EMISSIONS AND GROWTH: Trends and Cycles in a Globalized World

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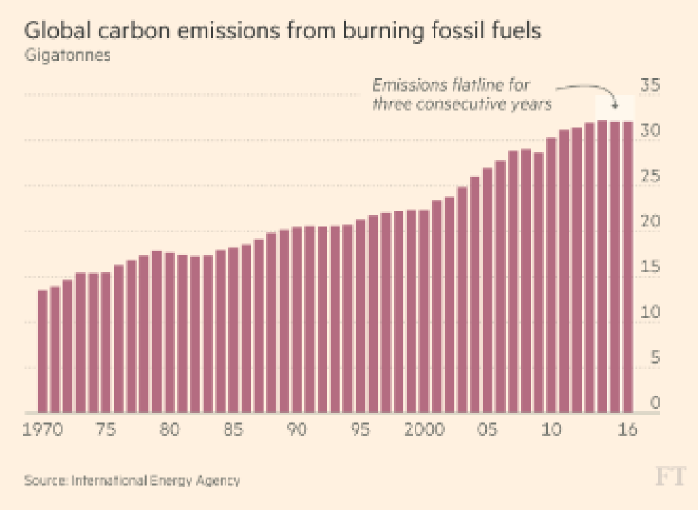
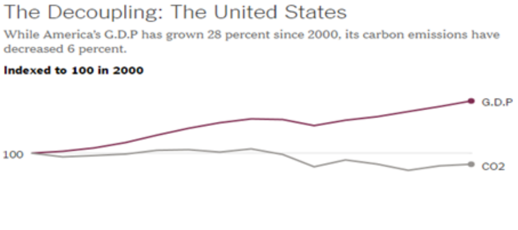
Outline

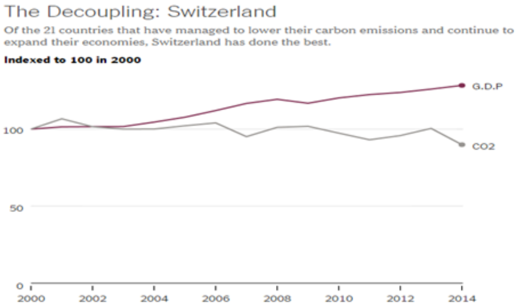
1. **Motivation**
2. **Trends and Cycles**
   - Is there an Environmental Okun's Law?
   - Do Kuznets elasticities reflect a low-carbon transition?
3. **Trade and Emissions**
   - Trade matters for emissions
   - Revisiting Okun and Kuznets elasticities
4. **Exploring Cross-Country Differences**
5. **Concluding Remarks**

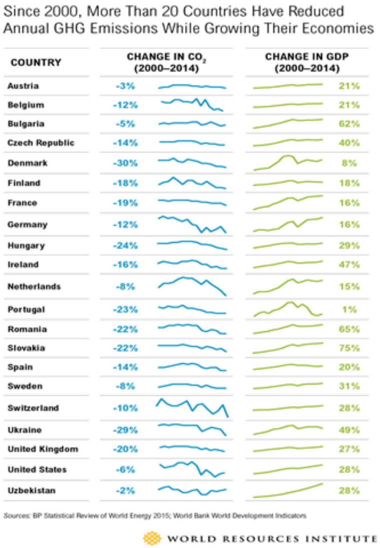
Where's the decoupling?



Where's the decoupling?







Since 2000, More Than 20 Countries Have Reduced Annual GHG Emissions While Growing Their Economies

COUNTRY	CHANGE IN CO_2 (2000–2014)	CHANGE IN GDP (2000–2014)
Austria	-3%	21%
Belgium	-12%	21%
Bulgaria	-5%	62%
Czech Republic	-14%	40%
Denmark	-30%	8%
Finland	-18%	18%
France	-19%	16%
Germany	-12%	16%
Hungary	-24%	29%
Ireland	-16%	47%
Netherlands	-8%	15%
Portugal	-23%	1%
Romania	-22%	65%
Slovakia	-22%	75%
Spain	-14%	20%
Sweden	-8%	31%
Switzerland	-10%	28%
Ukraine	-29%	49%
United Kingdom	-20%	27%
United States	-6%	28%
Uzbekistan	-2%	28%

Sources: BP Statistical Review of World Energy 2015; World Bank World Development Indicators

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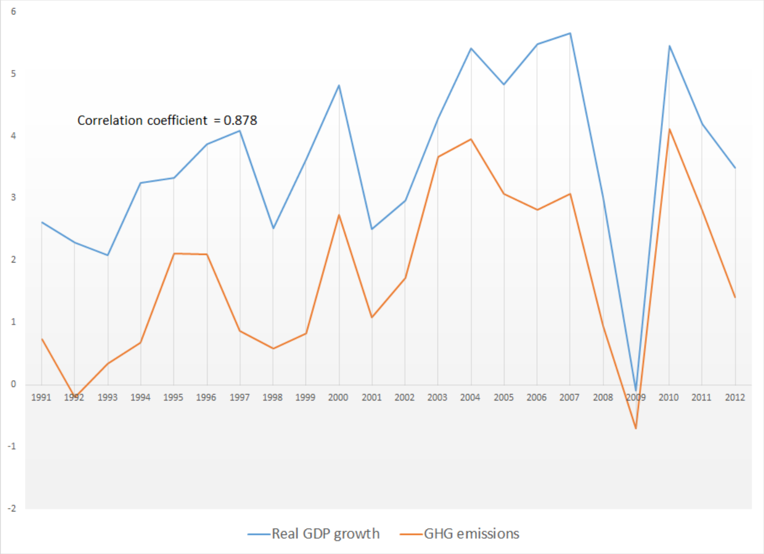
Where's the decoupling?



Key results: Trends vs. Cycles

1. Need to **distinguish trends from cycles**
    - An Environmental Okun's Law (EOL) sometimes obscures the Environmental Kuznets correlation (EKC).
2. **Decoupling between emissions and GDP is not so clear** when removing cyclical fluctuations: Production vs. consumption-based emissions complicate the story.
    - Production-based EKC estimates do show decoupling for many countries.
    - **BUT** very few have decoupled at the consumption level (e.g. Germany).
    - There have been some improvements nonetheless (policies, economic structure, income per capita).

A look at the literature

- Emissions and HP cycles: Heutel (2012), Doda (2014).
- Emissions and booms and busts: York (2012), Burke et al. (2015) and Sheldon (2017).
- Approving and disproving the EKC: Grossman and Krueger (1995), Dasgupta et al. (2002), Perman and Stern (2003), many more papers.
- Consumption-based emissions are relevant: Davis and Caldeira (2010), Peters et al. (2011), Peters and Hertwich (2008), Aichele and Felbermayr (2012), Pan et al. (2008).
- But not the panacea: Jakob et al. (2013), Jakob et al. (2014), and Kander et al. (2015).

Emissions data

- 3 main datasets:
  - Production-based GHG emissions, 1990-2012.
  - Consumption-based GHG emissions, 1990-2012.
  - Production-based CO_2 emissions, 1850-2009.
- Coverage spans 161 countries but focus of this presentation is mostly on the top 20 emitters.

