

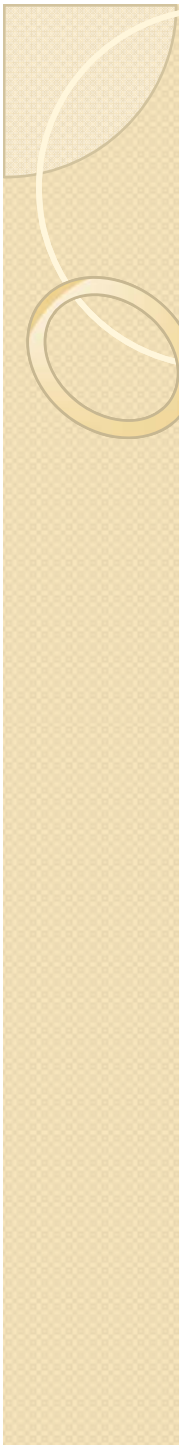
Analysis of Climate Policies with GDyn-E

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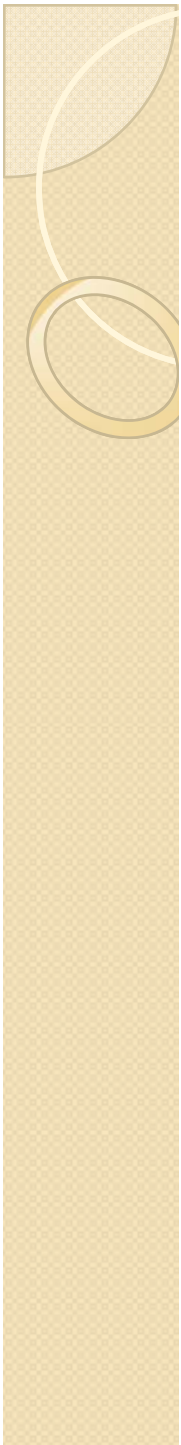
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Outline

- GDyn-E overview
- Application
 - Emission leakage associated with climate change mitigation
 - Decomposition
 - Sensitivity analysis
- Next steps

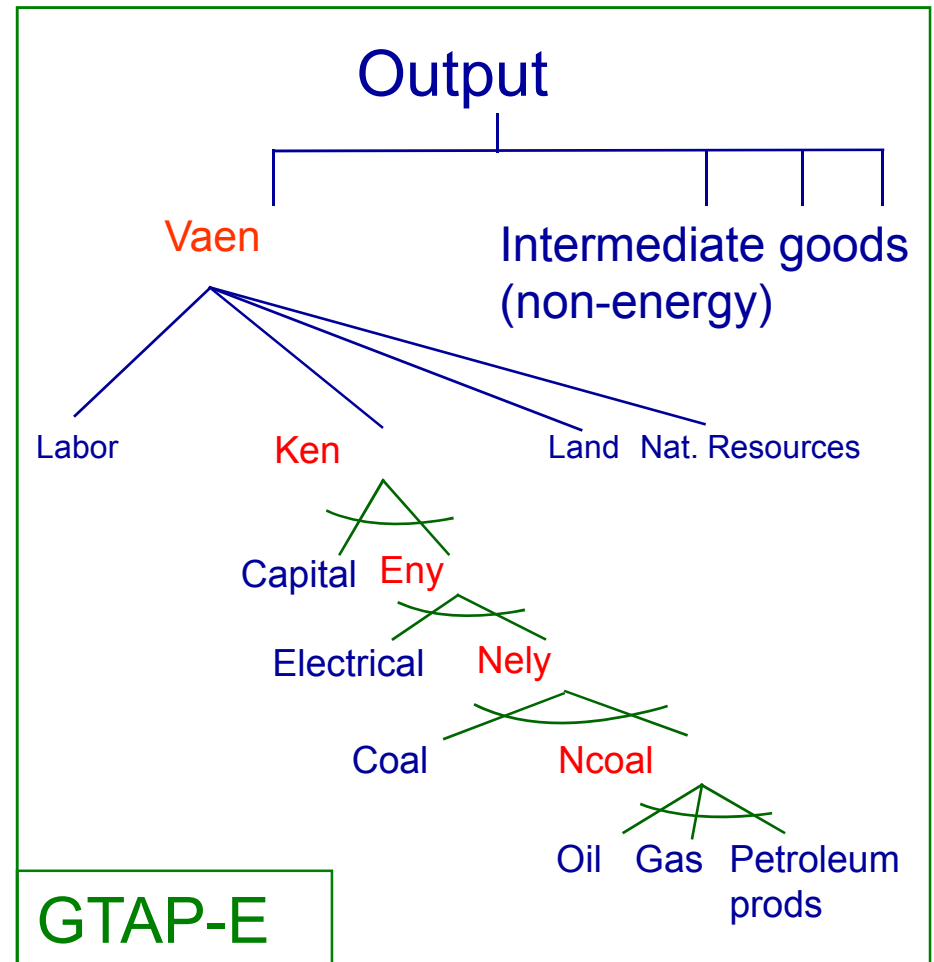
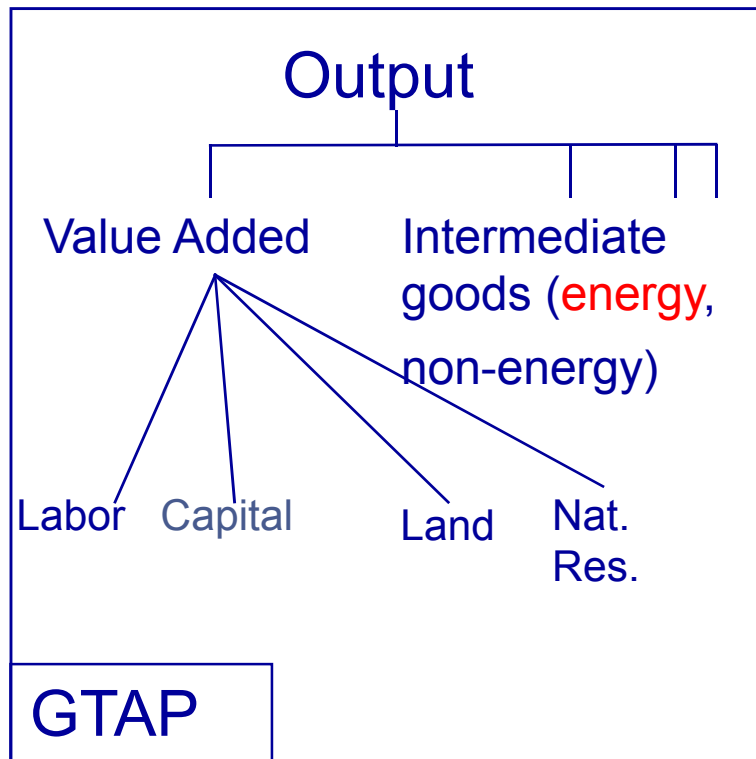


