

Pricing and Fossil Fuel Use: Fracking, CO₂, and Coal

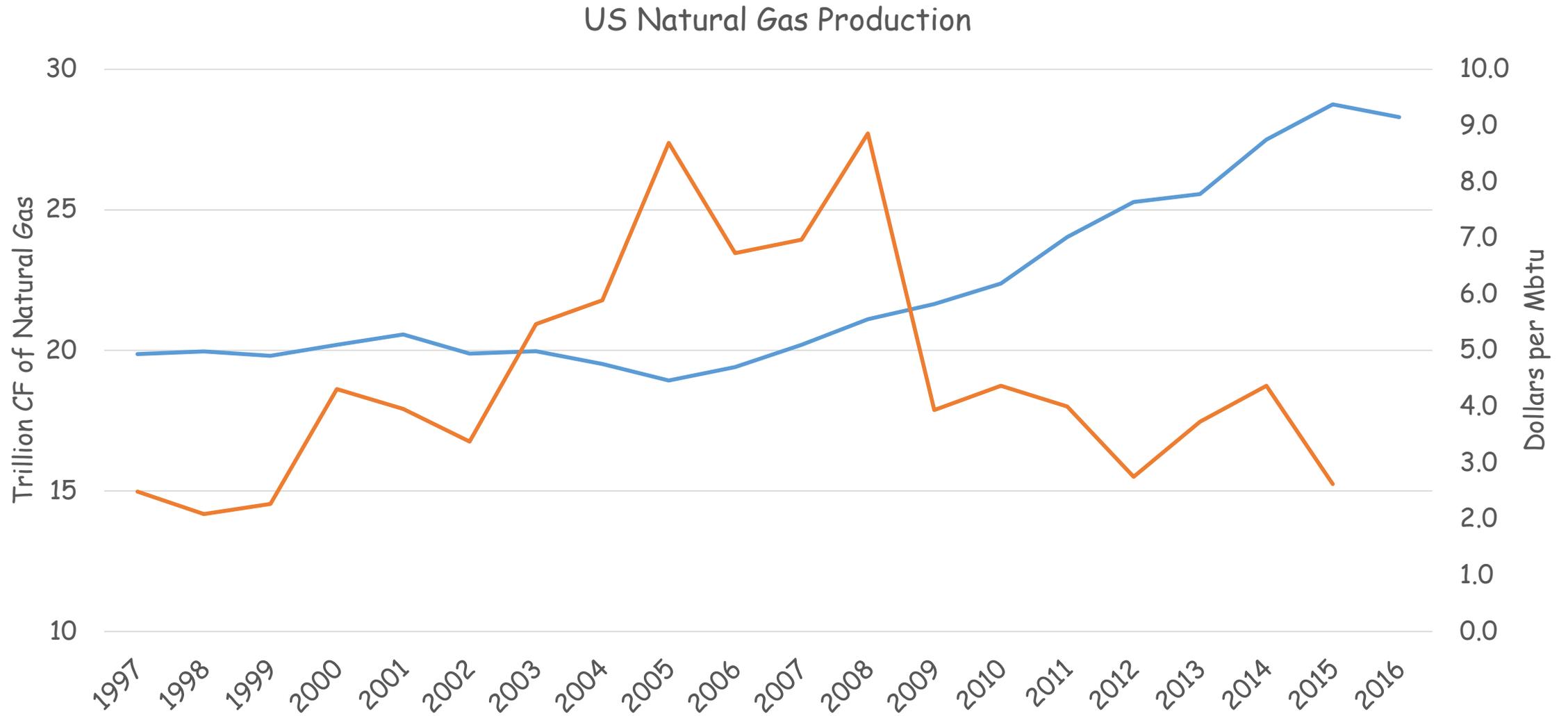
Christopher Knittel

George P. Shultz Professor of Energy Economics, Sloan School of Management, MIT
Director, Center for Energy and Environmental Policy Research, MIT
Co-Director, The E2e Project, MIT, UC Berkeley, U of Chicago

First: The graphs we have seen time and time again

- Hydraulic fracturing has fundamentally transformed a variety of hydrocarbon markets
- Easy one: The natural gas market within the US

