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RICE

Employment Impacts of Upstream Oil and Gas Investment in the United States

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INTRODUCTION

Anecdotal evidence about energy employment

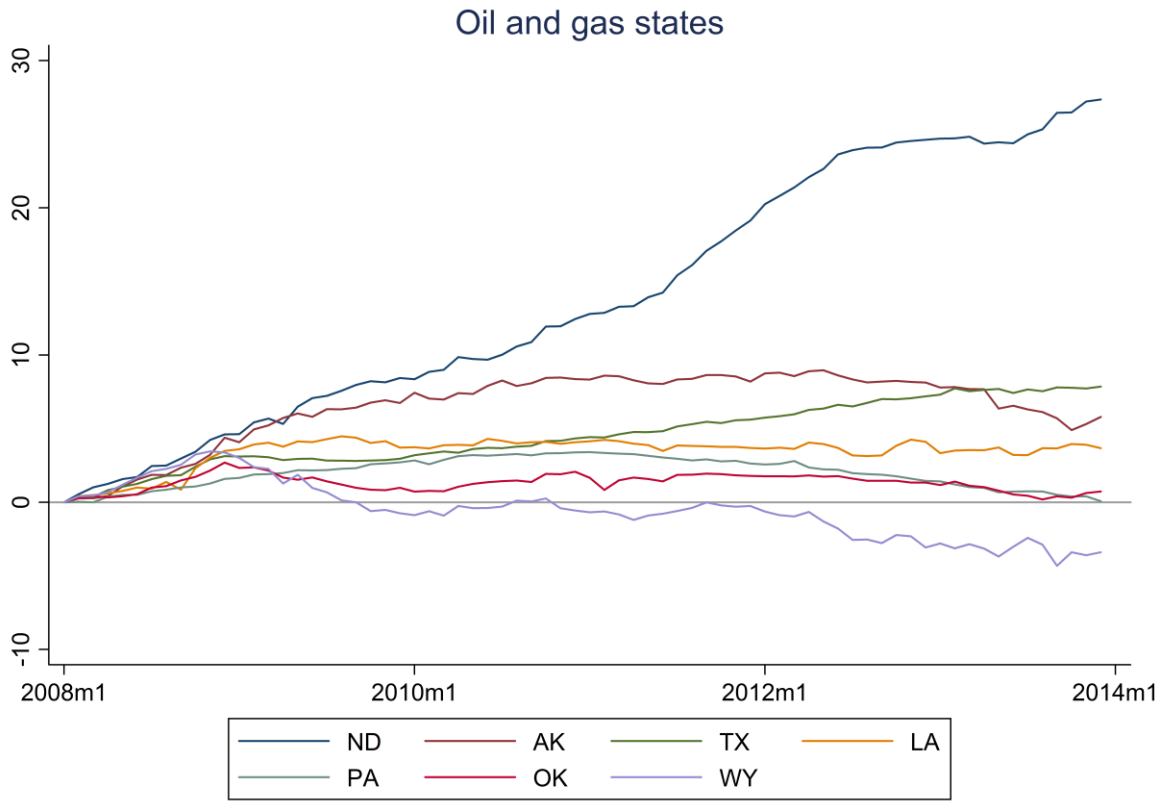
North Dakota tries to woo workers for empty jobs

By By James Mac Pherson March 18, 2014

BISMARCK, N.D. (AP) — North Dakota officials are sending a plea to people across the country: We need you.

The state's unprecedented oil bonanza has made it the economic darling of the nation — boasting a sturdy economy, a state government budget surplus, and its highest population ever, as swarms of people have migrated to North Dakota. But it hasn't been enough, officials say, citing some 25,000 more jobs than takers in all industries in the state.

Healthier labor markets?



Predictions about job creation

- Marcellus in PA (Considine et al. 2009, 2010)
  - 2008: 29,284
  - 2009: 44,098
- National employment impacts (IHS 2011)
  - 2010: 600,000
  - 2015: 870,000
  - 2035: 1.6 million
- Texas employment impacts (Hartley et al. 2013)
  - 1 well-count = 77 to 271 long-run jobs
  - 35,000–120,000 FTE Texas jobs in 2011
- IMF WEO 2013
  - 1.2 % increase in GDP after 12 years
  - 0.5 % increase in employment

Why this study?

- National scope
- Higher resolution (state-month)
- Reduced form
  - vs Input-Output
    - Too many assumptions
    - Tend to overestimate effects
    - Not for disruptive changes
  - vs Dynamic GE
    - No unemployment (ND story)

Research design

- Hypothesis: Exogenous upstream investment shocks drive employment growth
- Want employment multipliers
- Dynamic panel model
  - Allow time for adjustment (lags)

Two other key studies

- Hooker and Knetter (1997)
  - Similar research design
  - Effect of military spending on employment
  - Dynamic panel model with time + state FE
  - Asymmetric responses

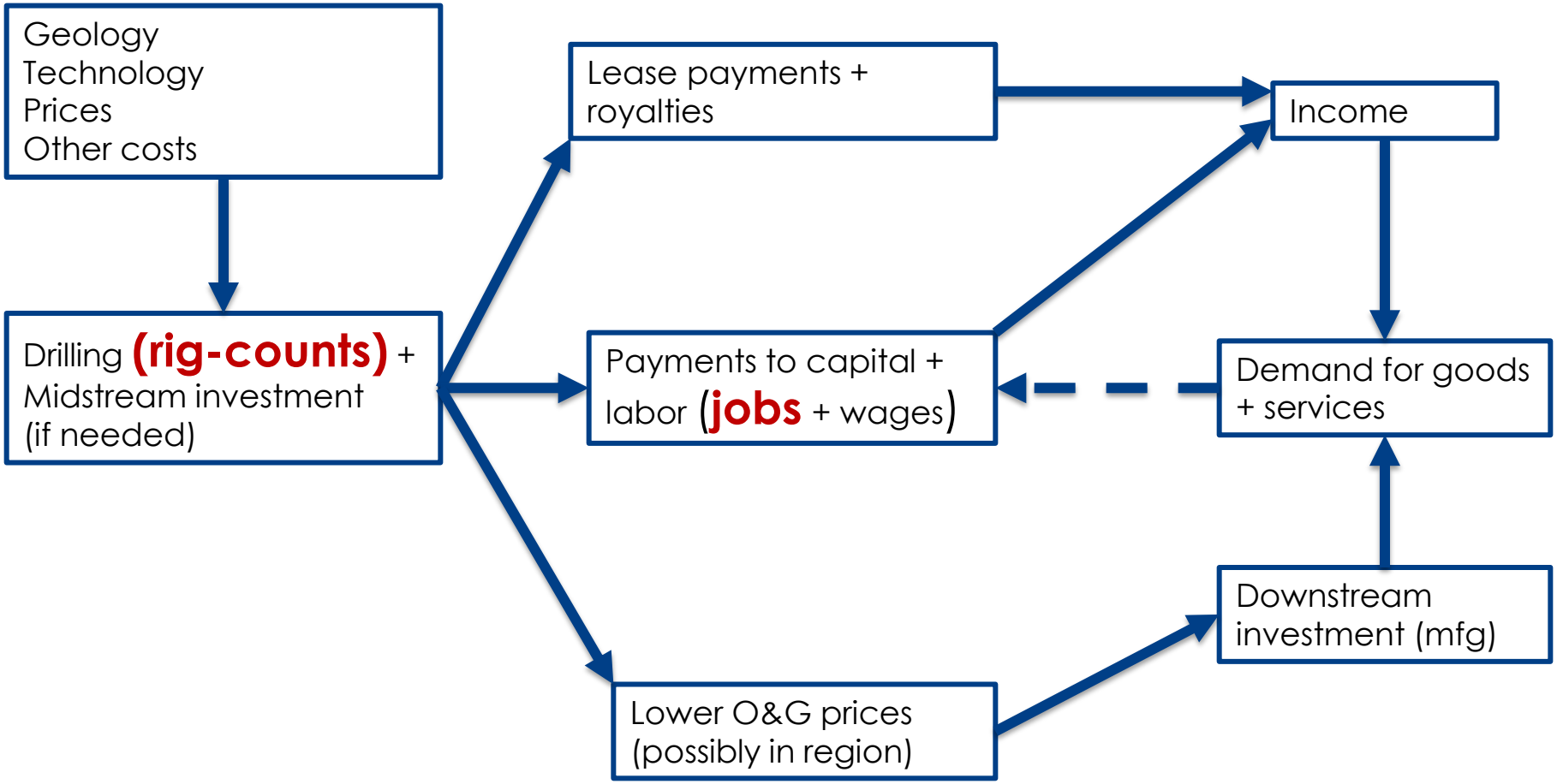
- Blanchard and Katz (1992)
  - VAR with employment, unemployment, participation
  - Migration returns states to equilibrium
    - (Population is endogenous)
  - Quantities, not wages adjust

