Drilling and Debt

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Motivation

- How debt affects real activities of a firm is a central question in finance
- Traditional agency costs of debt
  - Underinvestment (Myers, 1977)
  - Risk-shifting (Jensen and Meckling, 1976)
  - Empirical work is scarce
- Debt renegotiations, financial covenants and collateral play a central role in mitigating the agency costs of debt:
  - Aghion and Bolton, 1992; Dewatripont and Tirole, 1994; Gorton and Kahn, 2000
  - Chava and Roberts, 2008; Roberts and Sufi, 2009
- **This paper:**
  - Can debt lead to value destruction under watchful eye of debt holders?

This paper

- Explore new mechanism on how debt affects the real actions of a firm?
- We document:
  - High leverage firms distort the timing and composition of investment.
  - These actions are at the expense of long run higher return and higher net present value (NPV) investment decisions
  - The behavior is most pronounced around debt renegotiations.
  - The behavior is likely to enhance collateral.

Debt and the Real Actions of Firms

- Three traditional problems impeding research in this area:
  - Hard to observe actions at project or operational level
  - Assessing whether a decision is value maximizing
  - Omitted endogenous variables could be related to both firm-level investment decisions and leverage

Our Solution: Unique Empirical Design

- Three traditional problems impeding research in this area:

  - Hard to observe actions at project or operational level
  - **Project level data**

  - Assessing whether a decision is value maximizing
  - **Very clear counterfactual using contango episode**

  - Omitted endogenous variables could be related to both firm-level investment decisions and leverage
  - **DiD analysis**

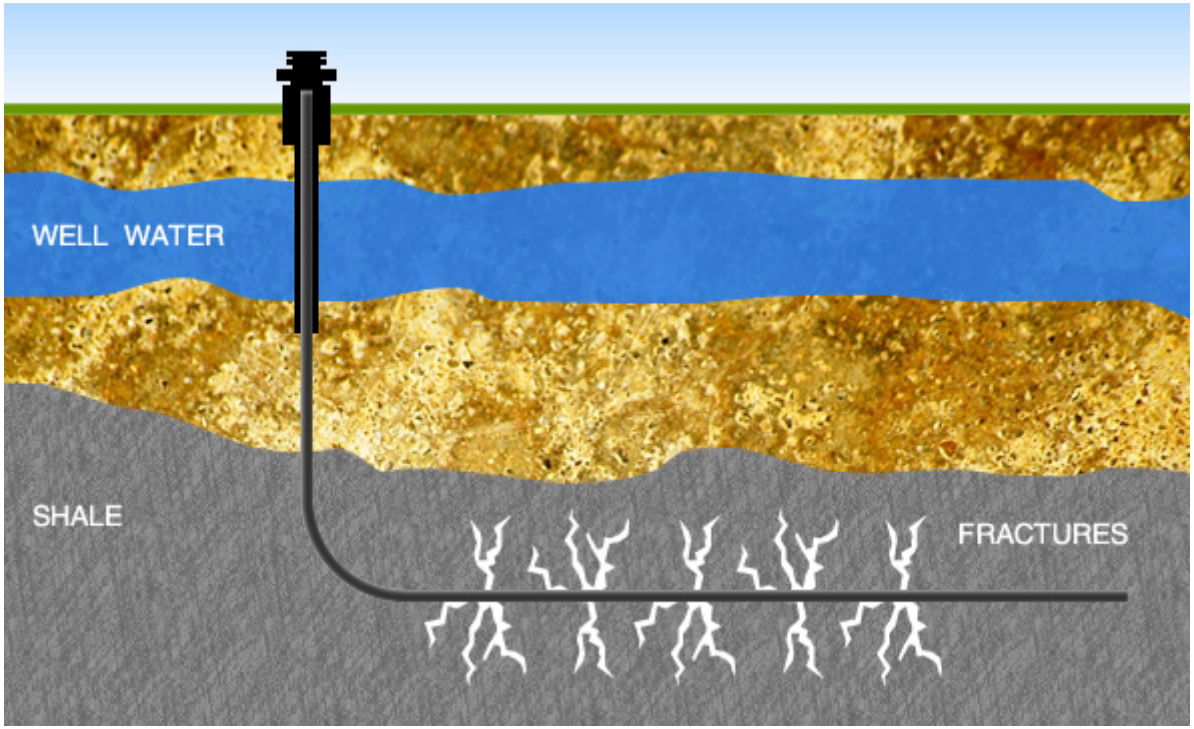
I. Observe Firm Behavior at Project Level

