Shale and the US Economy: Three Counterfactuals

Arora, Vipin

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Vipin Arora[2]

Abstract

I use three different—and simple—counterfactuals to approximate the real GDP and employment effects of US oil and gas production from shale over the 2011 to 2015 period. Real GDP growth would have been 0.7 to 0.2 percentage points lower on average each year over that period without such increases; employment growth 0.5 to 0.1 percentage points lower.

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[1] The analysis and conclusions expressed here are those of the author and not necessarily those of any affiliated organizations.

[2] Email: arora.vk13@gmail.com.

Introduction

Like food or sports, US oil and gas production from shale is a sure-fire conversation starter. People have strongly held views on everything associated with shale—from the reason for technological breakthroughs to environmental impacts. The macroeconomic implications are no different: it appears that US shale either saved the economy, or else did very little. Most of the corresponding studies attempt to separate out economic effects—estimating jobs created, dollars spent, or additional value added from oil and gas production. Few ask "What if": what if oil and gas production from shale had not increased?

In this paper I study such a counterfactual. I use three distinct—and relatively simple—methods to estimate what real GDP and employment growth may have been without the technical breakthroughs that spurred the American oil and gas sector. The results indicate that real GDP growth would have been between 0.7 and 0.2 percentage points lower on average each year over that period. Employment growth would have been 0.5 to 0.1 percentage points lower.

The primary advantage of using counterfactual analysis is estimation of net benefits or losses—the gains or declines in economic activity without higher oil and gas production relative to what actually happened. Standard analyses of the shale boom, in contrast, are about quantifying the economic impacts of the higher production and are silent on alternative scenarios.

A major issue with counterfactuals, particularly in assessing economy-wide implications, is defining what they should be. The other—insurmountable—problem is the need to have a picture of the US economy without higher oil and gas production. While assuming lower production is simple, many other parts of the economy not directly related to extraction also adjusted, and it is impossible to model all of the changes. For both of these reasons I use three different counterfactual definitions throughout the paper.

There are many studies related to shale and the US economy. These differ among various dimensions: level of analysis (international, US, state and local); methods (econometric, equilibrium, input-output); time-frame (forecasts, historical); fuel (oil, gas); and the measure of interest (real GDP, employment, consumer surplus, stock market capitalization, welfare, producer surplus).[3] Most focus on quantifying what happened or extrapolating what happened to the future.

The counterfactuals I generate in this paper are different, in that they quantify the economic effects by assuming certain rules-of-thumb related to oil and gas production were in-line with historical estimates from 2011 to 2015. While all of the counterfactuals leave out important facets of the shale phenomenon and changes in the economy for simplicity, they provide insight on how the oil and gas sector may have affected the economy over this period.

The first—contributions—takes real GDP growth in the years between 2011 and 2015 and removes the contributions to real GDP growth from the oil and gas extraction sector. These are replaced with the average historical contributions from that sector, which are much smaller.

[3] See for example Arora (2014) and the references therein; CBO (2014); EMF (2013); Feyrer et al. (2017); Hausman and Kellogg (2015); and Mason et al (2015).

Next is the constant shares counterfactual. Here, I assume that the share of GDP accounted for by the oil and gas extraction industry remains at historical averages between 2011 and 2015. As with the first method, the historical values are substantially smaller than the actual ones.

Finally, I also use two different macroeconomic models to estimate impacts. The only changes I make in the models is to remove historical oil and gas production values and replace them with projections from the Energy Information Administration's (EIA's) Annual Energy Outlook 2011 (AEO2011), and to slightly reduce investment. AEO2011 projections are the most relevant for these counterfactual scenarios because they were released early in 2011.

With these real GDP estimates in hand, I then use a variant of Okun's Law—a historically estimated relationship between employment and output—to back out the employment impacts from each counterfactual.

The contributions method—the one showing the smallest effects—estimates that real GDP growth would have averaged 1.9%/year between 2011 and 2015, slightly below the actual rate of 2.1%/year. The constant shares method shows the largest effects, estimating that real GDP growth would have averaged 1.4%/year instead. Employment growth shows the same trends: 0.9%/year for the contributions method and 0.5%/year for constant shares, versus 1%/year for the simulated actuals. Results from the third method—macroeconomic model simulations—fall in-between the other two for both real GDP and employment.

Methods and Data

I use three different—and simple—approaches to approximate the economic effects of oil and gas production from shale in the United States between 2011 and 2015.

