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CLIMATE-RELATED SCENARIOS FOR FINANCIAL STABILITY ASSESSMENT: AN APPLICATION TO FRANCE

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NOËMIE LISACK,
THOMAS ALLEN, MATEO CAICEDO, STÉPHANE DEES,
ANNABELLE DE GAYE, FULVIO PEGORARO, MARIE RABATE
& COLLEAGUES*
BANQUE DE FRANCE

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Structure

1. Objectives and scenario selection

2. Conceptual framework and results
    a. Macroeconomic modeling
    b. Sectoral modeling
    c. Infra-sectoral modeling
    d. Financial modeling

1. Objectives and scenario selection

Objectives

Design scenarios for the purpose of climate-related financial risk assessment

- Develop a **conceptual framework** that links climate outcomes, transition scenarios and macroeconomic and sectoral impacts

- **Build 3 consistent scenarios:** one **baseline** and **two adverse** variants that are relevant from a financial stability perspective

- Focus on **transition risks**

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Specificities of climate scenarios

	Standard scenarios	Climate change scenarios	
		Transition risks	Physical risks
Horizon	Short to medium run	Short, medium and **long run**	Short, medium and **long run**
Scenario drivers	Economic and financial	**Climate policy and technological change**	Conditional on outcomes of transition scenarios and/or **environmental dynamics**
Shock values	Guidance from historical data	Little to no guidance from history	Little to no guidance from history
Aggregation	National	**Sectoral**	Sectoral and **geographical**
Feedback loops	Work in progress (e.g. macro models with financial frictions)	Work in progress (e.g. interaction between policy and economy)	**Interaction climate - economy**

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NGFS scenarios

- NGFS released **a set of high-level reference scenarios** in June 2020, produced jointly with an academic consortium
- The first phase explores **8 scenarios** consistent with the NGFS framework
- They explore futures in which:
  - Different **temperature outcomes** are reached (e.g. 1.5°C, > 2°C, 3°C+)
  - **Emissions reductions** start soon or are delayed (to 2030)
  - All **technologies** are available or not

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Building on the NGFS

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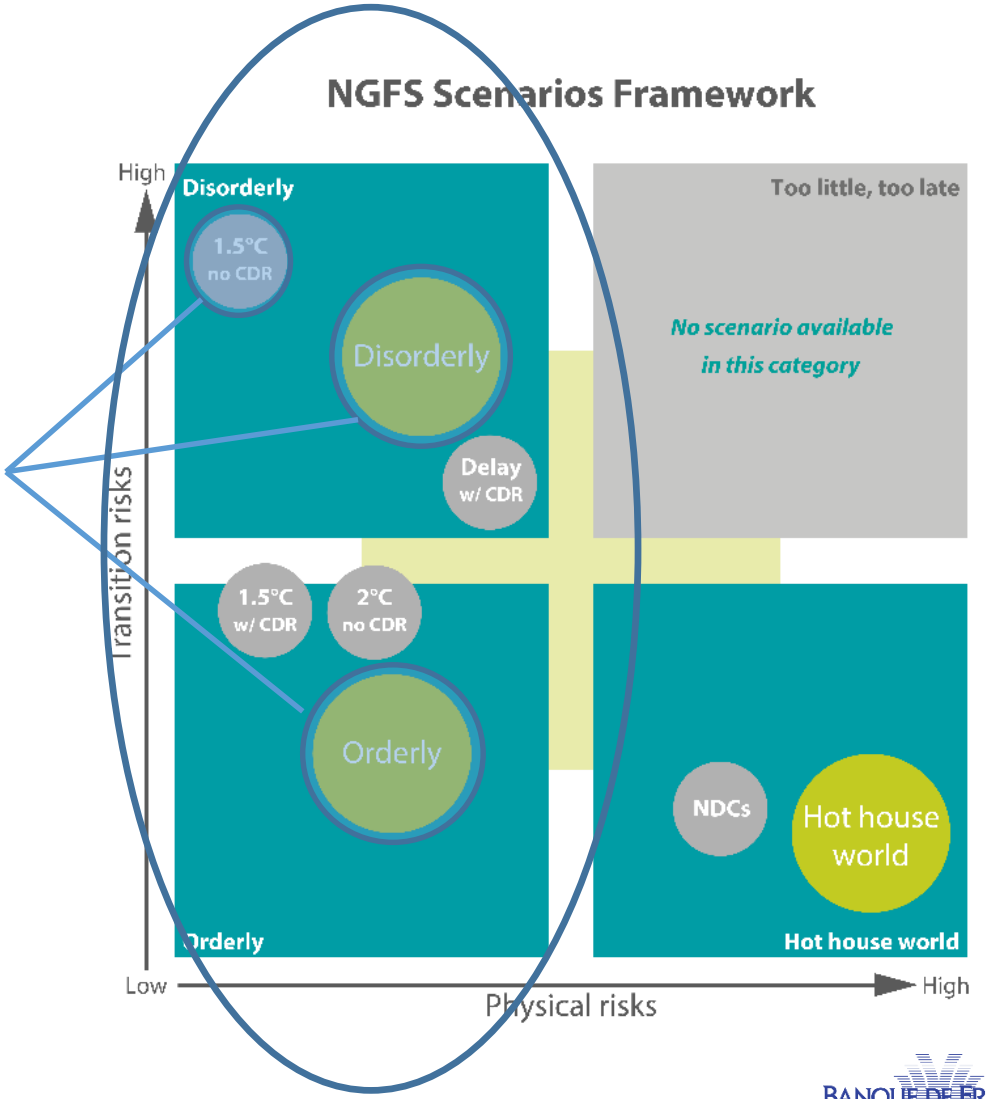
Our exercise is based on 3 transition scenarios



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Scenario narratives

The exercise analyses 3 scenarios:

- 1 **baseline** scenario and 2 **adverse variants**
- 2 shock variables related to transition risks:
  - **carbon price**
  - **productivity**
- Adverse variants depending on:
  - **Timing** of the shocks
  - **Size** of the shocks
  - Assumptions about technology – **productivity**
- **Time horizon: 2020-2050**

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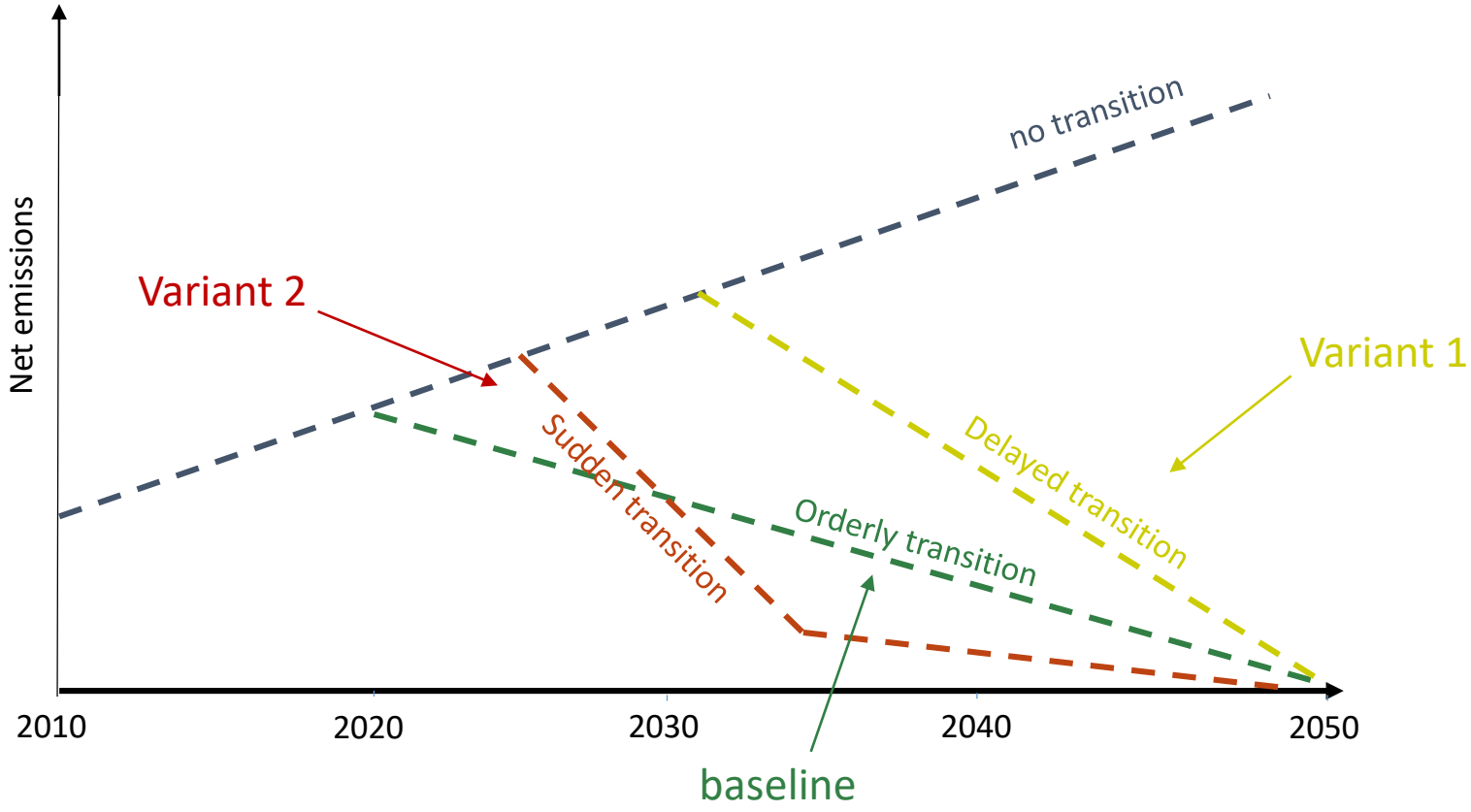
Building on the NGFS

