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Energy efficient R&D investment and Aggregate Energy Demand: Evidence from OECD Countries

Amin Karimu & Runar Brännlund

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Plan of the talk

- Motivation for the paper
- Aim
- Empirical model
- Results
- Conclusion

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Motivation

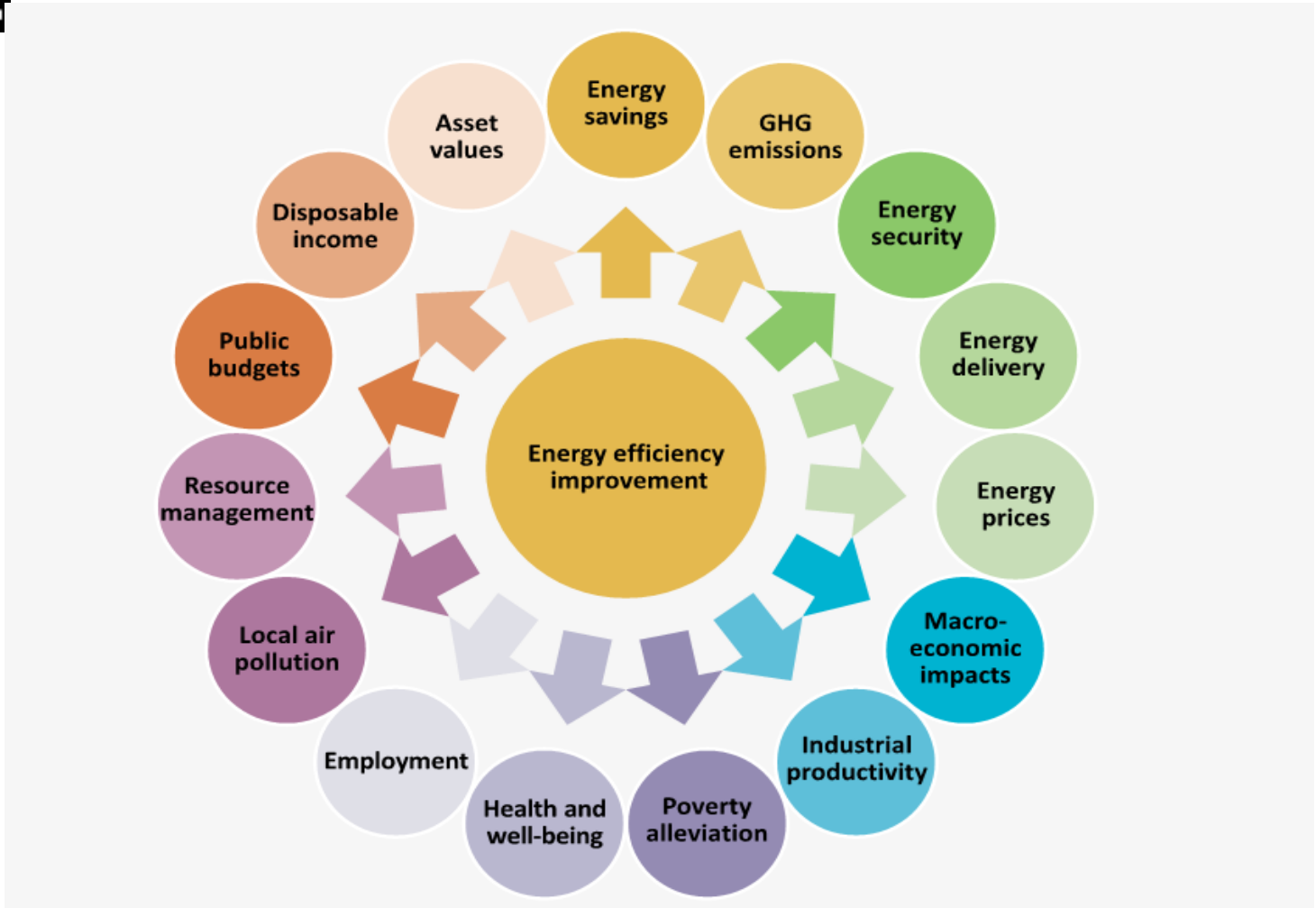

