The impact of technological spillovers and capital trade on climate policies

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Shortcomings in current state-of-the-art IA models

- modeling induced technical change
- alternative energy technologies (e.g. biomass energy, carbon sequestration)
- interregional linkages (e.g. foreign investments into the energy sector)
- interactions between climate policies and capital markets
- Concerns of South (e.g., intra- and intergenerational equity and responsibility) are neglected
- Policy instruments are treated exogenously
- Spillovers beyond substitution and leakage effects
- Integration of land use and vegetation models

Hypotheses:

- Technological spillovers will impact cost of climate policy
- Emissions trading will intensify foreign investments and capital trade
- Forerunners in climate policies benefit from spillover effects

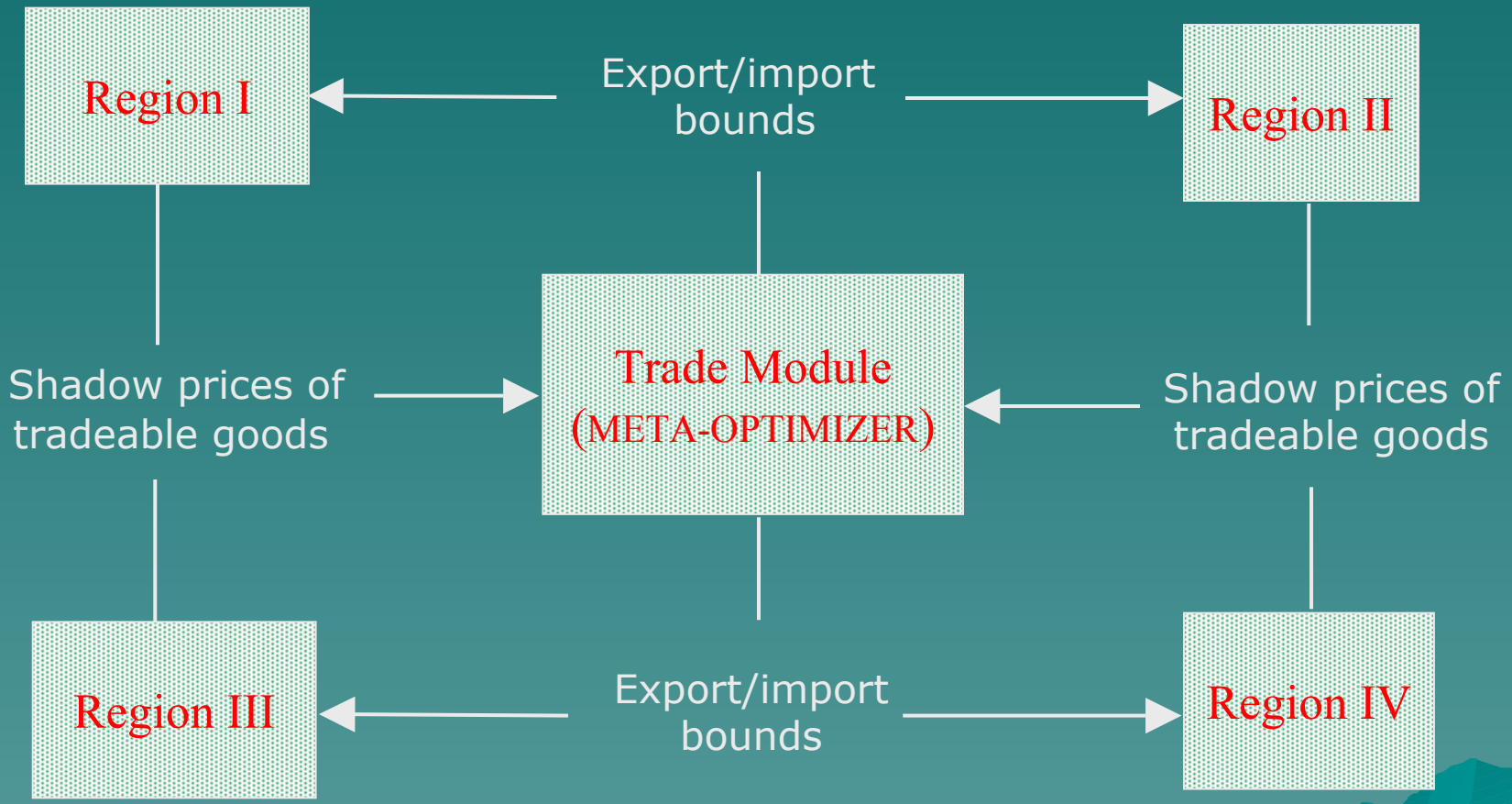
- New approach to multiregion modeling (within an economic growth model framework)
  - Alternative to Negishi approach
  - able to capture technological spillovers triggered by foreign direct investments (exemplary for interregional externalities, IRTS effects)
  - Based on algorithm to find an intertemporal optimum (equilibrium solution)

Capturing technological spillovers

- Negishi approach does not completely internalize spillover effect (production prices)
- Modular approach completely internalizes spillover effect based on distinguished import and export prices:

$$p_{rij}(t)=\partial U_i(t)/\partial X_{rij}(t) \quad pe_{irj}(t)=\partial U_i(t)/\partial X_{irj}(t)$$