What type of transition to reach zero net emissions by 2050?

Orderly (baseline) and disorderly scenarios (2 adverse variants)



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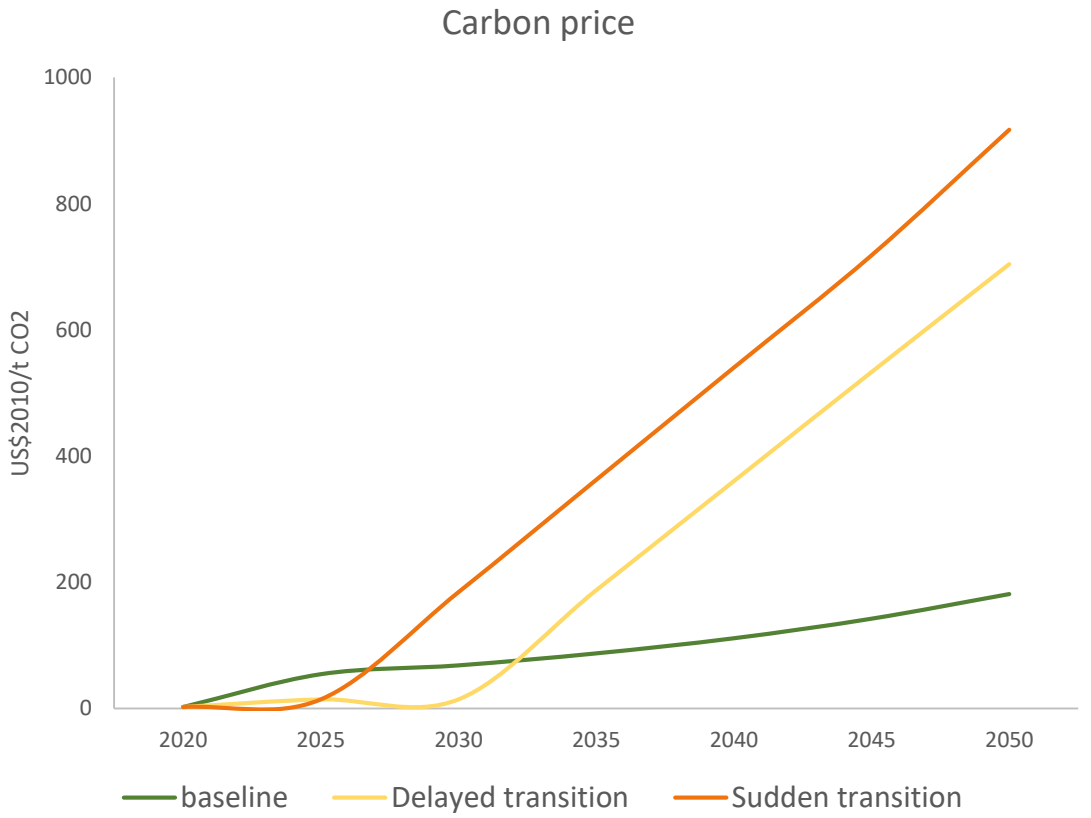
SHOCKS

- **Carbon prices:**

  3 trajectories aligned with the NGFS *high-level* reference scenarios

  - Variant 1: from $14 in 2030 to $704 in 2050 (/t CO2)
  - Variant 2: from $14 in 2025 to $917 in 2050 (/t CO2)



- **Calibration:**

  - *Delayed transition*: Calibrated on the NGFS GDP outcomes, assuming positive productivity gains and postponed increases in carbon prices

  - *Sudden transition*: Constant productivity – no calibration on the NGFS GDP outcomes

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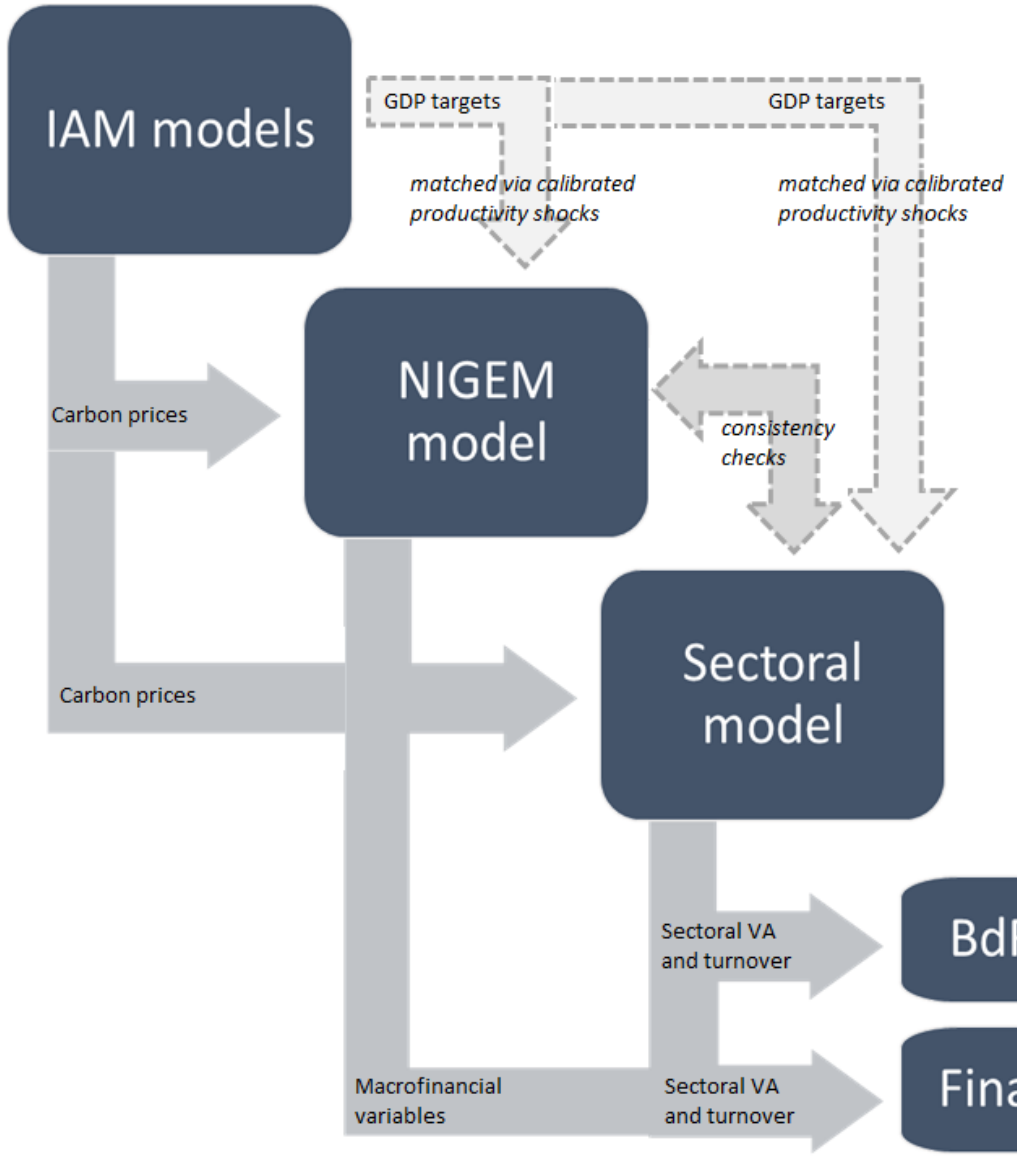
3. Modeling and results

MODELING ARCHITECTURE



- **NGFS *high-level* Reference scenarios**
- Outputs: carbon prices, GHG emissions

- **Country-level macroeconomic model**
- Outputs : Macrofinancial variables (inflation, employment, etc.)