DATA

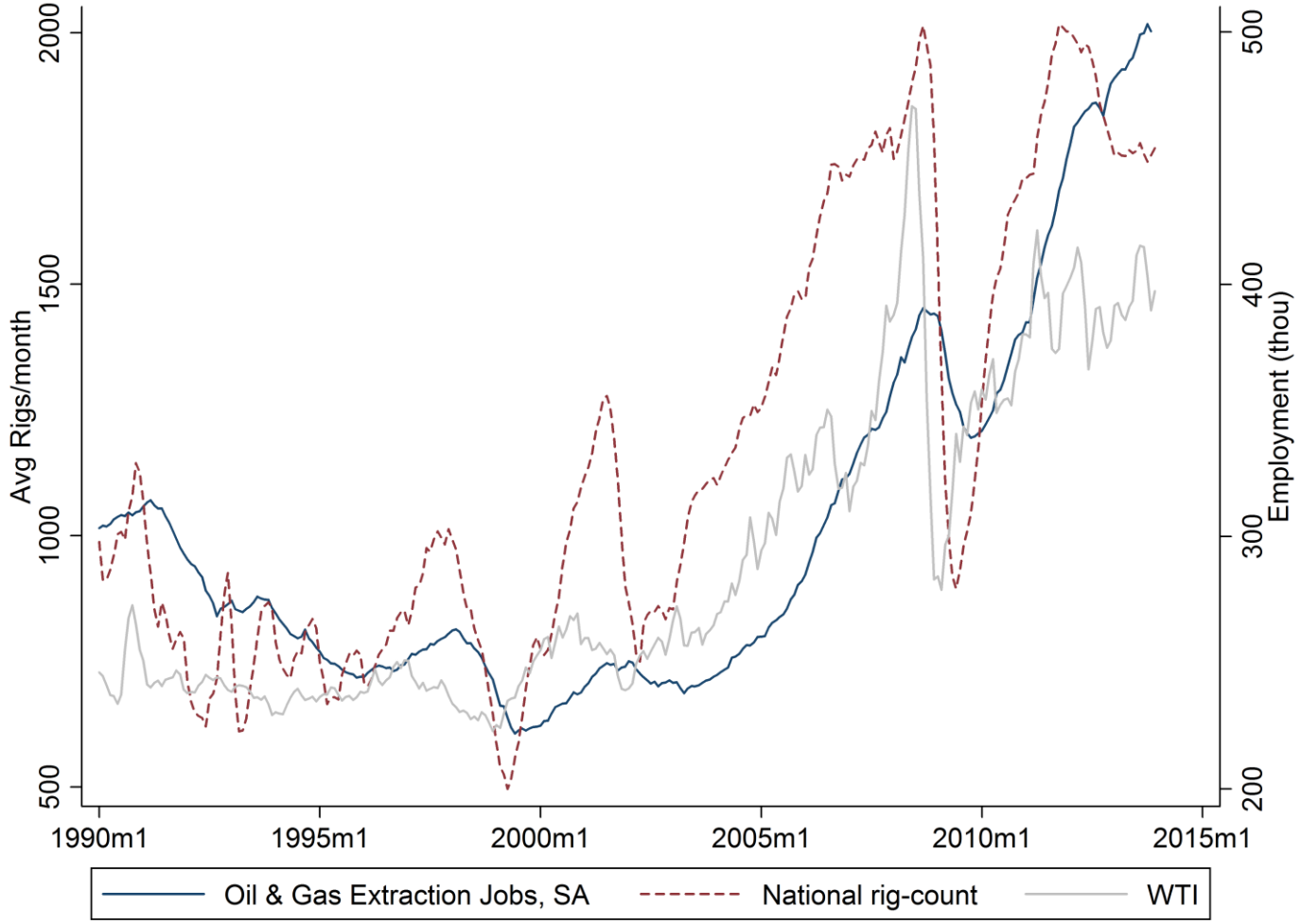
Baker Hughes rig-counts

- Number of rigs "actively exploring for or developing oil or natural gas"
- Plausibly exogenous
- Timing
  - Coincident with investment
  - Leading indicator of production
- Heterogeneity in drilling?
  - Type (offshore, geology, process)
  - Origin of inputs
  - Cost

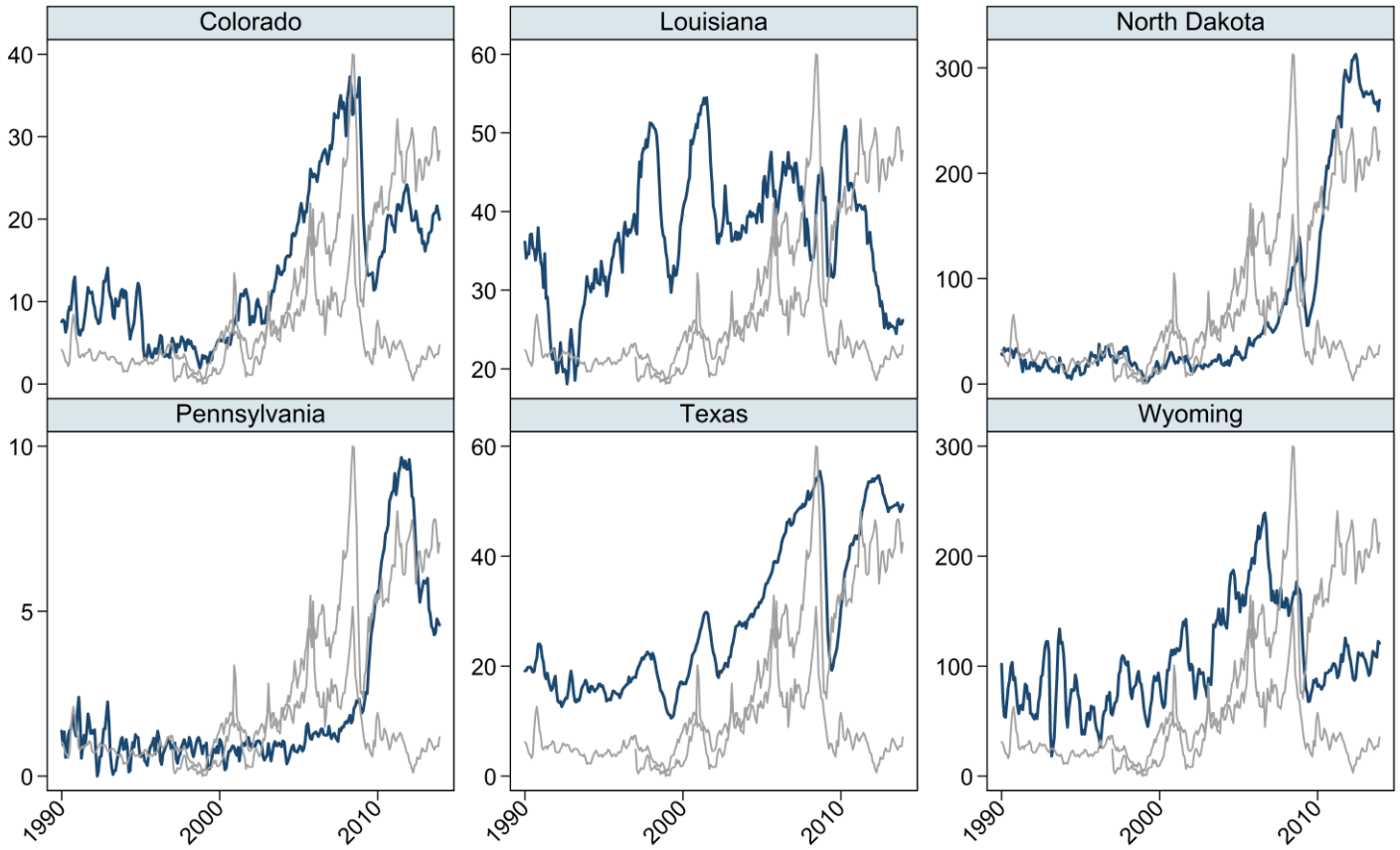
Rig-counts in the economy



Rig-counts at US level



Rig-counts/millionPeople$_{1990}$
(with WTI and HH)



