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Workshop on Distributed Energy Management Systems
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Welfare Comparison of FIT and RPS

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Purpose of this study

The purpose of this study is to

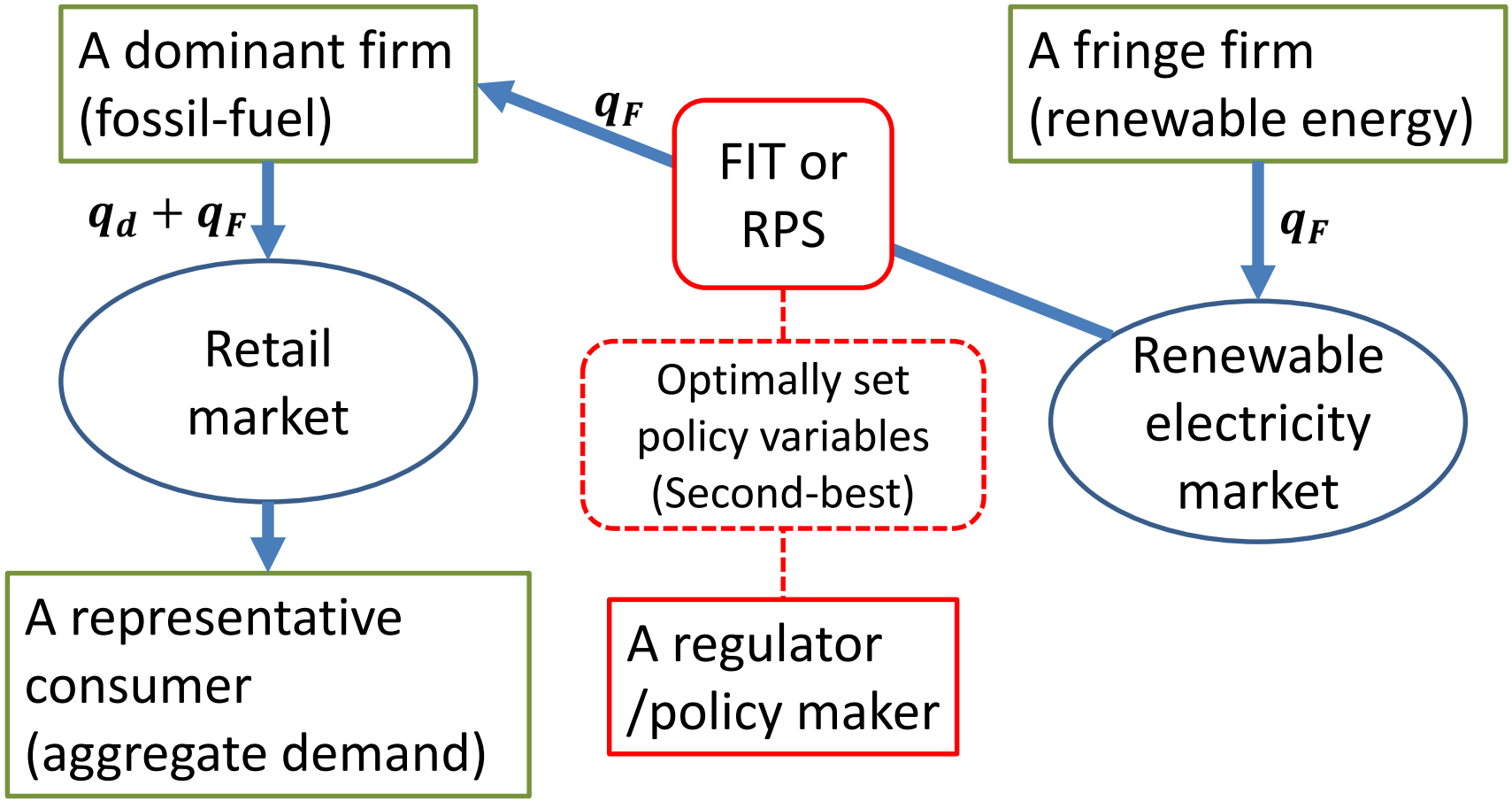
- compare second-best social welfare of FIT (feed-in tariff) and RPS (renewable portfolio standard), which are mainstream policy schemes to promote generation from renewable energy sources (RES),

- reveal theoretical condition under which either scheme generates higher second-best social welfare than the other.