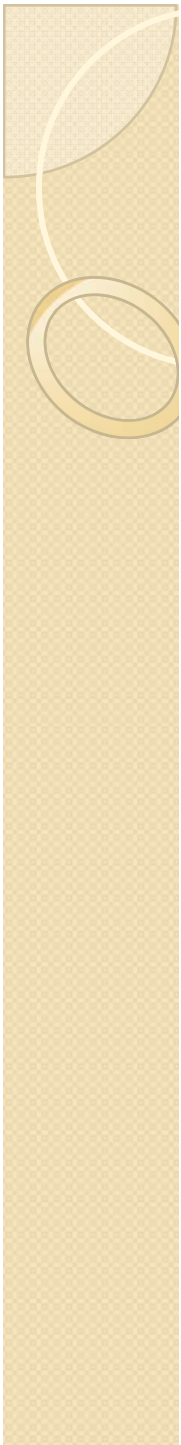
GDyn-E overview

- Merge two models
 - Dynamic GTAP model GDyn (Ianchovichina and McDougall, 2001)
 - Disequilibrium mechanism for determining the regional supply of investments
 - GTAP-E (Burniaux and Truong, 2002; McDougall and Golub, 2007)
 - Energy substitution in production and consumption
 - Carbon dioxide emissions from fossil fuel combustion
 - No non-CO2 emissions and no carbon-free energy sources
 - Emission trading

Production Structure: GTAP-E

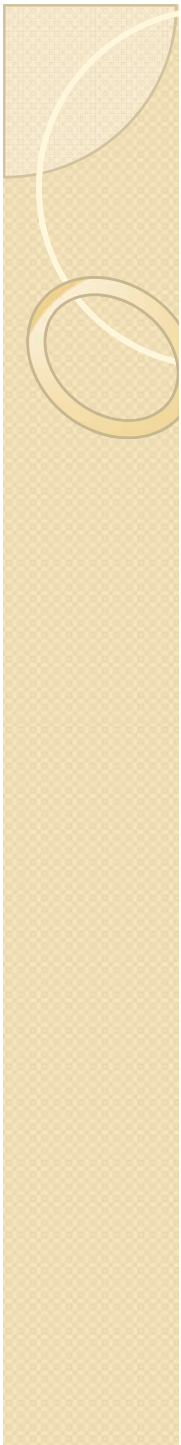
= GTAP + energy substitution (inter-KE and inter-fuel)





