Macroeconomic Effects of Climate Policies for Road Transport:
Efficiency Agreements v. Fuel Taxation

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Jonathan Rubin

University of Maine

Terry Barker

University of Cambridge

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Outline

- Results
- Intro: macroeconomic models of energy efficiency improvements
  - CGE v. Sectoral models
  - Integration of top-down, bottom-up modelling
- Modelling the macroeconomic rebound effect using MDM-E3
- Application to transport sector
- Findings and conclusions

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Results

- Voluntary efficiency agreement
  - Positive macroeconomic impacts
    - GDP, employment, inflation
  - Reductions in energy demand & CO_2
- Equivalent fuel taxes (in terms of CO_2)
  - Without revenue recycling
    - Lower GDP & employment
  - With revenue recycling that reduces income taxes
    - Eliminates negative macroeconomic impacts
    - Equity/distributional issues remain
- Inflation neutral scenario, VA & fuel duties

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Macroeconomic Modeling of Energy

- CGE models
  - rigid treatment of energy as factor of production in a production function with labor and capital
- Econometric models
  - traditional approach with energy demand equations
  - Literature on income and price elasticities

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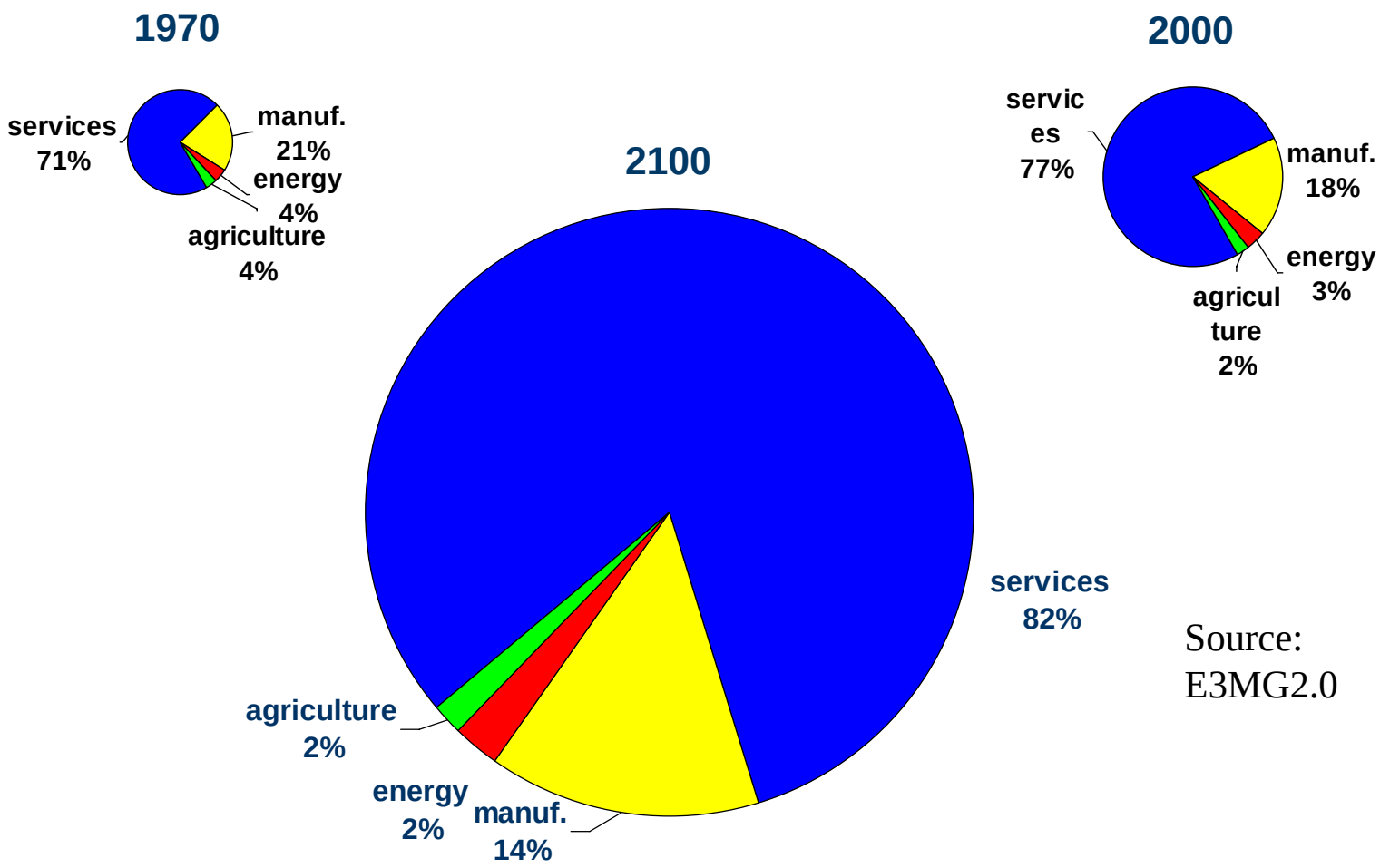
Global GHG mitigation in context: energy in world GDP



