Raphael Trotignon - PhD Defense
Under the supervision of Professor Christian de Perthuis

In Search of the Carbon Price

The European Union CO_2 Emission Trading Scheme: From *ex ante* and *ex post* analysis to the projection in 2020

October 17th, 2012 – Paris Dauphine University (D520)
Climate Economics Chair - raphael.trotignon@chaireeconomieduclimat.org

Introduction

• This thesis is the result of five years studying the European Emission Trading Scheme, the most complete experience of carbon pricing to date

• An **empirical analysis** based on *ex ante/ex post* comparison

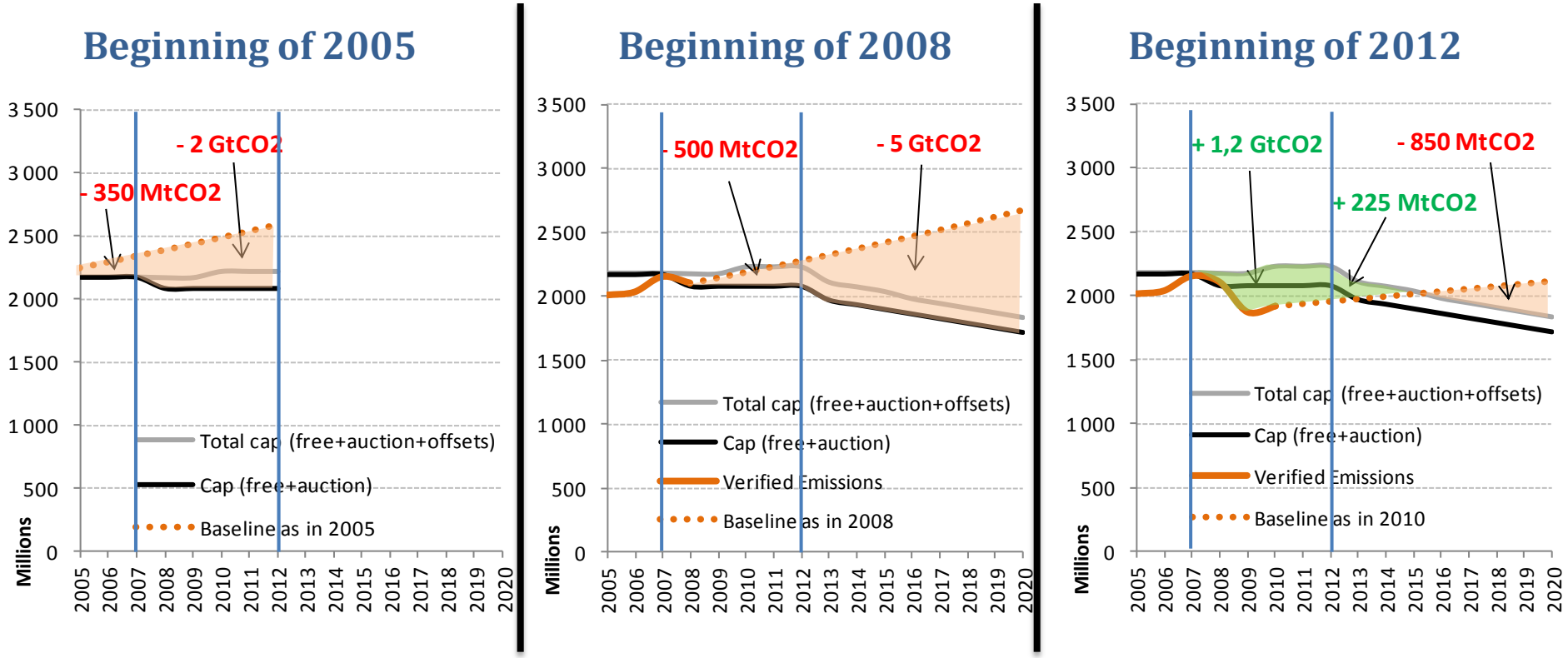
• Supplemented by the creation of **a simulation model**, an original approach

• In a context full of uncertainties, nobody knows the "right" carbon price: it is necessary to combine the **three core flexibility mechanisms** associated to the EU ETS to understand the market development (Chapter I)

• Analysis build by progressively integrating in the model: **baseline** emissions and **abatement** (Chapter II), the use of **offsets** (Chapter III), and **banking and borrowing** (Chapter IV)

• Eventually, shift from an *ex post* use to a **prospective** use of the model to 2020 (Chapter V)