Figure 1: Multiple benefits of energy efficiency

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Motivation

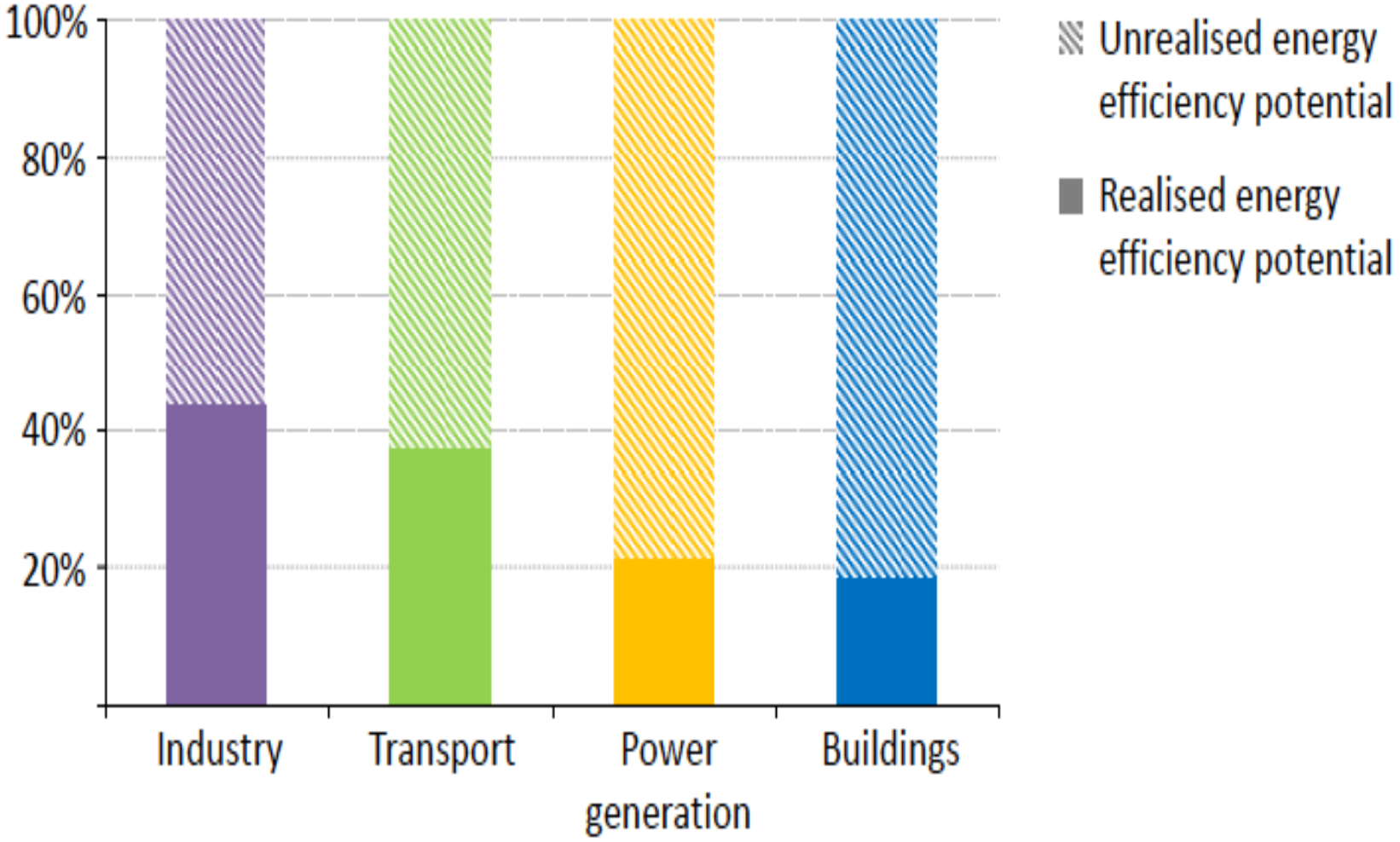

Figure 2: Energy efficiency potentials

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Motivation

- Rebound effect range from 10 to 50%.
- No empirical studies on the direct effect of energy efficient R&D capital on energy demand and the potential CO_2 reduction.