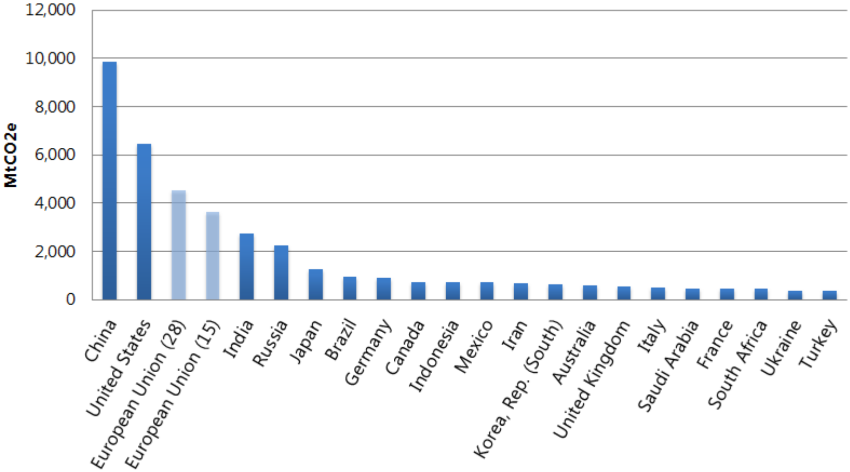
Sample statistics

Gas	Emissions source	Data source
Carbon dioxide (CO_2)	Fossil fuel comb.	IEA, 2014
	Gas flaring	US-EIA, 2014
	Cement manuf.	CDIAC, 2015
	LUCF	FAO, 2014
Methane (CH_4)	Agriculture	FAO, 2014
	LUCF	FAO, 2014
	Waste	US-EPA, 2012
	Industrial proc.	US-EPA, 2012
Nitrous oxide (N_2O)	Agriculture	FAO, 2014
	LUCF	FAO, 2014
	Waste	US-EPA, 2012
	Industrial proc.	US-EPA, 2012
Fluorinated gases	NA	US-EPA, 2012

Sector	Emissions source	Gas	Data source
Agriculture	Enteric Ferm., Rice Cult.	CH_4	FAO, 2014
	Agricultural Soils	N_2O	FAO, 2014
	Manure Mngt, Other Ag.	CH_4, N_2O	FAO, 2014
Energy	Electricity & Heat	CO_2	IEA, 2014
	Manufacturing & Const.	CO_2	IEA, 2014
	Transportation	CO_2	IEA, 2014
	Other Fuel Combustion	CO_2	IEA, 2014
		CH_4, N_2O	US-EPA, 2012
	Fugitive Emissions	CO_2	US-EIA, 2014
		CH_4, N_2O	US-EPA, 2012
Ind. Pr.	Cement	CO_2	CDIAC, 2015
	Other I.P.	N_2O, CH_4	US-EPA, 2012
		F-gases	US-EPA, 2012
Waste	Landfills, Wastewater Tr.	CH_4	US-EPA, 2012
	Human Sewage, Other W.	N_2O, CH_4	US-EPA, 2012
LUCF	Forest, crop, and other	CO_2, CH_4, N_2O	FAO, 2014

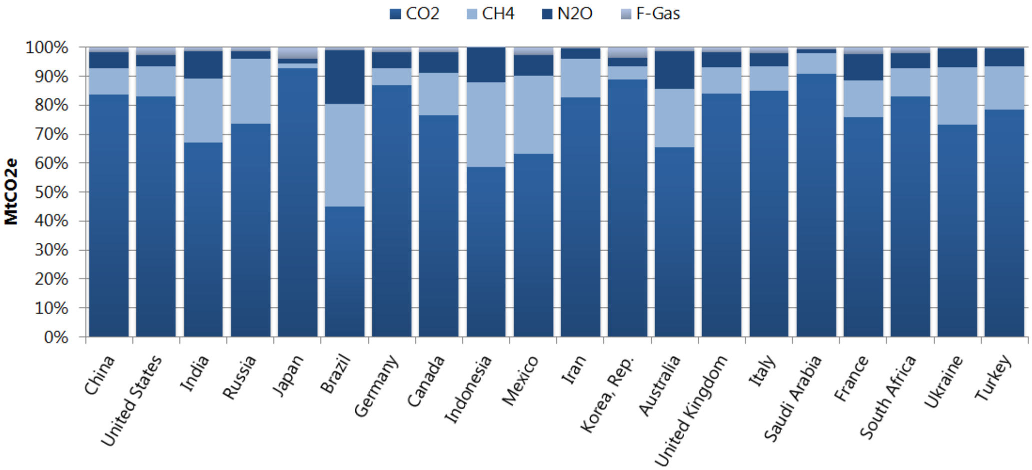
Aggregation: IPCC 2^{nd} AR

Top 20 world emitters



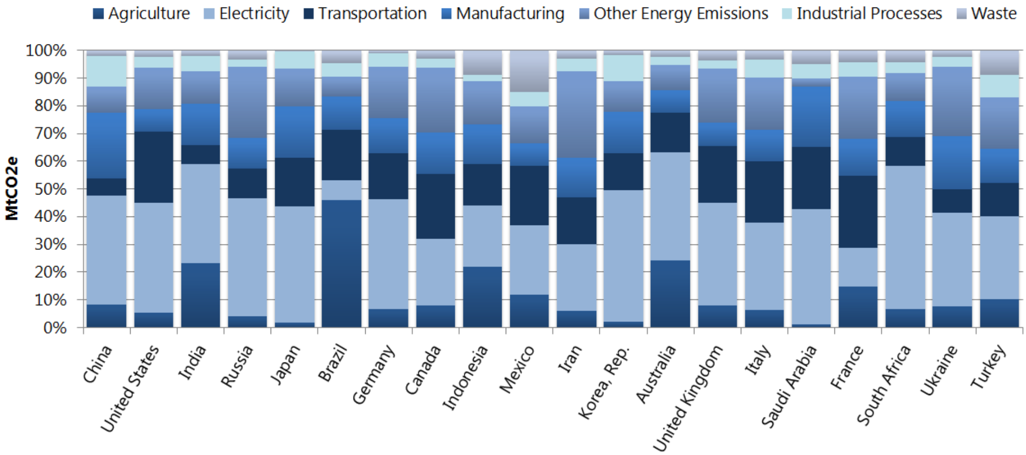
- The 20 largest GHG emitters contribute 74% of world emissions and account for 63% of the world's population and 77% of world's GDP.

Most emissions are in the form of CO_2 and CH_4...



- Why look beyond CO_2?
  - 26% of emissions do not derive from CO_2.

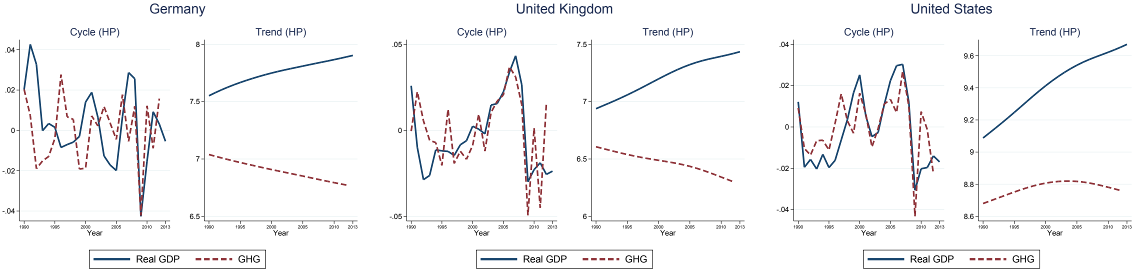
...and from the energy and agricultural sectors



- Why look beyond CO_2?
  - CO_2 underestimates economic activity in major agriculture producers (e.g. Australia, Brazil, Indonesia, Mexico).

Trends and Cycles

Cycles can obscure trend movements



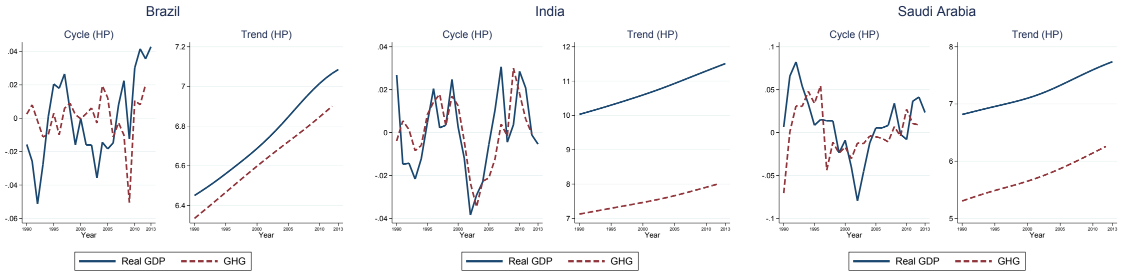
- Cyclical and trend components extracted with the Hodrick-Prescott (HP) filter, with smoothing parameter = 100.

