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ET LE DÉVELOPPEMENT

Models to support discussion on the climate/development nexus

The IMACLIM experience

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Presentation outline

- Methodology
 - The economy-wide dimension of the energy transition modelling challenge at a glance
 - IMACLIM: A hybrid top-down/bottom-up modelling architecture
 - ...Operating in 'second-best' transitional setting
 - ...Covering distributional issues
- Applied analysis
 - Brazil: oil exploration in a low-carbon development context
 - South Africa: technical rigidities/carbon tax recycling into education
 - Saudi Arabia: macroeconomics of oil price variations

Methodology

The economy-wide dimension of the low-carbon transition modelling challenge at a glance

- Energy transitions are an **investment challenge**: they can crowd out other investment and raise the risk of stranded assets
- They change **costs** of E services, which prompts **structural change** of economic activity via **Input-Output relationships** under **inertia** of consumption and production structures
- They are framed by direct & indirect, price & non-price **public policies**
- **Distributional impacts** affect aggregate savings and investment behaviour
- **Exchange rate adjustments** compensate trade balance impacts and retroact on domestic purchasing power—**or do not**
- Economy-wide impacts feed back on **energy mix, energy costs** and **merit order** of technological options

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- Energy transitions are an investment challenge: they can crowd out other investment and raise the risk of stranded assets
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**In total,
What aggregate impact on
growth, unemployment,
income inequality?**

A hybrid TD/BU modelling architecture

- ‘Top-down’ (TD) **economy-wide** analysis
 - Input-output accounts of **comprehensive economic flows interactions** inc. international trade, disaggregated in **2 to 20+ sectors** depending on focus
- Coupled to ‘bottom-up’ (BU) modelling of **energy systems**
 - Because standard optimisation functions of households’ and firms’ choices ill-adapted to complex aggregate adjustments of inert, discrete systems
 - Soft coupling with **local-partner** BU models via iteration of linking-variables exchange, to convergence
- Based on **reconciled energy balance and national accounts data**
 - Matrices of **energy expenses & flows** linked by explicit consumer-price matrix
 - Modelling of **agent-specific prices** beyond tax differentiation

...That accounts for transition dynamics rather than model long-term equilibria

- Imperfect factor mobility and input substitution
 - Labour segmented in **skill levels** hampers sectoral mobility
 - Investment flow, **not K stock**, mobile and technologically flexible
 - **Technical asymptotes** constrain conventional substitution, when used
- Regulated markets
 - **Equilibrium unemployment** to account for L regulations/market imperfections
 - Agent-specific prices allow modelling **administered prices**
 - Real exchange rate variations reflect **fixed nominal rate** if required
- ‘Second best’ economic setting if only for distorting tax systems
 - 1st best options not necessarily... 1st best (Lipsey and Lancaster, 1956)

...In a framework that captures income distribution issues

- IO framework extended to Social Accounting Matrix
 - Income of primary factors including **natural resource rent** properly distributed across households, firms, public administrations—**public involvement** issues
 - Secondary distribution via transfers including direct taxes, social transfers and interest payments on **net debt positions** tracked as accumulated deficits
- Transition policies mix of market incentives and regulations that affect **public income** via structural change and relative price shifts
- Distribution across agents of aggregate gains or losses hangs on **public budget closure** assumption: adjusting taxes vs expenses vs public debt

...to capture distributional impacts and shifts of
aggregate Investment and Savings behavior

Applied analysis

3 illustrations

IMACLIM-Brazil

A co-development with COPPE-UFRJ

- Base year 2005, SAM from IBGE, E balance from EPE – ministry of energy
- 12 sectors, 6 E: bioenergy, coal, oil, natural gas, refined oil, electricity; 6 non-E: freight transportation, passenger transportation, livestock, agroindustry, industry, composite
- Coupled to MATRIZ or BLUM models at COPPE
- Transport and fuel demand modelling: private transport bundle with LDVs in utility function; substitution between gasoline and ethanol to reflect the specifics of the Brazilian LDV fleet ('flex fuel')
- Oil sector modelling: exogenous output, endogenous domestic demand defines export capacity

Low-carbon development and oil exploration

- 2°C-compatible Deep Decarbonisation scenario has low GDP cost ... thanks to oil exports that leak CO2 emissions and hamper economic diversification