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Aim of the Paper

- Provide empirical evidence on R&D capital elasticity with respect to aggregate energy demand for a sample of OECD countries.
- Provide the policy effect of an increase in energy efficient R&D investment on energy demand for a sample of OECD countries.
- Assess the potential impact of energy efficient R&D investment on CO_2 reduction for a sample of OECD countries.

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Key questions

The key questions of this paper are:

- What is the “own”-energy efficient R&D capital elasticity, when spillover effects are difficult to quantify?
- What is the potential contribution of energy efficient R&D investment on aggregate energy demand?
- Is there a diminishing return to energy efficient R&D investment?
- Which countries in the sample are likely to benefit more from a policy that increase energy efficient R&D investment

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Theoretical Background

$$Max \quad \sum_{t=0}^{T} \beta^t U(C_t, E_t) \tag{1}$$

$$P_{c,t}C_t + P_{E,t}E_t + P_{k,t}I_t + S_t \leq Y_t + (1+r)S_{t-1} \tag{2}$$

$$E_t = \frac{u_t}{\lambda_t} K_t \tag{3}$$

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Theoretical Background

- The first order condition for the household problem reads:

$$U_k \frac{u_t^*}{\lambda_t} = U_z \left[P_{E,t} \frac{u_t^*}{\lambda_t} + P_{k,t} - P_{k,t+1} \left(\frac{1-\delta}{1+r} \right) \right]$$

- This states that the consumer will allocate income such that the marginal value of energy services from the capital stock is equal to the marginal value of consumption of all other goods.

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Theoretical Background

- Energy demand can be expressed as a function of the user cost of capital, the capital stock, and capacity utilisation.
- From the above we can generally express energy demand as:

$$E_t = E\left(Y_t, P_{E,t}, P_{R,t}, \lambda_t, P_{\mathrm{c},t}\right) \qquad (4)$$

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Econometric Model

- The reduced-from model we estimate is:

$$e_{it} = \beta_1 p_{it} + \beta_2 y_{it} + \beta_3 hhd_{it} + \beta_4 r_{it} + \varepsilon_{it}$$

(small letters are logarithms, e.g. $e = \ln(E)$)

- We estimate the above model using four different estimators,each with a different restriction.
  - Fixed effect estimator (FE)
  - Mean group (MG) estimator
  - Augmented mean group (AMG) estimator
  - Common correlated mean group estimator (CCMG)

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Econometric Model

- The MG, AMG and CCMG are heterogenous panel estimators that do not restrict the slope coefficients to be constant across the panel unit.
- Both AMG and CCMG are based on the unobserved common factor modelling framework and accounts for cross sectional dependence (unobserved common factors including spillovers).

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Data

- The variables include
  - Energy consumption (E) in ktoe (per capita).
  - GDP (*Y*) in billions of 2,000 US$ using PPP.
  - Real energy price index (*P*) at 2,000 US dollars.
  - Heating degree days (*hhd*) .
  - Energy efficient R&D expenditures.
- All the variables are in annual frequency form 1960 to 2006.

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Data

- The variables include
  - Most of the data are from the IEA.
    - Adeyemi et al. (2010) compiled the data on E,P,Y.
  - Heating degree days (hdd) taken from Eurostat and National Oceanic and Atmospheric Administration (NOAA).
  - Energy efficient R&D expenditures retrieved from the International Energy Agency (IEA).

