The Impact of Unconventional Oil and Gas Developments on Employment and Population Dynamics: A County-Level Analysis of Migration Inflow and Outflow

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- This paper uses a difference in difference methodology to determine whether producing oil and gas via shale has an economically significant effect on migration dynamics and on the job market in terms of the number of employed individuals, the number of establishments, total wages and average annual pay per person in twenty-six counties in Ohio and Pennsylvania.

- creating a control group of counties with similar employment by industry and comparing employment and wage trends in the control group to those counties in the treatment group that are witnessing oil and gas drilling.

- The employment, population and wage trends of a control group of thirteen counties with similar employment by industry that did not begin producing shale gas around 2011 is compared to thirteen counties in a treatment group that did begin oil and gas production at that time.

Introduction
Research Question

- The research question is whether producing oil and gas via shale have an economically significant effect on the job market, specifically the number of employed individuals in these counties.
- The analysis incorporates migration inflow and outflow between counties in the control and treatment groups.
- As most studies focus on wages and employment, less is known about the population dynamics as a result of new wells openings in mostly rural areas, namely migration inflows and outflows as a result of new job opportunities.

- Introduction
  - Motivation
  - Contribution
- Literature
- Methodology and the Data
- Results
- Conclusion

Introduction:
Motivation

- The horizontal drilling techniques with hydraulic fracturing made it possible to unlock large quantities of shale oil and gas that were previously unprofitable to extract.
- Technological innovations in hydraulic fracturing, or “fracking,” have led to a dramatic increase in U.S. oil and natural gas production.
- Development of unconventional, tight oil and gas formations has led to rapid economic, social, and environmental changes in predominantly rural, agricultural communities across the United States.

Introduction:
Motivation

- Previous literature has mostly ignored population trends or used synthetic control groups to measure the economic impact of shale gas, however this paper incorporates actual migration flows, to account for the fact that people may move to a neighboring county with shale development for new job openings.

- However, the labor allocation may also be affected by others moving away from production sites permanently because of concerns about environmental and social impacts.

Introduction:
Contribution

- In this analysis, I complied data regarding gas production from shale, number of paid employees, annual payrolls, number of establishments, population change, migration inflows and outflows and employment in each county.

- Many papers in the literature left out actual migration flows. If migration left out, it is more difficult to properly measure labor market differences between counties. Two neighboring counties one with shale development, one with no shale might have different migration dynamics.

- Weather shale boom has created net migration into the boom counties is an important socio-economic question.

Literature Review

A Brief Summary

- According to the most literature on this issue, impacts on regional labor markets have been significant as average wages and employment have risen (Allcott and Keniston 2014, Weber 2014, Paredes et al. 2015, Brown 2015, Cosgrove et al. 2015, Munasib and Rickman 2015, Komarek 2016, Agerton et al. 2017, Gittings and Roach 2019, Wilson 2020).

- In the literature a number of studies work on spillovers to other sectors of the economy outside of resource extraction and focus on long-run effects (Brown, 2014, Maniloff and Mastromonaco 2014, Weinstein 2014, Miljkovic and Ripplinger 2016, Tsvetkova and Partridge 2017, Feyrer et al. 2017, Green et al. 2017).

Literature Review
A Brief Summary

- On the other hand, there is a line of research that study the potential negative impacts of shale developments.
  - Blanco and Grier (2012) and Rickman et al. (2017) show that educational attainment and human capital development may be lower in areas that are resource dependent.
  - Betzet al. (2015) and Tsvetkova and Partridge (2017) both show that long-run growth may be hurt by resource dependence.
  - Murshed and Serino (2011) considers poor industry diversification.
  - Negative environmental impacts including air and water pollution (Ellsworth 2013, Keranen et al. 2013, Wang et al. 2014, Fry et al. 2015).
  - Significant changes to the population (Parkins and Angell 2011).

Methodology and the Data

- My empirical strategy uses a ‘difference-in-differences’ approach to identify the effect on the labor market.

- The data set used for this analysis is panel data covering a group of twelve rural Ohio counties and fourteen Pennsylvania counties over the fourteen years from 2005 to 2018, collected quarterly.
  - Ohio Department of Natural Resources
  - Pennsylvania Center for Workforce Information & Analysis
  - Pennsylvania , The Department of Environmental Protection
  - Bureau of Labor Statistics.
  - Ohio Development Services Agency
  - United States Census Bureau.
  - United States Census Bureau, County Business Patterns.

