Moderating the costs of implementing global climate policy in a post-Kyoto world

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Presented at CAS Beijing

November, 2014

Background and objective

- Climate negotiations raise the concerns about the issue of the short and long-term macroeconomic impacts and competitiveness loss.Since Copenhagen COP, many debates on the burden sharing and nancial transfer of GHG mitigation between Annex I and developing countries.
- This study aims to evaluate the strategies and consequences of di erent negotiations schemes across Annex I and emerging countries in terms of emissions reduction and impacts on GDP growth.
- We investigate the extent to which global instruments (emissions trading) and domestic complementary policies (scal reform) may help mitigate economic costs when combined with appropriate tax recycling regimes.

Existing Literature

- The international emission trading between parties is a cost-saving and exible policy instrument in environmental regulations, and suited to restrict the emissions of a uniformly dispersed pollutant such as CO_2 (Tietenberg 1985, Klaassen 1996).
- Pizer (2002) demonstrates that the expected welfare gains from optimal price is signi cantly higher than optimal quantity policy to address global emissions mitigation even under suboptimal condition.
- However, the climate policy instruments often have to address a second-best world (Sassi et al.2010), and the uniform price policy seems to be very di cult to implement as most developing countries are reluctant to accept global emissions caps. Partial participation would be an alternative policy choice during the transition period.

- A number of application of CGE models to evaluate economic implications for climate policies under di erent policy circumstances, especially in the sectoral agreement based approach:
  - Carone et al.(2009) use a game theory based CGE model to show that emission trade would be e ective even when countries behave non cooperatively.Smaller groups perform better than agreements with larger number of countries.
  - Hamdi-Cherif et al.(2011) show that a sectoral agreement based emission trading policy (electric power sector) with reduction in pre-existing taxes would achieve almost the same emissions reduction targets in the case of global cap and trade scenario. Redistribution of auction revenue is found to be more cost-e ective than lump sum transfer to households, in line with Parry(1995).
  - Gavard et al.(2011) analyze trade carbon permits between the Chinese electricity sector and a U.S. economy-wide cap-and-trade program using the MIT EPPA model. And this sectoral policy induces signi cant nancial transfers between the two countries. Nearly half of capped emissions in the U.S (valued at $42bn) will be purchased from China in 2030.

Simulation method

- Numerical simulations have been carried out with IMACLIM-R model(developed at CIRED) which accounts for imperfect foresight and infrastructure inertia as a result of short-sighted investments.
- In order to identify the main drivers of the structural changes of carbon emissions mitigation and to account for uncertainty of prospective energy supply and demand and underlying energy price, we simulate several combinations of parameters associating oil market(e.g. OPEC's strategies) with technological progress.

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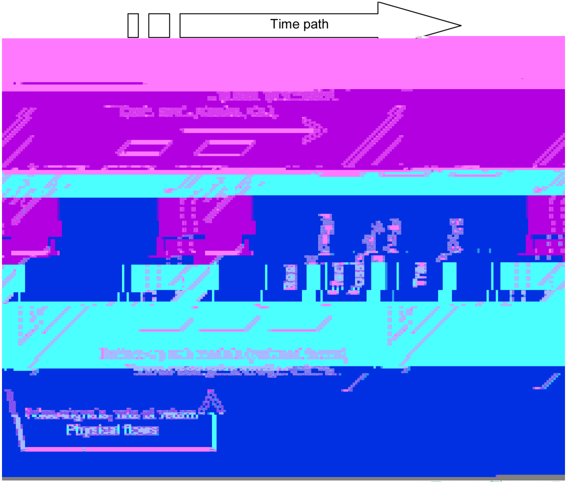
Drivers of endogenous technical change may be twofold:

- knowledge progress along with capital accumulation (learning by doing);
- changes in relative price of production factors(Hicks induced innovation)partly due to public policy.

- IMACLIM-R is a hybrid CGE model which combine the TD and BU approaches by ensuring the consistence between energy and economy in the modelling framework.
  - 12 regions and 12 sectors,
  - hybrid model of money and physical ows.
  - both the characteristics of myopic agents and infrastructure's inertia result in high transition costs in the case of climate policy constraints.
- A comprehensive description of the model is available in Crassous et al. (2008); Guivarch et al.(2009); Sassi et al.(2010); Cassen et al.(2010);and Rozenberg et al.(2010).

IMACLIM is characterised by a recursive dynamic framework:

Schematic representation of IMACLIM model



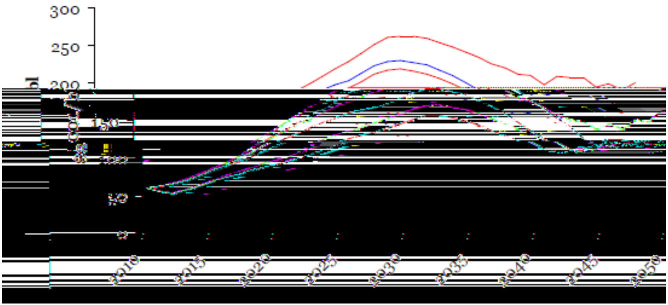
Storylines description

- BAU scenario refers to the situation in which no climate policy is implemented in any country over the period.
- In policy scenarios, world emissions trajectories are imposed exogenously to pursue certain climate targets (Copenhagen pledges or international agreement).
- Policy scenarios simulated in this study comprise an array of assumptions of engagement of Annex I countries and India and China in terms of carbon intensity reduction pledges announced at the Copenhagen COP.

Tax recycling regime

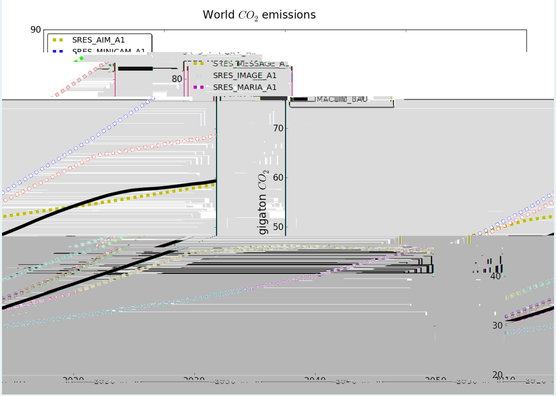
- Based on revenue-neutral, carbon tax is assumed to be recycled in two fashions:
  1. Only to households(HLDS);
  2. Recycled to all carbon tax payers including producers (LS).
- Only fossil fuels combustion related CO_2 emissions are accounted for, land use change and other GHG emissions are excluded.
- Note that the trading mechanism *per se* will not change the world emission pro les, it is actually playing a role of nancial resource transfer to minimise the global costs to achieve the emissions targets.
- Under 450ppm scenarios, no international emissions trading is allowed and every country make mitigation e orts only domestically.

