# Nationally and Internationally Optimal Climate Policies: External Balances versus Environmental Preferences

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# Motivation

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## EU–US divide in climate change policy

- In the US, perceived domestic costs of climate policy are higher while benefits of doing so are lower
  - Differences in perceived costs of climate policy in terms of domestic welfare are influenced by external balances
  - Differences in perceived benefits of climate change policy are based on diverging public environmental preferences
- Comparing the EU to the US, there is evidently a difference both in external balances (IMF, 2006) and in environmental preferences of citizens (Böhringer and Vogt, 2004)
- Can these differences in external balances (net foreign asset position) and in environmental preferences lead to different strategies to climate change policy?

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# Motivation

- Under the assumption that each national government choses its emission permit levels by maximising the sum of economic and environmental welfare, how are **differences in nationally optimal permit levels** driven by the **external balances** and/or **environmental preferences** of the respective countries?
- **Are these nationally optimal emission permit levels internationally optimal (Pareto efficient)**, in line with the trade–based and fiscal competition arguments of the efficiency of nationally optimal policy setting?
- And if not, **are they lower than the nationally optimal solution**, in line with the autarky equilibrium game–theoretic literature?

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# Model structure

- Diamond–type OLG growth model with neoclassical production
- two–country version of Ono's (2002) closed–economy model
- two large, equally developed economic areas
- identical production technology, but different environmental preferences
- complete specialization in goods production across countries
- national emission permit trading systems
- one country is a net debtor, the other one a net creditor
- international trade in goods and in government bonds
- labor and capital immobile

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# Profit maximization and environmental quality

- **Profit maximization (Home)**

$$\pi_t = M (k_t)^{\alpha_K} \left(p_t\right)^{\alpha_P} - q_t k_t - w_t + e_t \left(S - p_t\right)$$

- **National permit markets:**
  - supply of permits $S$, $S^*$
  - market clearing: $p_t = S$, $p_t^* = S^*$
- **Environmental quality (global public good)**

$$E_{t+1} = \mu \bar{E} + (1-\mu) E_t - p_{t+1} - p_{t+1}^*$$

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# Utility maximization and government

- **Household (Home)**

  max $\quad U_t = \zeta \ln x_t^1 + (1-\zeta)\ln y_t^1 + \beta\left[\zeta \ln x_{t+1}^2 + (1-\zeta)\ln y_{t+1}^2 + \xi \ln E_{t+1}\right]$

  subject to

  $$x_t^1 + \frac{1}{h_t} y_t^1 + k_{t+1} + b_{t+1}^H + (1/h_t)\, b_{t+1}^{*,H} = w_t - \tau_t$$

  $$x_{t+1}^2 + \frac{1}{h_{t+1}} y_{t+1}^2 = (1+i_{t+1})\left[k_{t+1} + b_{t+1}^H\right] + \left(1+i_{t+1}^*\right)\frac{1}{h_{t+1}} b_{t+1}^{*,H},$$

- **Government (Home)**
  - government bonds: $b_t = b_t^H + b_t^F$
  - balanced budget: $\tau_t + e_t S = i_t b_t$

- similar optimization problems for Foreign $(*)$, but different environmental preferences $\xi^* \neq \xi$

# Intertemporal equilibrium dynamics

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- **International interest parity** $h_{t+1} = h_t \frac{\left(1 + i^*_{t+1}\right)}{\left(1 + i_{t+1}\right)}$

- **International asset market clearing**

$$h_t k_{t+1} + k^*_{t+1} = h_t \left[\sigma_0 (k_t)^{\alpha_K} - b(\sigma\ i_t + 1)\right] + \sigma^*_0 \left(k^*_t\right)^{\alpha_K} - b^* \left(\sigma\ i^*_t + 1\right)$$

- **Combined goods market clearing**

$$h_t k_{t+1} - \frac{\zeta}{(1-\zeta)} k^*_{t+1} = h_t M (k_t)^{\alpha_K} (S)^{\alpha_P} - \frac{\zeta}{(1-\zeta)} M \left(k^*_t\right)^{\alpha^*_K} \left(S^*\right)^{\alpha^*_P}$$