Other data

- Employment
  - *Current Establishment Survey (BLS)*
  - Private, non-farm
  - Not seasonally adjusted
- Industrial Production Index (IPI)
- Population
  - 1990 Census
  - No concerns about endogenous migration

MODELS

Two models

Per-capita (interpretability)

$$\Delta \frac{Emp_{it}}{Pop_{i,1990}} = \alpha(L)\Delta \frac{Emp_{i,t-1}}{Pop_{i,1990}} + \beta(L)\Delta \frac{Rigs_{it}}{Pop_{i,1990}}$$

$$+\gamma_1(L)\Delta \frac{NatEmp_{t-1}}{NatPop_{1990}} + \gamma_2(L)\Delta \mathrm{IPI_t} + \eta_{im} + \epsilon_{it} \qquad (1)$$

Growth rates (stability)

$$\Delta \log Emp_{it} = \alpha(L)\Delta \log Emp_{i,t-1} + \beta(L)\Delta \frac{Rigs_{it}}{Pop_{i,1990}}$$

$$+\gamma_1(L)\Delta NatEmp_{t-1} + \gamma_2(L)\Delta IPI_t + \eta_{im} + \epsilon_{it} \qquad (2)$$

Interpretation

- Per capita: $\beta_k \times 1000 =$ jobs from ΔRig_{t-k}
- Logs: $\beta_k/10$ = % growth from $\Delta Rig_{t-k}/MilPpl_{1990}$
- Impact effect = $\hat{\beta}_0$
- Long-run multiplier (LRM) = $\sum_{k=0}^{10} \hat{\beta}_k \,/\left(1 - \sum_{k=1}^{12} \hat{\alpha}_k\right)$

Detail

- Difference away unit roots
- Use Feb 1992–Dec 2013
- Lags
  - Employment lag 1 to 12
  - Rig-counts contemporaneous to lag 10
  - IPI contemporaneous to lag 12
  - Nat'l Employment lag 1 to 3

Estimation

- Concerns addressed
  - Heteroskedasticity + autocorrelation
  - Cross-sectional dependency of errors (Driscoll-Kraay)

- Four models
  - OLS
  - Cluster-robust (state-level)
  - Driscoll-Kraay HAC (**`xtscc`**)
  - FGLS
    - State-specific AR(1)
    - Cross-section

Model specification

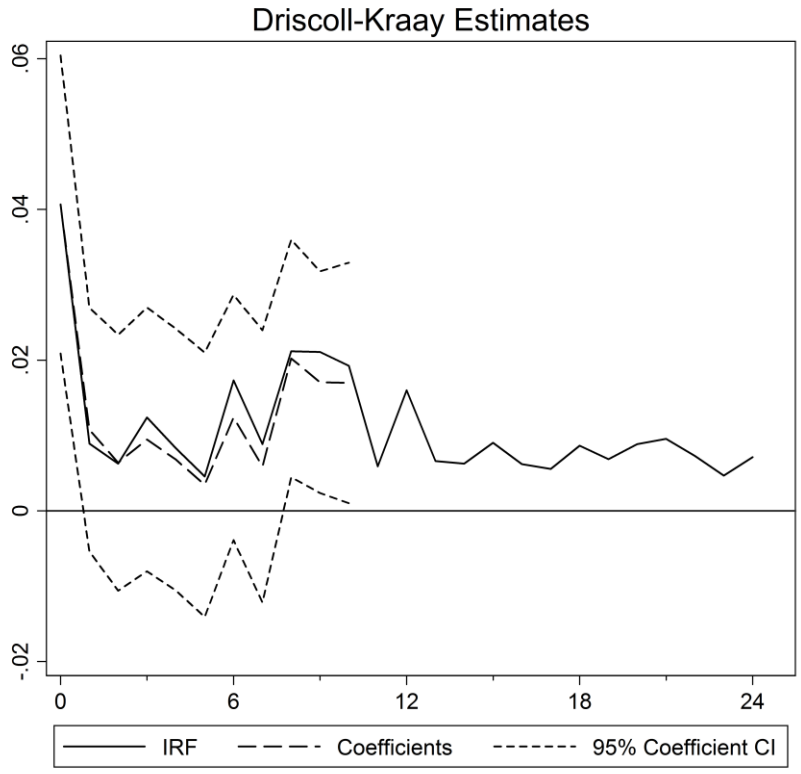
- Tried a variety of specifications
  - More lags
  - Time FE
  - State-specific coefficients on IPI_t or $NatEmp_{t-1}$
- No material change and worse BIC with

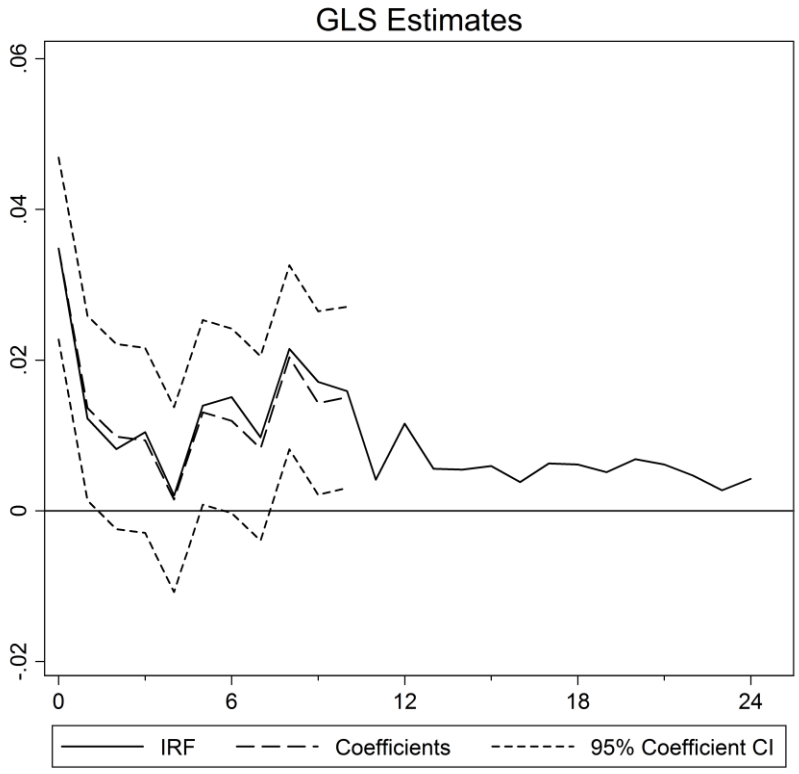
RESULTS

Results

- OLS, Driscoll-Kraay and FGLS consistent
- Jobs per rig-count (1)
  - 35–41 in t
  - 286–382 in long run
  - Similar to Hartley et al. (2013)
- Growth change per rig-count/million people (2)
  - 0.0085–0.0115 percent in t
  - 0.0541–0.0623 in long run
- Not sure why delayed impact in $t + 9$