I. *Ex ante* vs. *ex post*

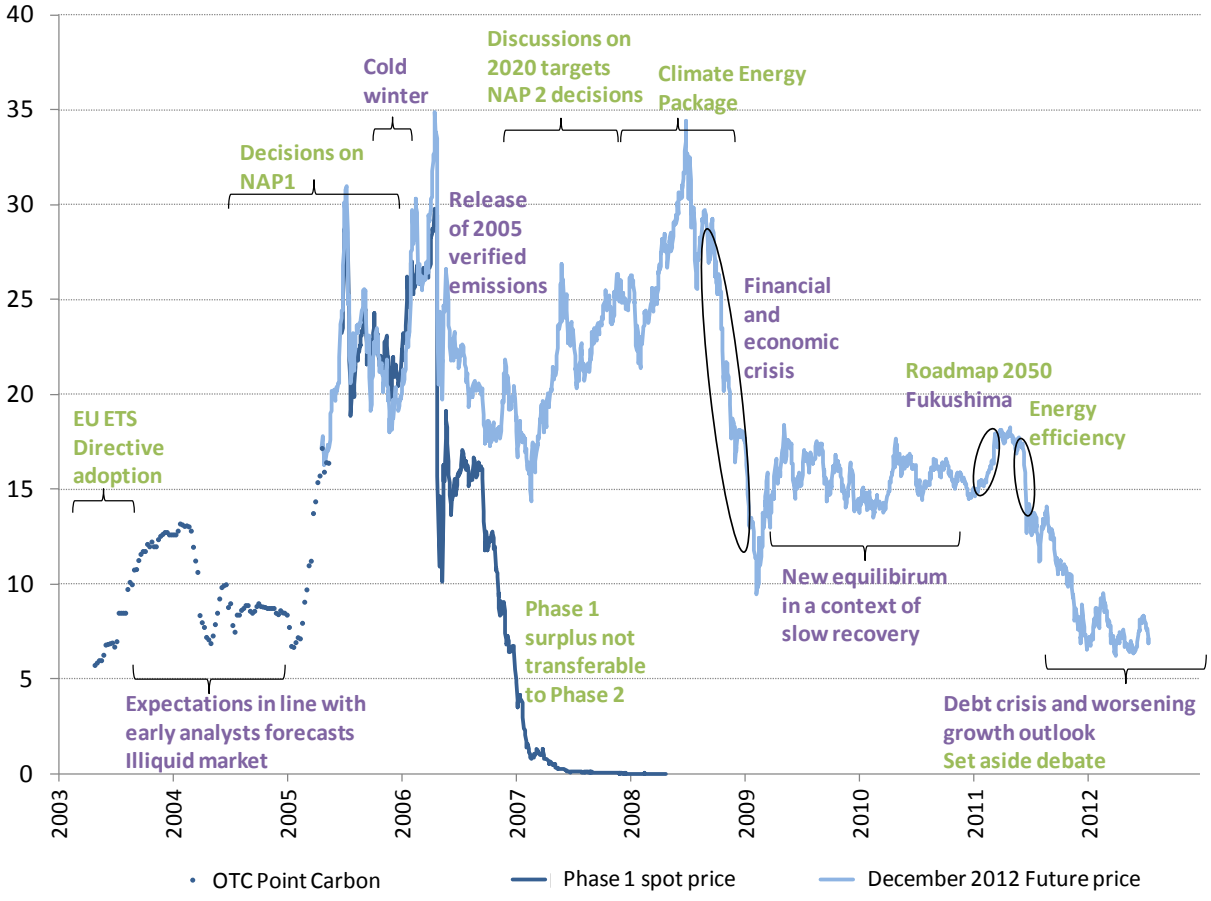


- Difference between initial expectations and actual outcome:
  - Past emission reductions (carbon price and economic crisis)
  - Decentralized use of offsets, supplemental to the cap
  - Interactions with other policies
  - Weakened anticipations

I. The observed price

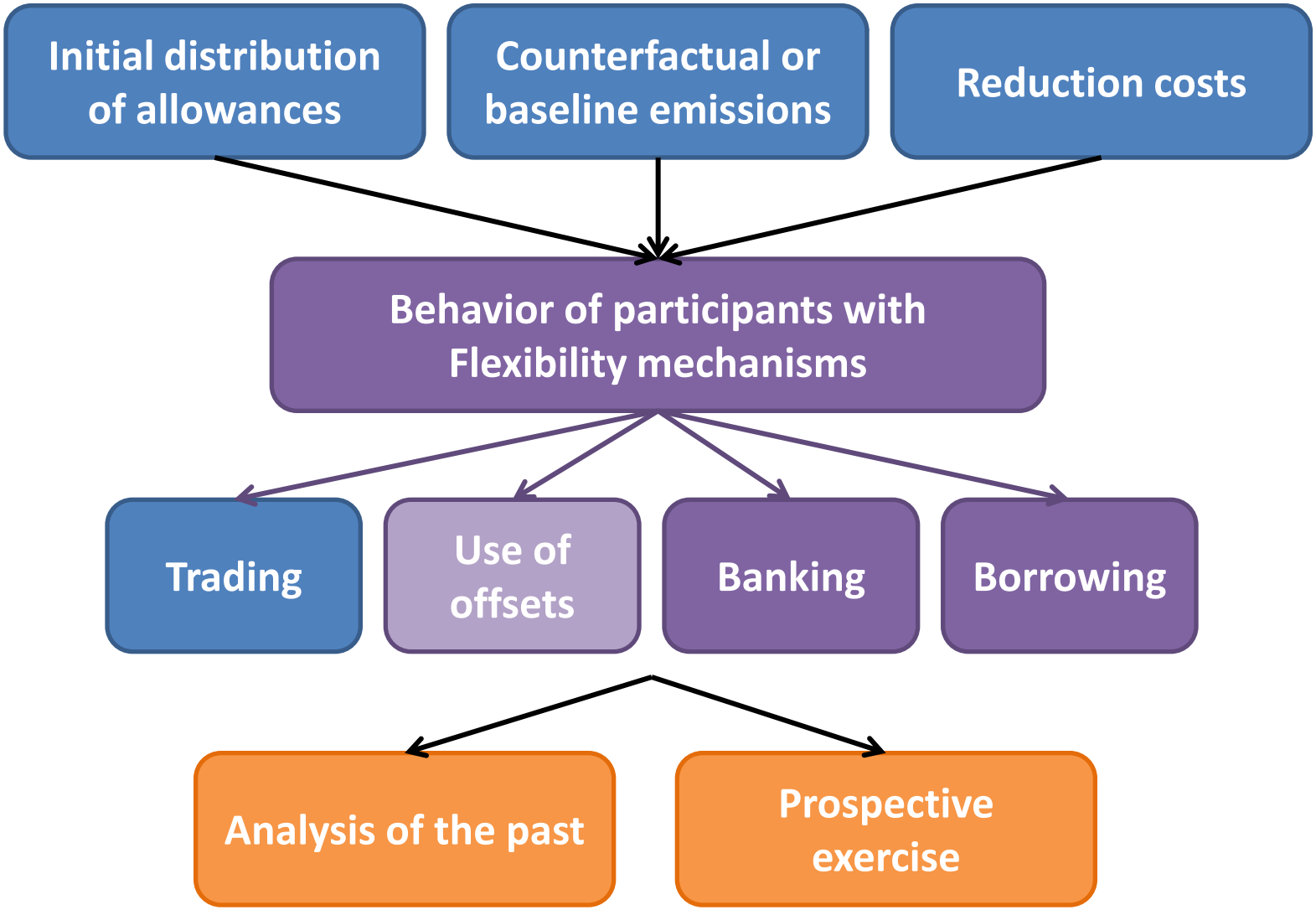
- The price is very different from initial expectations
- A "classic" for cap-and-trade programs (SO_2, Kyoto, RGGI)
- Capacity to drive short term and long term reductions in this context?
- Given uncertainties, the key for understanding the market is the dynamics provided by the three flexibility mechanisms

Observed spot and DEC12 price over 2005-2012



Source: Climate Economics Chair

I. Methodology



Outline

Part I - Emissions trading: the key role of flexibility

Part II - A prototype of ZEPHYR-Flex based on abatement and trading

Part III - The use of carbon offsets: Good or Evil?