- **Environmental quality** $E_{t+1} = \mu \bar{E} + (1-\mu) E_t - S - S^*$

- **Steady state** $(h, k, k^*, E) = \left(h_t, k_t, k^*_t, E_t\right) = \left(h_{t+1}, k_{t+1}, k^*_{t+1}, E_{t+1}\right)$

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- For given Foreign permit level $S^*$, Home chooses its permit level $S$ to maximize steady state welfare $W(k(S,S^*),h(S,S^*),S,S^*) = U(x^1,y^1,x^2,y^2,E)$

$$\frac{\mathrm{d}W}{\mathrm{d}S} = W_k\frac{\partial k}{\partial S} + W_h\frac{\partial h}{\partial S} + W_S = 0, \qquad (1)$$

where $\partial h/\partial S < 0$, $\partial k/\partial S > 0$, $\partial k^*/\partial S > 0$, and $\partial E/\partial S < 0$.

- for the special case of $b = 0$ and $b^* > 0$, such that the Golden Rule ($i = 0$) applies, and equal expenditure share for Home and Foreign goods, $\zeta = 1-\zeta$, Home's reaction function is:

$$S^H(S^*) = \frac{(1+\beta)\alpha_P\zeta}{\beta\xi(1-\alpha_K)+(1+\beta)\alpha_P\zeta}\left[\mu\bar{E}-S^*\right], \qquad (2)$$

where $C = [\sigma(1-\alpha_K)-\alpha_K]^2/\left[\alpha_K-\sigma^2(1-\alpha_K)^2\right] > 0$.

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- Proceeding similarly for Foreign,

$$\frac{\mathrm{d}W^*}{\mathrm{d}S^*} = W^*_{k^*}\frac{\partial k^*}{\partial S^*} + W^*_h \frac{\partial h}{\partial S^*} + W^*_{S^*} = 0, \tag{3}$$

gives the following reaction function:

$$S^F(S^*) = \mu\bar{E} - \left[1 + \frac{\beta\xi^*(1-\alpha_K)}{(1+\beta)\alpha_P(C+1-\zeta)}\right] S^*, \tag{4}$$