- **Sector-level disaggregation**
- Outputs: VA and turnover for 55 sectors

- **Firm-level disaggregation**
- Outputs: PDs

- Outputs: Market valuation, etc.

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3a. Macro model

Macro Model: NiGEM

- Multi country new keynesian general equilibrium model
- Carbon emissions not present => carbon tax implemented through **calibrated increases in fossil fuel prices** (inspired by work by DNB)

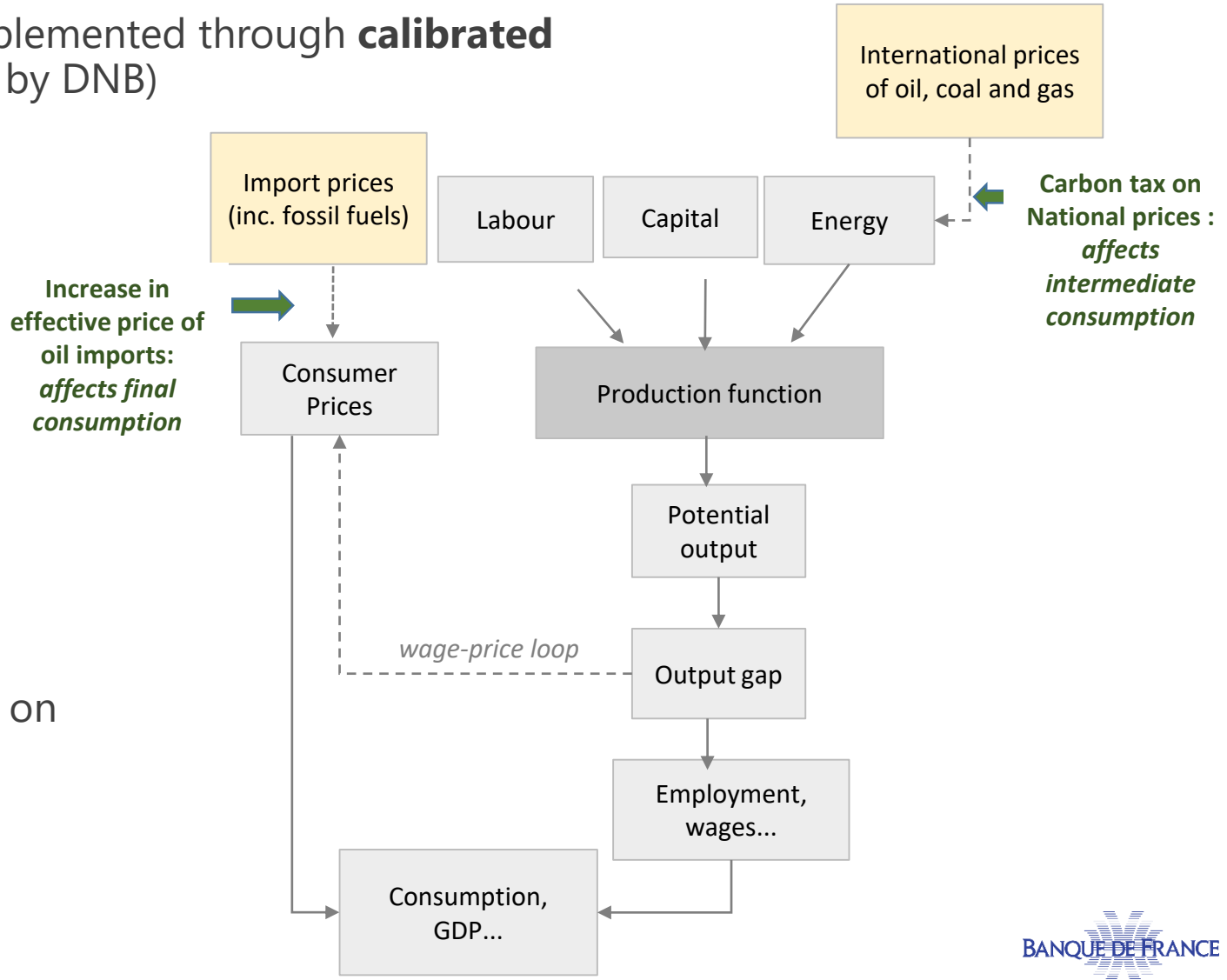
- 2 main **transmission channels**:
  - **Energy prices as intermediate cost**: intermediate input in production function; affects oil intensity

    'Effective' price of fossil fuel$_{country\ X}$ = *International price + Carbon tax*$_{country\ X}$

  - **Energy prices for households**: 'effective' price of imported fossil fuels is included in consumption price index (excise tax on petroleum products in France)

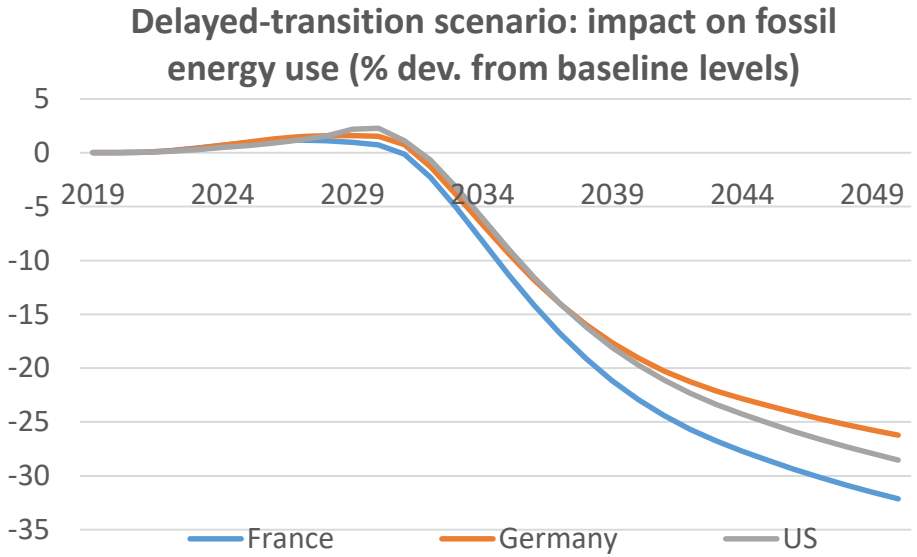
    -> direct impact on consumer prices

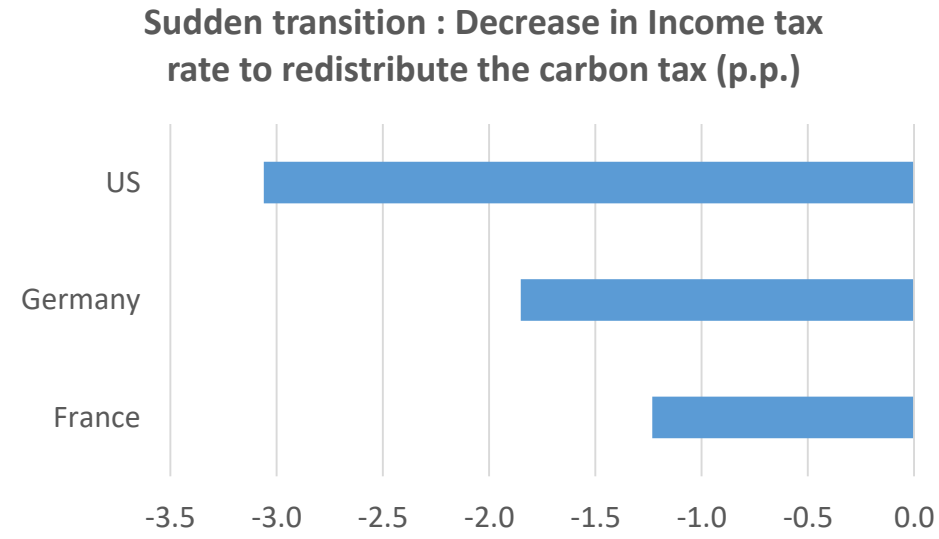
- **Impact on aggregate variables:** GDP, consumption, wages, unemployment



