1 What is Fracking?

1.1 Definition of Fracking

Def: A method of unconventional oil and gas development that involves injecting pressurized liquid, materials, and proppants into a bore in order ot stimulate well production.

1.1.1 Unconventional Oil

1. 20% were formed in the Cenozoic age
   (a) 65 million years ago
2. 10% were formed in the Paleozoic age
   (a) 541 to 252 million years ago
3. 70% of oil deposits existing today were formed in the Mesozoic age
   (a) 252 to 66 million years ago
   (b) transistion from desert to a tropical climate,
      i. with large amounts of plankton in the ocean.
   (c) significant tectonic, climate and evolutionary activity.
      i. gradual rifting of the supercontinent Pangaea into separate landmasses that would move into their current positions during the next era.
      ii. The climate of the Mesozoic was varied, alternating between warming and cooling periods.
      iii. Overall, however, the Earth was hotter than it is today.
      iv. Dinosaurs first appeared in the Mid-Triassic,
         A. and became the dominant terrestrial vertebrates in the Late Triassic or Early Jurassic,
         B. occupying this position for about 150 or 135 million years until their demise at the end of the Cretaceous.
         C. the first mammals also appeared during the Mesozoic, but would remain smallless than 15 kg (33 lb)until the Cenozoic.

1.2 History of Fracking

1. The Battle of Fredericksburg, Virginia (December 1115, 1862)

   > Battle of Fredericksburg: the Army of the Potomac crossing the Rappahannock River in the morning of December 13, 1862, by Kurz and Allison (1888)

   (a) North was loosing confidence and Lincoln need a win.
      i. Confederate armies had been on the move earlier in the fall, invading Kentucky and Maryland, and although each had been turned back, those armies remained intact and capable of further action.
   (b) Convinced Maj. Gen. Ambrose E. Burnside to replace Maj. Gen. George B. McClellan as commander of the Army of the Potomac in Virginia.
      i. Burnside's Plan
         A. feigning a movement on Culpeper Court House, Orange Court House, or Gordonsville.
         B. Then rapidly shift his army southeast and cross the Rappahannock River to Fredericksburg,
         C. surprise Robert E. Lee
      ii. Plan didn't work
         A. not entirely Burnside's fault as bureaucracy held up the pontoons
         B. but still ill-conceived as it relied on speed and deception
   (c) The outcome
      i. Futile frontal attacks on December 13 against entrenched Confederate defenders on the heights behind the city.

ii. remembered as one of the most one-sided battles of the war,
A. Union casualties more than 2-1
B. A visitor to the battlefield described the battle to U.S. President Abraham Lincoln as a "butchery.

2. Colonel Edward A. L. Roberts
   (a) lieutenant colonel in the 28th New Jersey Volunteer Infantry
      i. in the Right Grand Division of Burnside's Army of the Potomac.
      ii. had been court-martialed for "intoxication on dress parade" in November and was waiting for the results from the military court.
   (b) assumed command after commander was shot in the face.
      i. "We went into action under a most galling and deadly fire of shot and shell, and continued in action until near dark. Officers and men conducted themselves well.
   (c) A month later, the court martial found him guilty and he was cashiered in January of 1863
3. The Exploding Torpedo
   (a) Roberts had noticed shells falling in the canal transferred the force of their underwater explosions sideways
      i. transformed his observation into what he described as"superincumbent fluid tamping.
   (b) He received the first of his many patents for an"Improvement in Exploding Torpedoes in Artesian Wells on April 25, 1865.
      i. torpedo or bomb was lowered down the well to a desired depth. The
      ii. 15-20lbs of gunpowder (later nitroglycerin).
      iii. borehole filled with water to concentrate the concussion and more efficiently fracture surrounding oil strata.
      $\Rightarrow$ "fluid tamping
   (c) Founded Roberts Petroleum Torpedo Company.
      i. Roberts charged $100-200 per torpedo & a royalty amounting to 1/15 of the increased oil production
         A. $1,540.53 in today's dollarsa
      ii. To avoid paying the exorbitant fees, an owner of a well would often hire men who illegally produced their own torpedoes and used them at nightthe practice giving rise to term"moonlighting".
      iii. Roberts spent $250,000 to protect his patent from the "moonlighters" by hiring the Pinkerton National Detective Agency and filing numerous lawsuits.
         A. $3.85 million today
   (d) Roberts' torpedo patents expired in 1879.

first hydraulic fracturing experiment,

1. conducted in 1947 at the Hugoton gas field in southwestern Kansas by Stanolind
2. 1,000 US gallons of gelled gasoline (essentially napalm) and sand
3. did not work well

The modern slickwater frack

1. In 1997, Nick Steinsberger, an engineer of Mitchell Energy (now part of Devon Energy), applied the slickwater fracturing technique, using more water and higher pump pressure than previous fracturing techniques, in the Barnett Shale of north Texas.
2. In 1998, the new technique proved to be successful when the first 90 days gas production from the well called S.H. Griffin No. 3 exceeded production of any of the company's previous wells
3. This new completion technique made gas extraction widely economical in the Barnett Shale, and was later applied to other shales, including the Eagle Ford and Bakken Shale
4. George P. Mitchell has been called the "father of fracking" because of his role in applying it in shales
5. The first horizontal well in the Barnett Shale was drilled in 1991, but was not widely done in the Barnett until it was demonstrated that gas could be economically extracted from vertical wells in the Barnett