Model (market structure)

The model consists of

- two markets (retail market, renewable electricity market)
- Four players (a dominant firm, a fringe firm, a representative consumer, a regulator)



Model

The fringe firm

- produces electricity using renewable energy sources,
- maximizes its profit with respect to its output (q_F) taking renewable electricity price (P_R) as given.

$$\max_{q_F} \pi_F = P_R q_F - \frac{1}{2} c_F (q_F)^2 - FC_F.$$

where

q_F: output of the fringe firm

P_R: price for electricity generated from RES

(price in the renewable electricity market)

$c_F(q_F)^2/2$: (quadratic) production cost function

FC_F: fixed cost

Model

The dominant firm

- produces electricity using conventional fossil fuel technology which generates negative externality on the environment,
- purchases electricity generated from renewable energy sources in the renewable electricity market,
- exercises market power both in a retail (as a monopoly) and a renewable electricity market (as a monopsony),
- sells total output of the fringe and its own in the retail market.
- maximizes the profit with respect to its output (q_d), anticipating the impact on the fringe output:

$$\max_{q_d} \pi_d = PQ - \frac{1}{2} c_d (q_d)^2 - P_R q_F \,.$$

P: retail price

Q: total output ($Q = q_F + q_d$)

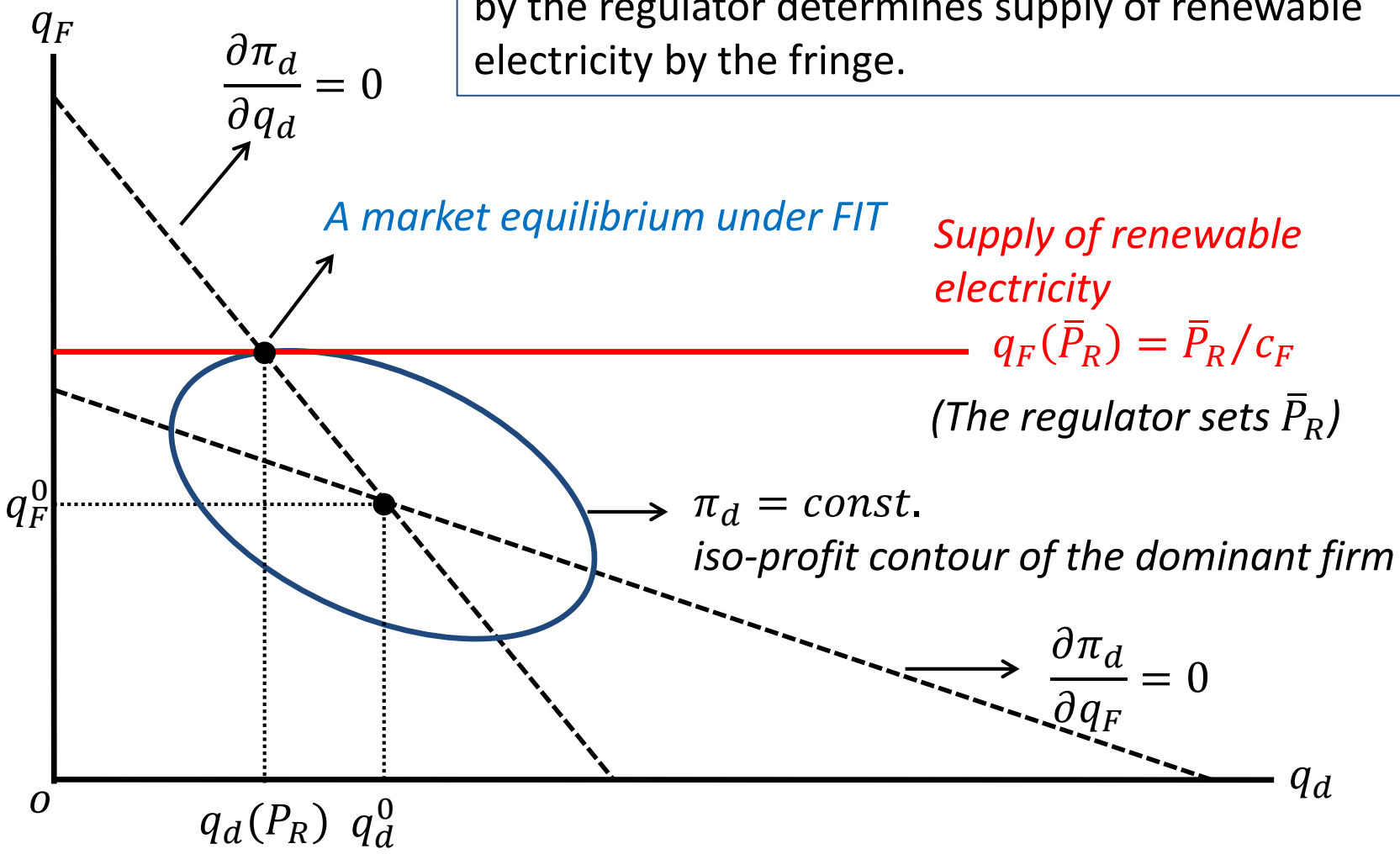
FIT and RPS

- FIT mandates the dominant firm to purchase renewable electricity at a fixed price ($P_R = \bar{P}_R$) set by the regulator,

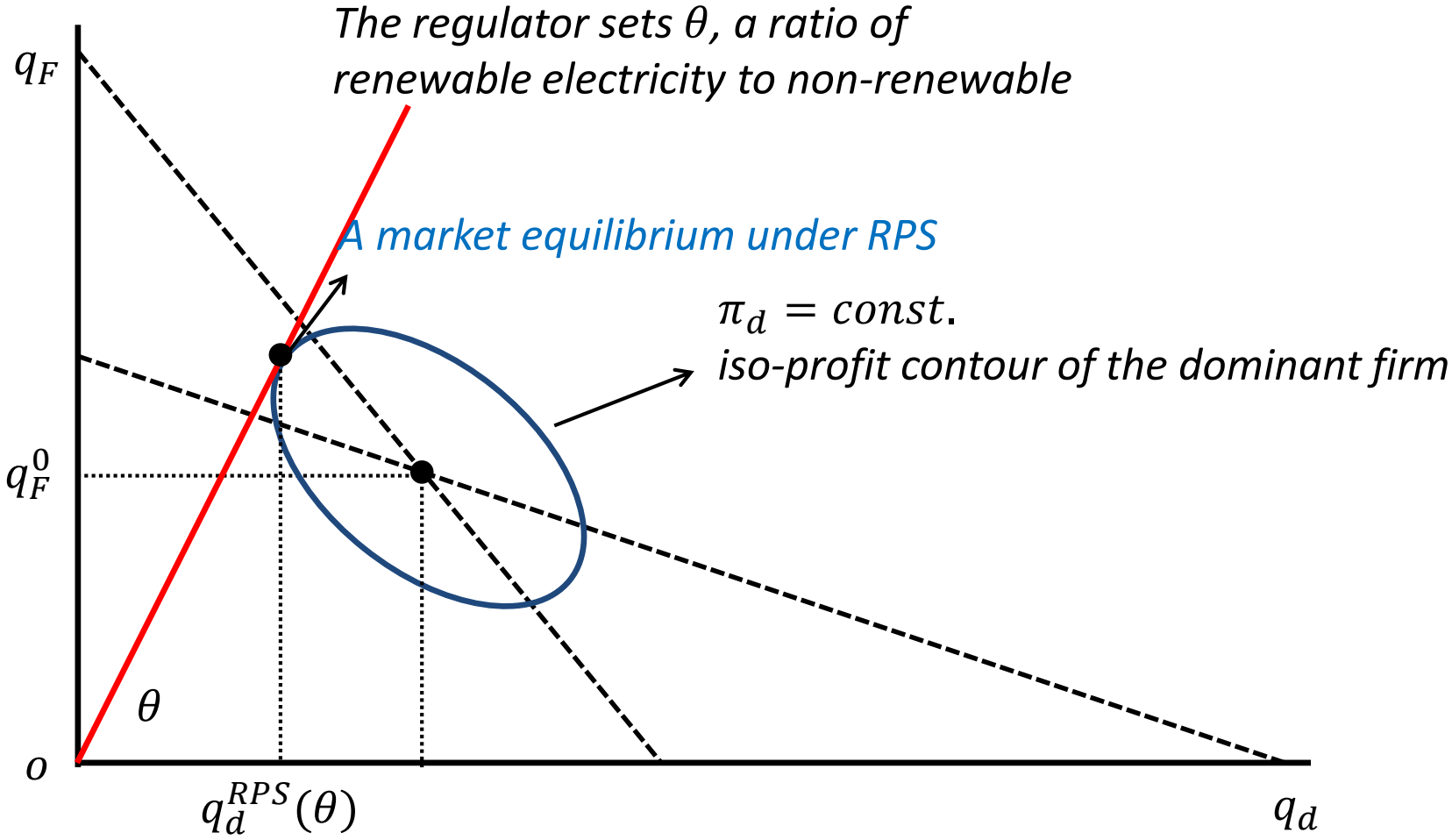
- RPS mandates the dominant firm to purchase a certain proportion of electricity to its own output from renewable energy sources; $q_F = \theta q_d$.