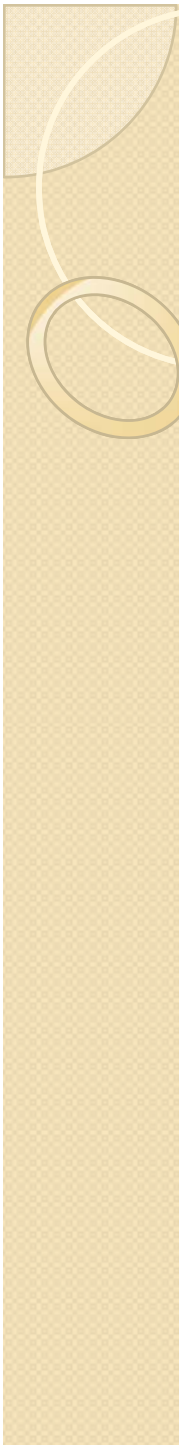
GDyn model

- Multi-sector, multi-region, recursive dynamic GE model
- Extends standard static GTAP model (Hertel, 1997)
 - Time path of the global economy
 - Endogenous capital accumulation
 - Adaptive expectations theory of investments
 - International capital mobility
 - Disequilibrium approach
 - Imperfect capital mobility in the short to medium run (disparities in the rates of return across regions)
 - Perfect capital mobility in the long run (disparities are eliminated)
 - Asset location and asset ownership are separately defined
 - Foreign capital ownership and foreign income flows



Emission leakage associated with climate change mitigation

- Earlier work by Burniaux (2001)
- GHG emission reduction policy implemented by a group of countries may result in increase in emissions in the rest of the world, or “carbon leakage”
- Illustrative scenario: Annex I countries reduce their emissions from 2004 to 2020
- The “leakage rate” is defined as the ratio of the additional emissions in the non-Annex I countries to the emission reduction achieved in Annex I countries



Channels of carbon leakage

(Burniaux, 2001)

- Non energy
 - Loss of competitiveness of energy-intensive industries in countries reducing emissions
 - Reallocation of foreign direct investments to non-participating countries
- Energy
 - Reduction in international fossil fuel prices results in increase in energy demand and emissions in non-participating countries
 - Supply response of fossil-fuel producers
 - Flexibility of production function