Mitchell Philanthropy

1. The Cynthia and George Mitchell Foundation
   (a) supports programs for the efficient and wise use of Earth's resources.[24]
   (b) $400 million in grants to causes, programs, and institutions.
      i. science,
      ii. environmental sustainability, and
      iii. sustainability science-related fields,
      iv. current grant-making programs focus on clean energy, water, and natural gas sustainability.
2. The Woodlands Conference series and the International George and Cynthia Mitchell Prize, both dedicated to sustainable development.
3. underwrote the National Academies' Our Common Journey: A Transition Toward Sustainability,
   (a) 1999 report that defined the role of science and technology in moving toward sustainability.
   (b) As a follow-up to Our Common Journey, Mitchell donated $20 million to create the George and Cynthia Mitchell Endowment for Sustainability Science at the National Academy of Sciences committed to advancing science and technology in support of sustainable development.
4. founded the Houston Advanced Research Center
   (a) explores strategies for sustainable development at the regional level.
   (b) donated $25 million to the Endowment for Regional Sustainability Science to support HARC's work in sustainability science.
5. donations totaling nearly $100 million to Texas A&M– $55 million to University Physics department
   (a) two new buildings
      i. The George P. and Cynthia W. Mitchell Fundamental Physics and Astronomy Building and the
      ii. George P. Mitchell Physics Building. In 2012, he committed an additional
   (b) Mitchell Institute for Fundamental Physics and Astronomy.
   (c) supported Giant Magellan Telescope project, t
6. Texas A&M University at Galveston Marine Sciences Program

The oil boom

1. horizontal drilling, hydrofracturing, and three-dimensional seismic imaging.
2. High natural gas prices enabled some firms to risk experimenting with the new technique.
3. In 2000, the amount of fuel pro- duced from vertically drilled wells greatly exceeded that from horizontal wells

1.3 Frack Jobs

1.4 Fracking Bans

2 The Benefits of Fracking

We track the geographic and temporal propagation of local economic shocks from new oil and gas production generated by hydrofracturing. Each million dollars of new production produces $80,000 in wage income and $132,000 in royalty and business income within a county. Within 100 miles, one million dollars of new production generates $257,000 in wages and $286,000 in royalty and business income. Roughly two-thirds of the wage income increase persists for two years. Assuming no general equilibrium effects, new extraction increased aggregate US employment by as many as 640,000, and decreased the unemployment rate by 0.43 during the Great Recession.

Within a 100-mile radius, each million dollars in new production is associated with wage increases of $257,000 and 2.13 jobs, about three times as large as the effects at the county level. Each million dollars also generates almost $286,000 in royalty payments and increased business income within a 100-mile radius. Overall, we conclude that 54 percent of the value of new production shows up in households within

h the lags. The first panel of Figure 4 shows the impulse response for BLS wage income, IRS other income, and the sum of the two for a one-unit shock.44 We see two general patterns. First, for the BLS data the impact gets smaller over the next two years but is still significant two full years after new production occurs. Each $1 of new production generates a wage increase of 0.27 in the initial year that shrinks to 0.17 two years later. After two years, we find that two-thirds of the initial effect persists. Second, for the IRS royalty and business income the large 0.30 impact in the first year is completely wiped out by a negative coefficient in the first lag. This suggests that this income boost is a one-year affair. There may be two reasons why we see fleeting effects. First, Newell, Prest, and Vissing (2016) show that there is steep decline in production after a well opens. Only 12 months after the start of production the median well is producing about 40 percent of the initial peak and, by 24 months, less than 25 percent. Second, some of the royalty income may come in the form of bonus payments which will occur before production begins, further tilting the impact toward the initial date of production. Summing the IRS and BLS data, we see fairly modest impacts two years after new production.

Government wages sees the largest increase in the year after new production. The hospitality indus- try, finance, and business services collectively see very small increases in wages in the initial year of production but increasing income over the next two years. These delayed increases in nonmining wages may reflect consumption smoothing and a ramp

Panel A decomposes the contemporaneous income gains from new production combining the IRS and BLS income results over various distances. Panel B sums the effect over three years using the estimates from our main results. See text for details

3 The Costs of Fracking

Only 2 of the consensus risks identified by the experts are unique to the shale gas development process, and both have potential impacts on surface water. The remaining 10 consensus risks relate to practices common to gas and oil development in general, such as the construction of roads, well pads, and pipelines and the potential for leaks in casing and cementing.

Figure 4. Severity-Probability Scores for High-priority Accident Pathways by Group Light gray: 4.05.9 percent of sample. Medium gray: 6.07.9 percent of sample. Dark gray: 8.0 percent or more of sample.

- The net cost associated with air emissions from hydraulic fracturing is $17.5 billion per year with a range from $9.76 billion to $25.9 billion.
- Habitat fragmentation damages amounts to $4.11 billion (range of$3.5 billion to $4.45 billion).
- Groundwater pollution of private drinking water wells due to surface spills at the well pad and infrastructure was estimated at $1 billion (range of $0.5 to $1.6 billion). There was insufficient data to estimate the effects of underground contamination from hydraulic fracturing wells themselves on drinking water wells.
- There is also opportunity costs associated with the quantity of water used in drilling and reduced residential property value losses that to- gether amount to about one-quarter of a billion dollars.
- Since a substantial amount of the hydraulic fracturing occurs in sparsely settled regions (e.g., northeastern Utah, Wyoming, western North Dakota) or predominantly rural areas, only a fraction of the U.S. population bears the environmental costs of fracturing but the benefits are spread throughout the U.S.

4 Conclusion