Market equilibrium under FIT

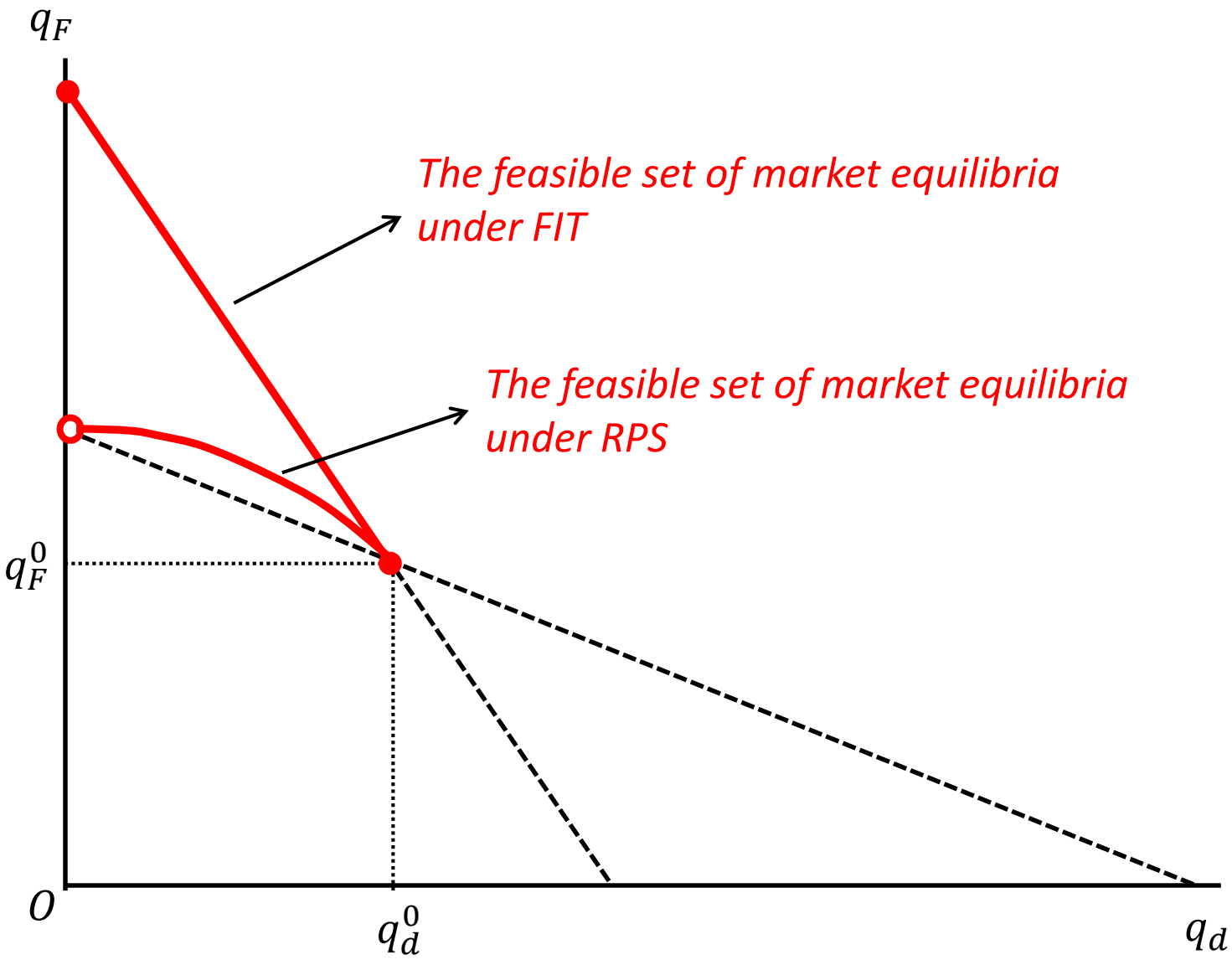
Under FIT, fixed price for renewable electricity (P_R) set by the regulator determines supply of renewable electricity by the fringe.