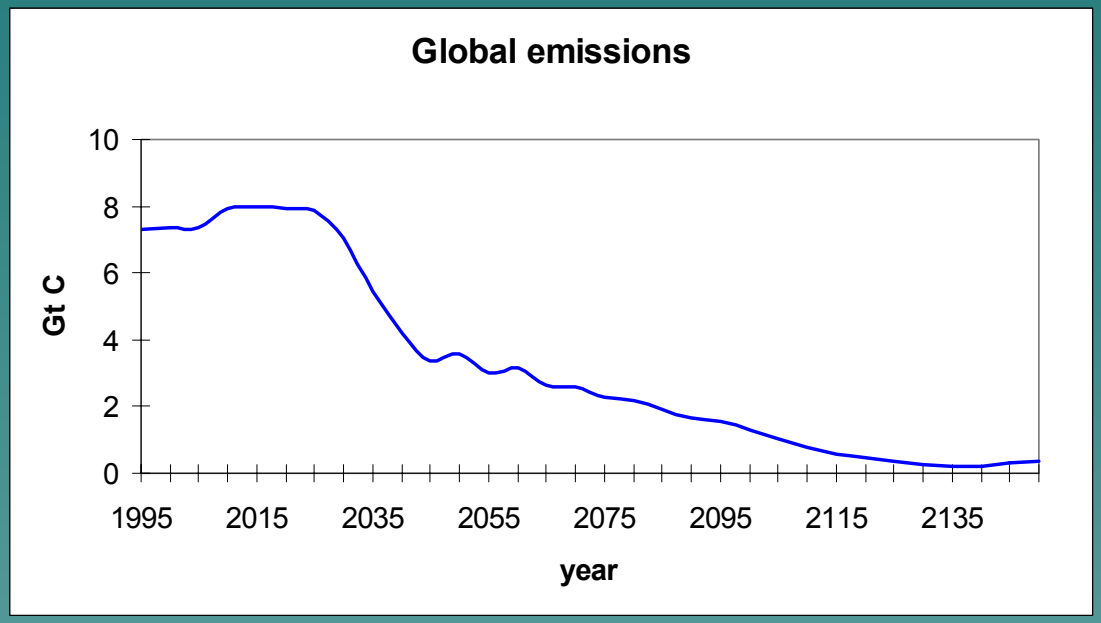
Model Structure



Climate Policy

Keep global mean temperature below 2°C

Resulting global emission paths (from MIND):



International Emissions Trading

- Globally allocated emission rights correspond to global emission path
- Contraction& Convergence allocation rule
- Transition from Grandfathering to Equal per Capita allocation
- Emission permits allow to extract fossil resources

Region modules

- Ramsey type economic growth model (maximizes intertemporal welfare of a representative household)
- Control variables: investments, trade flows, sectoral share on aggregated capital stock
- Foreign trade (consumption good, investment good, energy resources, emission permits)
- Net exports/imports are restricted by bounds:

$$x^{k}_{ir}(t) \le X^{k-1}_{ir}(t) , \qquad x^{k}_{ri}(t) \ge X^{k-1}_{ri}(t)$$

Generic Model – 4 World Regions

- IR1 – industrialized world region, low energy resources endowment (e.g. Europe)
- IR2 – industrialized world region (e.g. North America)
- DR1 – developing world region, high energy resources endowment (e.g. OPEC+)
- DR2 – developing world region, high productivity growth (e.g. China, India)

Spillovers via foreign direct investments

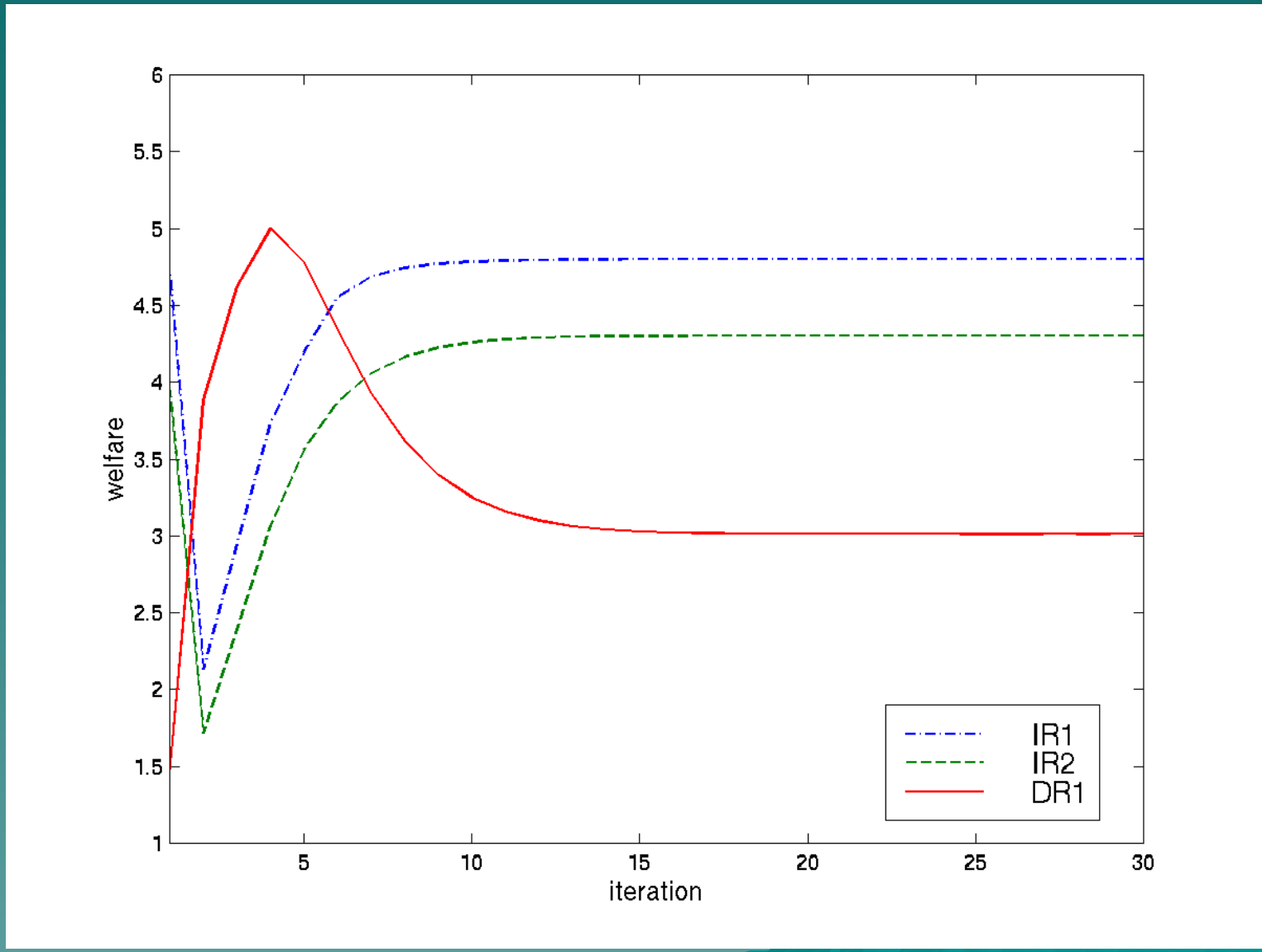
$$\Delta TFP_i = \Sigma_r (FDI_{ri}(t)/K_i(t))^{\gamma} * \beta^*(TFP_r(t)-TFP_i(t))$$

