Learning Where to Drill

Drilling Decisions and Geological Quality in the Haynesville Shale

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Increasing output per well in shale

- Learning *how* to drill better
  - Firms learn about the production process
  - Learning makes all locations produce more
  - ***Technology vanquishes Malthus***

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- Changing *where* we drill
  - Today we focus on locations with better geology...
  - ...but tomorrow we're stuck with worse locations
  - ***Wells can't all be above average***
- *Fracking's Secret Problem—Oil Wells Aren't Producing as Much as Forecast* (WSJ: Jan 2, 2019)

Where firms choose to drill matters

- Production data doesn't come from random wells
- Firms are more likely to drill better geology
  1) We can't observe what firms believe about geology
  2) How firms choose where to drill changes over time
     a) Prices
     b) Mineral lease expirations
     c) Learning about geology
- "Selection on unobservables"
- Ignoring selection & extrapolating past productivity to future implies
  1) Overestimation of technology
  2) Overestimation of supply
- Accounting for geology in Covert (2015), Montgomery and O'Sullivan (2017), Smith (2017), and Smith and Lee (2017)

Research questions

- Are firms learning about *where* to drill, not just *how* to drill?
- Once firms hold leases by production, do they switch to better locations?
- In short run, do learning & lease expirations cause increases in aggregate output/well?
- In the long, run will depletion of sweet-spots cause decreases?

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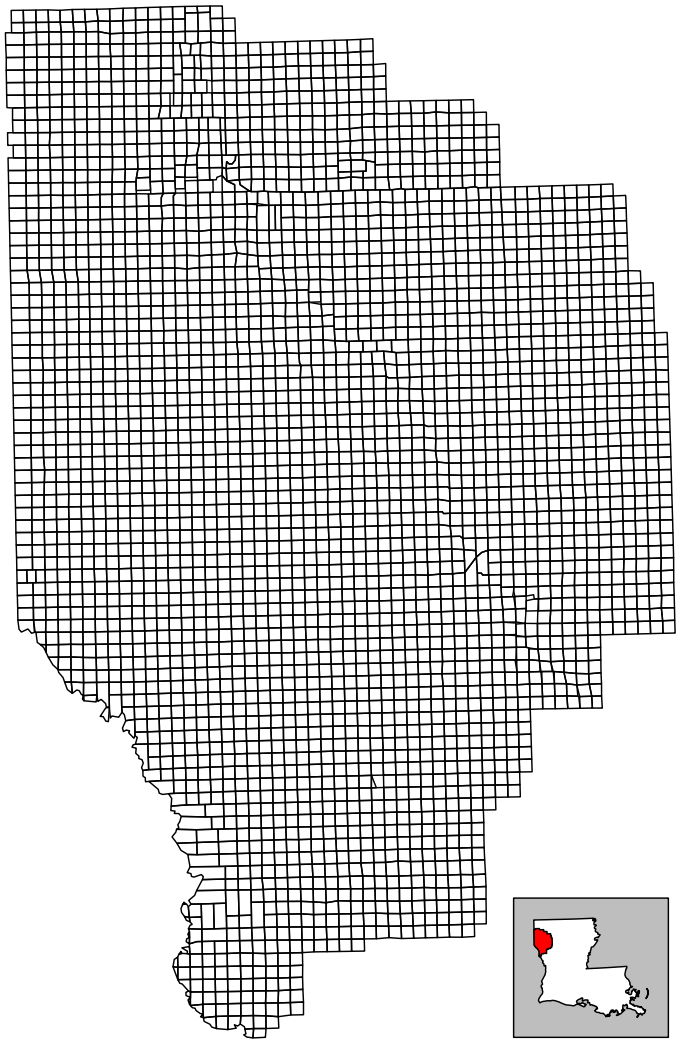
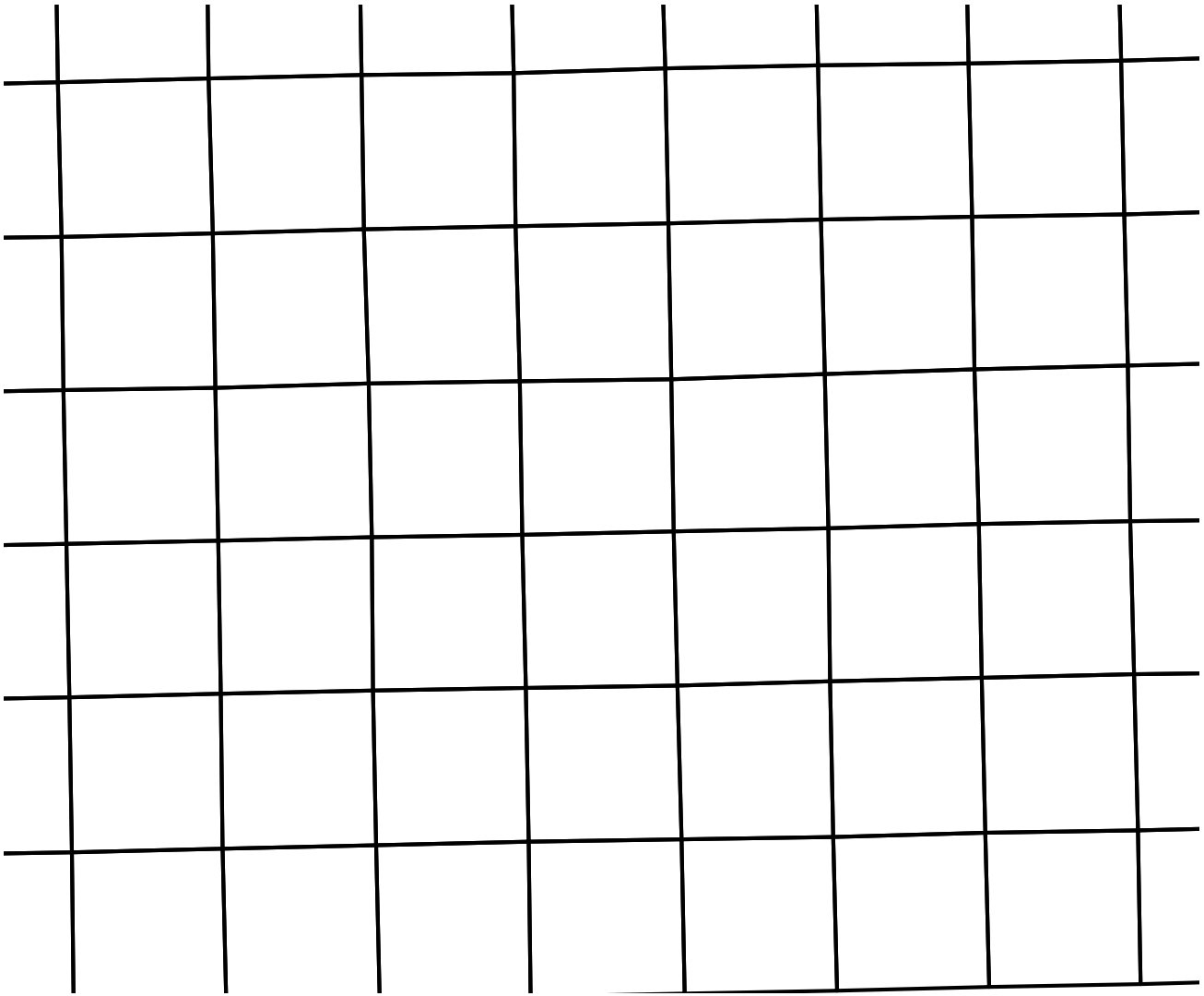
- Production
  - Multiple wells measure unobserved quality