Market equilibrium under RPS



The feasible sets of market equilibria



Trade-off between FIT and RPS

In this market structure,

- FIT (feed-in tariff) has an advantage of eliminating the market power of the dominant firm in the renewable electricity market.

- RPS internalize the externality of non-renewable energy sources by imposing the dominant firm to purchase a proportion of electricity from renewable energy sources.

Second-best optimization by the regulator

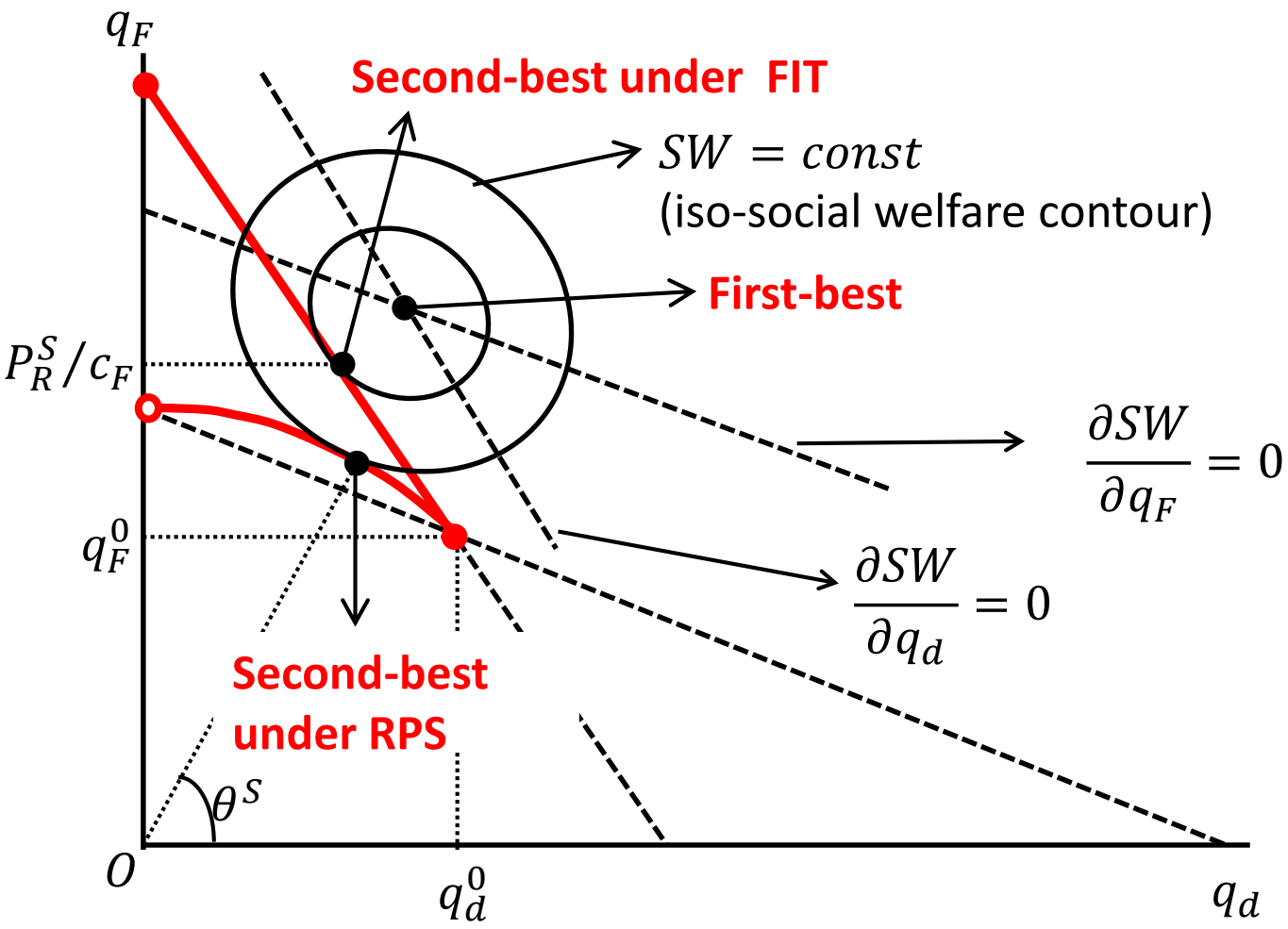
- The regulator is not able to directly set respective outputs of the dominant and fringe firm (first-best is not achievable).
- It maximizes social welfare with respect to policy variables under FIT and RPS respectively, anticipating the market equilibrium.

$$\max_{\beta} SW = \int P\, dq - \frac{1}{2} c_d (q_d)^2 - \frac{1}{2} c_F (q_F)^2 - \delta q_d$$

