SPECIALISTS IN EMPIRICAL ECONOMIC RESEARCH

MODELLING THE REBOUND EFFECT IN PANTA RHEI

Inforum Conference, September 2019, Sochi, Russia

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ReCap
Makro-Rebounds begrenzen

Bundesministerium für Bildung und Forschung

FONA
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The Rebound Effect

- Definition: “[...] some or all of the expected reductions in energy consumption as a result of energy efficiency improvements are offset by an increasing demand for energy services [...]”

  Barker et al. 2008: The Macroeconomic Rebound Effect and the UK Economy

- Straight forward example:
  - ⇨ 10 % increase in energy efficiency
  - ⇨ 6 % decrease in energy consumption
  - ⇨ 40 % rebound effect

Project and motivation

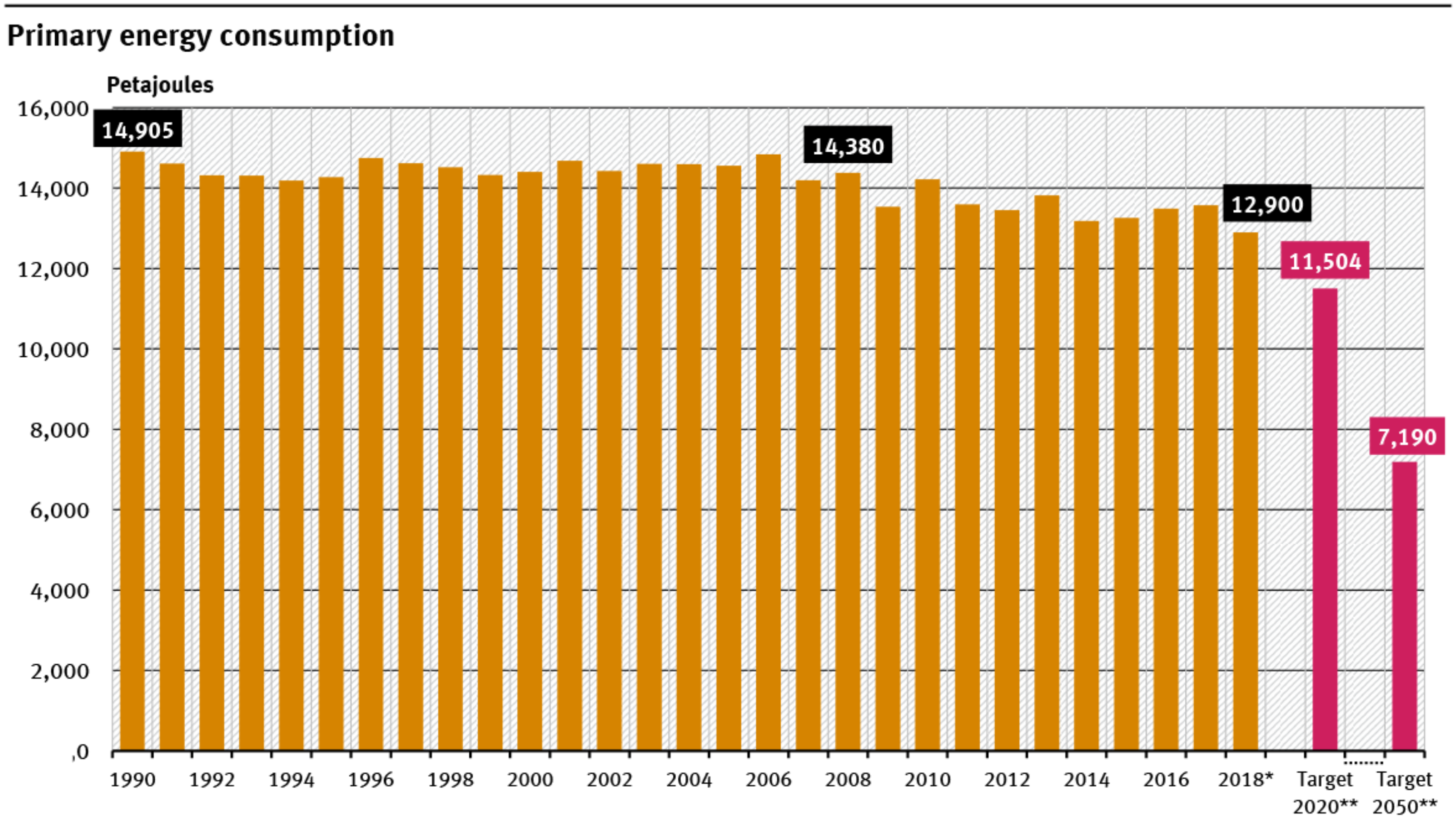
- ReCap project (https://www.macro-rebounds.org/english/)
  - ⇨ **Re**considering the Role of Energy and Resource Productivity for Economic Growth, and Developing Policy Options for **Cap**ping Macro-Level Rebound Effects
  - ⇨ Three year project funded by BMBF as part of FONA
  - ⇨ Partners: IÖW Berlin (lead), University of Göttingen