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Data

- The Countries in the study are:
- Austria, Belgium, Denmark, France, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the UK and the USA

Data

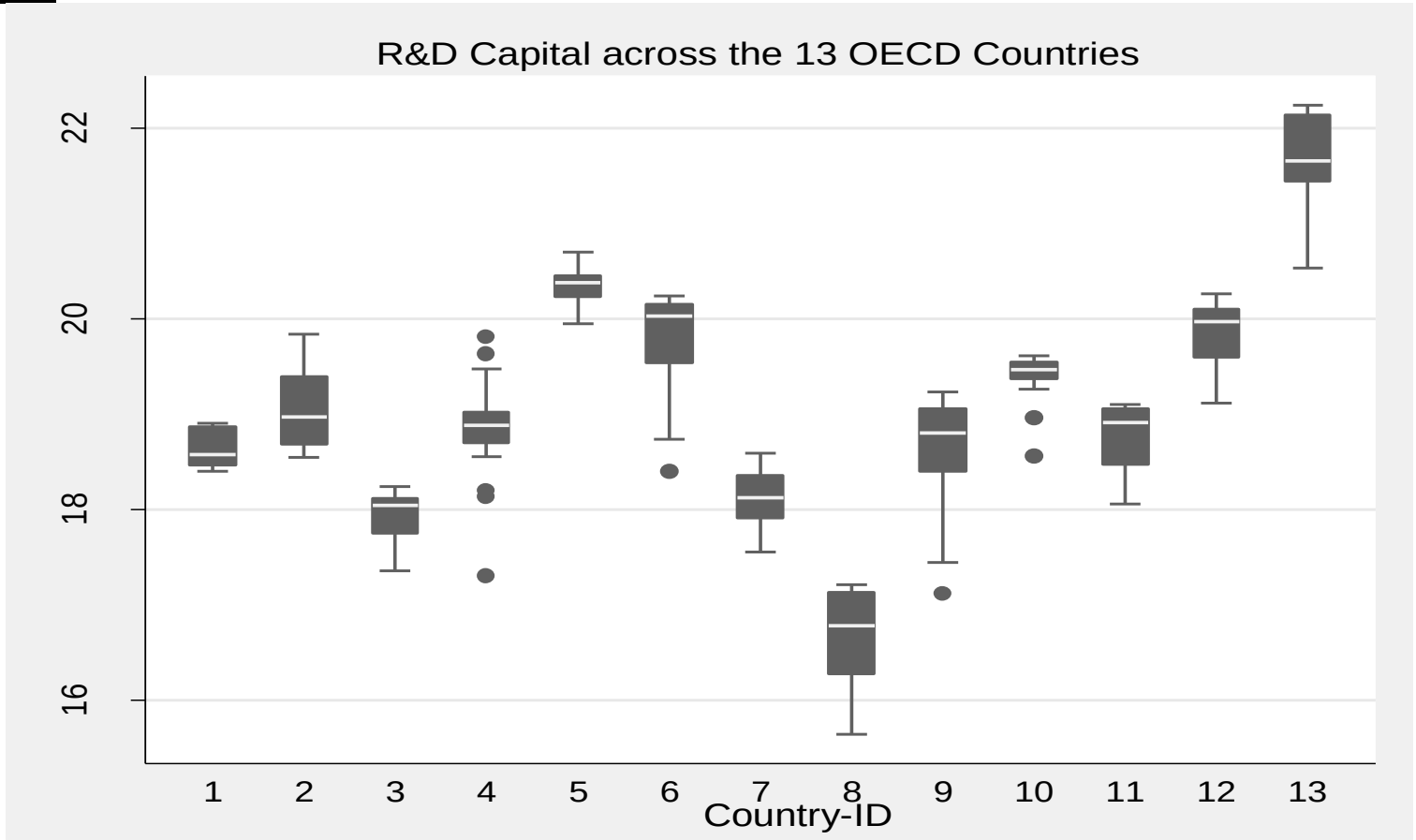

Figure 1: Boxplot showing the variability of the median value for R&D capital across 13 OECD countries. (*Note: the Country-ID, 1=Austria, 2=Belgium, 3= Denmark, 4=France, 5=Italy,6=Netherland,7=Norway,8=Portugal, 9=Spain, 10=Sweden,11=Switzerland, 12=UK, 13=USA*)