Scenario	EU target	Participants	Trading



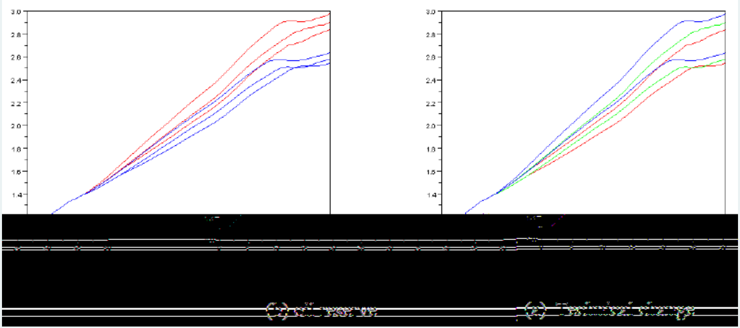
- There exist considerable di erence amongst six core scenarios; ranging between 150 – 250$US\$/bbl$ by 2035.
- Oil reserve assumptions in uence heavily the oil price.
- Also,slower pace of technical change results in accelerated rise in oil price.
- The decline in oil price is explained by deployment of electric vehicles (partly decarbonized car eet) from 2030 as well as endogenous technical change.

Global CO_2 emissions BAU compared with SRES



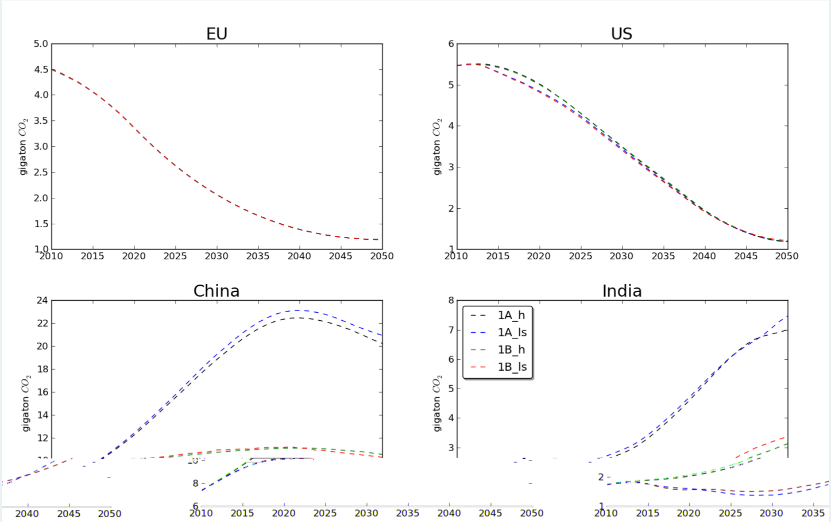
- IMACLIM's central BAU falls in the SRES A1 family
- sustained GDP growth in the world through 2050 $\rightarrow$ 2.8% per year

Global CO_2 emissions under BAU



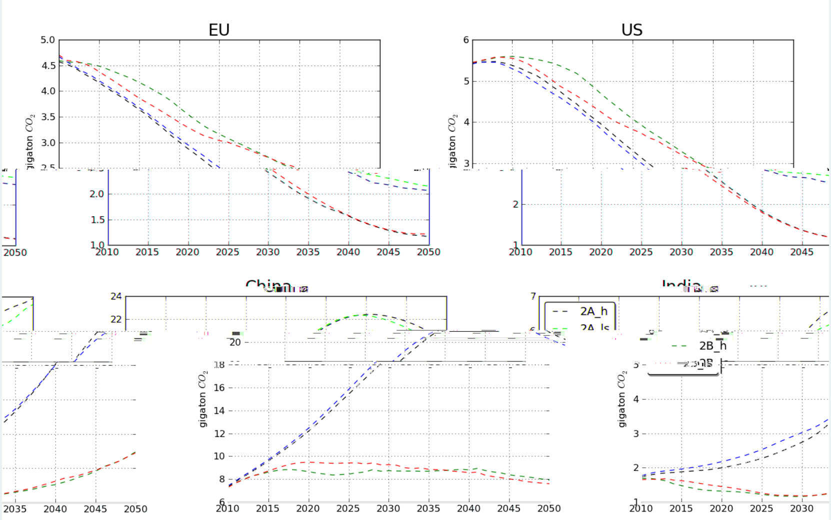
- CO_2 emissions grow steadily in all scenarios until 2040; due to oil reserve depletion mechanism; and faster penetration of energy technologies reflect gradual transformation in production system , in which case the emissions trajectories bend downward sharply by 2050.
- Emissions are likely to stabilize around 2050 regardless of oil reserve assumptions (price effect will drive up the uptake of low carbon technologies).