▸ Filtering methods

▸ Estimation methods

▸ Variance decomposition

Cycles can obscure trend movements



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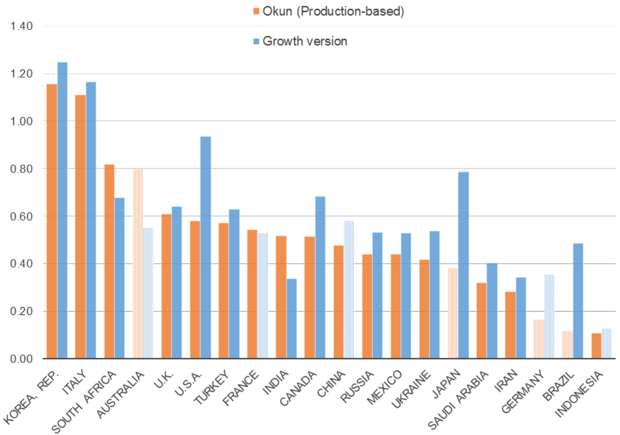
Filtering methods

Estimation methods

Variance decomposition

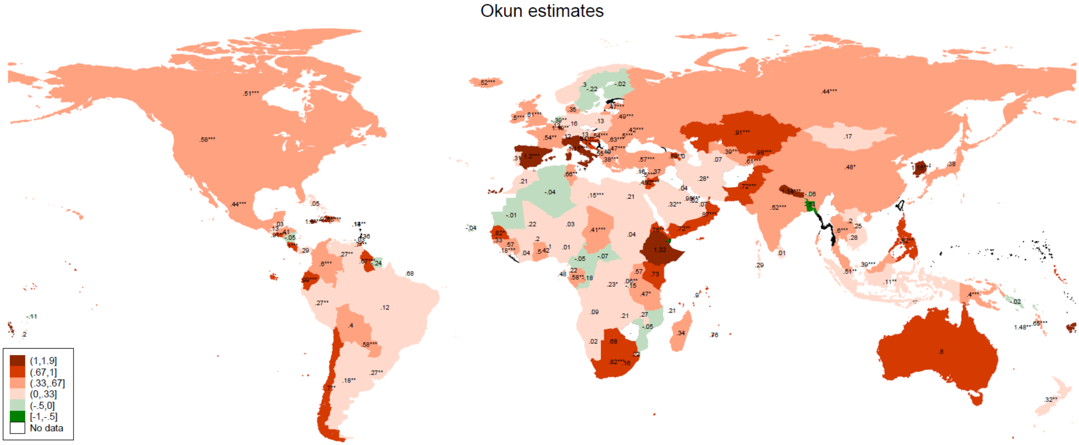
There is an Environmental Okun's Law



- Cyclical relationship

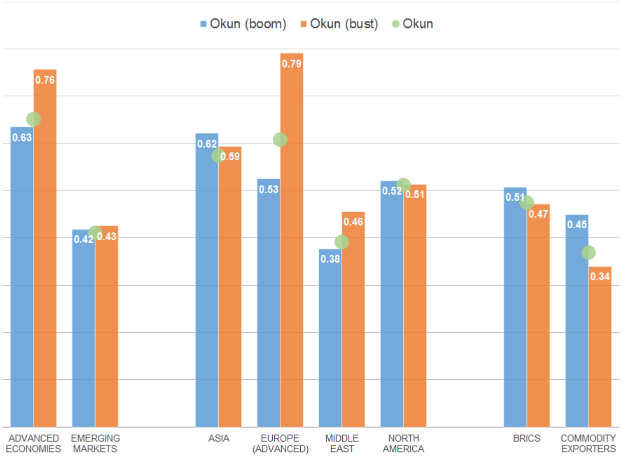
$$e_t^c = \beta^{\text{okun}} y_t^c + \varepsilon_t^c$$

Okun elasticities around the world



Note: *** p<0.01, ** p<0.05, * p<0.1, NS not statistically significant.

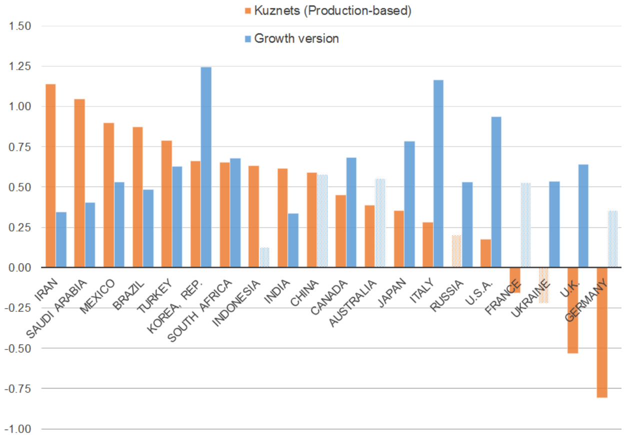
Booms and busts



- Decomposing the Environmental Okun's Law in periods of expansions and contractions

$$e_t^c = \beta^{\text{okun, boom}} y_t^{c,\text{ boom}} + \beta^{\text{okun, bust}} y_t^{c,\text{ bust}} + \varepsilon_t^c$$

Do Kuznets elasticities reflect a low-carbon transition?

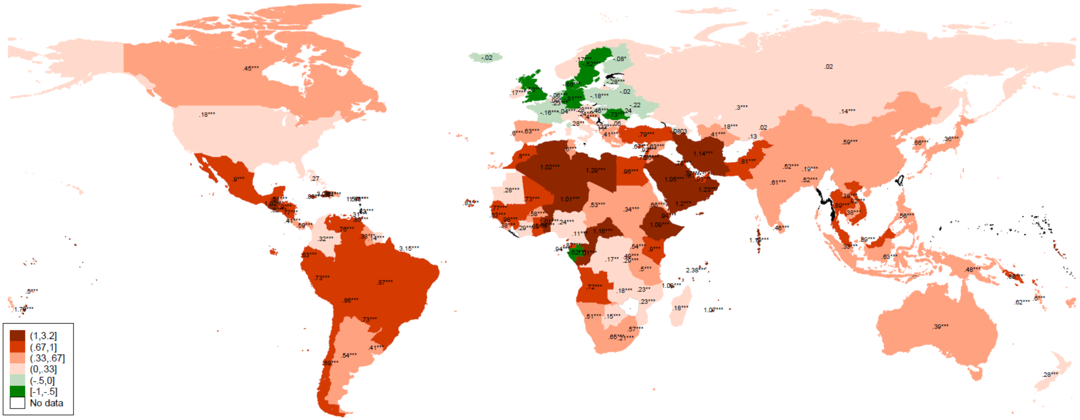


- Trend relationship

$$e_t^\tau = \gamma + \beta^{\text{kuznets}} y_t^\tau + \varepsilon_t^\tau$$

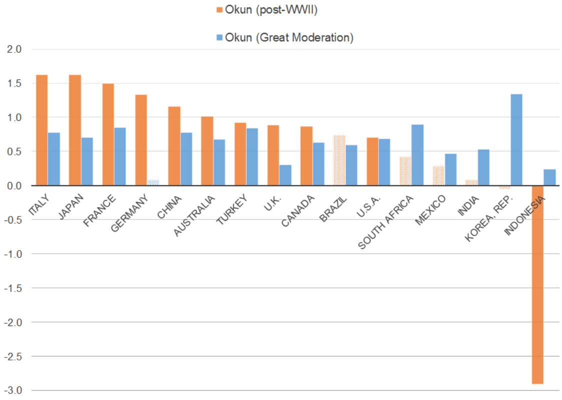
Kuznets elasticities around the world

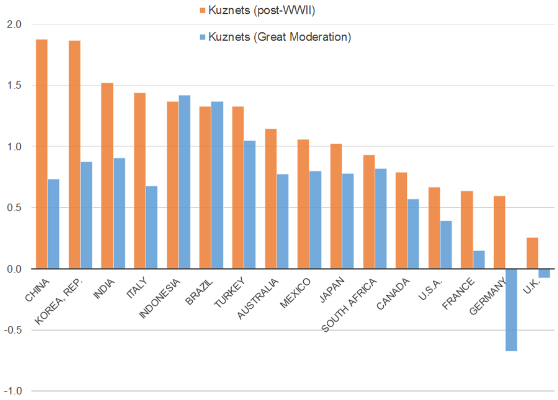
Kuznets estimates



Note: *** p<0.01, ** p<0.05, * p<0.1, NS not statistically significant.