Source: E3MG2.0

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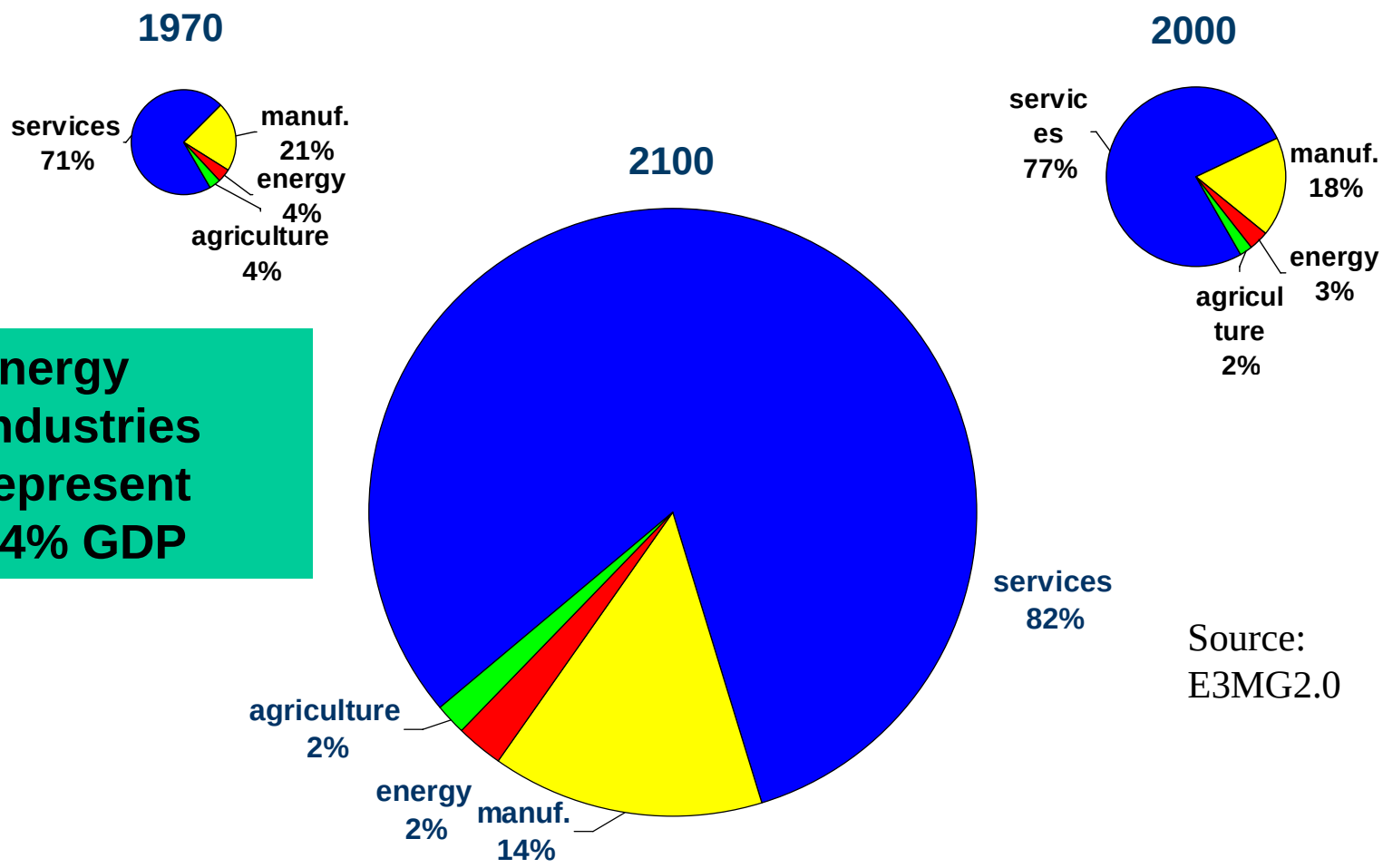
Global GHG mitigation in context: energy in world GDP



