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Rebound Effects
The State of Knowledge

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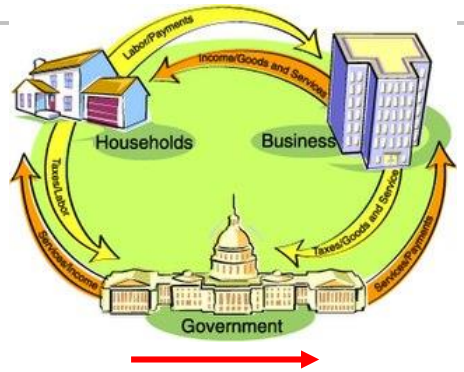
Economy-wide = Direct + Indirect + Macroeconomic



Macroeconomic

Changes in input and commodity prices, investment, trade etc.

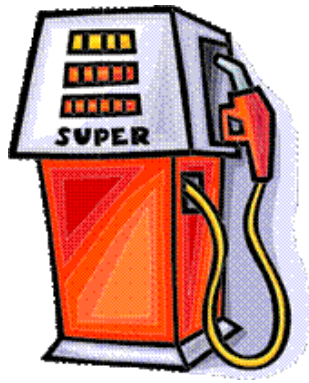
Changes in regional and global energy use

Indirect

Lower fuel bills

Buy more goods

More energy



Less energy

Direct

Lower running costs

Drive further and more often in emptier cars

Purchase larger and more powerful cars

More energy

Publications on rebound effects and energy 1990-2020

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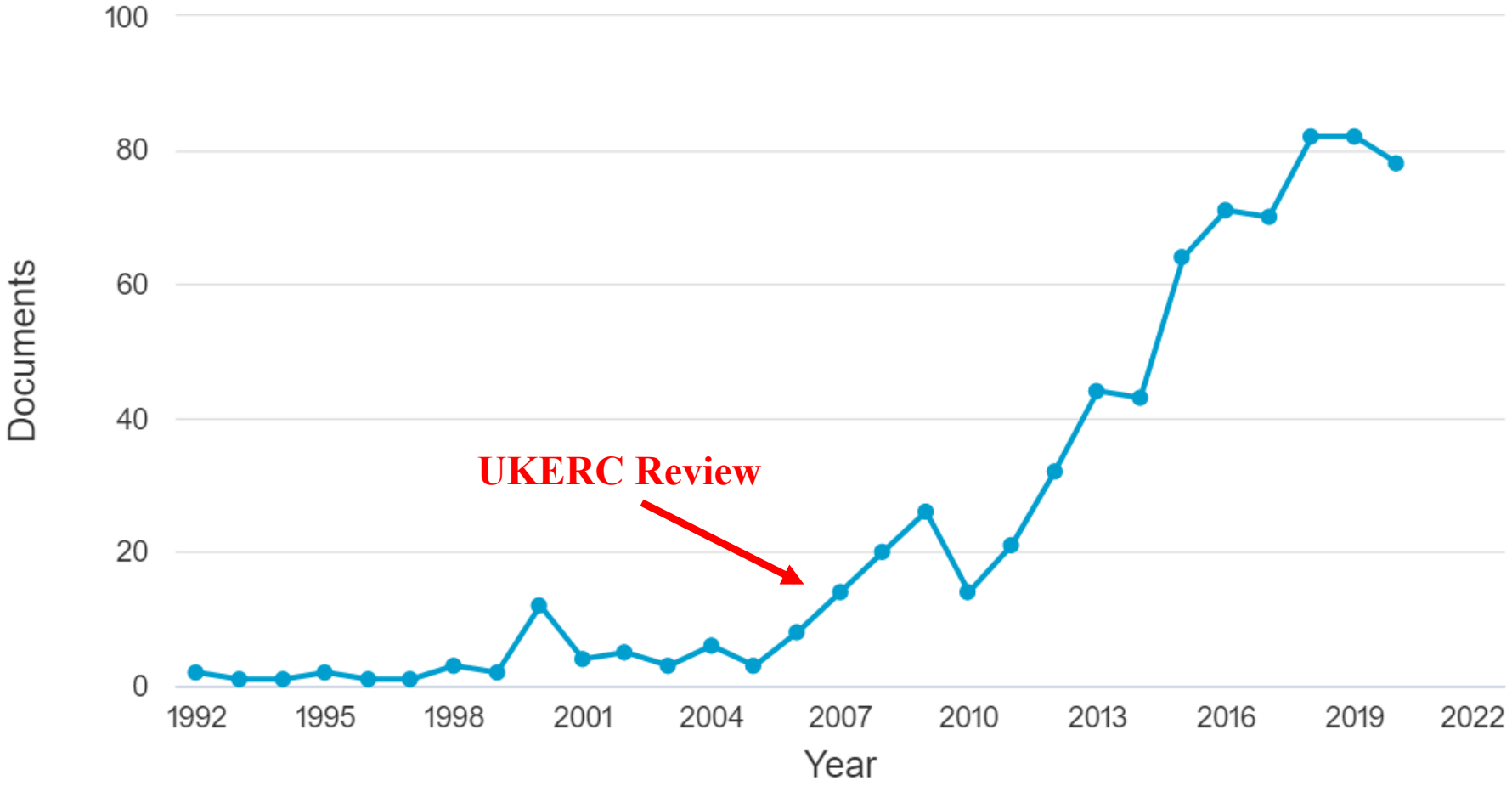