- The problem: energy consumption is declining less than expected
  - ⇨ Have rebound effects been neglected?
  - ⇨ What are magnitude and drivers of rebounds?
  - ⇨ How to model and address them?

The problem

Target of the German Energy Concept:

Reduction of the primary energy consumption by 20% until 2020



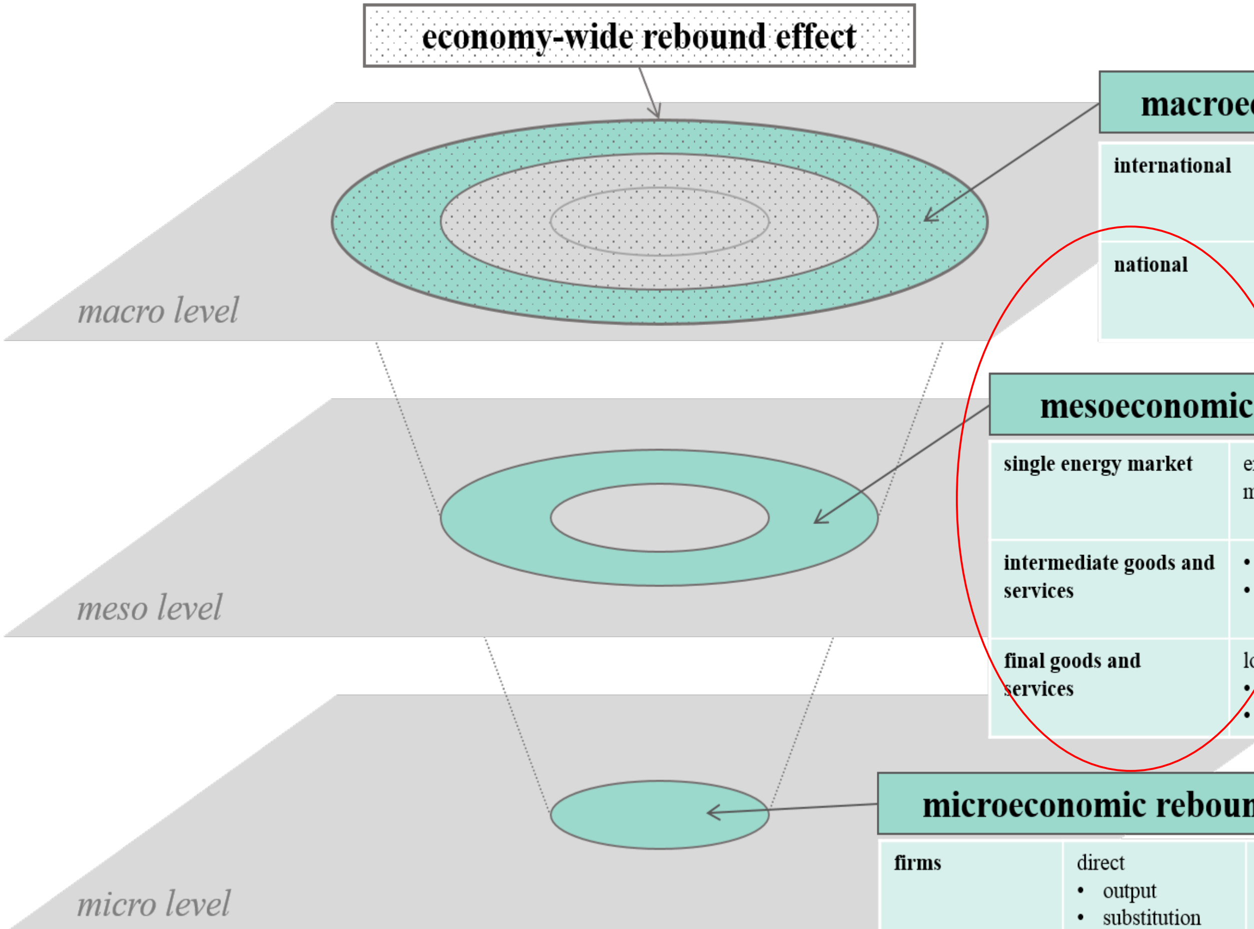
* preliminary figures
** Targets of the Energy Concept and the German Sustainable Development Strategy: Reduction of the primary energy consumption by 20 % until 2020 and by 50 % until 2050 (base year 2008)

