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Reducing economy-wide rebound without sacrificing macroeconomic benefits?

ECONOMIC AND SOCIAL RESEARCH INSTITUTE, DUBLIN
UCD ENERGY INSTITUTE AND ELECTRICITY RESEARCH CENTRE SYMPOSIUM, 23 NOVEMBER 2015

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EPSRC 'WORKING WITH THE [EUED] CENTRES':
'ENERGY SAVING INNOVATIONS AND ECONOMY-WIDE REBOUND EFFECTS'
CEP AND FRASER OF ALLANDER INSTITUTE (STRATHCLYDE)
WITH THE EUED CENTRE FOR INNOVATION AND ENERGY DEMAND (SUSSEX)

Rebound effects – what do we know and what remains to be understood?

Direct

Cost-effective efficiency improvements make energy services cheaper, thereby encouraging increased consumption of those services.

Indirect

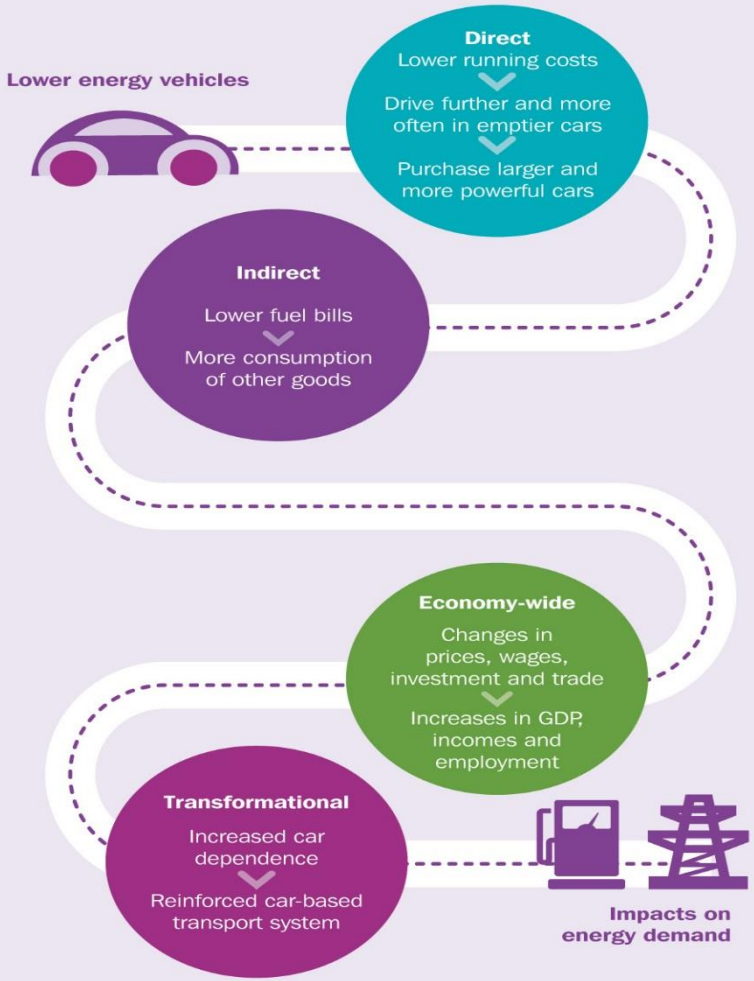
Cost savings from energy efficiency improvements may be spent on other goods and services whose provision involves energy use and emissions at different stages of their international supply chains. For example, savings on gasoline bills may be used to purchase laptops made in Asia and shipped to the UK.

Economy-wide

Shifts in consumption patterns may trigger multiple changes in prices, investments and incomes in both domestic and international markets. Energy efficiency improvements by firms may lower output prices, boost productivity and competiveness, encourage economic expansion and thereby increase energy consumption.

Transformational

In some cases, efficiency improvements may help open up markets for new technologies and systems, triggering entirely new energy-using applications, products and industries.



Impacts of low-energy innovations are uncertain and often unexpected.

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Key findings from our previous research:

1. Nature of economy-wide response to increased energy efficiency differs depending on whether efficiency improves in final consumption or production sectors – **demand-driven vs. productivity led economic expansion**

2. Energy efficiency on production side of economy generally accompanied by net economic benefits: improved competitiveness, increased GDP, total employment and investment

   - Same processes as improved efficiency in any input
   - However, in the case of energy, there are two issues:
   - Generally a less important/smaller scale input to production than capital or labour
   - A 'produced' input – need to consider impact on/response of energy producers

   - But productivity-led expansion will give us some extent of ***economy-wide rebound***
   - *Just a standard economy-environment trade-off?*

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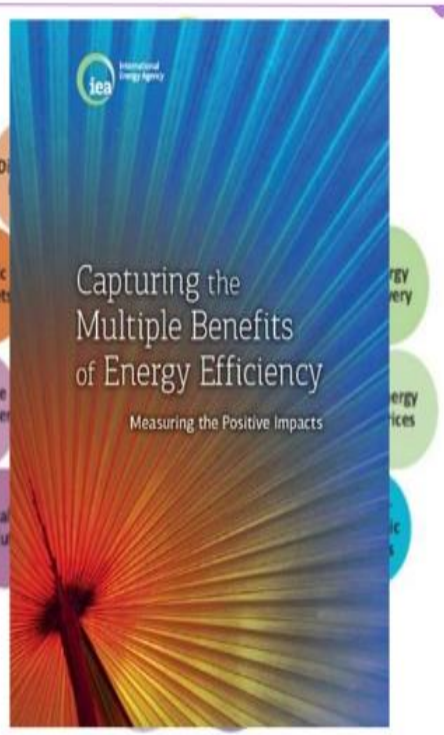
EE has multiple benefits

DATABUILD



IEA (2014), *Capturing the Multiple Benefits of Energy Efficiency*, OECD/IEA, Paris.