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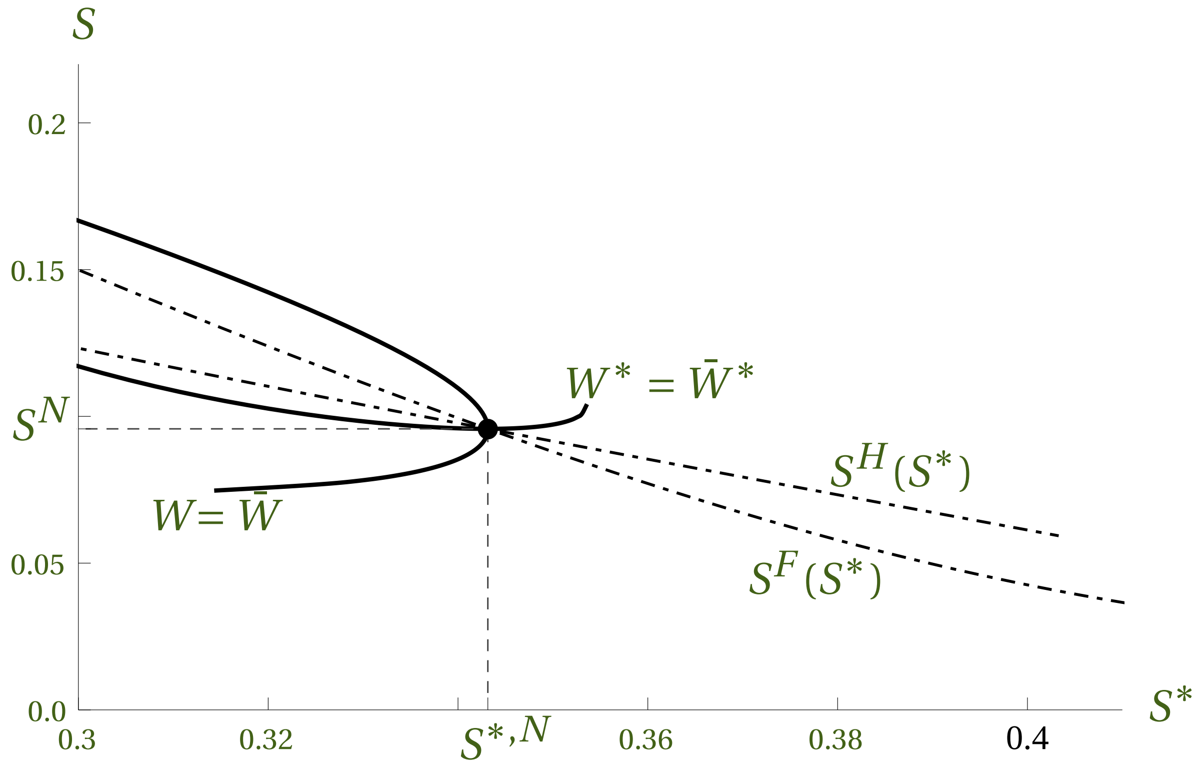
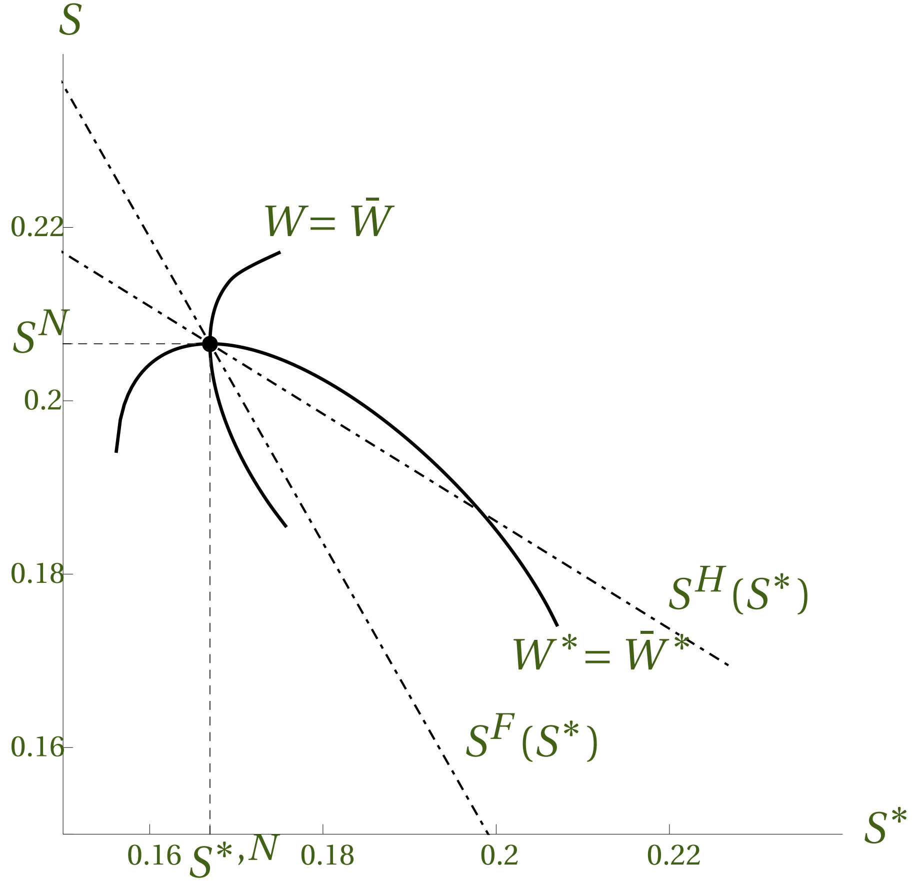
**Case 1: Home is a net foreign creditor country and does not have a lower preference for the environment than Foreign** ($b = 0.15$, $b^* = 0.65$ and $\xi = 0.125$, $\xi^* = 0.1$): $S^N < S^{*,N}$