Methodology and the Data

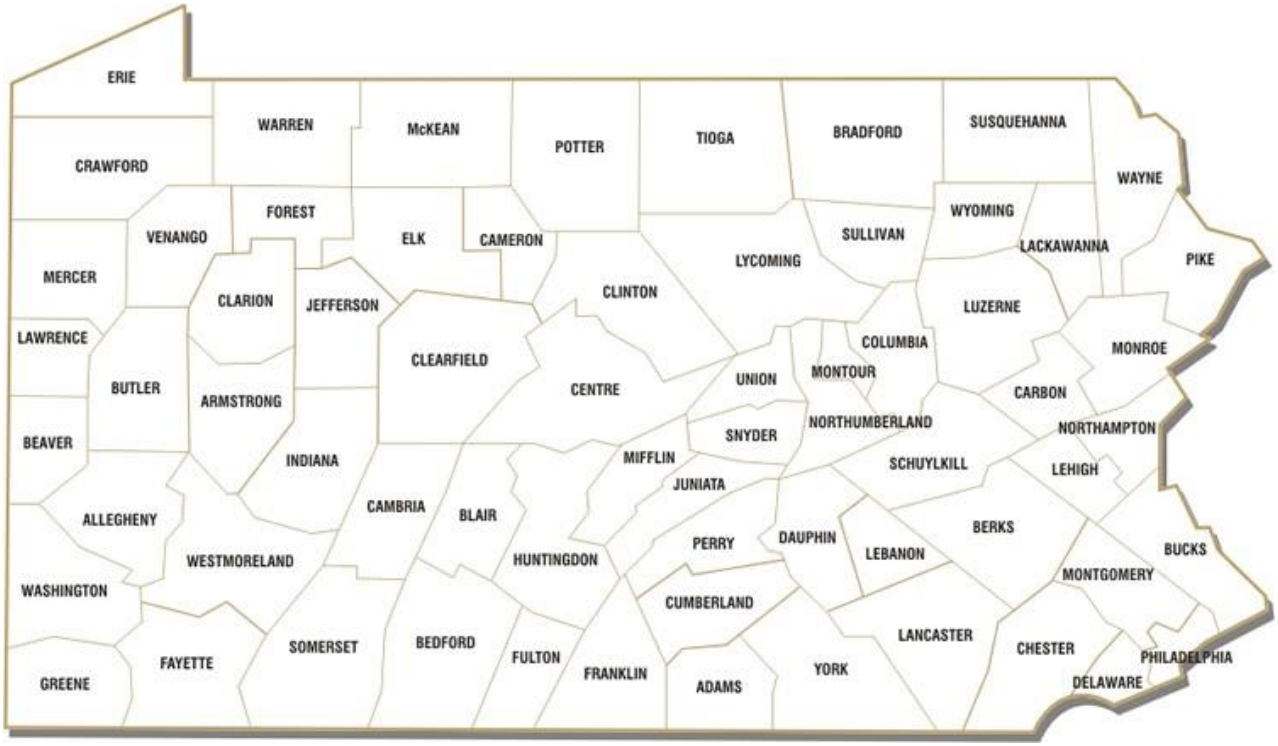
- The six producing counties in Ohio are Belmont, Monroe, Carroll, Harrison, Noble, and Jefferson, and the seven producing counties in Pennsylvania are Bradford, Susquehanna, Lycoming, Tioga, Washington, Greene, and Wyoming.
  - These counties consist of the treatment group as the boom counties.

- The six non-producing counties in Ohio—Fairfield, Perry, Pike, Ross, Vinton and Morgan—and the seven non-producing counties in Pennsylvania—Snyder, Clinton, Columbia, Potter, Union, Beaver, and Fayette
  - These counties were chosen because they are comparable in terms of location and economic and demographic characteristics to the counties in the group of producers. The counties are rural eastern/southeastern Ohio counties and southwestern/northern Pennsylvania counties that either border one another or are in close proximity, and are expected to act as a reasonable control group for the treated observations.