Contributions

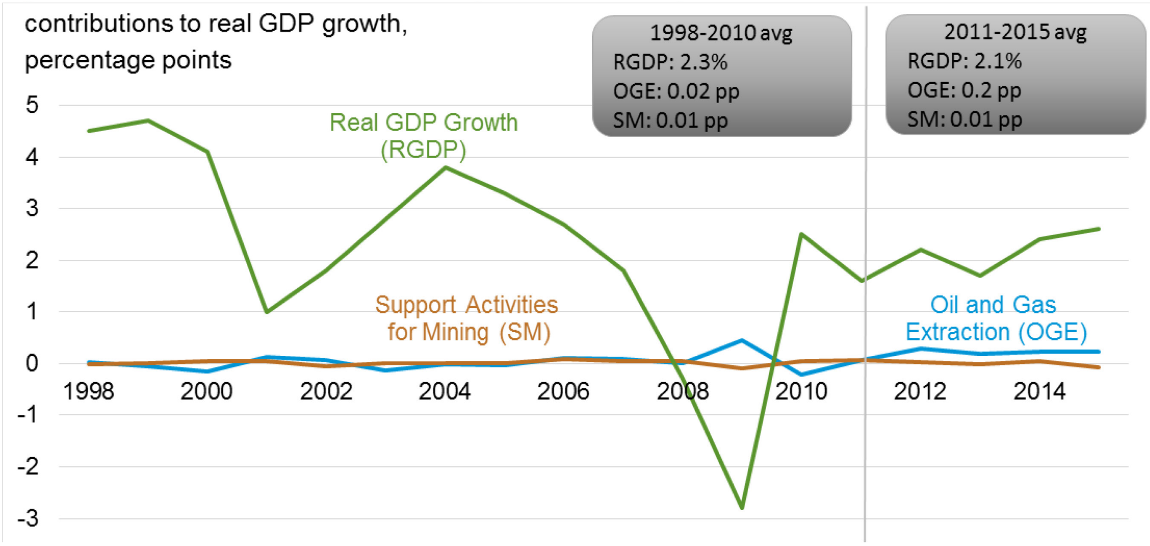
I consider the first approach—based on contributions to real GDP growth—to be a lower bound on potential economic impacts. I take real GDP growth in the years between 2011 and 2015 and subtract contributions from the oil and gas extraction and mining support sectors. These are replaced with the average historical contributions from those sectors.

To arrive at my estimate, I use the GDP-by-industry accounts of the U.S. Bureau of Economic Analysis (BEA).[4] Within these accounts there is a table labeled "Contributions to Percent Change in Real Gross Domestic Product by Industry" that quantifies how much each sector contributed to real U.S. GDP growth.

From the table I extract the contributions of oil and gas extraction and support activities for mining to real GDP growth since 1998 (the earliest available). On average, these two sectors contributed about 0.08 percentage points to real GDP growth from 1998-2015. However, the value was much higher over the 2011-2015 period, at 0.21, and much lower between 1998 and 2010, at 0.03 percentage points (Figure 1).

[4] See https://www.bea.gov/industry/gdpbyind_data.htm.