Fracking and US Natural Gas Production



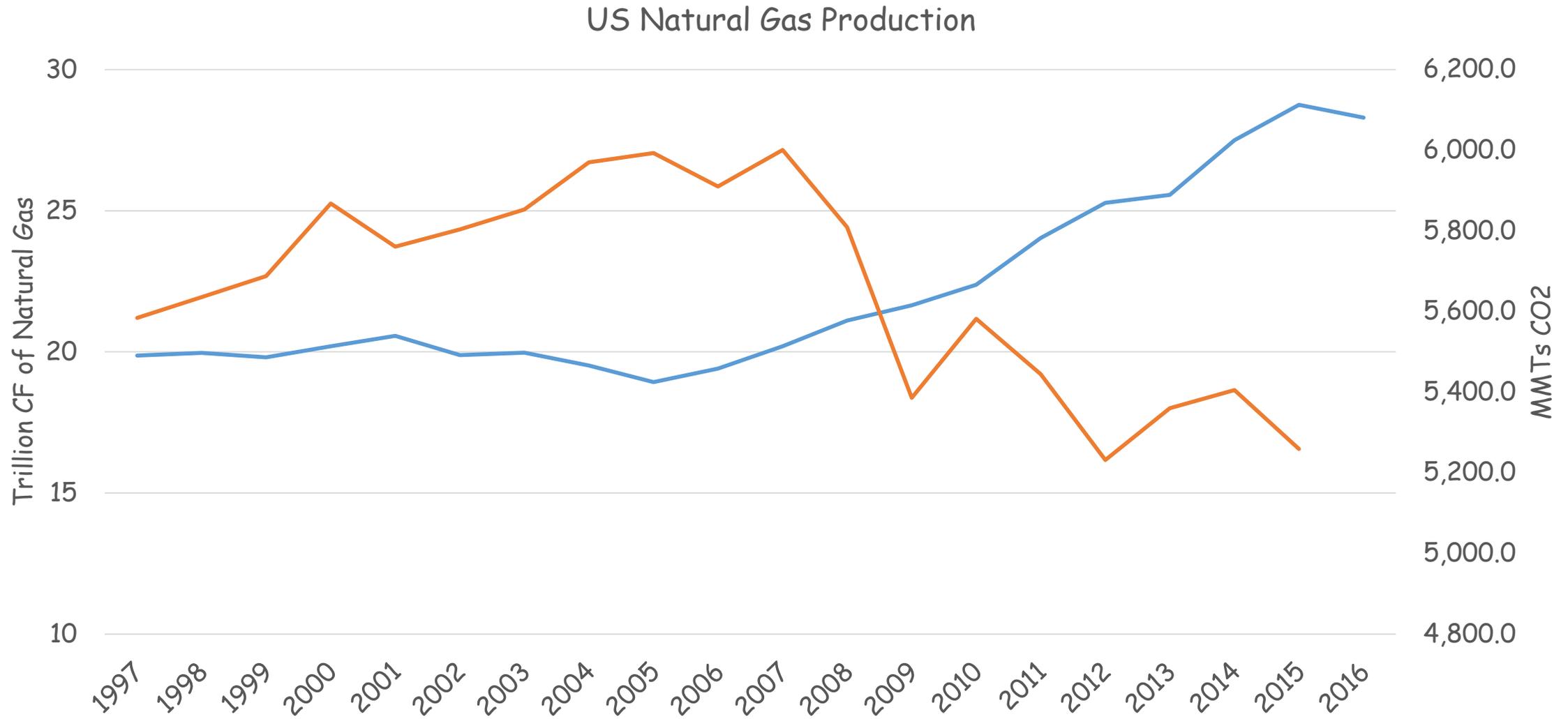
Credited with reducing US GHG emissions

- Share of electricity coming from coal in 2008: 48.2%
- Share of electricity coming from coal in 2016: 30.4%

- Share of electricity coming from natural gas in 2008: 21.4%
- Share of electricity coming from natural gas in 2008: 33.8%

- GHG emissions have followed suit
 - (Great recession hasn't hurt either)

Fracking and US GHG emissions

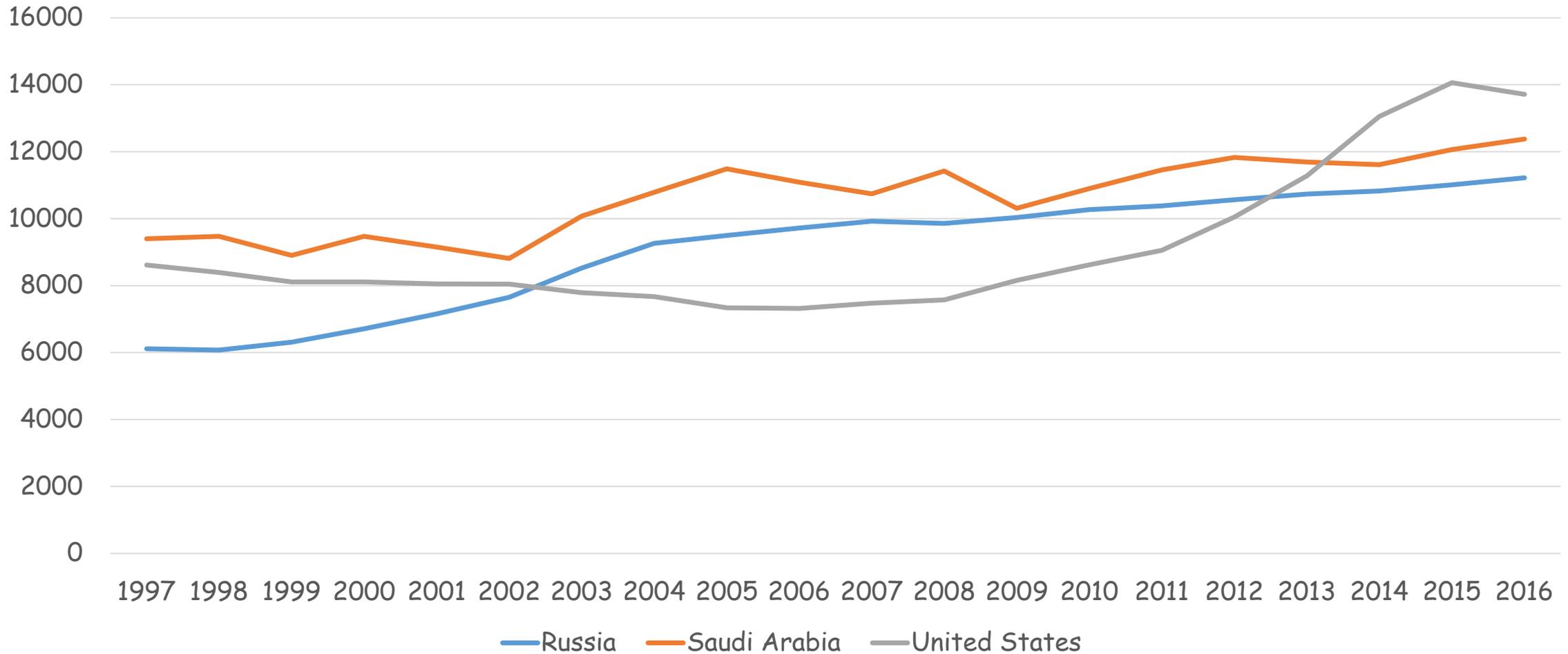


Fracking has also affected other energy markets

- Transformed the geopolitics of oil
- Reduced the amount of market power that OPEC, Saudi Arabia and Russia enjoy