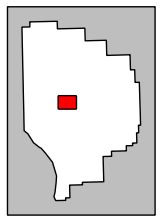
Unit of observation: 1 sq mi section

- Louisiana's Haynesville shale (2003–2016)
- Unit of observation: 1 sq. mile section
- All parties in a section must participate in each well
- Reveals which wells are *not* drilled

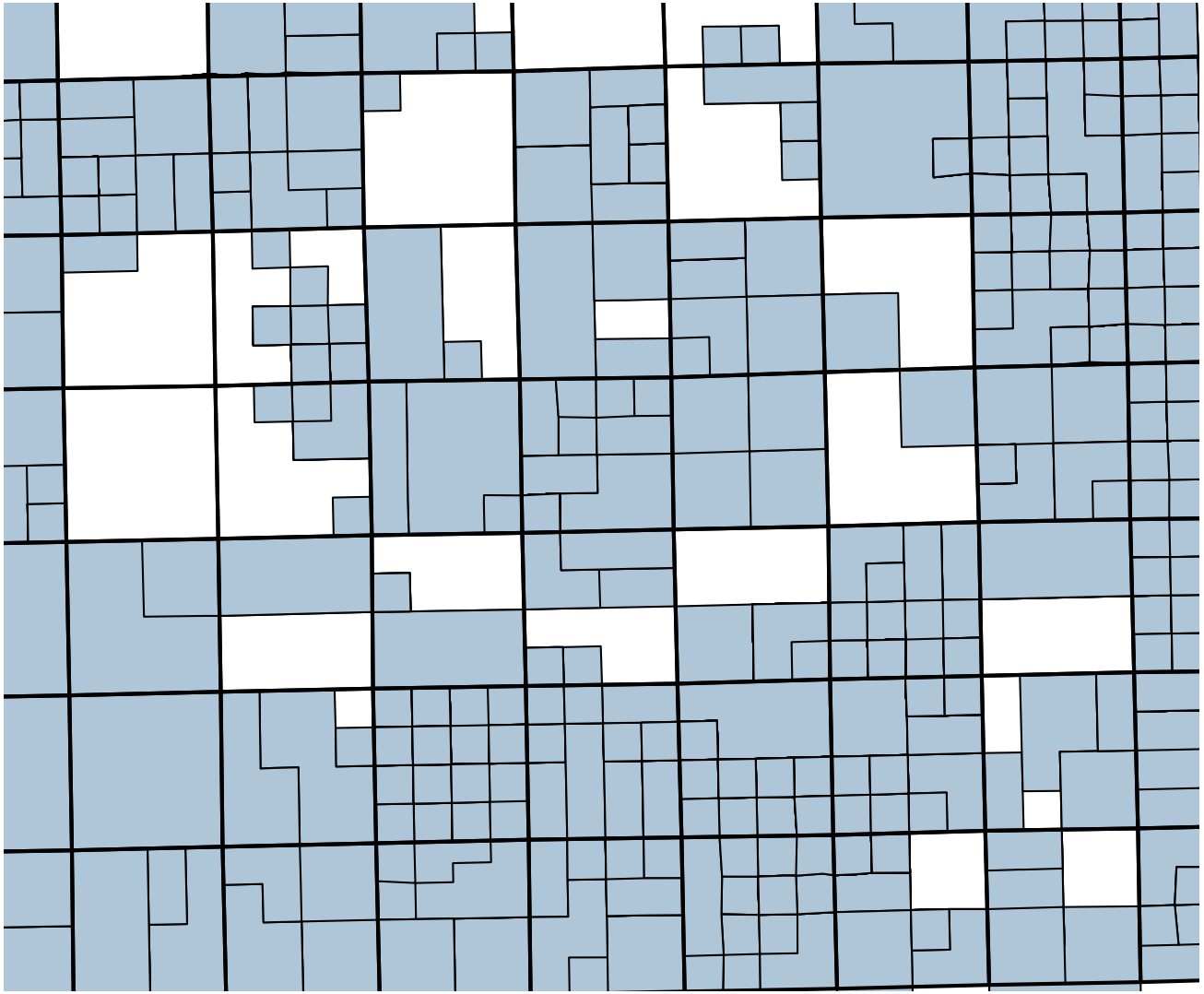


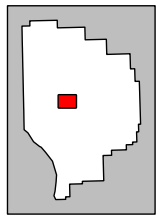
Data: Sections



