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International spillover and rebound effects from increased energy efficiency in Germany

SIMON KOESLER, KIM SWALES AND KAREN TURNER

EMAIL: [KAREN.TURNER@STRATH.AC.UK](mailto:karen.turner@strath.ac.uk)

11TH INTERNATIONAL CONFERENCE, EUROPEAN SOCIETY FOR ECOLOGICAL ECONOMICS

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Increased energy efficiency in industry

- Increased efficiency in use of energy (e.g., electricity) lowers price of 'energy service' (e.g. lighting) delivered by physical energy inputs
 - If not (immediately) market price – though decreased energy demand may impact
 - Energy supply response is crucial
- Lower costs mean improved competitiveness
- In efficiency improving firm, and also downstream if output price reduces accordingly
- Triggers productivity-led growth in economy
- Also 'rebound' effects in energy use by efficient firm and across economy as growth triggered
 - Again, energy supply response is key: may dampen rebound if revenues, returns, capacity negatively affected by reduced demand



How much of a problem is 'the rebound effect'?

- Rebound is triggered by the initial change in the price of an energy service
- Ripple effects as incomes and other prices change – response builds from direct to 'indirect' and economy-wide' rebound in a wider set of energy uses
- One suggestion to 'counter' rebound – offset the initial energy service price trigger through, for example, a tax on energy use
- ***But are we sure we want to counter/stifle the rebound trigger?***
- Rebound will cause us to lose some of the energy savings that may be expected (from an engineering perspective) when we introduce energy saving technologies
- But energy saving is just one (albeit very important) dimension in a wider range of potential benefits from improved energy efficiency
- Key point: the rebound trigger is also a trigger for economic growth processes and, if we understand it, we can compensate for rebound in delivering energy savings



Focus of German work

- Impacts of increased energy efficiency by firms/industry in one country on energy use in others?
- May be key in context of national targets under, e.g. EU 20-20-20
- Also, taking wider view of changes in competitiveness and comparative advantage
- Outcomes depend crucially on supply conditions



Problem and approach

- Question – will rebound grow as we expand the boundaries of the economy?
- Concerned with international spillover effects through trade in goods and services
- Don't get clear signals from trade theory – 2x2x2 models don't consider intermediates (focus on final goods/services) or changes in efficiency in use of intermediates
- So need a numerical model to experiment with
- Here, global computable general equilibrium (CGE) model – Germany, other EU27 (aggregated to one region in results) and 'rest of the world'
- 8 sectors per region, including 2 produced energy supply (electricity and gas, E, and coke, refined petroleum and nuclear, CPN)



2 scenarios

- Simulation 1: 10% increase in energy efficiency in German “Manufacturing”
- Simulation 2: 10% increase in energy efficiency in all German production sectors

List of sectors

Sector	Associated WIOD Sectors / NACE Classification
Electricity and Gas	40
Coke, Refined Petroleum and Nuclear Fuel	23
Primary Goods	1t2, 5, 10t14, 20
Food, Drink and Tobacco	15t16
Manufacturing	17t18, 19, 21t22, 24, 25, 26, 27t28, 29, 30t33, 34t35, 36t37
Construction	45
Transport	60, 61, 62
Services	50, 51, 52, 55, 63, 64, J, 70, 71t74, 75, 80, 85, 90t93, 95



Macroeconomic impacts

- Germany – small positive macro effects and net reduction total industrial energy use; household incomes and energy use increase
- Net reduction total energy use
- REU and ROW – mixed picture with some extent ‘crowding out’
- But industrial and total energy use falls in both

Table 2

Change in key macroeconomic indicators

Scenario 1: 10% increase in energy efficiency in German manufacturing

	Germany	REU	ROW
GDP (Expenditure Approach)	0.1332%	-0.0006%	0.0002%
Exports	0.0254%	-0.0079%	-0.0041%
Imports	0.0322%	-0.0070%	-0.0047%
Public & private consumption	0.1453%	0.0003%	-0.0004%
CPI	0.2309%	0.0034%	0.0000%
Capital rental	0.3255%	0.0088%	-0.0007%
Nominal wage	0.3696%	0.0077%	0.0000%
Aggregate price of energy	0.2440%	0.0078%	0.0001%
Consumption energy use	0.1453%	0.0004%	-0.0004%
Industrial energy use	-1.4965%	-0.0067%	-0.0031%
Total domestic energy use	-0.8069%	-0.0041%	-0.0024%



Table 3
Changes in sectoral price, output and energy use
Scenario 1: 10% increase in energy efficiency in German “Manufacturing”

Sectoral impacts

- Germany – price falls, output rises with falling energy use in targeted sector
- All other sectors – price rises as factor prices rise
- Energy supply hit worse due to falling demand
- Crowding out external manufacturing and contraction external energy supply

	Price	Output	Energy
Germany			
Electricity and Gas	0.2732%	-0.9322%	-0.9261%
Coke, Refined Petroleum and Nuclear Fuel	0.1741%	-0.7427%	-0.7105%
Primary	0.2628%	-0.6743%	-0.6907%
Food, Drink and Tobacco	0.2479%	-0.5512%	-0.5910%
Manufacturing	-0.0833%	0.4328%	-4.3559%
Construction	0.2368%	0.1144%	0.0690%
Transport	0.2820%	-0.2761%	-0.1814%
Services	0.3186%	0.0675%	0.0611%
REU			
Electricity and Gas	0.0065%	0.0073%	0.0053%
Coke, Refined Petroleum and Nuclear Fuel	0.0057%	-0.0172%	-0.0247%
Primary	0.0062%	0.0403%	0.0395%
Food, Drink and Tobacco	0.0059%	0.0872%	0.0842%
Manufacturing	-0.0003%	-0.0719%	-0.0780%
Construction	0.0026%	0.0032%	0.0018%
Transport	0.0059%	0.0292%	0.0296%
Services	0.0044%	0.0059%	0.0044%
ROW			
Electricity and Gas	0.0000%	-0.0008%	-0.0010%
Coke, Refined Petroleum and Nuclear Fuel	0.0001%	0.0003%	-0.0002%
Primary	0.0001%	0.0027%	0.0025%
Food, Drink and Tobacco	0.0005%	0.0113%	0.0115%
Manufacturing	-0.0004%	-0.0183%	-0.0194%
Construction	0.0000%	0.0002%	0.0001%
Transport	0.0005%	0.0087%	0.0085%
Services	0.0002%	0.0014%	0.0019%



Scale?