Source: German Federal Environment Agency on basis of the Working Group on Energy Balances (AGEB), Evaluation Tables on the Energy Balance for Germany 1990 to 2017, as of 07/2018; for 2016/2017 - AGEB: Primary energy consumption, as of 12/2018

Source: Umweltbundesamt

Rebound definition in ReCap

- Only part of rebound effects considered in PANTA RHEI



macroeconomic rebound effects		
international	international trade and relocation	international energy markets
national	general market price of energy	macroeconomic multiplier

mesoeconomic rebound effects	
single energy market	energy price in one energy market
intermediate goods and services	• output • lower prices and higher sales
final goods and services	lower prices and higher sales • income • substitution

microeconomic rebound effects		
firms	direct • output • substitution	indirect
housholds	direct • output • substitution	indirect

Literature on modelling rebounds

- Broad range of macroeconomic models for various uses
  - ⇨ Rebounds are just sometimes considered explicitly
  - ⇨ Rebounds and policies are rarely modelled together
- Four models examining the macro-rebound screened in detail

Model Type	Publication of Choice	Size of the Rebound Effect
Macroeconomic (growth) Model	Saunders (2000)	n.a.
Computable general equilibrium model	Allan et al. (2007)	55-62% short term 27-31% long term
	Koesler et al. (2016)	47-55% depending on scope and scenario
Macroeconometric Model	Barker et al. (2008)	11% (Macro) + 15% (Micro) = 26%