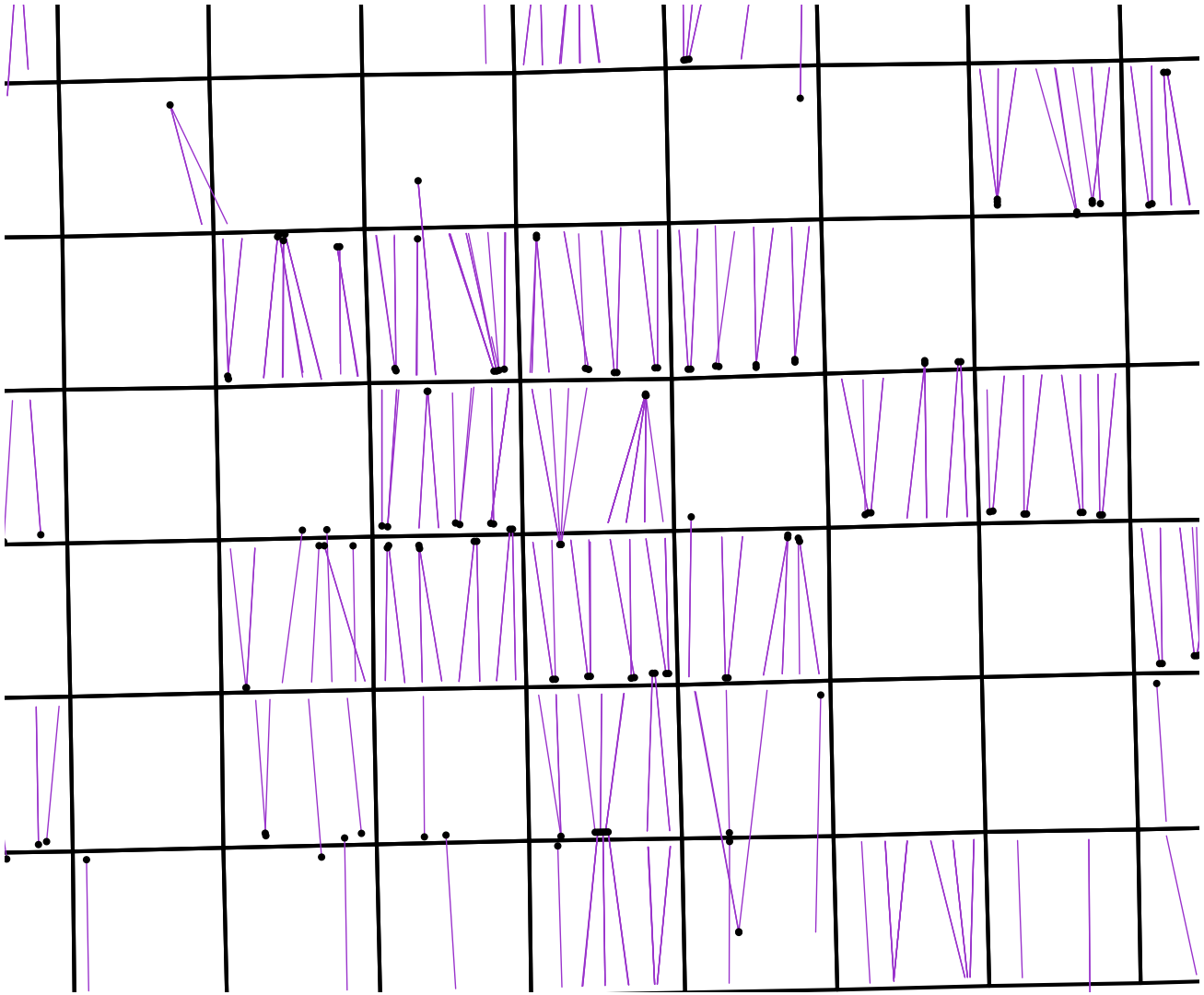


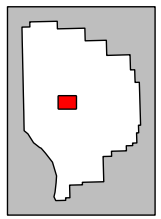
Data: Leases



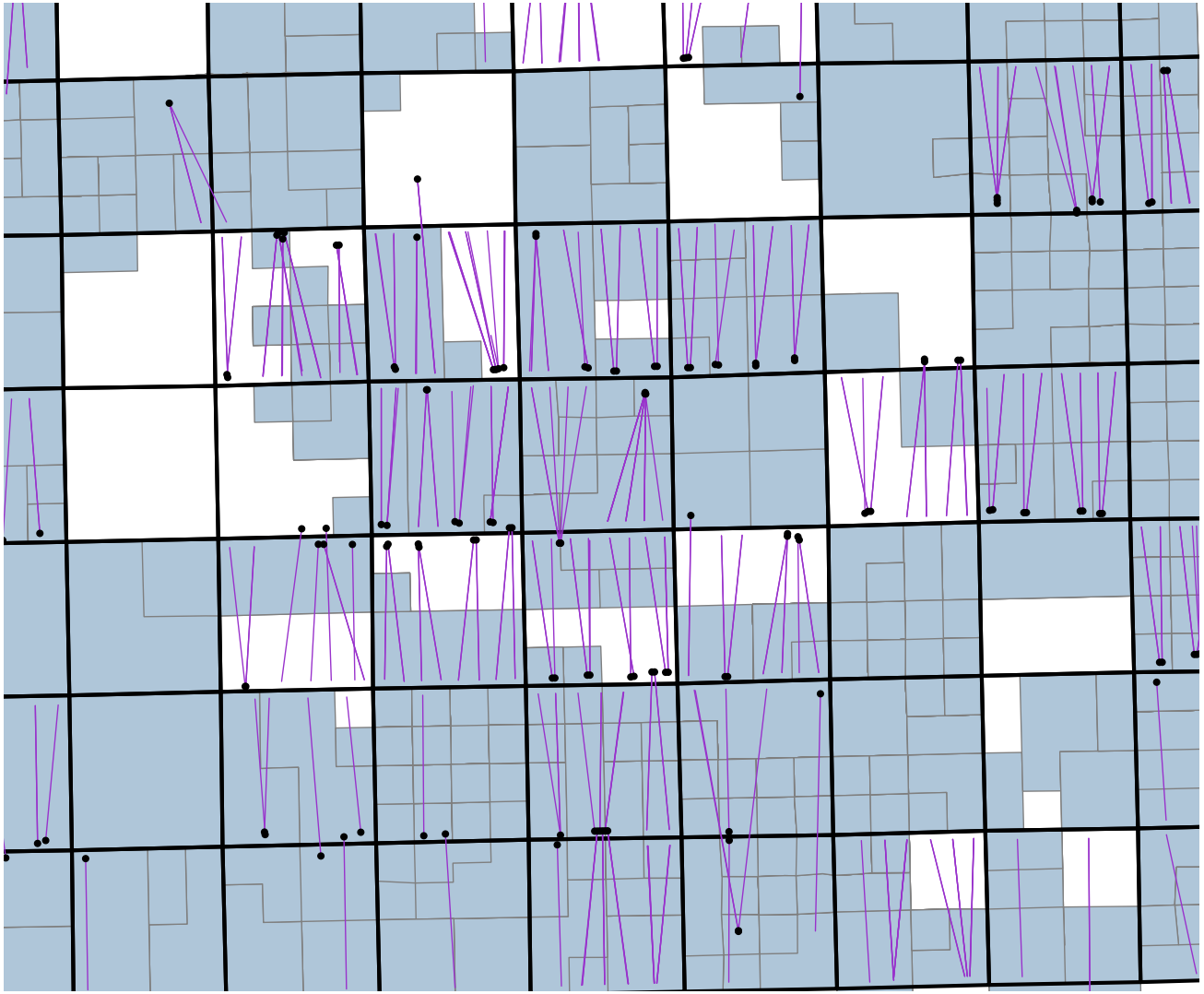


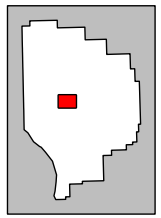
Data: Wells & Production





Data: Complete investment history





What firms know & learn affects 3 outcomes

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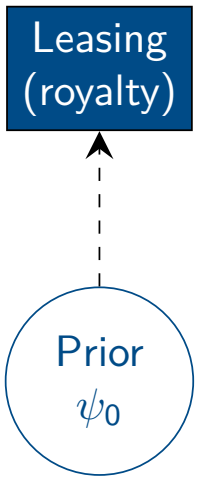