Calibrating NiGEM

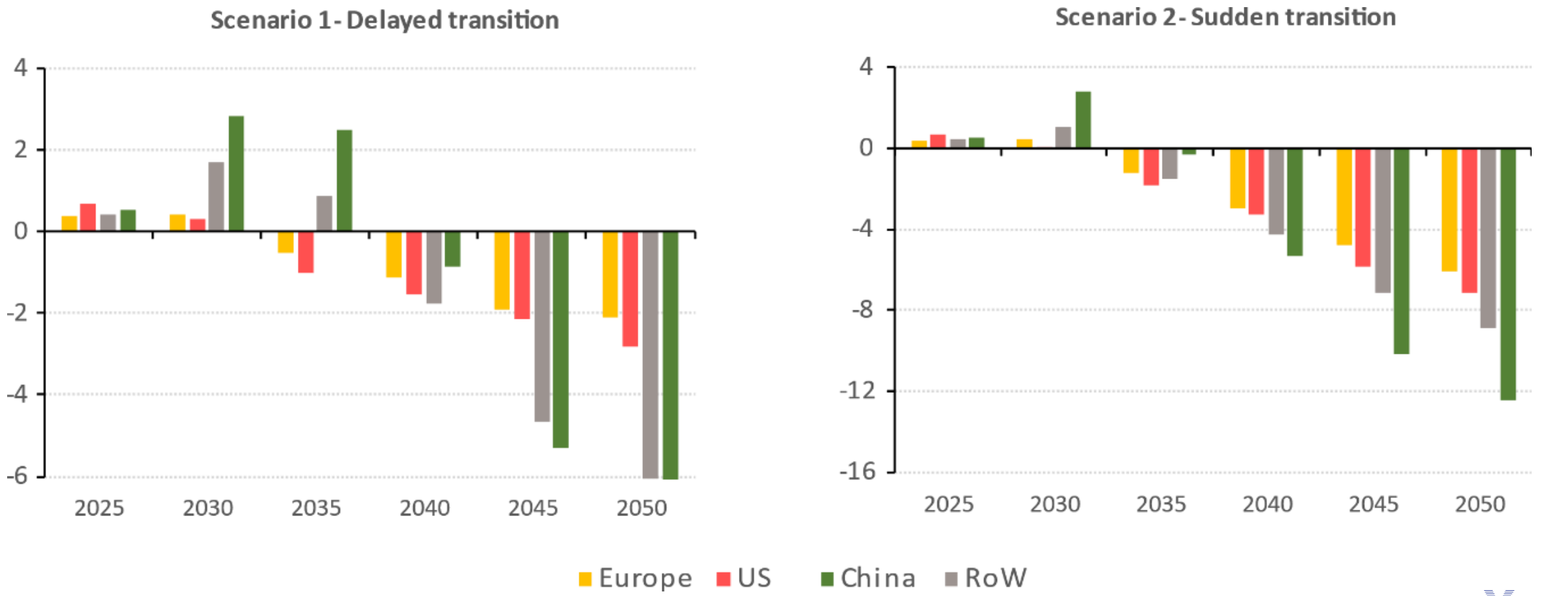
- **Fossil fuel prices:**
  - shock calibrated to reflect the CO_2 emissions of burning oil-equivalent barrels of fossil fuel
- **Redistribution** of tax proceeds:
  - to **households** through a decrease in income tax
- **Endogenous monetary policy reaction:**
  - supply shock has large inflationary effects => ST interest rates tend to rise and have further recessionary effects
  - => Reaction function has been adjusted to decrease inflation coefficient and to increase inertia
- **Consistency checks** with sectoral model:
  - Matching the aggregate GDP impacts using technological shocks
  - Adjusted to IAM results in delayed transition
  - Adjusted to sectoral model in sudden transition





Macroeconomic Impacts

Real GDP levels (% deviation from baseline)



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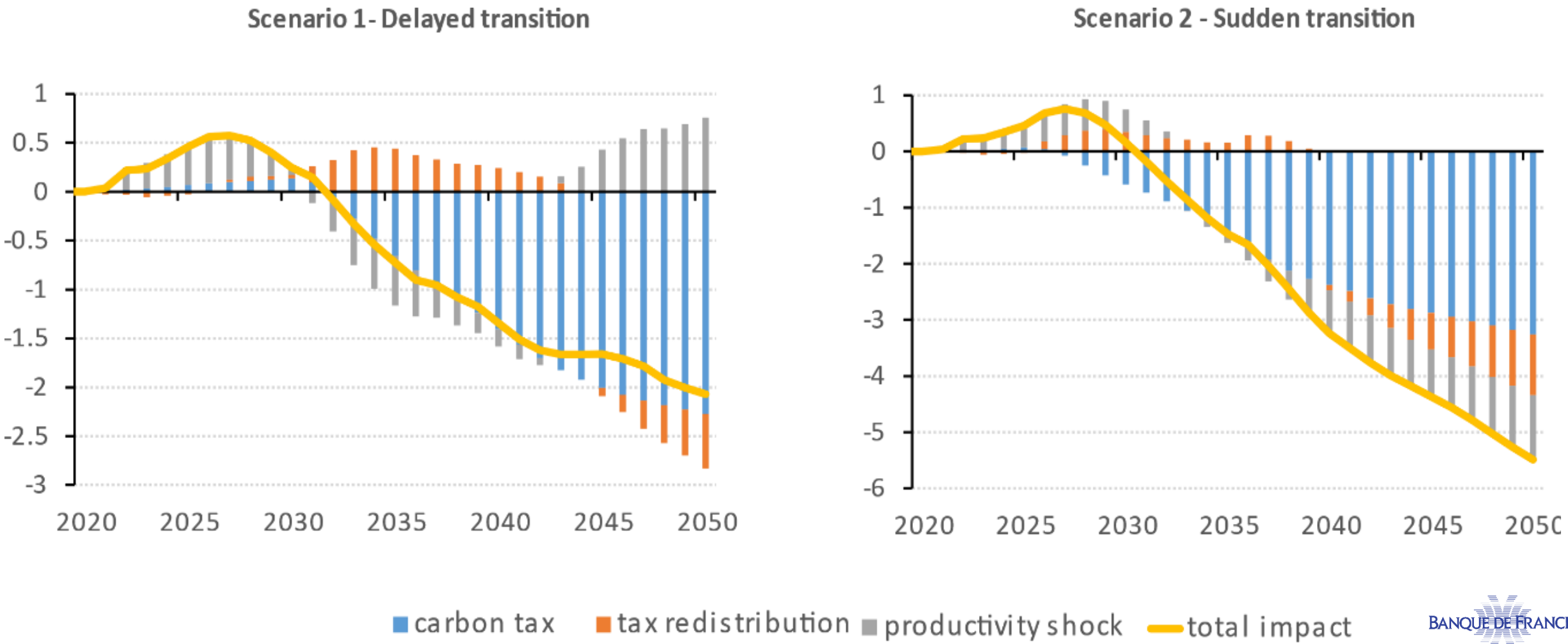
Macroeconomic Impacts

Contributions to GDP impacts in Europe (% deviation from baseline)