Part IV - The calibration of ZEPHYR-Flex and the results on the first two trading periods

Part V - Looking ahead: a multi-level regulation challenge

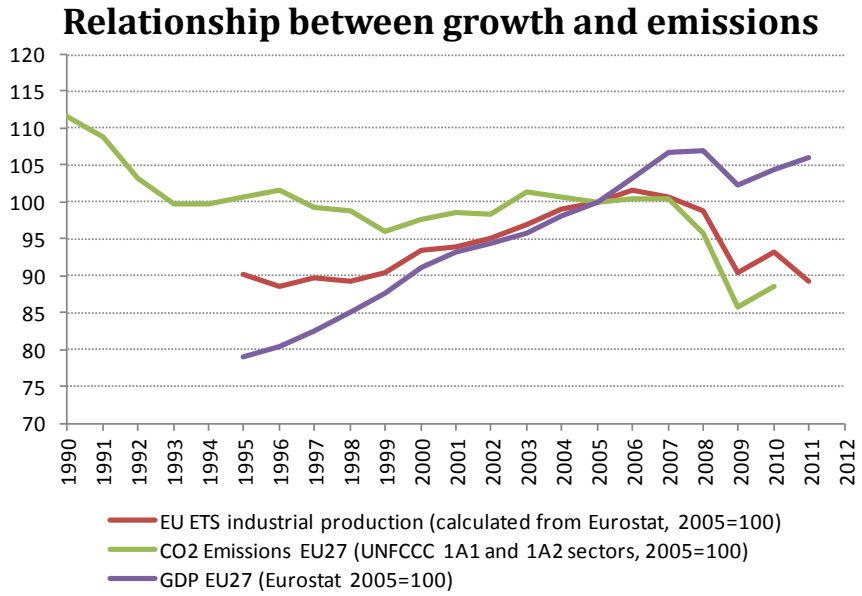
II. Baseline emissions

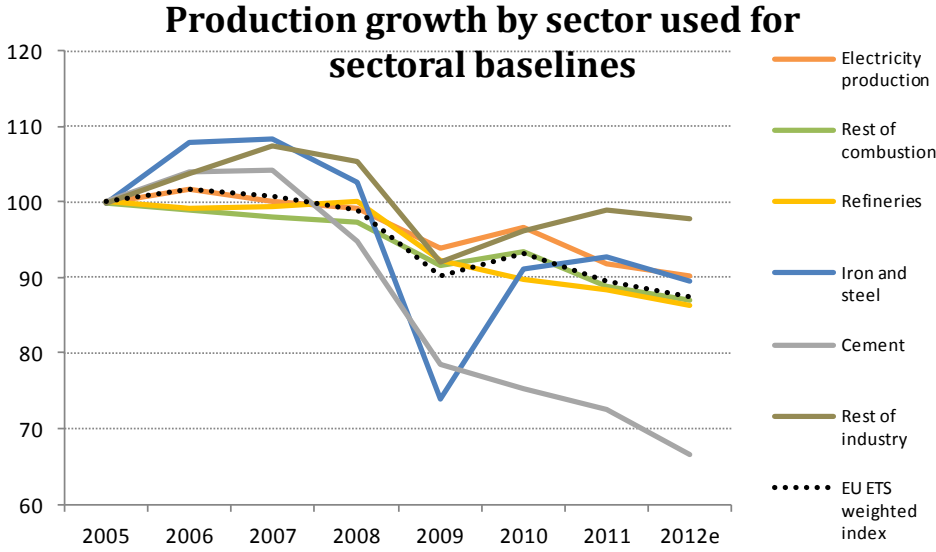
- Emissions as they would be without carbon policies

- Scenarios based on the past relationship between GDP growth and emissions

- Using production indexes as a sectoral breakdown of gross production rates

- And an elasticity of emissions to production
(0.6 in general; 1.2 in case of economic choc)
Limit: Not differentiated by sector