Per-capita


Driscoll-Kraay Estimates
.06
.04
.02
0
-.02
0
6
12
18
24
IRF
Coefficients
95% Coefficient CI

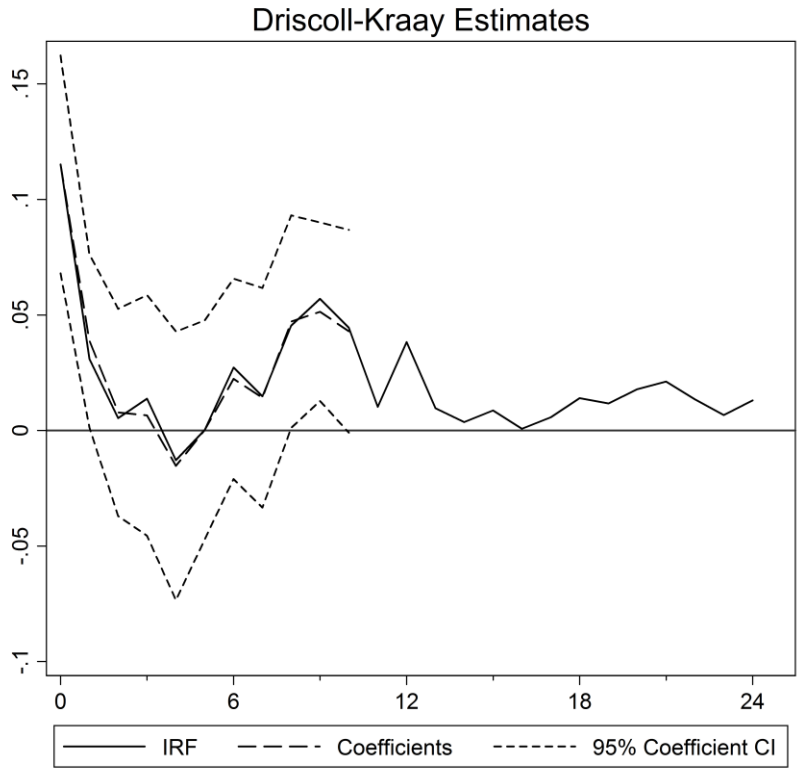

GLS Estimates
.06
.04
.02
0
-.02
0
6
12
18
24
IRF
Coefficients
95% Coefficient CI

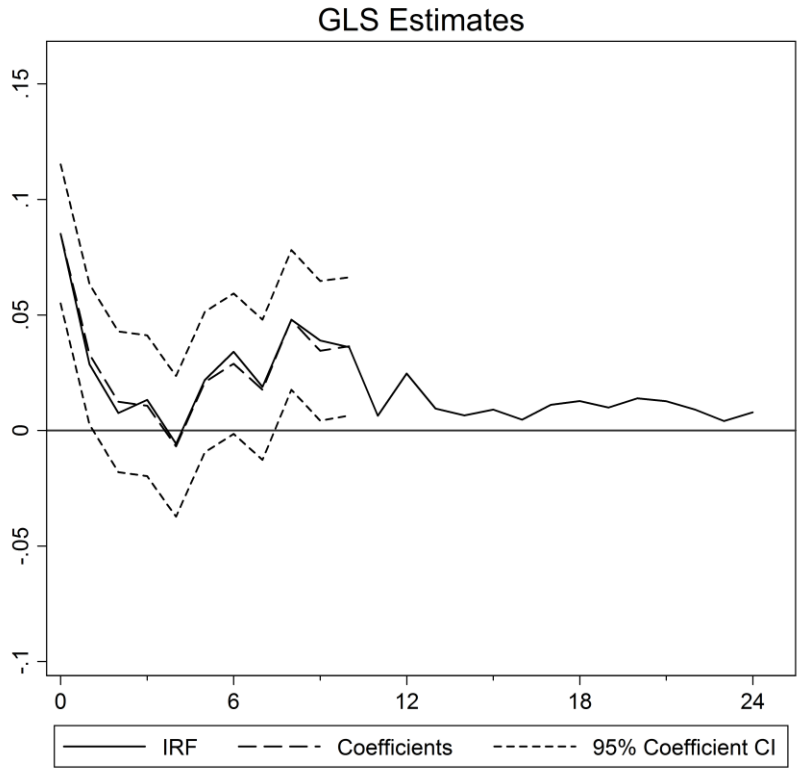
Per-capita

	OLS Coef.	OLS	SE Cluster	Driscoll-Kray	GLS	
$\hat{\beta}_0$	0.0407	(0.00716)***	(0.00782)***	(0.0101)***	0.0348	(0.00616)***
$\hat{\beta}_1$	0.0108	(0.00730)	(0.00605)$^+$	(0.00825)	0.0136	(0.00624)*
$\hat{\beta}_2$	0.00639	(0.00734)	(0.0109)	(0.00866)	0.00985	(0.00626)
$\hat{\beta}_3$	0.00947	(0.00732)	(0.00597)	(0.00893)	0.00936	(0.00626)
$\hat{\beta}_4$	0.00680	(0.00731)	(0.00381)$^+$	(0.00886)	0.00149	(0.00626)
$\hat{\beta}_5$	0.00346	(0.00726)	(0.00798)	(0.00895)	0.0131	(0.00625)*
$\hat{\beta}_6$	0.0124	(0.00729)$^+$	(0.0113)	(0.00830)	0.0119	(0.00625)$^+$
$\hat{\beta}_7$	0.00592	(0.00728)	(0.0141)	(0.00921)	0.00829	(0.00624)
$\hat{\beta}_8$	0.0202	(0.00726)**	(0.00606)**	(0.00804)*	0.0204	(0.00623)**
$\hat{\beta}_9$	0.0171	(0.00724)*	(0.0125)	(0.00750)*	0.0143	(0.00622)*
$\hat{\beta}_{10}$	0.0170	(0.00711)*	(0.00443)***	(0.00814)*	0.0151	(0.00613)*
LRM	0.382	(0.0532)***	(0.0533)***	(0.127)**	0.286	
$\sum \hat{\beta}_k$	0.150	(0.0194)***	(0.0195)***	(0.0275)***	0.152	(0.0169)***
$\Pr[\boldsymbol{\beta} = \mathbf{0}]$		3.39e-12	1.55e-17	0.000235		7.13e-16

Includes 12 lags of state employment plus macroeconomic controls and state-month fixed effects.
13,150 observations over 263 months.
Standard errors in parentheses
$^+$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Growth rates





Growth rates

	OLS Coef.	SE OLS	SE Cluster	SE Driscoll-Kray	GLS	
$\hat{\beta}_0$	0.115	(0.0164)***	(0.0219)***	(0.0240)***	0.0851	(0.0154)***
$\hat{\beta}_1$	0.0389	(0.0167)*	(0.0123)**	(0.0192)*	0.0330	(0.0155)*
$\hat{\beta}_2$	0.00781	(0.0168)	(0.0221)	(0.0229)	0.0124	(0.0155)
$\hat{\beta}_3$	0.00653	(0.0168)	(0.0151)	(0.0266)	0.0107	(0.0155)
$\hat{\beta}_4$	-0.0153	(0.0167)	(0.0101)	(0.0297)	-0.00685	(0.0155)
$\hat{\beta}_5$	0.000236	(0.0166)	(0.0204)	(0.0242)	0.0210	(0.0155)
$\hat{\beta}_6$	0.0224	(0.0167)	(0.0292)	(0.0221)	0.0289	(0.0155)$^+$
$\hat{\beta}_7$	0.0142	(0.0166)	(0.0286)	(0.0242)	0.0177	(0.0155)
$\hat{\beta}_8$	0.0472	(0.0166)**	(0.0199)*	(0.0234)*	0.0479	(0.0154)**
$\hat{\beta}_9$	0.0514	(0.0165)**	(0.0237)*	(0.0197)*	0.0345	(0.0154)*
$\hat{\beta}_{10}$	0.0430	(0.0163)**	(0.0107)***	(0.0224)$^+$	0.0364	(0.0153)*
LRM	0.623	(0.0874)***	(0.0691)***	(0.172)***	0.541	–
$\sum \hat{\beta}_k$	0.331	(0.0442)***	0.0270)***	(0.0799)***	0.321	(0.0422)***
$\Pr[\boldsymbol{\beta} = \mathbf{0}]$		2.74e-17	9.09e-21	0.0000314		1.78e-12