Petroleum production across key nations

Total Petroleum and Other Liquids



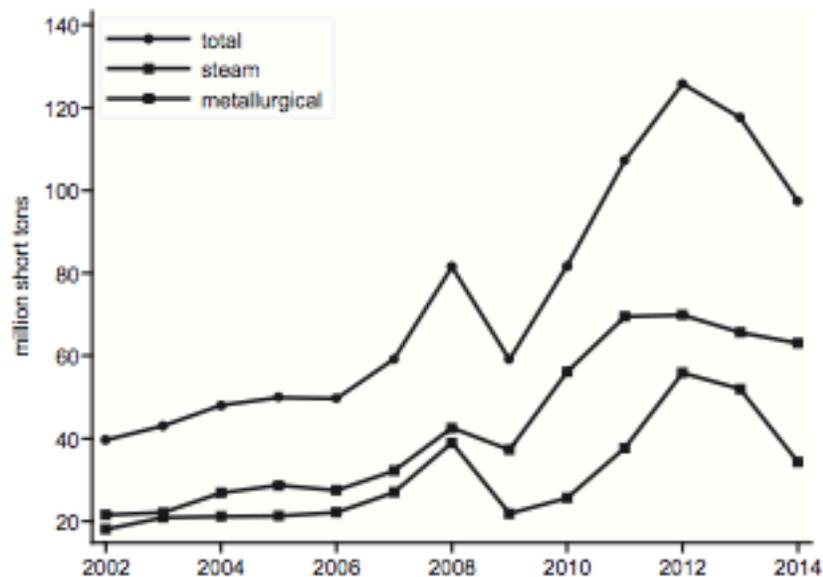
But...

- Economists are much too negative for us to simply accept that fracking is all good!
 - Bartik, Currie, Greenstone, and Knittel (CEEPR WP 2016) look at the local effects of fracking
 - Find positive net benefits, but there are some negatives
- Knittel, Metaxoglou, and Trindade (*Oxf Rev Ec Pol* 2016) discusses how the net impact on emissions is ambiguous
 - Depends on what happens to the coal displaced in the US
 - We do not estimate the net affect, however

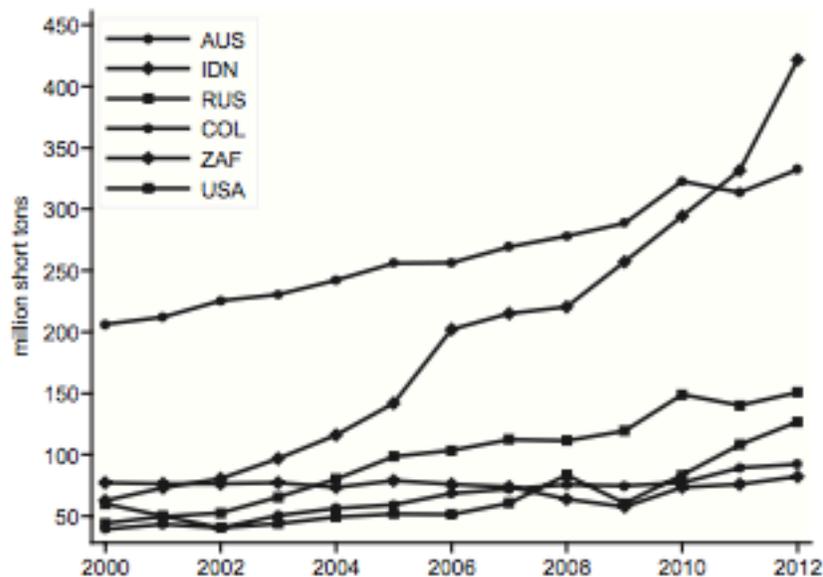
Big unknown: Coal exports

Figure 4: Coal exports

(a) US coal exports



(b) Coal exports by country



Note: The figure is based on authors' calculations using the International Energy Statistics from EIA. We use ISO alpha-3 country codes for the legend in panel (b).

Goals of current work

- 1. What is the net effect of cheaper natural gas on CO₂ emissions
 - Many moving parts
 - Drop in US emissions from coal -> natural gas switching **GOOD**
 - Increase in US coal exports **BAD**
 - -> Change in other exporting nations' exports **GOOD**
 - Drop in LNG prices (not studied today) **GOOD/BAD**
 - Reduction in renewable R&D (not studied today) **BAD**
- 2. What's been the major weapon in the “war on coal”?
 - How much of the drop in coal production is due to natural gas prices?

May have to rethink the project...

- Yesterday, US Secretary of State Rick Perry said the following while visiting a coal plant in West Virginia:
- “Here’s a little economics lesson: supply and demand. You put the supply out there and the demand will follow”
 - » --- Rick Perry, July 6, 2017

Drawing on a number of papers

Are we fracked

P
g
Ch
Ox
DC
Pu
Feb
Exp
Thor
Mich
Chri
JOU
VOL
(pp.)

Th
W
Nat
Disp
Mar
Christo

October

Christop

Stata/SE 14.0 — EIA_coal_production_monthly.dta

Log Viewer Graph Do-file Editor Data Editor Data Browser

Results

```
. areg lcoal_prod_stons lprice_ng_elecp, absorb(code), if code ~="ZZZ_US"
```

Linear regression, absorbing indicators

Number of obs	=	4,030
F(1, 4003)	=	28.64
Prob > F	=	0.0000
R-squared	=	0.9508
Adj R-squared	=	0.9505
Root MSE	=	0.5124

lcoal_prod_stons	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]
lprice_ng_elecp	.1399319	.0261484	5.35	0.000	.0886665 .1911973

Does U.S. Export Global Warming?

