Analyzing the economic and environmental relevance of green corridors for the decarbonization of road freight transport in France

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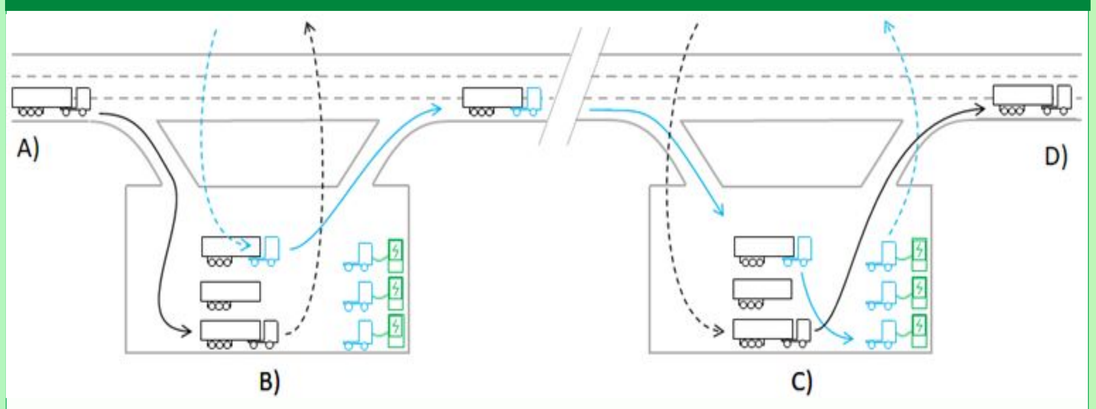
OBJECTIVE AND METHODOLOGY

- **Objective:** study the socioeconomic relevance of a **prospective transport service in which highway managers would propose to freight carriers decarbonized shuttles to move their shipments on highways**
- **Steps:** 1) Analytical model with several regulation schemes
  2) Empirical calibration for various technologies

HOW THE GREEN CORRIDOR WORKS



1) The carrier's truck enters a platform (B) at the highway entry
2) **Its trailer is connected to a decarbonized vehicle** operated by the highway manager
3) **The decarbonized vehicle carries the trailer up to the highway exit** where it enters a second platform (C)
4) The trailer is connected to another of the carrier's trucks, which drives to the final destination (D)

MODEL

- **Total joint profit of the highway manager** (i.e. highway revenue + new service revenue) :

$$\pi = \underbrace{(1-\tau_0)p_0Q_0 + (1-\tau_1)p_1Q_1}_{\text{Net of taxes revenues made on the new service (Q1) and on the standard trucks (Q0)}} - \underbrace{I_1}_{\text{New service production costs}} - \underbrace{u(Q_0+Q_1)}_{\text{Pavement damages}}$$

- **Social welfare :**

$$SW = \pi - \underbrace{Q_0CG_0 - Q_1CG_1}_{\text{Total generalized costs}} + \underbrace{\alpha FP}_{\text{Cost of public funds}} - \underbrace{Q_0E_0 - Q_1E_1}_{\text{Environmental costs}}$$

- **Carriers' choice depends on generalized costs:**

  - Not using the service :

$$CG_0 = \underbrace{c_d d_{AD}}_{\text{Money costs linked to vkm}} + \underbrace{p_0 d_{BC}}_{\text{Highway toll}} + \underbrace{(c_w + c_k + c_g)(t_{AD} + t_{break})}_{\text{Time costs linked to drivers, capital and goods}}$$

  - Using the service :

$$CG_1 = c_d(d_{AB} + d_{CD}) + \underbrace{p_1 d_{BC}}_{\text{Service price}} + (c_w + c_k + c_g)(t_{AB} + t_{CD}) + c_g(t_{BC} + \underbrace{2t_{load}}_{\text{Goods' immobilization}})$$

$\Rightarrow$ Demand function : $Q_1 = a - b(CG_1 - CG_0)$

- **Service production cost for the highway manager:**

$$I_1^\theta = \underbrace{(c_k^\theta t_C^\theta + c_w(t_R + t_{BC}) + c_d^\theta d_{BC})Q_1^\theta}_{\text{Shuttles' costs: Money and time costs linked to drivers and vehicles}} + \underbrace{K_P}_{\text{Fixed cost}} + \underbrace{\underbrace{(k_P(t_R + t_L^\theta)}_{\text{Parking costs}} + \underbrace{k_L^\theta t_L^\theta)Q_1^\theta}_{\text{Charging station costs}}}_{\text{Platform costs}}$$

COMPARED TECHNOLOGIES

- **Battery electric vehicles** (BEV) with fast or slow charging
- **Liquified natural gaz** (LNG)
- **Hydrogen**
- **Electrical Road System** (ERS) on 70% or 100% of the highway to charge the decarbonized vehicles as they drive