	GOVERNMENTAL NDC scenario	OIL-intensive scenario	Deep Decarb. scenario
Real GDP deviation (% GOV)	-	+0.44	-0.14
Real exch. rate dev. (% GOV)	-	-1.5	+3.0
Real Hh income dev. (% GOV)	-	+0.3	+0.9
Industry exports dev. (% GOV)	-	+0.8	-1.8
Industry output dev. (% GOV)	-	+0.9	-1.5
Oil exports revenue (% GDP)	2.7	2.5	3.0

Source: Lefèvre, Wills and Hourcade, 2018, *Climate Policy*

IMACLIM-South Africa

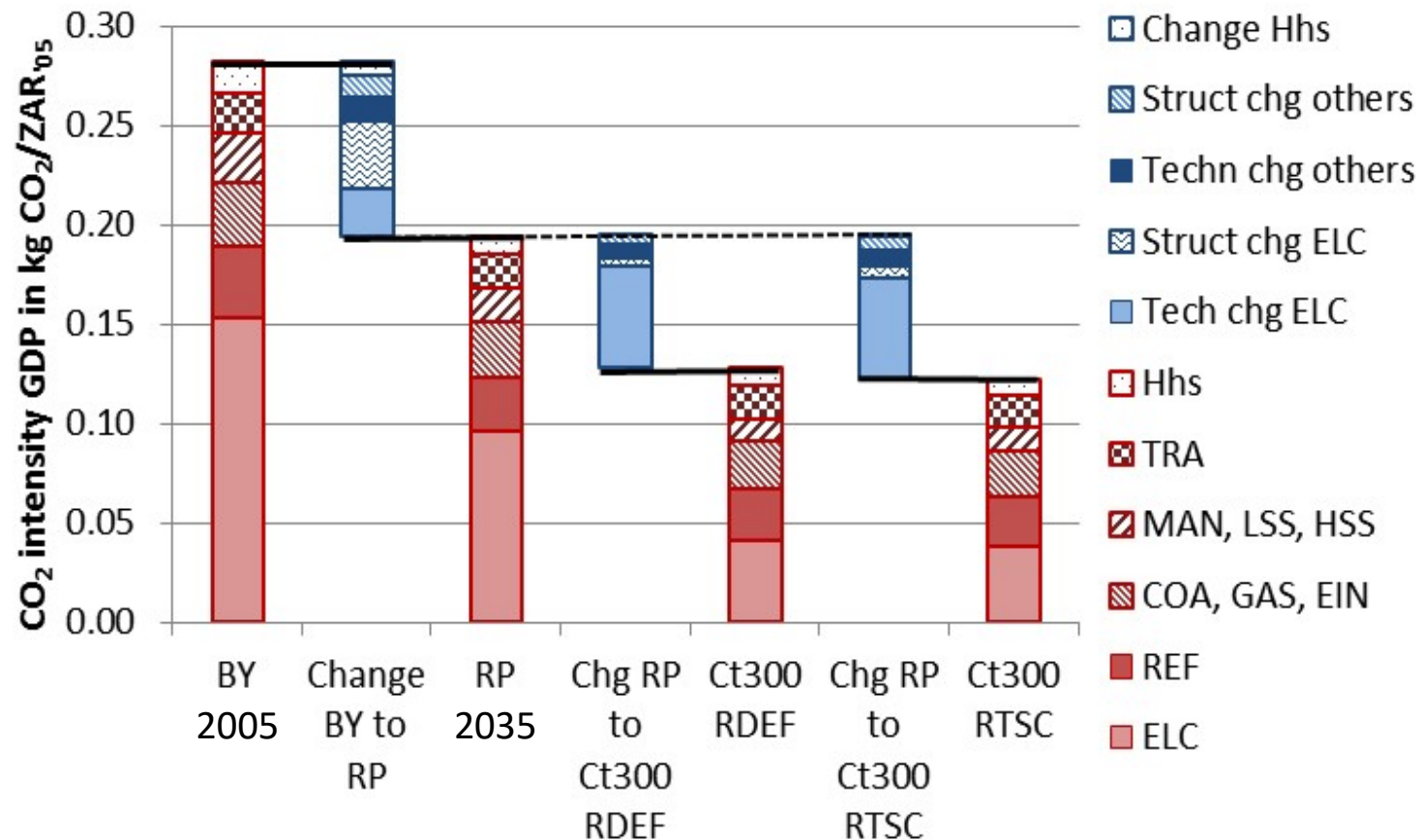
With academic support from ERC-CTU

- Base year 2005, SAM from StatsSA, energy data from RSA, ERC, IEA
- 10 Sectors, 5E: coal, oil, natural gas, refined oil, electricity;
5 non-E: energy-intensive industries, manufacturing, transport services, low-skill sector, high-skill services
- Partial hybridisation with South Africa TIMES model (SATIM) of ERC on technical coefficients of electricity sector
- Labour disaggregated in 3 segmented, imperfect, skill markets
- 5 household classes

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South-Africa 2035

Mitigation potential mostly in power generation



Source: Schers, J., PhD thesis, CIRED

South-Africa 2035

Closing the 'skills gap' favours activity... and CO₂

- 2035 impact of yearly diverting ZAR7.5B of carbon tax proceeds (ca 10% of ZAR100 carbon tax income) to allow 750k additional high-skill actives in 2035 (+11%)
- For 3 carbon tax scenarios with different recycling options

Scenario	2035 GDP	2035 <i>u</i>	2035 CO ₂	2035 CO ₂ /GDP	Income gap*
ZAR100 C tax funding L subsidies	+5.7%	-2.2 pts	+4.6%	-1.0%	-2.2%
ZAR300 C tax funding L subsidies	+4.3%	-1.4 pts	+3.5%	-0.8%	-2.4%
ZAR100 C tax funding sales tax cuts	+5.1%	-2.2 pts	+4.5%	-1.0%	-2.2%

*Income gap measured as ratio of household-class-5 income to class-1 income

Source: Schers, J., PhD thesis, CIRED

IMACLIM-Saudi Arabia

With academic support from KAPSARC

- Base year 2010, SAM from SAMA, energy data from SAMA, IEA, ARAMCO...