Figure 1: Contributions to real US GDP growth in select years



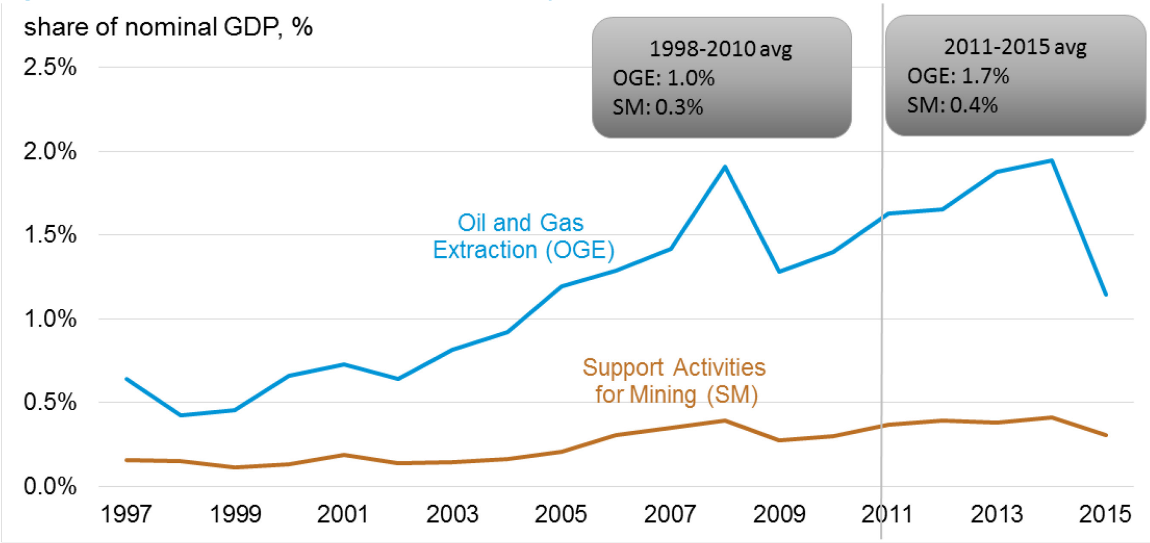
To calculate what real GDP growth may have been without greater oil and gas production, I first subtract the average contributions of oil and gas extraction and mining support from 2011-2015 from real GDP growth. I then add back in the average historical contributions (1998-2010) for these sectors. For example, real GDP grew 1.6% in 2011; using this method I calculate the adjusted growth rate—based on historical contributions—to be 1.42% (1.6-0.21+0.03 = 1.42).

Constant Shares

The second method also relies on the BEA's GDP-by-industry accounts. Here, I assume that the share of nominal GDP due to oil and gas extraction and support activities for mining stays at its long run average between 2011 and 2015. I can then calculate the difference from the actual value, subtract this from nominal GDP, and then convert the value to real terms to get a counterfactual estimate for the economic impacts.

The BEA accounts show that oil and gas extraction and support activities for mining accounted for about 1.2% of nominal U.S. GDP from 1997-2010 (Figure 2). This rose to just above 2% from 2011-2015.

Figure 2: Shares of nominal US GDP in select years



To get an estimate of economic impacts I assume that the share of nominal GDP stayed constant at 1.2%, about 0.8 percentage points lower than the average for 2011-2015. This 0.8 percentage point difference is my estimate of the economic benefits of increased oil and gas production. For example, this is about 128 billion dollars in 2011 (0.008*nominal GDP in 2011), 133 billion in 2012, and so on.

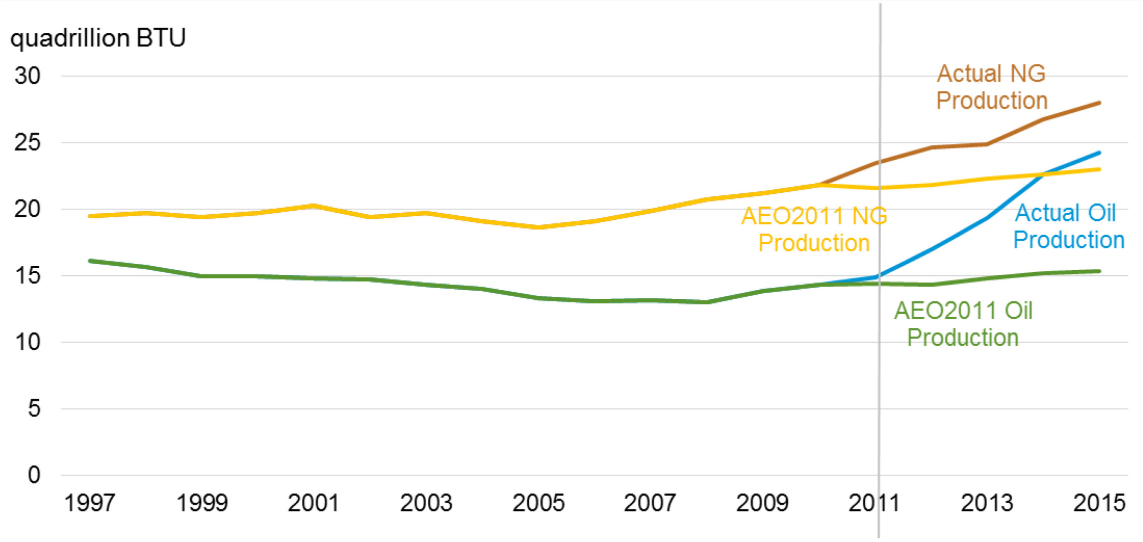
I then adjust these values for inflation using weighted price indices for oil and gas extraction and mining support, also available from the BEA's GDP-by-industry accounts. The final step is to subtract this amount from actual real GDP.[5]

Macroeconomic Models

The third method uses macroeconometric models to estimate economic impacts. I assume in each simulation that US oil and natural gas production from 2011-2015 is the same value as projected in AEO2011 (Figure 3).