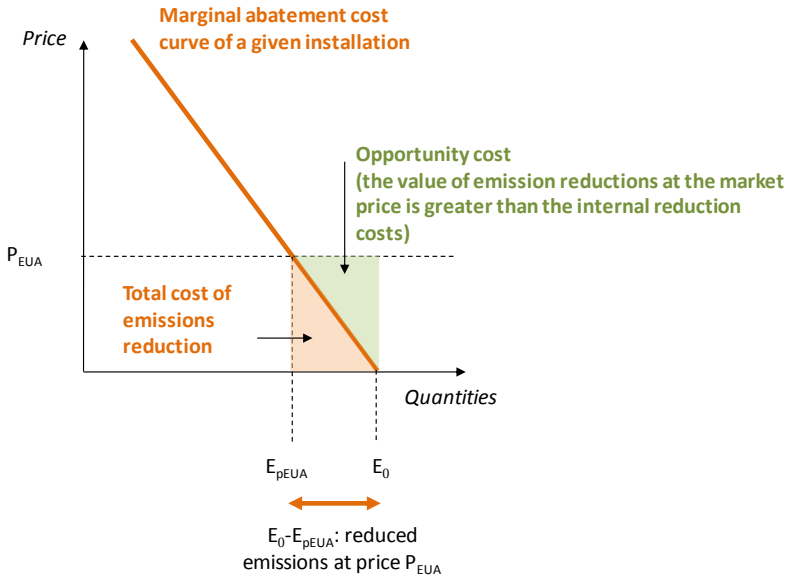


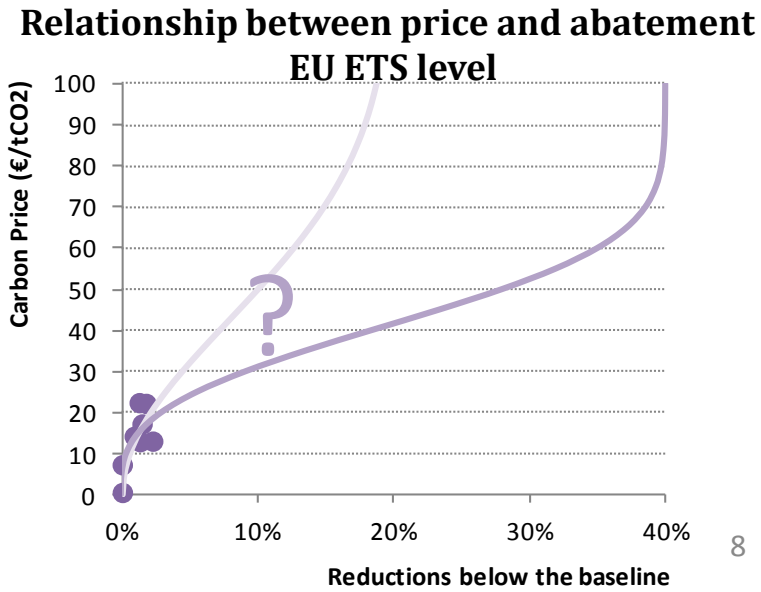
II. Abatement

- In the model, abatement is done instantly
- Perfect recognition of opportunity cost
- A share of reductions are removed from the emission baseline the following years
- Hypothesis on abatement costs of participating entities, by sector

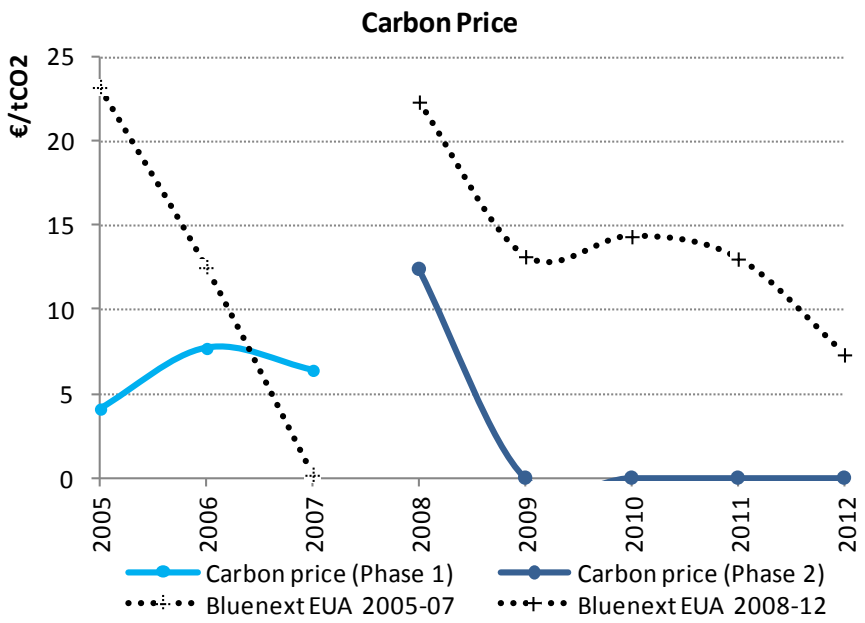
$$E_p = E_0\left(1-\alpha\left(1-e^{-\left(\frac{p}{\tau}\right)^{\beta}}\right)\right)$$

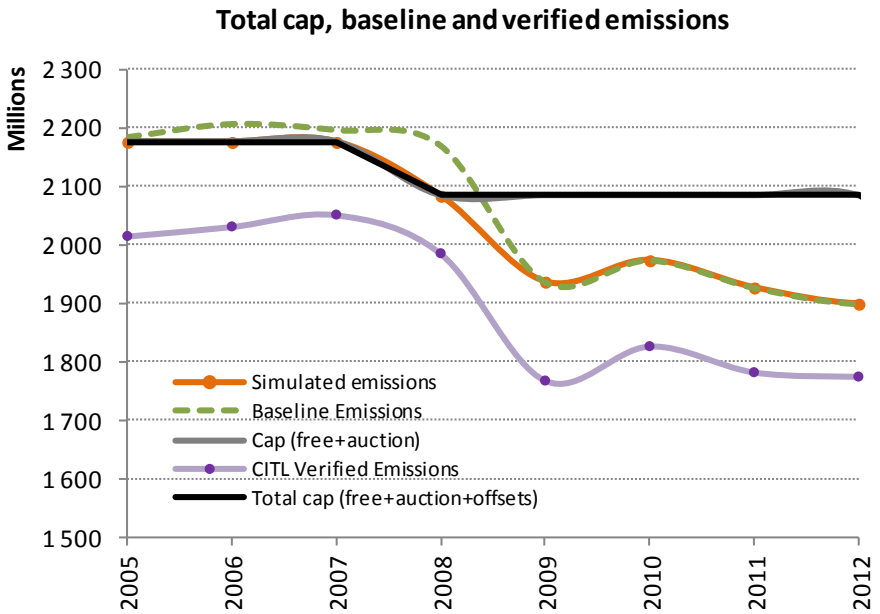
- Cost can evolve over time





II. Results with trading only





With **trading only** (no banking, no borrowing, no offsets):

- Does not replicate observations
- Despite the existence of a net surplus, trades are necessary for short installations to be compliant
- Trading is very efficient to lower compliance costs

→ price is zero as soon as baseline emissions are below the cap (assumption of zero transaction costs in the model)

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III. Offsets: Good or Evil?