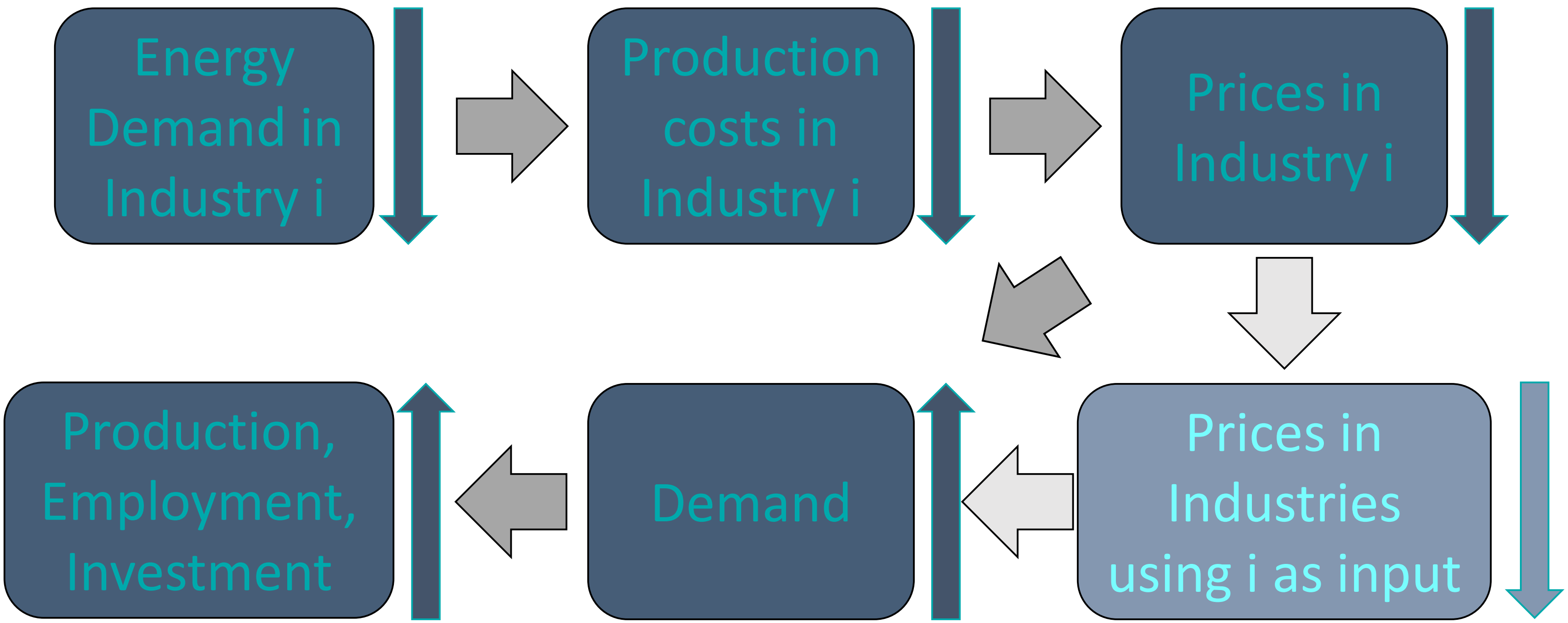
Modelling rebounds in PANTA RHEI

- PANTA RHEI:
  - Macroeconometric energy and environmental national model (INFORUM type, similar to E3ME)
  - Parameters econometrically derived from historical time series, no neoclassical general equilibrium
  - Based on official statistics (SNA, time series of IOT)
  - Bottom-up (63 sectors)
  - Fully interdependent
  - Energy balance systematic
  - Open for expert information/input from bottom-up models
  - **Net impacts** (direct, indirect, induced effects)
- Comparison of models results for different scenarios: Energy efficiency increase or energy policy compared to Reference

The Rebound Channel in Panta Rhei

1. Autonomous increase in energy efficiency in industry (or in transport or housing): +10% in manufacturing from 2021 on

▶ *Final Energy Demand (Variable eevb) decreases by 10% of its 2021 value from 2021 onwards in all sectors belonging to manufacturing via fix*



The Rebound Channel in Panta Rhei

2. Lower electricity prices due to lower demand:
   exogenous assumption as the most expensive power plant in Germany or neighbour countries sets the price
   Wholesale price: -1 €Cent/kWh from 2021 onwards

► *reduction of epstromhh[1] by 1 (procurement component of electricity price for households) via fix*

3. Higher private consumption due to higher income and lower (energy) prices

► *Creation of a variable representing the hypothetical real income gain, used to calculate a higher cpvr (final consumption of households in real terms)*