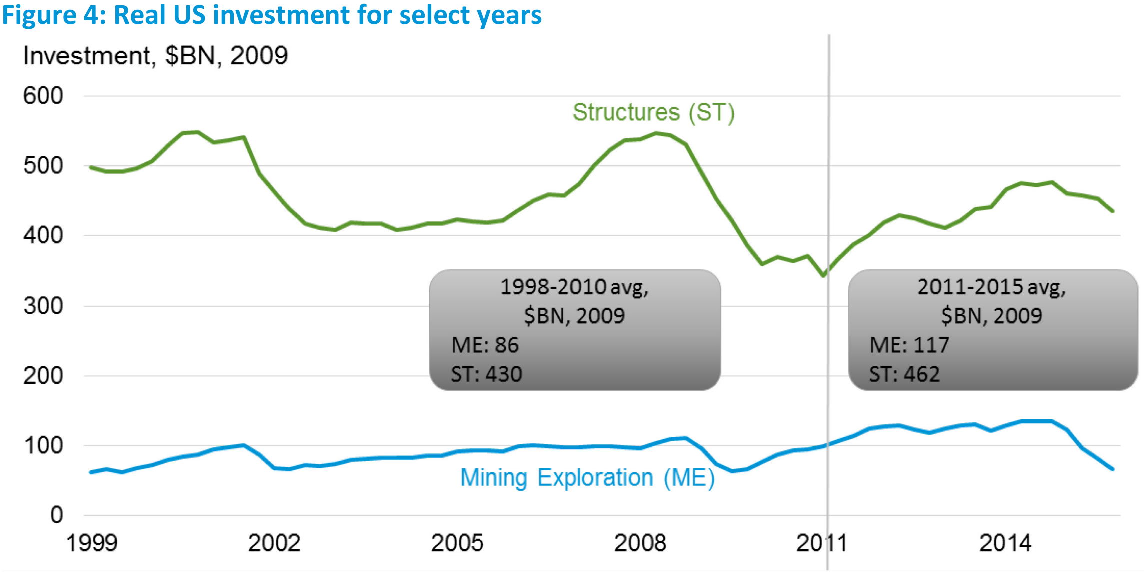
[5] I could have used the GDP deflator here instead of weighted indices from the mining sector to convert from nominal to real. I believe the detailed price indices are a better option given the volatility in output prices from the mining sector over the 2011-2015 period, as compared with the relative stability of the GDP deflator.

Figure 3: Actual and projected US oil and natural gas production from AEO2011 for select years



I also reduce total private fixed investment in the models between 2011 and 2015 by 31 billion each year. This reduction is the average amount that investment in mining exploration, shafts, and wells exceeded its historical average (1999-2010) during the 2011 to 2015 period (Figure 4). The investment values are all taken from the BEA's National Income and Product Accounts.[6]

Figure 4: Real US investment for select years



The two macroeconomic models I use in the simulation have been commercially available for many years—from Oxford Economics and IHS/Markit. Both are demand-driven in the short-run and supply constrained in the long-run. The Oxford model is fully global, while the IHS/Markit model is US-only.[7]

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[6] See https://www.bea.gov/iTable/index_nipa.cfm.

[7] The model baselines I use rely on data through early-2017 for all of the US economy (besides the adjustments to oil and gas production and investment).

Employment
The three methods described above all provide estimates in terms of real GDP—both growth rates and levels. To get employment figures that correspond with those numbers I use a variant of Okun's Law—a historically estimated relationship between employment and output.[8]