• Major characteristic of the EU ETS: articulation with the Kyoto Protocol's flexibility mechanisms, with quantitative and qualitative restrictions

• The attitude towards offsets has changed: initially worshiped, Kyoto offsets are now perceived as aggravating "disequilibrium" on the EUA market

• In the thesis:
  • Observation of prices
  • Use of offsets at the installation level

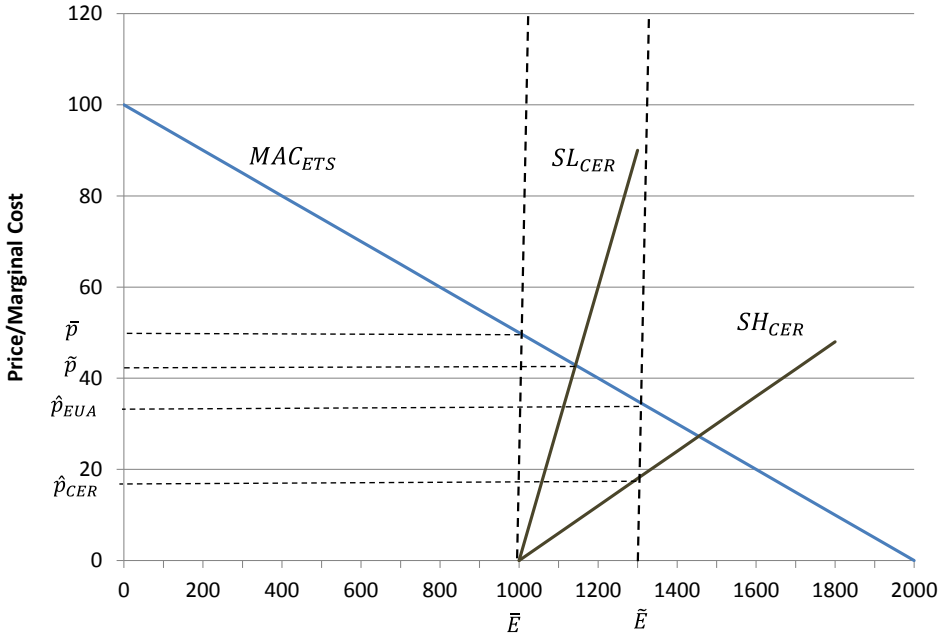
→Effect on past EUA equilibrium price with ZEPHYR-Flex

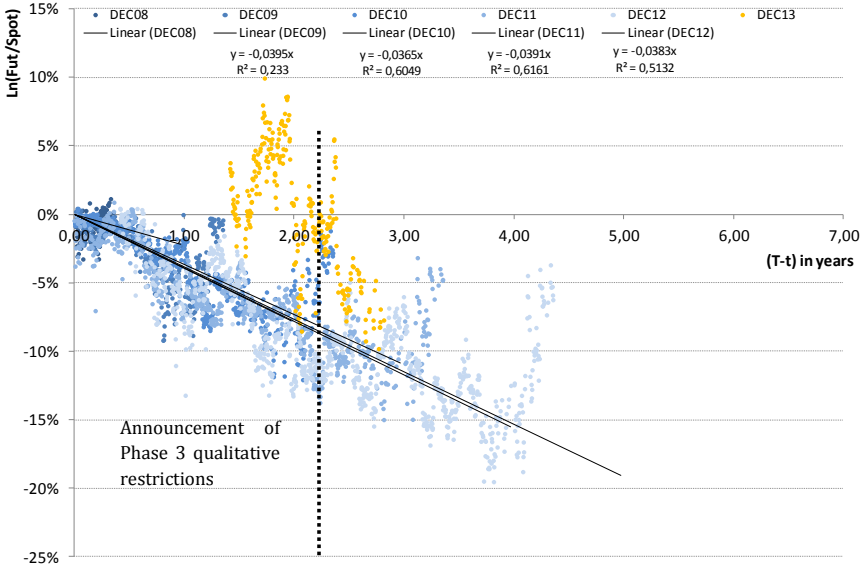
→Scenario for the use of offsets up to 2020

III. Price evidence

- Existence of spot discount depends on whether the limit is binding or not

- Different time discounts if offsets and allowances are not perceived as fully equivalent for future use

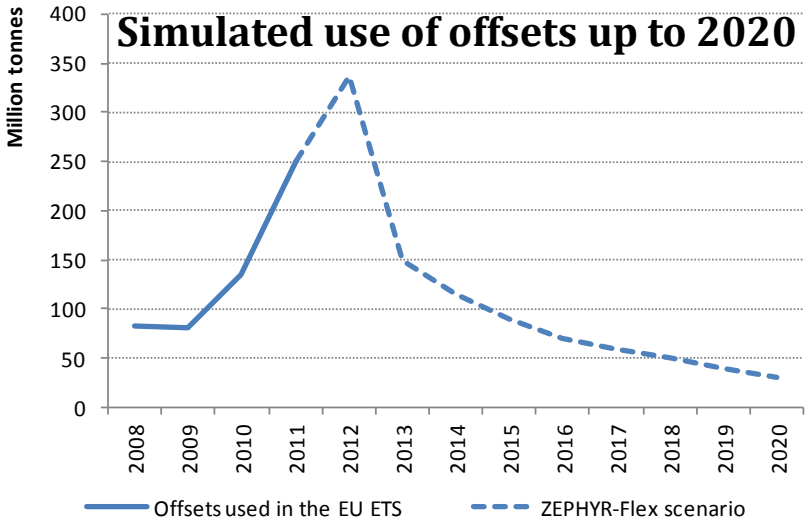




III. Observed and forecasted use

Average intensity of offsets use, by category of behavior etc…

2008	2009	2010	2011	2008	2009	2010	2011	Average use of annual limit
✓	✓	✓	✓	83%	73%	92%	98%	86%
✓	✓	✓	✗	108%	118%	127%		118%
✓	✓	✗	✓	118%	96%		128%	114%
✓	✓	✗	✗	86%	70%			78%
✓	✗	✓	✓	91%		148%	147%	129%
✓	✗	✓	✗	83%		151%		117%
✓	✗	✗	✓	85%			182%	133%
✓	✗	✗	✗	133%				133%
✗	✓	✓	✓		116%	115%	104%	112%
✗	✓	✓	✗		127%	71%		99%
✗	✓	✗	✓		95%		109%	102%
✗	✓	✗	✗		135%			135%
✗	✗	✓	✓			171%	186%	179%
✗	✗	✓	✗			281%		281%
✗	✗	✗	✓				256%	256%
✗	✗	✗	✗					0%