Results

Table 2: Regression Results

	FE	MG	AMG	CCMG
p	-0.251**	-0.125***	-0.120***	-0.158**
	(0.098)	(0.035)	(0.034)	(0.073)
y	0.906**	0.593***	0.537***	0.265
	(0.413)	(0.095)	(0.106)	(0.170)
R&Dcap	-0.087***	-0.041**	-0.034**	-0.036
	(0.025)	(0.020)	(0.016)	(0.032)
hhd	0.036	0.224***	0.123**	0.123***
	(0.023)	(0.035)	(0.044)	(0.033)
Trend	yes	yes	yes	yes
Constant	14.27	-0.959	-0.561	-0.158
	(12.391)	(0.769)	(0.698)	(1.077)
Diagnostics				
CD-test	2.44	2.28	-1.61	-1.83
	[0.015]	[0.022]	[0.108]	[0.067]
Integration	*I*(1)	*I*(0)	*I*(0)	*I*(0)
N	351	351	351	351

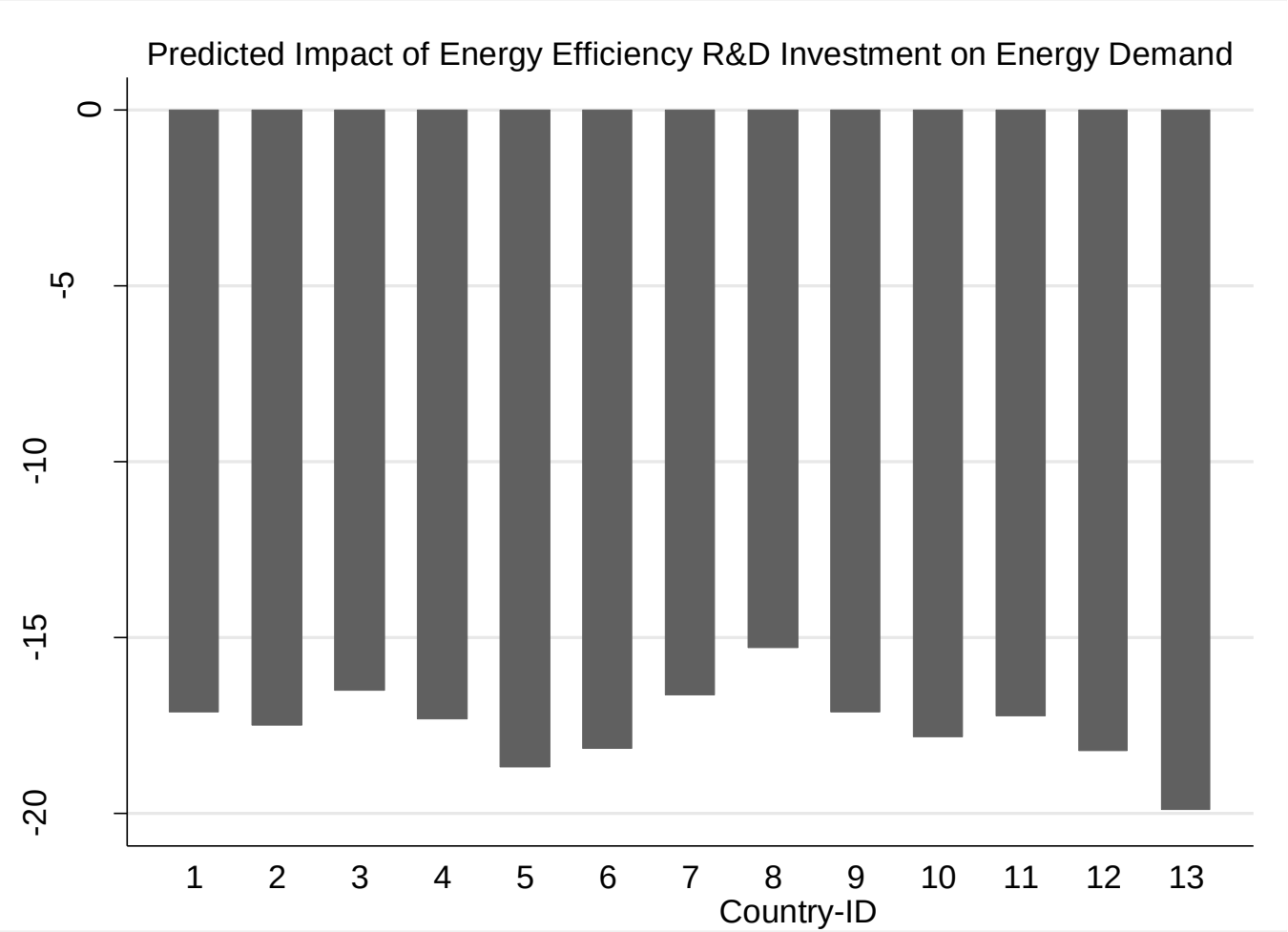

Figure A1: Predicted impact (cumulated over 1980-2006) of Eneregy Efficiency R&D investment on energy demand for 13 OECD countreis.

Note: the Country-ID, 1=Austria, 2=Belgium, 3= Denmark, 4=France, 5=Italy,6=Netherland, 7=Norway,8=Portugal, 9=Spain, 10=Sweden,11=Switzerland, 12=UK, 13=USA

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Table 3: The effects of 100 million US$ increase in R&D investment in energy efficiency on energy demand.

Country	Austria	Belgium	Denmark	France	Italy	Netherland	Norway
%Energy Reduction	-3.34	-2.62	-5.08	-0.84	-0.69	-0.67	-8.09

Country	Portugal	Spain	Sweden	Switzerland	UK	USA
%Energy Reduction	-34.8	-4.13	-1.19	-1.98	-0.79	-0.08

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Table 4: Carbon dioxide emission reduction from 100 million US$ increase in energy efficient R&D investment.

Country	Austria	Belgium	Denmark	France	Italy	Netherland	Norway
$\%CO_2$ Reduction	-1.28	-1.0	-1.94	-0.32	-0.26	-0.26	-3.10

Country	Portugal	Spain	Sweden	Switzerland	UK	USA
$\%CO_2$ Reduction	-13.32	-1.58	-0.46	-0.76	-0.30	-0.03