Partitioning the long time series shows some improvement





- Kuznets elasticities have reduced significantly during the Great Moderation, averaging 0.7 (from 1.1) for the largest emitters and 0.9 (from 1.7) for the entire sample.
- Okun elasticities do not show much improvement.

Robustness checks

VAR.	(1) Okun	(2) Kuznets
Growth version	0.821	-0.058
Time-varying (1990-2012)	0.578	0.934
Hamilton filtering	0.683	0.970
BK filtering	0.579	0.977
CF filtering	0.563	0.769
Bayesian estimation	0.997	0.998
Boom	0.877	-
Bust	0.859	-
Consumption-based GHG	0.532	0.665
CO_2 (1990-2012)	0.845	0.969
CO_2 (long time series)	0.278	0.567
GHG with LULUCF	0.810	0.928

Note: Columns (1) and (2) refer to the baseline calibration.

HP vs. Other filters (Hamilton, Baxter-King, Christiano-Fitzgerald)

OLS vs. Bayesian

Kuznets residuals

Trade and Emissions

Some decoupling BUT we live in an integrated world

- So far, we have looked at the relationship between output and emissions at the national level.
  - However, in climate change terms this does not make much sense. The same unit of pollutant expelled to the atmosphere in the U.S. or China has on average the same effect on GHG concentrations.
  - Countries may have just shifted production elsewhere, while keeping similar carbon-intensive consumption patterns.
- Over the recent years, efforts to come up with a consumption-based accounting of emissions to take into consideration the emission transfers via international trade.
  - Understanding emissions transfers via trade and FDI would give a more accurate view of our Okun and Kuznets estimates and could shed light on the extent of the pollution heaven hypothesis.

Evidence from panel data

VARIABLE	(1) ΔGHG	(2) ΔGHG	(3) GHG^{cycle}	(4) GHG^{cycle}	(5) GHG^{trend}	(6) GHG^{trend}
ΔReal GDP	0.322***	0.302***				
	(0.022)	(0.021)				
ΔPartners' real GDP		0.328**				
		(0.162)				
Real GDP^{cycle}			0.295***	0.283***		
			(0.017)	(0.016)		
Partners' real GDP^{cycle}				0.282**		
				(0.122)		
Real GDP^{trend}					0.686***	0.689***
					(0.013)	(0.013)
Partners' real GDP^{trend}						0.901***
						(0.076)
Constant	0.006	-0.002			2.321***	-2.220***
	(0.016)	(0.016)			(0.118)	(0.395)
Country effects	Yes	Yes	Yes	Yes	Yes	Yes
Time effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,705	3,554	3,880	3,721	3,880	3,721
R-squared	0.186	0.203	0.097	0.105	0.996	0.996

Note: *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Standard errors in parentheses.

- Real GDP growth in main trading partners helps explain growth in emissions at the individual country level:
  - A 1 p.p. ↗ in a country's main trading partners real GDP growth is associated with a 0.3 p.p. ↗ in emissions growth.

Evidence from panel data

- An ↗ in real exports (or imports) is correlated with an ↗ in world emissions of about 0.1 for the cyclical time series and of about 0.5 to 0.6 for trend components.

  ▸ World trade and emissions

- ↗ exports of goods and services (in real terms) are associated with ↗ in GHG emissions (between 8 and 10% for a 1 p.p. ↗ depending on which model is considered (growth rates, cycles, or trends).

  ▸ GDP decomposition and emissions

- Trading with certain regions of the world seem to entail greater carbon intensities

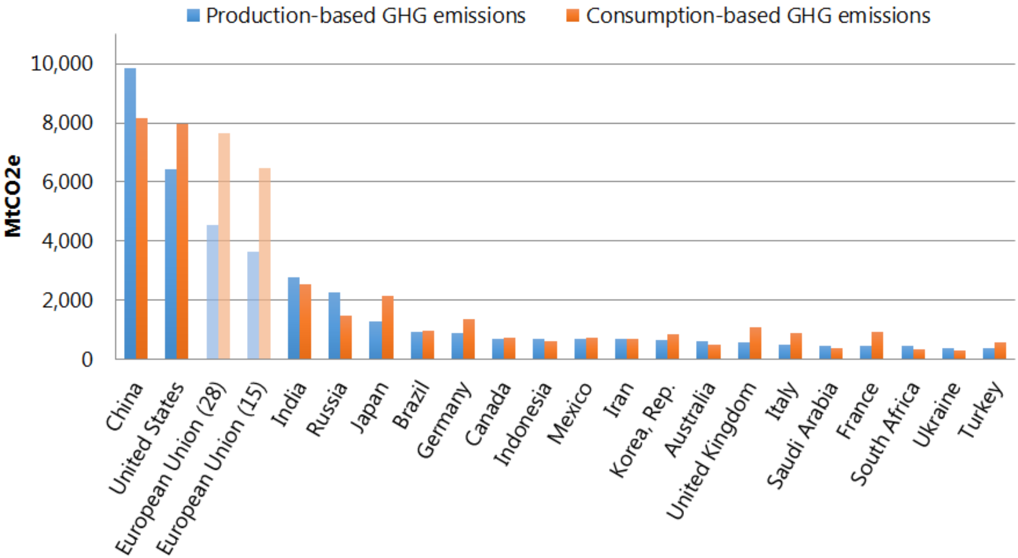
  ▸ GDP decomposition, regional trade, and emissions

- Trading certain types of goods also entail greater carbon intensities

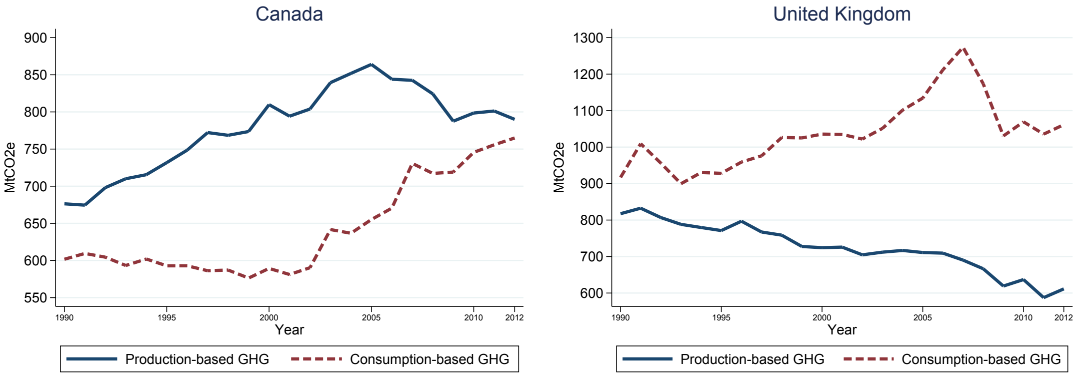
  ▸ GDP decomposition, sectoral trade, and emissions

- **At the trend level, ↗ in imports reduces emissions more than the equivalent ↗ in exports** (for any types of goods and services and for any region).