TFP: Total factor productivity

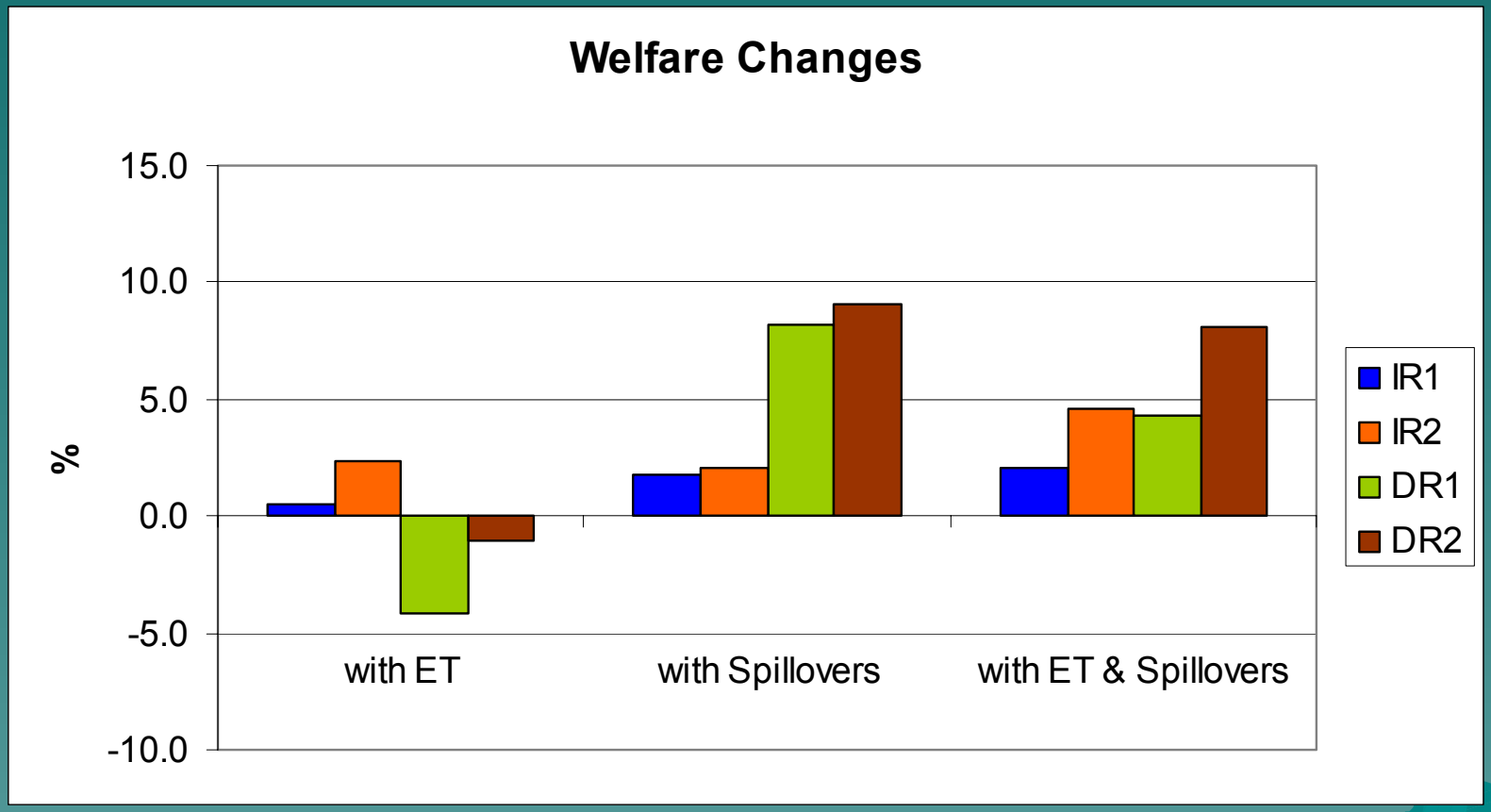
K: Capital stock

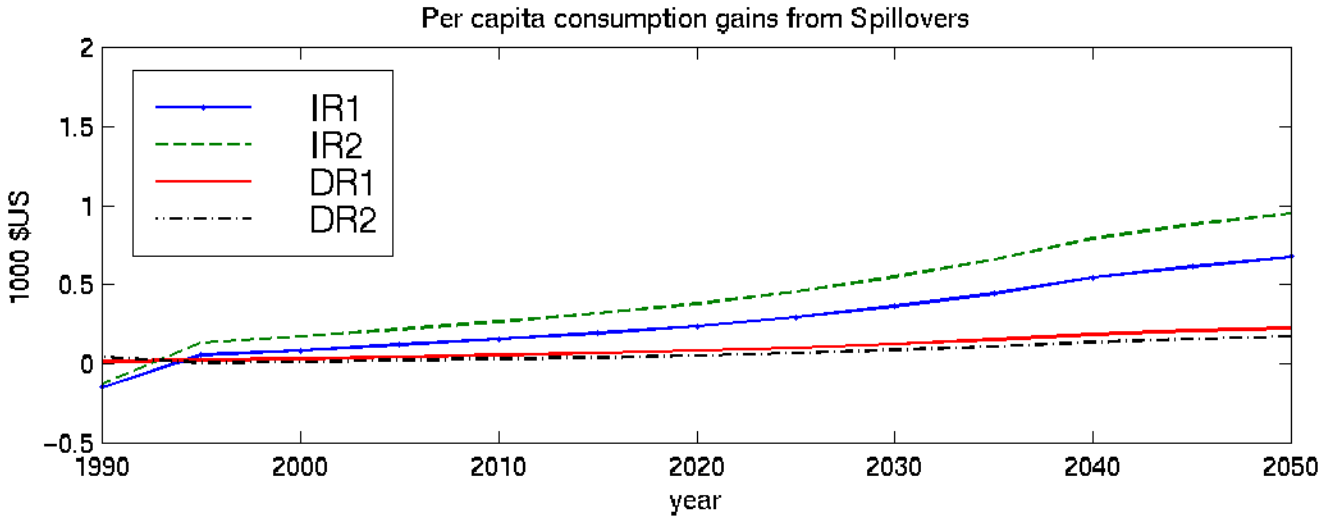
γ, β: Parameters

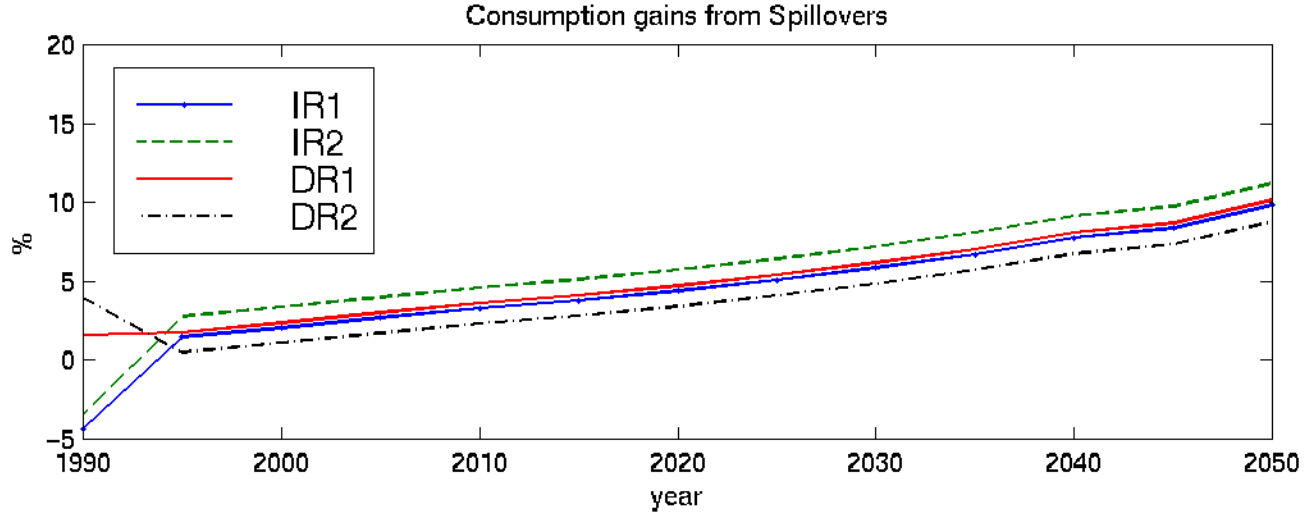
Convergence of regional welfare measure