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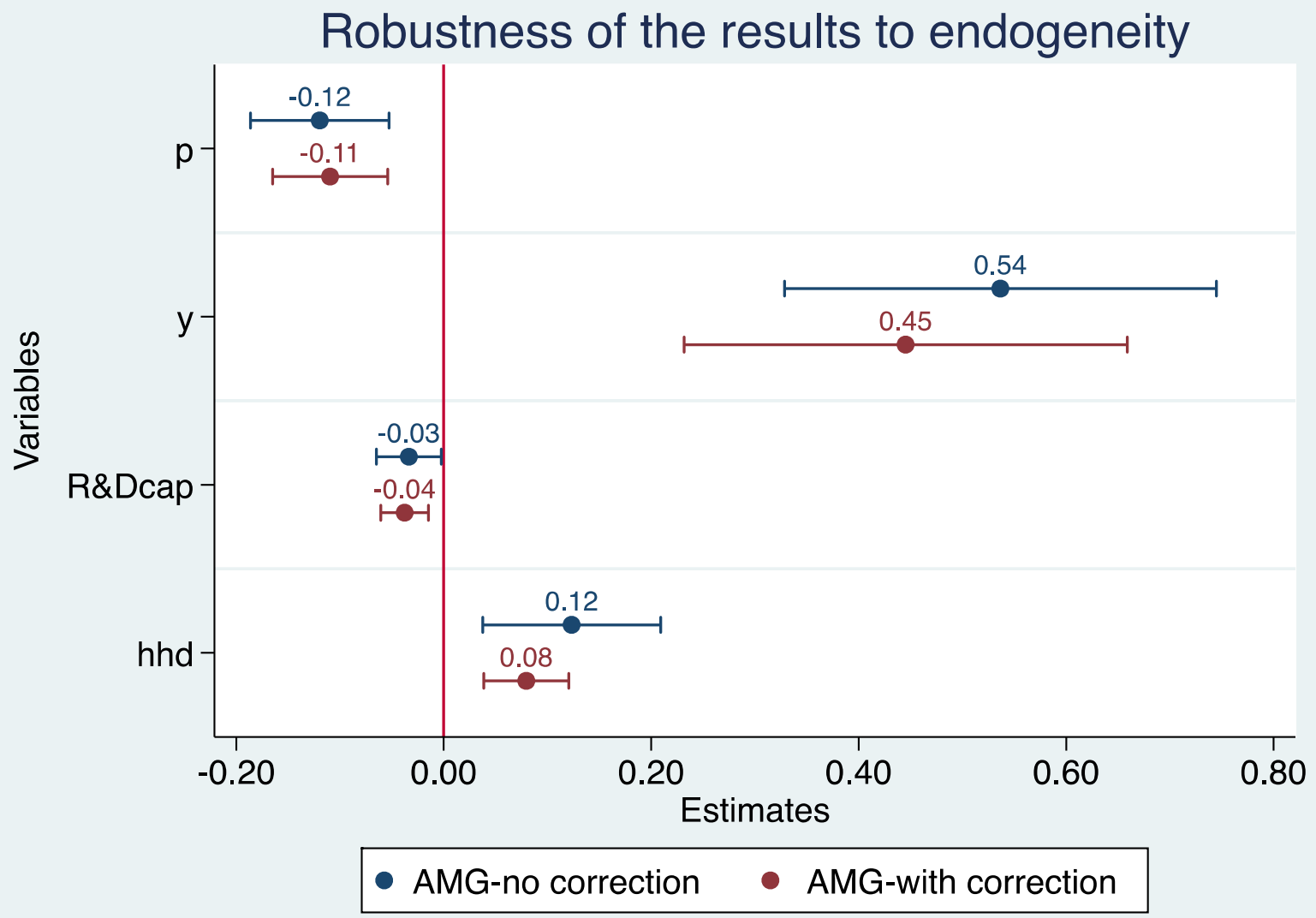
