Critical Raw Materials

Dienstag, 13. April 2021 20:41

- Diversity in terms of supply countries : at max 65% of the annual consumption
- Set the Russian imports to the EU to zero

→ Effectiveness percentage limit
→ how liquid is the global market
→ Increase in transport costs
→ Strategic reserve → stockpilling

Interaction

→ countries are committing

③ Increase supply

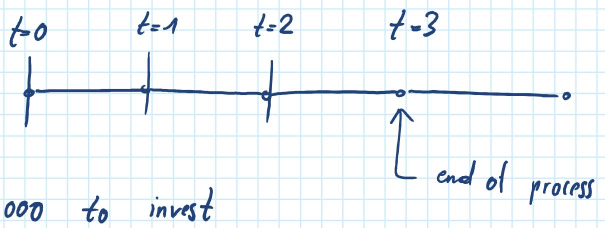
↳ Logistic stockpilling maintaining existing equipment

fraction of the winter demand

4.5 bcm / daily use of natural gas in Italy

↳ Time that it takes to develop new production capacities

→ Substitution possibilities at certain costs



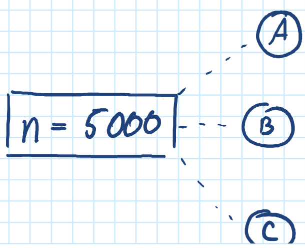
5 000 to invest

Option { A, B

State $n \in \{0, 5000, 10\,000\}$ ... n dollars in account

decisions : $x_t \in \{A, B, \text{no investment}\}$

→ the set of „allowable" decisions changed, depending on the stage and state



A	−5000	0.3
	+5000	0.7
B	0	0.9
	+5000	0.1

+5000 0.1

Market Clearing — Marktpreis — Market Clearing — Marktpreis — MC ...

LEADER

FOLLOWER1 FOLLOWER2

ohne strategisches Verhalten

min costs

s.t.:

Erweiterung der Kapazität (Abgefragte Menge) 2025 2026

Investitionsvolumen $\hat{=}$ Abgefragten Menge im Schritt zuvor

↳ Erweiterung des Portfolios entspricht dem kumulierten

⇒ Konstanter Profit pro Einheit

$t \in T = \{2025, 2030, 2035\}$

α_t ... Discount factor

π_t ... Profit at timestep t

λ_t ... Market clearing price at timestep t

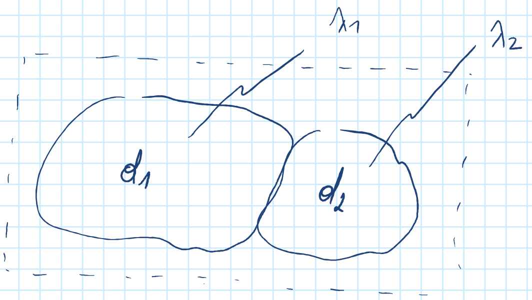
c ... Production costs of major supplier

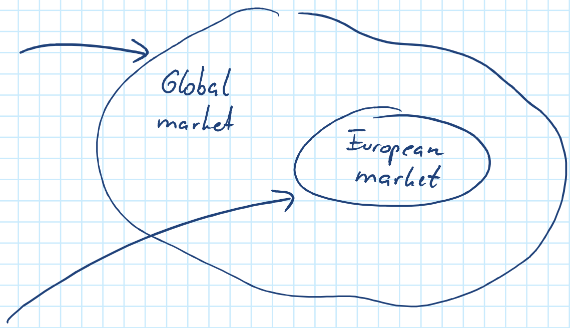
q_t ... Quantity delivered to / retrived from the market

$$\max \sum_t \alpha_t \times \pi_t = \max \sum_t \frac{1}{(1+i)^{t-t_0}} \left\{ (\lambda_t - c) \times q_t \right\}$$

p_t ... Price offer by the major supplier at timestep t

$\tilde{q}_t$ ... Quantity offer by the major supplier at timestep t





Russian ... q^{RUS}

Russian quantity q^{RUS}

All other generators:

→ Diversifizierung

→ Kleine Russian Imports

→ Global market

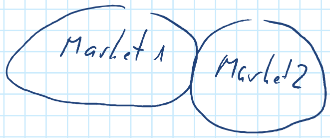
→ European market

$\sum$ Generators $\geq$ European Demand

$d \in D$ ... demand

$g \in G$ ... generation

i ... major supply/generation (with market power)



$$\min \text{ costs} = \min \sum_{g \in G} c_g \times p_G$$

s.t.: $\quad 0 \leq p_g \leq \overline{p}_g \quad : \forall\ g \in G$

$$\sum_{d \in D} p_d - \sum_{g \in G} p_G = 0 \quad : \lambda$$

Welthandel (Global trade) → Market 1 (M1)