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Our research question:

- **Can we reduce economy-wide rebound without sacrificing macroeconomic benefits?**

- Economy-wide rebound – how all types of energy use in the economy are impacted by an energy efficiency improvement (any/all types of energy use) in a given area/sector(s)

- *What if increased efficiency in production leads to a reduction in the relative price of something that is a substitute for an energy-intensive activity elsewhere in the economy?*

- For example, public vs. private transport?

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Key finding/policy implication:

- **YES, we can we reduce economy-wide rebound without sacrificing macroeconomic benefits**
- Increasing energy efficiency in public/freight transport delivers energy savings at sectoral and economy-wide levels
- But with some potential energy savings lost to rebound as the economy expands
- *However, the more households are prepared to substitute away from private towards public/freight options, the magnitude of economy-wide rebound falls*
- ***Without sacrificing macroeconomic benefits***

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Fig. 1. New household consumption structure in our UKENVI multi-sector economy-wide CGE

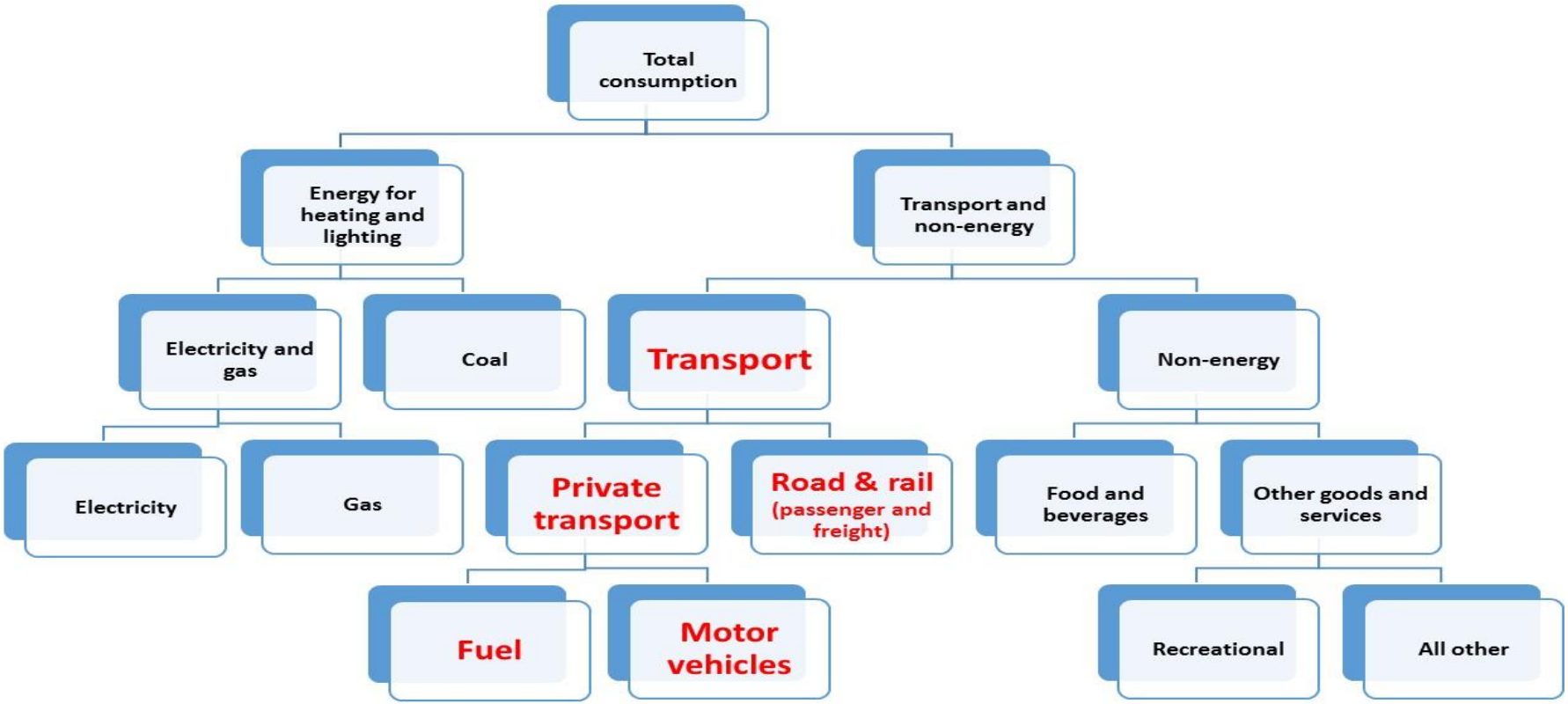
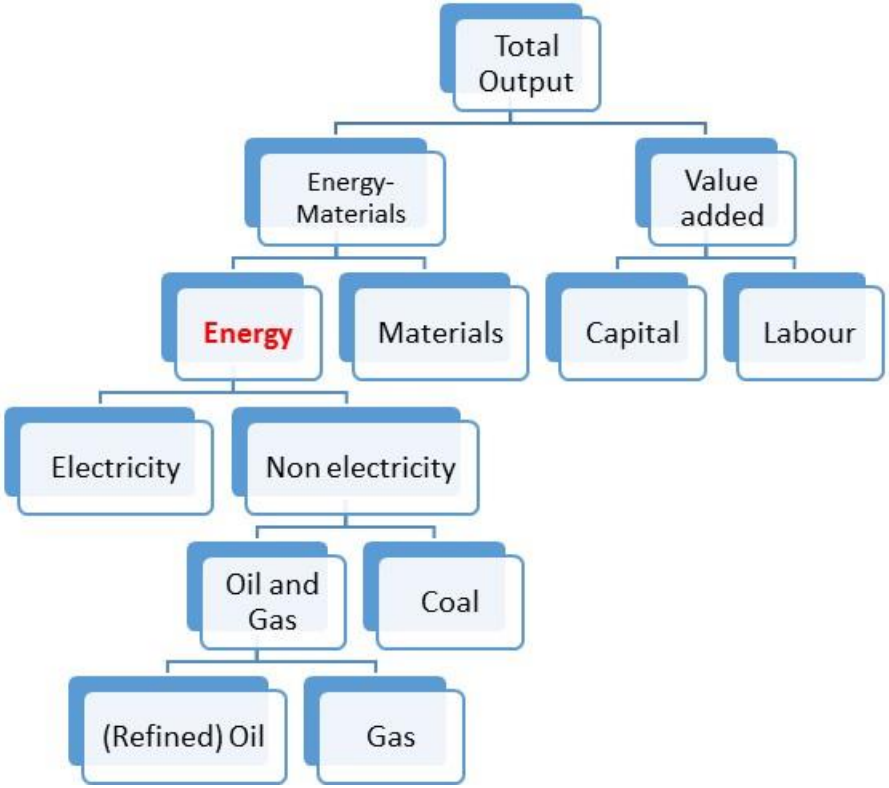