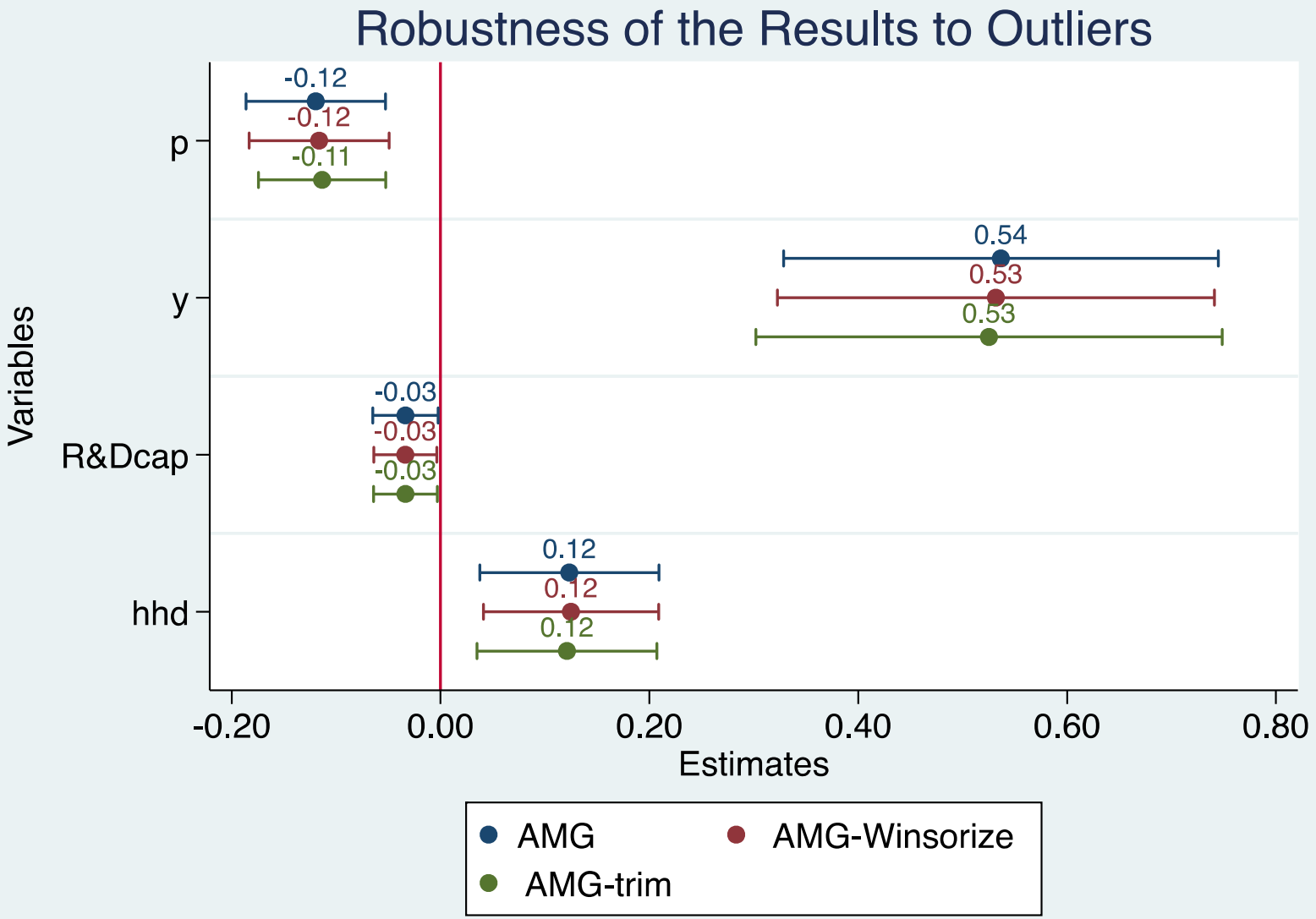
Robustness Checks