Methodology and the Data

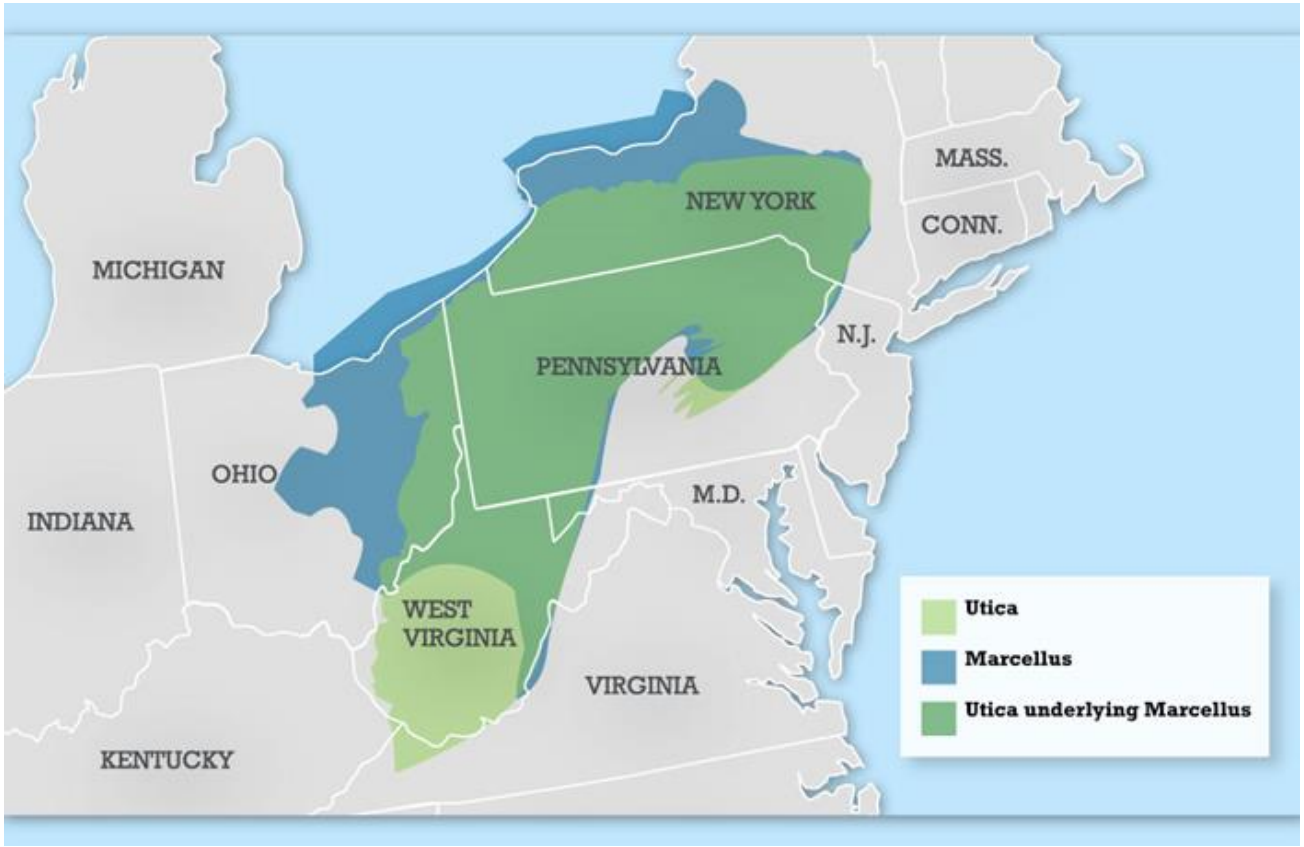
Ohio counties: source: transportation.ohio.gov

Methodology and the Data



Pennsylvania counties: source: https://co.lawrence.pa.us/pennsylvania-county-websites/