energy industries represent <4% GDP

Source: E3MG2.0

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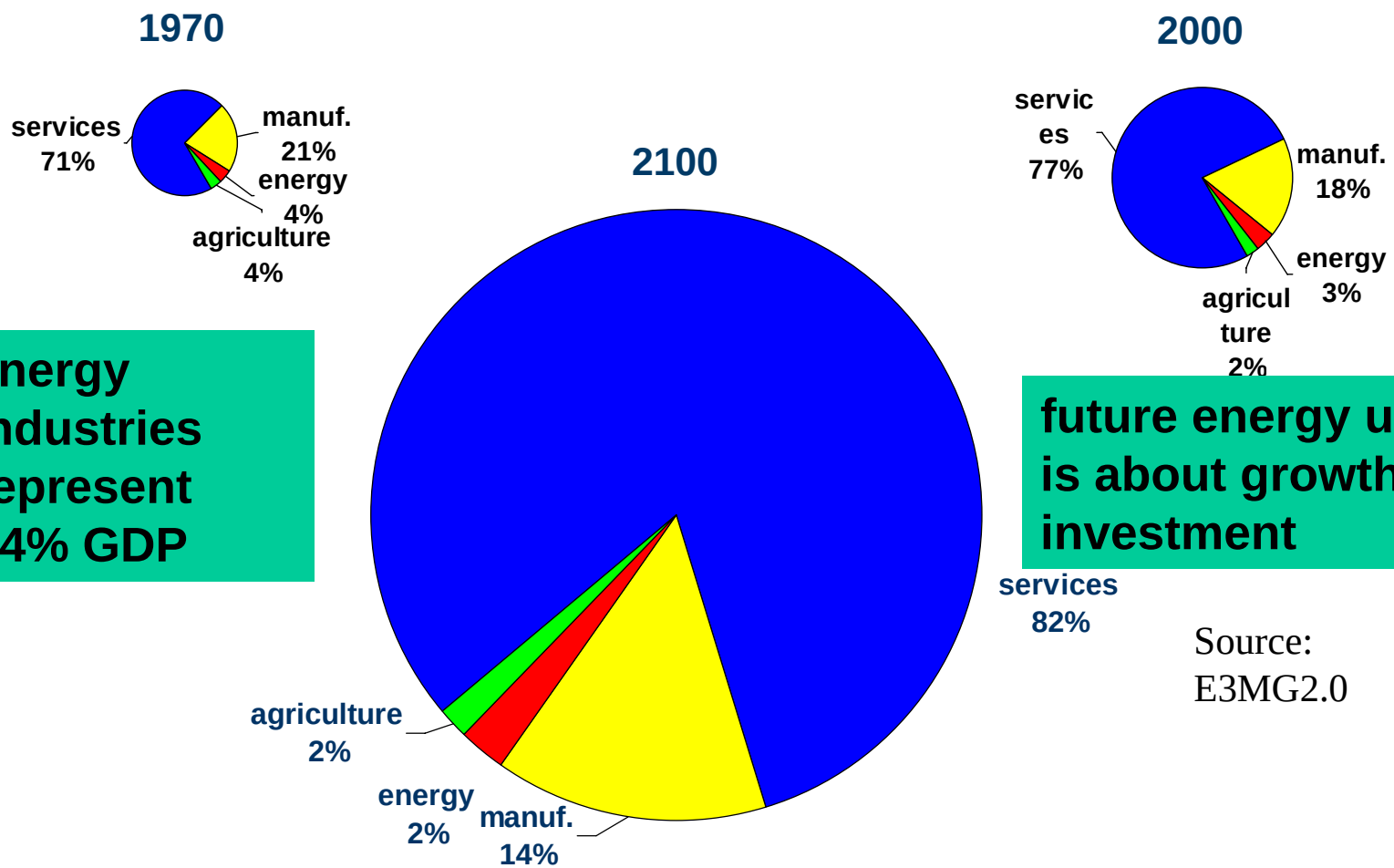
Global GHG mitigation in context: energy in world GDP



energy industries represent <4% GDP

future energy use is about growth & investment

Source: E3MG2.0

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Literature

- **Economy-wide studies that assume full efficiency report that the regulatory policies incur costs**
  - Parry and Williams (1999) - CGE compare 8 policy instruments to reduce CO2
    - Find: High costs of the energy efficiency regulations, exacerbated by tax interaction effects
  - Smulders and Nooij (2003) - CGE analyse energy conservation on technology and economic growth
    - Find: Policies that reduce the level of energy use unambiguously depress output levels
  - Pizer et al. (2006) - CGE calibrated to sectoral models of the US
    - Find: CAFE standards to be significantly more expensive than broad carbon taxes.