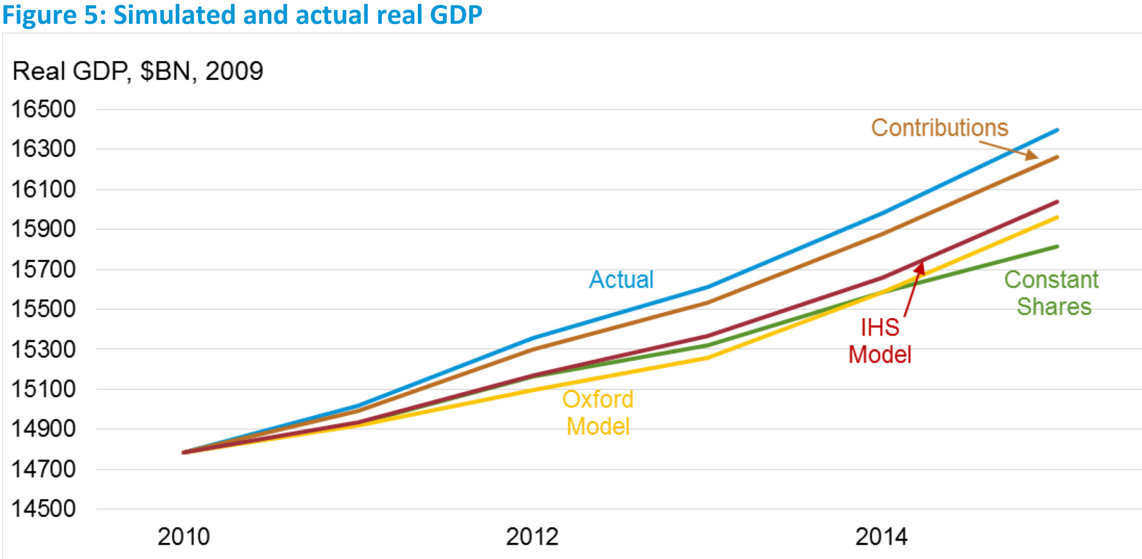
I first regress total non-farm employment on real GDP from 1948 to 2010—an estimate of Okun's equation. I then use that equation to forecast employment from 2011 through 2015 by substituting in the level of real GDP from each of the three methods above, as well as actual real GDP. Instead of using actual employment values to compare against, I use simulated actual values—employment forecasts from the estimated version of Okun's Law based upon actual real GDP.

Results
The results for real GDP are shown in Figure 5 (levels) and Figure 6 (growth rates), while those for employment are in Figure 7 (levels) and Figure 8 (growth rates). A summary of all results is presented in Table 1.

The general pattern is that the contributions methods shows the smallest benefits of increased oil and gas production over the 2011 to 2015 period, while constant shares has the largest. Both macroeconomic models are in the middle.

Using the contributions method, the level of real US GDP is about 0.8% lower in 2015 than the actual value (Figure 5). The constant shares method, in contrast, lowers the level of real GDP 3.5% below the actual value by 2015. The two macroeconomic models show real GDP effects 2.2% or 2.7% below actual in 2015.

Figure 5: Simulated and actual real GDP



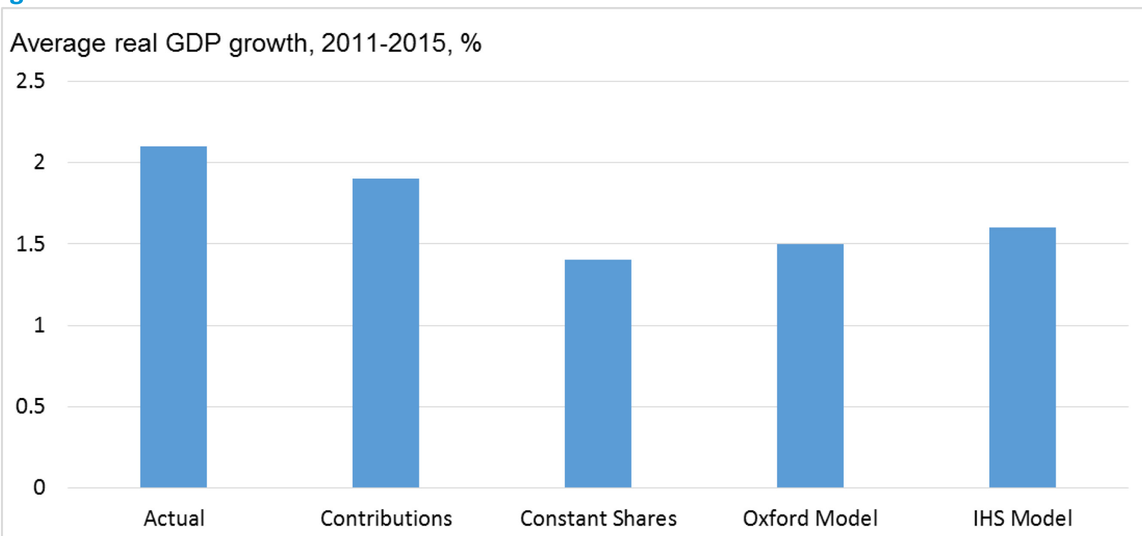
In terms of real GDP growth, contributions reduces the average from 2011 to 2015 to 1.9%, down from the actual value of 2.1%—shaving almost a tenth off of real GDP growth (Figure 6).