COMPARED REGULATION SCHEMES

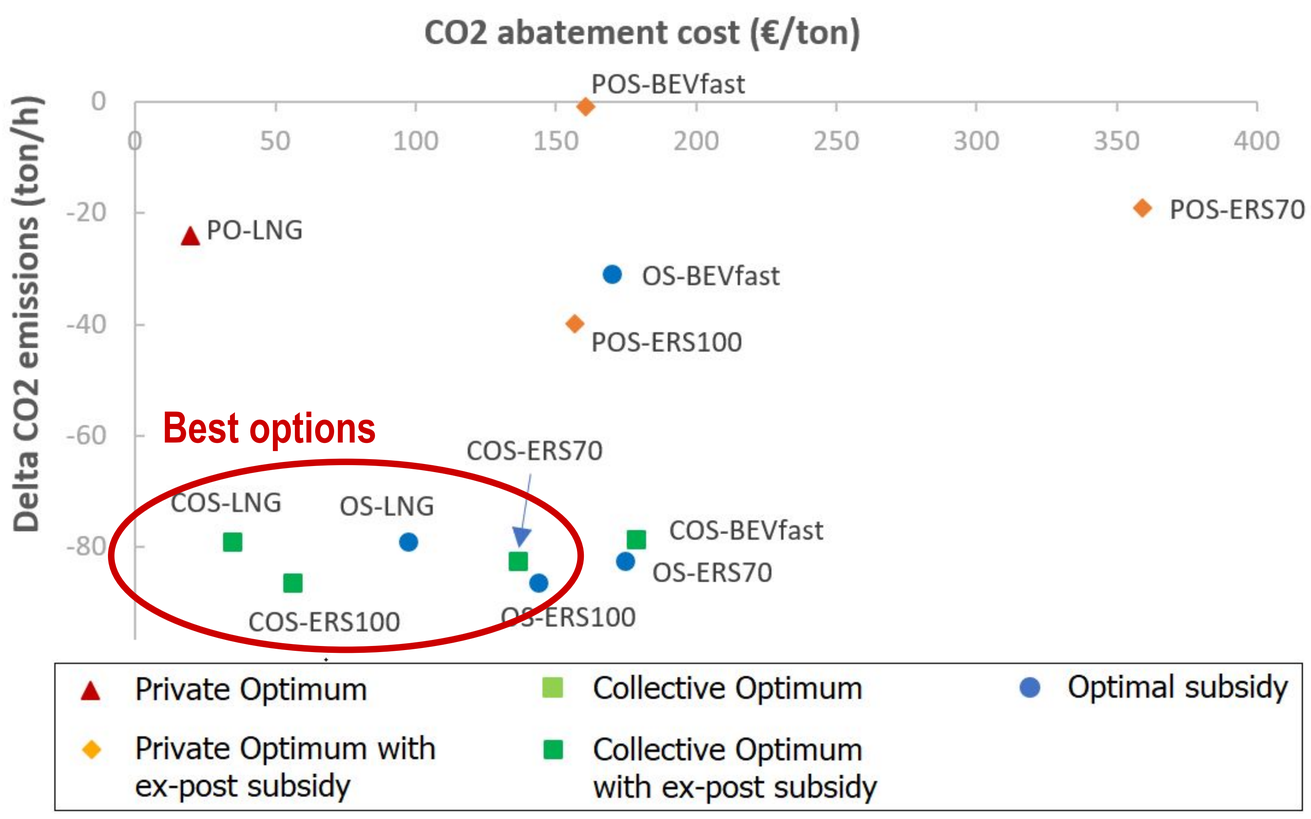
- **Private optimum:**
  - PO : The highway manager freely chooses the price of the service
  - POS : Same with an ex-post subsidy to make the service profitable
- **Collective optimum (// concession agreement)**:
  - CO : The price is fixed by the state
  - COS : Same with an ex-post subsidy to make the service profitable
- **Second-best collective optimum:**
  - OS : The state provides a **per vehicle-kilometer subsidy** and the highway manager takes it into account when freely choosing the price of the service

PARAMETERS FOR THE VARIOUS TECHNOLOGIES

Option	Diesel	BEV fast charge	BEV slow charge	LNG	Hydrogen	ERS70	ERS100
Consumption [unit/km]	0,300 L	1,250 kWh	1,200 kWh	0,257 kg	0,085 kg	1,250 kWh	1,250 kWh
Energy price incl. tax [€/unit]	1,40	0,25	0,25	0,887	9,300	0,25	0,25
Vehicle purchase price (- subvention)	**100k**	**315k (-50k)**	**315k (-50k)**	**145k**	**400k (-50k)**	**262k (-50k)**	**181k (-50k)**
CO2 usage emissions [g/km]	**837**	**57**	**57**	**130**	**250**	**57**	**57**
Other CO2 emissions [g/km]	26	103	103	26	26	65	30
Charging station [€]	-	**500k**	**150k**	**1500k**	**2500k**	**500k**	**500k**
Other investments [€]	-	**2M** (1,5+0,5)	**2M** (1,5+0,5)	**1,5M**	**1,5M**	**450M** (1,5+0,5+ 2x224)	**642M** (1,5+0,5+ 2x320)

BASELINE RESULTS

Comparison of the technologies and regulations based on 2 criteria:



CONCLUSIONS

- **Technologies:**
  - Hydrogen truck too costly, BEV slow charge not productive enough
  - BEV fast charge may be pertinent but very costly
  - **ERS are very pertinent (optimally on 100% of the corridor)**
  - Biogaz is best if available
- **Regulation:**
  - **Is indispensable and very costly for public finances**
  - Is justified based on the CO2 abatement cost (< 200 €/t)
  - **The "concession agreement" is the least costly**
  - The "kilometric subsidy" leads to huge and costly transfers