The sunny side of green transport policies: the double dividend effect in a two-sided market

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Transport and pollution

- The transport sector is responsible for 23% of global GHG emissions.
- Potential route of decarbonizing the transport sector: diffusion of electric vehicles (EVs).
- Governments are using a wide array of incentives to foster adoption of EVs.
- Adoption is still limited.
  - Not sufficient EV charging infrastructure (EVCS).

EVs and charging stations

- Network effects: as the number of EVCSs increases, the value of EVs is enhanced.

  → More EVs sales increase demand for EVCSs and hence their profitability.

- Who invests in EVCSs?
  - Governments
  - Manufactories of EVs
  - …

Retailers love electric cars

Source: obs/IKEA Deutschland GmbH & Co. KG/Inter IKEA Systems B.V. 2015

Two-sided market

Three characteristic elements:

1. Platform providing goods to distinct groups of consumers
2. Network externalities exist across groups of consumers
   - ≠ complementary goods, e.g. razor and blades, because the externality of the purchase decision is not internalized.
3. Non neutral price structure
   - Price below marginal cost can be optimal (e.g. free newspapers)

The market for EVs, gasoline vehicles (GVs) and EVCSs can be represented by a two-sided market with network externalities.

Research questions

- Which policies can favor the diffusion of EVs in a two-sided market with network externalities?
- Which policy mix maximizes welfare?
- How is welfare affected by a reduction in the number of GVs?