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3b. Sectoral model

Sectoral Model: Overview

- Inspired by production networks literature and work by DNB
- Detailed presentation in Devulder & Lisack (2020)

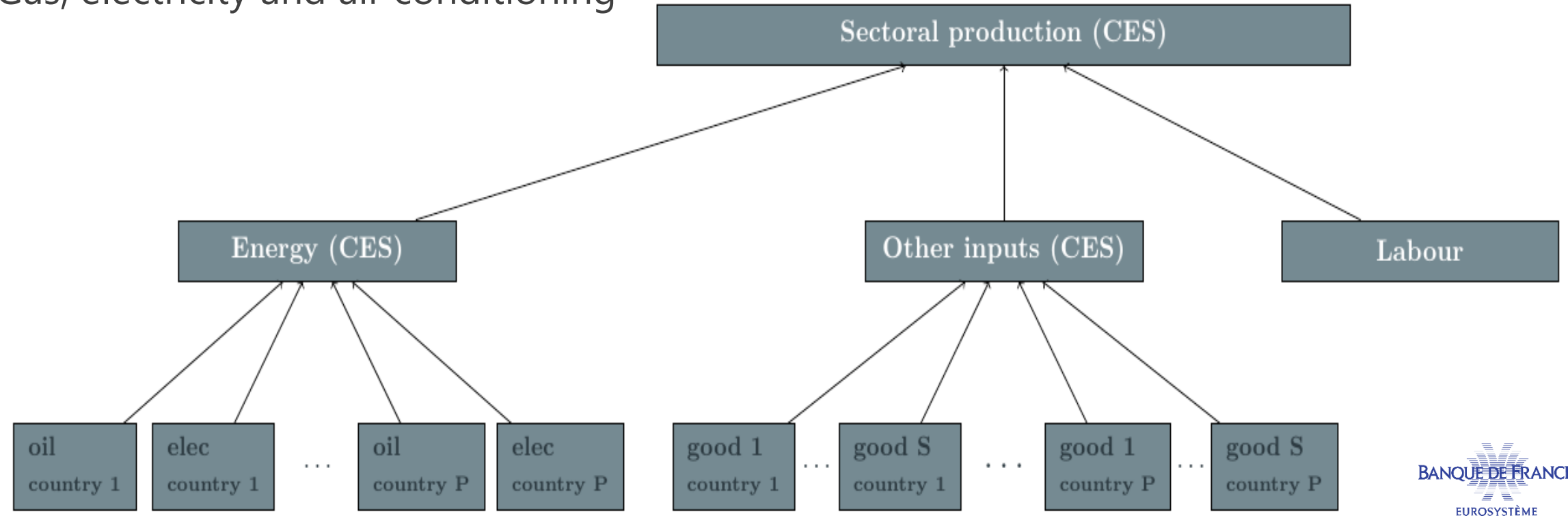
Main ingredients:

- **Multi-country, multi-sector** model
- Calibrated on WIOD data (2014)
- Real, static, general equilibrium
- Horizon of 5 to 10 years
- Complete markets
- **Sectoral production network**, perfect competition within sectors
- One representative household per country, no migrations
- **Tax proceeds redistributed to households** as a lump-sum transfer

Sectoral Model: Production Network

Substitution:

- Across goods, energy and labour ($\theta = 0.8$)
- Across sectoral goods ($\epsilon = 0.4$)
- Across energy types ($\sigma = 1.5$):
  - Coke and oil refining
  - Gas, electricity and air conditioning



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Sectoral Model: Shocks

Taxes:

- On **final purchase** of oil & coke by households
- On **intermediate purchase** of oil & coke by producers
- On **production**
- Tax rates related to sectoral GHG emissions:
  - CO2 emissions
  - Sectoral non-CO2 emissions (methane, nitrous oxyde)
- Calibrated following the NGFS carbon price path

Labour productivity:

- One shock per country, homogeneous across sectors within each country
- Only in the delayed transition scenario
- Calibrated to match the NGFS aggregate GDP impacts

=> **Impacts** on:
- Real **value added**
- Real **turnover**

for each sector

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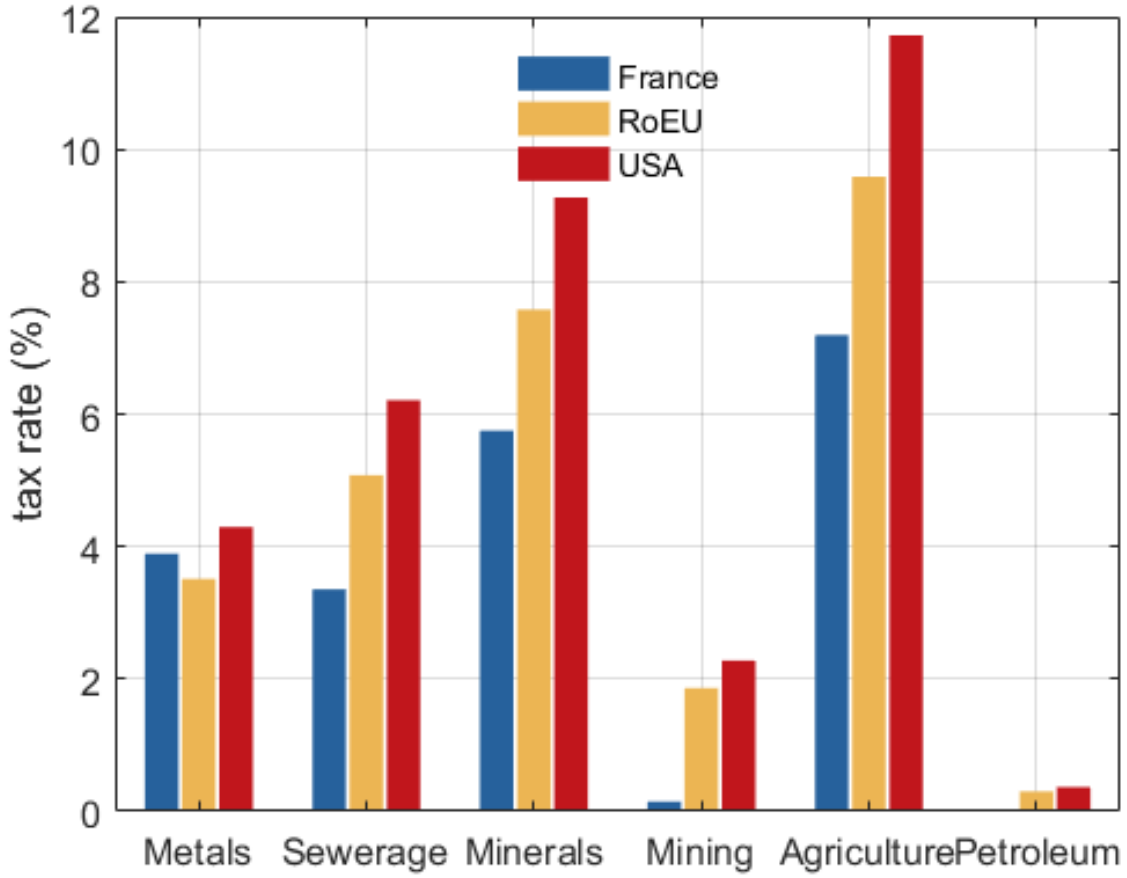
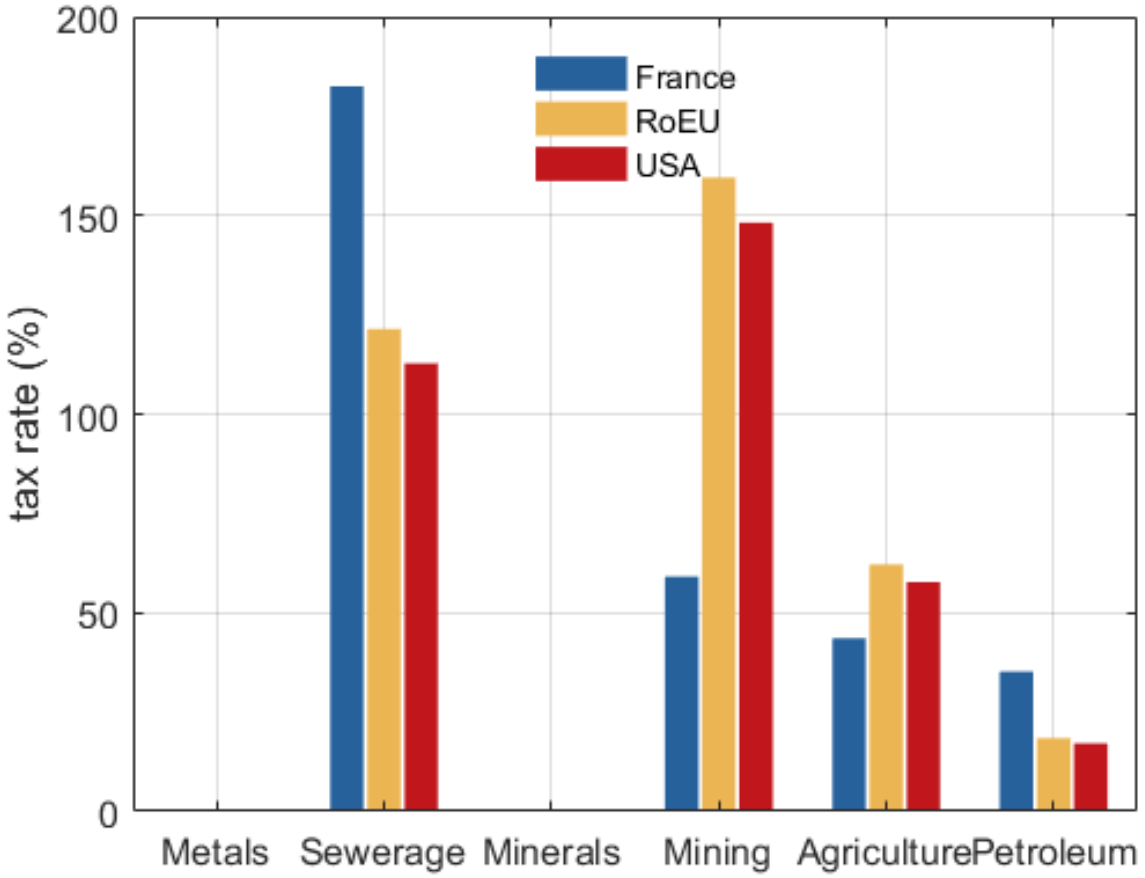
Sectoral Tax Rates