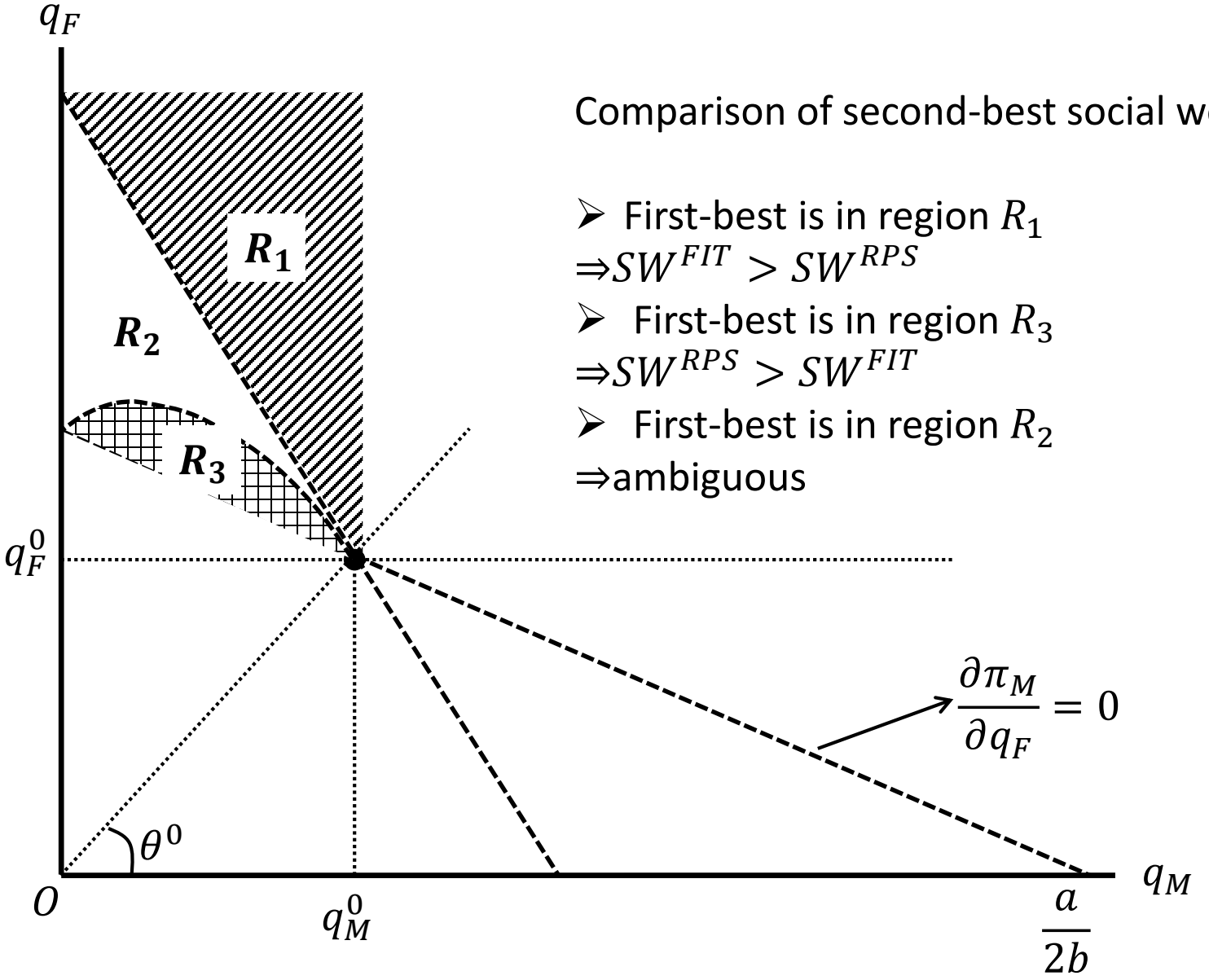
β: policy variable (P_R for FIT, $\theta \equiv q_F / q_d$ for RPS)

δ: marginal external cost of producing electricity from fossil-fuel power generation