Avg royalty rate	r_i	section i

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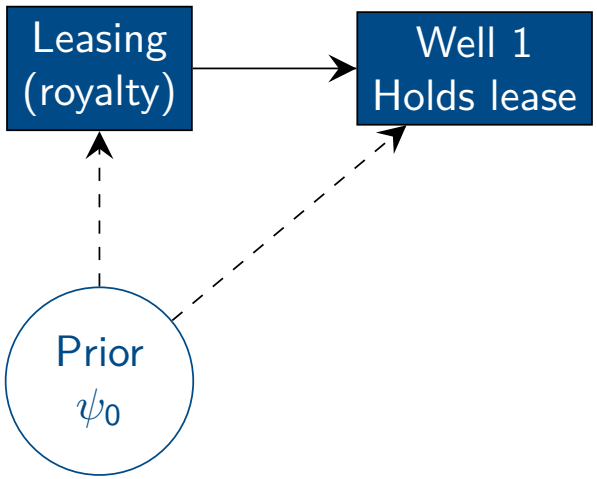

Avg royalty rate	r_i	section i
Num wells drilled	d_{it}	section-quarter it

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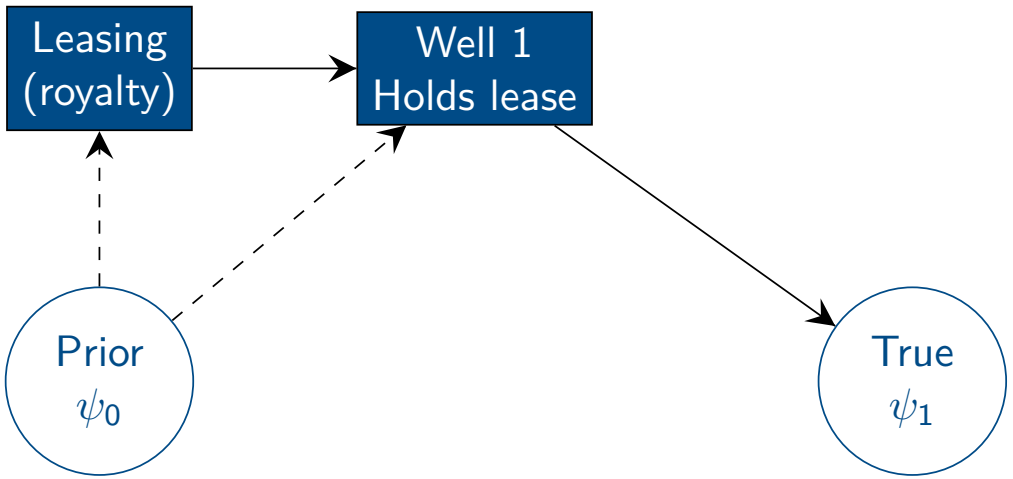

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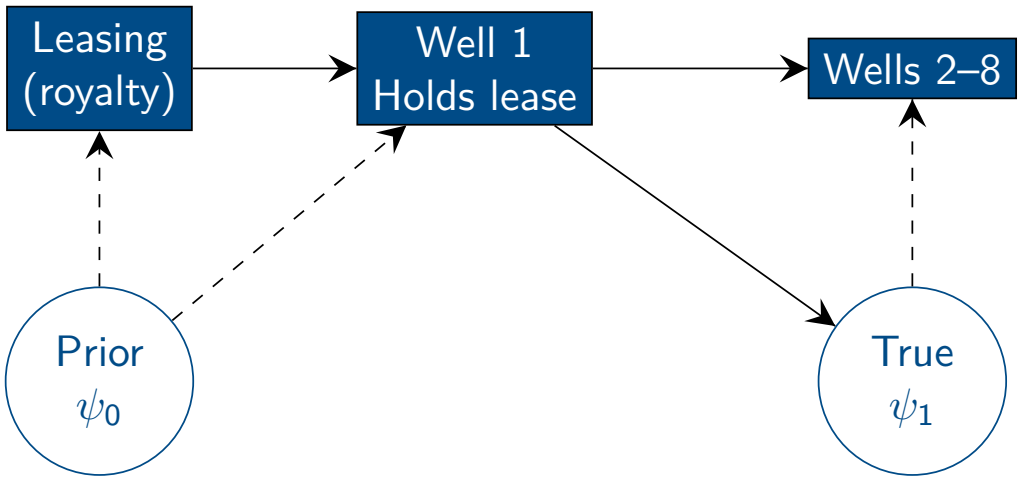