Fig. 2. KLEM production structure in our UKENVI multi-sector economy-wide CGE model



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UKENVI CGE model (1)

- Multi-sector economy-wide CGE model of the UK national economy
- 2010 social accounting matrix
- 30 production sectors producing 30 outputs
- Here, government expenditure exogenous and no BOP or government budget constraint
- Competitive goods markets
- One exogenous region – rest of the world (ROW)
- UK and ROW products imperfect substitutes (Armington assumption) and export demand responds to changes in prices

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UKENVI CGE model (2)

- Here, recursive dynamic/myopic adjustment process
  - option for fully intertemporal adjustment, perfect foresight
- Investment responds to return on capital at sectoral level (share of gap actual and desired in each period)
- Initially, labour supply fixed at national level, with pool of unemployed labour and real wage bargaining process (negatively related to unemployment)
- Sensitivity analysis allowing flow migration (relative wage, +ve, and unemployment rate, -ve, differentials UK and external labour market)
- To consider maximum macroeconomic expansion
- Key focus sensitivity analysis – impact of varying substitutability between Private Transport and Road and Rail in household consumption decision (0.5 in central case; vary 0.1→1.1)

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Increased efficiency in energy use in Road and Rail

- Previous work with Sam Anson (Scottish Government) focussing on Scottish road transport sector published in Energy Policy (2009)
- Focus and key findings there – how economy-wide rebound dampened by energy supply response, particularly in refining/distribution of diesel fuel

- Step10% improvement in efficiency in all energy use in the Road and Rail sector
- i.e. produce the same output using 10% less physical energy input
- Reduces price of energy service delivered
- Positive competitiveness spills forward through all sectors that directly or indirectly use Road and Rail output as input to production
- As found previously, increased gross investment, but 'disinvestment' in energy supply sectors, particularly Refined Fuel
- Puts downward pressure on rebound over long-run
- Necessary but not sufficient condition for economy-wide rebound to be bigger in the short-run than in the long-run

Figure 3. Disinvestment in UK Electricity, Gas and Refined Fuels production (central case - % change from base year values)