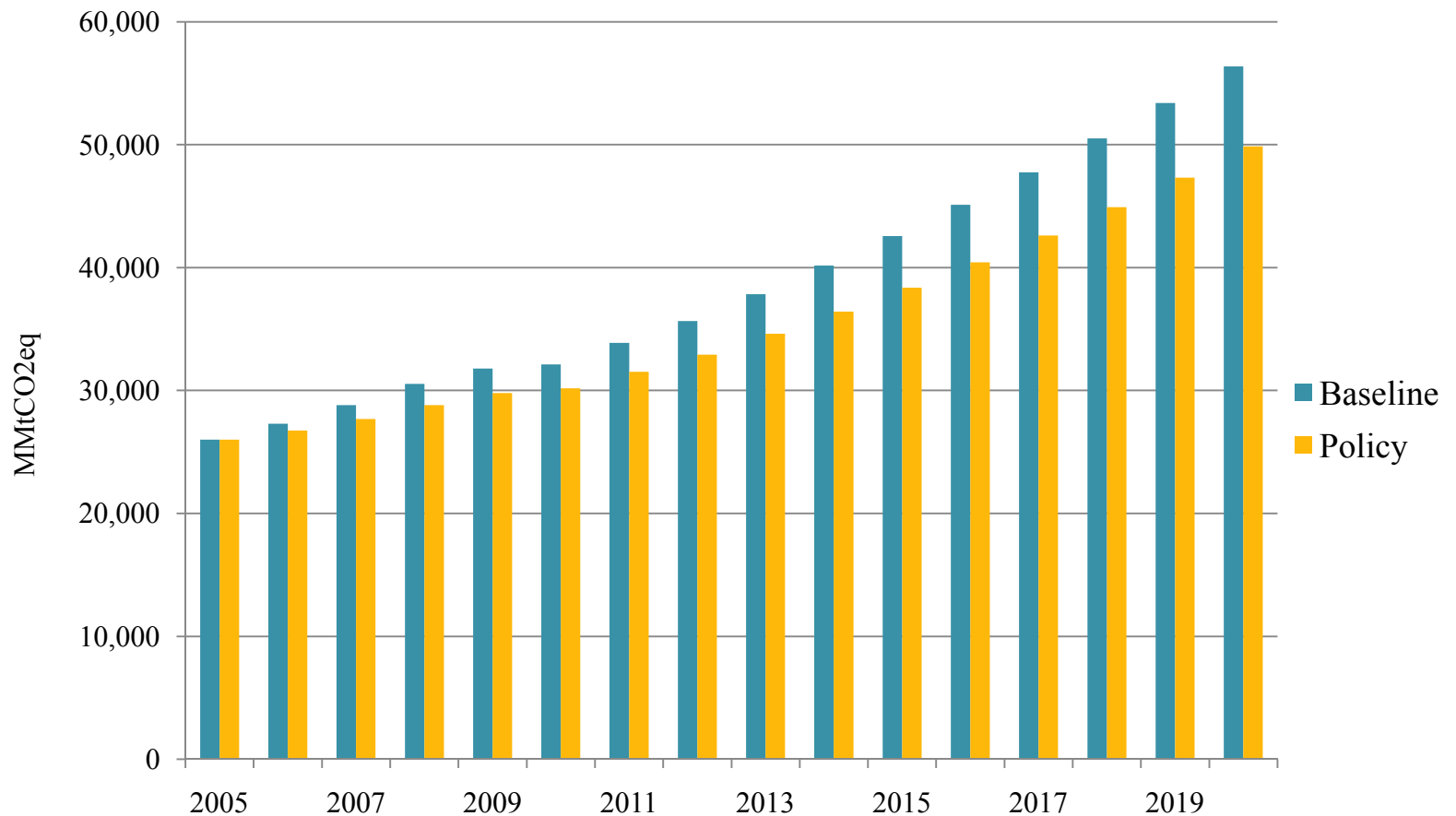
Baseline

- Starting point is the world economy in 2004, as depicted in the GDyn v.7 data base
 - 21 sector x 20 region aggregation
- Use GDyn v7 Baseline (Chappuis and Walmsley, 2011)
 - Population and skilled and unskilled labor growth rates
 - 2004-2010 GDP growth rates
- GDP growth
 - Exogenous 2004-2010 (GDyn v.7 baseline)
 - Endogenous 2011-2020
 - Assumption about economy-wide factor productivity growth rate
Examples: China 8%, India 7%, USA 2%