Methodology and the Data



Marcellus and Utica Shales in Ohio:
source: https://marcelluscoalition.org/

Methodology and the Data

Pennsylvania
Population Dynamics

	Total Inflow	Total Outflow	Net Migration	Average Population	Average # Employed
Bradford (2012-2018)	1598	2739	-1141	61,631	28,980
Bradford (2005-2011)	1891	2293	-402	62,358	29,420
Susquehanna (2012-2018)	1675	1747	-72	41,702	20,100
Susquehanna (2005-2011)	1362	2174	-812	42,252	20,280
Lycoming (2012-2018)	4912	4780	132	115,475	56,260
Lycoming (2005-2011)	5056	4948	108	116,963	56,040
Tioga (2012-2018)	1516	2097	-581	41,515	18,760
Tioga (2005-2011)	2188	1634	554	41,764	19,220
Washington (2012-2018)	9297	9544	-247	207,638	100,340
Washington (2005-2011)	9066	8684	382	207,922	98,760
Greene (2012-2018)	1767	2327	-560	37,415	16,760
Greene (2005-2011)	2808	1624	1184	38,802	17,140
Wyoming (2012-2018)	1463	1482	-19	27,811	13,180
Wyoming (2005-2011)	1326	1613	-287	28,190	13,240
Snyder (2012-2018)	1722	1504	218	40,377	19,140
Snyder (2005-2011)	2066	1613	-287	39,344	18,240
Clinton (2012-2018)	2342	1731	611	39,313	17,400
Clinton (2005-2011)	3141	1401	1740	38,549	17,640
Columbia (2012-2018)	3986	3932	54	66,541	32,100
Columbia (2005-2011)	4190	3456	734	66,453	32,700
Potter (2012-2018)	727	859	-132	17,103	6,880
Potter (2005-2011)	732	915	-183	17,240	7,080
Union (2012-2018)	4534	2904	1630	45,065	18,420
Union (2005-2011)	4762	2781	1981	44,519	17,240
Beaver (2012-2018)	6505	7126	-621	167,871	80,180
Beaver (2005-2011)	6567	5965	602	171,328	81,220
Fayette (2012-2018)	4358	5130	-772	133,102	53,760
Fayette (2005-2011)	3814	4857	-1043	138,855	56,700

Methodology and the Data

Ohio
Population Dynamics

	Total Inflow	Total Outflow	Net Migration	Average Population	Average # Employed
Belmont (2012-2018)	3609	3309	300	68,889	23,285
Belmont (2005-2011)	2884	2625	215	70,202	22,848
Monroe (2012-2018)	360	979	-638	14,239	3,648
Monroe (2005-2011)	284	506	-222	14,671	2,995
Carroll (2012-2018)	1355	1547	-192	27,825	6,720
Carroll (2005-2011)	1087	1697	-610	28,823	5,694
Harrison (2012-2018)	642	1284	-642	15,397	3,897
Harrison (2005-2011)	583	784	-201	15,811	3,383
Noble (2012-2018)	1490	1075	415	14,498	3,193
Noble (2005-2011)	1621	1011	610	14,667	3,006
Jefferson (2012-2018)	555	352	203	67,360	20,789
Jefferson (2005-2011)	2,606	2,918	-312	68,848	23,187
Fairfield (2012-2018)	10354	9002	1352	151,526	42,129
Fairfield (2005-2011)	9140	8340	800	146,009	39,509
Perry (2012-2018)	2115	2346	-231	35,983	5,786
Perry (2005-2011)	1505	1491	14	36,083	5,844
Pike (2012-2018)	1542	1312	230	28,291	9,338
Pike (2005-2011)	1849	1571	278	28,650	9,137
Ross (2012-2018)	4594	3983	611	77,125	27,449
Ross (2005-2011)	4348	4962	-614	77703	25,949
Vinton (2012-2018)	659	1068	-409	13,142	2,222
Vinton (2005-2011)	727	862	-135	13,392	2,200
Morgan (2012-2018)	497	701	-204	14,762	2,610
Morgan (2005-2011)	547	1243	-696	14,781	2,443

Methodology and the Data

Ohio: Gas Production from Shale (MMCF)
(1 MMCF = 1,000,000 cubic feet of gas)

(1 MMCF = 1,000,000 cubic feet of gas)

	Belmont (1)	Carroll (2)	Harrison (3)	Jefferson (4)	Monroe (5)	Noble (6)
2011	0	1,038	1,523	0	0	0
2012	0	7,752	2,447	1,624	233	358
2013	12,361	50,224	12,659	4,171	9,724	4,267
2014	95,247	161,138	49,976	7,775	59,404	38,341
2015	270,252	212,604	140,168	6,749	136,479	99,012
2016	493,386	196,352	187,876	46,012	259,950	111,364
2017	779,408	141,217	154,492	144,368	304,684	109,669
2018	955,724	119,458	159,296	352,464	542,456	113,448