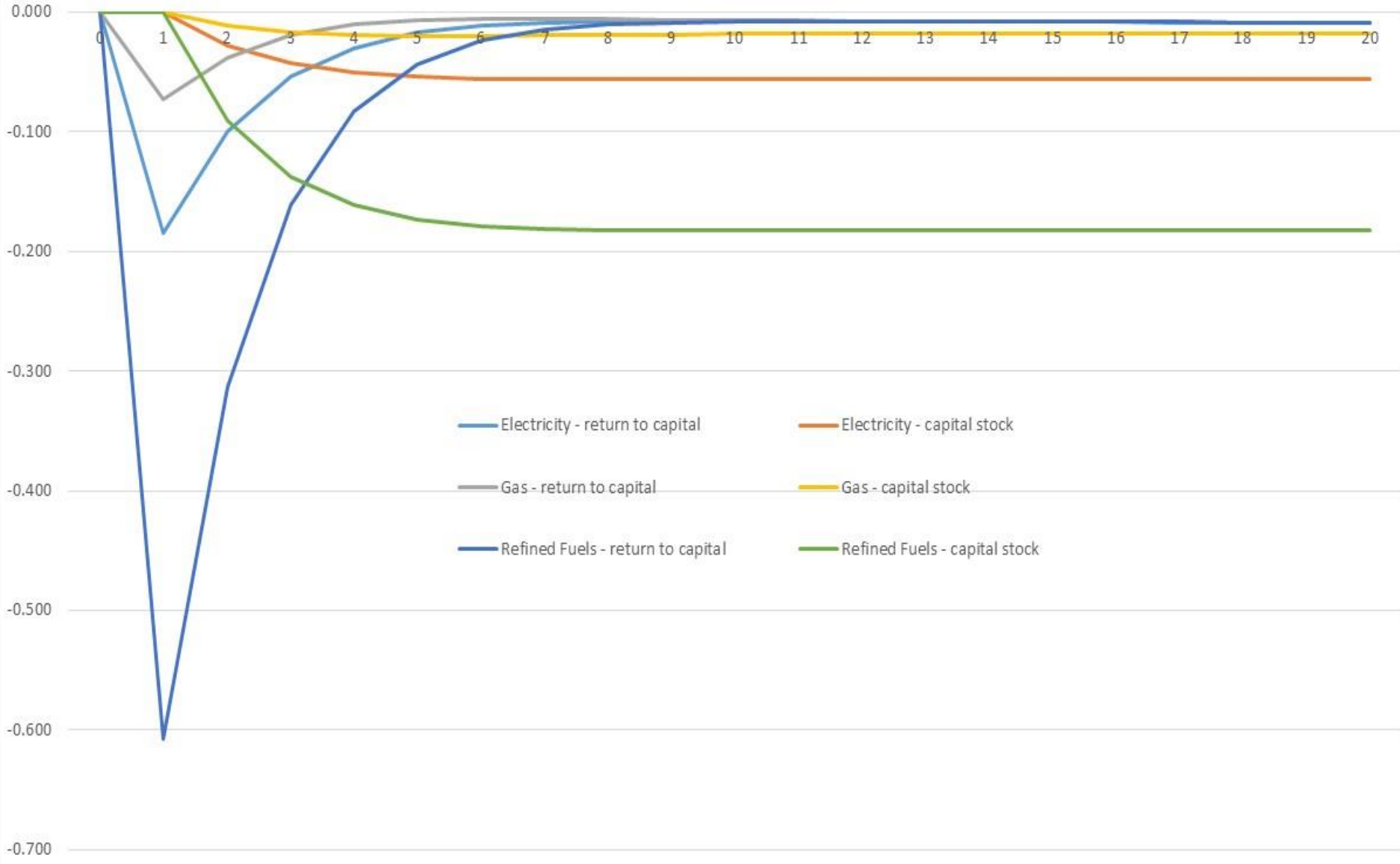


Figure 4. Long-run changes in output and energy use in industries other than Road and Rail (central case)