Note: Scopus; ("rebound effect" AND "energy"); academic articles only

Trends in rebound research

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Progress:

- More services and resources (water, land use, materials)
- More economic mechanisms (direct, indirect, economy-wide)
- More regions (especially China)
- More methodologies (e.g. CGE, growth accounting, SFA)
- More disciplines (e.g. environmental psychology, industrial ecology)

Stasis:

- Data limitations constrain empirical topics
- System complexity constrains identification of causality
- Methodological limitations constrain confidence in results
- Disciplinary boundaries constrain interdisciplinary investigations
- Controversy and neglect of policy constrain communication

What is energy efficiency?

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$$Efficiency = \frac{Useful\_outputs}{Energy\_inputs}$$

- Different **measures** for useful outputs and energy inputs (thermodynamic, physical, economic)
- Different **choices** for system boundary
- Different **sources** and **costs** of improvement (exogenous technical change, price-induced substitution, regulatory standards)
- Changes in **attributes** and **productivity** of other inputs
- Improvement in one measure need not imply an improvement in another

$$Y = f(\pi K, \rho L, \tau E, \upsilon M) \qquad \theta_E = Y / E$$

$$\Delta\tau \neq \Delta\theta_E$$

Evidence for direct rebound effects

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- Most studies estimate **modest** short/medium-run direct rebound effects: **5-40%**
- Typically use **econometric** analysis of secondary data and estimate rebound from elasticities of energy service demand
- Fuel prices elasticities provide an **upper bound** on direct rebound
- *Methodological Challenges*:
  - data availability and limited variation in energy efficiency
  - endogeneity of energy efficiency;
  - asymmetry of price/efficiency responses;
  - changes in product/service attributes;
  - multiple services and multiple energy carriers
- Direct rebounds are frequently **larger** for low income groups and may **decline** in future as demand saturates and incomes increase