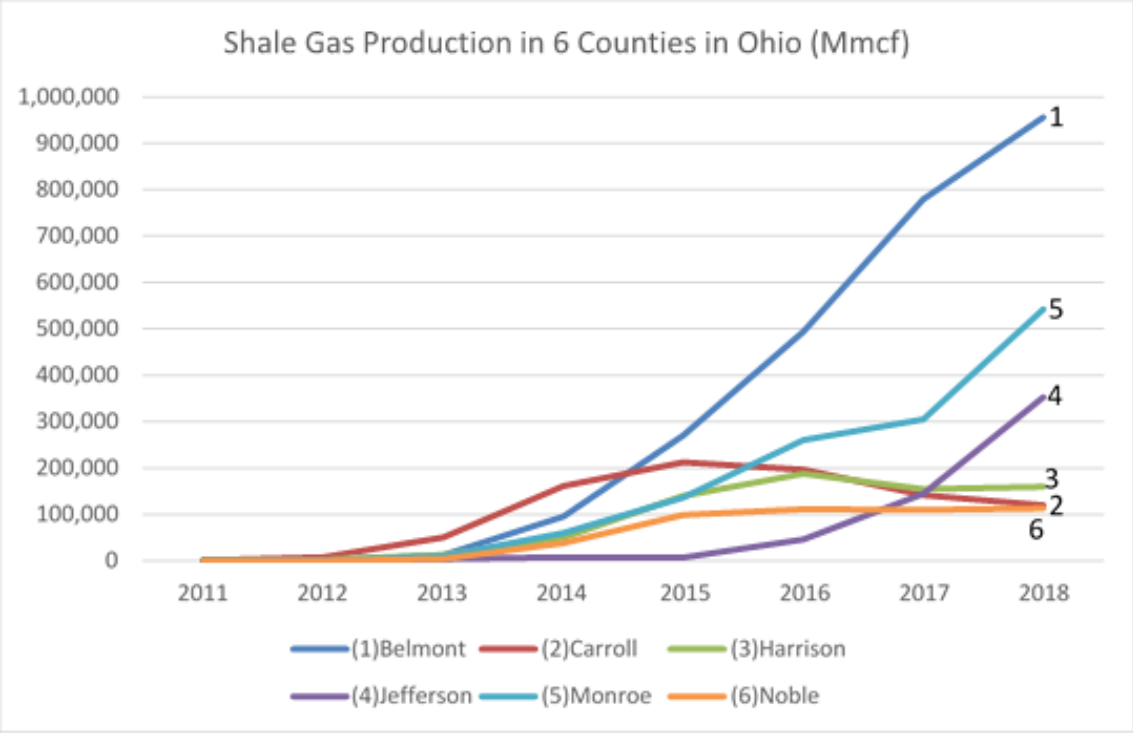
Methodology and the Data

Pennsylvania: Gas Production from Shale (MMCF)
(1 MMCF = 1,000,000 cubic feet of gas)

	Bradford(1)	Susquehanna(2)	Lycoming(3)	Tioga(4)	Washington(5)	Greene(6)	Wyoming(7)
2009	17,288	16,473	2,526	5,068	25,342	32,802	0
2010	66,401	60,813	11,503	37,791	46,651	48,441	3,177
2011	288,461	201,473	80,832	126,611	113,924	118,919	14,467
2012	520,251	430,721	230,202	202,809	179,028	180,505	66,233
2013	713,571	692,330	413,057	219,168	259,653	317,112	151,069
2014	818,020	947,962	533,074	207,552	449,628	376,396	248,818
2015	726,480	1,129,091	453,491	198,897	663,154	532,287	264,723
2016	711,496	1,213,162	420,620	194,138	838,910	693,812	278,008
2017	709,169	1,306,878	344,304	220,607	945,843	659,880	354,940
2018	765,242	1,464,726	355,824	301,434	1,164,390	798,347	344,825
2019	886,196	1,668,082	375,086	348,574	1,181,052	1,013,077	316,030