# Nationally optimal permit levels

**Case 2: Home is a net foreign creditor country and has considerable lower environmental preferences** ($b = 0.15$, $b^* = 0.20$ and $\xi = 0.1$, $\xi^* = 0.125$): $S^N > S^{*,N}$



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**Proposition 1 (Nash equilibrium permit levels)** *Suppose that* $\zeta = 1 - \zeta$, $b = 0$ *and* $b^* > 0$ *(Home is a net foreign creditor and Foreign a net foreign debtor) such that* $i = 0$*. Then, the nationally optimal, i.e. Nash, permit levels* $(S^N, S^{*,N})$ *are given by:*

$$S^N = \frac{\xi^*}{\xi} \frac{\zeta}{\zeta + C} S^{*,N}. \quad (5)$$

*If moreover* $\xi \geq \xi^*$*, then it is optimal for Home to chose a lower permit level than Foreign:* $S^N < S^{*,N}$*.*

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# Internationally optimal permit levels

- Home maximises its welfare by choosing domestic and foreign permit levels under the constraint that Foreign achieves welfare at the level of the nationally optimal solution:

$$\max_{\{S,S^*\}} W\left(k(S,S^*), h(S,S^*), S, S^*\right), \qquad (6)$$
$$\text{subject to} \quad W^*\left(k^*(S,S^*), h(S,S^*), S, S^*\right) = \bar{W}^*.$$

- The slopes of the welfare indifference curves (marginal rates of substitution) are equalised across countries:

$$\underbrace{\left.\frac{\mathrm{d}S}{\mathrm{d}S^*}\right|_{\mathrm{d}W=0}}_{=\frac{\mathrm{d}W/\mathrm{d}S^*}{\mathrm{d}W/\mathrm{d}S}} = \underbrace{\left.\frac{\mathrm{d}S}{\mathrm{d}S^*}\right|_{\mathrm{d}W^*=0}}_{=\frac{\mathrm{d}W^*/\mathrm{d}S^*}{\mathrm{d}W^*/\mathrm{d}S}}. \qquad (7)$$

**Proposition 2** *Nationally optimal permit levels are internationally non–optimal (Pareto inefficient).*

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**Proposition 3** *Suppose Home is a net foreign creditor and Foreign a net foreign debtor such that* $0 \leq b < b^*$. *Then, three cases can emerge with respect to the Pareto efficient permit levels* $\left(S^{PE}, S^{*,PE}\right)$*:*

(i) *When at* $\left(S^N, S^{*,N}\right)$ $\mathrm{d}W/\mathrm{d}S^* < 0$ *and* $\mathrm{dMRS}^*/\mathrm{d}S^* < 0$, *then* $S^{PE} > S^N$ *and* $S^{*,PE} < S^{*,N}$.

(ii) *When at* $\left(S^N, S^{*,N}\right)$ $\mathrm{d}W/\mathrm{d}S^* > 0$ *and* $\mathrm{dMRS}^*/\mathrm{d}S^* > 0$, *then* $S^{PE} < S^N$ *and* $S^{*,PE} > S^{*,N}$.

(iii) *When at* $\left(S^N, S^{*,N}\right)$ $\mathrm{d}W/\mathrm{d}S^* < 0$ *and* $\mathrm{dMRS}^*/\mathrm{d}S^* > 0$, *then* $S^{PE} < S^N$ *and* $S^{*,PE} < S^{*,N}$.