Coal Exports and the Shale Gas Boom

Christopher R. Knittel

Konstantinos Metaxoglou

Anson Soderbery

Andre Trindade *

June 21, 2017

PRELIMINARY & INCOMPLETE—PLEASE DO NOT CITE

Fracking and coal export markets

- Rely on recent advances in empirical international trade to estimate supply (export) and demand (import) elasticities for coal
- Allows us to estimate how the shift out in the US export curve affects export decisions of other countries

Key graphs

Figure 1: U.S. coal exports and domestic price of natural gas

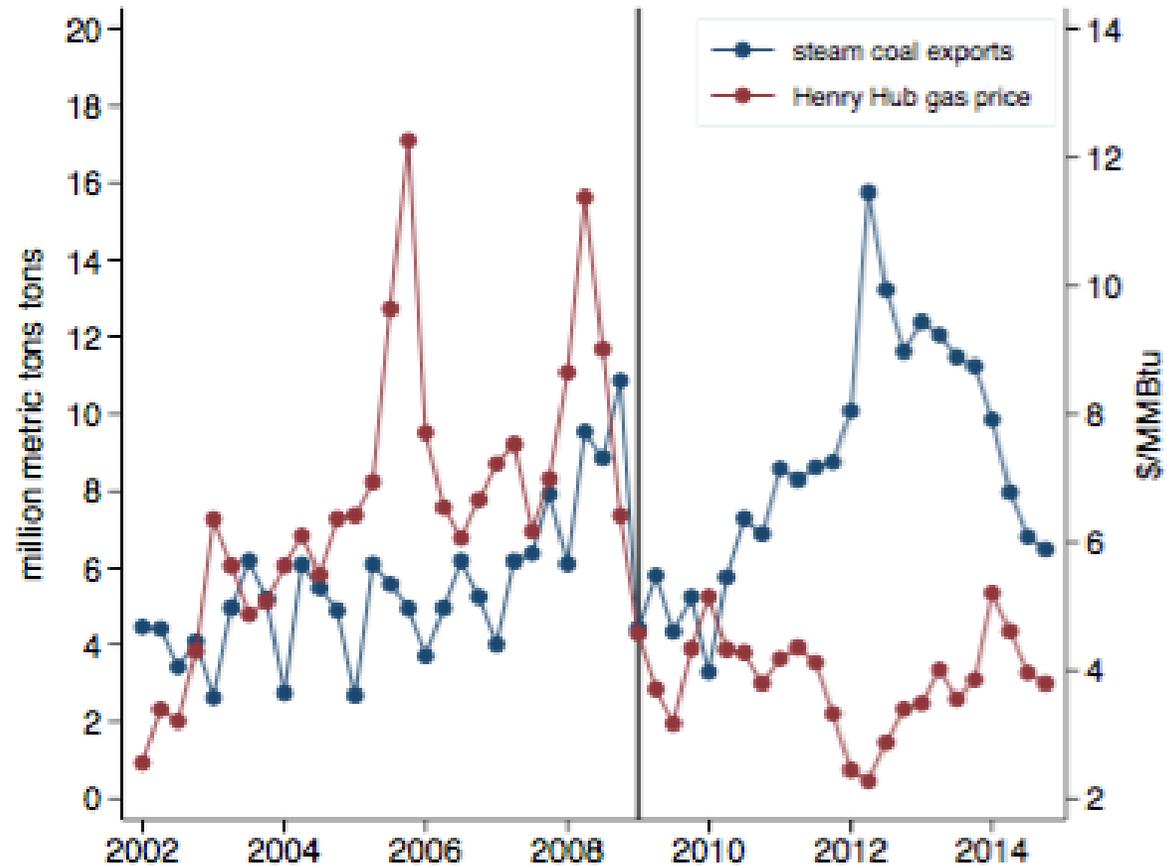
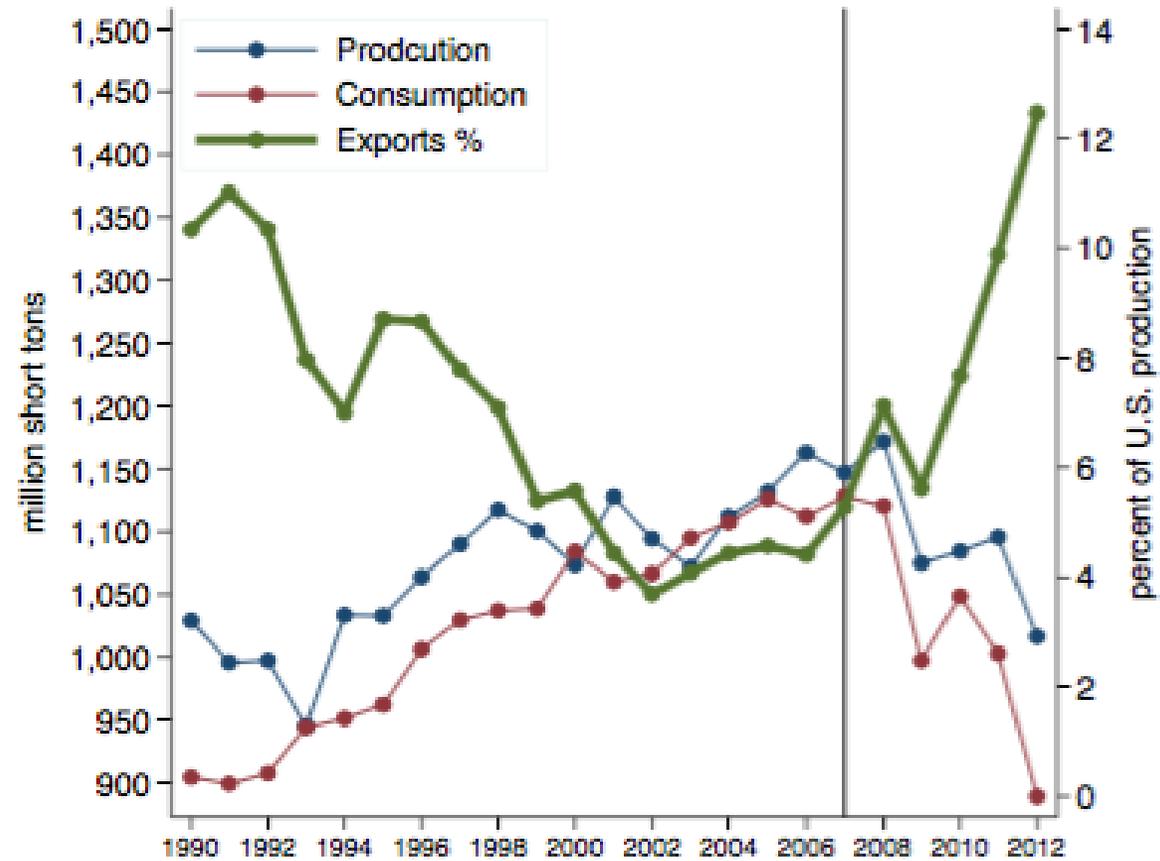


