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Regional economic impacts of the shale gas and tight oil boom: A synthetic control analysis

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ABSTRACT

The dramatic increase in oil and gas production from shale formations has led to an intense interest in its impact on local area economies. Exploration, drilling and extraction are associated with direct increases in employment and income in the energy industry, but little is known about the impacts on other parts of local economies. Increased energy sector employment and income can have positive spillover effects through increased purchases of intermediate goods and induced local spending. Negative spillover effects can occur through rising local factor and goods prices and adverse effects on the local area quality of life. Therefore, this paper examines the net economic impacts of oil and gas production from shale formations for key shale oil and gas producing areas in Arkansas, North Dakota and Pennsylvania. The synthetic control method (Abadie and Gardeazabal, 2003; Abadie et al., 2010) is used to establish a baseline projection for the local economies in the absence of increased energy development, allowing for estimation of the net regional economic effects of increased shale oil and gas production.

1. Introduction

Following decades of concerns with U.S. dependence on energy imports, a new combination of horizontal drilling and hydraulic fracturing during the previous decade led to dramatic increases in U.S. energy production. The percentage of all wells drilled horizontally increased from approximately 10% at the beginning of 2005 to over 58% by the end of 2011, and to over 67% by the middle of 2014 (Baker Hughes, Inc., 2014). Production of natural gas increased over 35% from 2005 to 2013, while the production of oil increased nearly 44% from 2005 to 2013.[2] In its 2013 Annual Energy Outlook, the U.S. Energy Information Administration (U.S. Energy Information Administration, 2013) projects a 113% increase in U.S. shale gas production by 2040, raising its share of total natural gas production from 34 to 50%. EIA projects tight oil production, which includes oil produced from "very low permeability shale, sandstone, and carbonate formations" (U.S. Energy Information Administration, 2013, page 82), to peak in 2021 at nearly triple the 2011 level. The dramatic increase and projected growing importance of unconventional oil and gas extraction has spawned intense interest in both its potential economic benefits and potential adverse impacts on local populations.

A study by IHS (2012) that was supported by the American Petroleum Institute, the Institute for 21st Century Energy, the American Chemistry Council, and the Natural Gas Supply Association, estimated the number of U.S. jobs associated with unconventional oil and gas production to be 1.7 million in 2012, projecting them to reach 3.5 million by 2035. The study was based on the use of IMPLAN, a widely used input–output economic impact modeling system. However, in a review of several studies sponsored by the energy industry that used similar methodology, Kinnaman (2011) finds the studies of economic impacts to be based on questionable assumptions that likely overstate the economic benefits of shale gas extraction: e.g., assumptions of excess supply in the economy that ignore potential crowding-out effects and a lack of economy-wide consistency in attributing exogenous impacts that lead to over counting economic impacts of energy development. In fact, Brown et al. (2013) find smaller actual economic impacts of natural gas extraction in general than reported by studies using input–output models. In addition, adverse effects on the local environment and quality of life may negatively affect agriculture and tourism (White, 2012; Lydersen, 2013) and inhibit in-migration of households, reducing population and employment growth. Input–output models and standard econometric models used in the industry-sponsored studies do not account for these potential adverse effects. Kinnaman (2011) notes the

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[2] Natural gas production data were obtained from the U.S. Energy Information Administration at http://www.eia.gov/dnav/ng/hist/n9050us2M.htm, while oil production data were obtained at http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=MCRFPUS1&f=A, both on June 13, 2014.

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paucity or near absence of relevant studies that have gone through the peer review process of an economic journal.[3]

Therefore, this study examines the net economic impacts of oil and gas production from shale formations for key energy producing areas. The areas chosen are located in the states of Arkansas, North Dakota and Pennsylvania; all three states are ranked in the top-ten oil and gas producing states by IHS (2012), but had more limited energy sector employment prior to the shale oil and gas boom, unlike states like Oklahoma and Texas. The synthetic control method (Abadie et al., 2010) (SCM) is used to establish a baseline projection for the local economies in the absence of increased shale-based energy extraction, allowing for estimation of its net regional economic effects. The estimated effects reveal the balance of potential positive economic impacts versus negative economic impacts, making SCM preferred over input–output-based studies, which by design only capture potential impacts from increases in local spending.

An advantage of SCM is transparency in constructing the counterfactual. It is a weighted-average of comparison/control units based on demonstrated affinities. In SCM no single match with all the comparable characteristics to the shale oil and gas areas is required as it is in case studies or some matching approaches. We employ permutations or randomization tests for inference which, given the problem in hand, is an improvement over standard-error-based inference in regression models. We estimate impacts for several economic outcomes, including those that are sector-specific to assess industry spillover effects. Because of geographic spillovers aggregates of counties are examined. The impacts also are only estimated for nonmetropolitan counties because of the likely greater difficulty in identifying treatment effects in much larger economies. The impacts are first estimated for all nonmetropolitan oil and gas counties in each state. Then to capture potential broader geographic spillovers the impacts are estimated for all nonmetropolitan counties in each state. Subsets of oil and gas counties also are examined to assess whether there is variation related to the intensity of energy extraction in the area.