The Rebound Channel in Panta Rhei

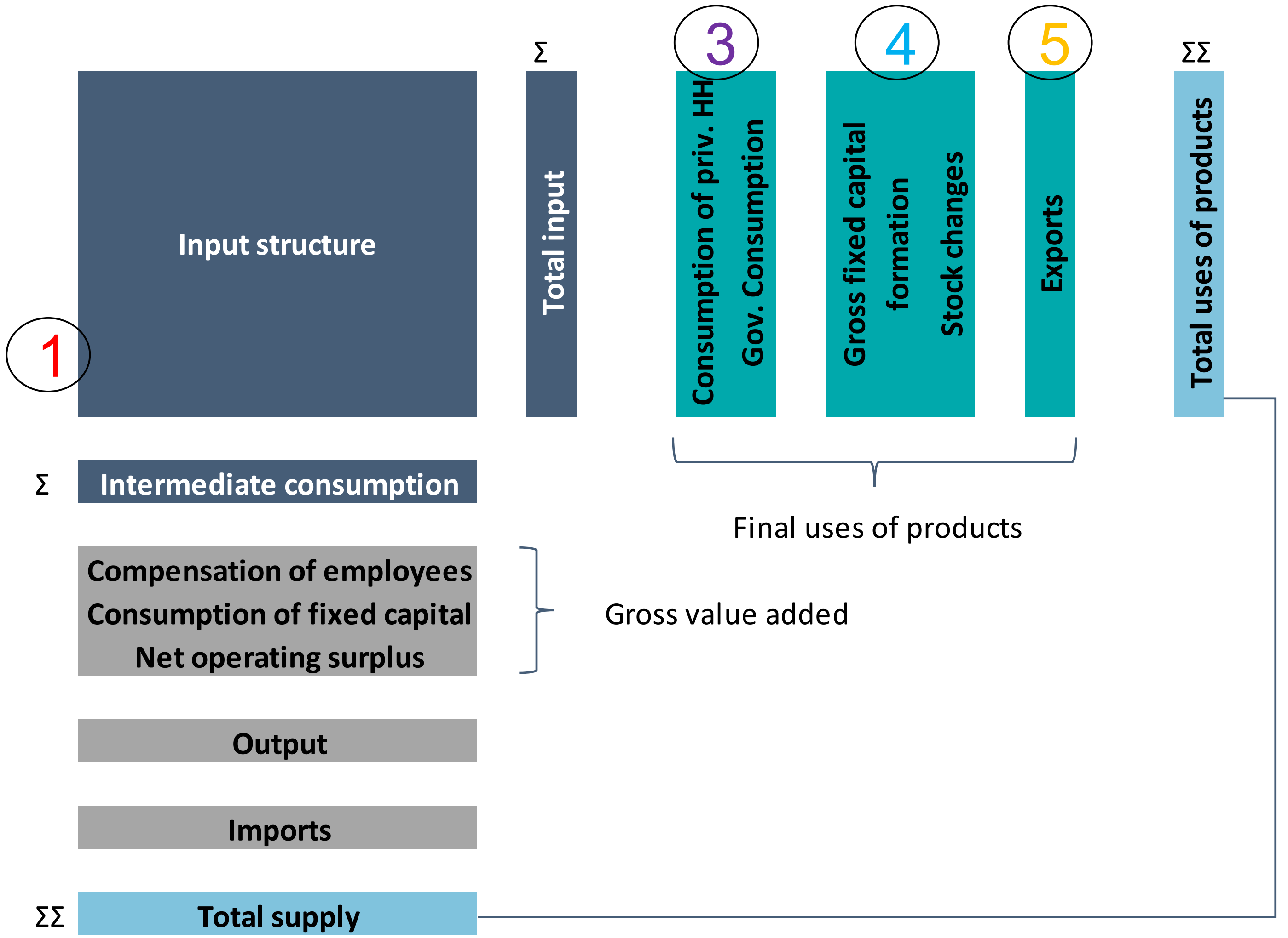
4. (Additional) Investment in more energy-efficient production in industry (25 BN € in 2021 according to another study)

► *irsr (equipment investment, various elements) and ibsr (building investment, by energy supply) are raised*

5. Higher exports due to lower production costs (export prices): price elasticity of exports 5 (instead of 1)

► *exn (Exports) modified by multiples of the resulting delta from previous scenarios*