Second-best optimization by the regulator



Second-best social welfare



Comparison of second-best social welfare

- First-best is in region R_1

$\Rightarrow SW^{FIT} > SW^{RPS}$

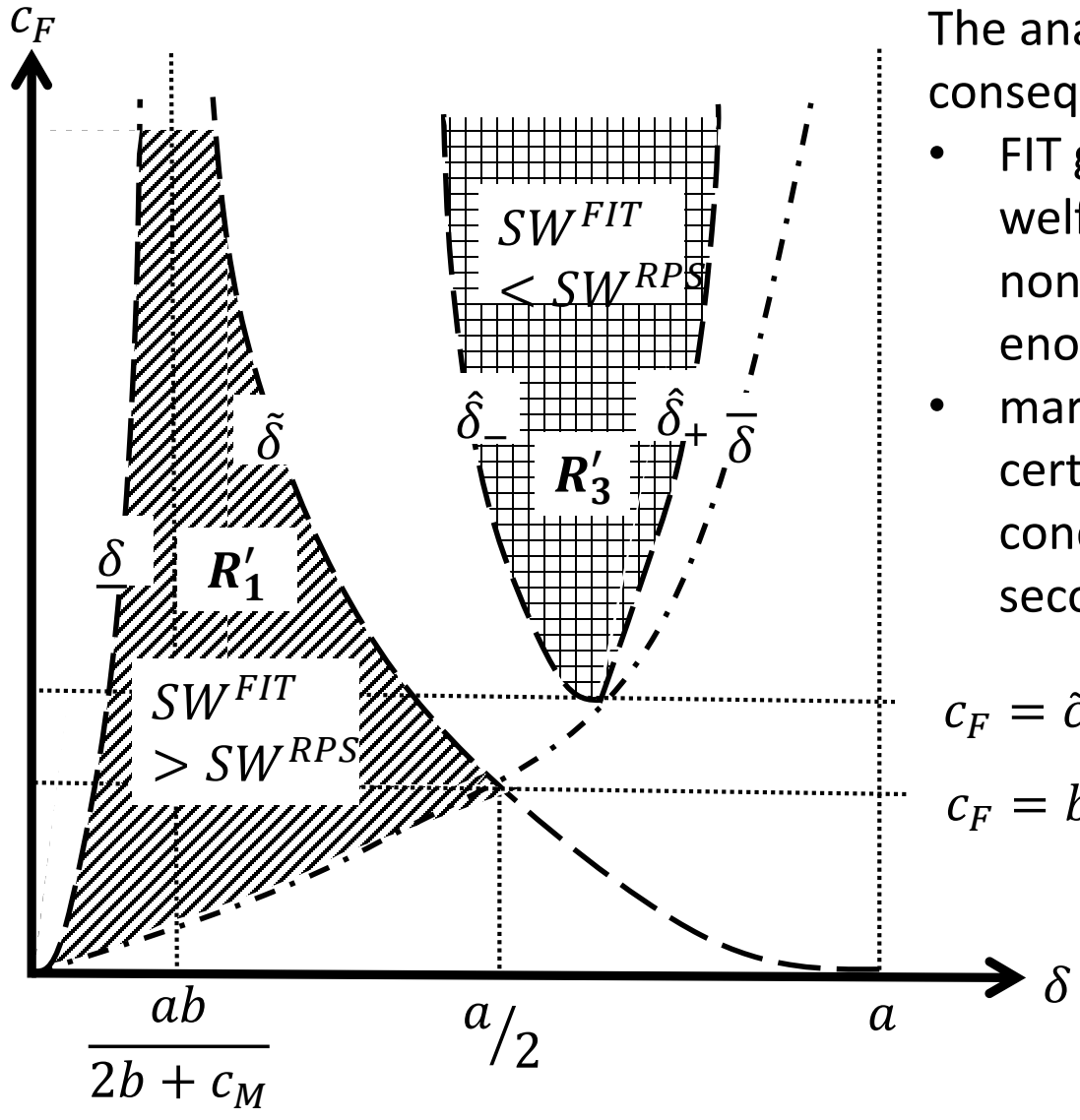
- First-best is in region R_3

$\Rightarrow SW^{RPS} > SW^{FIT}$

- First-best is in region R_2

$\Rightarrow$ambiguous

Comparative second-best efficiency on δ-c_F plane



The analysis indicates that as the consequence of the tradeoff,

- FIT generates higher second-best social welfare if the marginal external cost of non-renewable technology (δ) is small enough,
- marginal external cost (δ) higher than a certain threshold is a necessary condition for RPS to generate higher second-best efficiency.

$c_F = \tilde{c}_F$

$c_F = b$

RPS with quota

We further proposed a design of institutional arrangement to achieve first-best by incorporating a quota ($\bar{q}_F$) with RPS, in order to adjust the market power in the renewable electricity market.

$$\max_{q_d} \pi_d^{RPS} = P(q_M + q_F) - \frac{1}{2} c_M q_M^2 - P_R(q_F - \bar{q}_F)$$

Future work

Future work

- explicitly consider strategic access charge pricing by a monopolist in the network sector,

- investigate impacts of network unbundling on comparative efficiency of FIT and RPS.

Thank you very much for your attention