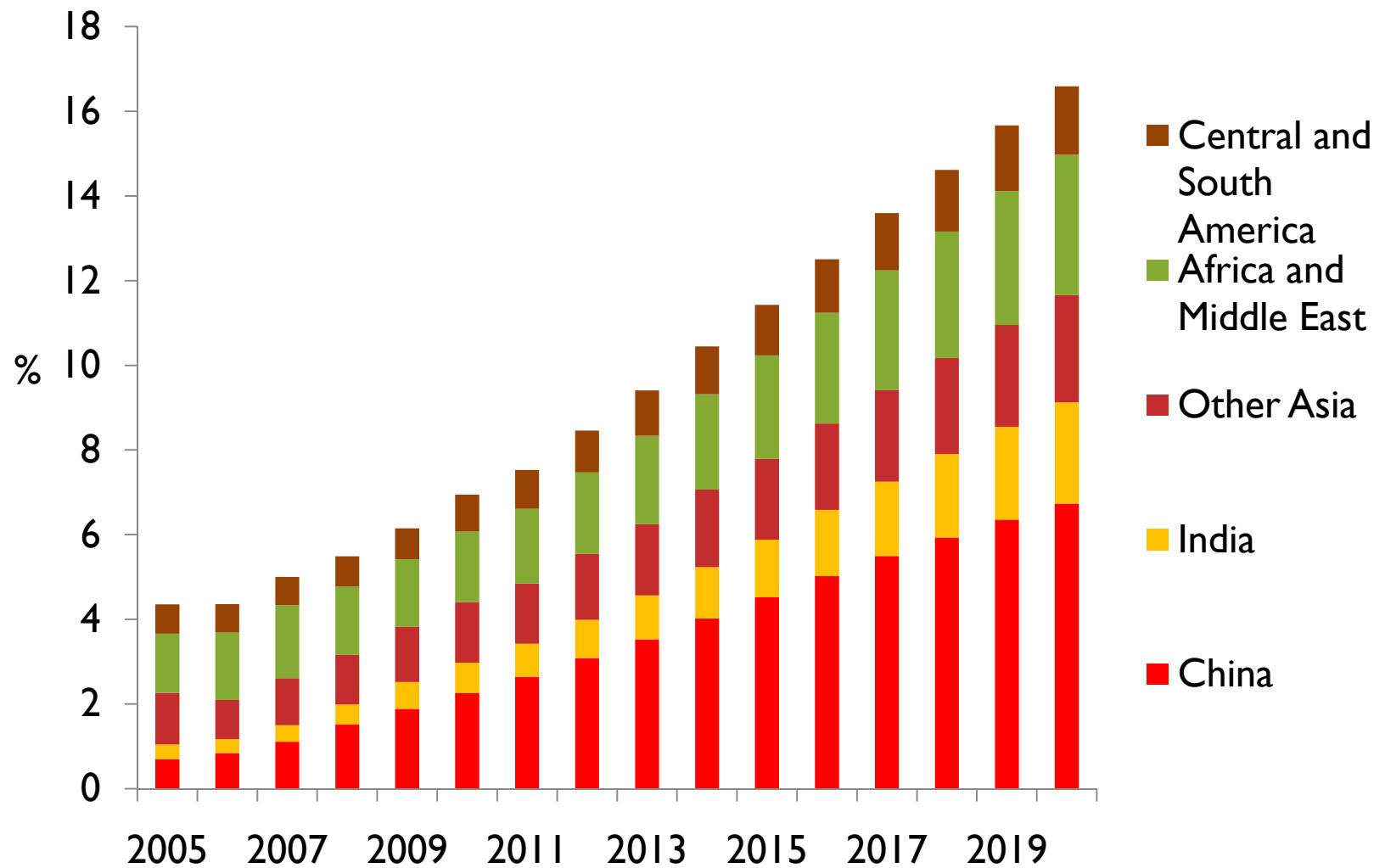
Policy

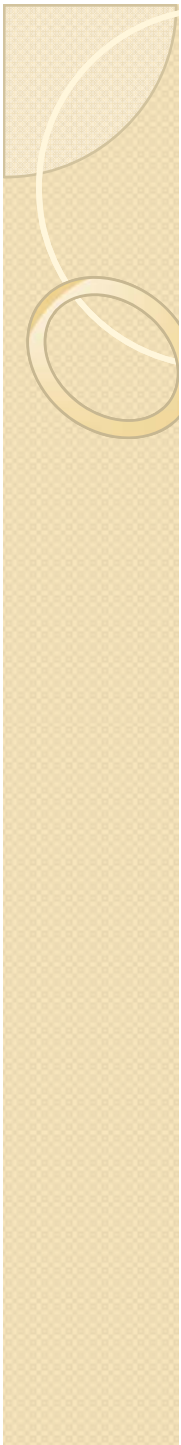
Annex I region	Copenhagen commitment to reduce emissions by 2020	GDyn-E change in emissions, %/year
EU27	20% compared with 1990	-1.158
Japan	25% compared with 1990	-2.6
Canada	17 % compared with 2005	-1.158
Oceania	New Zealand: 10-20% compared with 1990 Australia: 5-25% compared with 2000	-1.8
Russia	15–25 % compared with 1990	0.5
Other Europe	Norway: 30% compared with 1990	-3.6
Other CEE CIS	Belarus: 5–10 % compared with 1990 Ukraine: 20% compared with 1990	3.6
USA	17% compared with 2005	-1.158