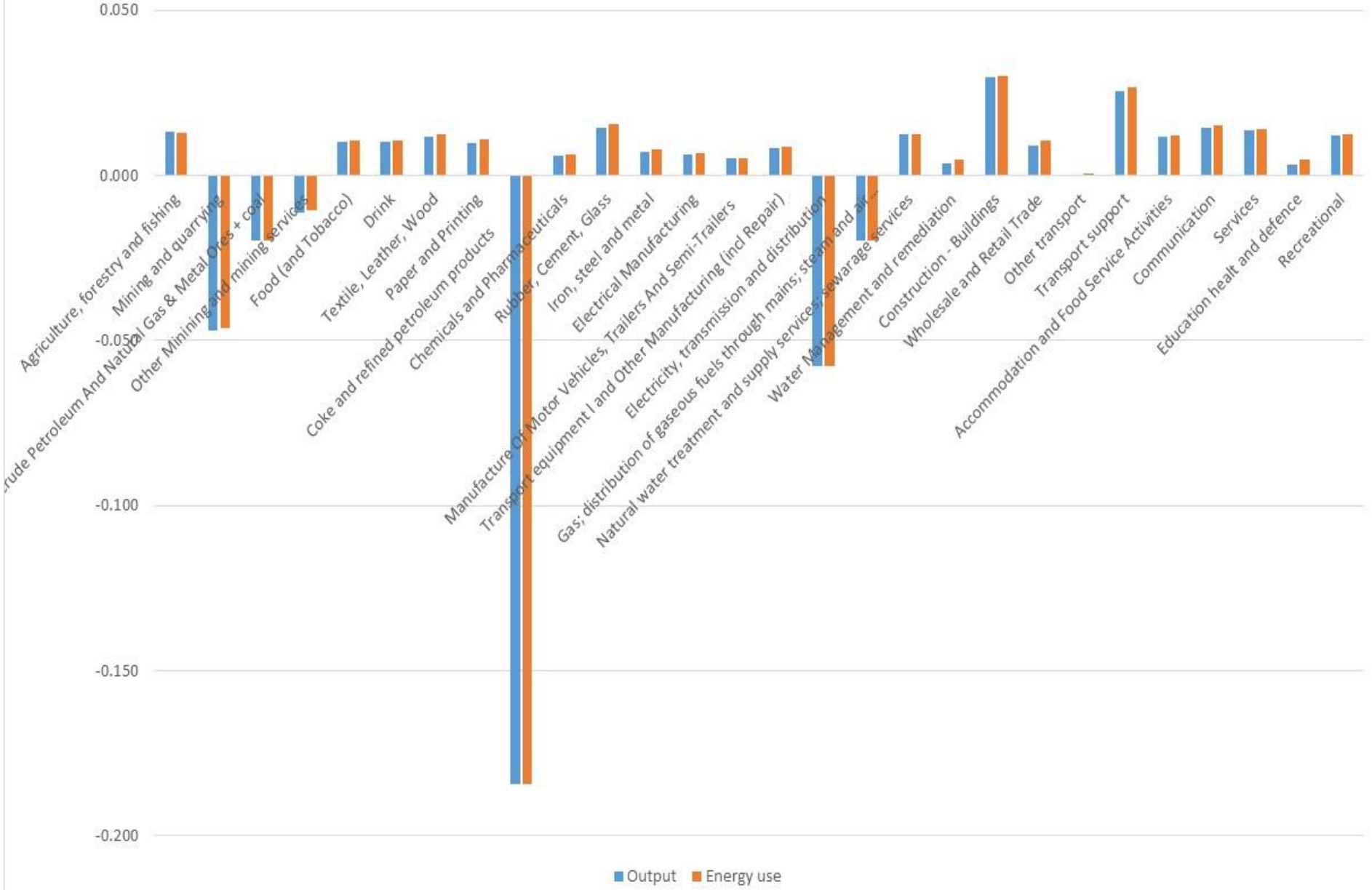


Table 1. Macroeconomic and key energy use impacts (%) of a 10% increase in energy efficiency in the 'Road and Rail ' industry (central case scenario)

	Short run	Long run	
		No migration	Flow migration
GDP	0.004	0.011	0.038
Consumer Price Index	0.005	-0.007	-0.021
Unemployment Rate	-0.102	-0.146	0.000
Total Employment	0.007	0.009	0.036
Nominal Gross Wage	0.015	0.008	-0.021
Real Gross Wage	0.010	0.015	0.000
Labour supply	0.000	0.000	0.036
Replacment cost of capital	0.002	-0.009	-0.022
Investment	0.033	0.014	0.041
Capital Stock	0.000	0.014	0.041
Households Consumption	0.014	0.014	0.025
Household Income	0.013	0.015	0.025
Share of household income spent on energy	0.002	-0.007	-0.008
Gov deficit	-0.067	-0.085	-0.199
Export REU	-0.012	0.006	0.030
Export ROW	-0.014	0.006	0.032

Table 1. Macroeconomic and key energy use impacts (%) of a 10% increase in energy efficiency in the 'Road and Rail ' industry (central case scenario)

	Short run	Long run	
		No migration	Flow migration
Energy price	-0.005	-0.003	-0.014
Energy Productivity (GDP/energy use)	0.080	0.090	0.090
Energy use in houdeholds	0.015	0.008	0.017
Energy use in Industry	-0.119	-0.121	-0.095
Total energy use in UK	-0.082	-0.085	-0.064
Rebound - Road and Rail industry	**36.473**	**36.662**	**36.885**
Rebound - all production	**4.213**	**3.119**	**23.352**
Rebound - economy-wide	**9.502**	**6.063**	**29.668**
Production use of domestic energy	-0.116	-0.119	-0.087
Production use of imported energy	-0.125	-0.122	-0.116
Household use of domestic energy	0.018	0.010	0.025
Household use of imported energy	0.008	0.002	-0.010

Figure 5. Impact on household use of road and rail transport of varying elasticity of subsitution between private and public/commercial transport in the household consumption choice (% change)