Figure 2: U.S. coal production, consumption, and exports



Particulars

- Countries import/export anthracite, bituminous, or “other” coal
- Each country has a supply and demand curve for international coal
- Countries have other-country specific demand for coal
 - Captures trade costs or the suitability of a given supply to local markets
 - Demand is of the Constant Elasticity of Substitution (CES) variety
- Empirical challenge: separately estimating supply and demand elasticities along with movements in demand during Great Recession
 - This is where advances in international trade literature help

But-for World

- Given the estimates, we can ask: “what would have coal imports/exports been absent the fracking revolution”
 - Effectively, a shift in of the US-coal export curve
- The model re-calculates trade flows
- Major lesson: *I shouldn't be so cynical*
 - US fracking's main effect was to shift exports around
 - That is, for the most part, the increase in US exports displaced other coal exports

What would have happened?

Table 4: Counterfactual analysis:
economic outcomes, world 2007–2014

Year	Coal Value			Coal Quantity			Coal Price		
	actual	CF	% change	actual	CF	% change	actual	CF	% change
2007	57.536	57.431	-0.183	757.457	753.738	-0.491	75.960	76.195	0.310
2008	97.802	97.955	0.156	752.626	744.007	-1.145	129.948	131.658	1.316
2009	79.809	79.837	0.035	746.000	739.788	-0.833	106.983	107.919	0.875
2010	94.144	93.908	-0.251	806.681	800.177	-0.806	116.705	117.359	0.560
2011	139.864	141.249	0.990	940.417	937.477	-0.313	148.726	150.669	1.307
2012	134.643	138.787	3.078	1081.249	1090.478	0.853	124.525	127.272	2.206
2013	118.824	121.512	2.262	1173.095	1174.722	0.139	101.291	103.439	2.120
2014	103.909	104.282	0.359	1143.131	1133.943	-0.804	90.898	91.964	1.172
TOTAL	826.531	834.960	1.020	7400.659	7374.329	-0.356	111.683	113.225	1.380

Note: Values in billion USD, quantities are in million metric tons, and prices in USD/metric ton.
CF stands for counterfactual.

Winners and losers

Table 7: Counterfactual analysis:
economic outcomes, major exporters 2007–2014

Country	Coal Value			Coal Quantity			Coal Price		
	Actual	CF	% Change	Actual	CF	% Change	Actual	CF	% Change
AUS	289.239	302.318	4.522	2092.253	2156.323	3.062	138.243	140.201	1.416
IDN	148.537	151.823	2.213	1825.252	1853.640	1.555	81.379	81.905	0.647
RUS	90.480	98.465	8.825	791.248	843.699	6.629	114.351	116.706	2.060
USA	82.155	51.608	-37.183	581.746	315.057	-45.843	141.222	163.805	15.991
COL	45.126	51.134	13.314	476.619	526.778	10.524	94.679	97.069	2.525
ZAF	39.384	40.773	3.526	387.468	396.217	2.258	101.644	102.905	1.240
CAN	45.294	49.356	8.966	274.290	290.316	5.843	165.134	170.006	2.951
VNM	13.285	13.288	0.027	173.135	173.157	0.013	76.730	76.741	0.014
KAZ	4.897	5.062	3.365	160.722	161.475	0.469	30.470	31.348	2.883
CHN	17.301	17.462	0.931	134.671	135.405	0.545	128.465	128.959	0.384
MNG	7.170	7.560	5.449	108.697	113.821	4.714	65.960	66.423	0.701
PRK	5.887	5.887	0.000	69.227	69.227	-0.000	85.043	85.043	0.000
UKR	5.831	6.006	2.999	65.880	67.269	2.108	88.517	89.289	0.872
POL	6.906	7.633	10.523	54.883	58.958	7.425	125.833	129.463	2.885
CZE	4.886	5.598	14.578	30.584	33.934	10.952	159.742	164.962	3.268
VEN	2.484	2.727	9.793	22.953	24.494	6.711	108.201	111.326	2.888
CHE	1.764	1.764	0.000	20.301	20.301	-0.000	86.880	86.880	0.000
NLD	1.700	1.832	7.749	15.228	15.942	4.688	111.662	114.927	2.924
NZL	2.795	2.830	1.263	15.073	15.245	1.139	185.405	185.632	0.122
TOTAL	815.120	823.125	0.982	7300.230	7271.257	-0.397	111.657	113.203	1.384

Note: Values in billion USD, quantities are in million metric tons, and prices in USD/metric ton. CF stands for counterfactual. Entries are sorted in descending order of actual quantity.