CO_2 emissions across regions without trading



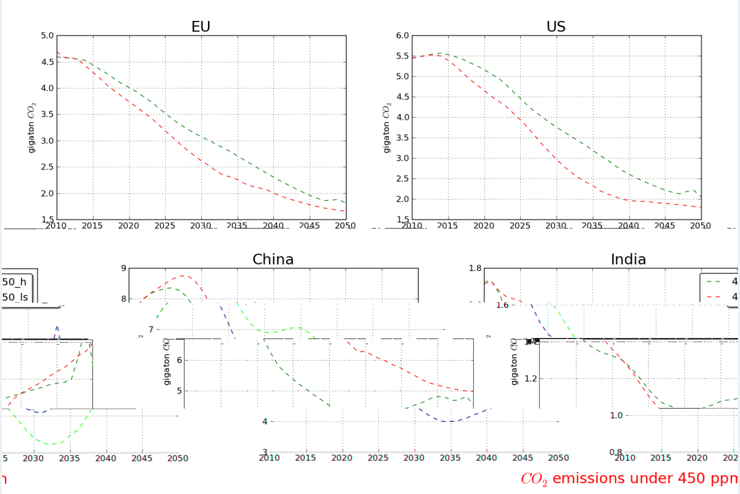
CO_2 emissions without emission trading

CO_2 emissions across regions with trading

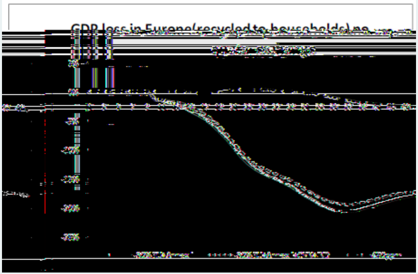


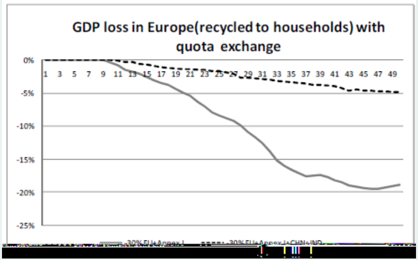
CO2 emissions with emission trading

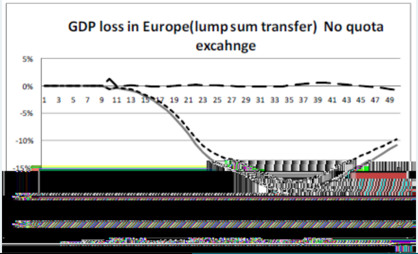
CO_2 emissions across regions in 450 ppm scenario

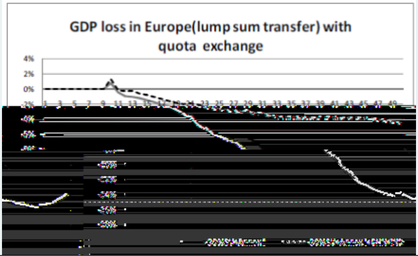


GDP growth variation in EU (relative to BAU)



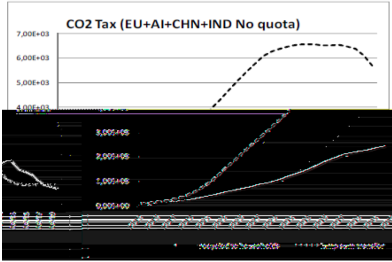


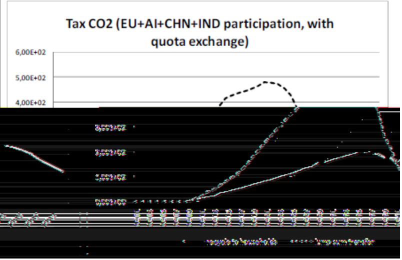


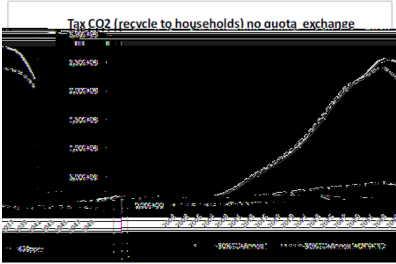


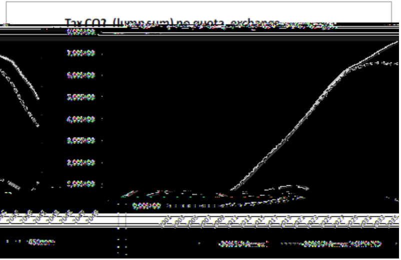
Comments on impacts on GDP growth in EU

- GDP growth rate loss in EU would be reduced signi cantly when India and China commit to their Copenhagen pledges. This is not surprising as the negative impact on economic competitiveness of EU would be largely mitigated when other regions participate in climate mitigation actions instead of acting alone.
- Most importantly, the variation in GDP growth rate in EU would be nearly neutral in the case of global caps aiming at 450*ppm*.


CO2 Tax (EU+AI+CHN+IND No quota)
7,00E+03
6,00E+03
5,00E+03


Tax CO2 (EU+AI+CHN+IND participation, with quota exchange)
6,00E+02
5,00E+02
4,00E+02


Tax CO2 (recycle to households) no quota exchange



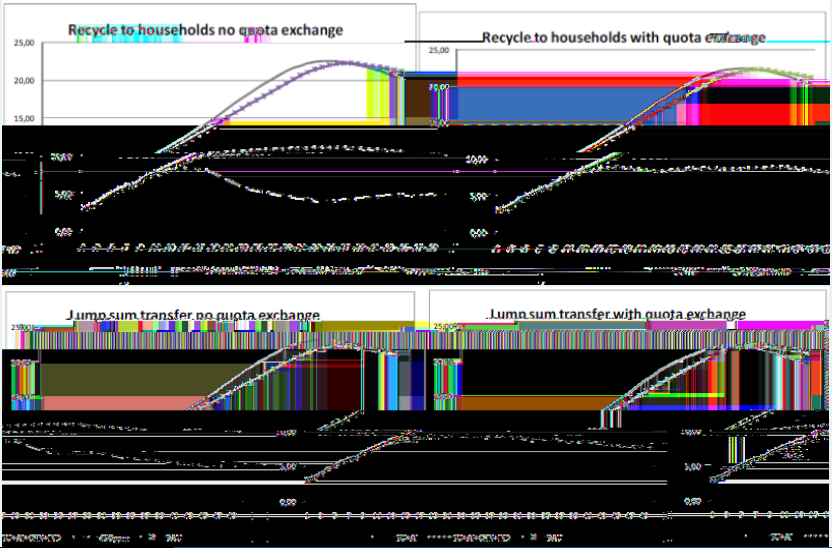
Isses of carbon tax recycling

- The carbon tax recycling regime has extremely impact on carbon tax to achieve the emissions targets in Europe. Lump-sum redistribution results in a factor of 3 of carbon tax compared to recycling to households.
- This result is somewhat counterintuitive since reduction in pre-tax is thought to be more cost-e cient than recycling to households for enhancing the economic competitiveness in most cases.
- Also, the global caps for 450ppm would reduce signi cantly the carbon tax burden in Europe, this is consistent with the ndings in existing literature.

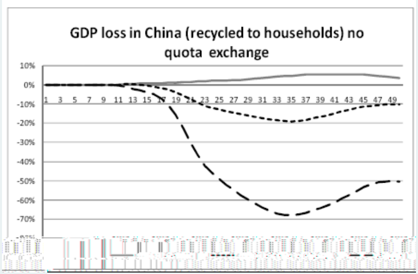
The case of US.