Net exporter of emissions vs. Net importers of emissions



Net exporter of emissions vs. Net importers of emissions



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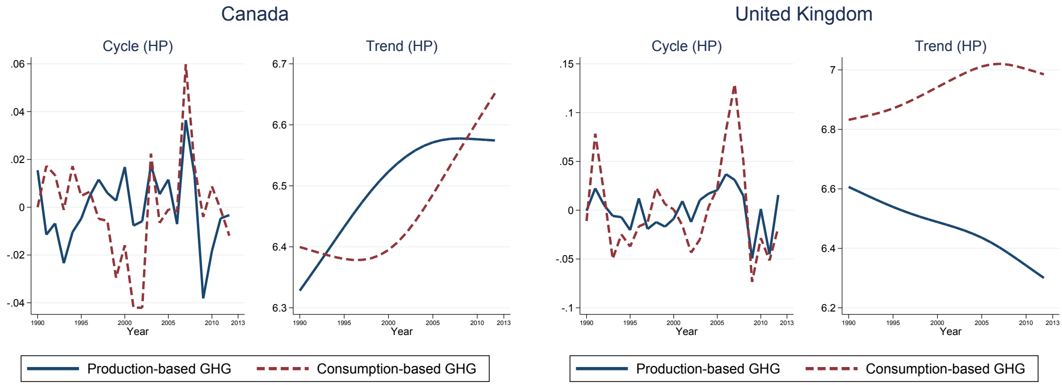
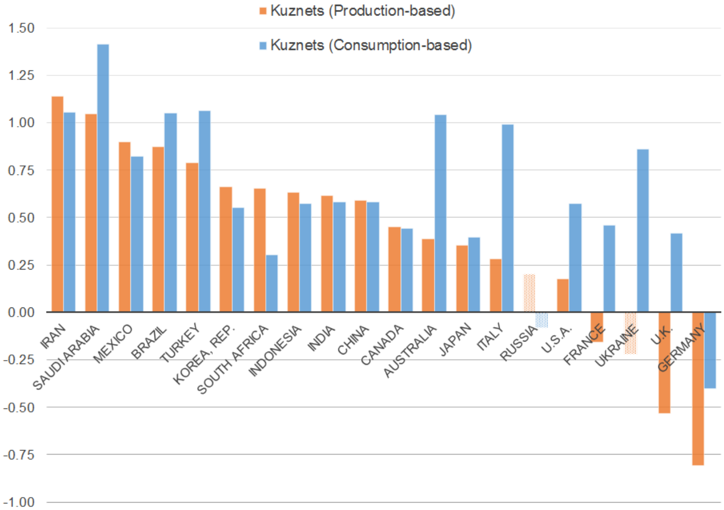


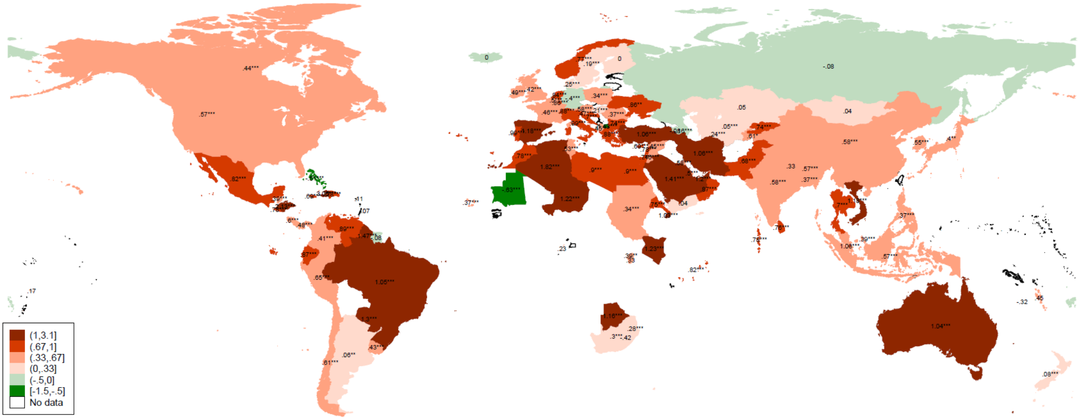
Revisiting Kuznets elasticities



Consumption-based Okun elasticities - Top 20

Revisiting Kuznets elasticities

Kuznets estimates

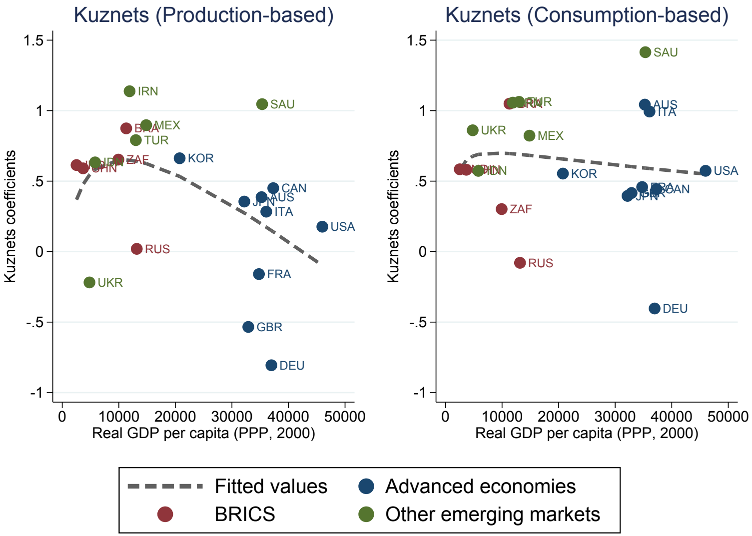


Note: *** p<0.01, ** p<0.05, * p<0.1, NS not statistically significant.

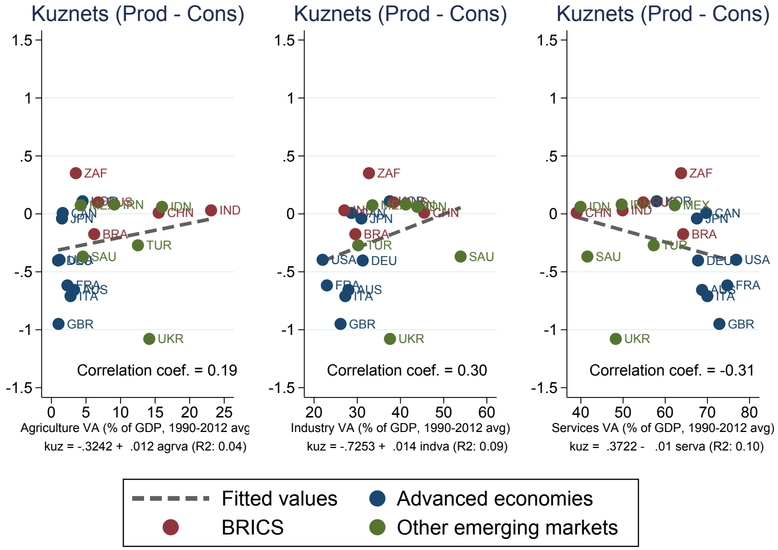
▸ Consumption-based Okun elasticities - All countries

Exploring Cross-Country Differences

Kuznets elasticities and per capita GDP

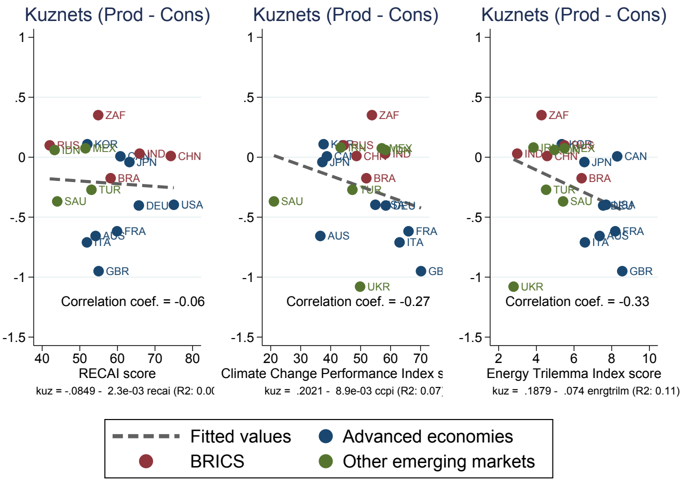


Kuznets elasticities and economic structure



- Countries with larger agricultural and industrial sectors tend to have similar consumption-based and production-based Kuznets elasticities.

Kuznets elasticities and policy environment



- Policy environment matters for both long-run elasticities: well-ranked countries tend to have lower (Production and Consumption) Kuznets.
  - But not for short-run elasticities.

Measures: i) Germanwatch Climate Change Performance Index, ii) EY Renewable Energy Attractiveness Index, iii) WB CPIA environmental sustainability index, iv) World Energy Council Trilemma Index.