Country	Coal Value			Coal Quantity			Coal Price		
	Actual	CF	% Change	Actual	CF	% Change	Actual	CF	% Change
AUS	289.239	302.318	4.522	2092.253	2156.323	3.062	138.243	140.201	1.416
IDN	148.537	151.823	2.213	1825.252	1853.640	1.555	81.379	81.905	0.647
RUS	90.480	98.465	8.825	791.248	843.699	6.629	114.351	116.706	2.060
USA	82.155	51.608	-37.183	581.746	315.057	-45.843	141.222	163.805	15.991
COL	45.126	51.134	13.314	476.619	526.778	10.524	94.679	97.069	2.525
ZAF	39.384	40.773	3.526	387.468	396.217	2.258	101.644	102.905	1.240
CAN	45.294	49.356	8.966	274.290	290.316	5.843	165.134	170.006	2.951
VNM	13.285	13.288	0.027	173.135	173.157	0.013	76.730	76.741	0.014
KAZ	4.897	5.062	3.365	160.722	161.475	0.469	30.470	31.348	2.883
CHN	17.301	17.462	0.931	134.671	135.405	0.545	128.465	128.959	0.384

MNG	7.170	7.560	5.449	108.697	113.821	4.714	65.960	66.423	0.701
PRK	5.887	5.887	0.000	69.227	69.227	-0.000	85.043	85.043	0.000
UKR	5.831	6.006	2.999	65.880	67.269	2.108	88.517	89.289	0.872
POL	6.906	7.633	10.523	54.883	58.958	7.425	125.833	129.463	2.885
CZE	4.886	5.598	14.578	30.584	33.934	10.952	159.742	164.962	3.268
VEN	2.484	2.727	9.793	22.953	24.494	6.711	108.201	111.326	2.888
CHE	1.764	1.764	0.000	20.301	20.301	-0.000	86.880	86.880	0.000
NLD	1.700	1.832	7.749	15.228	15.942	4.688	111.662	114.927	2.924
NZL	2.795	2.830	1.263	15.073	15.245	1.139	185.405	185.632	0.122
TOTAL	815.120	823.125	0.982	7300.230	7271.257	-0.397	111.657	113.203	1.384

Lessons

- This work suggests that the decrease in US GHG emissions are “real”
- While exports increased, they displaced other coal production
- Lower exports from places like Australia, Czech, etc full offset the increase in US exports
- This would suggest more NG is good for CO₂, at least in the short to medium term

Related question: The War on Coal



Related question: The War on Coal

- Can President Trump bring back the coal jobs?
- Comes down to the answer to a basic question: how much of the drop in coal production in the US is due to natural gas prices?
 - Recall: President Trump also plans to have MORE drilling
- The **maximum** impact of environmental regulation on coal production is $1 - NG\text{-price-effect}$

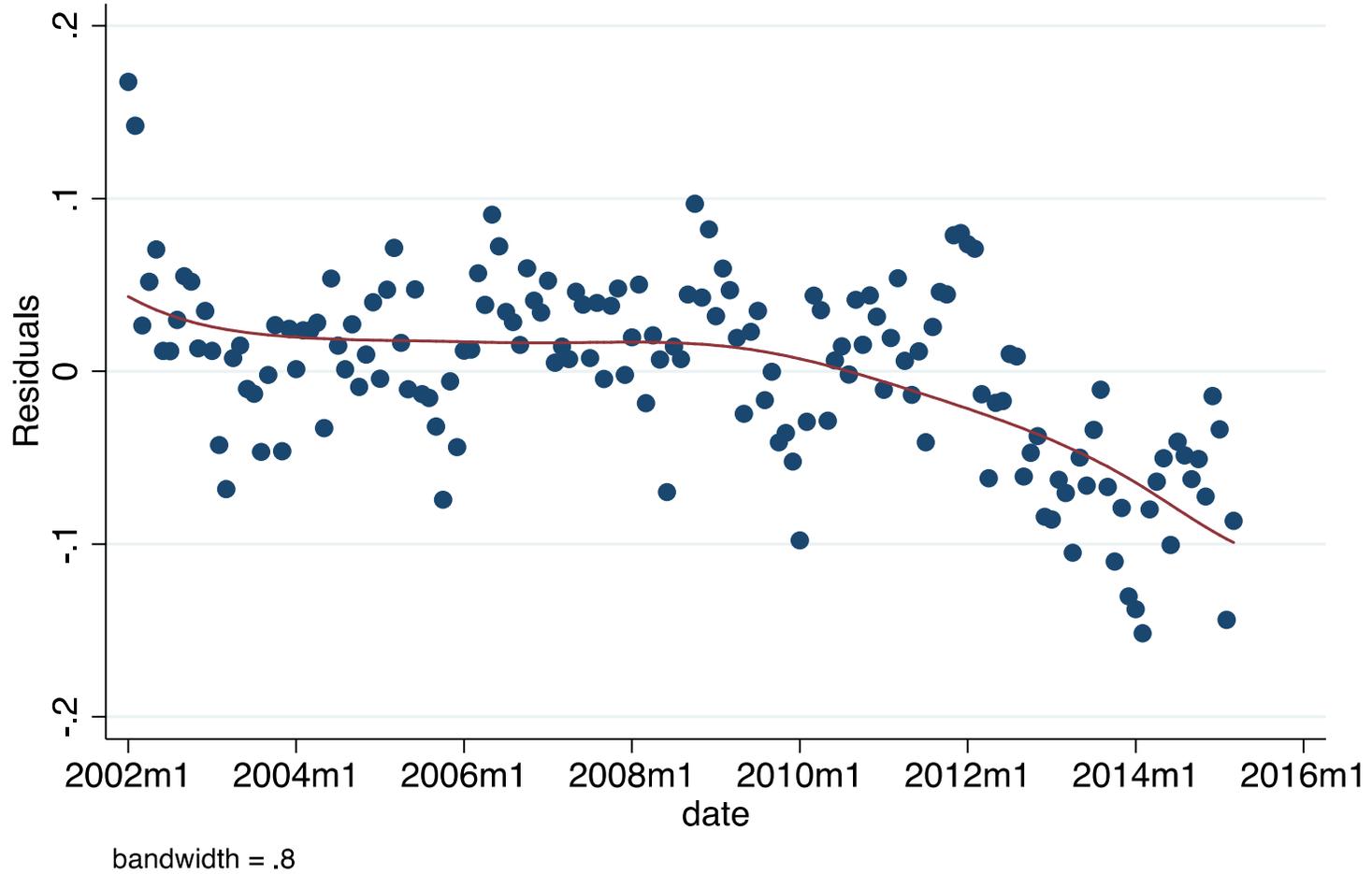
Decomposing coal production

- Simple exercise:
- Use regression analysis to decompose state-level coal production into the natural gas effect and everything else
 - “Everything else” is the residual
 - The maximum amount that can be explained by regulation
 - More complicated models yield very similar results
- Plot the residuals for different geographic areas