- Compact 2-sector 'KLEM' aggregation to tackle macroeconomics of currency peg: 3.75 Saudi Riyals to 1 USD since 1986 ⇒ hard link between trade balance contribution to GDP and real effective exchange rate
- (13-sector version at trial stage ⇒ diversification issues)
- Hybridisation with Kapsarc Energy Model (KEM), one-way so far
- Planned disaggregation of labour in high/low skill and national/foreign

*Financial support from
Electricité de France (EDF)*

Saudi Arabia 2032

Global mitigation & cumulated foreign assets

- 2032 impact of IEA World Energy Outlook 2016 scenarios changing oil price only: +14% in CPS, -28% in 450S compared to NPS baseline---constant oil exports
- Maintaining investment share reduces GDP loss but at the cost of much-reduced domestic savings---what share of decrease supported by public budgets?

Scenario	2032 GDP 2011 = 1	2032 <i>u</i> rate 2011 = 5.4%	2032 REER 2011 = 1	2032 B/GDP 2011 = 29.3%	CFA* Bn 2011 USD
NPS Includes NDCs	1.711	6.4%	1.160	9.6%	1,261
CPS	1.724	5.7%	1.130	13%	1,678
450S 2°C-compatible	1.683	7.9%	1.225	2.5%	499

*Cumulated foreign assets from 2011 to 2032

Source: Soummane, Gherzi, WP CIRED

Co-development of IMACLIM-country models

A critical challenge to facilitate NDC discussion

- Running
 - Global IMACLIM-R (EMF, IAMC)
 - France
 - Brazil with COPPE-UFRJ
 - South Africa with ERC-CTU
- Expected end-of-year
 - Saudi Arabia with KAPSARC
 - India with PSG-IIMA
 - China with EEE-Tsinghua
- Starting
 - Russia with CENRE-NRU HSE Moscow
 - Argentina with Bariloche F.
- **Methodological frontier**
 - Informal economies
 - Macro-financial issues and stranded assets threats
 - Link to industrial policies and trade issues ⇨ diversification

Thank you for your attention

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IMACLIM Network webpage under construction at

<http://www.centre-cired.fr/index.php/en/imaclim-network/>