+ Assumptions :
- Phase 3 rules
- Phase 3 offset supply
- Evolution of behavior

III. Lessons from Linking

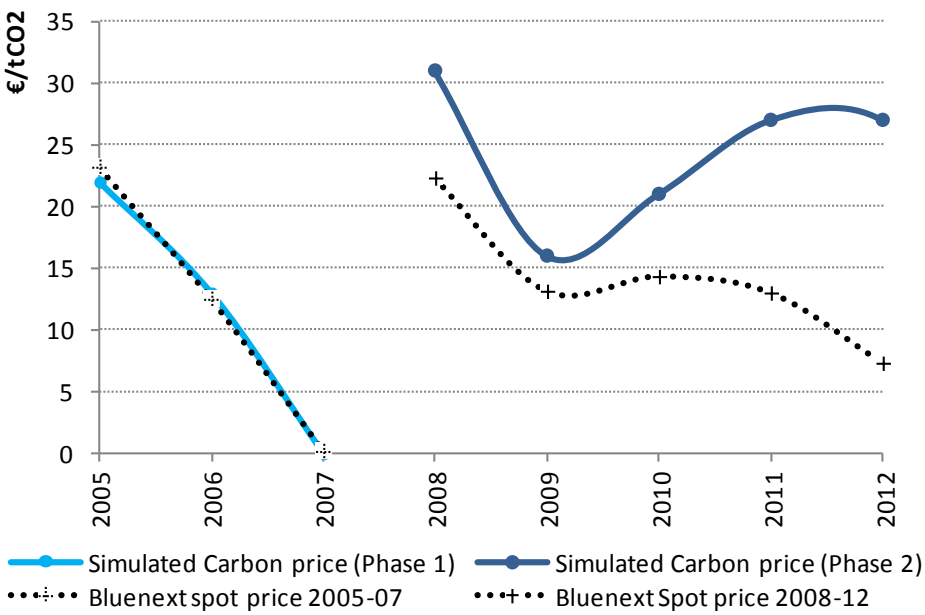
• Decentralized rules can lead to more uncertainty on the cap, and thus on future price and emission trajectory

• Legacy from the Kyoto framework: relying on outside standards can raise regulatory issues

• Applying *ex post* restrictions: intervention on the rules/criteria can have an opposite effect in the short term

• Clearly an arbitrage by participants on the market, leading to a relatively high use of offsets (550Mt in four years), and lower compliance costs

• Nevertheless, economic optimum not fully established
  - information problems
  - reputational concerns
  - transaction costs



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IV. Complete version of the model

We add the time flexibility into ZEPHYR-Flex: the banking and borrowing provisions

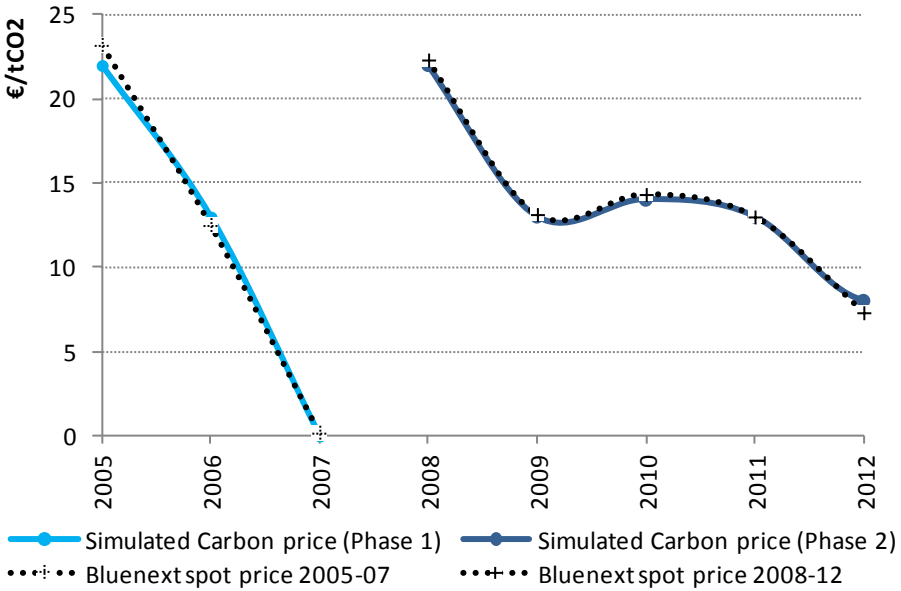
Time flexibility mechanisms implies to represent the **anticipations of participants** which play an essential role in our calibration exercise. Three decision criteria (see behavior table in Annex):

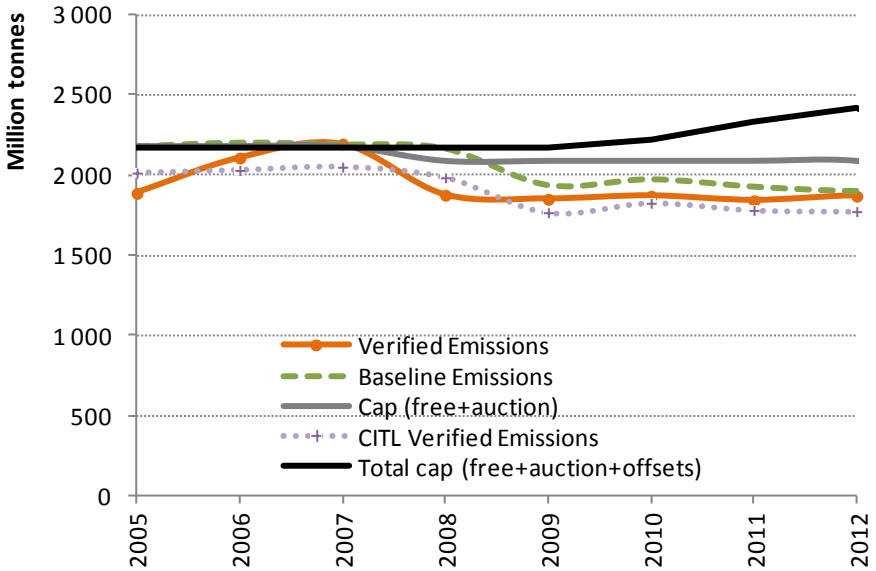
1/ Present **internal position** (EUA Stock – Baseline Emissions)
Perfectly known