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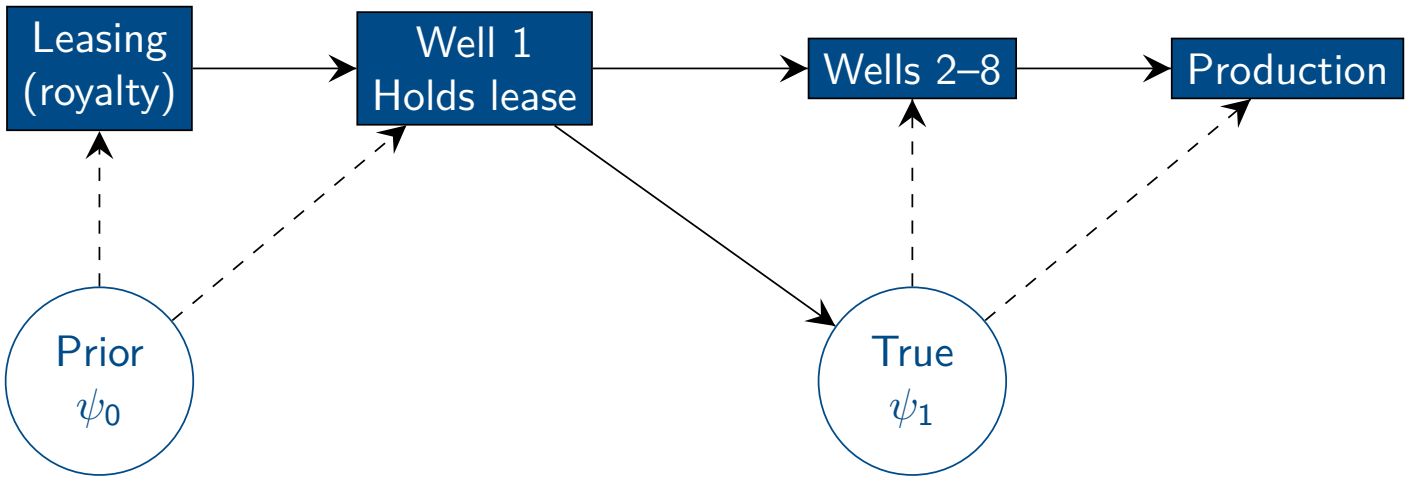

Avg royalty rate	r_i	section i
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Production	$\log q_{iwt}$	section-well-month iwt

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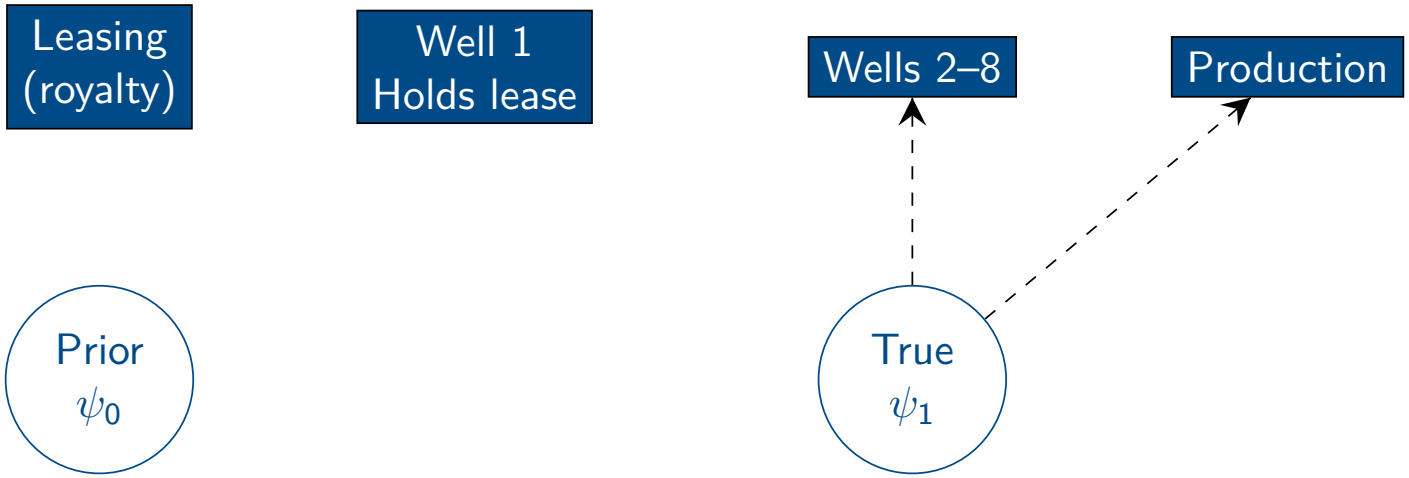
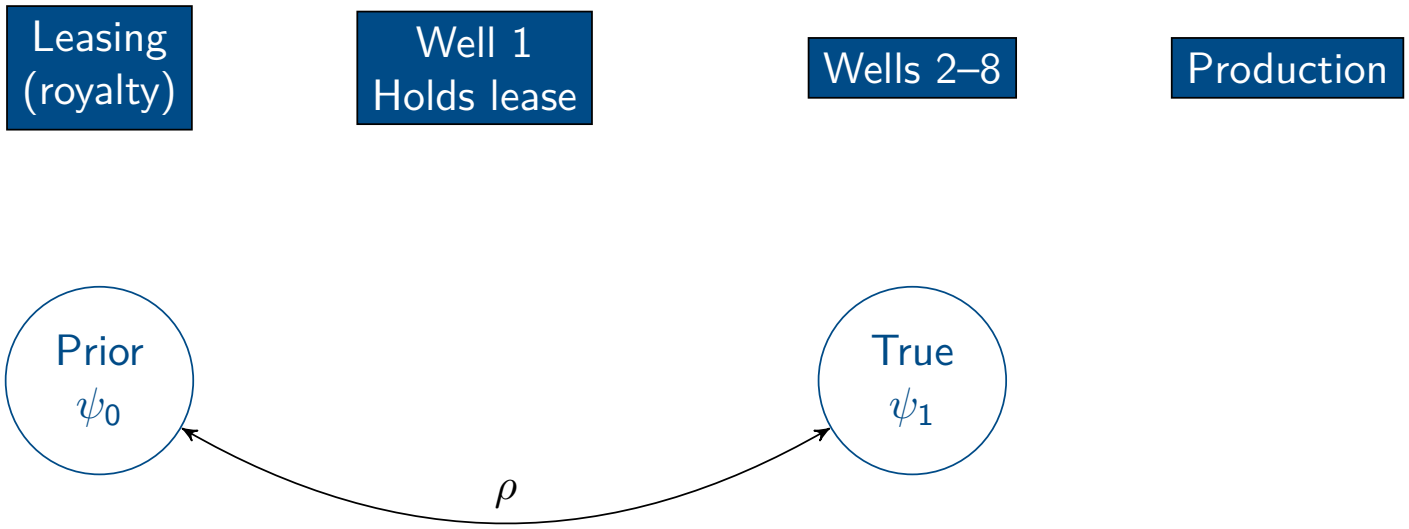