Europäischer Handel (European trade) → Market 2 (M2)

$$\cancel{\min \text{ costs of } M1 + M2 = \min \sum_{g \in G} c_g \times \{ q_{g,M1} + q_{g,M2} \}}$$

$$\cancel{0 \leq q_{g,M1} + q_{g,M2} \leq \overline{q}_g \quad : \forall\ g \in G}$$

$$\cancel{\sum_{d \in M_1} q_d = \sum_{g \in G} q_{g,M1} \quad : \lambda_{M1}}$$

$$\cancel{\sum_{d \in M_2} q_d = \sum_{g \in G} q_{g,M2} \quad : \lambda_{M2}}$$

$\boxed{\text{Nebenbedingung } \lambda_{M1} = \lambda_{M2}}$

~~$q_{g,M2} = 0 \quad : \forall g \in G_{embargo}$~~

~~$q_{g,M2} \leq 0.65 \times \sum_{d \in M_2} q_d$~~

$\Rightarrow$ Mit insgesamt 3 Timesteps $\{2025, 2030, 2035\}$

$\rightarrow$ Veränderung von der maximalen Produktionskapazität

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Lower level: $t \in T \ldots \{2025, 2030, 2035\}$ $\quad m \in M \ldots \{$Market 1, Market 2$\}$

$g \in G \ldots \{$Generator 1, Generator 2, ...$\}$ $\rightarrow$ Generator 1 is the major supplier

$$\min_{x} \text{ costs of both markets } M1 + M2 = \min \sum_{t \in T} \sum_{g \in G} C_g \times \{q_{g,t,M1} + q_{g,t,M2}\}$$

$$\boxed{= \min \sum_{t \in T} \sum_{g \in G} \sum_{m \in M} C_g \times q_{g,t,m}}$$

(1) $\quad 0 \leq q_{g,t,M1} + q_{g,t,M2} \quad : \forall g,t \quad (\mu^1_{g,t})$ ✓

(2) $\quad q_{g,t,M1} + q_{g,t,M2} \leq \bar{q}_{g,t} \quad : \forall g,t \quad (\mu^2_{g,t})$ ✓

(3) $\quad \sum_{d \in M1} d_{d,t} = \sum_{g \in G} q_{g,t,M1} \quad : \forall t \quad (\lambda^1_t)$ ✓

(4) $\quad \sum_{d \in M2} d_{d,t} = \sum_{g \in G} q_{g,t,M2} \quad : \forall t \quad (\lambda^2_t)$ ✓

$\boxed{\begin{array}{l} \bar{q}_{g,t} \ \ldots \text{ is a parameter } \forall t \wedge g = \text{Generator 1} \\ \bar{q}_{g,t} \ \ldots \text{ is a variable } \forall t \wedge g \neq \text{Generator 1} \end{array}}$

(5) $\quad q_{g,t,M1} = 0 \quad : \forall g \in G_{embargo}, t \quad (\lambda^3_{g,t})$ ✓

(6) $\quad q_{g,t,M1} \leq 0{,}65 \times \sum_{d \in M1} d_{d,t} \quad : \forall g,t \quad (\lambda^4_{g,t})$ ✓

$-q_{g,t,M1} - q_{g,t,M2} \leq 0 \quad : \forall g,t \quad \Leftrightarrow \mu^1_{g,t}$ ✓

$q_{g,t,M1} + q_{g,t,M2} - \bar{q}_{g,t} \leq 0 \quad : \forall g,t \quad \Leftrightarrow \mu^2_{g,t}$ ✓

$\sum_{d \in M1} d_{d,t} - \sum_{g \in G} q_{g,t,M1} = 0 \quad : \forall t \quad \Leftrightarrow \lambda^1_t$ ✓

$\sum_{d \in M2} d_{d,t} - \sum_{g \in G} q_{g,t,M2} = 0 \quad : \forall t \quad \Leftrightarrow \lambda^2_t$ ✓

$q_{g,t,M1} = 0 \quad : \forall g \in G_{embargo}, t \quad \Leftrightarrow (\lambda^3_{g,t})$ ✓

$$q_{g,t,M1} - 0{,}65 \times \sum_{d \in M1} d_{d,t} \quad : \forall g,t \Leftrightarrow (\lambda^4_{g,t})$$ ✓

$\Rightarrow$ Derive KKT conditions [dual problem of $\underbrace{(1)-(6)}_{\text{No capacity expansion constraint included!}}$]

$$\mathcal{L}(x,\nu,\lambda) = \sum_t \sum_g \sum_m c_g \, q_{g,t,m} + \sum_t \sum_g \nu^1_{g,t} \left[-q_{g,t,M1} - q_{g,t,M2} \right]$$

$$+ \sum_t \sum_g \nu^2_{g,t} \left[q_{g,t,M1} + q_{g,t,M2} - \bar{q}_{g,t} \right]$$

$$+ \sum_t \lambda^1_t \left[\sum_{d \in M1} d_{d,t} - \sum_{g \in G} q_{g,t,M1} \right]$$

$$\sum_t \lambda^2_t \left[\sum_{d \in M2} d_{d,t} - \sum_{g \in G} q_{g,t,M2} \right]$$

$$+ \sum_{g \in G_{embargo}} \lambda^3_{g,t} \left[q_{g,t,M1} \right]$$

$$+ \sum_t \sum_g \lambda^4_{g,t} \left[q_{g,t,M1} - 0{,}65 \cdot \sum_{d \in M1} d_{d,t} \right]$$

KKT Conditions

$$\nabla \mathcal{L} = 0$$

$\vdots$

Is it possible to add (new) constraints here?

such as:

(A) $\lambda^1_t = \lambda^2_t \quad : \forall t$

(B) $\bar{q}_{g,t} = f\left(\lambda^1_{t-1}\right) \quad : \forall g \setminus \{\text{Generator } 1\}, t$

→ using SOS2 variables