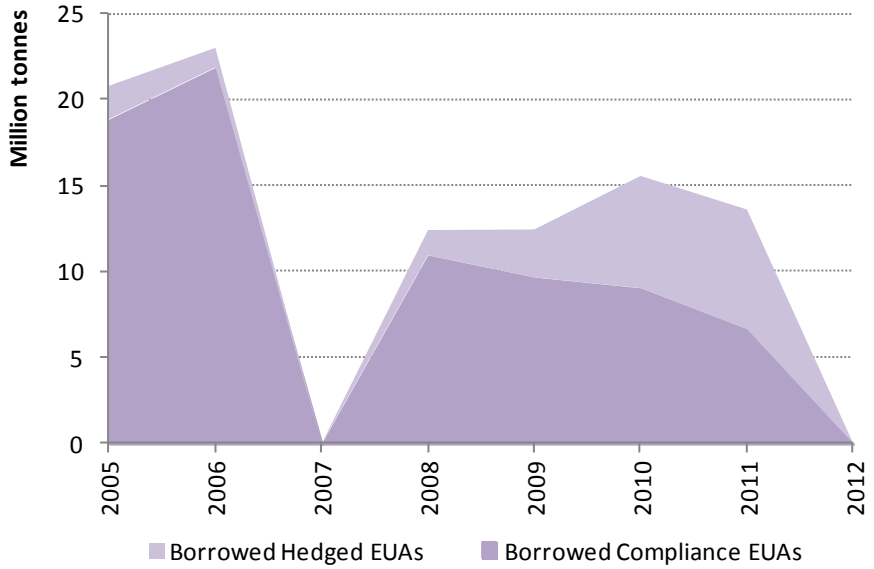
2/ Anticipated **future internal position** (Expected growth compared to free allocations) over an anticipation period
Imperfectly anticipated

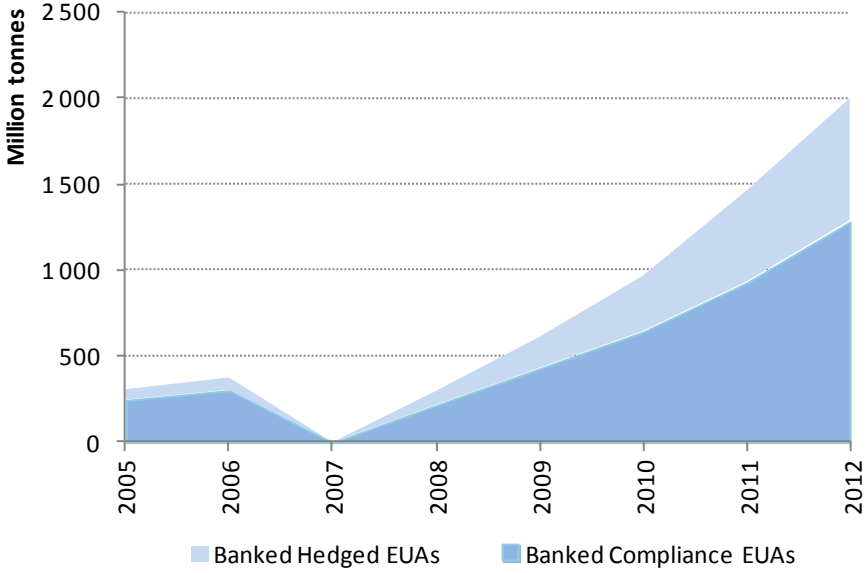
3/ **Market position** through anticipation of bullish or bearish price
Random (parameterized)

IV. Results after calibration









IV. Results after calibration

• The EU ETS induced a cumulated amount of **emission reduction of about 1,540 Mt** over the first two Phases. **60%** have been obtained outside the scheme's perimeter through the use **of carbon offsets** (900 Mt)

• The total compliance costs are estimated at **30 bn€** (reductions, offsets and auctions); exchange of allowances between participants represents a value of **18 bn€** over the first two phases

• Given the level of the allowance cap, the cumulated **net banking is close to 2,000 Mt** at the end of 2012

→Anticipations are preventing the price from being zero

→ Dynamic of behavior in the future ? (shift to auctions, change of behavior following an intervention from public authority…)

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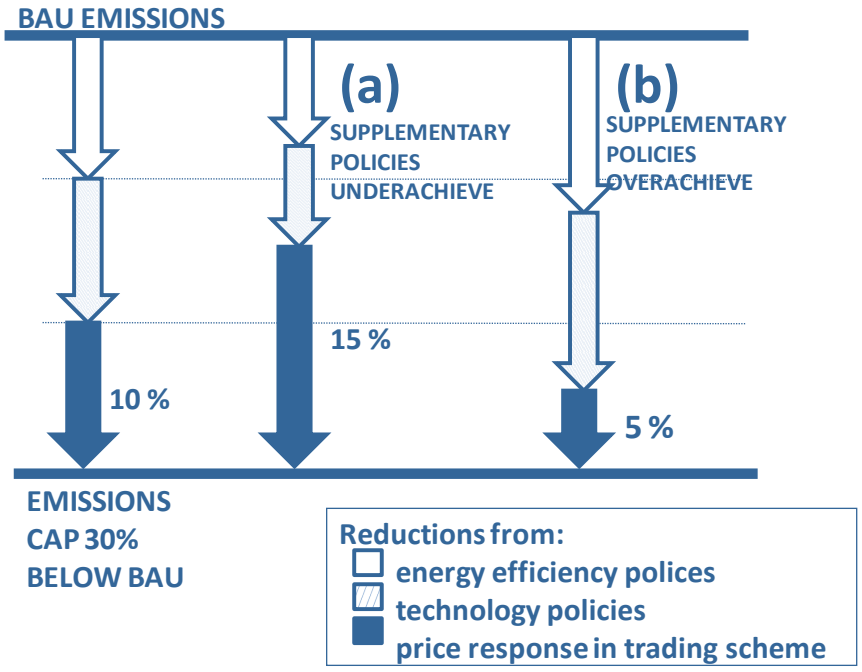
V. Baseline with policy interactions