Carbon tax rates for a price of 100USD/tCO2e

Production tax rates (related to GHG emissions, excluding CO2)

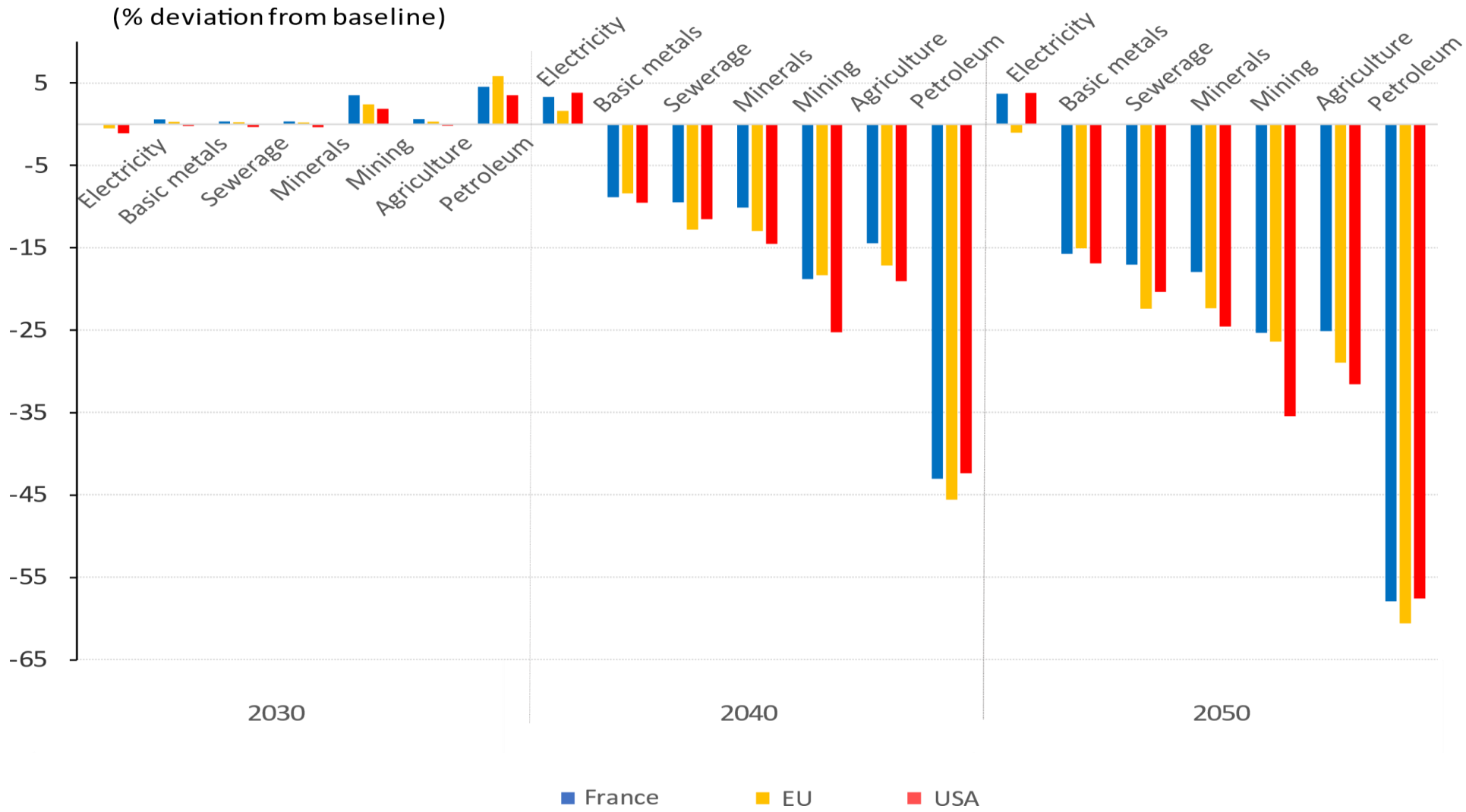


Oil & coke inputs tax rates (related to CO2 emissions)



Sectoral Impacts

Impacts on sectoral real value added (sudden transition)