Evidence for indirect rebound effects

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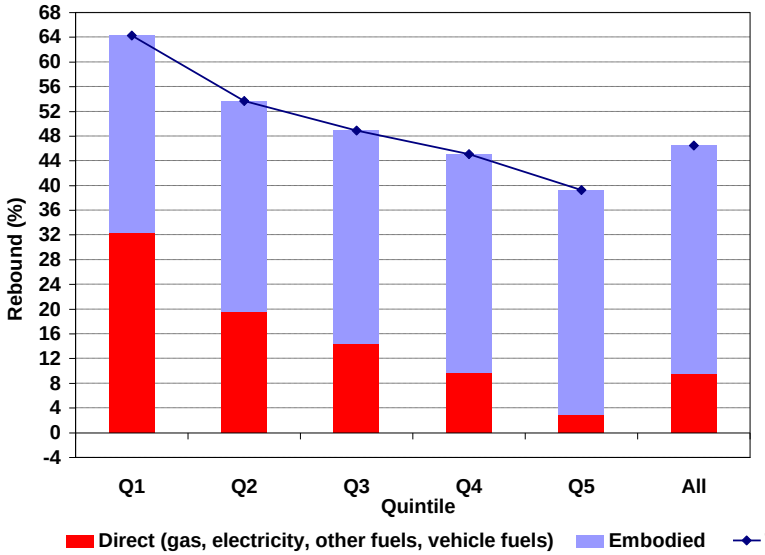
- For consumers, typically estimated from expenditure or cross-price elasticity of energy (service) demand, combined with estimates of embodied energy/carbon from input-output models (static)
- Studies estimating **income effects only** suggest **modest** rebounds **(0-32%)** for measures affecting household energy use and **larger** rebounds **(25-65%)** for measures affecting vehicle fuel use
- The few studies that include **substitution effects** suggest **larger** rebounds
- Rebound larger for **low income** groups



Evidence for economy-wide rebound effects

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- Measurement difficult – most studies use **CGE models** to estimate impact of energy-augmenting technical change
- Brockway et al (2021) - 21 CGE studies give mean (median) estimate of economy-wide rebound of **58%** (55%) (range 12% to 200%)
- Brockway et al (2021) - 12 non-CGE studies (macro-econometric models, econometric analysis, growth accounting) give a mean estimate of **71%**
- **Consistency** despite methodological diversity – suggesting that economy-wide rebounds may erode **more than half** of the potential energy savings
- Relevant mechanisms **poorly captured** by both integrated assessment and global energy models

Source: Brockway et al (2021)

Economic and psychological perspectives on consumer rebounds

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- ***Rebound*** *(financial resources)*: e.g. if cycling is less expensive than car travel, this may **financially enable** a long-distance vacation
- ***Economists*** focus on **quantifying** rebounds but pay little attention to their psychological **drivers**
- ***Negative spill-over*** *(moral resources)*: e.g. if cycling is less carbon intensive than car travel, this may **morally licence** a long-distance vacation
- ***Psychologists*** focus on **explaining** spill-overs but pay little attention to their environmental **impacts**
- Rebounds can be negative and spill-overs can be positive – reinforcing energy savings
- Larger cost savings may lead to larger rebounds and emphasising cost savings may encourage negative spill-over

Source: Sorrell et al (2020)

Green consumers?

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- Most people have only **limited understanding** of the relative environmental impact of different activities
- They may view actions with only marginal emission savings as providing a **moral licence** for emission-intensive actions
- Few psychological studies estimate **direct** emissions, and even fewer include **indirect** emissions
- The few that do find **little correlation** between total emissions and either environmental values or pro-environmental behaviours (e.g. Bleys *et al*., 2018; Kennedy *et al*, 2013)

Values-action gap reinforced by action-impact gap

Source: Sorrell et al (2020)

Rebound policy

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- **Carbon pricing** may offset rebounds – price should rise over time with portion of revenue used for low-carbon investments
- **Carbon caps** may contain rebounds – preferably economy wide, but politically challenging
- **Border carbon adjustments** may reduce leakage – but likely confined to particular goods
- **Targeted energy efficiency policies** may incentivise substitution away from high-carbon processes and activities

Summary

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- Rebound effects are challenging to estimate, but the size and quality of the evidence base is improving
- Estimated size of effects tends to **increase** with the scope, system boundary and timeframe of the analysis
- Evidence suggests **modest** direct and indirect rebounds in most instances, but **larger** economy-wide rebounds
- Rebound effects do **not** undermine the rationale for energy efficiency policy – energy is saved, welfare improves, productivity increases
- But global energy scenarios may **underestimate** future energy demand