Global emissions from fossil fuel combustion



Carbon leakage

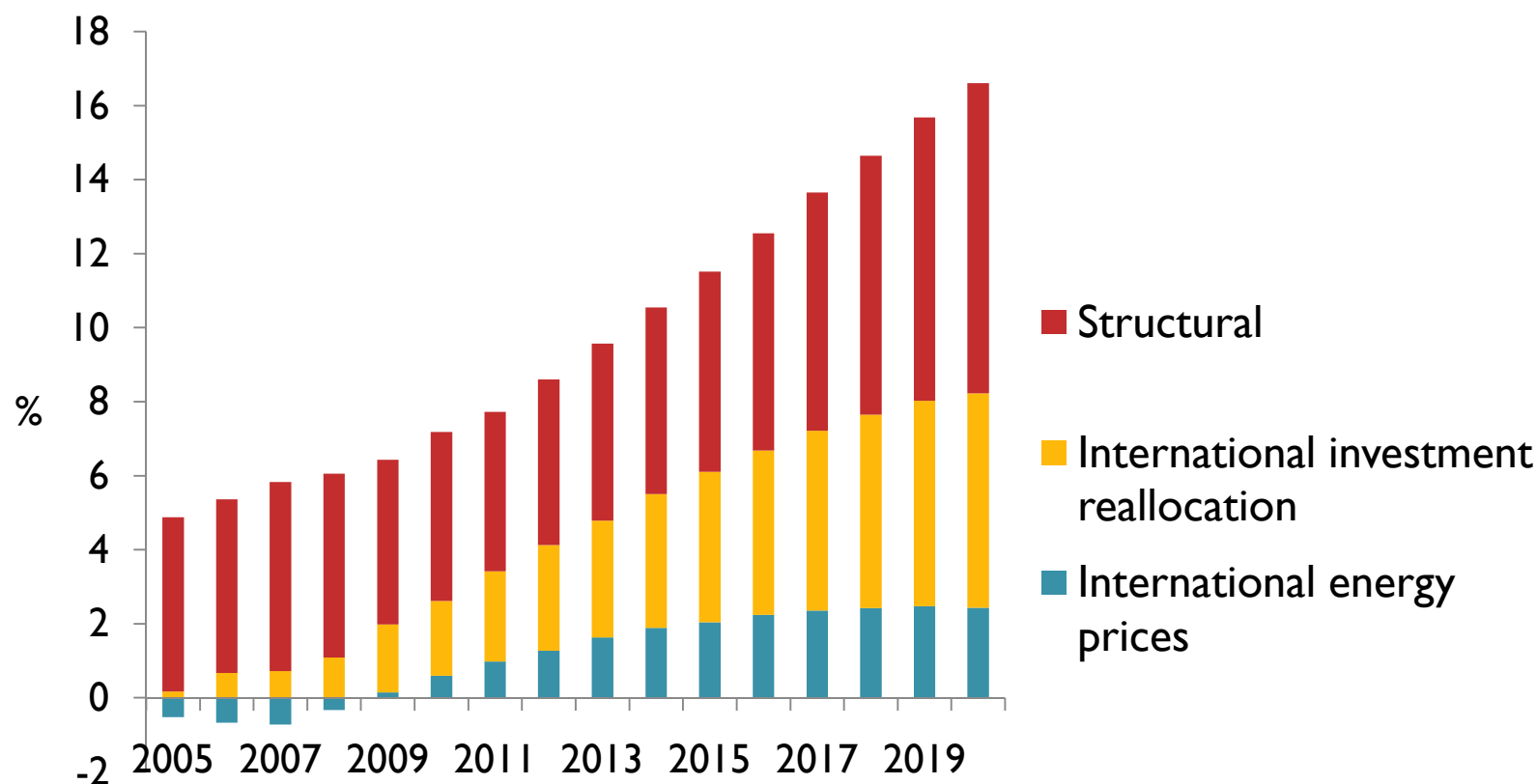




Decomposition of carbon leakage

- Two intermediate scenarios between policy and baseline (Burniaux, 2001)
 - (1) Annex I emission reduction scenario with fossil fuel prices fixed at the baseline level
 - (2) As above, plus capital stock in each region is kept fixed at the same level as in the baseline scenario
- Three channels of carbon leakage
 - International energy prices
 - Policy – (1)
 - International reallocation of investment
 - (1) – (2)
 - Structural
 - (2) – baseline