Includes 12 lags of state employment plus macroeconomic controls and state-month fixed effects.
13,150 observations over 263 months.
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Recall

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  - 35,000–120,000 FTE jobs in 2011
- IMF WEO 2013
  - 0.5 % increase in employment in 12 years

Our long-run estimates

Year	ND	PA	TX	USA
1990	1,242	-669	32,207	53,137
1991	-3,249	765	-38,323	-126,343
1992	-306	3,937	6,021	49,715
1993	-306	-6,575	-14,450	-26,377
1994	-765	-229	-2,829	-15,673
1995	3,058	-382	-9,939	-20,031
1996	-344	765	20,050	33,679
1997	2,389	96	26,090	61,738
1998	-6,556	-860	-61,126	-140,066
1999	2,370	153	29,435	58,030
2000	1,070	765	46,103	114,224
2001	-1,281	421	-11,258	-75,003
2002	96	-1,816	-5,543	-17,202
2003	421	1,472	41,267	98,780
2004	1,988	-765	23,166	50,231
2005	1,988	2,523	47,632	85,859
2006	4,358	1,070	45,109	94,652
2007	6,441	382	39,604	35,456
2008	11,946	2,198	-22,077	-11,086
2009	-7,760	14,469	-136,186	-232,941
2010	32,111	15,215	105,661	205,742
2011	14,756	3,211	63,382	111,701
2012	-4,224	-15,406	-28,269	-83,642
2013	-765	-6,116	1,625	-5,161
Total	**58,678**	**14,624**	**197,352**	**299,419**

- Based on per-capita LRM
- Caveats
  - Changing frequency
  - Aggregating over states
  - LRM, not dynamics
- Conclusions?
  - Positive, but modest
  - Much smaller than I/O
  - Consistent with Hartley et al. (2011)

TWO EXTENSIONS

Robustness check

- Drop each producing state
  - Does investment in new places have greater effect?
  - Concerns over backwards supply-chain links (TX)
- Generally no effect
- But ND seems to drive employment effect *down*

ND in disequilibrium?

- Blanchard and Katz (1992)
- Very low unemployment
- Sluggish employment adjustment
- Slow migration

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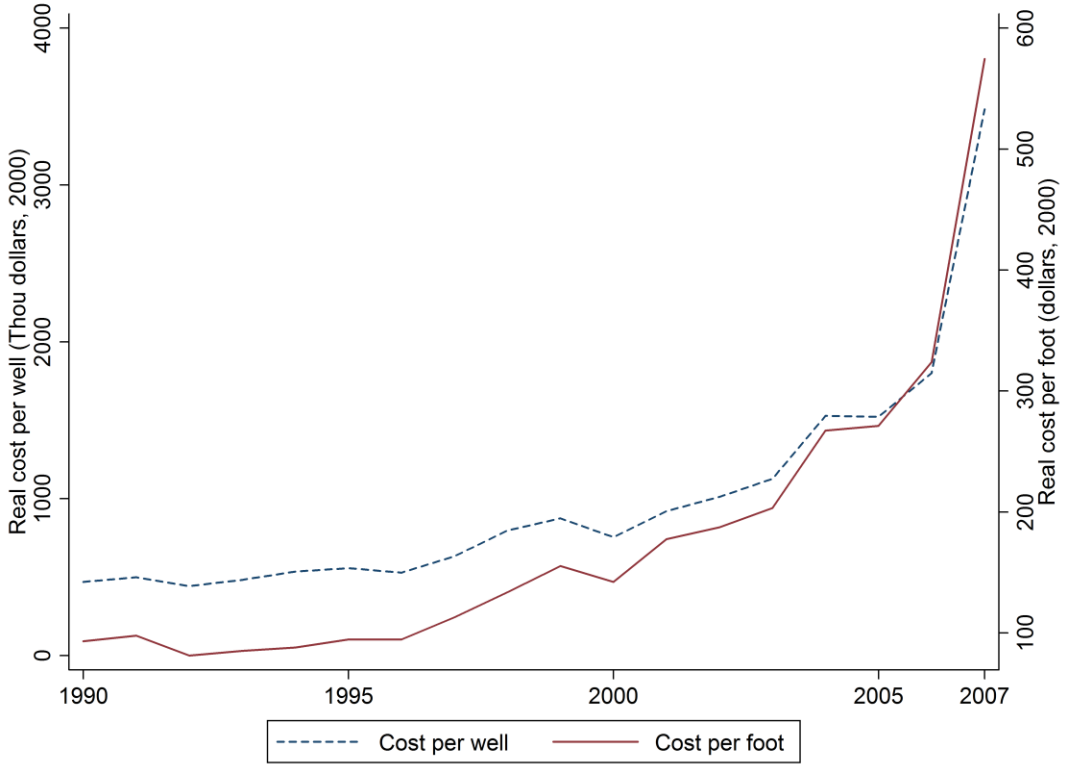
Pre/Post 2008

- Allow break in $\beta(L)$ between 2007 and 2008
- Significant at ~5% with robust SE
- Pre-2008 ↓ and post-2008 ↑ (some)
  - Per-capita (OLS):
    - $\hat{\beta}(1) = 0.150$
    - $\hat{\beta}_1(1) = 0.109$ versus $\hat{\beta}_{2008}(1) = 0.182$
  - Growth rates (OLS):
    - $\hat{\beta}(1) = 0.331$
    - $\hat{\beta}_1(1) = 0.205$ versus $\hat{\beta}_2(1) = 0.395$

Why a break in $\beta(L)$?

- Drilling in new states requires new infrastructure?
- Productivity changes?



Possible extensions

- More on dynamics
  - Asymmetry
  - Unemployment, wages & migration
  - Why impact in month t+9?
- Annual estimation
  - Convert 1968-1999 data
  - Analyze more labor-market variables
- Why a break in 2008?
  - Productivity
  - Infrastructure in place
- Australia or Canada?

QUESTIONS?

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Table 3: Per-capita specification testing