- Energy price, income and R&D capital are likely endogenous in the model.
- Possible outlier effect, especially on the R&D capital given the few outliers detected for France, Netherland, Spain and Sweden.
- We made two robustness checks
  1. Endogeneity effect
  2. Outlier effect

Robustness Checks



Robustness Checks



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Summary

- Our key result indicate a negative “own” R&D capital elasticity on energy demand.
- The R&D capital elasticity is small in our preferred model relative to estimates based on the fixed effect model.
- Increasing energy efficient R&D investment will result in reduction in aggregate energy demand that varies significantly across the sampled countries.
- The USA will experience the lowest reduction, while Portugal the highest reduction.
  - Due to a high investment in energy efficient R&D capital in the USA, relative to Portugal, which kick start higher diminishing returns in the USA .

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Conclusion

- Our analysis shed light on the impact of energy efficient R&D capital on energy demand which can be important for policies focusing on energy efficiency measures in reducing energy demand.
- It also highlight the importance of spillover effects and other unobserved common factors in influencing the estimates if we only rely on the separability assumption for identification of “private/own” R&D capital elasticity.
- It also shows that while energy efficiency measures are important, we need other measures to complement efficiency measures to achieve sizeable reduction in energy demand and the associated CO_2 reduction.
- The results also illustrates the differences in marginal abatement costs

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Thank You !!!