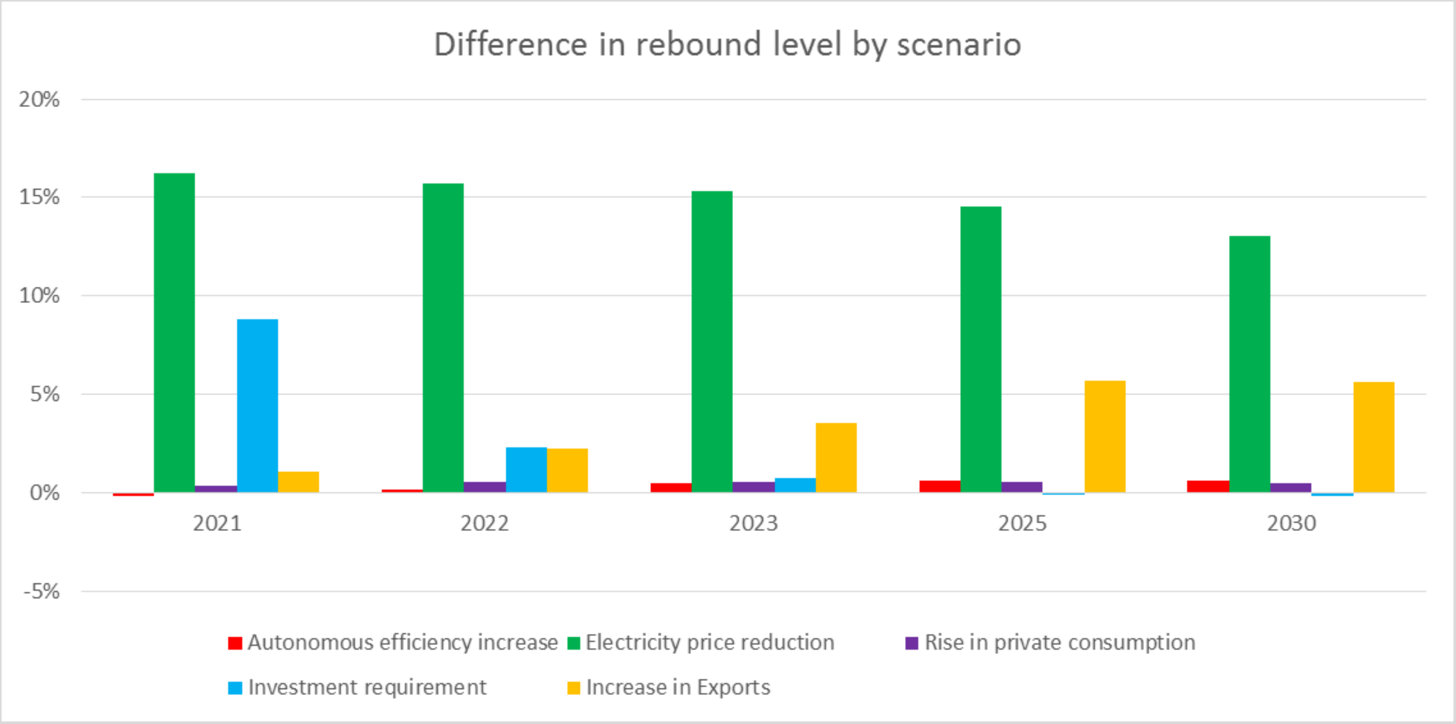
Schematic overview



Rebound effects – first results

- Model based calculation of the rebound:

$$1-\frac{\Delta eevb_{scenario\ x}}{\Delta eevb_{initial\ fix}}$$



Summary and outlook

- Rebound effects due to autonomous increase in energy efficiency are low in PANTA RHEI
  - ⇨ Parameters of behavioural equations are estimated econometrically (are they too low in the long term?)
  - ⇨ Less optimistic about substitution possibilities (elasticities) than neoclassical CGE models
  - ⇨ Macroeconomic/sectoral approach does not cover all rebounds (on micro level/international level)
- Model adjustment
  - ⇨ Elasticities for industry from ex-post estimations (using very detailed cost structure data from German manufacturing)
  - ⇨ Sensitivity analyses

Summary and outlook (2)

- Main research interest is in policies to reduce rebound effects (not in modelling rebounds)
- Implementing different policy sets in the model and compare macroeconomic effects
  - ⇨ Current policy
  - ⇨ Prices (taxes, caps, market-based instruments)
  - ⇨ Regulation
  - ⇨ Policy mixes and rebound-proof policies
- Develop/evaluate rebound-proof policies with stakeholders and also discuss model characteristics such as elasticities

Thank you for your attention.