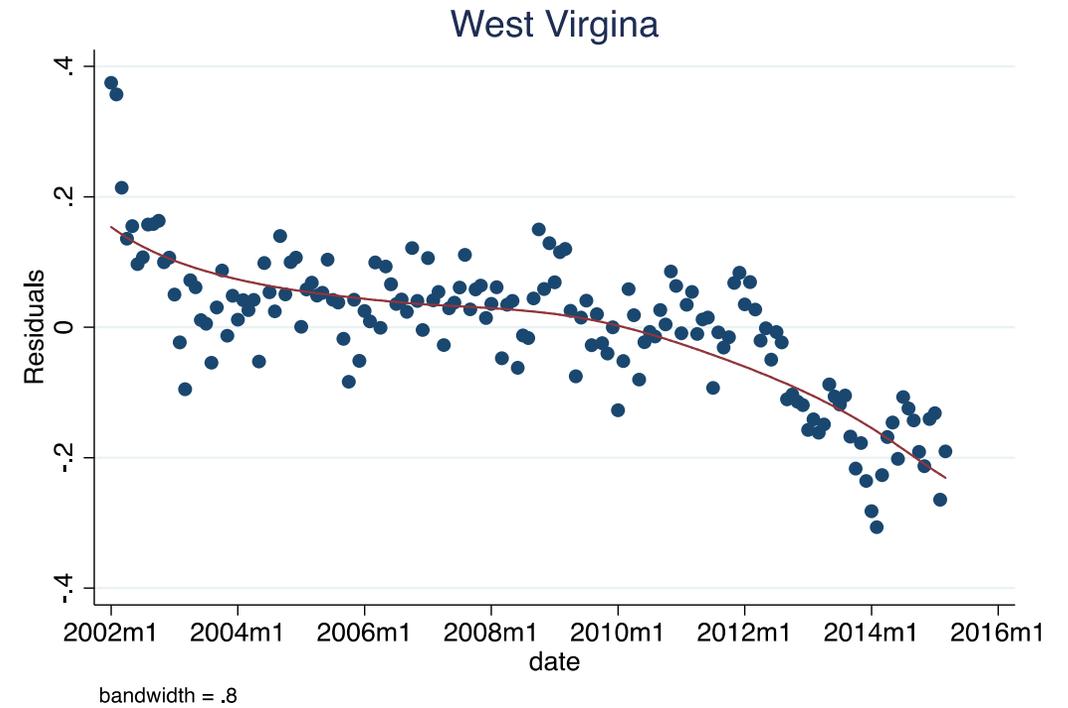
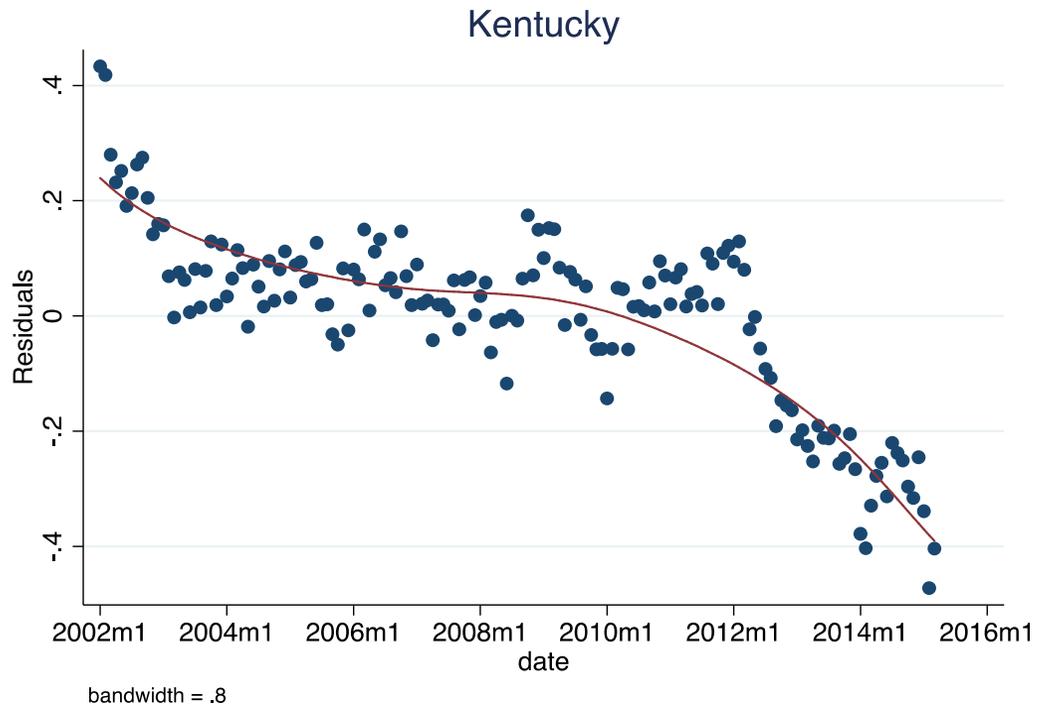
US as a whole