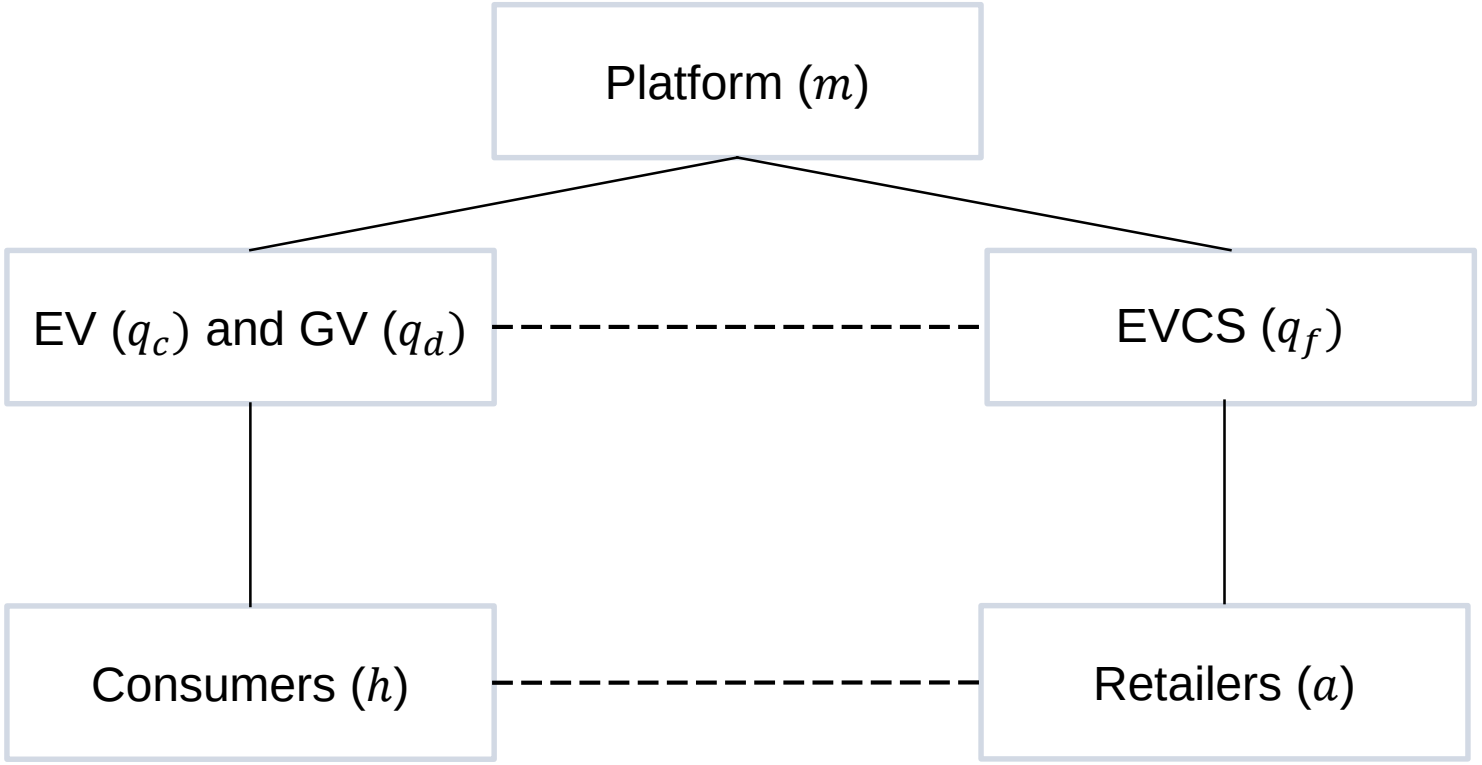
Relation to the literature

- Environmental policies in the automobile market (Jacobsen, 2013; Yu et al., 2016; Springel, 2016) and externalities in the new technology market (Jae and Stavins, 1994; Economides, 1996; Arthur, 1989).
- Two-sided markets and network effects (Rochet and Tirole, 2003; Tirole, 2004; Armstrong, 2006; Katz and Shapiro, 1986; Farrell and Saloner, 1985; Church and Gandal; 2004).
- Two-sided markets and EVs adoption (Yu et al., 2016; Springel, 2016; Jang et al., 2018).

Contribution

- Include the additional effect of substitution with GVs together with the network effects.
- Provide a new channel highlighting the need for policies favoring EVs.
- Display the optimal policy mix depending on the network intensity.
- Show the existence of a double dividend in the presence of network effects.

Model setup



Utility function of consumer

- Häckner (2000) and Melitz and Ottaviano (2008): quasi-linear utility.

$$U_h(q_{0,h}, q_c, q_d; q_f) = q_{0,h} + \sum_i \alpha_i q_i - \frac{1}{2}\left(\sum_i q_i^2 + 2(\gamma_1 q_c q_d - \gamma_2 q_c q_f)\right)$$

$$\text{s.t} \quad q_{0,h} + p_c q_c + p_d q_d \leq m_h, \ where\ i \in \{c, d\}$$

$q_{0,\mathrm{h}} \geq 0$	Numeraire good
$q_i \geq 0, \mathrm{i} \in \{c, d\}$	Chosen quantity of EVs and GVs
$a_i q_i \geq 0$	Direct benefit
$\gamma_1 \in [0,1]$	Substitution btw EVs and GVs
$\gamma_2 \in [0, \infty)$	Network effect btw EVs and EVCSs
$\gamma_2 q_c q_f$	Indirect benefit

Objective function of retailers

$$F_a(q_{0,a}, q_f; q_c) = q_{0,a} + \alpha_f q_f - \frac{1}{2}(q_f^2 - \gamma_4 q_c q_f)$$

s.t $\quad q_{0,a} + p_f q_f \leq m_a$

$q_{0,\mathrm{a}} \geq 0$	Numeraire good
$q_f \geq 0$	Chosen quantity of EVCSs
$a_f q_f \geq 0$	Direct benefit
$\gamma_4 \in [0, \infty)$	Network effect btw EVs and EVCSs
$\gamma_4 q_c q_f$	Indirect benefit

Demand functions

Inverse demand for EVs, GVs and EVCSs are

$$p_c = \alpha_c - q_c - \gamma_1 q_d + \gamma_2 q_f,$$

$$p_d = \alpha_d - q_d - \gamma_1 q_c,$$

$$p_f = \alpha_f - q_f + \gamma_4 q_c.$$

- Positive impact of network effects γ_2 and γ_4.
- Negative impact of substitution effect γ_1.