Decomposition of carbon leakage



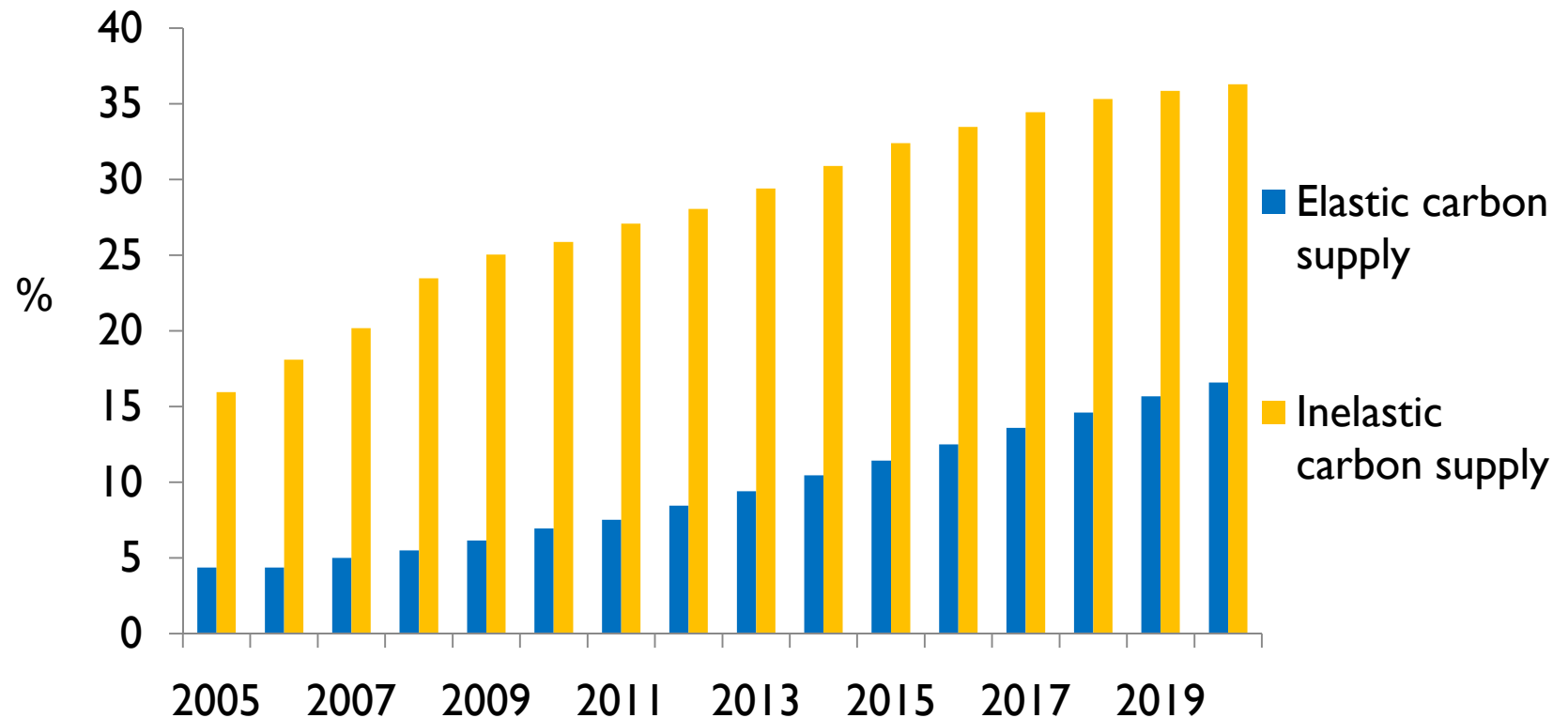
Initial negative leakage through international energy prices channel

- Oil and gas are in inelastic supply relative to coal
- When Annex I reduces emissions, world oil and gas prices fall more relative to coal
- Non-Annex I producers use more oil and gas and less coal

Production structure parameters

Element of GDyn-E production structure	Standard GTAP-E parameters (Burniaux and Truong)	Alternative parameters (Beckman, Hertel and Tyner)
Value added – energy in: Coal Oil Gas	3 - 4 (supply el. 10) 0.32-0.4 (supply el. 1) 0. - 1.55 (supply el. 4)	0.32-0.4 (supply el. 1) 0.08-0.1 (supply el. 0.25) 0. - 0.23 (supply el. 0.6)
Capital – energy (all)	0.5	0.25
Electricity – non electricity (all)	1	0.16
Coal – non coal (all)	0.5	0.07
Oil, gas, petroleum products (all)	1	0.25