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Literature

- A main alternative approach: detailed sectoral studies that feed into a CGE macroeconomic model
  - Roland-Holst (2006) uses a CGE model for California to assess energy efficiency policies for CO_2 reductions
    - Find: CO_2-efficiency policies can reduce transportation CO_2 emissions by nearly 6% and increase Gross State Output by over 2%

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The approach using MDM-E3

(Multisectoral Dynamic Model – w/ Energy-Environment-Economy system)

- MDM is a multisectoral regional econometric model of the UK economy developed in the 1990s
- Equilibrium & constant returns to scale are not assumed
- The solutions are dynamic, integrated and consistent across the model and submodels
- Energy demand is derived from demand for heat, power from demand for final products
  - No explicit production function
  - 2-level hierarchy: aggregate energy demand equations and fuel share equations
  - Aggregate demand affected by industrial output of user industry, household spending in total, relative prices, temperature, technical progress indicator, trends, efficiency policies

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MDM-E3 theory and data

- Econometric, dynamic, structural, post-Keynesian
  - based on time series and cross-section data
  - cointegration techniques identify long-run trends in 22 sets of equations
  - Structural: 50 industries, 13 energy users, 11 energy carriers, 51 HH categories
- Assumptions
  - Social groups (not representative agents) i.e. parameters vary across sectors and regions
  - Variable returns to scale and degrees of competition across sectors
  - Path dependency and emphasis on “history” rather than “equilibrium”
  - Short-term and long-run solutions
- With induced technological change
  - Technological Progress Indicators (TPI) (incl. R&D) in many equations e.g. in energy-use, export, import, price, employment equations

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Energy Submodel

Energy Users

1 Power Generation
2 Other Transformation
3 Energy industries own use
4 Iron and Steel
5 Mineral Products
6 Chemicals
7 Other Industry
8 Rail Transport
9 Road Transport
10 Water Transport
11 Air Transport
12 Domestic Use (Households)
13 Other Final Demand (including commerce, government, agriculture and construction)

} **Energy-Intensive Industries**

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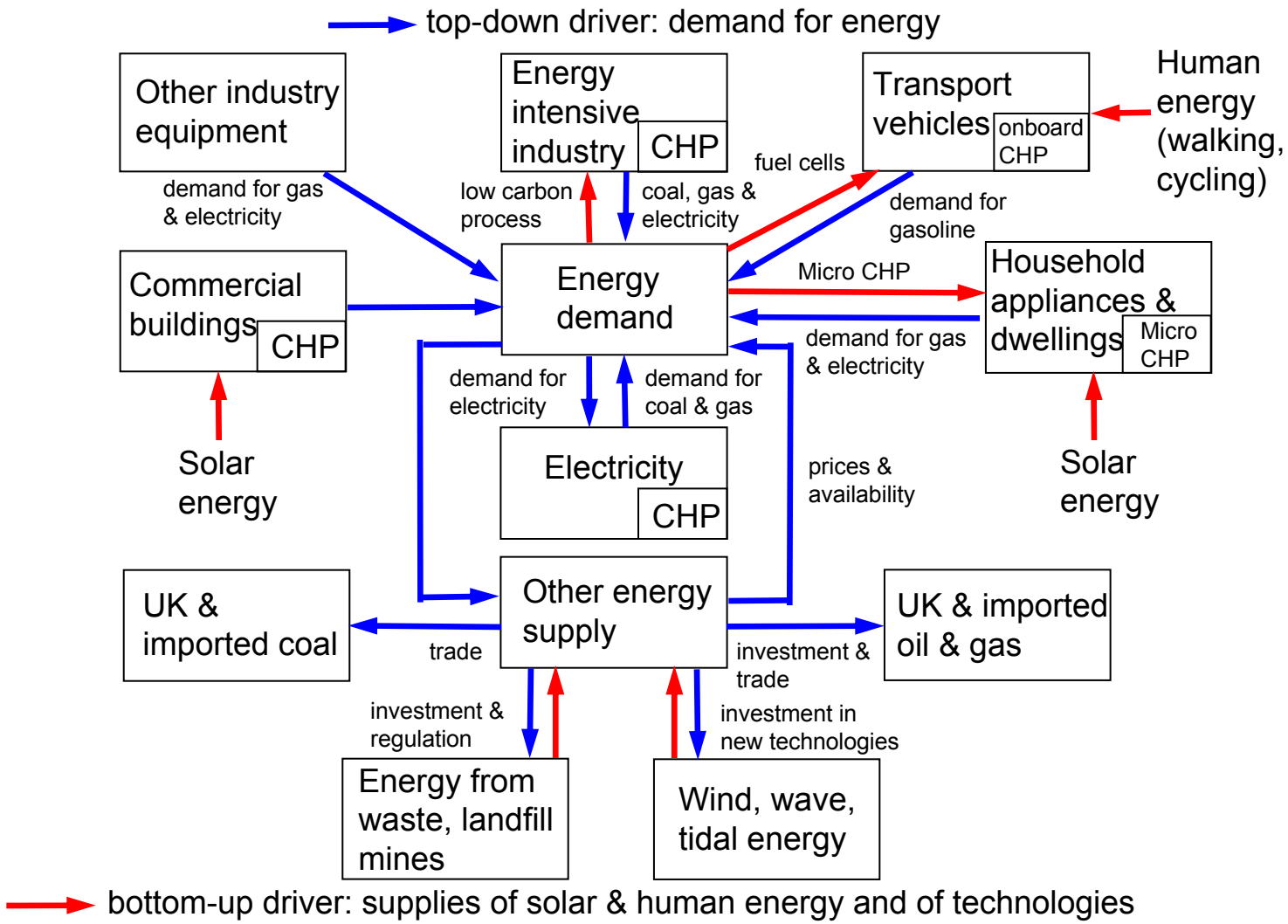
The UK Energy System in MDM-E3