A platform setting quantities on both sides

A monopolistic platform maximizes

$$\pi = \sum_i (p_i - c_i) q_i$$

which yields profit-maximizing quantities q_c^*, q_d^* and q_f^*, such that

- each good depends on the demands for all the three goods
- and the quantities chosen depend on the intensity of the network effects.

First best solution

A social planner maximizes total welfare w

$$w = \pi + U_h + F_a - \phi q_d$$

which yields welfare-maximizing quantities q_c^{fb}, q_d^{fb} and q_f^{fb}, such that

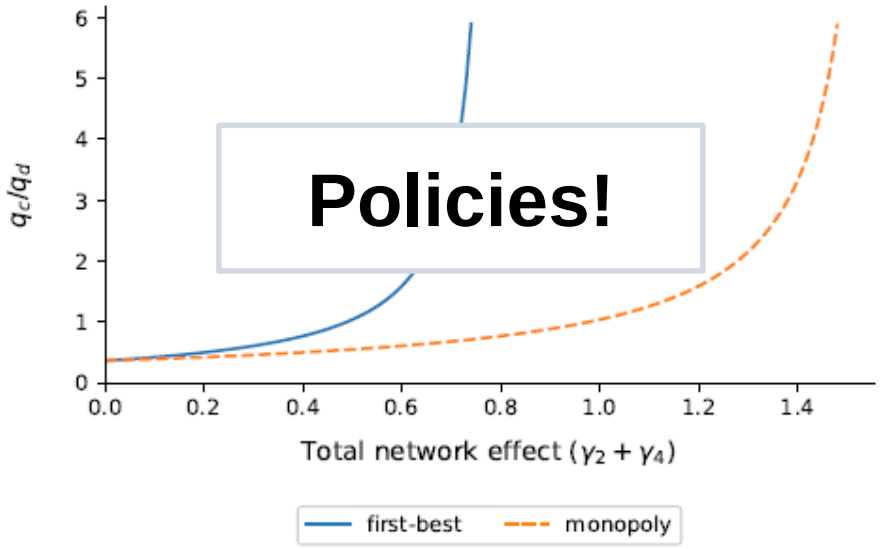
- each good depends on the demands for all the three goods
- and the quantities chosen depend on the intensity of the network effects.

Ratio development without environmental damage

In the presence of network effects:

- there is a higher ratio of EVs to GVs in the first best case.

  → too many GVs relative to EVs in the monopolistic case.

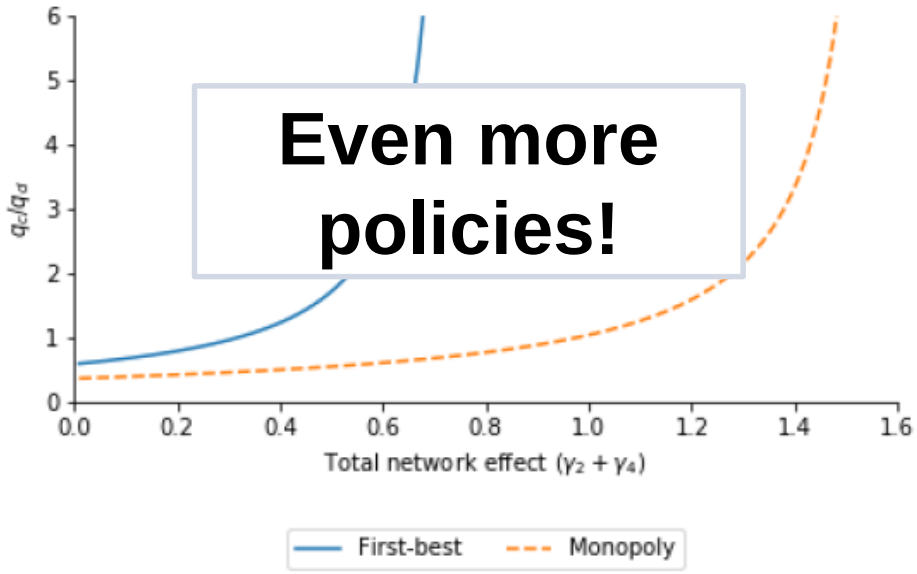


Ratio development with environmental damage

Adding environmental damage:

- increases the difference between the first best and monopolistic case even more.

  → the two externalities boost each other.



Welfare maximization: Setup

Policy maker uses:

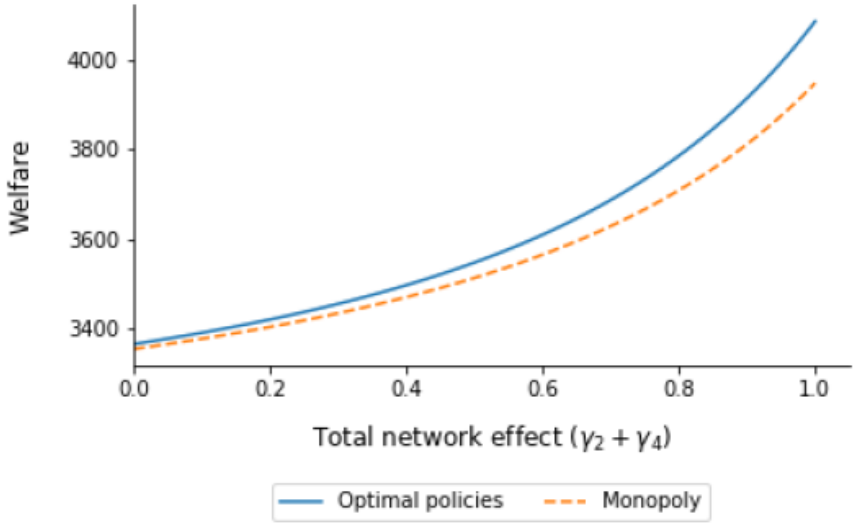
- subsidies on EVs demand,
- taxes on GVs demand
- and subsidies on EVCSs demand

to maximize welfare.

Restriction: Budget has to be balanced.

Welfare maximization: Comparison

- Without network effects, improvement is possible because of the environmental damage.
- With network effects, larger improvement becomes possible.

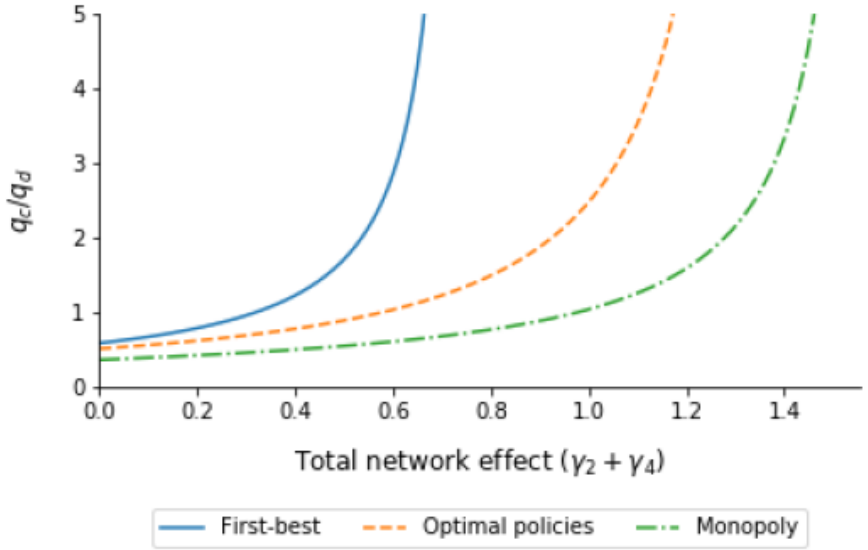


Welfare maximization: Ratio adjustment

In the presence of environmental damage and/or network effects:

- optimal policies favor EVs

  → policies are used to get closer to the first best ratio.