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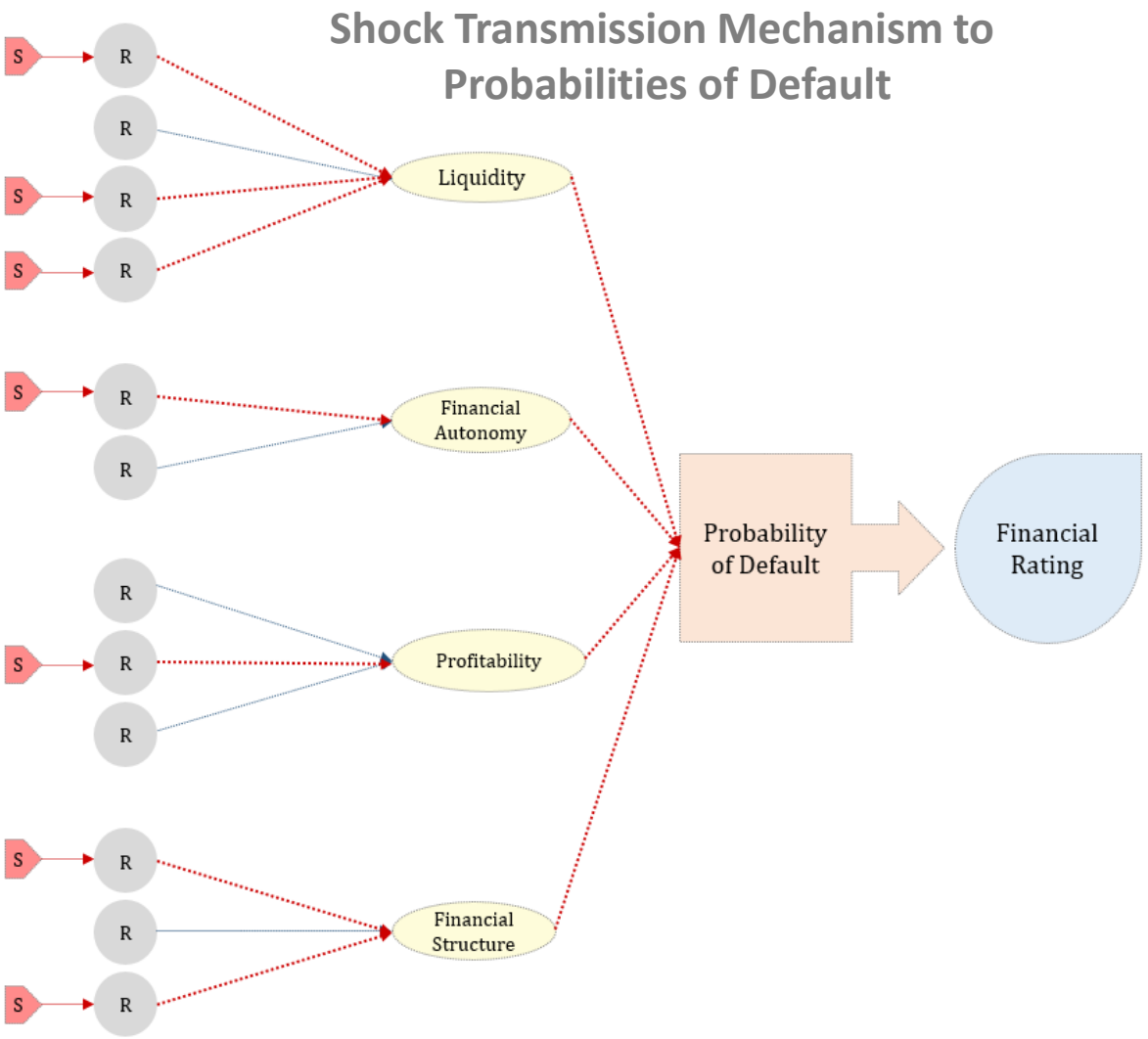
3c. Infra-Sectoral model

Infra-Sectoral Model

Using Credit Risk to disentangle between winners & losers



Model

- NFC Credit Risk rating
- 7 different macro-sector models

Data & Default Definition

- Around 270K firms per year.
- Yearly firm accounting data from **FIBEN** (2011-2017).
- Payment default data from the French national Central **Credit Register** (2012-2018).
- **One-year horizon binary default** complying with Eurosystem standards and Basel Committee definition.

Probabilities of default estimated using Financial Ratios and Theme based categorical variables

Shock Transmission Mechanism:

- Impacts on real value added and real turn-over

⇒ firm-level financial aggregates

⇒ affect financial ratios and **probabilities of default**

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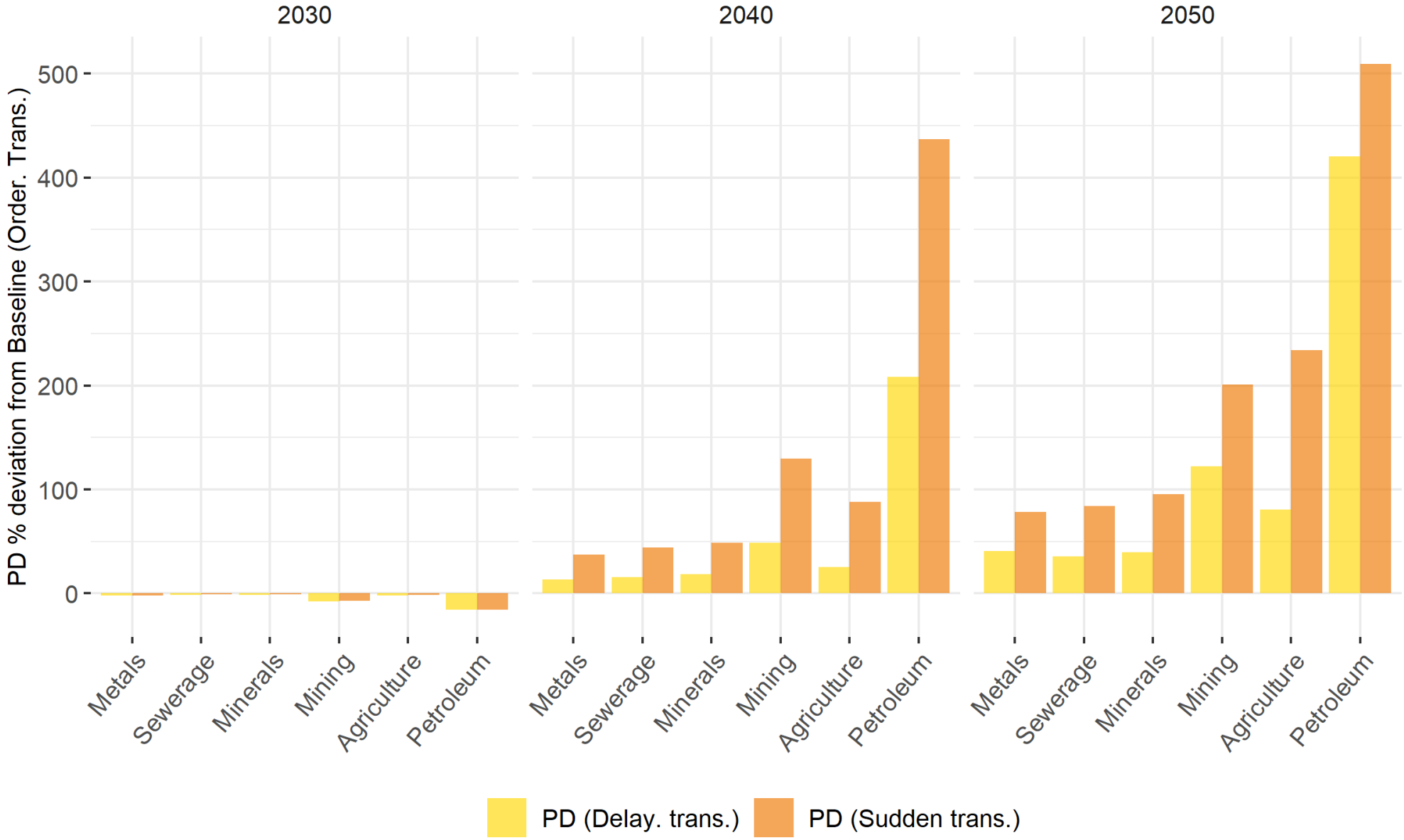
Infra-Sectoral Impacts