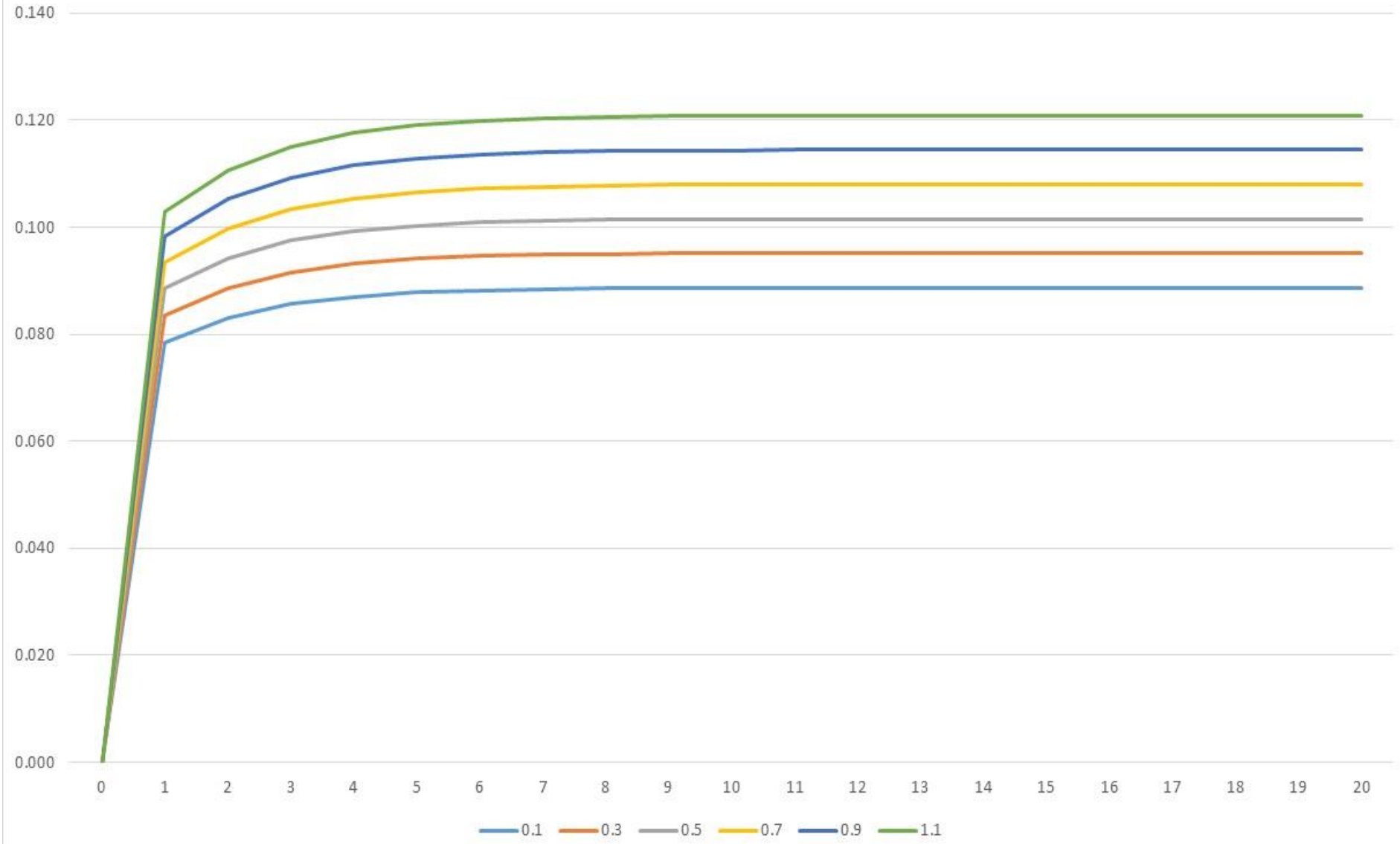


Figure 6. Impact on household use of refined fuels of varying elasticity of subsitution between private and public/commercial transport in the household consumption choice (% change)

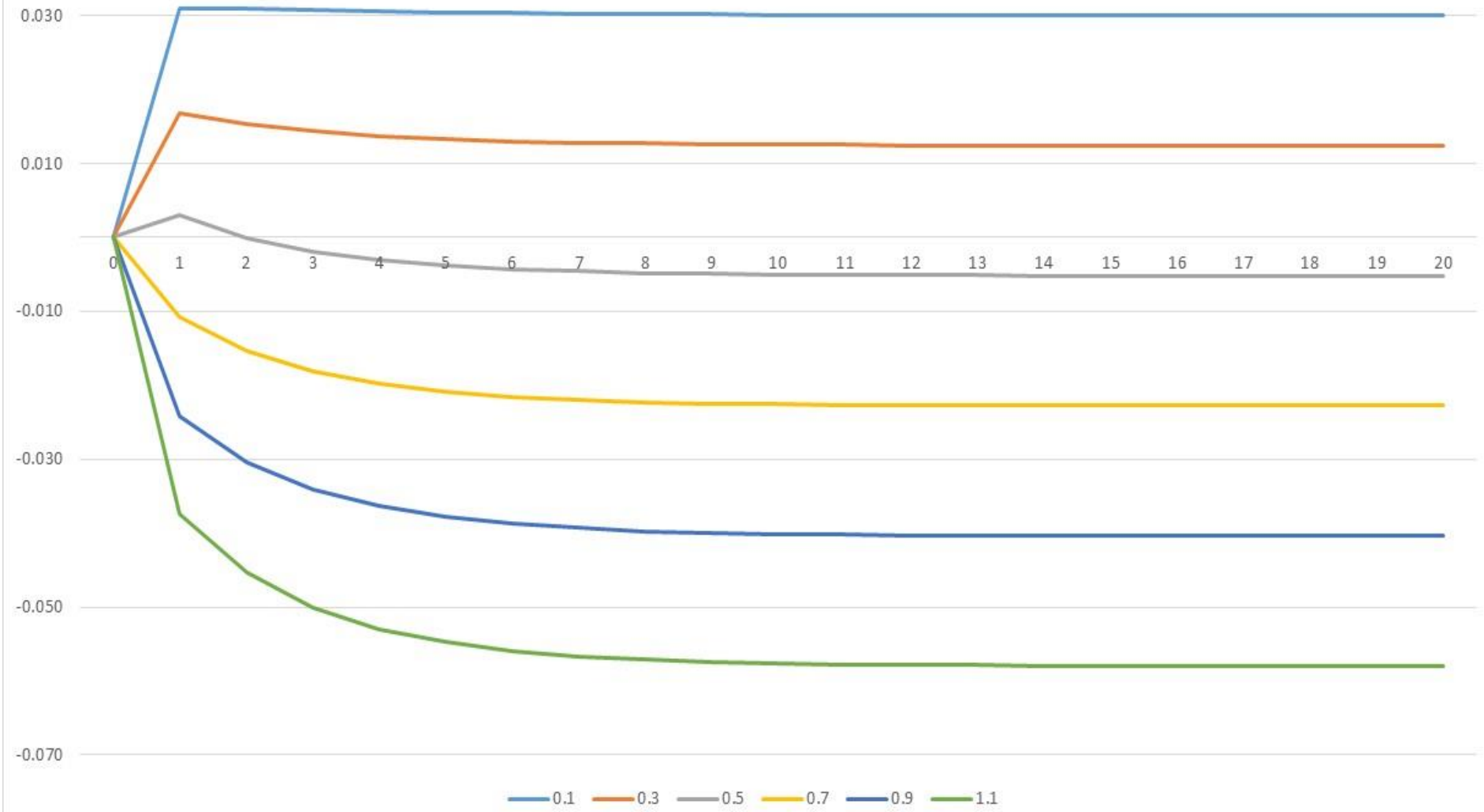


Figure 7. Impact on long-run general equilibrium rebound effects of varying elasticity of subsitution between private and public/commercial transport in the household consumption choice (no migration)