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$\hat{\beta}_0$	0.0407***	0.0310***	0.0409***	0.0438***	0.0504***	0.0426***	0.0400***	0.0479***	0.0500***	0.0327***
	(5.68)	(4.80)	(5.77)	(5.97)	(6.60)	(5.89)	(5.47)	(6.40)	(6.66)	(5.09)
$\hat{\beta}_1$	0.0108	0.0118$^+$	0.0103	0.0128$^+$	0.0105	0.00987	0.00874	0.0106	0.0135$^+$	0.0124$^+$
	(1.48)	(1.79)	(1.42)	(1.75)	(1.34)	(1.34)	(1.17)	(1.38)	(1.77)	(1.90)
$\hat{\beta}_2$	0.00639	0.00455	0.00782		0.00756	0.00825	0.00496	0.00767	0.00942	0.00483
	(0.87)	(0.69)	(1.08)		(0.96)	(1.11)	(0.66)	(1.00)	(1.23)	(0.74)
$\hat{\beta}_3$	0.00947	0.00585	0.00918		0.00649	0.0103	0.00721	0.00907	0.00801	0.00832
	(1.29)	(0.89)	(1.27)		(0.83)	(1.39)	(0.97)	(1.19)	(1.04)	(1.27)
$\hat{\beta}_4$	0.00680	0.00814	0.00912		-0.0000104	0.00601	0.00266	0.00295	-0.000395	0.00848
	(0.93)	(1.23)	(1.26)		(-0.00)	(0.81)	(0.36)	(0.39)	(-0.05)	(1.29)
$\hat{\beta}_5$	0.00346	0.0110$^+$	0.00332		-0.000744	0.00357	0.000802	0.00338	0.00208	0.0121$^+$
	(0.48)	(1.68)	(0.46)		(-0.10)	(0.49)	(0.11)	(0.45)	(0.27)	(1.87)
$\hat{\beta}_6$	0.0124$^+$	0.0143*	0.00833		0.00788	0.0120	0.0123$^+$	0.0137$^+$	0.0114	0.0155*
	(1.70)	(2.17)	(1.15)		(1.01)	(1.63)	(1.65)	(1.80)	(1.50)	(2.40)
$\hat{\beta}_7$	0.00592	0.00827	0.00491		-0.00174	0.00384	0.00490	0.00391	0.00234	0.0100
	(0.81)	(1.26)	(0.68)		(-0.22)	(0.52)	(0.66)	(0.52)	(0.31)	(1.54)
$\hat{\beta}_8$	0.0202**	0.0207**	0.0188**		0.0127	0.0204**	0.0188*	0.0181*	0.0127$^+$	0.0210**
	(2.78)	(3.15)	(2.60)		(1.64)	(2.78)	(2.54)	(2.39)	(1.68)	(3.24)
$\hat{\beta}_9$	0.0171*	0.0142*	0.0139$^+$		0.00902	0.0172*	0.0156*	0.0138$^+$	0.0103	0.0159*
	(2.36)	(2.17)	(1.93)		(1.17)	(2.35)	(2.11)	(1.83)	(1.36)	(2.46)
$\hat{\beta}_{10}$	0.0170*	0.0158*	0.0135$^+$		0.00538	0.0168*	0.0151*	0.0115	0.00731	0.0180**
	(2.39)	(2.46)	(1.88)		(0.71)	(2.34)	(2.08)	(1.55)	(0.98)	(2.83)
State employment (12 lags)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Nat'l Employment (13 lags)	Yes	–	Yes	Yes	–	–	Yes	Yes	–	Yes
IPI (t and 12 lags)	Yes	–	Yes	Yes	–	Yes	–	–	Yes	–
Time FE	–	Yes	–	–	–	–	–	–	–	Yes
State employment (to lag 24)	–	–	Yes	–	–	–	–	–	–	–
24 lags of rigs	–	–	Yes	–	–	–	–	–	–	–
Additional NatEmp and IPI lags	–	–	Yes	–	–	–	–	–	–	–
$State * NatEmp_{t-1}$	–	–	–	–	–	–	–	Yes	–	Yes
$State * IPI_t$	–	–	–	–	–	–	–	–	Yes	Yes
Parameters	49	274	98	18	23	36	36	73	73	372
BIC	-134893.3	-135999.5	-134928.9	-134273.5	-133337.3	-134684.5	-134451.7	-133585.6	-133491.5	-135544.3
LRM	0.382	0.393	0.489	0.110	0.439	0.321	0.322	0.230	0.428	0.281
σ_{LRM}	0.0532	0.0516	0.0788	0.0186	0.0853	0.0432	0.0509	0.0331	0.0688	0.0329
Pr[LRM = 0]	6.94e-13	2.75e-14	5.35e-10	3.93e-09	0.000000263	1.16e-13	2.64e-10	3.92e-12	5.22e-10	1.38e-17
$\sum \hat{\beta}_k$	0.150	0.146	0.199	0.0566	0.107	0.151	0.131	0.143	0.127	0.159
Pr[$\sum \hat{\beta}_k \leq 0$]	5.22e-15	1.01e-16	4.73e-11	6.78e-10	9.07e-08	7.15e-15	1.57e-11	2.58e-12	1.69e-10	4.83e-19
Pr[F_{rigs}]	3.39e-12	2.03e-12	2.01e-10	2.47e-10	4.65e-09	2.01e-12	1.49e-09	3.49e-11	8.79e-11	1.01e-14

t statistics in parentheses

$^+$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4: Logs specification testing

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$\hat{\beta}_0$	0.115***	0.0945***	0.112***	0.127***	0.144***	0.118***	0.117***	0.133***	0.145***	0.0966***
	(7.03)	(6.40)	(6.88)	(7.49)	(8.13)	(7.12)	(6.98)	(7.62)	(8.34)	(6.53)
$\hat{\beta}_1$	0.0389*	0.0426**	0.0370*	0.0396*	0.0366*	0.0353*	0.0351*	0.0353*	0.0436*	0.0389**
	(2.33)	(2.84)	(2.24)	(2.34)	(2.03)	(2.08)	(2.05)	(1.99)	(2.46)	(2.58)
$\hat{\beta}_2$	0.00781	0.0131	0.0170		0.00566	0.0116	0.00299	0.00775	0.0111	0.0102
	(0.47)	(0.87)	(1.02)		(0.31)	(0.68)	(0.17)	(0.44)	(0.63)	(0.68)
$\hat{\beta}_3$	0.00653	0.00236	0.00769		-0.00693	0.00797	0.000925	0.00230	0.00141	0.0107
	(0.39)	(0.16)	(0.46)		(-0.38)	(0.47)	(0.05)	(0.13)	(0.08)	(0.71)
$\hat{\beta}_4$	-0.0153	-0.00755	-0.00853		-0.0345^{+}	-0.0162	-0.0266	-0.0277	-0.0336^{+}	-0.0104
	(-0.91)	(-0.50)	(-0.51)		(-1.91)	(-0.95)	(-1.55)	(-1.56)	(-1.89)	(-0.69)
$\hat{\beta}_5$	0.000236	0.0104	0.00392		-0.00788	-0.00123	-0.00498	-0.00230	-0.00351	0.00994
	(0.01)	(0.70)	(0.24)		(-0.44)	(-0.07)	(-0.29)	(-0.13)	(-0.20)	(0.67)
$\hat{\beta}_6$	0.0224	0.0282^{+}	0.0167		0.0200	0.0257	0.0226	0.0256	0.0257	0.0266^{+}
	(1.34)	(1.88)	(1.01)		(1.11)	(1.52)	(1.33)	(1.45)	(1.45)	(1.79)
$\hat{\beta}_7$	0.0142	0.0161	0.0208		0.00803	0.0157	0.0137	0.0163	0.0120	0.0139
	(0.85)	(1.08)	(1.25)		(0.45)	(0.93)	(0.80)	(0.93)	(0.68)	(0.93)
$\hat{\beta}_8$	0.0472**	0.0488**	0.0511**		0.0345^{+}	0.0493**	0.0408*	0.0415*	0.0337^{+}	0.0463**
	(2.84)	(3.26)	(3.09)		(1.93)	(2.93)	(2.41)	(2.37)	(1.92)	(3.12)
$\hat{\beta}_9$	0.0514**	0.0420**	0.0474**		0.0355*	0.0487**	0.0473**	0.0453**	0.0385*	0.0445**
	(3.11)	(2.82)	(2.87)		(1.99)	(2.90)	(2.80)	(2.59)	(2.19)	(3.00)
$\hat{\beta}_{10}$	0.0430**	0.0446**	0.0313^{+}		0.0163	0.0437**	0.0375*	0.0288^{+}	0.0181	0.0425**
	(2.64)	(3.04)	(1.90)		(0.93)	(2.65)	(2.26)	(1.68)	(1.05)	(2.90)
State employment (12 lags)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Nat'l Employment (13 lags)	Yes	–	Yes	Yes	–	–	Yes	Yes	–	Yes
IPI (t and 12 lags)	Yes	–	Yes	Yes	–	Yes	–	–	Yes	–
Time FE	–	Yes	–	–	–	–	–	–	–	Yes
State employment (to lag 24)	–	–	Yes	–	–	–	–	–	–	–
24 lags of rigs	–	–	Yes	–	–	–	–	–	–	–
Additional NatEmp and IPI lags	–	–	Yes	–	–	–	–	–	–	–
$State * NatEmp_{t-1}$	–	–	–	–	–	–	–	Yes	–	Yes
$State * IPI_t$	–	–	–	–	–	–	–	–	Yes	Yes
Parameters	49	274	98	18	23	36	36	73	73	372
BIC	-113199.6	-114359.2	-113242.4	-112398.8	-111374.9	-112922.0	-112707.4	-111535.8	-111434.1	-113730.2
LRM	0.623	0.647	1.036	0.258	0.951	0.561	0.522	0.470	0.923	0.511
σ_{LRM}	0.0874	0.0820	0.151	0.0349	0.182	0.0761	0.0849	0.0730	0.149	0.0656
Pr[LRM = 0]	1.11e-12	3.34e-15	6.73e-12	1.56e-13	0.000000190	1.79e-13	7.83e-10	1.28e-10	6.22e-10	7.16e-15
$\sum \hat{\beta}_k$	0.331	0.335	0.510	0.166	0.251	0.339	0.286	0.306	0.292	0.330
Pr[$\sum \hat{\beta}_k \leq 0$]	3.65e-14	4.91e-17	2.16e-13	8.52e-15	6.33e-08	2.16e-14	1.10e-10	7.56e-11	1.98e-10	6.87e-16
Pr[F_{rigs}]	2.74e-17	1.01e-17	1.75e-16	6.04e-16	7.70e-16	2.56e-17	3.96e-15	7.15e-16	5.63e-18	9.17e-17

t statistics in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5: Sequential Elimination of each state (Per-capita specification)