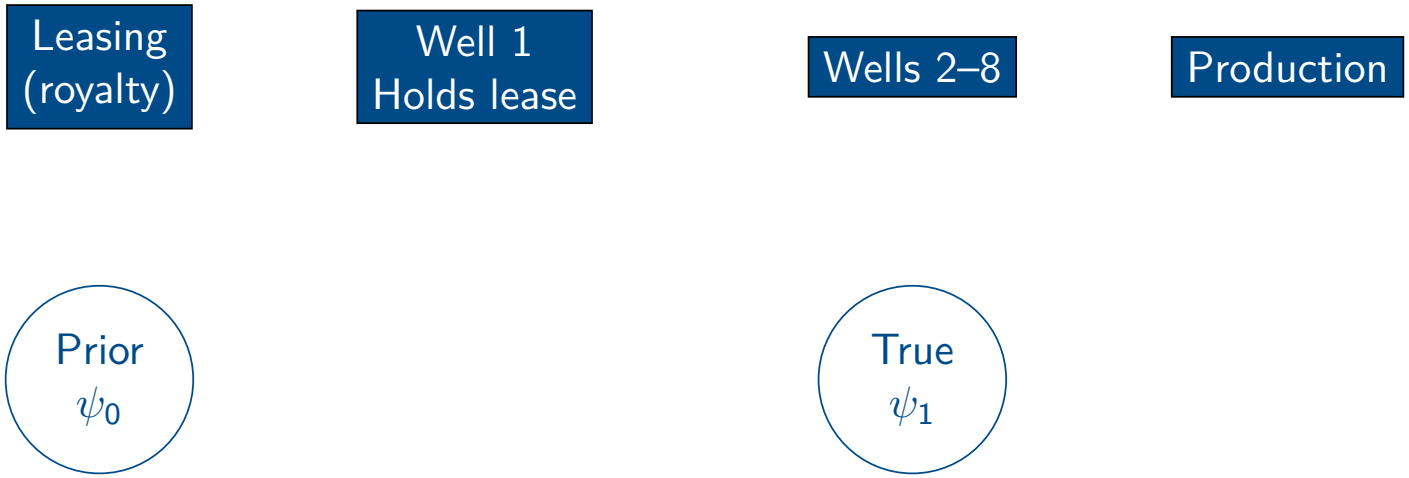
- Identification: ψ_1 affects drilling & production in same way

What firms know & learn affects 3 outcomes



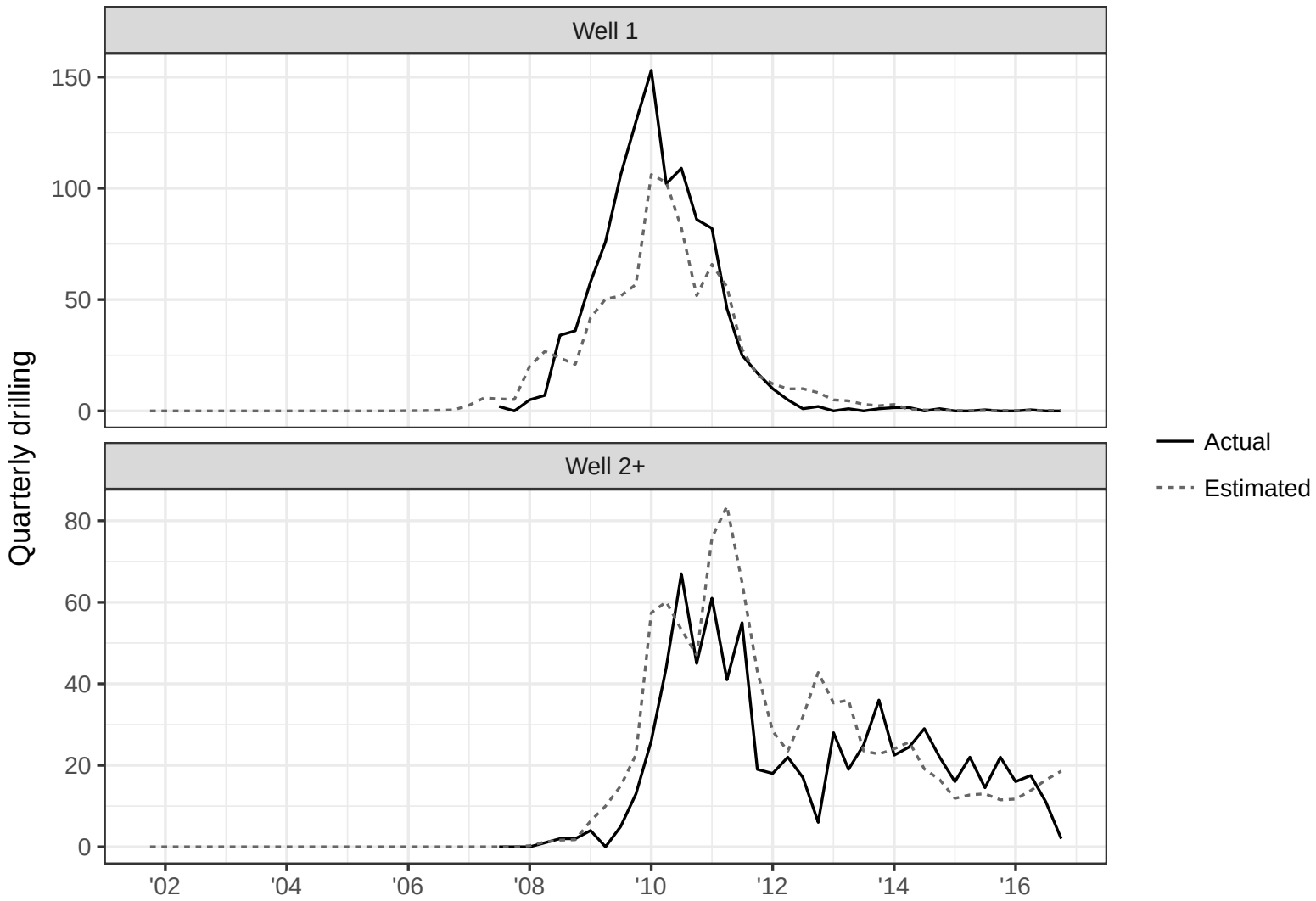
- Identification: of ρ:
  1) Correlation of royalty, acceleration of drilling, output
  2) Dispersion of Well 1 timing