[8] See Ball et al. (2016).

Keeping these sectors at their constant share lowers average real GDP growth between 2011 and 2015 to 1.4%—well below the actual value of 2.1%. The two macroeconomic models have average annual growth of 1.5% and 1.6% in those years under this scenario.

The numbers for the contributions method are almost certainly a lower bound on the potential economic impacts, as I have ignored any multiplier effects oil and gas production have had throughout the rest of the supply chain. I have also excluded the potential benefits of lower input costs for oil and natural gas users, and much of the investment related to increasing oil and gas production—from railroads to pipelines.

Figure 6: Simulated and actual real GDP



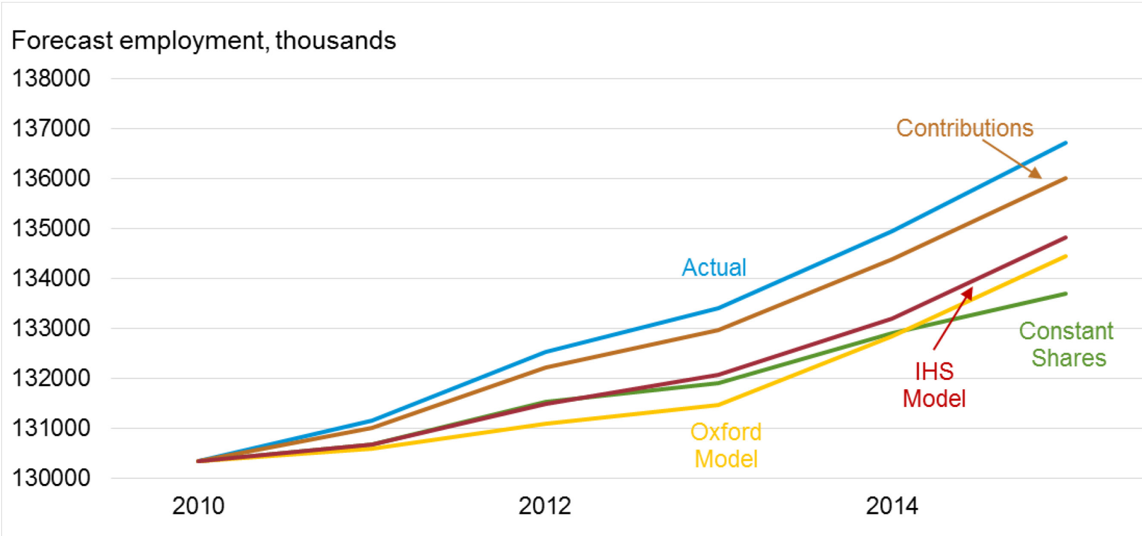
Why is the constant shares estimate so much larger than just looking at contributions to real GDP growth or the macroeconomic models? Most important is probably the fact that it assumes any value added accounted for by oil and gas extraction and mining support above and beyond the long-run average is gone from the economy. While this is unrealistic and makes the impacts appear larger than they actually are, this method still does not account for any multiplier effects that increased oil and gas production have had on other sectors. I am unsure which is larger.

Table 1: Result summary

Method	Average real GDP growth %, 2011-2015 (Actual = 2.1)	Percent real GDP below actual in 2015	Average employment growth %, 2011-2015 (Sim Actual = 1)	Percent employment below sim actual in 2015
Contributions	1.9	0.8	0.9	0.5
Constant share	1.4	3.5	0.5	2.2
Oxford	1.5	2.7	0.6	1.7
IHS/Markit	1.6	2.2	0.7	1.4