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Literature

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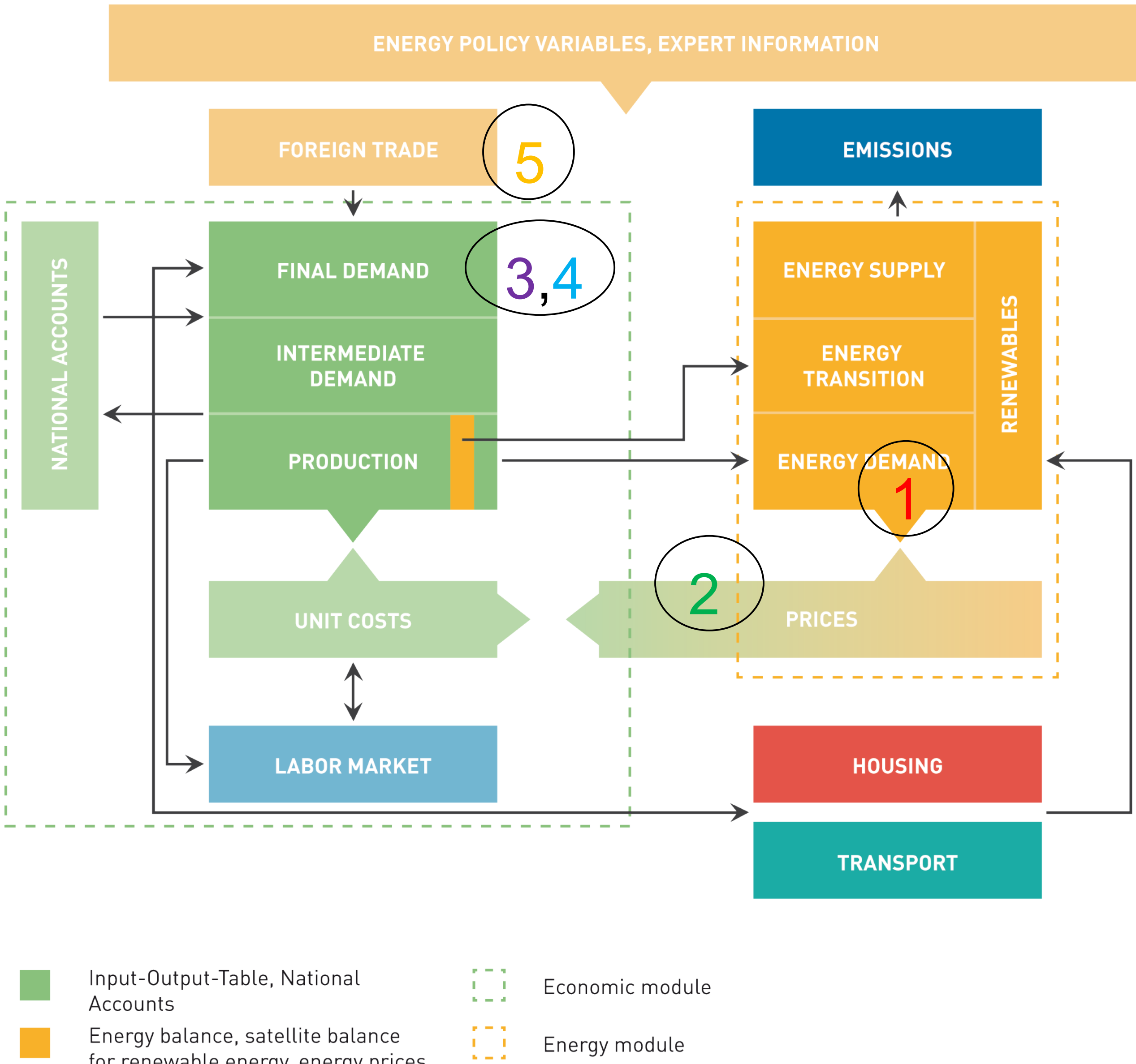
Model characteristics and results

	Saunders	Allan et al.	Barker et al.	Koesler et al.
Causal shock	Rise in energy productivity by 20%	Rise in energy productivity by 5%	Various policy measures	Rise in energy productivity by 10% (depending on sc.)
Production function	Cobb-Douglas	Multi-level production functions (CES, sector specific)	No explicitly stated production funct.; diff. factor demand functions	KLEM (CES, sector/country specific)
Elasticity of subs-titution	1 (between labour, capital, and Energy)	0.3 (between energy and non-energy components)	0.8	Various; between 0.15 and 0.72
Effect on GDP	Short term: +1%-2% Long term: 14% higher	Short t.: +0.11% Long t. +0.17%	+1.26%	- Sc. 1: Germany: +0.13%; ROW: +0%
Rebound effects	Not quantified	- Electricity production: 62% s. t., 27% l. t. - Remaining energy prod.: 55% s. t., 31% l. t.	- Macro rebound (by their definition): 11% - Direct rebound: 15% (exogenous) Total rebound: 26%	- 47% - 57%, depending on scope and scenario