PDs more and more impacted over time



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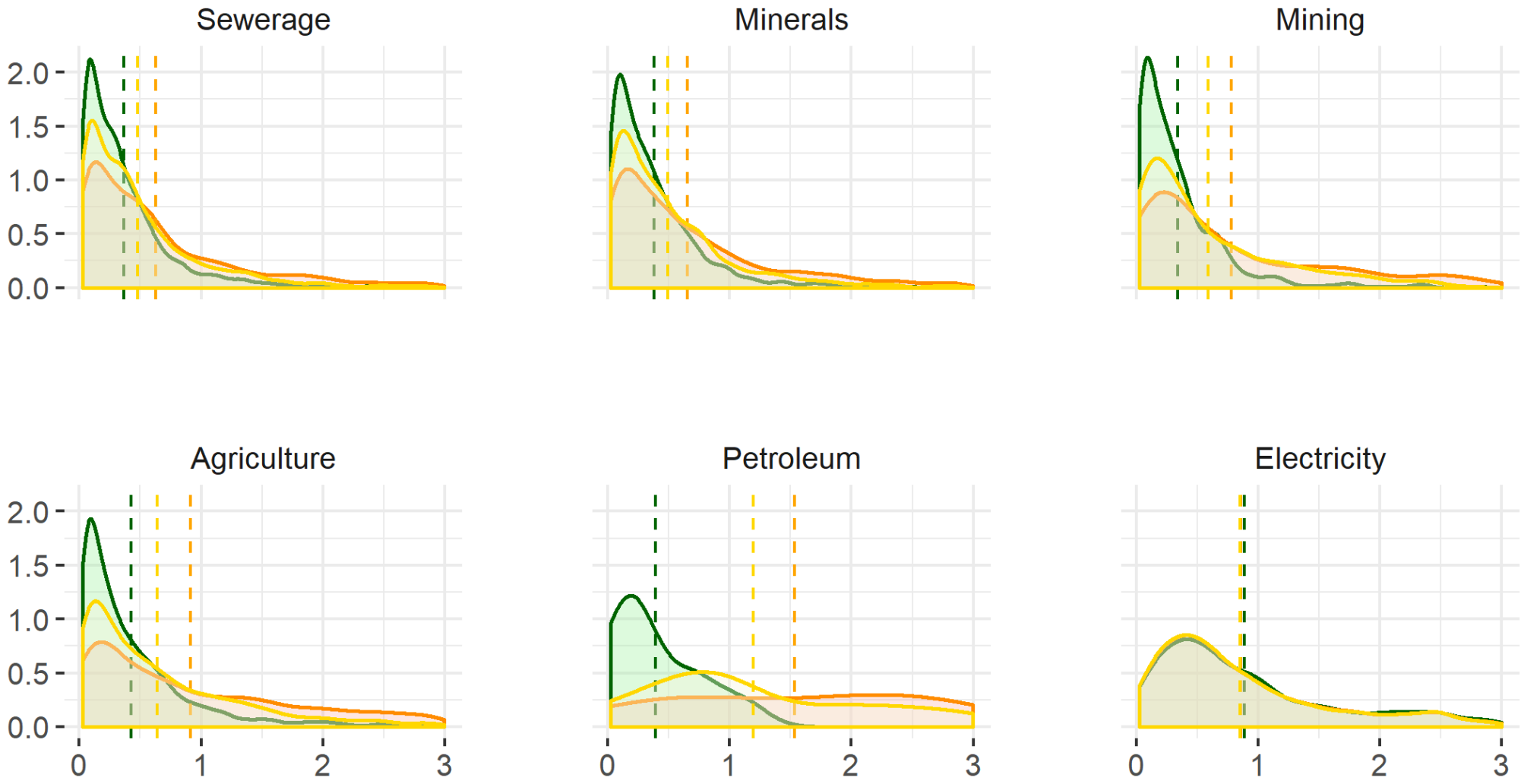
Infra-Sectoral Impacts

Probability of Default densities across scenarios (in 2050)



Dashed lines: median

Delayed Trans. Orderly Trans. Sudden Trans.

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Infra-Sectoral Impacts

PDs for top 3 impacted firms (in 2050)

PD (Order. trans.) 2050

PD (Delay. trans.) 2050

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3d. Financial modules

Stock price impacts

- **Relative stock price change as of 2020**
  - if investors were reevaluating their anticipated dividend stream
  - taking into account the new information associated with the two adverse scenarios

- Evaluation via discounting of scenario-based dividend streams (Dividend Discount Model) for each sector and economic area.

- Obtained by combining results from NiGEM and Sectoral models.

- We have a 3-steps procedure:
  - NiGEM and Sectoral models provide **projections of turn-over and value added** between 2025 and 2050.
  - **Distributed dividends** assumed to be 50% of return on capital (33% of value added).
  - **Dividend stream discounted** using an average index **stock return** and a projection of a sector-specific **risk-correction component**.

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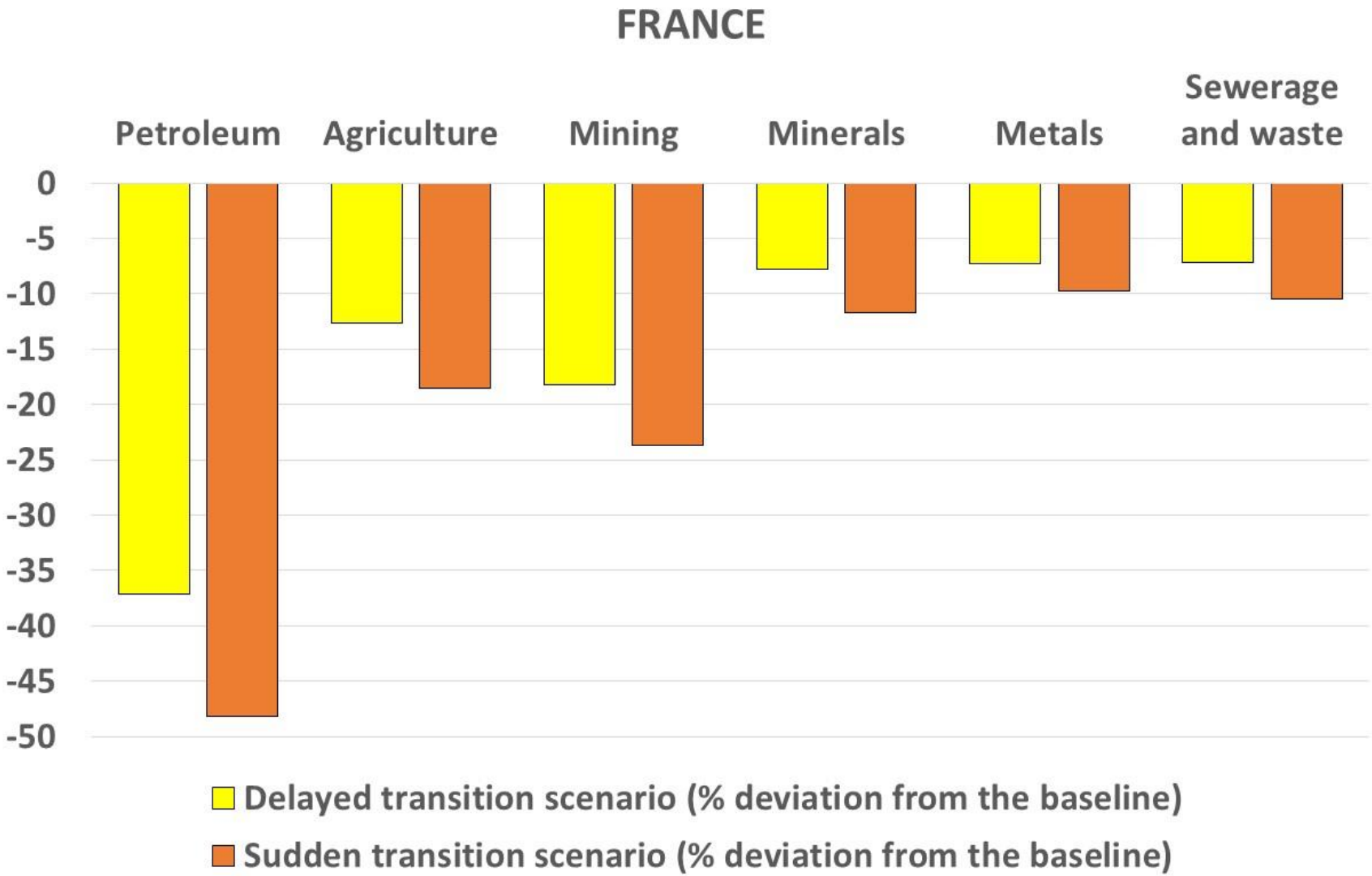
Stock price impacts
by sector (% deviation from baseline)



- Perfect and instantaneous revision of market expectations
- significant repricing for some sectors
- **First-round effects** here
- If simultaneous sales: possibility of second-round losses on these assets

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Additional financial variables

- Risk-free term structure
  - based on no-arbitrage Term Structure Model
- Corporate credit spreads
  - projections of credit spread with one year maturity for any scenario from 2020 to 2050 using the BdF rating model
  - Longer maturities (2 to 5 years) obtained using a Bayesian VAR and conditional forecasts (projections) given the future path from 2020 to 2050 of the one year maturity credit spread

Conclusion

- Scenarios used for the **pilot exercise** conducted by the **ACPR**, along an additional variant with physical risks

- **Work in progress**:
  - New NGFS reference scenarios
  - NiGEM developments
  - Improvements in the models coupling
  - On-going comparison study with models from other French institutions