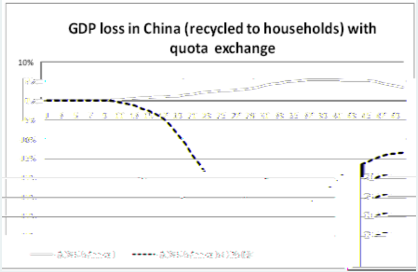
- Similar to the situation in Europe, US would need less e orts in emissions reduction when China and India participate in the climate deal and ful l their pledges.
- US GDP would su er most in the case of non-participation of China and India with LS of carbon tax recycling, GDP growth rate be 25% lower relative to the BAU case, compared to only less than 3% when India and China commit to their Copenhagen pledges.
- 450 ppm would make US GDP increase much faster than other scenarios as its comparative economic competitiveness would be enhanced at the expense of China and India and other emerging countries.

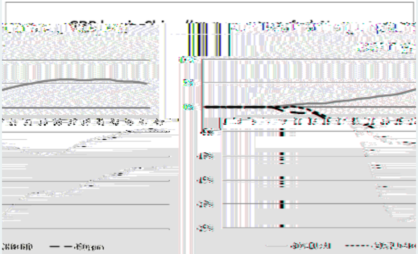
China's CO_2 emissions trajectories

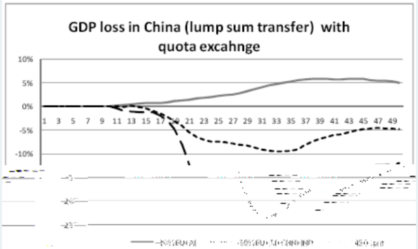


GDP growth variation in China (relative to BAU)









Impacts on China's CO_2 emissions

- China's emissions would be lower than BAU when participating in the global climate deal together with Annex I and India. China does have incentives to to reduce further if the allowances can be traded internationally.
- Global emissions would be higher than BAU in the case of participation of Annex I only; consistent with the theoretical prediction of carbon leakage.

Impacts on China's GDP growth

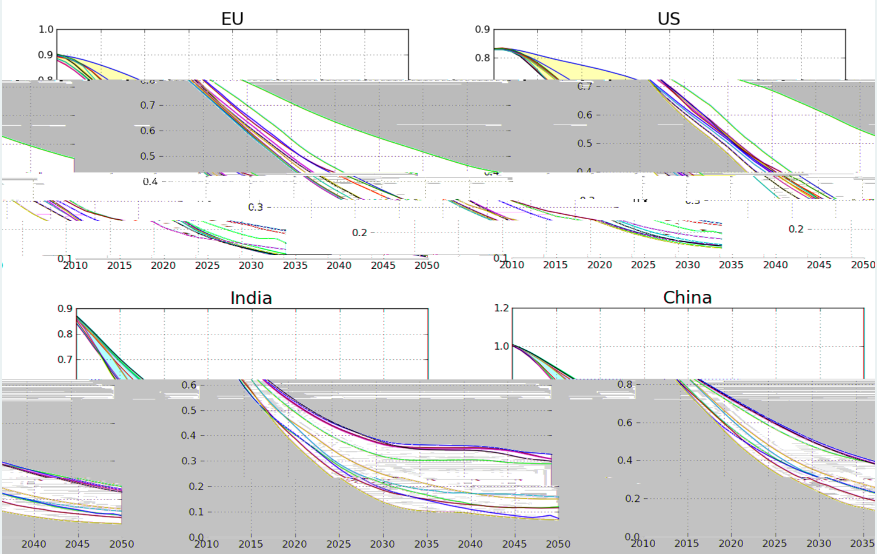
- Unlike EU, non-participation of China (non commitment of Copenhagen pledge) will make Chinese GDP increase faster at the expense of Europe and other Annex I countries, as its comparative advantages are enhanced by gaining larger market share as the relative production price is lower.
- By contrast, the commitment to 450ppm trajectory would be extremely costly for China's economy as its annual real GDP growth rate may be sacri ced signi cantly.

Two main factors may explain the large reduction in GDP growth rate for strong climate policy

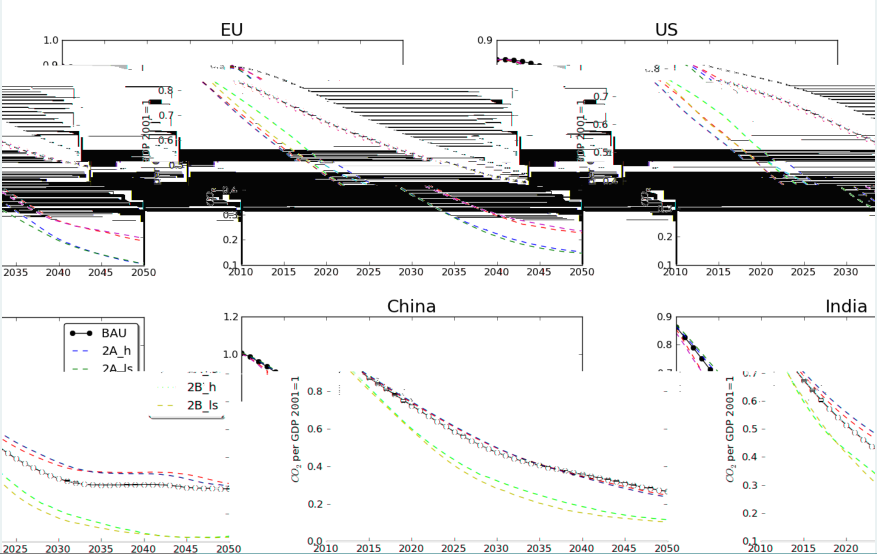
- The sharp decrease in exterior demand for energy and carbon intensive goods and services, the exports shrink consequently on the one hand;
- Ageing demography as well as decreasing working population result in declining saving rates and sluggish domestic consumption and investment.

Tax recycling is crucial in determining the negative impact of implementing strong climate policy, instruments must be selected with care to minimize the negative impacts on GDP.