	AL	AK	AZ	AR	CA	CO	FL	GA	HI
LRM	0.382	0.359	0.369	0.385	0.385	0.382	0.377	0.384	0.378
	(0.0536)	(0.0519)	(0.0505)	(0.0538)	(0.0538)	(0.0532)	(0.0524)	(0.0533)	(0.0527)
	[1.07e-12]	[4.74e-12]	[3.01e-13]	[8.64e-13]	[8.81e-13]	[7.78e-13]	[6.73e-13]	[5.54e-13]	[8.07e-13]
$\sum \beta_k$	0.150	0.141	0.152	0.151	0.151	0.151	0.151	0.150	0.150
	(0.0195)	(0.0191)	(0.0194)	(0.0195)	(0.0195)	(0.0195)	(0.0195)	(0.0193)	(0.0194)
	ID	IL	IN	KS	KY	LA	MD	MI	MS
LRM	0.382	0.384	0.382	0.388	0.383	0.401	0.385	0.380	0.384
	(0.0533)	(0.0537)	(0.0535)	(0.0542)	(0.0537)	(0.0557)	(0.0539)	(0.0534)	(0.0535)
	[7.35e-13]	[9.96e-13]	[9.51e-13]	[8.80e-13]	[1.07e-12]	[5.86e-13]	[9.44e-13]	[1.05e-12]	[7.61e-13]
$\sum \beta_k$	0.150	0.150	0.150	0.151	0.150	0.151	0.150	0.149	0.151
	(0.0193)	(0.0195)	(0.0194)	(0.0195)	(0.0195)	(0.0192)	(0.0194)	(0.0194)	(0.0195)
	MT	NE	NV	NM	NY	ND	OH	OK	OR
LRM	0.385	0.388	0.338	0.389	0.382	0.383	0.383	0.379	0.384
	(0.0542)	(0.0541)	(0.0404)	(0.0543)	(0.0535)	(0.0659)	(0.0536)	(0.0547)	(0.0534)
	[1.32e-12]	[7.64e-13]	[6.37e-17]	[7.59e-13]	[1.01e-12]	[6.24e-09]	[1.00e-12]	[4.23e-12]	[6.72e-13]
$\sum \beta_k$	0.150	0.151	0.169	0.154	0.150	0.152	0.150	0.148	0.151
	(0.0196)	(0.0194)	(0.0186)	(0.0199)	(0.0195)	(0.0245)	(0.0195)	(0.0199)	(0.0195)
	PA	SD	TN	TX	UT	VA	WA	WV	WY
LRM	0.381	0.383	0.383	0.372	0.373	0.384	0.387	0.387	0.398
	(0.0536)	(0.0538)	(0.0534)	(0.0540)	(0.0525)	(0.0537)	(0.0538)	(0.0535)	(0.0675)
	[1.23e-12]	[1.09e-12]	[8.56e-13]	[5.80e-12]	[1.32e-12]	[9.56e-13]	[7.01e-13]	[5.49e-13]	[3.73e-09]
$\sum \beta_k$	0.150	0.149	0.150	0.146	0.149	0.150	0.151	0.152	0.155
	(0.0195)	(0.0194)	(0.0195)	(0.0197)	(0.0194)	(0.0195)	(0.0194)	(0.0195)	(0.0250)

Standard errors in parentheses. p-values in brackets.

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 6: Sequential Elimination of each state (Logs specification)

	AL	AK	AZ	AR	CA	CO	FL	GA	HI
LRM	0.623	0.609	0.602	0.626	0.624	0.621	0.613	0.624	0.607
	(0.0879)	(0.0865)	(0.0833)	(0.0882)	(0.0877)	(0.0872)	(0.0858)	(0.0872)	(0.0849)
	[1.51e-12]	[1.96e-12]	[5.38e-13]	[1.38e-12]	[1.11e-12]	[1.17e-12]	[9.90e-13]	[9.05e-13]	[9.66e-13]
$\sum \beta_k$	0.331	0.321	0.336	0.332	0.334	0.334	0.333	0.333	0.333
	(0.0445)	(0.0434)	(0.0443)	(0.0445)	(0.0445)	(0.0446)	(0.0444)	(0.0442)	(0.0443)
	ID	IL	IN	KS	KY	LA	MD	MI	MS
LRM	0.621	0.626	0.623	0.632	0.625	0.669	0.627	0.618	0.624
	(0.0868)	(0.0884)	(0.0877)	(0.0889)	(0.0882)	(0.0925)	(0.0886)	(0.0869)	(0.0868)
	[8.43e-13]	[1.51e-12]	[1.31e-12]	[1.22e-12]	[1.52e-12]	[5.05e-13]	[1.49e-12]	[1.16e-12]	[6.88e-13]
$\sum \beta_k$	0.333	0.332	0.331	0.333	0.330	0.332	0.330	0.330	0.335
	(0.0442)	(0.0445)	(0.0444)	(0.0444)	(0.0443)	(0.0432)	(0.0442)	(0.0440)	(0.0442)
	MT	NE	NV	NM	NY	ND	OH	OK	OR
LRM	0.627	0.631	0.600	0.626	0.621	0.632	0.625	0.607	0.623
	(0.0889)	(0.0886)	(0.0803)	(0.0881)	(0.0878)	(0.109)	(0.0881)	(0.0898)	(0.0872)
	[1.79e-12]	[1.11e-12]	[8.19e-14]	[1.26e-12]	[1.55e-12]	[6.75e-09]	[1.46e-12]	[1.43e-11]	[9.59e-13]
$\sum \beta_k$	0.331	0.333	0.346	0.338	0.331	0.339	0.331	0.320	0.334
	(0.0445)	(0.0443)	(0.0440)	(0.0453)	(0.0445)	(0.0559)	(0.0445)	(0.0453)	(0.0444)
	PA	SD	TN	TX	UT	VA	WA	WV	WY
LRM	0.620	0.625	0.621	0.608	0.606	0.624	0.628	0.633	0.634
	(0.0881)	(0.0881)	(0.0874)	(0.0888)	(0.0857)	(0.0882)	(0.0881)	(0.0882)	(0.111)
	[2.11e-12]	[1.38e-12]	[1.29e-12]	[7.50e-12]	[1.68e-12]	[1.51e-12]	[1.07e-12]	[7.82e-13]	[1.06e-08]
$\sum \beta_k$	0.330	0.331	0.332	0.323	0.330	0.331	0.333	0.335	0.335
	(0.0445)	(0.0443)	(0.0444)	(0.0450)	(0.0445)	(0.0444)	(0.0443)	(0.0443)	(0.0566)

Standard errors in parentheses. p-values in brackets.