U.S. Total

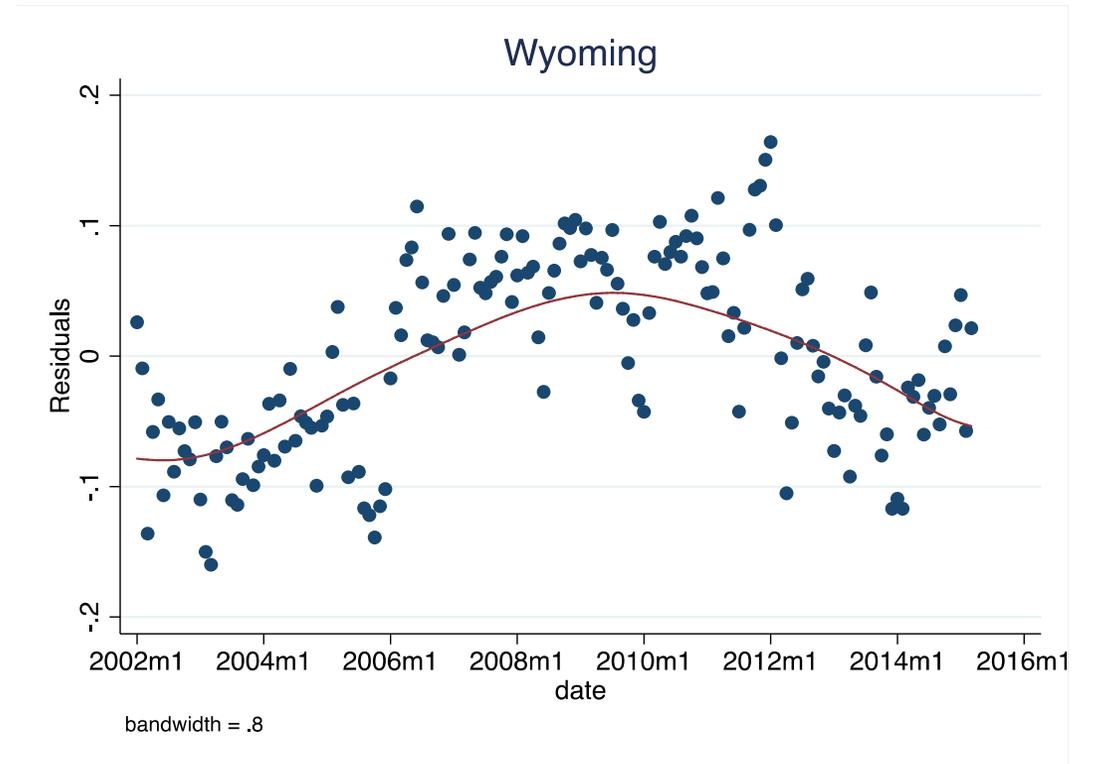
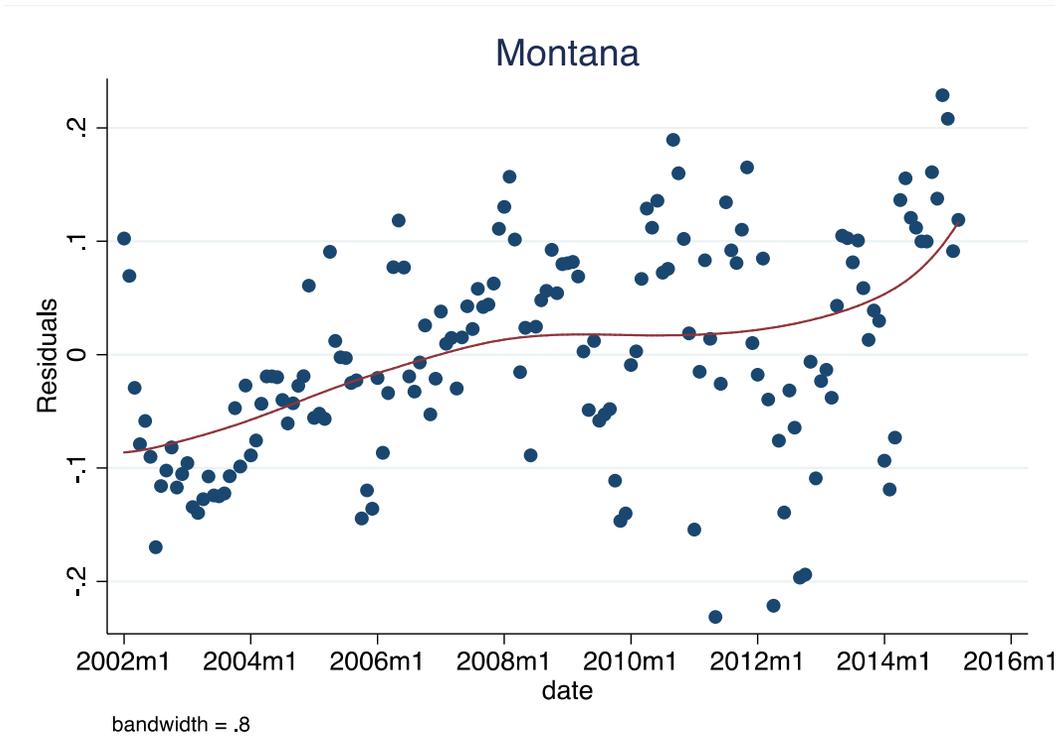
Regulation < 15%



There have been big losers



But, shift to Powder River Basin coal



Lessons

- Bringing back the coal jobs is likely going to require banning fracking
 - Of course President Trump's goal is to *increase* fracking
- Different pieces of the President's energy plan are at odds with each other

Wrapping up

- While fracking led to an increase in US coal exports, these exports displaced other nations' exports
- The net effect of the cheaper natural gas has been to reduce global emissions
 - Works for short term objectives, may not for longer term objectives
- Coal jobs are likely gone for quite some time