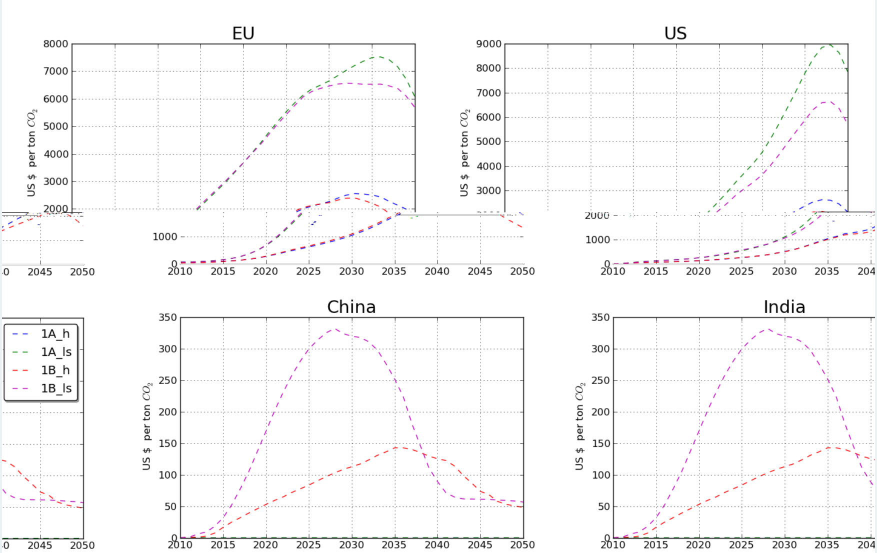
Carbon intensity reduction across 4 regions in all scenarios



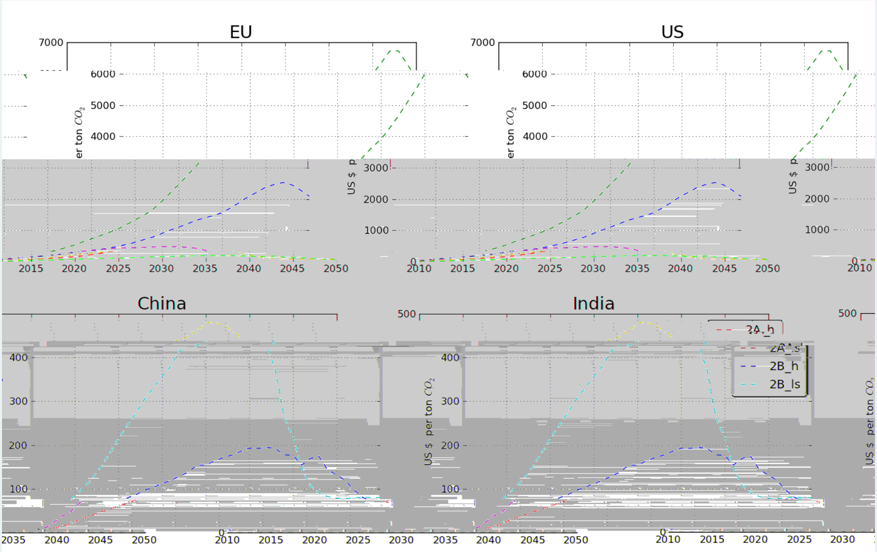
Carbon intensity reduction across 4 regions with trading



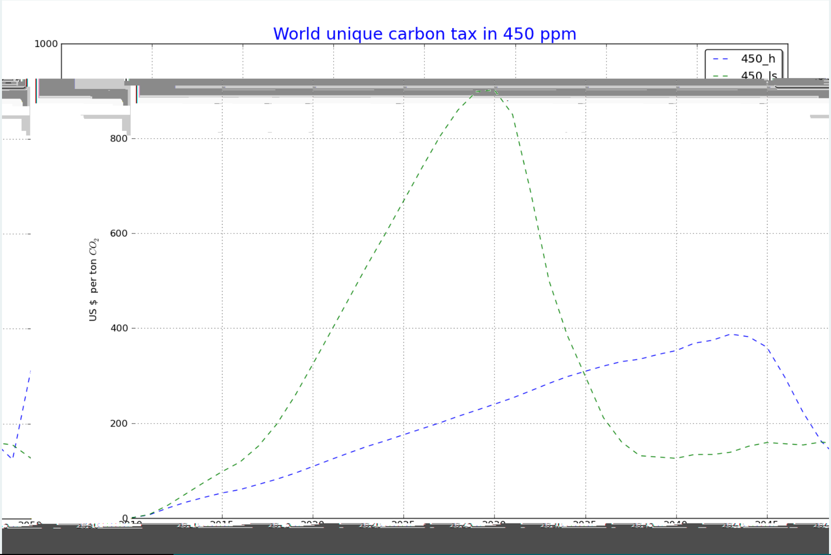
Carbon tax across regions when no trade is allowed