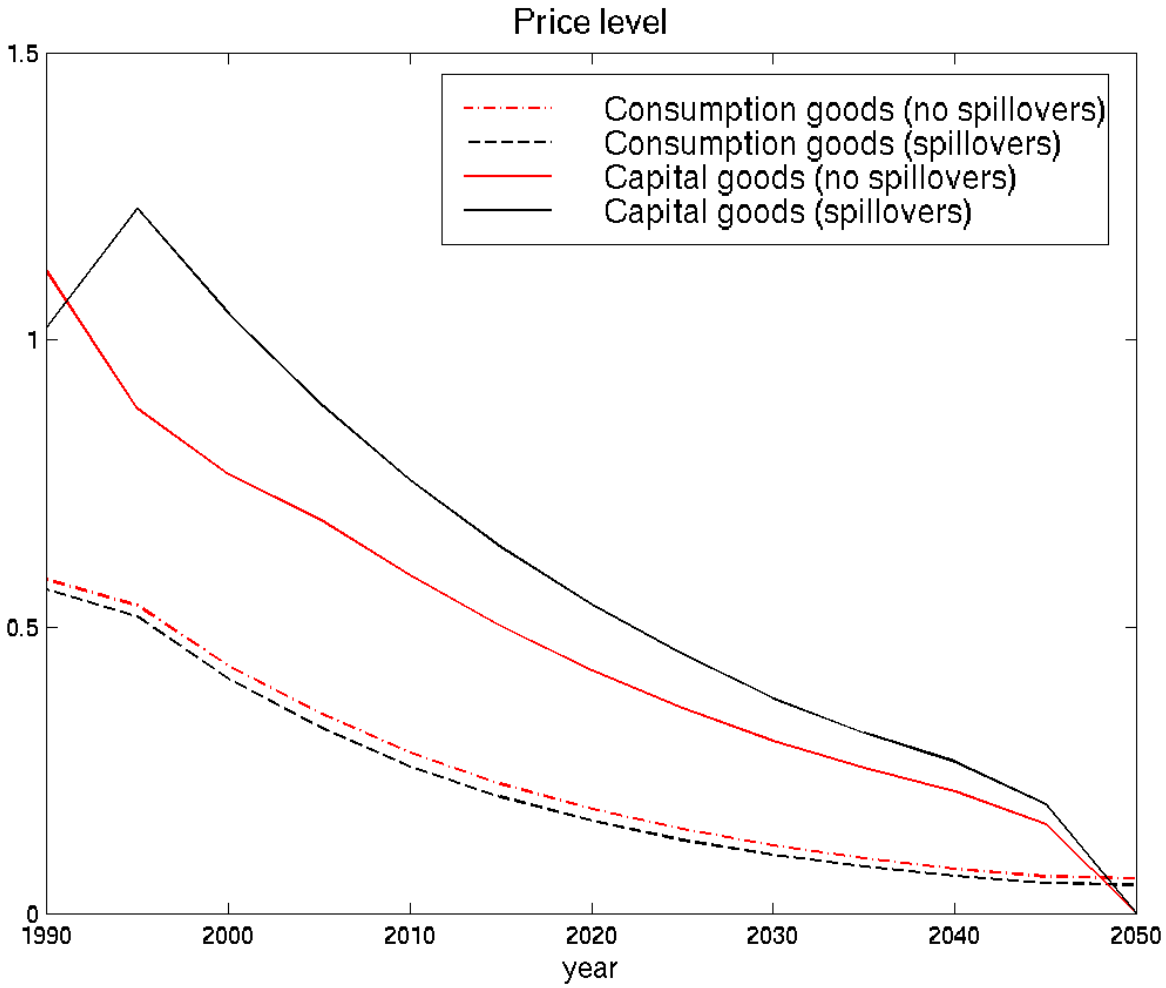


Climate Policy




Per capita consumption gains from Spillovers
1000 $US
year
IR1
IR2
DR1
DR2
2
1.5
1
0.5
0
−0.5
1990
2000
2010
2020
2030
2040
2050