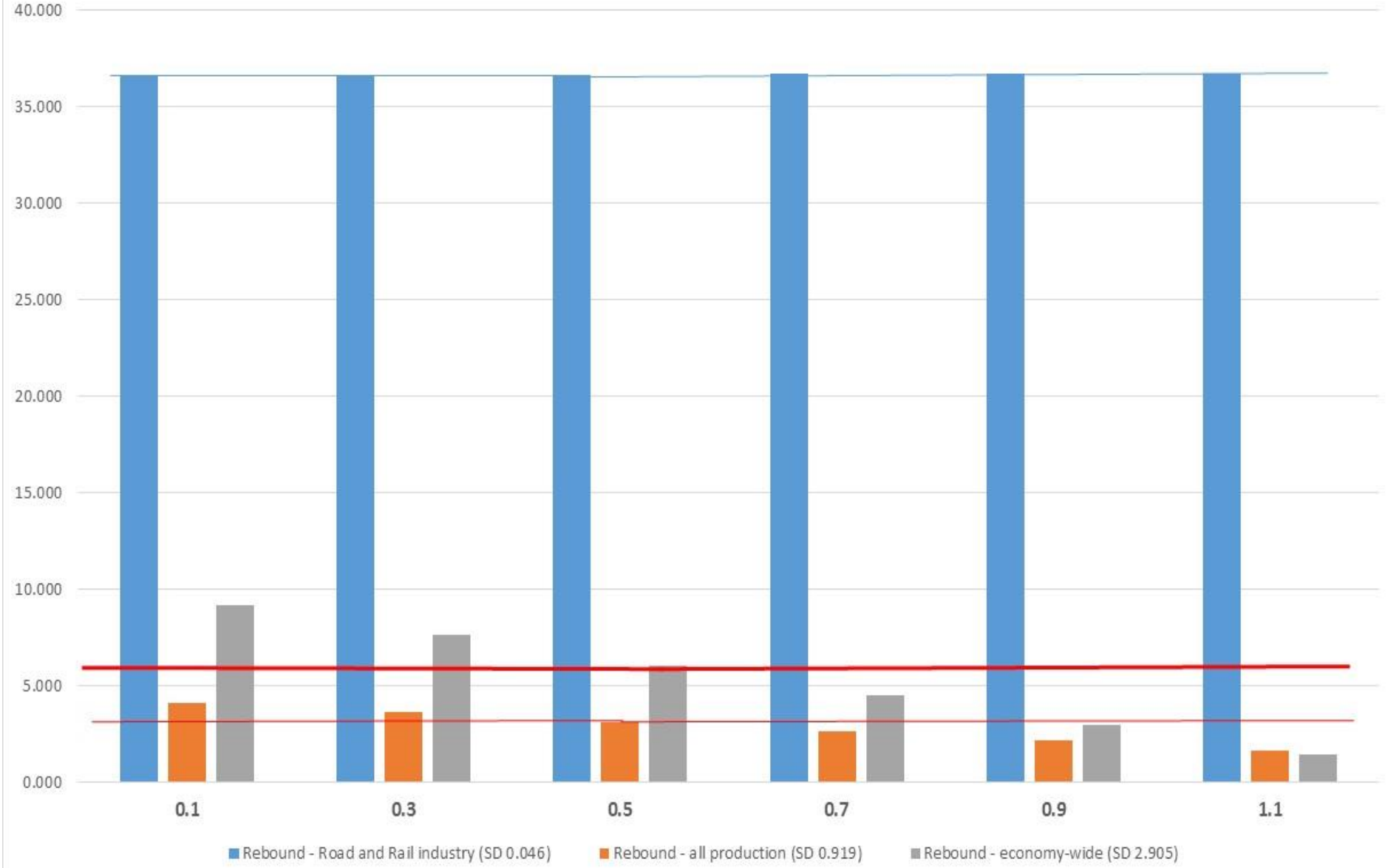
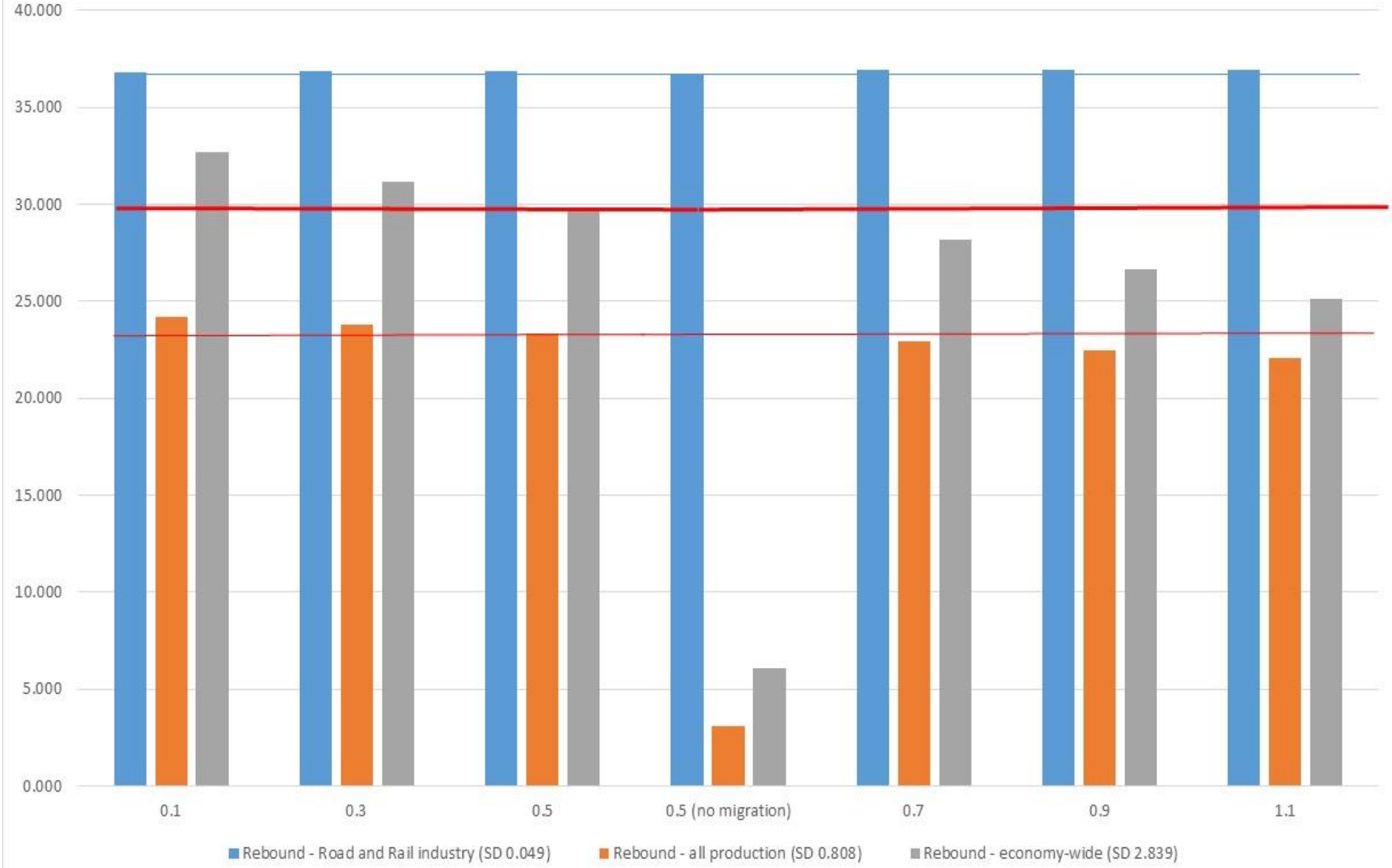