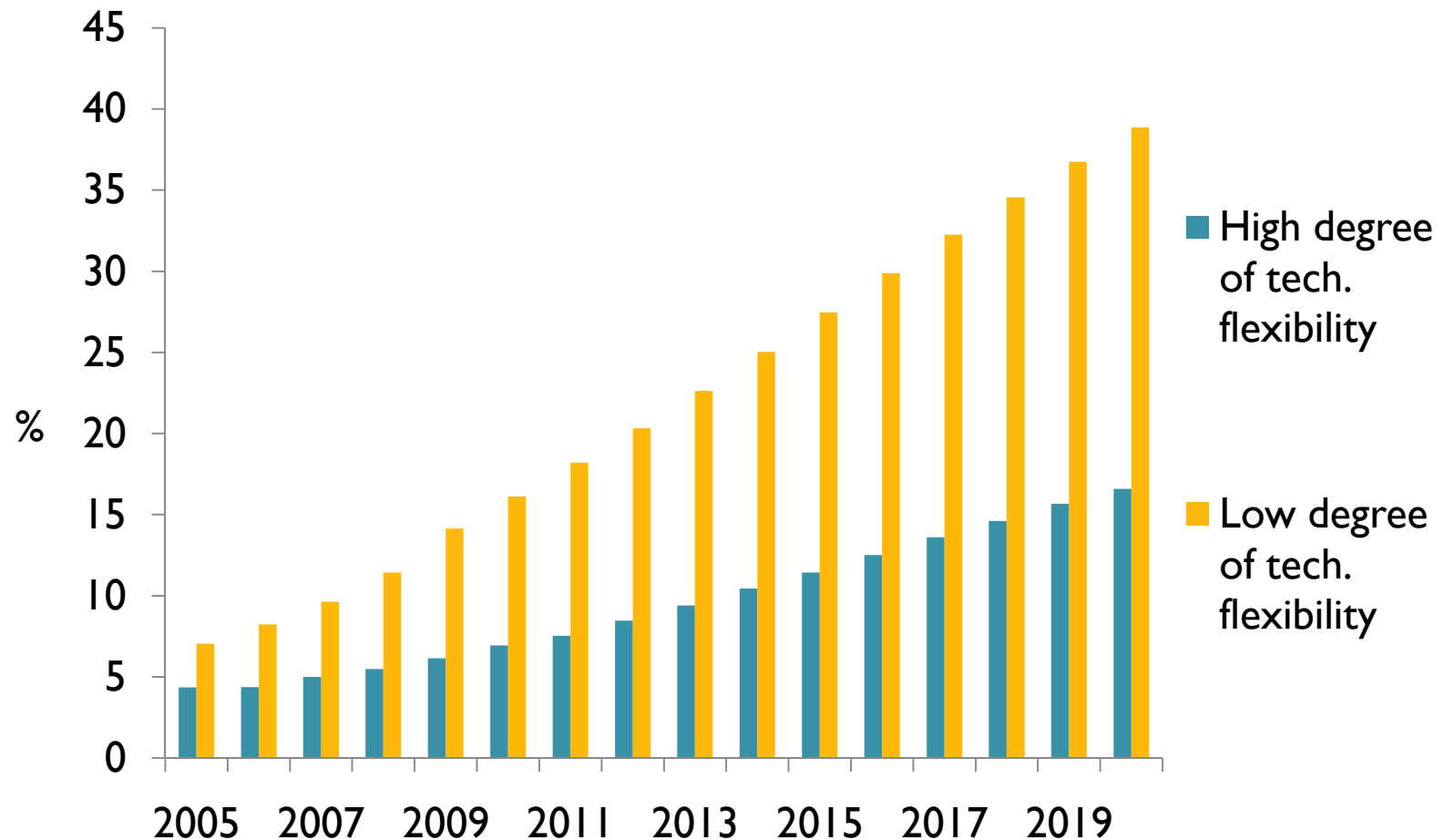
Supply elasticity of carbon matters for the size of carbon leakage



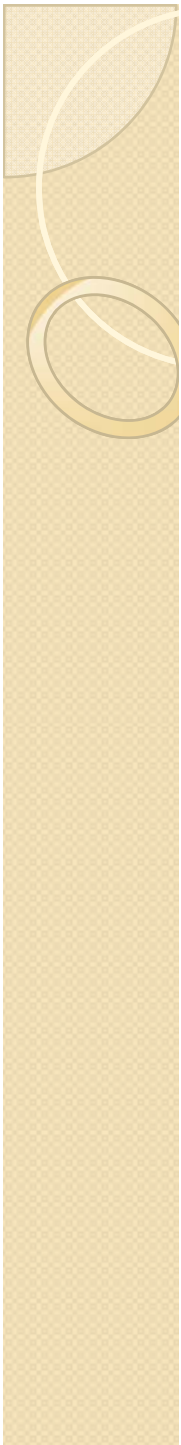
Elastic carbon supply in Burniaux and Truong (2002)

Inelastic carbon supply in Beckman, Hertel and Tyner (forthcoming)

Degree of substitution in the production function matters for size of carbon leakage



High degree of inter fuel substitutability in Burniaux and Truong (2002)
Low degree of inter fuel substitutability in Beckman, Hertel and Tyner (forthcoming)



Summary

- GDyn-E model
 - Energy substitution, emissions, trading
 - Disequilibrium mechanism for determining the regional supply of investments
- Carbon leakage
 - Elasticity of carbon supply and degree of technological flexibility are important for the size of the leakage
 - Leakage due to international capital reallocation
 - More important over time
 - Larger with high degree of complementarity between capital and energy