Consumption gains from Spillovers
%
year
IR1
IR2
DR1
DR2
20
15
10
5
0
−5
1990
2000
2010
2020
2030
2040
2050


Price level
Consumption goods (no spillovers)
Consumption goods (spillovers)
Capital goods (no spillovers)
Capital goods (spillovers)
1.5
1
0.5
0
1990
2000
2010
2020
2030
2040
2050
year

REMIND1.0

Incorporates advanced features of the global IA model MIND:

- endogenous technological change (LBD, R&D)
- separate energy and extraction sector
- Investment dynamics
- No CCS

4 World Regions:

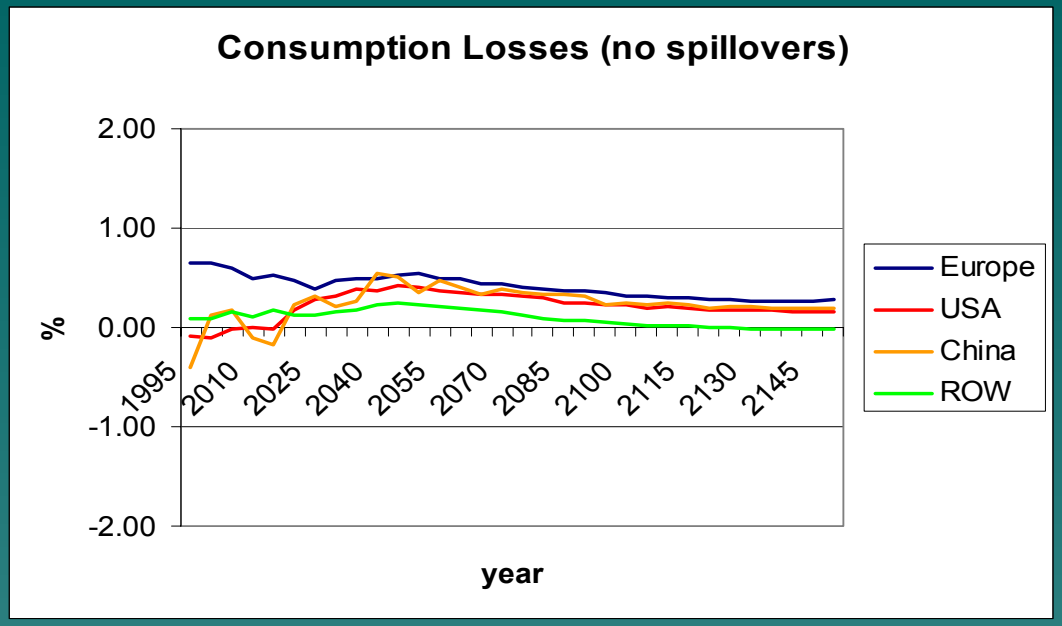
- Europe – industrialized world region, low energy intensity
- USA – industrialized world region, high labour productivity
- China – developing world region, high productivity growth
- ROW

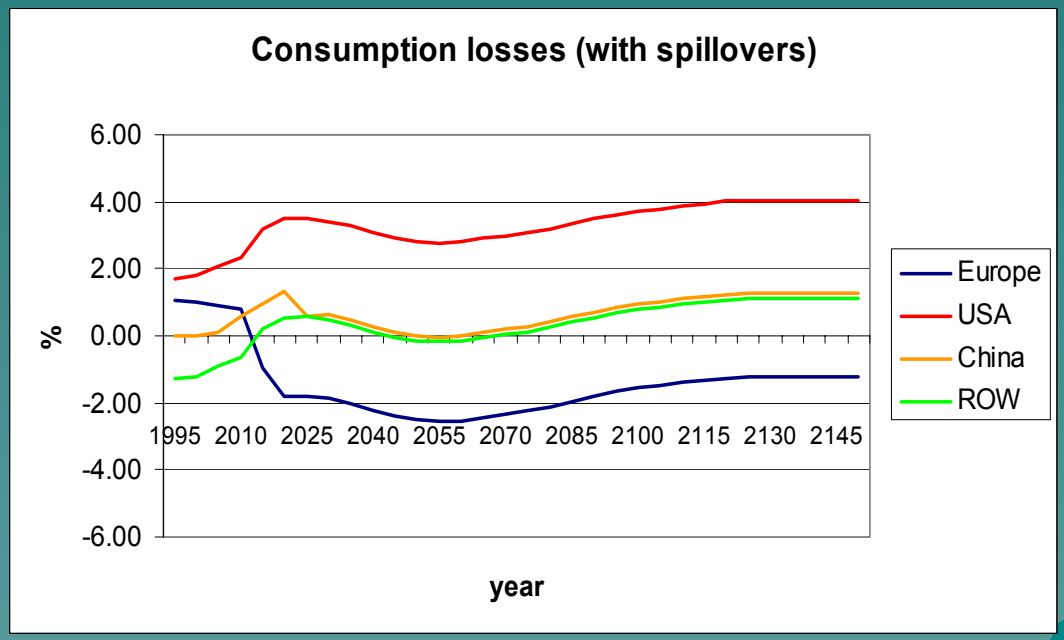
Spillovers via foreign direct investments