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MDM-E3 & Transport

- Top-down macroeconomic model
- Bottom-up transport system efficiency feedback to macro economy
  - Efficiency improvements estimated offline
- Feedback from macro economy not incorporated in detailed transport sector

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MDM-E3 : Aggregate Energy-Demand Equations

- Autoregressive distributed lag (ARDL) model
  - energy consumption (Et) depends on
  - energy price (Pt), output (Yt), temperature (TEt) & lagged values:

$$E_t = a_0 + a_1 P_t + a_2 Y_t + a_3 TE_t + a_4 E_{t-1} + a_5 Y_{t-1} + a_6 P_{t-1} + a_7 TE_{t-1} + \varepsilon_t$$

- Re-parameterisation give error-correction mechanism (ECM) model:

$$\Delta E_t = b_0 + b_1 \Delta P_t + b_2 \Delta Y_t + b_3 \Delta TE_t + b_4 (E_{t-1} - b_5 P_{t-1} - b_6 Y_{t-1} - b_7 TE_{t-1}) + \varepsilon_t$$

- Augmented by time trends and/or accumulated investment to represent energy efficiency improvements
- ECM model distinguishes between long-term and adjustment parameters

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UK Transport Efficiency Policies

- Voluntary Agreements on vehicle CO2 emissions reductions
  - European Commission and the European, Japanese and Korean Automobile Manufacturers Association to reduce average CO2 emissions from their new cars to 140 g/km by 2008 -2009
  - Targets are expected to be met via fuel saving technologies
- Company Car Tax
  - Company cars are taxed on a percentage of their list price according to one of 21 CO2 emissions bands.
- Graduated Vehicle Excise Duty
  - GVED - the annual vehicle tax charge – new cars placed in one of four VED rate bands according to their CO2 emissions
- Projected to reduce transport energy use by 3.1 mtoe

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Rebound Effects

Direct, indirect, economy-wide

- Three direct rebound effects
  - More mileage driven
  - More comfort taking (air-conditioning)
  - Shift to larger vehicles
  - These offset 25% of the estimated gross energy savings from the policies
- Indirect and economy-wide (result of model)
  - Indirect and economy-wide rebound **7%** beyond direct
- Total: 32%

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Impacts of VAs on Key Macroeconomic Variables

Sector	2000	2005	2010
Final Energy Demand (mtoe, level)	-0.29	-1.86	-2.89
Final Energy Demand (% level)	-0.18	-1.20	-1.81
CO_2 Emissions (mtC, level)	-0.26	-1.61	-2.42
CO_2 Emissions (%, level)	-0.17	-1.11	-1.80
GDP (%, level)	0.05	0.43	0.48
GDP Deflator (%, level)	-0.05	-0.77	-1.28
Employment (%, level)	0.00	0.19	0.28
Public Sector Borrowing (%GDP, level)	0.00	0.15	0.22