Conclusions from the literature review

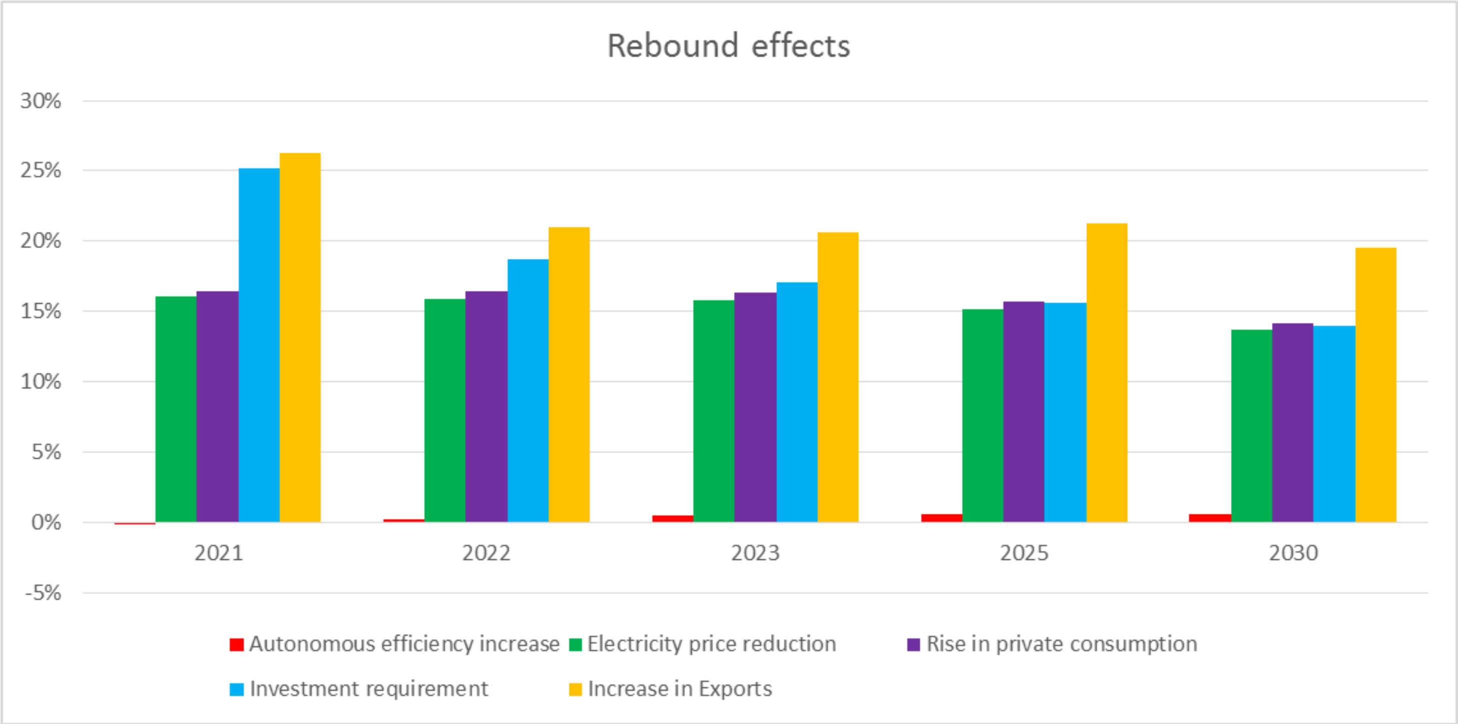
- Similar comparisons of a scenario with autonomous increase in energy efficiency with a reference case throughout publications
  - ⇨ Direct effect on the production function
  - ⇨ Private households only indirectly affected
- An exception is Barker et al. modelling explicit policies
- Elasticities along the cause-impact chain are responsible for the size of the rebound effects (in particular SE of energy)
  - ⇨ Need for discussion about the relationship between energy and capital (substitutes vs. complements)
- Although causal shocks (increase in energy efficiency) are largely the same, results differ significantly
- High(er) rebound effects in CGE models

How to model rebounds in PANTA RHEI?



Rebound effects – first results

- Model based calculation of the rebound:
  - ⇨ Delta(eevb(scenario)) / delta(eevb(fix))



Rebound effects – first results

- Model based calculation of the rebound:

$$1 - \frac{\Delta eevb_{scenario}}{\Delta eevb_{fix}}$$