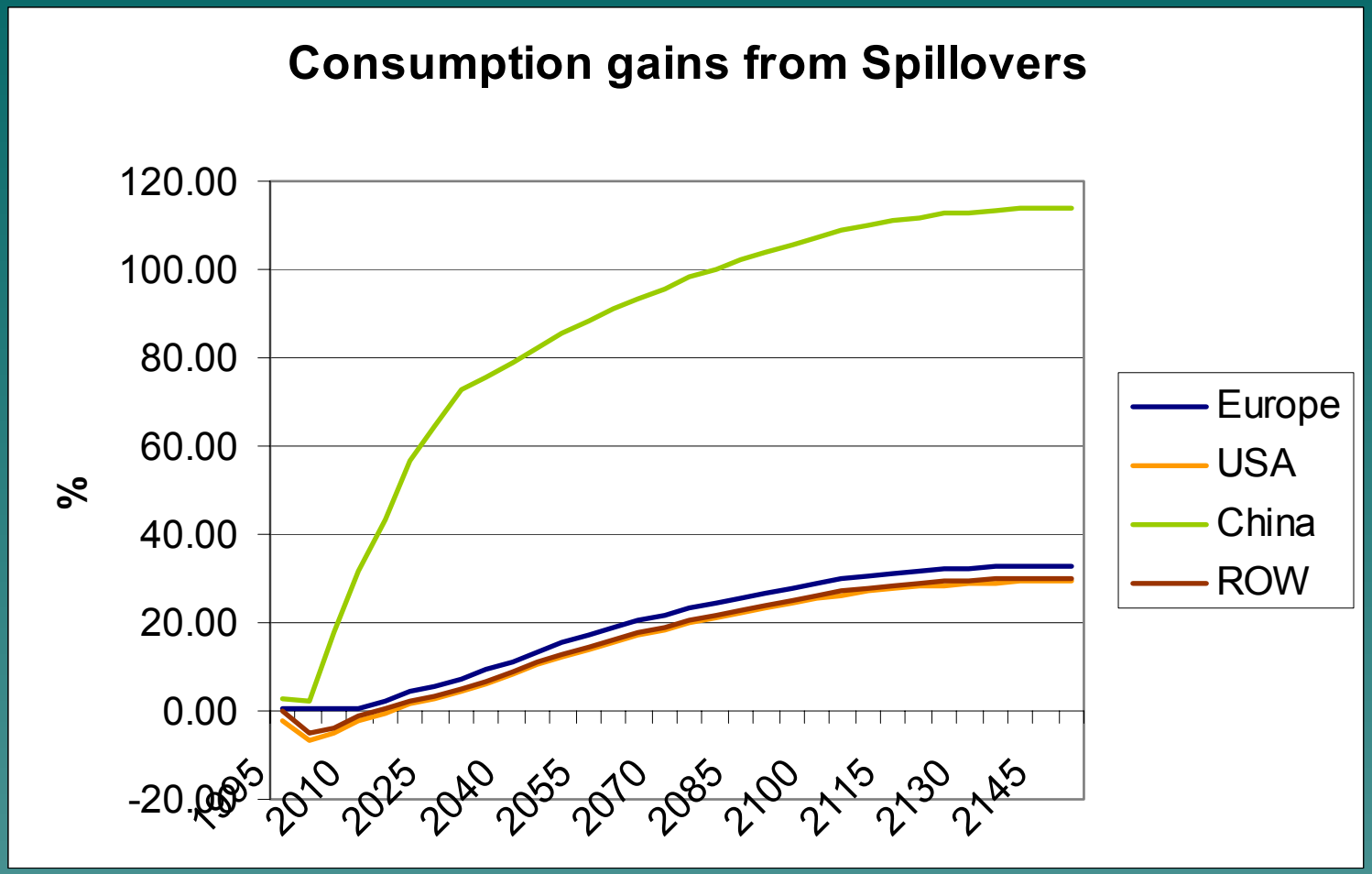
$$\Delta LE_i = FDI_{USA,i}(t)/K_i(t)^{\gamma} * \beta*(LE_{USA}(t)-LE_i(t))$$

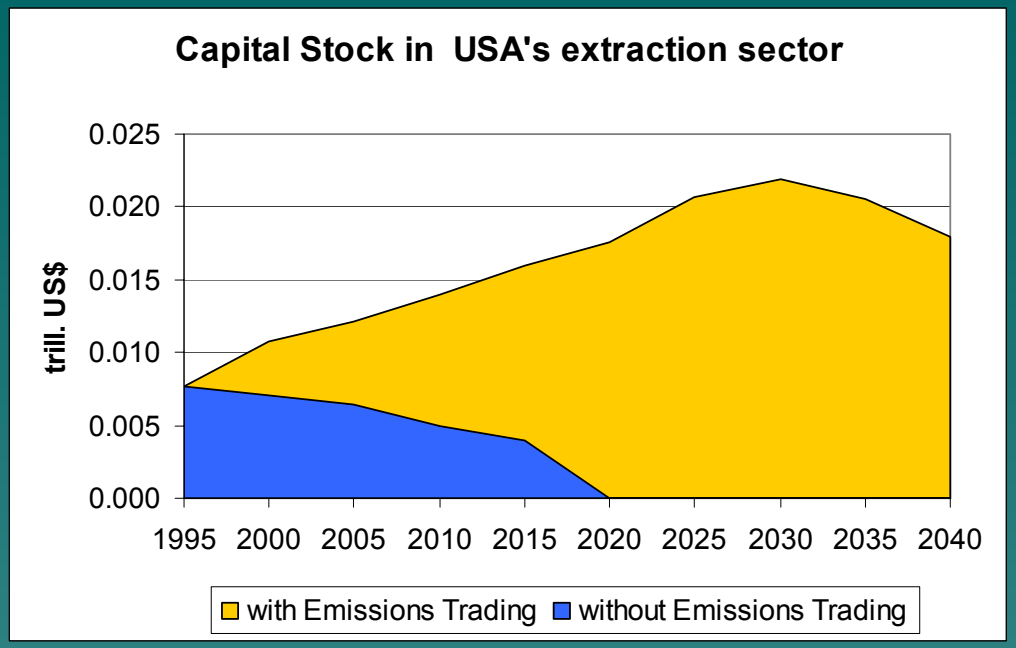
$$\Delta EE_i = FDI_{EUR,i}(t)/K_i(t)^{\gamma} * \beta*(EE_{EUR}(t)-EE_i(t))$$