What firms know & learn affects 3 outcomes

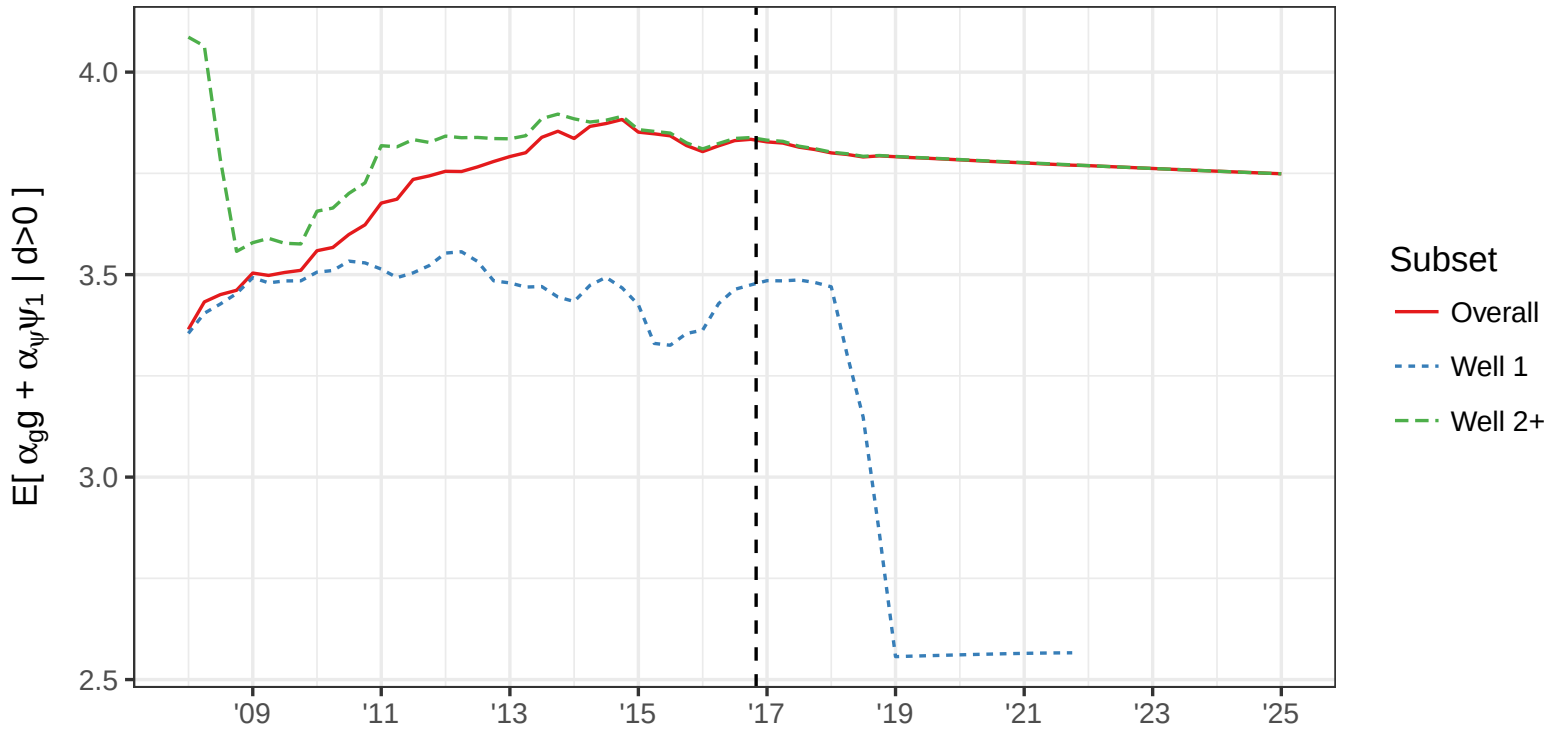


- Identification: of ρ:
  1) Correlation of royalty, acceleration of drilling, output
  2) Dispersion of Well 1 timing
  3) $\hat{\rho} = 0.66$