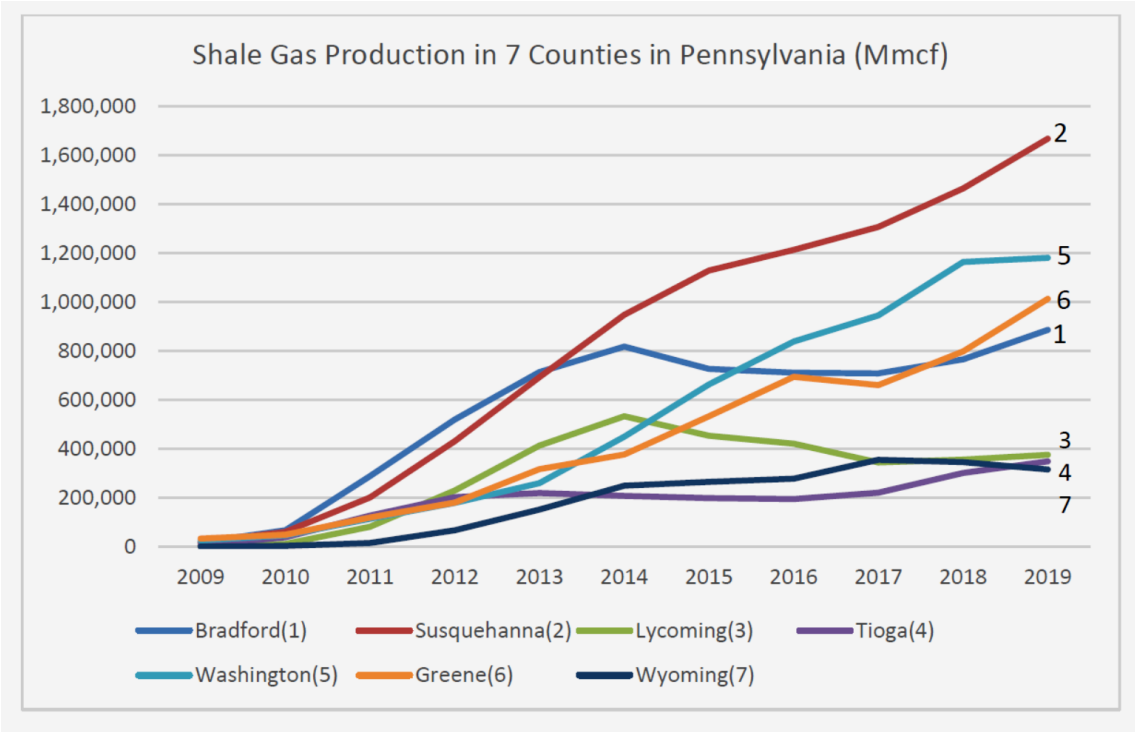
Methodology and the Data

Ohio Gas Production from Shale (MMCF)
(1 MMCF = 1,000,000 cubic feet of gas)



Methodology and the Data

Pennsylvania Gas Production from Shale (MMCF)
(1 MMCF = 1,000,000 cubic feet of gas)



Empirical Model and Results

Table 1: Summary statistics, Annual Means: Gas production, population, payrolls, migration (N=1456, Labor Market variables 2005-2018, Gas Production 2011-2018)

Variable	Mean	SD
Gas Production PA (Mmcf=1000Mcf)	432,713	391,229
Gas Production OH (Mmcf=1000Mcf)	136,608	199,841
Population	60,687	51,684
Total Wages (000)	791,469	869,087
Number of Employed	20,102	19,415
Annual Payroll per worker	37,443	5857
Number of Establishments	1373	1245
Migration Inflow	578	495
Migration Outflow	564	461

Empirical Model and Results

Table 2: growth rate of variables 2005-2011 prior to Shale Gas Production

	Non-boom counties		Boom counties		Difference in means	*p*-value
	Mean	SD	Mean	SD		
Population	-0.0123	0.04	-0.0240	0.02	0.0117	0.1270
Annual Payroll	0.0600	0.09	0.0500	0.06	0.0100	0.1265
Number of Employed	0.0400	0.06	0.0418	0.05	-0.0018	0.8214
Annual Payroll per worker	0.0230	0.04	0.0250	0.03	-0.0020	0.8414
Number of Establishments	0.0100	0.01	0.0009	0.01	0.0091	0.9104
Migration Inflow	0.0010	0.02	0.0090	0.02	-0.0080	0.9020
Migration Outflow	0.0010	0.00	0.0090	0.00	-0.0080	0.9020

