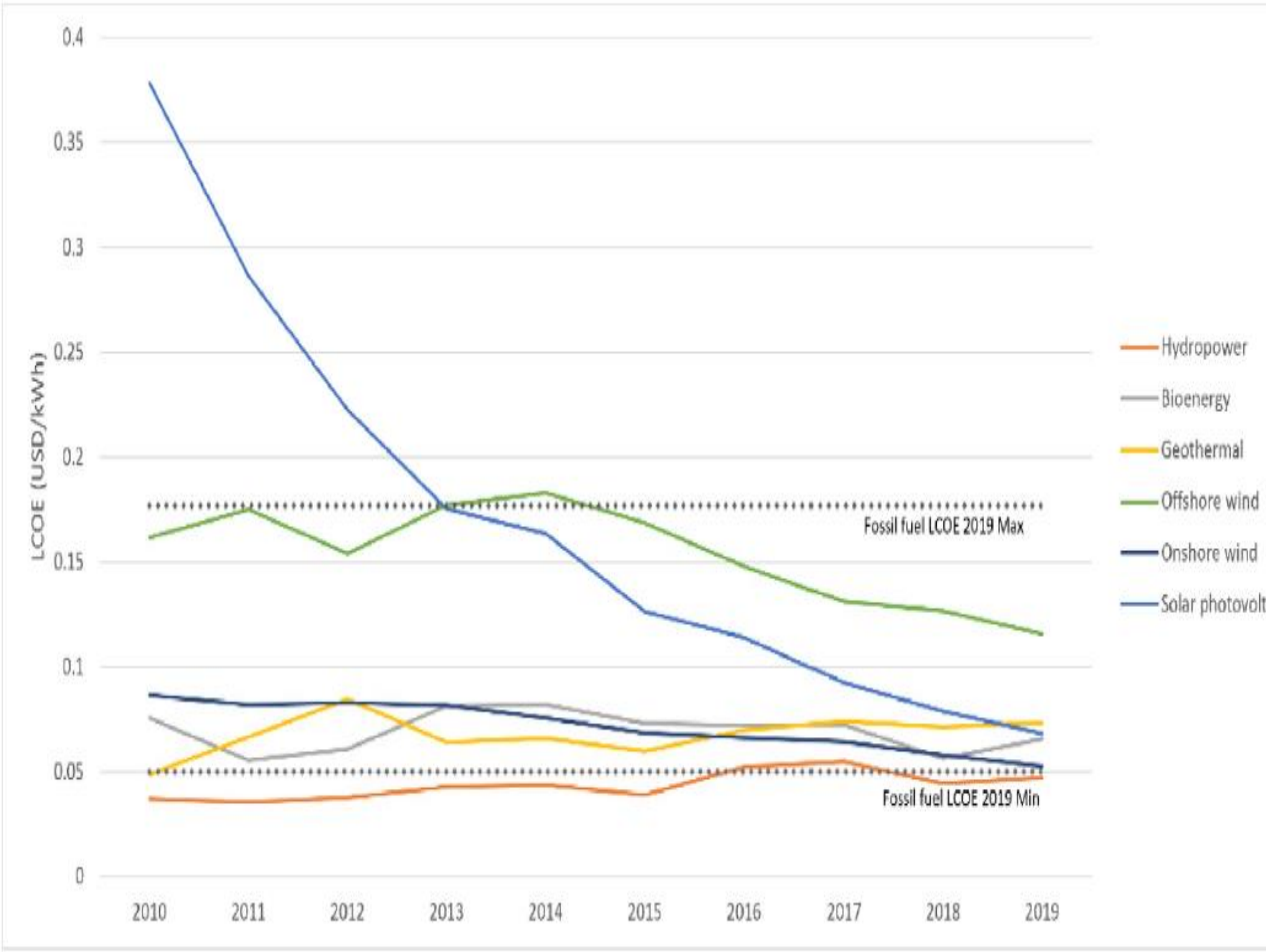


VII. Private sector=>Cost advantage? Declining energy costs -- but who wins the game in the future?

=>Future conflict expected:

- Fossil fuel countries can can reduce supply and increase the price: Backstop technology,
- Renewable energy, can enter, reducing the demand for fossil fuel, see our book ch. 6.

=> Conclusion: R&D, innovations and market entry of renewables should be subsidized



VIII. Conclusions

- Driving forces....from inventions, and innovations to phasing in of new technology,see Acemoglu et al 2012), and Aghion et al (2023), regulation, carbon tax, and subsidies, see our new paper on Nordic countries
- Obstacles ....from resistance of established oligopolies, entry, and competition barriers, to now green renewable technology firms and ESG firms (but the issue of disclosure)
- Importance of

➢ Financial sector

➢ Public sector