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Efficiency v. Fiscal Policies to Reduce Transport CO_2 Emissions

Impact	**VAs**		
Additional fuel duties (%/ year 2000-10)	0		
Change in standard rate of Income Tax (%)	0		
Final Energy Demand (%)	-1.81		
CO_2 Emissions (%)	-1.80		
GDP (%)	0.48		
GDP Deflator (%)	-1.28		
Employment (%)	0.28		

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Efficiency v. Fiscal Policies to Reduce Transport CO_2 Emissions

Impact	**VAs**	**Fuel Duties**	
Additional fuel duties (%/ year 2000-10)	0	4.85	
Change in standard rate of Income Tax (%)	0	0	
Final Energy Demand (%)	-1.81	-2.25	
CO_2 Emissions (%)	-1.80	-1.81	
GDP (%)	0.48	-0.84	
GDP Deflator (%)	-1.28	3.16	
Employment (%)	0.28	-0.52	

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Efficiency v. Fiscal Policies to Reduce Transport CO_2 Emissions

Impact	**VAs**	**Fuel Duties**	**Fuel Duties Revenue Recycling**
Additional fuel duties (%/ year 2000-10)	0	4.85	3.850
Change in standard rate of Income Tax (%)	0	0	-3.540
Final Energy Demand (%)	-1.81	-2.25	-1.86
CO_2 Emissions (%)	-1.80	-1.81	-1.82
GDP (%)	0.48	-0.84	-0.43
GDP Deflator (%)	-1.28	3.16	-1.29
Employment (%)	0.28	-0.52	0.00

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Efficiency v. Fiscal Policies to Reduce Transport CO_2 Emissions

Impact	VAs	Fuel Duties	Inflation-neutral: VAs & Fuel Duties
Additional fuel duties (%/ year 2000-10)	0	4.85	2.025
Change in standard rate of Income Tax (%)	0	0	0
Final Energy Demand (%)	-1.81	-2.25	-2.37
CO_2 Emissions (%)	-1.80	-1.81	-2.42
GDP (%)	0.48	-0.84	0.24
GDP Deflator (%)	-1.28	3.16	0.00
Employment (%)	0.28	-0.52	0.04

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Efficiency v. Fiscal Policies to Reduce Transport CO_2 Emissions

Impact	**VAs**		
Public Sector Net Borrowing (£bn)	3.2		
Fuel duty revenues (%)	-10.7		
Energy demand (mtoe)			
Industry	-107		
Road transport	-2818		
Air transport	34		
Households	14		

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Efficiency v. Fiscal Policies to Reduce Transport CO_2 Emissions

Impact	**VAs**	**Fuel Duties**	
Public Sector Net Borrowing (£bn)	3.2	-0.3	
Fuel duty revenues (%)	-10.7	+40.9	
Energy demand (mtoe)			
Industry	-107	105	
Road transport	-2818	-3675	
Air transport	34	-44	
Households	14	-7	

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Efficiency v. Fiscal Policies to Reduce Transport CO_2 Emissions

Impact	**VAs**	**Fuel Duties**	**Fuel Duties Revenue Recycling**
Public Sector Net Borrowing (£bn)	3.2	-0.3	3.1
Fuel duty revenues (%)	-10.7	+40.9	+26.0
Energy demand (mtoe)			
Industry	-107	105	-24
Road transport	-2818	-3675	-2783
Air transport	34	-44	-9
Households	14	-7	-143

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Discussion & Summary

- VAs 1.8% CO2 Reduction
- VAs v. fuel duties
  - Achieving the same CO2 reduction, no recycling of revenues, no monetary responses
  - Energy use in the transport sector goes down more with fuel duties than with the VAs, but at a cost of loss in GDP of 0.84% instead of a gain of 0.48%.
  - Rate of duty on road fuels has to rise by 4.85% a year (real)
  - Effects on inflation and growth is very marked
    - Fuel duties increasing prices
    - Employment is reduced by 0.5%
- VA's & smaller fuel duties for inflation-neutrality
  - More effective in reducing energy and emissions

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Discussion & Summary

- Our approach enables a partial integration of top-down macroeconomic aspects and bottom-up energy systems
  - We do not assume that resources are used at full economic efficiency
- Limitations
- Bottom-up energy savings and direct rebound effects had to be imposed on the model
  - These are below the level of disaggregation possible
  - No feedbacks incorporated from the wider macroeconomic effects to the bottom-up energy savings
- Future work is to develop greater sectoral detail for better integration with the macro model

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