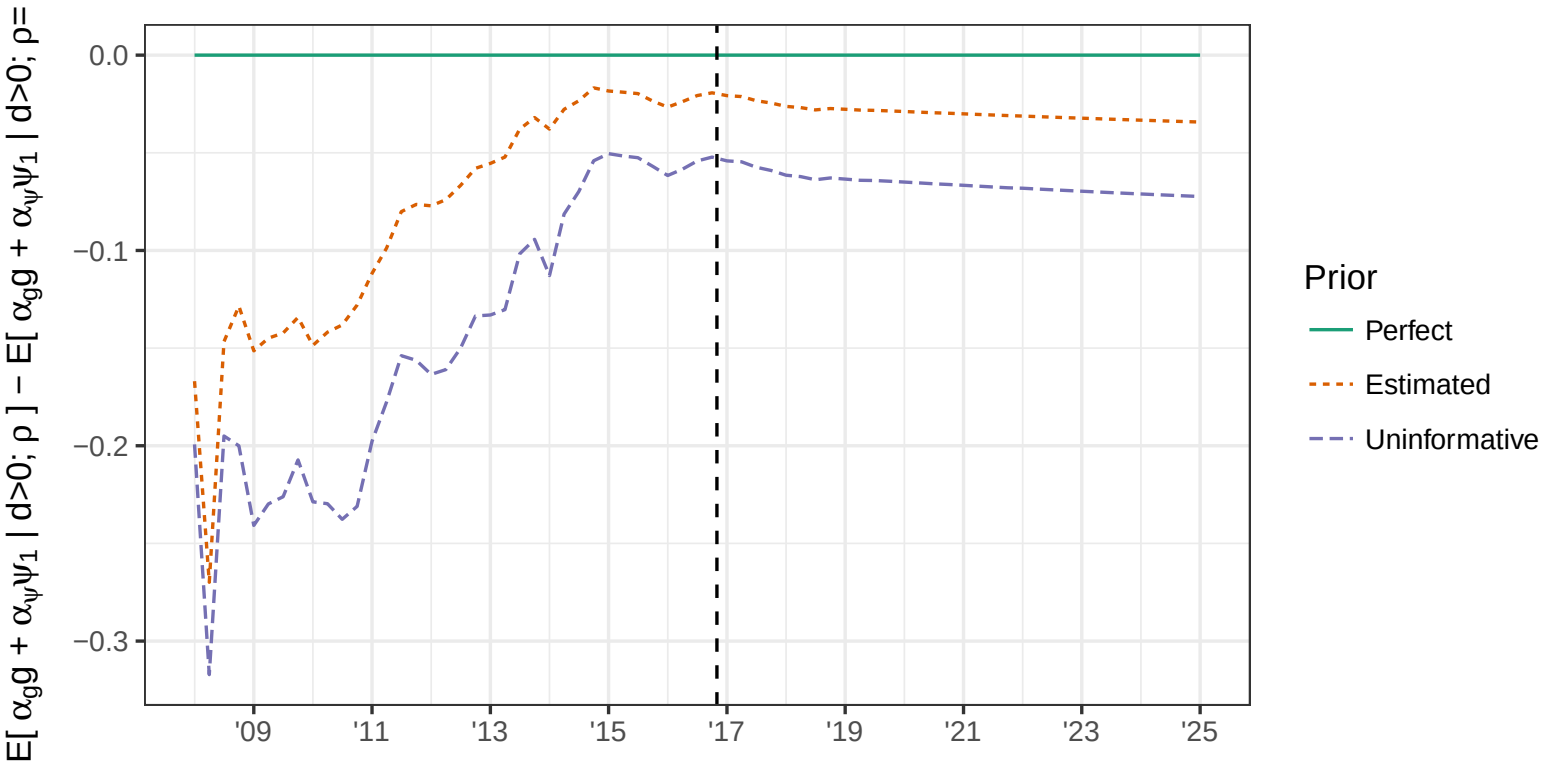
Model fit: Quarterly drilling rate



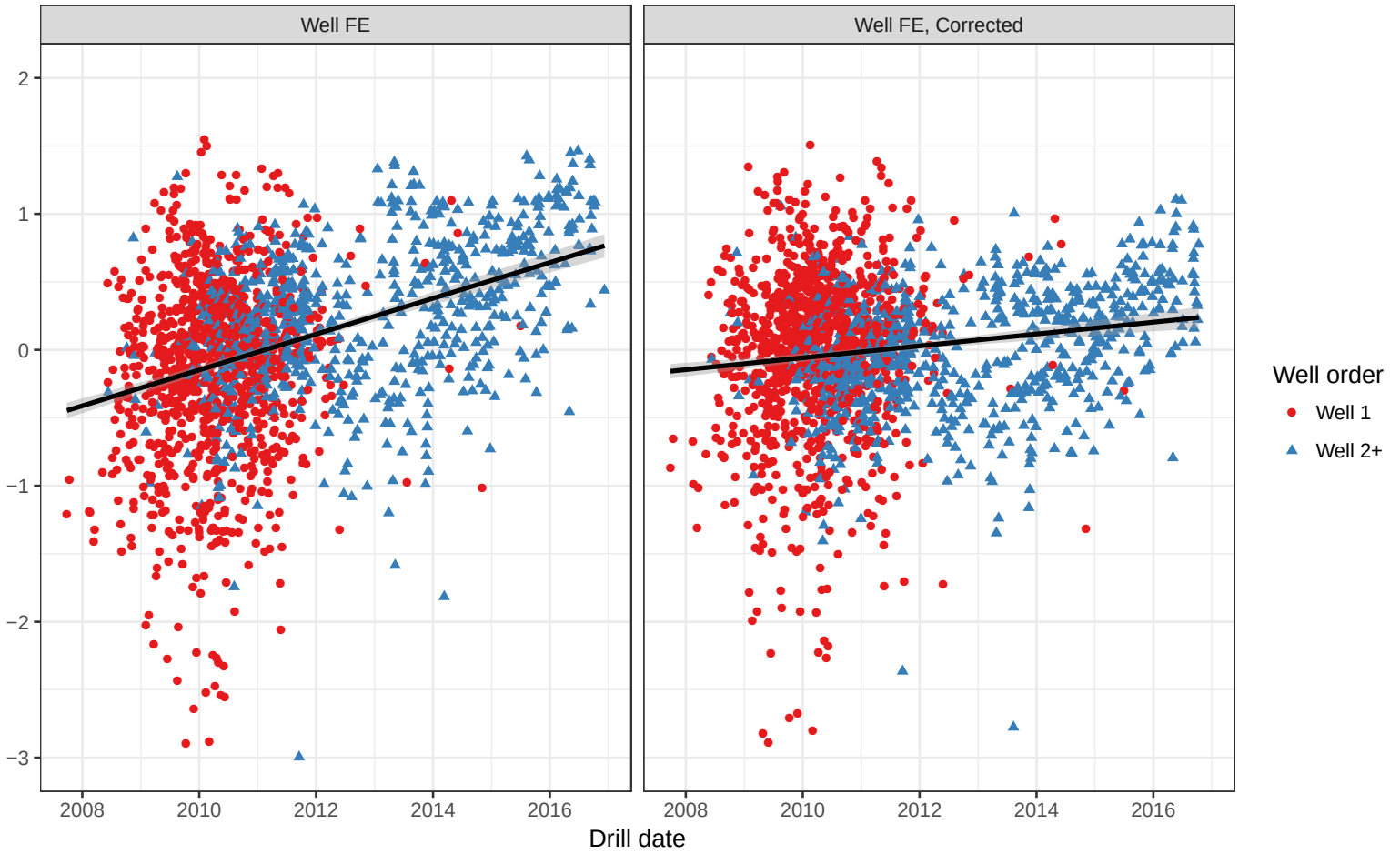
Simulation: Well 1 vs Wells 2–8 drives productivity



Simulation: Learning drives productivity



Well FE over time: With & without controls



Conclusion

- What's new here
  - Dynamic model of learning over space
  - Aggregate implications of firms choosing *where* to drill
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  - Dynamic model of learning over space
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  - Exploit regulatory structure in model, data
- Preliminary findings
  - Where firms drill matters for aggregate output/well
  - Firms are learning about *where* to drill, not just *how* to drill
  - Rising output per well can be explained by
    - Learning about geology (15–20%)
    - Lease expirations
    - Falling prices

Thank you!

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