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 7: Tests for break in 2008

	Per-capita		Per-capita		Logs		Logs	
$\hat{\beta}_0$	0.0407***	(4.03)	0.0277*	(2.63)	0.115***	(4.79)	0.103**	(3.49)
$\hat{\beta}_1$	0.0108	(1.31)	0.00000240	(0.00)	0.0389*	(2.03)	0.0162	(0.71)
$\hat{\beta}_2$	0.00639	(0.74)	0.0110	(1.18)	0.00781	(0.34)	0.0000278	(0.00)
$\hat{\beta}_3$	0.00947	(1.06)	-0.000980	(-0.10)	0.00653	(0.25)	-0.0390	(-1.42)
$\hat{\beta}_4$	0.00680	(0.77)	0.00707	(0.63)	-0.0153	(-0.52)	-0.0363	(-1.05)
$\hat{\beta}_5$	0.00346	(0.39)	-0.00401	(-0.44)	0.000236	(0.01)	-0.0227	(-0.85)
$\hat{\beta}_6$	0.0124	(1.49)	0.0133	(1.51)	0.0224	(1.01)	0.0236	(0.94)
$\hat{\beta}_7$	0.00592	(0.64)	0.000159	(0.01)	0.0142	(0.58)	0.00210	(0.08)
$\hat{\beta}_8$	0.0202*	(2.51)	0.0208*	(2.15)	0.0472*	(2.01)	0.0569*	(2.20)
$\hat{\beta}_9$	0.0171*	(2.27)	0.0169$^+$	(1.86)	0.0514*	(2.61)	0.0535*	(2.11)
$\hat{\beta}_{10}$	0.0170*	(2.08)	0.0175$^+$	(1.88)	0.0430$^+$	(1.92)	0.0477	(1.62)
$\hat{\beta}_{0,2008}$			0.0335	(1.36)			-0.0199	(-0.36)
$\hat{\beta}_{1,2008}$			0.0362*	(2.13)			0.0480	(1.41)
$\hat{\beta}_{2,2008}$			-0.0368	(-1.53)			-0.0331	(-0.74)
$\hat{\beta}_{3,2008}$			0.0393*	(2.09)			0.163***	(3.86)
$\hat{\beta}_{4,2008}$			-0.0129	(-0.75)			0.0494	(1.11)
$\hat{\beta}_{5,2008}$			0.0267	(1.08)			0.0899	(1.58)
$\hat{\beta}_{6,2008}$			-0.0167	(-0.79)			-0.0367	(-0.75)
$\hat{\beta}_{7,2008}$			0.0266	(1.35)			0.0551	(1.23)
$\hat{\beta}_{8,2008}$			-0.0141	(-0.85)			-0.0722$^+$	(-1.76)
$\hat{\beta}_{9,2008}$			0.00250	(0.14)			-0.0110	(-0.24)
$\hat{\beta}_{10,2008}$			-0.0119	(-0.74)			-0.0427	(-1.05)
Test of $\beta_{2008} \sim F_{11,49}$			2.207				3.827	
Pr[F]			0.0292				0.000531	
LRM_0	0.382**	[0.127]	0.279*	[0.118]	0.623***	[0.172]	0.387$^+$	[0.211]
LRM_{2008}			0.463**	[0.156]			0.745***	[0.209]
$\sum \beta_k$	0.150***	[0.0275]	0.109**	[0.0361]	0.331***	[0.0799]	0.205 $^+$	[0.112]
$\sum \beta_k + \beta_{k,2008}$			0.182***	[0.0395]			0.395***	[0.0988]

Includes 12 lags of state employment plus macroeconomic controls and state-month fixed effects.

13,150 observations over 263 months. LRM_0 is for whole sample or pre-2008.

$\beta_{k,2008}$ corresponds to $\mathbf{1}[Year \geq 2008] \times \Delta Rigs_{i,t-k}/Pop_{i,1990}$

t statistics in parentheses. SE in brackets. $^+$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 8: Estimated job impact (per-capita specification)

	Impact in t (β_0)				Long-run effect			
Year	ND	PA	TX	USA	ND	PA	TX	USA
1992	-33	419	640	5,288	-306	3,937	6,021	49,715
1993	-33	-699	-1,537	-2,806	-306	-6,575	-14,500	-26,400
1994	-81	-24	-301	-1,667	-765	-229	-2,829	-15,700
1995	325	-41	-1,057	-2,131	3,058	-382	-9,939	-20,000
1996	-37	81	2,133	3,582	-344	765	20,050	33,679
1997	254	10	2,775	6,567	2,389	96	26,090	61,738
1998	-697	-91	-6,502	-14,900	-6,556	-860	-61,100	-140,000
1999	252	16	3,131	6,172	2,370	153	29,435	58,030
2000	114	81	4,904	12,149	1,070	765	46,103	114,000
2001	-136	45	-1,197	-7,977	-1,281	421	-11,300	-75,000
2002	10	-193	-590	-1,830	96	-1,816	-5,543	-17,200
2003	45	157	4,389	10,507	421	1,472	41,267	98,780
2004	211	-81	2,464	5,343	1,988	-765	23,166	50,231
2005	211	268	5,066	9,132	1,988	2,523	47,632	85,859
2006	464	114	4,798	10,067	4,358	1,070	45,109	94,652
2007	685	41	4,212	3,771	6,441	382	39,604	35,456
2008	1,271	234	-2,348	-1,179	11,946	2,198	-22,100	-11,100
2009	-825	1,539	-14,500	-24,800	-7,760	14,469	-136,000	-233,000
2010	3,415	1,618	11,238	21,883	32,111	15,215	106,000	206,000
2011	1,569	342	6,741	11,881	14,756	3,211	63,382	112,000
2012	-449	-1,639	-3,007	-8,896	-4,224	-15,400	-28,300	-83,600
2013	-81	-651	173	-549	-765	-6,116	1,625	-5,161
Total	6,455	1,545	21,626	39,607	60,687	14,532	203,872	372,980

Table 9: Estimated percentage employment growth (logs specification)

	Impact in t (β_0)				Long-run effect			
Year	ND	PA	TX	USA	ND	PA	TX	USA
1992	-0.01	0.01	0.01	0.00	-0.08	0.05	0.06	0.00
1993	-0.01	-0.02	-0.03	0.00	-0.08	-0.09	-0.14	0.00
1994	-0.04	0.00	-0.01	0.00	-0.20	0.00	-0.03	0.00
1995	0.14	0.00	-0.02	0.00	0.78	-0.01	-0.10	0.00
1996	-0.02	0.00	0.04	0.00	-0.09	0.01	0.19	0.00
1997	0.11	0.00	0.05	0.00	0.61	0.00	0.25	0.00
1998	-0.31	0.00	-0.11	0.00	-1.68	-0.01	-0.58	0.00
1999	0.11	0.00	0.05	0.00	0.61	0.00	0.28	0.00
2000	0.05	0.00	0.08	0.00	0.27	0.01	0.44	0.00
2001	-0.06	0.00	-0.02	0.00	-0.33	0.01	-0.11	0.00
2002	0.00	0.00	-0.01	0.00	0.02	-0.02	-0.05	0.00
2003	0.02	0.00	0.07	0.00	0.11	0.02	0.39	0.00
2004	0.09	0.00	0.04	0.00	0.51	-0.01	0.22	0.00
2005	0.09	0.01	0.08	0.00	0.51	0.03	0.46	0.00
2006	0.21	0.00	0.08	0.00	1.11	0.01	0.43	0.00
2007	0.30	0.00	0.07	0.00	1.65	0.01	0.38	0.00
2008	0.56	0.01	-0.04	0.00	3.05	0.03	-0.21	0.00
2009	-0.37	0.04	-0.24	0.00	-1.98	0.20	-1.30	0.00
2010	1.52	0.04	0.19	0.00	8.21	0.21	1.01	0.00
2011	0.70	0.01	0.11	0.00	3.77	0.04	0.61	0.00
2012	-0.20	-0.04	-0.05	0.00	-1.08	-0.21	-0.27	0.00
2013	-0.04	-0.02	0.00	0.00	-0.20	-0.08	0.02	0.00
Total	2.87	0.04	0.36	0.00	15.51	0.20	1.94	0.00