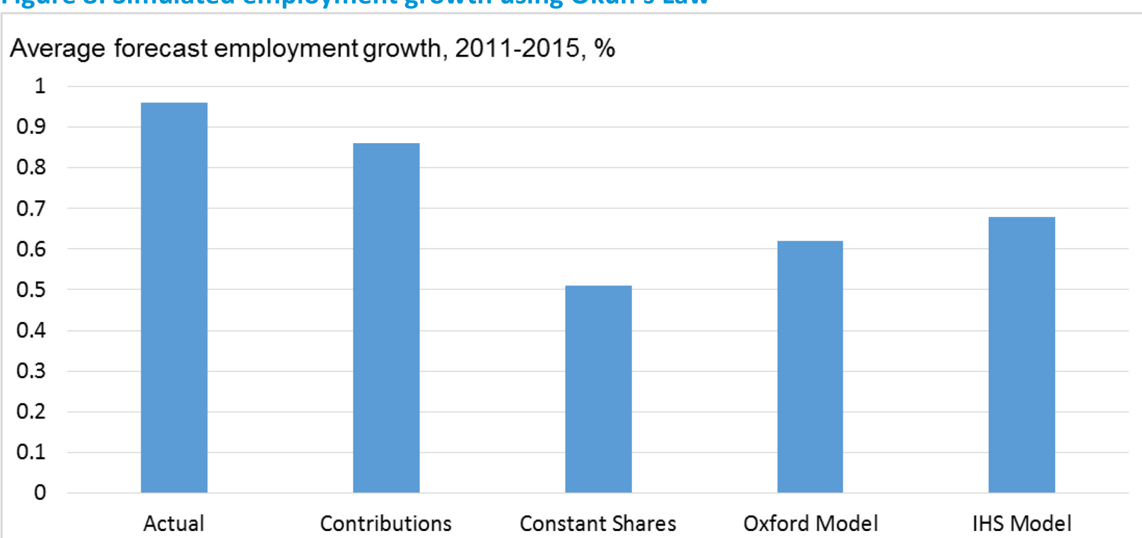
The employment numbers are consistent with those of real GDP: the constant share method finds that shale had the largest benefits, while contributions finds it to have the least. In terms of the level of employment in 2015, contributions is 0.5% below the actual, while constant shares is 2.2% lower (Figure 7).

Figure 7: Simulated employment using Okun's Law



For employment growth, the constant shares method estimates that it would have only been 0.5% per year between 2011 and 2015 if oil and gas production had not increased (Figure 8). The contributions method estimates that employment growth would have been 0.9% per year in this case, close to the simulated actual value of 1%.

Figure 8: Simulated employment growth using Okun's Law



As with real GDP, the macroeconomic models are in-between the other two methods. The Oxford model results are closer to the constant shares ones (0.6%), whereas the IHS/Markit model is almost directly between constant shares and contributions (0.7%).

Conclusion

'If you ask me a question I don't know,' Yogi Berra once quipped, 'I'm not going to answer.' This is a common reaction when asking counterfactual questions, one I try to avoid in this paper. Rather, I ask: What if US oil and gas production from shale had not increased?

Throughout the paper I have mentioned so-called multiplier effects from oil and gas production. The multipliers I am referring to are the additional economic gains outside of the oil and gas sector due to greater production from shale. These concentrate mainly in the oil and gas supply chain—think drilling equipment, trucks, or any important input to the extraction process—but also include restaurants, retail, and even railroads.

This multiplier effect on other industries of an extra dollar of oil and gas output is quantified by the BEA in a total requirements coefficient. These are available every year in the BEA's industry accounts for the mining sector.[9] Interestingly, the value of such coefficients for the mining sector has steadily decreased since the late-1990s, meaning that an additional dollars' worth of output in the mining sector has led to less spending outside of it over time. The economy is getting less bang for its mining buck.

The same basic story holds when looking at the mining sector's input to other industries. When another industry produces an additional dollar's worth of output, it often uses mining sector products such as oil. The input coefficient associated with mining in many industries—chemicals and transportation, to name a couple—has either stayed flat or decreased over time.

Taken together, the fact that both input and output requirements coefficients associated with the mining sector have not increased means that the multiplier effects are no larger than they were 20 years ago. So any changes in the economic effects of oil and gas production from shale are due to the large increases in output, not to changes in transmission through the supply chain. I believe it also means the macro-focused counterfactuals I have used above are appropriate to the task.

Although I believe the counterfactuals to be appropriate, throughout the paper I have emphasized their limitations—particularly the difficulty in constructing a 'what if' case with all of the changes that took place between 2011 and 2015. Even with this major caveat, I still believe employing such counterfactuals is a useful exercise.

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