Concluding Remarks

Policy implications

- Emissions, like GDP, moves in cycles.
  - There is a strong cyclical relationship between emissions and output: **the Environmental Okun's Law** (0.6 on average for each income group).
    - Emissions could be low simply because the economy is in a recession or high during booms.
  - Useful for calibrating IAMs and predicting emissions.
- Advanced economies have managed to transition to a low-carbon path but globalization may have played an important role:
  - **Emissions embodied in international trade matter.**
    - Kuznets differ greatly across country income groups for production- and consumption-based emissions. **The Great Moderation is characterized by much lower Kuznets elasticities.**
    - Advanced economies tend to have smaller production-based Kuznets BUT larger consumption-based Kuznets: **decoupling only visible for Germany**.
  - Larger shares of **Industry VA** is correlated with larger production- and consumption-based Kuznets (also for agriculture, but weaker link).
  - **Better policies, better Kuznets** estimates across the board.
  - **EKC hypothesis** holds weakly for production-based emissions.
    - Still, there may be room for **carbon-intensive specialization** in trade.
- Two sets of policies: taming business cycle and structural targeting trend.

Thank you!

Appendix

Sample statistics

VARIABLE	Obs.	Mean	Std. Dev.	Min	Max.
Advanced economies (29 countries, 1990-2012)					
GHG emissions	667	473.4	1,182.2	2.7	6,865.2
	667	636.7	1,433.6	-13.4	8,897.5
CO_2 emissions	667	391.9	995.0	1.8	5,830.5
	667	456.3	1,110.9	2.1	6,918.6
Emerging markets (79 countries, 1990-2012)					
GHG emissions	1,817	233.8	803.4	0.1	10,975.5
	1,725	208.7	670.3	-169.3	9,337.2
CO_2 emissions	1,817	164.0	635.6	0	9,312.5
	1,725	147.7	523.4	-7.5	7,683.3
Low income countries (53 countries, 1990-2012)					
GHG emissions	1,217	32.3	51.4	0.0	296.7
	1,125	-6.7	99.8	-1,474.2	245.0
CO_2 emissions	1,217	8.8	22.7	0.0	173.1
	1,125	9.0	20.2	-0.9	176.4

Note: For each variable, the first row corresponds to production-based emissions and the second row to consumption-based emissions. Summary statistics are for countries with at least 21 observations of emissions and real GDP.

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Emissions aggregation

- IPCC's 2nd Assessment Report 100-year Global Warming Potentials (GWP-100) for non-CO2 emissions.
  - Although some have low ozone depletion potential, they have high 100-year global warming potentials.
  - Methane's atmospheric lifetime is around 12y, but it traps 28 times more heat per mass unit than carbon dioxide!

CO_2 conversion rates (100-year Global Warming Potentials, GWP-100)

Gas	AR2	AR5
Carbon dioxide (CO_2)	1	1
Methane (CH_4)	21	28
Nitrous Oxide (N_2O)	310	265
Hydroflourocarbon (HFC-23)	11,700	12,400
Difluoromethane (HFC-32)	650	677
Pentafluoroethane (HFC-125)	2,800	3,170
Tetrafluoroethane (HFC-125)	1,300	1,300
Trifluoroethane (HFC-143a)	3,800	4,800
Difluoroethane (HFC-152a)	140	138
Carbon Tetrafluoride (CF_4)	6,500	6,630
Hexafluoroethane (C_2F_6)	9,200	11,100
Sulfur Hexafluoride (SF_6)	23,900	23,500

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Filtering methods

1. *Hodrick-Prescott (HP) filter:* extracts the cyclical and trends components (c_t and τ_t, respectively) by

$$\min_{\tau_t} \left\{ \sum_{t=1}^{T} (y_t - \tau_t)^2 + \lambda \sum_{t=1}^{T} [(\tau_t - \tau_{t-1}) - (\tau_{t-1} - \tau_{t-2})]^2 \right\},$$

where λ is the smoothing parameter set at 100 as common for annual data.

2. *Hamilton filter:* first estimate

$$y_{t+h} = \beta_0 + \sum_{j=0}^{k} \beta_{j+1} y_{t-j} + u_{t+h},$$

where h=2 and k=3. The non-stationary part provides the cyclical component $c_t = \hat{u}_t$, while the trend is given by $\tau_t = \hat{\beta}_0 + \sum_{j=0}^{k} \hat{\beta}_{j+1} y_{t-h-j}$.

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Estimation methods

1. *Ordinary Least Squares:* for each country in our dataset with at least 21 observations for a given environmental proxy.
2. *Bayesian Maximum Likelihood:* our priors are informed by the EKC relationship, i.e. we assume emissions elasticity wrt output for LICs (the weakly polluters) fluctuate around zero; for AEs fluctuate around 0.5; for EMEs (the heavy polluters) fluctuate around 1.
3. *Time-Varying Coefficients Model:* generalizes the standard linear regression model by introducing the assumption that coefficients vary over time. The variances are calculated by a M-o-M estimator that coincides with the ML estimator for large samples. As discussed by Aghion and Marinescu (2008), this method has several advantages.

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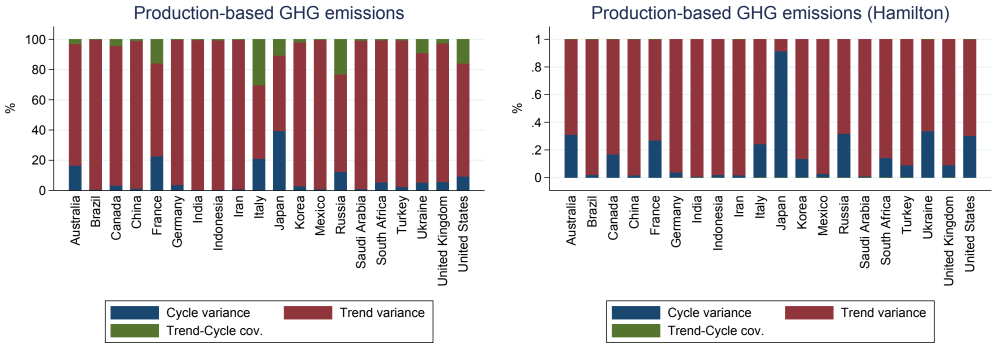
Variance decomposition



- Decomposing the variance of emissions as

$$Var(e_t) = Var(e_t^c) + Var(e_t^\tau) + 2Cov(e_t^c, e_t^\tau)$$

shows that the variance is captured mostly by the variance in trend emissions.

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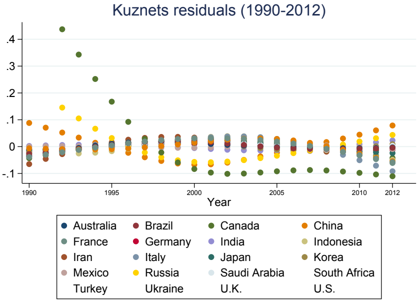
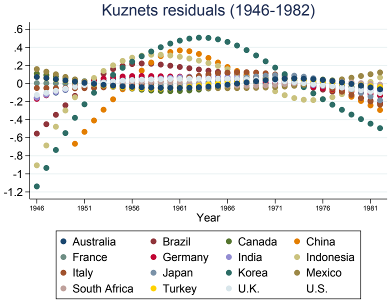
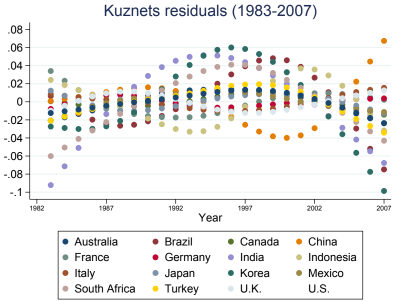
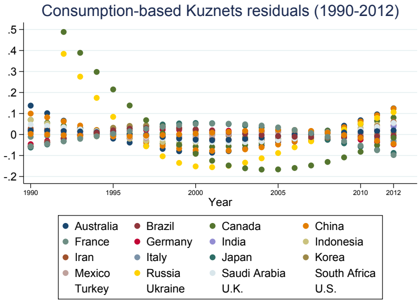
Kuznets residuals