Welfare maximization: Environmental targets

Many countries use

- subsidies on EVs
- and taxes on GVs

to achieve predefined environmental targets.

But: Taxes on GVs due to environmental reasons were not well received by the public.

→ Are there also economic reasons to use such targets?

Welfare maximization: target for GVs

Policy maker uses

- subsidies on EVs demand,
- taxes on GVs demand
- and subsidies on EVCSs demand

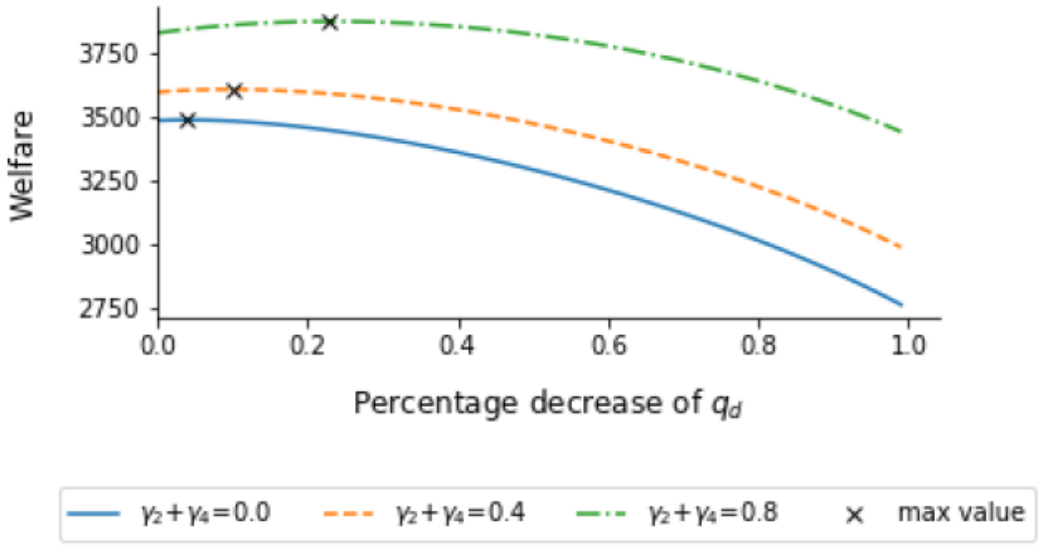
to decrease the amount of GVs by r %.

Restriction: Budget has to be balanced.