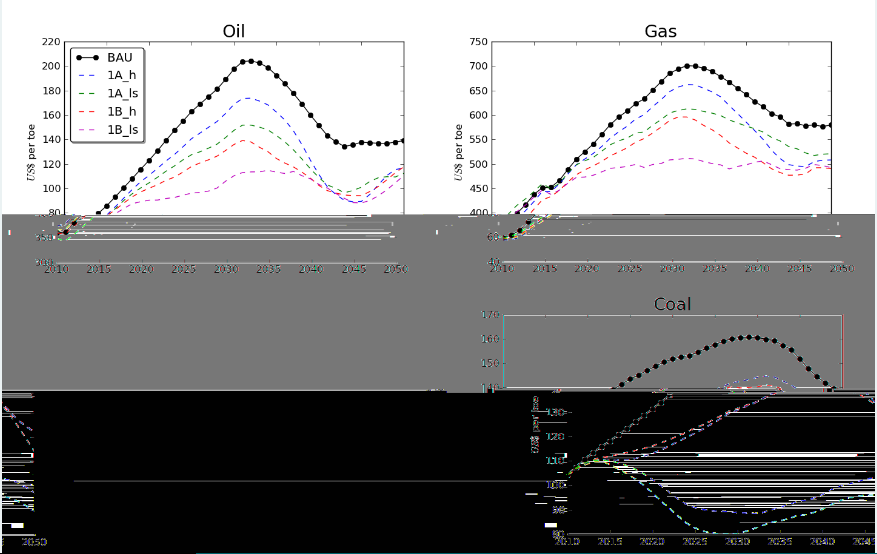
Carbon tax across regions with trading



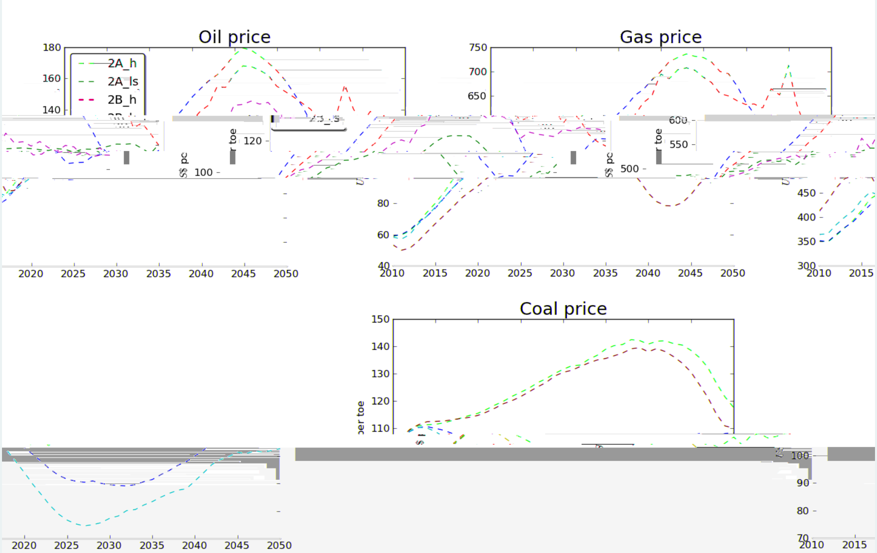
Unique carbon tax in 450 ppm scenario



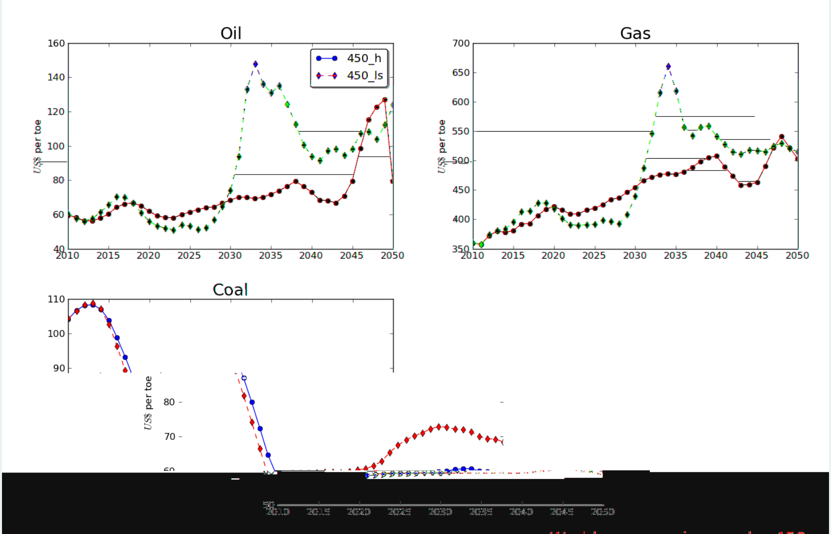
World energy prices without emission trading