# Internationally optimal permit levels

- Case (i): Home's welfare is increased by a decrease in $S^*$ such that Home's welfare can rise even when increasing $S$

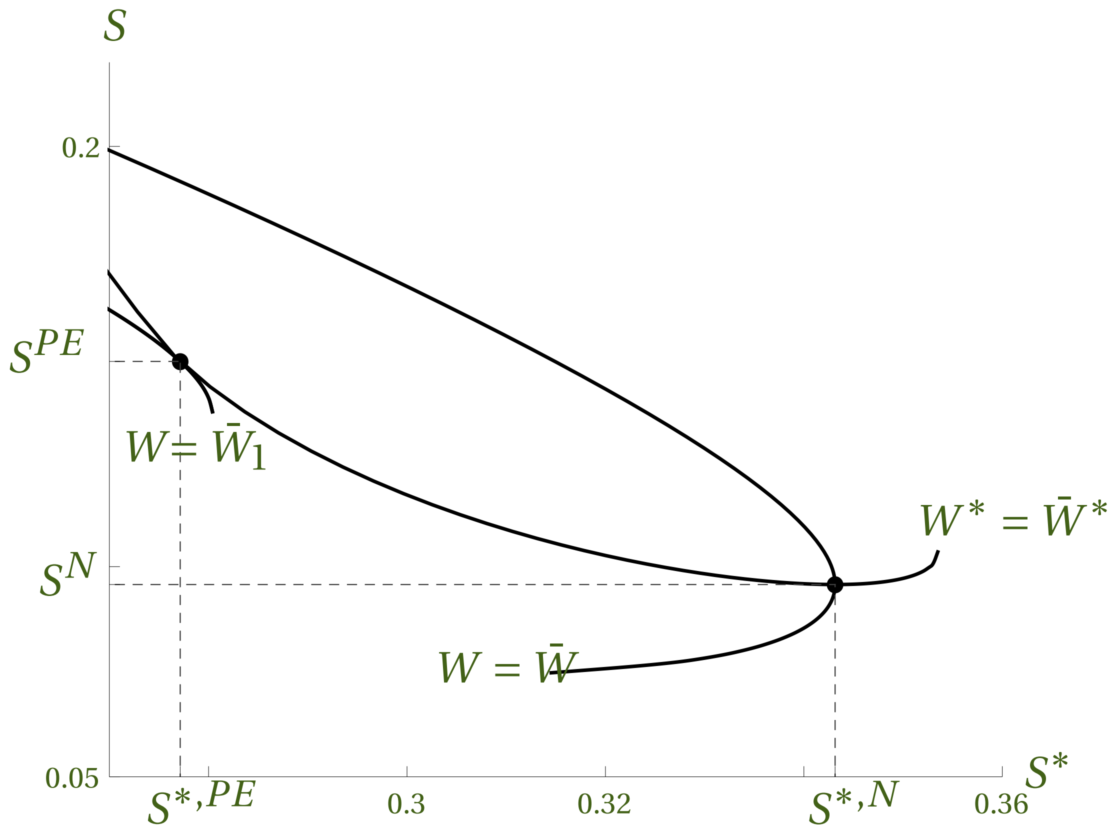


Figure 1: Counteracting permit level adjustments ($S^N < S^{PE}$ and $S^{*,N} > S^{*,PE}$) ($b = 0.15$, $b^* = 0.65$ and $\xi = 0.125$, $\xi^* = 0.1$)

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When Home is a net foreign creditor and has higher environmental preferences than Foreign (case i),

- it is nationally optimal for Home to set a stricter permit level than Foreign,
- Pareto efficiency requires that Foreign reduces its permit level while Home increases its level

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- Case (ii), Home's welfare is affected positively by an increase in $S^*$, but $S$ needs to fall in order to hold Foreign's welfare at its Nash level.