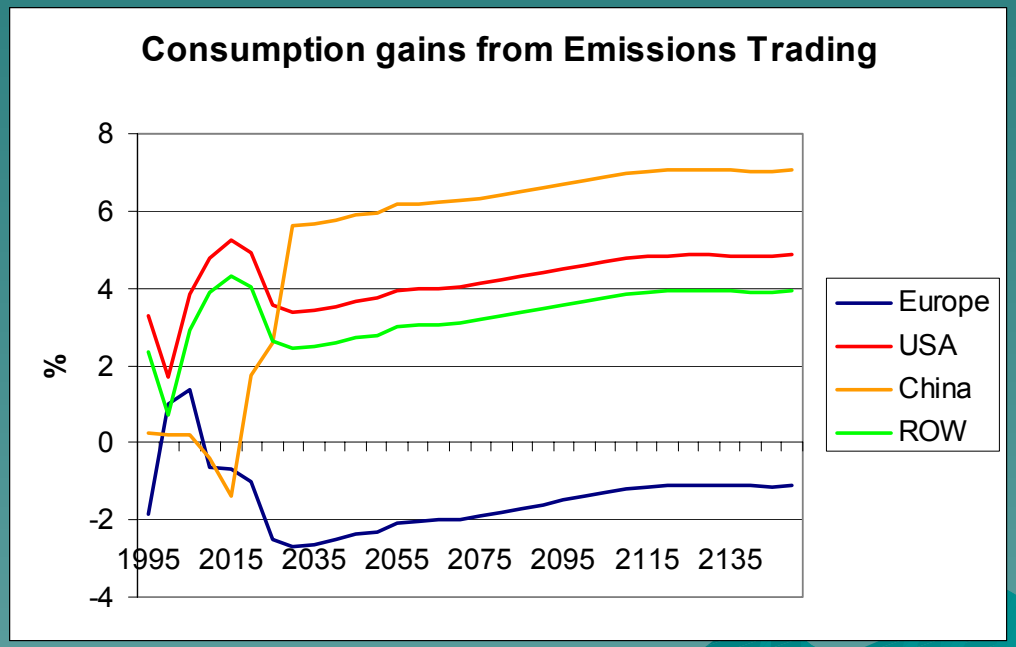
LE: Labour efficiency
EE: Energy efficiency
K: Capital stock
γ, β: Parameters

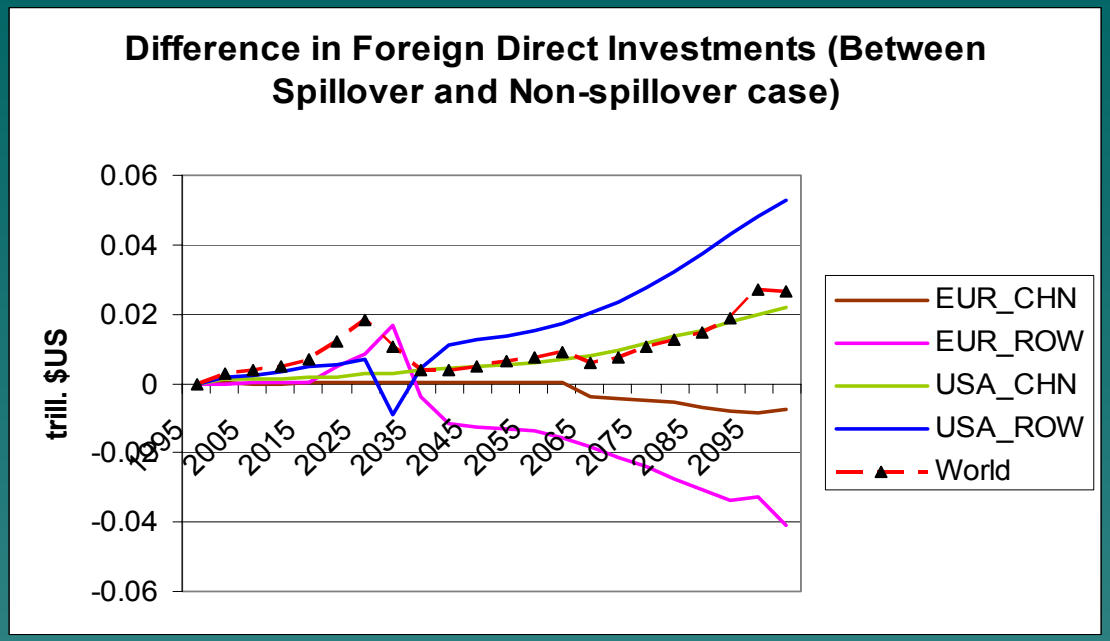

Consumption Losses (no spillovers)
2.00
1.00
0.00
-1.00
-2.00
%
1995
2010
2025
2040
2055
2070
2085
2100
2115
2130
2145
year
Europe
USA
China
ROW

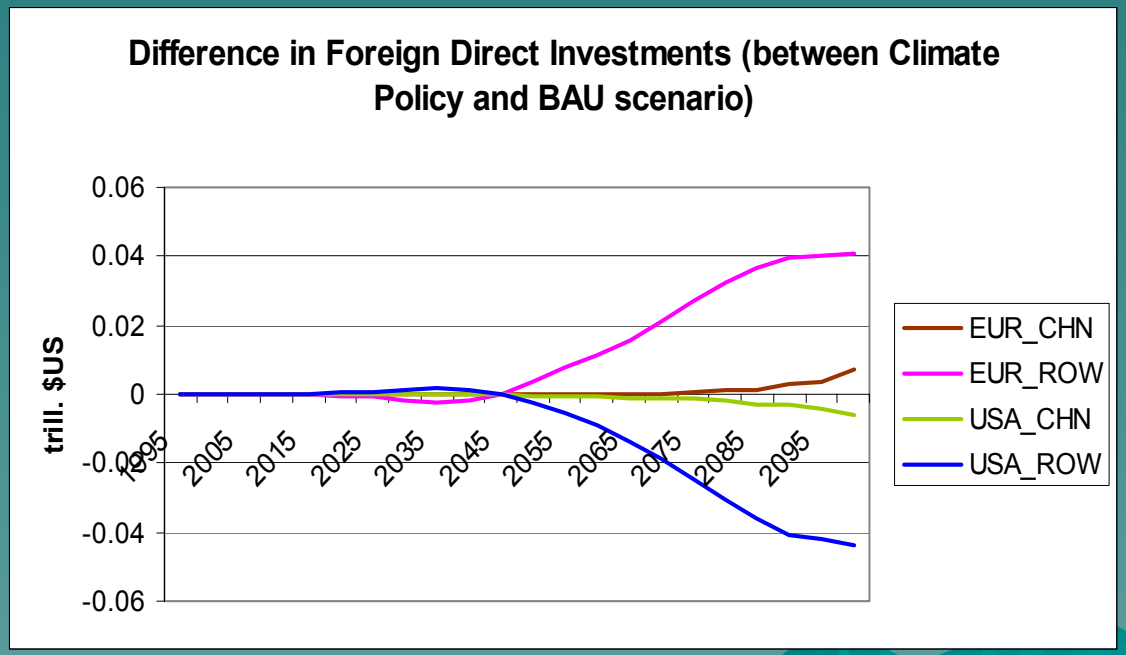

Consumption losses (with spillovers)
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
%
1995 2010 2025 2040 2055 2070 2085 2100 2115 2130 2145
year
Europe
USA
China
ROW