- Shift in favour of German manufacturing over REU and ROW
- Services and Construction grow in all regions
- FDT and Primary loses competitiveness in Germany, but enjoy growth in REU and ROW
- Global energy supply contracts

Table 4

Changes in output [Billion 2009 USD]

Scenario 1: 10% increase in energy efficiency in German "Manufacturing"

	Germany	REU	ROW	World
Regional total	5.002	-0.860	-1.973	2.169
Electricity & Gas	-1.579	0.054	-0.016	-1.541
Coke, Refined Petroleum and Nuclear Fuel	-0.526	-0.063	0.005	-0.584
Primary	-0.683	0.315	0.200	-0.168
Food, Drink and Tobacco	-0.940	0.824	0.424	0.308
Manufacturing	6.631	-3.124	-3.422	0.085
Construction	0.337	0.065	0.010	0.412
Transport	-0.424	0.245	0.255	0.076
Services	2.186	0.825	0.571	3.582



General energy efficiency boost in Germany?

- Bigger positive supply shock so bigger expansion
- Proportionate impact in REU and ROW still relatively small
- Note that German imports and exports both fall (contrast Scenario 1)

Table 5

Change in key macroeconomic indicators

Scenario 2: 10% increase in energy efficiency across all German sectors

	Germany	REU	ROW
GDP (Expenditure Approach)	0.5159%	-0.0050%	-0.0024%
Exports	-0.0873%	-0.0168%	-0.0021%
Imports	-0.1503%	-0.0108%	-0.0001%
Public & private consumption	0.4948%	0.0005%	-0.0003%
CPI	0.2079%	0.0048%	0.0000%
Price of capital	0.5998%	-0.0069%	-0.0009%
Price of labour	0.7173%	0.0094%	0.0001%
Price of energy (aggregate)	-1.2698%	-0.0082%	-0.0006%
Consumption energy use	0.4948%	0.0005%	-0.0003%
Industrial energy use	-5.3403%	-0.0600%	-0.0036%
Total domestic energy use	-2.8892%	-0.0386%	-0.0028%



Bigger global boost and redistribution

- Despite some net price increases (fixed factors), only German energy supply sectors contract
 - Releasing factors of production to feed expansion in other
- External energy supply also contracts due to lower industrial energy demand from Germany
 - But also because competitiveness of German sector has risen
- And here German FDT and Primary gain competitive advantage

Table 7

Changes in output [Billion 2009 USD]

Scenario 2: 10% increase in energy efficiency across all German sectors

	Germany	REU	ROW	World
Regional total	10.117	-1.311	-0.065	8.741
Electricity & Gas	-3.331	-1.364	-0.713	-5.408
Coke, Refined Petroleum and Nuclear Fuel	-0.423	-1.326	-0.648	-2.397
Primary	0.791	-0.672	-1.587	1.468
Food, Drink and Tobacco	0.900	-0.134	-0.099	0.667
Manufacturing	0.305	1.210	2.286	3.801
Construction	1.222	0.035	0.006	1.263
Transport	1.006	-0.424	-0.469	0.113
Services	9.647	1.364	1.158	12.169



Rebound?

- Contraction in own-country production in Scenario 1 mainly due to contractions of energy intensive German energy supply
- But increased household energy use pushes domestic economy-wide rebound back up
- Reduced activity in REU/ROW means rebound falls as we go global
- Assumption of fixed capital and labour supply key!

Table 8

General equilibrium rebound effects for Scenarios 1 (10% increase in energy efficiency in German “Manufacturing”) and Scenario 2 (10% increase in energy efficiency across all German sectors)

	Own-sector R_i	Own-country production R_p	Own-country total R_d	Global EUR_g	Global $WorldR_g$
Scenario 1					
Rebound [%]	56.44	47.63	51.31	50.22	48.11
Change [percentage points]		-8.81	3.68	-1.09	-2.11
Scenario 2					
Rebound [%]	n.a	46.60	50.18	47.28	46.58
Change [percentage points]			3.58	-2.90	-0.70



Key finding

In an global economy context, energy efficiency improvements in one country *will* impact energy demand (and supply) in others

- But this may not mean increased rebound
- While other policy approaches that take direct action to reduce energy use may inadvertently cause energy use to reallocate to other countries
- e.g. 'pollution haven' hypotheses involving 'carbon leakage' to countries with more relaxed energy/environmental policies
- As a result of changes in comparative advantage, **policy actions to support cost effective implementation of more energy efficient technologies may have 'negative leakage' effects**
- **Drawing energy use to more energy efficient locations and producers**



Thank you – questions?

- Download paper list of CEP occasional papers at <http://www.strath.ac.uk/ippi/ourpolicypapers/>
- Contact me at karen.turner@strath.ac.uk
- New EPSRC-funded project on ‘Energy Saving Innovations and Economy-Wide Rebound Effects’
 - UK case studies but theoretical as well as applied work
 - Imperfect competition in energy supply; capital investment/efficiency improvements embedded in durable goods
 - Joint with CIED EPSRC EUED centre (Steve Sorrell)



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