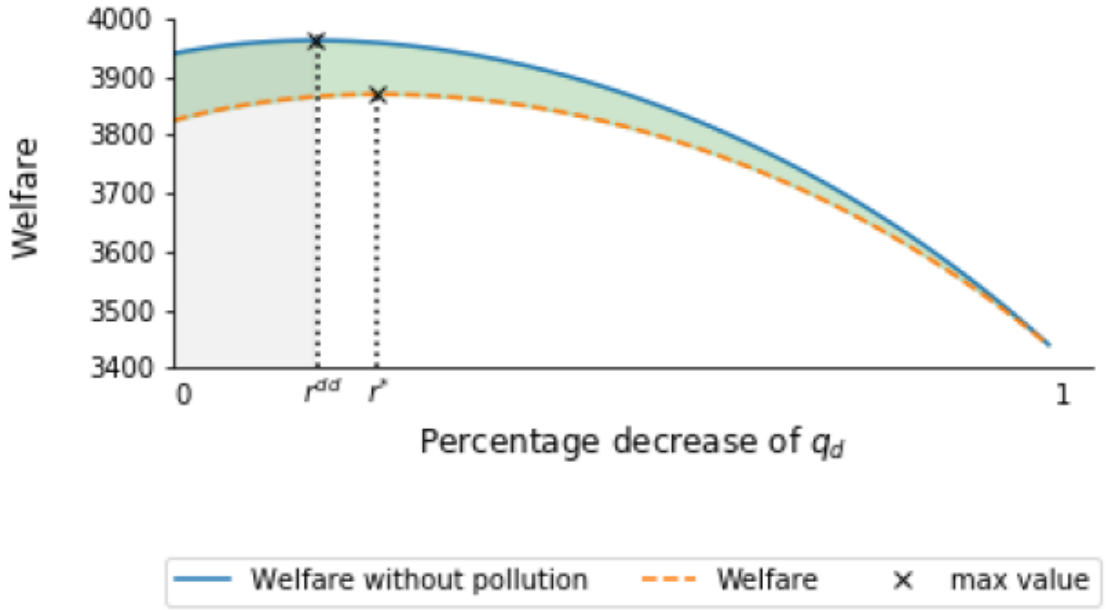
Welfare maximization: optimal target

Two main effects:

1. There is a range for policy instruments decreasing q_d which leads to higher welfare.
2. This range increases with the total network effect.



Welfare maximization: disentangling the externalities



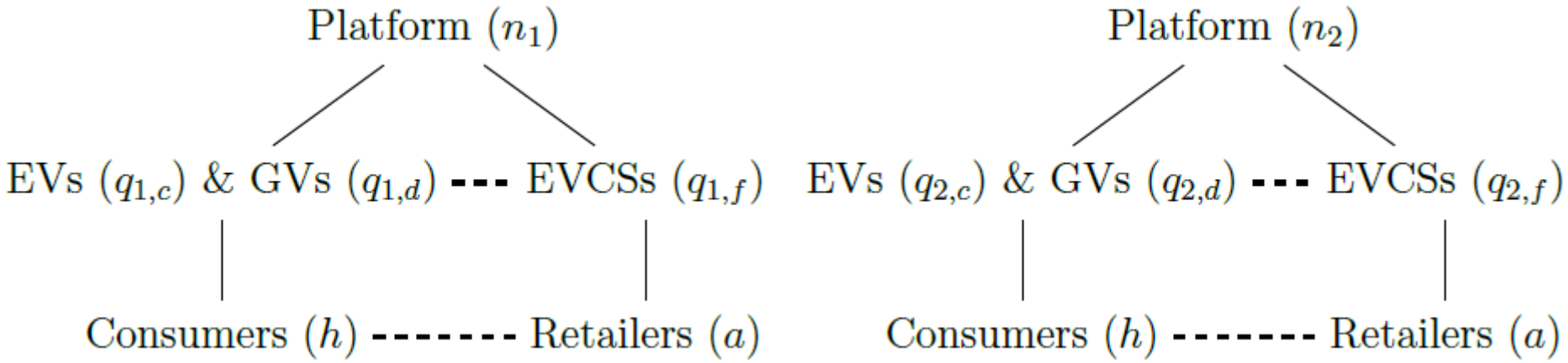
In the presence of network effects, there is a range for policy instruments which leads to a **strong double dividend** effect**.**

Summary

- Network effects have an impact on profit-maximizing quantities and prices.
- Policies targeting one side of the market generate feedback effects on the other.
- The set of welfare maximizing policies implies subsidies to electric vehicles and charging stations and taxes on gasoline vehicles.
- In the presence of network effects, optimal policies can offer a strong double dividend effect.