The next section discusses the potential channels of influence, both positive and negative, of unconventional oil and gas extraction on the regional economy. In so doing, key findings of related studies are presented and critiqued. Section 3 presents the empirical approach, including a description of the use of the synthetic control method, variable selection, and data sources. The results are presented and discussed in Section 4. The results suggest there are significantly positive benefits across nonmetropolitan North Dakota oil and gas counties for a wide range of regional economic measures. There are limited geographic spillovers, however, from the oil and gas counties to other North Dakota nonmetropolitan counties. Significantly positive effects are found in some of the employment measures for only a subset of Arkansas oil and gas producing counties, while no effects are found for Pennsylvania, including for subsets of its oil and gas producing counties. Back of the envelope calculations of likely wage and salary employment multipliers suggest that actual multiplier effects of shale oil and gas extraction likely fall well below estimates produced by input–output models. Section 5 contains summary statements and conclusions.

2. Unconventional gas and oil development and the local economy

Exploration, drilling and extraction of unconventional gas and oil are associated with direct increases in employment and income in the industry. Increased energy sector activity can have positive local spillover effects through increased firm purchases of locally-produced goods and services from other sectors (intermediate goods and services) and increased local spending by energy sector workers. Yet, negative spillover effects can occur through rising local factor and goods prices associated with increased local demand and adverse effects on the local area quality of life (White, 2012; Lydersen, 2013).

Industry sponsored studies of the economic impacts of unconventional gas and oil activities focus on the positive spillover effects, using tools that are designed to solely capture the positive spending effects (Kinnaman, 2011). Using the IMPLAN input–output model and its own database on trade flows, IHS (2012) estimates that over 1.2 million jobs were created during 2012 in unconventional gas and oil producing states, ranging from 576,000 in Texas to 33,000 in Arkansas. For the two other states of interest in this study, over 100,000 jobs are estimated to be created in Pennsylvania and over 70,000 in North Dakota. Over the forecast period, on average across the states only 20% of total estimated job gains are estimated by IHS to be direct, implying an employment multiplier of 5.

Using the IMPLAN model and adjusting it with survey data, Considine et al. (2009) estimate that over 29,000 jobs were created in Pennsylvania during 2008 by unconventional oil and gas activity. Considine et al. (2010) updated the earlier study to estimate that over 44,000 Pennsylvania jobs were created in 2009 by unconventional oil and gas activity. Kinnaman (2011) questions the assumptions of the study: 1) that all lease and royalty payments are spent in Pennsylvania the year they are received; and 2) that 95% of all direct expenses occur in Pennsylvania. It also is not clear whether the payments should be entered in the input–output model as direct payments, as it appears from the descriptions in the studies, because the IMPLAN SAM may already account for them when the energy sector is directly stimulated, which would lead to double counting.

To be sure, Kelsey et al. (2009) reported that 37% of workers in shale gas development in Pennsylvania were out-of-state residents, while landowners saved about 55% of their royalties/lease payments. Thus, they estimated total job impacts to be in the range of 23 to 24,000 in 2009. They report an output multiplier of approximately 1.9.

Similarly, using the IMPLAN model and an industry survey, Center for Business and Economic Research (2008) of the University of Arkansas estimated total job impacts of nearly 10,000 in Arkansas during 2007 from production in the Fayetteville shale play. The total employment impact projections for 2008–2012 ranged between 11 and 12,000. Employment multipliers across the years are in the range of 2.5–2.64.

Other research suggests that input–output models overstate the economic impacts of export-based activity in general. For example, Edmiston (2004) finds that input–output models overstated the multiplier effects of large new manufacturing plants. Computable general equilibrium (CGE) analysis of Harrigan and McGregor (1989) and Rickman (1992) suggest that the general overstatement of multiplier effects by input–output models relates to the absence of prices in the models and implicit assumptions of perfectly elastic supply. In CGE models with less than perfectly elastic supply, increased direct economic activity places upward pressure on prices, making other industries less competitive and reducing demand. This offsets the positive spillover effects from increased intermediate purchases and induced spending captured by input–output models. This is a phenomenon often noted in the resource curse literature (see footnote 2) and is very possible in some areas where unconventional oil and gas extraction is occurring.

Adverse effects on the natural environment and local quality of life also can offset economic gains associated with energy development, both to area resident well-being and to economic growth through negative feedback effects on tourism and migration. A number of potential risks to the local areas have been identified in the literature (Lipscomb et al., 2012; Rahm, 2011; White, 2012; Atkin, 2014): contamination of ground water, accidental chemical spills, reduction in air quality (e.g., dust, diesel fumes), noise, land footprint

[3] Numerous studies have examined whether there is a resource curse in the United States (e.g., Black et al., 2005; Papyrakis and Gerlagh, 2007; James and Aadland, 2011; Michaels, 2011; Douglas and Walker, 2012), but they are focused on energy development in regions broadly, where fluctuations in energy prices and other long-term trends related to energy development in the local areas would make it difficult to interpret the findings as related to the effects of unconventional energy extraction. The time periods of analysis in resource curse studies also typically are longer and not restricted to the period when unconventional energy development greatly accelerated.