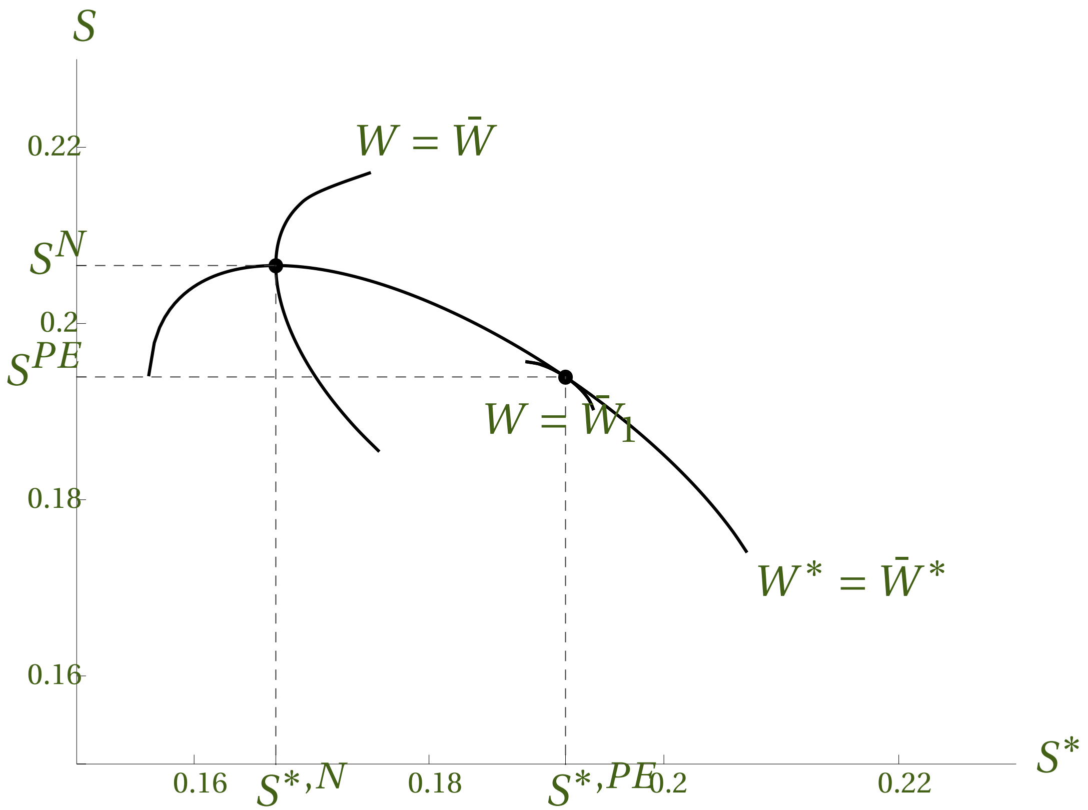


Figure 2: Counteracting permit level adjustments ($S^N > S^{PE}$ and $S^{*,N} < S^{*,PE}$) ($b = 0.15$, $b^* = 0.20$ and $\xi = 0.1$, $\xi^* = 0.125$)

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When Home is a net foreign creditor and has considerably lower environmental preferences but the difference in external balances is not too large (case ii),

- it is nationally optimal for Home to set a laxer permit level than Foreign
- For Pareto efficiency, Home needs to reduce its permit level while Foreign increases its permit level

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- Case (iii) results when Home can benefit from a reduction in both permit levels while Foreign's welfare remains unaffected (at the Nash welfare level).