Empirical Model and Results

$$NetMigration_{it} = \beta_0 + \beta_1 dummy1_{it} + \beta_2 dummy2_{it} + \beta_3 interaction_{it} + \varepsilon_{it}$$

- The estimated coefficient of is 0.026 however it is not statistically significant.
- This means that shale boom did not create a permanent migration.
- It is important to remind that the net migration variable is for all possible migration within the US, it does not only account for migration within the selected group.

Empirical Model and Results

$$NetMigration_{it} = \beta_0 + \beta_1 dummy1_{it} + \beta_2 dummy2_{it} + \beta_3 interaction_{it} + \varepsilon_{it}$$

$$Employment_{it} = \beta_0 + \beta_1 dummy1_{it} + \beta_2 dummy2_{it} + \beta_3 dummy3_{it} + \beta_4 \text{inflow}_{it} + \beta_5 \text{outflow}_{it} + \varepsilon_{it}$$

$$Annual\_Payrolls_{it} = \beta_0 + \beta_1 dummy1_{it} + \beta_2 dummy2_{it} + \beta_3 dummy3_{it} + \beta_4 \text{inflow}_{it} + \beta_5 \text{outflow}_{it} + \varepsilon_{it}$$

$$Establishments_{it} = \beta_0 + \beta_1 dummy1_{it} + \beta_2 dummy2_{it} + \beta_3 dummy3_{it} + \beta_4 \text{inflow}_{it} + \beta_5 \text{outflow}_{it} + \varepsilon_{it}$$

Results

Table 3: Migration Dynamics in Boom and Non-Boom Counties

	Model 1	Model 2	Model 3	Model 4	Model 5
Net Migration					(Only Ohio)
Fracking boom	-37**	-37**	-34.09**	-34.09**	-55.51***
	(17.64)	(17.96)	(17.44)	(17.44)	(17.95)
State Dummy (PA=1)		20.47**	20.47**		
		(9.84)	(9.84)		
Population			0.0001	0.0002	0.0016***
			(0.0004)	(0.0004)	(0.0005)
County FE	yes	yes	yes	yes	yes
Time FE	yes	yes	yes	yes	yes
N	1456	1456	1456	1456	672
Adj. R^2	0.09	0.09	0.08	0.076	0.43

	Model 6	Model 7	Model 8	Model 9	Model 10
Net Migration					(Only Ohio)
Fracking boom	-37**	-37**	-36.9**	-36.9**	-55.17***
	(17.64)	(17.96)	(17.64)	(17.64)	(17.95)
State Dummy (PA=1)		20.47**	20.47**		
		(9.84)	(9.84)		
Population			0.0001	0.0002	0.0016***
			(0.0004)	(0.0004)	(0.0005)
County FE	no	no	no	no	no
Time FE	no	no	no	no	no
N	1456	1456	1456	1456	672
Adj. R^2	0.075	0.08	0.08	0.077	0.44

Note: **p<0.05, ***p<0.01 Robust standard errors in parentheses.

Results

Table 4: The effect of the fracking boom and migration dynamics on employment, payrolls, establishments

	Model 1	Model 2	Model 3	Model 4	Model 5
Number of Employed					
Fracking boom	708***	712***	722***	556**	555**
	(292)	(225)	(221)	(234)	(230)
Population		0.32***	0.33***	0.35***	0.36***
		(0.018)	(0.046)	(0.016)	(0.048)
Migration Inflow	7.29***	3.98***	4.07***		
	(1.35)	(1.06)	(1.05)		
Migration Outflow	1.60	0.66	0.74		
	(1.15)	(0.89)	(0.87)		
State Dummy (PA=1)			3487**	3336	
			(1834)	(1803)	
Net Migration				0.85	0.78
				(0.86)	(0.86)
County FE	yes	yes	yes	yes	yes
Time FE	no	no	yes	yes	yes
N	1456	1456	1456	1456	1456
Adj. R^2	0.80	0.94	0.95	0.95	0.95
# of Establishments					
Fracking boom	29.5**	35***	35***	31.7***	31.8***
	(12.8)	(9.9)	(9.8)	(9.43)	(9.47)
Population		0.021***	0.02***	0.02***	0.22***
		(0.0008)	(0.0007)	(0.0006)	(0.0007)
Migration Inflow	0.12**	0.003	0.001		
	(0.06)	(0.043)	(0.04)		
Migration Outflow	0.09	0.08	0.08		
	(0.05)	0.04)	(0.04)		
State Dummy (PA=1)			294***	287***	
			(76.2)	(74.9)	
Net Migration				-0.06	-0.05
				(0.035)	(0.035)
County FE	yes	yes	yes	yes	yes
Time FE	no	no	yes	yes	yes
N	1456	1456	1456	1456	1456
Adj. R^2	0.68	0.97	0.98	0.98	0.97