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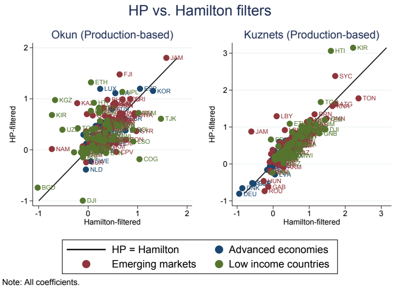
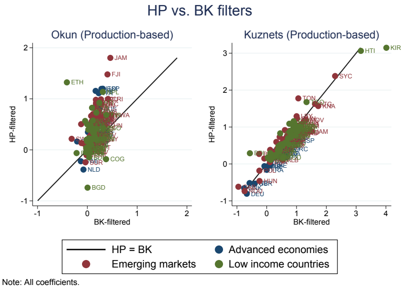
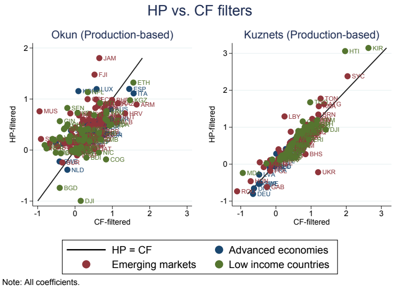
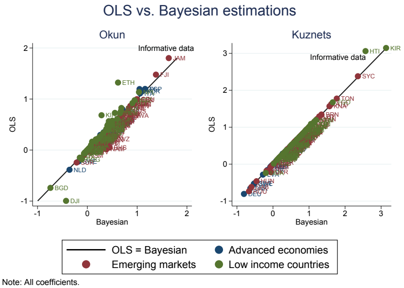
Contrasting estimates across filters and estimation methods









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World trade and emissions

VARIABLE	(1) ΔGHG	(2) ΔGHG	(3) GHG^{cycle}	(4) GHG^{cycle}	(5) GHG^{trend}	(6) GHG^{trend}
ΔReal Exports	0.113***					
	(0.030)					
ΔReal Imports		0.108***				
		(0.032)				
Real $Exports^{cycle}$			0.107***			
			(0.015)			
Real $Imports^{cycle}$				0.099***		
				(0.014)		
Real $Exports^{trend}$					0.509***	
					(0.020)	
Real $Imports^{trend}$						0.644***
						(0.037)
Constant					-1.222**	-4.299***
					(0.467)	(0.843)
Observations	22	22	23	23	23	23
R-squared	0.403	0.356	0.688	0.684	0.968	0.936

Note: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. Exports and imports of goods.

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GDP decomposition and emissions

VARIABLE	(1) ΔGHG	(2) GHG^{cycle}	(3) GHG^{trend}
ΔReal Hh. Cons.	0.088***		
	(0.019)		
ΔReal Cap. Spend. (GCF)	0.000*		
	(0.000)		
ΔReal Gov. Cons.	0.047***		
	(0.010)		
ΔReal Exports (G. & S.)	0.088***		
	(0.012)		
ΔReal Imports (G. & S.)	0.038***		
	(0.013)		
Real Hh. $Cons.^{cycle}$		0.108***	
		(0.016)	
Real Cap. Spend. $(GCF)^{cycle}$		0.044***	
		(0.007)	
Real Gov. $Cons.^{cycle}$		0.040***	
		(0.009)	
Real Exports $(G. \& S.)^{cycle}$		0.086***	
		(0.011)	
Real Imports $(G. \& S.)^{cycle}$		-0.009	
		(0.012)	
Real Hh. $Cons.^{trend}$			0.535***
			(0.023)
Real Cap. Spend. $(GCF)^{trend}$			0.076***
			(0.012)
Real Gov. $Cons.^{trend}$			0.239***
			(0.016)
Real Exports $(G. \& S.)^{trend}$			0.193***
			(0.015)
Real Imports $(G. \& S.)^{trend}$			-0.201***
			(0.020)
Constant	-0.002		-15.708***
	(0.016)		(0.528)
Country effects	Yes	Yes	Yes
Time effects	Yes	Yes	Yes
Observations	2,717	2,804	2,804
R-squared	0.226	0.145	0.995

Note: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses.

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GDP decomposition, regional trade, and emissions

VARIABLE	(1) ΔGHG	(2) GHG^{cycle}	(3) GHG^{trend}
Real Hh. Cons. Δ/ ^{cycle}/ ^{trend}	0.129*** (0.033)	0.144*** (0.028)	0.482*** (0.031)
Real Cap. Spend. (GCF) Δ/ ^{cycle}/ ^{trend}	0.000* (0.000)	0.052*** (0.010)	0.170*** (0.019)
Real Gov. Cons. Δ/ ^{cycle}/ ^{trend}	0.073*** (0.022)	0.048*** (0.016)	0.241*** (0.021)
Real Exports (Services) Δ/ ^{cycle}/ ^{trend}	0.010 (0.009)	0.102*** (0.018)	0.150*** (0.022)
Real Imports (Services) Δ/ ^{cycle}/ ^{trend}	0.096*** (0.023)	0.010 (0.021)	-0.307*** (0.028)
Real Exports (Goods) to Eastern Europe Δ/ ^{cycle}/ ^{trend}	-0.013 (0.094)	0.375*** (0.082)	0.156*** (0.022)
Real Exports (Goods) to Latin America Δ/ ^{cycle}/ ^{trend}	-2.557*** (0.758)	4.157*** (1.332)	0.052 (0.033)
Real Exports (Goods) to North Africa and M.E. Δ/ ^{cycle}/ ^{trend}	0.195 (0.319)	-0.181 (0.245)	0.174*** (0.023)
Real Exports (Goods) to Sub-Saharan Africa Δ/ ^{cycle}/ ^{trend}	0.164 (0.125)	0.130 (0.086)	0.151*** (0.022)
Real Exports (Goods) to W. Europe and N. America Δ/ ^{cycle}/ ^{trend}	0.024 (0.047)	0.105** (0.052)	0.152*** (0.022)
Real Exports (Goods) to East Asia Δ/ ^{cycle}/ ^{trend}	-0.072* (0.039)	0.067*** (0.023)	0.150*** (0.022)
Real Exports (Goods) to Southeast Asia Δ/ ^{cycle}/ ^{trend}	-0.050 (0.064)	0.039 (0.069)	0.147*** (0.022)
Real Exports (Goods) to South Asia Δ/ ^{cycle}/ ^{trend}	-0.325 (0.212)	-0.222 (0.297)	0.139*** (0.022)
Real Exports (Goods) to Pacific Δ/ ^{cycle}/ ^{trend}	-0.784** (0.307)	0.045 (0.302)	0.161*** (0.023)
Real Exports (Goods) to Caribbean Δ/ ^{cycle}/ ^{trend}	2.105 (8.843)	3.833 (12.912)	0.258** (0.101)
Real Imports (Goods) from Eastern Europe Δ/ ^{cycle}/ ^{trend}	0.060 (0.053)	0.068 (0.048)	-0.306*** (0.028)
Real Imports (Goods) from Latin America Δ/ ^{cycle}/ ^{trend}	-2.225 (2.098)	-1.849* (0.981)	-0.382*** (0.035)
Real Imports (Goods) from North Africa and M.E. Δ/ ^{cycle}/ ^{trend}	0.061 (0.212)	0.001 (0.062)	-0.315*** (0.029)
Real Imports (Goods) from Sub-Saharan Africa Δ/ ^{cycle}/ ^{trend}	0.107 (0.138)	0.228** (0.101)	-0.307*** (0.028)
Real Imports (Goods) from W. Europe and N. America Δ/ ^{cycle}/ ^{trend}	-0.515*** (0.146)	-0.340*** (0.115)	-0.304*** (0.028)
Real Imports (Goods) from East Asia Δ/ ^{cycle}/ ^{trend}	0.154*** (0.044)	0.012 (0.028)	-0.306*** (0.028)
Real Imports (Goods) from Southeast Asia Δ/ ^{cycle}/ ^{trend}	0.197 (0.166)	0.095 (0.096)	-0.311*** (0.028)
Real Imports (Goods) from South Asia Δ/ ^{cycle}/ ^{trend}	0.181 (0.318)	-0.335 (0.236)	-0.282*** (0.029)
Real Imports (Goods) from Pacific Δ/ ^{cycle}/ ^{trend}	0.113 (0.337)	-0.170 (0.202)	-0.320*** (0.029)
Real Imports (Goods) from Caribbean Δ/ ^{cycle}/ ^{trend}	9.614 (7.831)	3.310 (3.360)	-0.410*** (0.096)
Constant	0.001		-12.753***
	(0.012)		(0.717)
Country effects	Yes	Yes	Yes
Time effects	Yes	Yes	Yes
Observations	1,528	1,546	1,546
R-squared	0.351	0.357	0.998

Note: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses.