World energy prices with emission trading

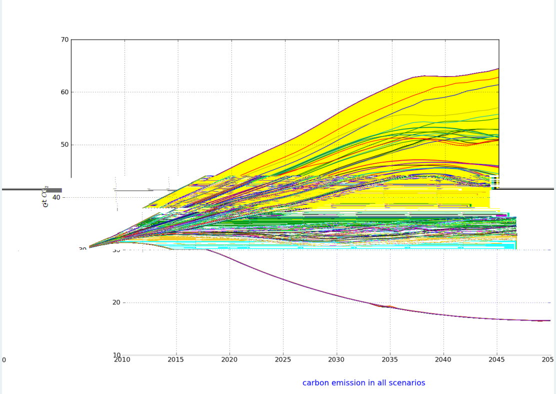


World energy prices in 450 ppm scenario



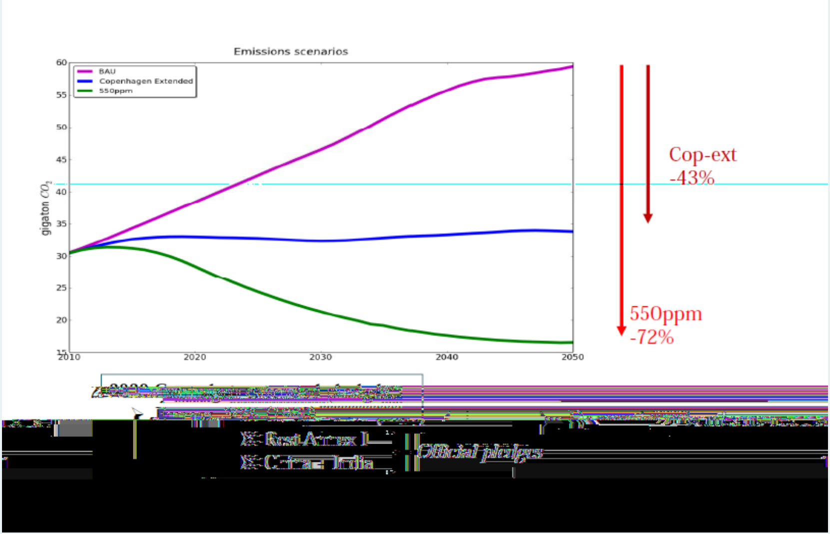
World energy prices under 450

Large uncertainty of emissions scenarios

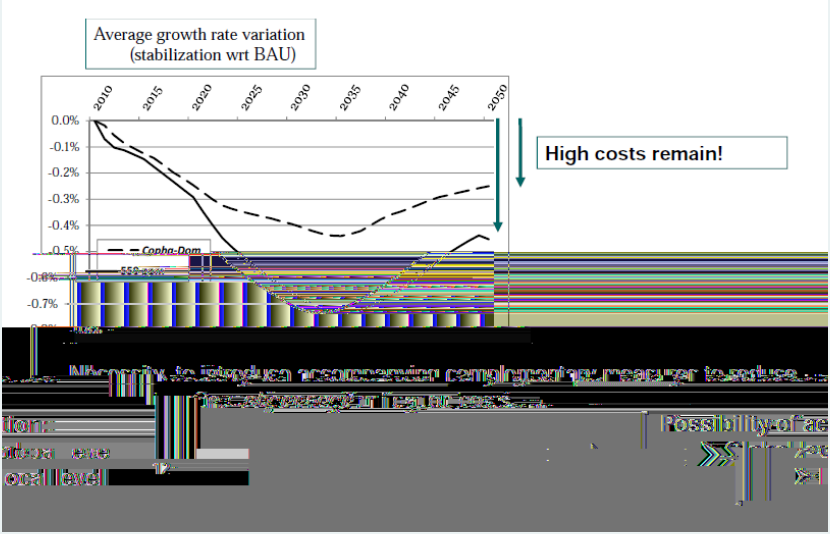


- emissions in 2050 may vary by a factor of 3 depending on climate policies
- 550 ppm scenario is a stringent target to achieve

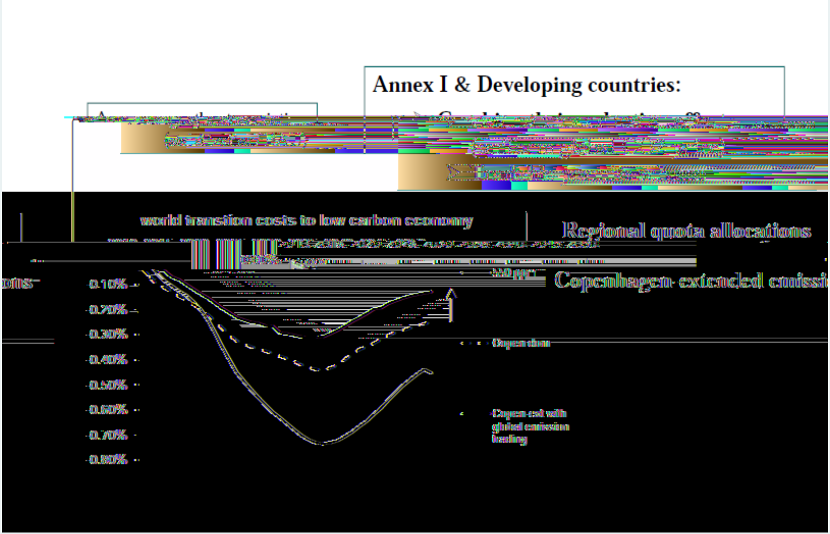
Copenhagen-extended with emissions trading



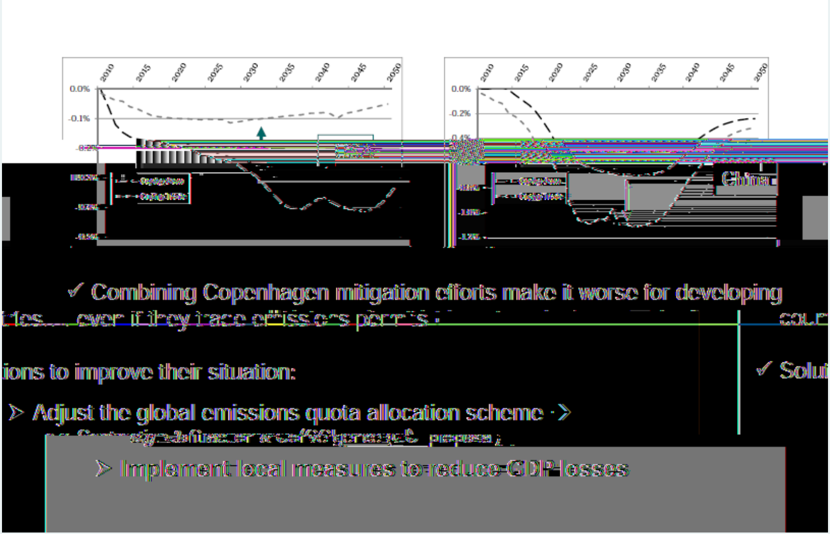
Copenhagen-extended macro costs



Copenhagen-extended & complementary measures:Global emissions trading



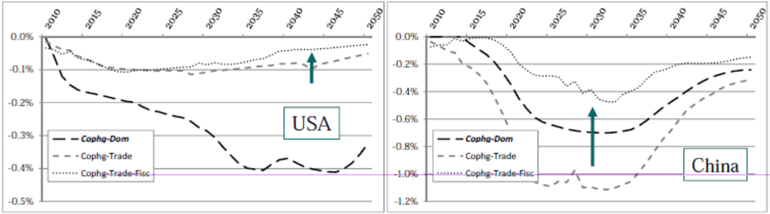
macro costs comparison in US and China



Copenhagen-extended, emissions trading and scal reform

Real lump-sum recycling of carbon tax revenues:

Transfer to households + Reduction of production taxes



- Emerging countries are energy/carbon intensive economies
- A carbon tax increases their production costs
- Reduction of production taxes partially offsets the impact of the carbon tax