Renewable Energy and Energy Efficiency policies can affect EU ETS perimeter's emissions independently from the EUA price:



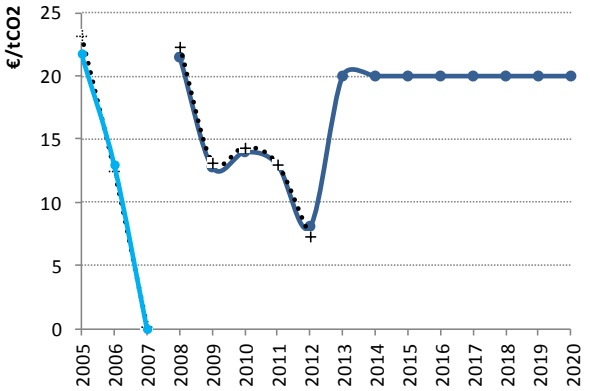
Source: Baron (2012)

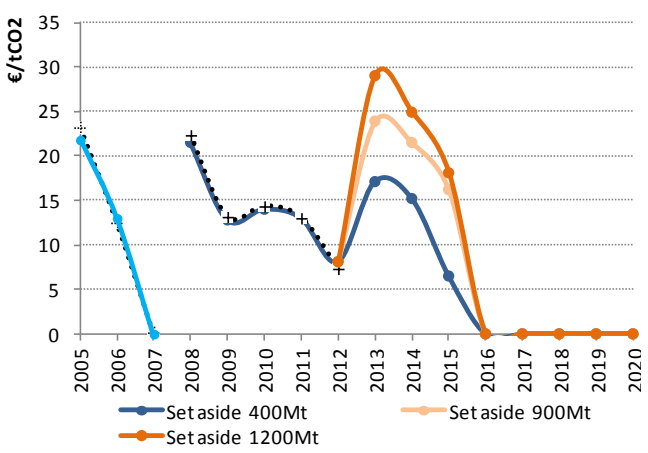
Integration in the model as a progressively lowered elasticity between production growth and baseline emissions growth
(average of 60 Mt/yr in Phase 2 to 100 Mt/yr in 2020)

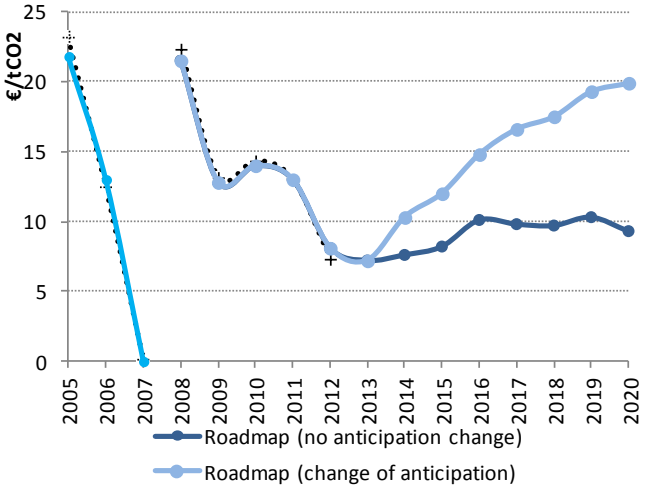
V. Simulation of interventions

Three intervention scenarios are tested with the model:

- The introduction of a reserve price of 20€/t at auctions
- A back-loading (or set-aside) of allowances as proposed by the Commission on July, 25th 2012
- A reevaluation of the allowance cap to 2020 and 2030 compatible with the Roadmap 2050







V. Lessons

• **Some intervention measures can induce more uncertainty and instability**, as they would not allow firms to set up "correct" anticipations by themselves

• It is very difficult to send the "right" incentives to market players in the absence of explicit **long term targets that are connected with the current and medium term cap** (US SO_2 trading program included a 30 years cap)

• The unforeseen evolution of the macro-economic context, the state of international carbon markets and the link with an offsetting mechanism are factors which can be extraordinarily **stimulating but also undermining** if not dealt with "appropriately"

Limits, and how to extend this work

Abatement

- The abatement costs curves by sectors, and their potential shift over time
- The effect of abatement on the baseline, and on cost curves: short term versus long term reductions, innovation effect…

Baseline emissions

- Sector elasticities
- Interactions with other policies
- Explicit link with relevant drivers (energy prices, country growth etc.)

Compliance and hedging behavior

- Transaction data (banking, borrowing, maybe more)
- Identification to a decision model ?

Modeling and Linking other markets

- Aviation, Australia, California ?

Chaire Economie du Climat
Université Paris-Dauphine
CDC Climat

Thank you for your attention

October 17th, 2012 – Paris Dauphine University (D520)

Climate Economics Chair - raphael.trotignon@chaireeconomieduclimat.org

Working papers and peer reviewed articles

• Trotignon, R. and Delbosc, A. (2008), Allowance Trading Patterns During the EU ETS Trial Period: What does the CITL reveal?, Climate Report n°13, CDC Climat Research, June 2008

• Ellerman, A. D. and Trotignon, R. (2009), Cross Border Trading and Borrowing in the EU ETS, *The Energy Journal*, Volume 30 (Special Issue 2), Climate Change Policies After 2012, 2009

• Trotignon, R. and Leguet, B. (2009), How Many CERs by 2013?, Mission Climat of Caisse des depots, Working Paper n°2009-5, August 2009

• Trotignon, R. and Solier, B. (2011), The European Market on the Road to Phase 3, in De Perthuis, C. and Jouvet, P-A., eds. (2011), Climate Economics in Progress 2011, Chapter 2, Economica, October 2011

• Trotignon, R (2012), Combining cap-and-trade with offsets: lessons from the EU-ETS, *Climate Policy*, Vol. 12, Iss. 3, 2012

• De Perthuis, C. and Trotignon, R. (2012), The European CO_2 allowances market: issues in the transition to Phase III, Climate Economics Chair, Information and Debates n°14, March 2012

Complete version of ZEPHYR-Flex