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GDP decomposition, sectoral trade, and emissions

VARIABLE	(1) ΔGHG	(2) GHG^{cycle}	(3) GHG^{trend}
Real Hh. Cons. $\Delta / ^{cycle} / ^{trend}$	0.091*** (0.019)	0.118*** (0.017)	0.384*** (0.024)
Real Cap. Spend. (GCF) $\Delta / ^{cycle} / ^{trend}$	0.000* (0.000)	0.034*** (0.007)	0.080*** (0.013)
Real Gov. Cons. $\Delta / ^{cycle} / ^{trend}$	0.037*** (0.010)	0.024** (0.009)	0.210*** (0.015)
Real Exports (Services) $\Delta / ^{cycle} / ^{trend}$	-0.000 (0.001)	0.069*** (0.012)	0.131*** (0.014)
Real Imports (Services) $\Delta / ^{cycle} / ^{trend}$	0.075*** (0.013)	0.018 (0.014)	-0.285*** (0.020)
Real Exports of Food $\Delta / ^{cycle} / ^{trend}$	-0.046 (0.031)	0.046** (0.018)	0.131*** (0.014)
Real Exports of Beverages and tobacco $\Delta / ^{cycle} / ^{trend}$	-0.229* (0.133)	0.025 (0.041)	0.132*** (0.015)
Real Exports of Crude materials (exc. fuels) $\Delta / ^{cycle} / ^{trend}$	0.110*** (0.043)	0.104*** (0.022)	0.132*** (0.014)
Real Exports of Mineral fuels $\Delta / ^{cycle} / ^{trend}$	-0.038** (0.016)	0.058*** (0.012)	0.131*** (0.014)
Real Exports of Animal and vegetable oils $\Delta / ^{cycle} / ^{trend}$	-0.903* (0.533)	-0.324 (0.293)	0.125*** (0.015)
Real Exports of Chemicals $\Delta / ^{cycle} / ^{trend}$	-0.079 (0.059)	0.064** (0.026)	0.130*** (0.014)
Real Exports of Manufactured goods $\Delta / ^{cycle} / ^{trend}$	-0.033 (0.025)	0.076*** (0.015)	0.132*** (0.014)
Real Exports of Machinery and transp. equip. $\Delta / ^{cycle} / ^{trend}$	-0.031 (0.025)	0.089*** (0.025)	0.131*** (0.014)
Real Exports of Miscellaneous manufacturing $\Delta / ^{cycle} / ^{trend}$	-0.036 (0.047)	0.051*** (0.017)	0.130*** (0.014)
Real Exports of Commodities $\Delta / ^{cycle} / ^{trend}$	0.002 (0.026)	0.070*** (0.018)	0.131*** (0.014)
Real Imports of Food $\Delta / ^{cycle} / ^{trend}$	0.071 (0.044)	0.050* (0.029)	-0.286*** (0.020)
Real Imports of Beverages and tobacco $\Delta / ^{cycle} / ^{trend}$	-0.087 (0.121)	0.006 (0.042)	-0.285*** (0.020)
Real Imports of Crude materials (exc. fuels) $\Delta / ^{cycle} / ^{trend}$	0.151 (0.123)	0.003 (0.039)	-0.283*** (0.020)
Real Imports of Mineral fuels $\Delta / ^{cycle} / ^{trend}$	0.043 (0.027)	0.021 (0.016)	-0.285*** (0.020)
Real Imports of Animal and vegetable oils $\Delta / ^{cycle} / ^{trend}$	-1.235** (0.578)	-0.456* (0.269)	-0.294*** (0.020)
Real Imports of Chemicals $\Delta / ^{cycle} / ^{trend}$	0.224*** (0.070)	0.040 (0.032)	-0.286*** (0.020)
Real Imports of Manufactured goods $\Delta / ^{cycle} / ^{trend}$	0.066 (0.048)	0.047 (0.028)	-0.283*** (0.020)
Real Imports of Machinery and transp. equip. $\Delta / ^{cycle} / ^{trend}$	0.097** (0.041)	0.004 (0.020)	-0.286*** (0.020)
Real Imports of Miscellaneous manufacturing $\Delta / ^{cycle} / ^{trend}$	0.189** (0.087)	-0.009 (0.038)	-0.283*** (0.020)
Real Imports of Commodities $\Delta / ^{cycle} / ^{trend}$	0.072*** (0.024)	0.015 (0.017)	-0.285*** (0.020)
Constant	-0.001		-6.633***
	(0.014)		(0.588)
Country effects	Yes	Yes	Yes
Time effects	Yes	Yes	Yes
Observations	2,439	2,490	2,490
R-squared	0.216	0.166	0.997

Note: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses.

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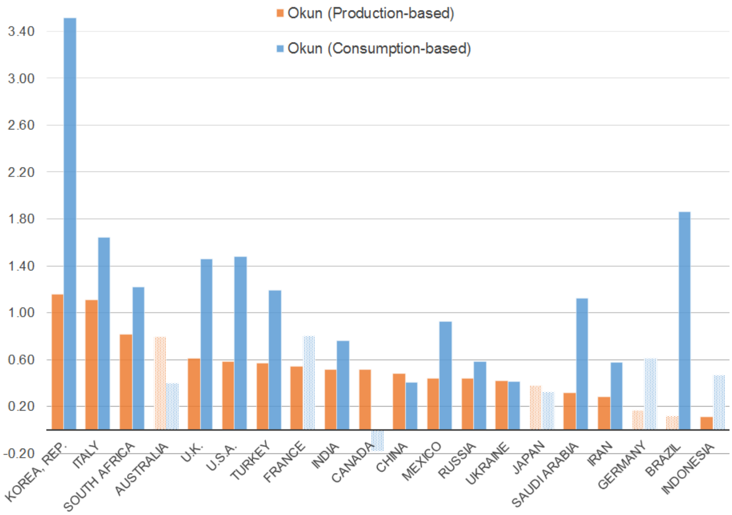
Revisiting Okun elasticities



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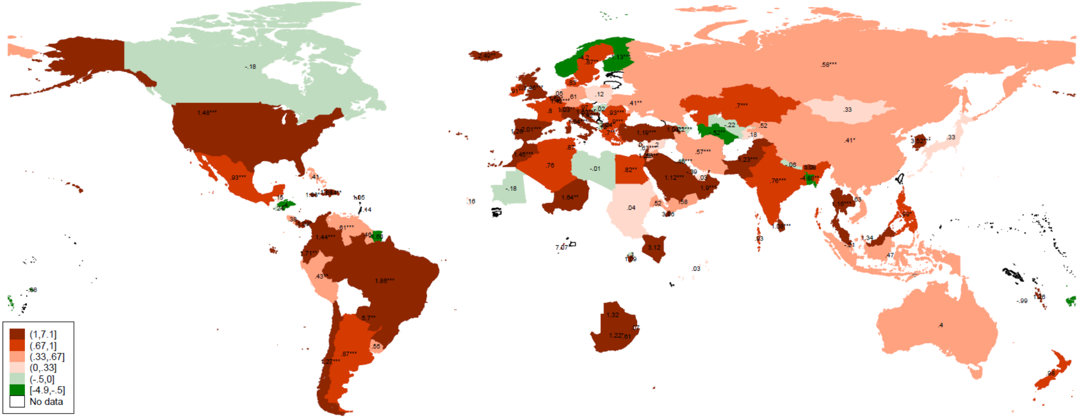
Revisiting Okun elasticities

Okun estimates



Note: *** p<0.01, ** p<0.05, * p<0.1, NS not statistically significant.

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