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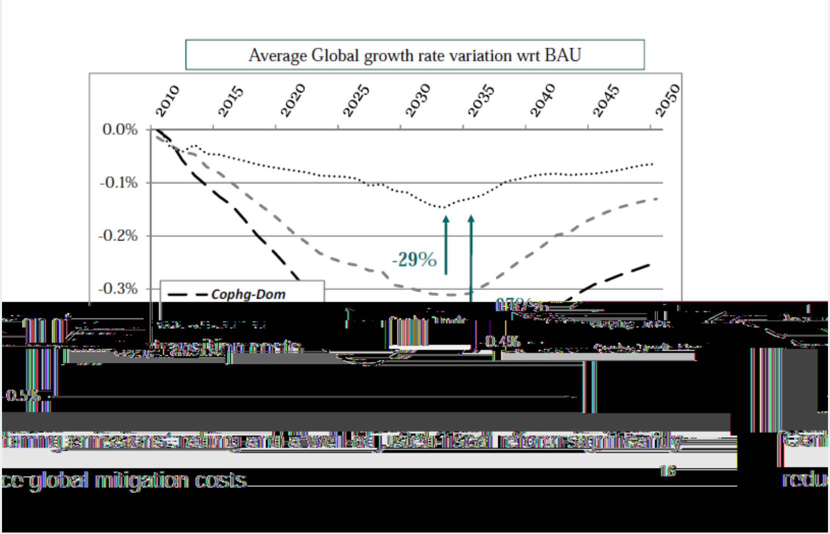
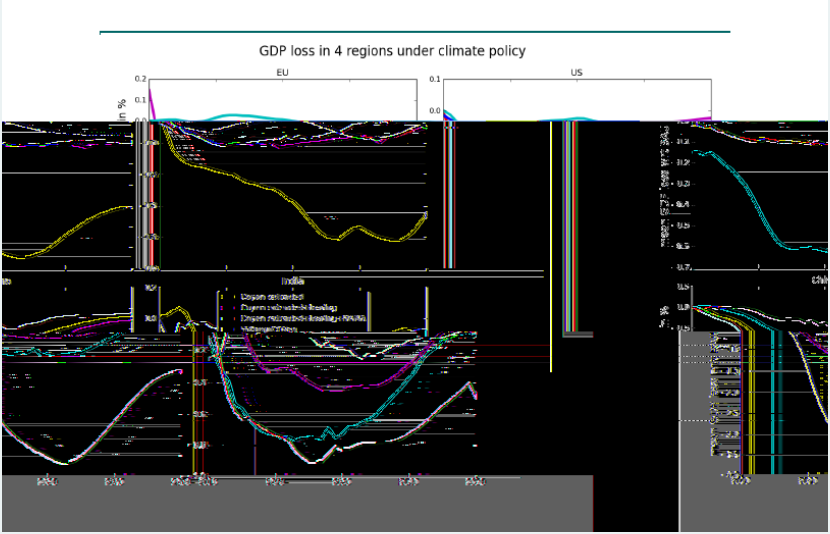
Copenhagen-extended, emissions trading and scal reform



Asymmetric impacts should be taken into account in global climate policy



Some remarks on the GDP loss in different regions

- Unlike EU, non-participation of China (non commitment of Copenhagen pledge) will make Chinese GDP increase faster at the expense of Europe and other Annex I countries, as its comparative advantages are enhanced by gaining larger market share as the relative production price is lower.
- By contrast, the commitment to $450ppm$ trajectory would be extremely costly for China's economy as its annual real GDP growth rate may be sacrificed significantly.

Main lessons for the world

- Trans-boundary emissions trading with the participation of India and China would reduce considerably the costs to world economy.
- Carbon tax recycling is crucial to narrowing the gap between di erent climate regimes.
  - LS is arguably preferred to transfer to households as the costs to GDP growth reduction could be nearly halved.
  - Speci cally, the costs in 450 ppm scenario could be reduced by more than twice by the mid-century.
  - World GDP growth loss is less when emerging countries like China and India are *NOT* involved in emissions reduction commitments whiles Annex I countries are obliged to abate.
  - GDP loss would be less in the case of global participation than unilateral commitment of Annex I countries if trading is allowed, otherwise the global participation would cause larger loss to world GDP even than 450 ppm case which is counterproductive for climate policy.

Conclusions and perspective

- Global climate agreement (e.g. Copenhagen, global C&T):
  - Signi cantly a ects developing countries in the short term
  - Combining e orts + Emissions trading partially limit the transition costs at the global level but have asymmetric implications at the regional level
  - The articulation of international and domestic policies such as adjusted scal and labour market reform is a way to smooth the transition
  - Appropriate climate nance compensation scheme needs to be designed to address the fairness and equity concerns of global climate policies

Perspectives

- The combinatory framework (quotas + national policies, as NAMAs) could be an acceptable option for developing countries
  - Is aligned with country speci c development priorities
  - O ers exibility for domestic policies to support the transition
  - A rst step towards a more ambitious global climate agreement

Summary

Our simulations show that

-

Producer's problem

The sectoral budget function determines the prices of final goods produced in each sector in the economy, i.e.

$$\boldsymbol{p_{k,i}} = \sum_{j} \boldsymbol{pIC_{i,j,k}} \cdot \boldsymbol{IC_{i,j,k}} + (\ \boldsymbol{_{k,i}} \cdot \boldsymbol{w_{k,i}}) \cdot l_{k,i} \cdot (1 + tax_{k,i}^{\boldsymbol{w_{k;i}}}) + \ _{k,i} \cdot \boldsymbol{p_{k,i}} \tag{1}$$

Consumer's problem

As IMACLIM comprises different regions and countries, international trade (imports and exports) are taken into account in consumer prices formulation, the final consumption price for households for good i in region k is determined by a CES function in the following way

$$\begin{aligned} pC_{k,i} \quad = \quad & [(b^{dom}_{k,j})^{\sigma_{k;i}} \cdot (p_{k,i} \cdot (1 + tax^{domC}_{k,i}))^{1-\sigma_{k;i}} \\ & + (1 - b^{dom}_{k,j})^{\sigma_{k;i}} \cdot (p^{imp}_{k,i} \cdot (1 + tax^{impC}_{k,i}))^{1-\sigma_{k;i}}]^{\frac{1}{1-\sigma_{k;i}}} \end{aligned} \tag{2}$$

Consumer's problem

The objective in IMACLIM is maximization of the household utility function (denoted U) that adopts the following form:

$$U = \prod_{goods_i} (C_i - bn_i)^{\xi_i} \cdot (S_{house} - bn_{house})^{\xi_{house}} \cdot (S_{mobility} - bn_{mobility})^{\xi_{mobility}} \quad (3)$$

$$i \in \{agriculture; industry; services\}$$

Government's problem and markets equilibria

government exhibits revenue neutral behaviour:

$$State\_budget_k = \sum tax = \sum_{sectors\ i} \boldsymbol{G_{k,i} \cdot pG_{k,i} + transfer_k + Infra\_inv_k} \quad (4)$$

Market clearing implies:

$$\boldsymbol{Q}_{i,j} = \boldsymbol{Q}_{dom_{i;j}} + \boldsymbol{Q}_{exp_{i;j}} + \boldsymbol{Q}_{ExpIT_{i;j}} \quad (5)$$

At each static equilibrium, the model solve a system of equations

$$Economy(X, Q, P) = \{Q; IC; DF; Imp; Exp; P\} = 0 \quad (6)$$