Results

Average Annual Pay					
Fracking boom	2431.3***	2442.5***	2443.1***	2281.2***	2285.8***
	(559)	(561.4)	(560.7)	(440.8)	(440.9)
Population		-0.006	-0.017	1.182***	0.031
		(0.03)	(0.02)	(0.359)	(0.017)
Migration Inflow	1.28	1.52	1.6		
	(2.22)	(2.47)	(2.45)		
Migration Outflow	2.53	2.68	2.82		
	(2.12)	(2.2)	(2.2)		
State Dummy (PA=1)			3203	2905	
			(1932)	(1885)	
Net Migration				-1.278	-1.27
				(1.59)	(1.6)
County FE	yes	yes	yes	yes	yes
Time FE	no	no	yes	yes	yes
N	1456	1456	1456	1456	1456
Adj. R^2	0.30	0.30	0.36	0.343	0.34
Total Wages (in thousands)					
Fracking boom	117408***	103651***	103570***	84602***	84915***
	(33823)	(32330)	(32259)	(32356)	(32374)
Population		11.1***	10.46***	15***	15.5***
		(1.6)	(1.64)	(1.17)	(1.14)
Migration Inflow	544***	197	199		
	(143)	(144)	(144)		
Migration Outflow	480***	320**	326***		
	(130)	(127)	(126)		
State Dummy (PA=1)			200361	172240	
			(126113)	(123172)	
Net Migration				-133	-132
				(116)	(116)
County FE	yes	yes	yes	yes	yes
Time FE	no	no	yes	yes	yes
N	1456	1456	1456	1456	1456
Adj. R^2	0.77	0.87	0.87	0.88	0.87

Note: **p<0.05, ***p<0.01 Robust standard errors in parentheses.

Conclusion

- The fracking boom had a negative impact on net migration, as about thirty-seven more people moved out of the fracking counties compared to the non-producing counties. The migration trend in boom and non-boom counties differed, significant at the 1% level.

- Furthermore, the negative impact on net migration was greater in Ohio (-55 at the 1% significance level) than it was in Pennsylvania (-19 at the 5% significance level). Even though this result is statistically significant, such a small number compared to these counties' populations cannot be considered to have an economically significant impact on the socio-demographics of these counties.

- This result suggests that the shale boom did not create permanent labor migration and was responsible for only a small migration outflow.

Conclusion

- In producing counties after the shale boom, the number of employed people increased by 722 compared to non-producing counties, the number of establishments is increased by 35, total wages is increased by $103,507,000, and the average annual pay per person increased by $2,443.
- All these impacts are statistically significant at the 1% level.
- These numbers suggest that the number of jobs in producing counties was 2.4 percent higher than it was in non-producing counties, the number of establishments was 1.1 percent higher, total wages were 3 higher, and the average annual pay was 1.5 percent higher.

Conclusion

- Based on this analysis, counties that adopt these shale production methods experienced a statistically and economically significant positive marginal effect on labor market outcomes.

- The analysis reveals a small but statistically significant negative impact on migration, as shale regions have experienced some migration outflows, as discussed in some sociology literature. The labor market results are significantly larger than the negative net migration effect.

- Despite the significant labor market impact with hydrofracking, the analysis found no significant migration into the producing areas that could be attributed to shale development. On the contrary, there was a net negative migration from these sites that could be attributable to negative social impacts and people's other concerns, although shale businesses may attract commuters and temporary workers from outside.