Extension: oligopolistic platform

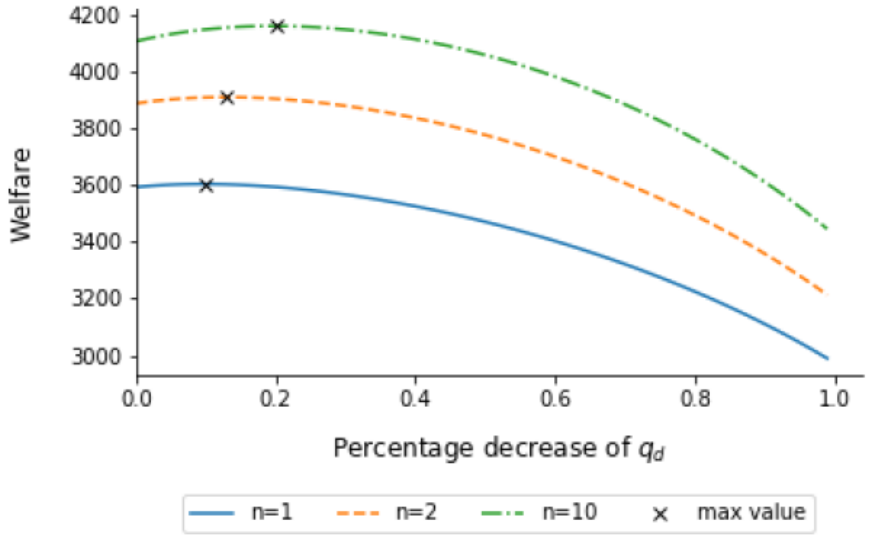
- n different platforms in the market.
- Cournot competition.



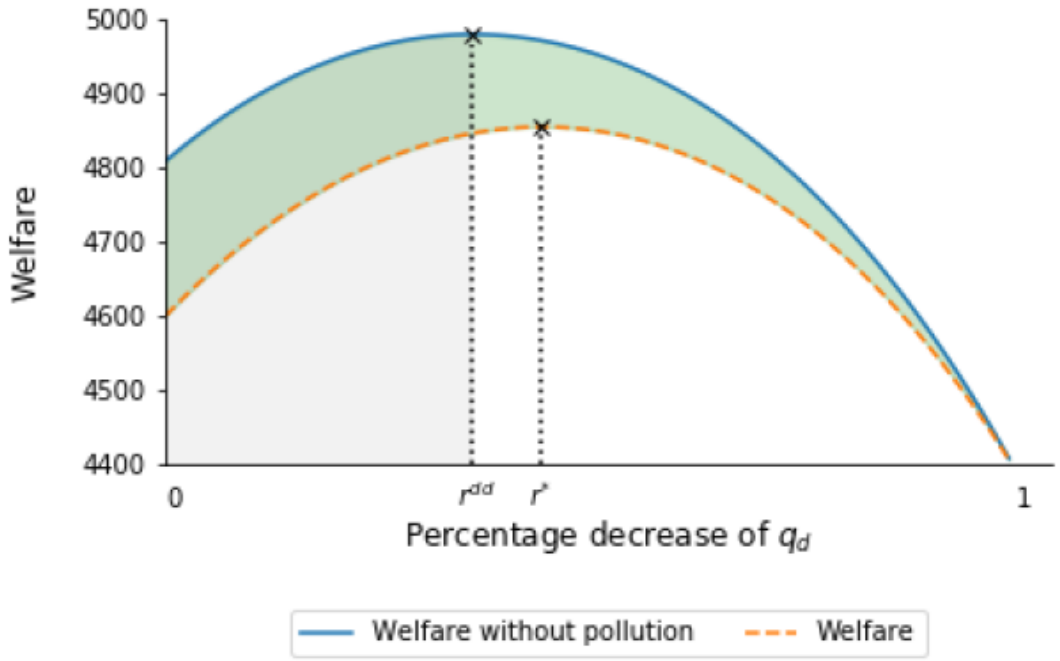
Extension: oligopolistic platform

Two main effects:

1. There is a range for policy instruments decreasing q_d which leads to higher welfare.
2. This range increases with the number of firms (and with the network effects).



Extension: oligopolistic platform



In the presence of network effects, a higher number of platforms increases the range for policy instruments leading to a **strong double dividend** effect**.**

Thank you