Figure 8. Impact on long-run general equilibrium rebound effects of varying elasticity of subsitution between private and public/commercial transport in the household consumption choice (with flow migration)



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Decomposition of rebound by energy type

$$R = \left(1 - \frac{AES}{PES}\right) x100$$

$$R_j = \left[1 + \frac{\dot{E}_j}{\alpha\gamma}\right] 100$$

- $\dot{E}_j$ is the proportionate change in energy use, type j (here total broken into refined fuels and all other energy use)
- γ is the proportionate (0.1, 10%) increase in energy efficiency in the targeted sector (here Road and Rail)
- α is Road and Rail use of fuel type j (base/reference year) as a share of total economy-wide domestic energy use (all UK industry, household and government final consumption)

Table 2. Disaggregating long-run economy-wide rebound - central case (0.5) with no migration

	Refined fuels	Electricity	Gas
Energy use (% change)	-0.285	-0.061	-0.022
Alpha	0.036	0.007	0.002
Rebound	21.186	17.356	-5.117
Standard deviation (0.1-1.1 range)	3.563	0.226	1.025

Table 3. Disaggregating long-run economy-wide rebound - central case(0.5) with migration

	Refined fuels	Electricity	Gas
Energy use (% change)	-0.265	-0.040	-0.002
Alpha	0.036	0.007	0.002
Rebound	26.502	46.170	89.674
Standard deviation (0.1-1.1 range)	3.649	0.029	0.387

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A key result in terms of modelling and informing policy (1)

- We've shown in previous work that macroeconomic impacts and rebound effects are sensitive to a number of key parameters and other elements of model specification
- Here, focus on how results are impacted when households respond in different ways to more competitive passenger/freight transport provision
- With particular focus on the choice between this and reliance on private transport, which is a relatively energy intensive consumption choice
- Varying this one elasticity causes the economy-wide rebound effect to change with only negligible impact on the key macroeconomic variables
- Or indeed on most of the sectoral level results outside of the Refined Fuel supply and Road and Rail sectors
- More variability in rebound in refined fuel use stemming from variation in private transport activity

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A key result in terms of modelling and informing policy (2)

- As in previous works (such as the Anson & Turner paper) we show that while macro impacts of increased energy efficiency in a single sector may not be that large, there can be important inter-sectoral effects

- ***And these are effects that would not be picked up either by a micro-focussed or a very macro-focussed analysis***

- ***In terms of policy, gives a focus for attention: making public transport (a) more efficient, (b) more attractive as a substitute for personal transport***

- ***Key questions:***
  - What is the current substitutability between private and public transport in the UK?
  - What type of changes to increase it?
  - How much difference would different types of changes/actions make?

- **Example of how an economy-wide CGE modelling study can provide questions for/link to a more micro-level project, and vice versa**

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Thank you for listening – questions?