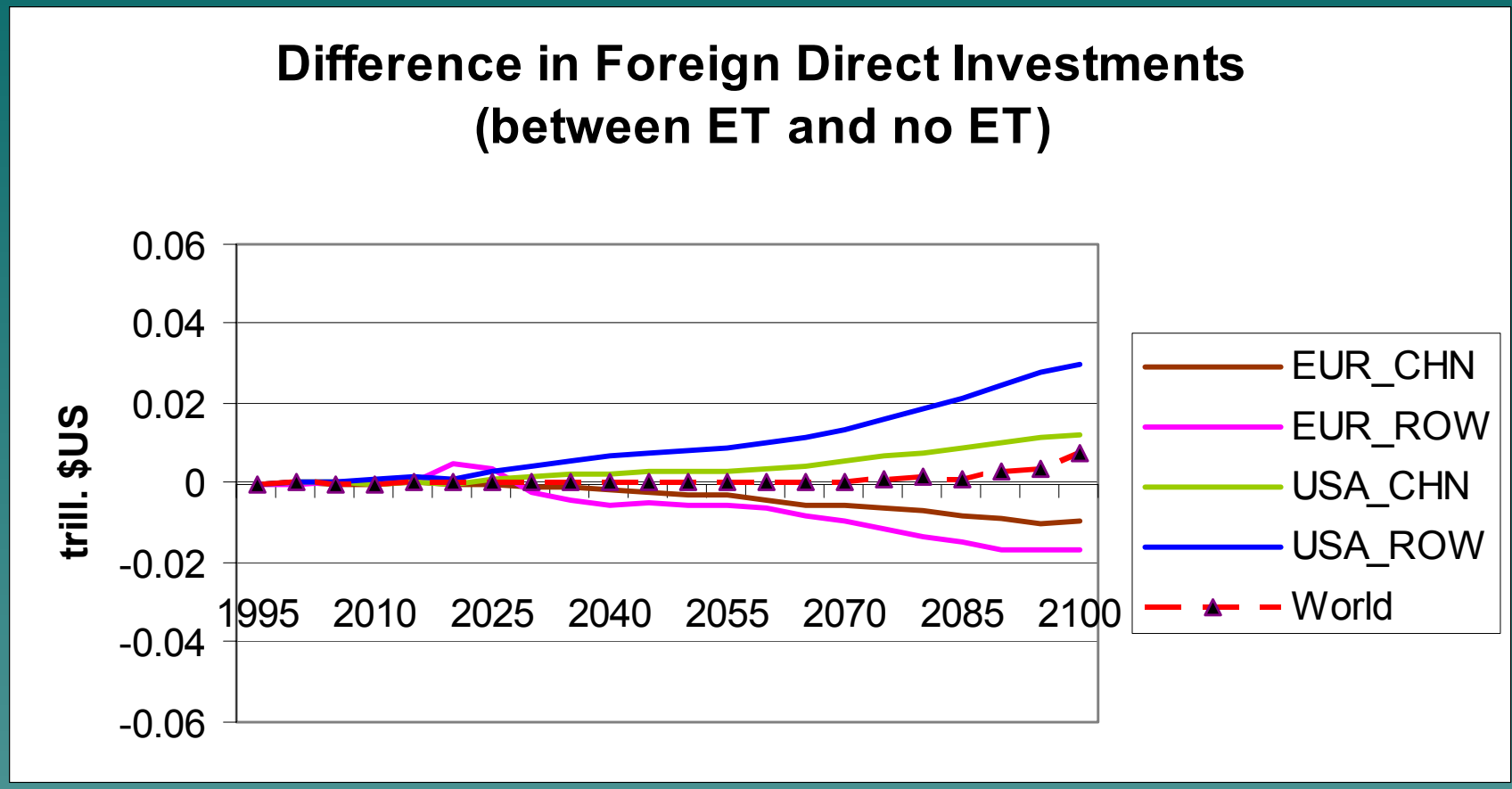

Consumption gains from Spillovers
120.00
100.00
80.00
60.00
40.00
20.00
0.00
-20.00
%
1995
2010
2025
2040
2055
2070
2085
2100
2115
2130
2145
Europe
USA
China
ROW


Capital Stock in USA's extraction sector
0.025
0.020
0.015
0.010
0.005
0.000
trill. US$
1995 2000 2005 2010 2015 2020 2025 2030 2035 2040
with Emissions Trading
without Emissions Trading


Consumption gains from Emissions Trading
8
6
4
2
0
-2
-4
%
1995 2015 2035 2055 2075 2095 2115 2135
Europe
USA
China
ROW


Difference in Foreign Direct Investments (Between Spillover and Non-spillover case)
trill. $US
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
1995
2005
2015
2025
2035
2045
2055
2065
2075
2085
2095
EUR_CHN
EUR_ROW
USA_CHN
USA_ROW
World


Difference in Foreign Direct Investments (between Climate Policy and BAU scenario)
trill. $US
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
1995
2005
2015
2025
2035
2045
2055
2065
2075
2085
2095
EUR_CHN
EUR_ROW
USA_CHN
USA_ROW


Difference in Foreign Direct Investments
(between ET and no ET)
trill. $US
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
1995
2010
2025
2040
2055
2070
2085
2100
EUR_CHN
EUR_ROW
USA_CHN
USA_ROW
World

Preliminary Conclusions

- Modelling technological spillovers will result in higher consumption levels
- Technological spillovers lead to different regional cost of mitigation
- Emissions trading and Climate Policy change the direction of foreign investments
- Forerunners in climate policy benefit from spillovers