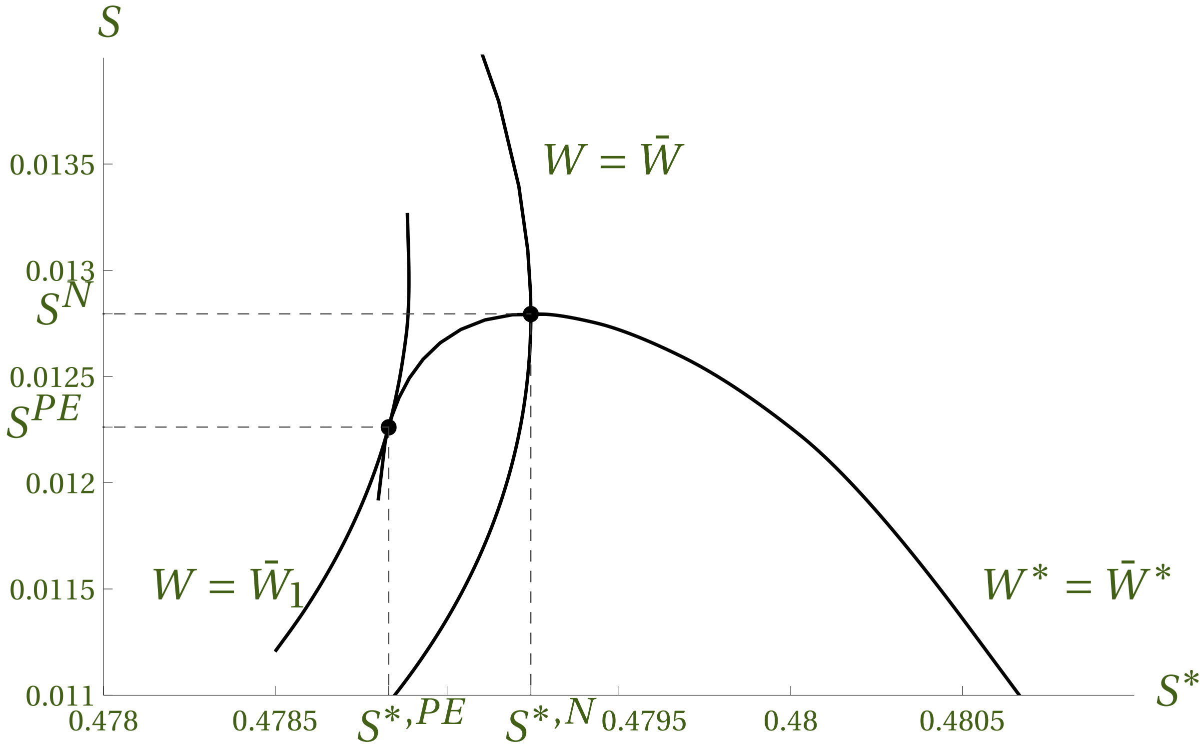


Figure 3: Matching permit level adjustments ($S^N > S^{PE}$ and $S^{*,N} > S^{*,PE}$) ($b = 0$, $b^* = 0.89$ and $\xi = 0.1$, $\xi^* = 0.125$)

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When Home is a net foreign creditor and has lower environmental preferences and the difference in external balances is substantial (case iii),

- Home's nationally optimal permit level is, as in case (i), stricter than in Foreign,
- but for Pareto efficiency Home and Foreign need to reduce their permit levels.

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**Proposition 4** *Suppose that* $\zeta = 1 - \zeta$, $b = 0$ *and* $b^* > 0$ *such that* $i = 0$. *Depending on the relative strength of environmental preferences, two cases can be distinguished:*

(i) *When* $\xi > \xi^*$, *then* $S^{PE} > S^N$ *and* $S^{*,PE} < S^{*,N}$.

(ii) *When* $\xi << \xi^*$, *then* $S^{PE} < S^N$ *and* $S^{*,PE} > S^{*,N}$.

# Conclusions

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- Regarding the empirical relevance of our findings, stylized facts suggest that the EU-15 is a net foreign creditor country with (slightly) higher environmental preferences than the net foreign debtor country US (=case i)
- Given the high uncertainty involved when estimating environmental preferences, also case (iii) could reflect real world circumstances, except for the large difference in external balances
- Case (ii) is certainly not a realistic description of reality and therefore of theoretical relevance only.

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# Conclusions

- A positive external balance decreases nationally optimal permit levels, and the same holds for higher domestic environmental preferences
- Nationally optimal emission permit levels are not internationally optimal (Pareto efficient)
- The direction and strength of differences in external balance and environmental preferences are decisive for internationally optimal permit levels to require either a permit level adjustment in opposite directions or a matched permit level reduction relative to Nash levels

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# References

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