- Focus on North American shale oil industry
- Unique data set:
  - Observe over 3,573 individual drilling projects started in September - November 2013 and September - November 2014
  - 76 distinct oil and gas public firms
  - Data on drilling starts, completion and start of production
  - Detailed data on well locations
  - Limited data on volume of production

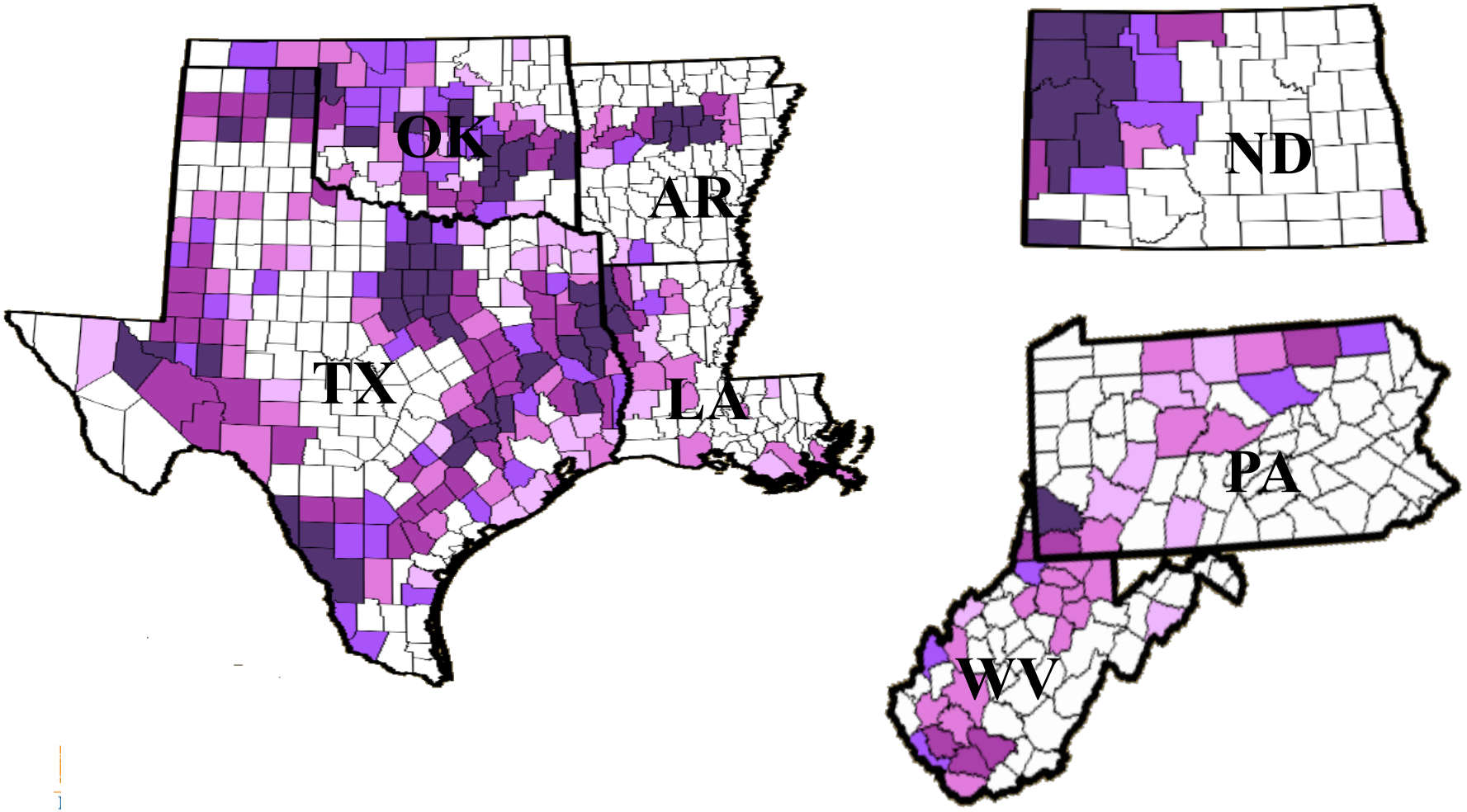
Drilling Process

- Investment in two stages

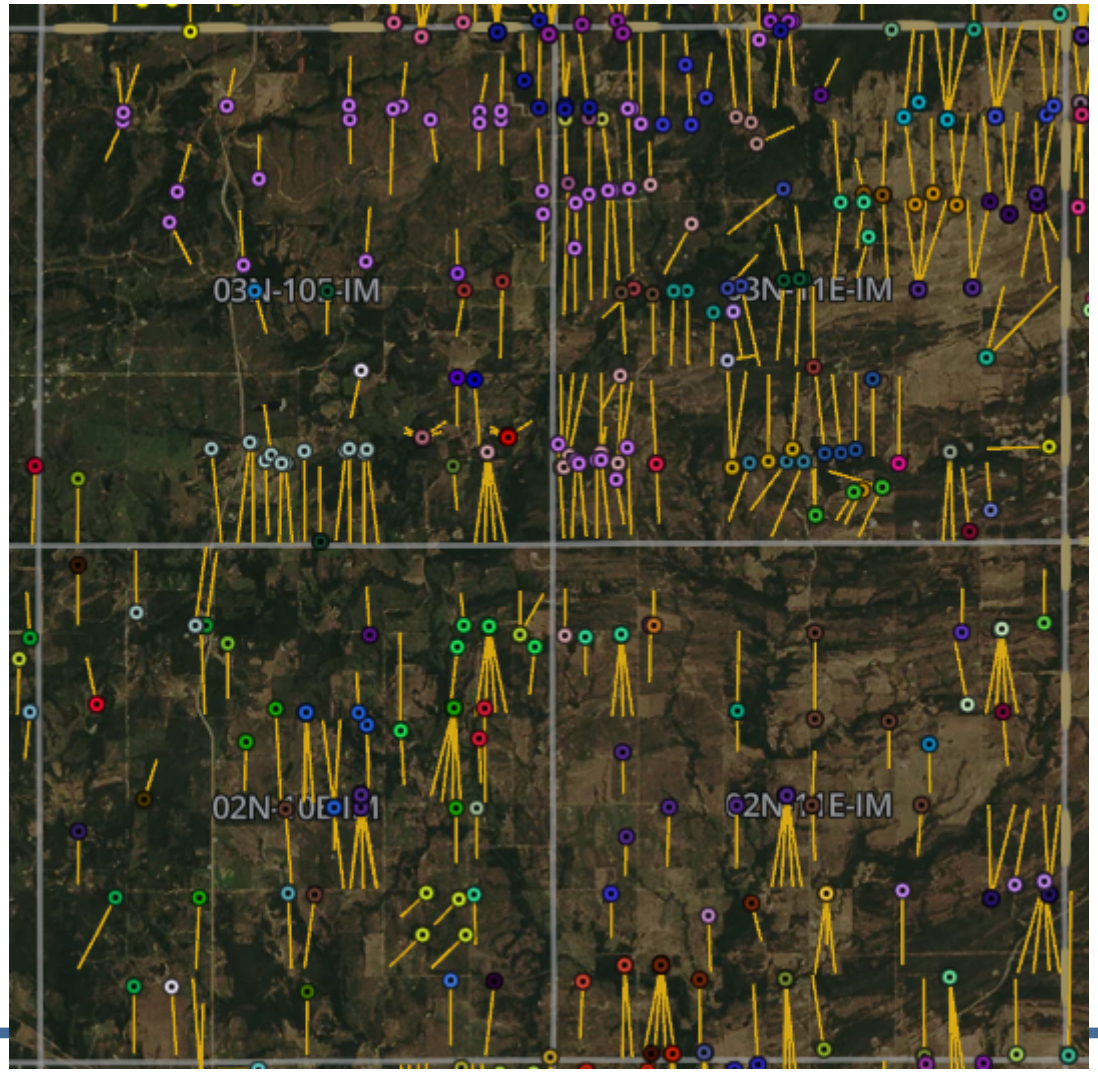
– **Stage I: drill the well. Average CAPEX of $3.5 million**
– **Stage II: complete the well. Average CAPEX of $3 million**
– Production starts immediately upon completion of a well
– About 0.3$ of EBITDA per month over 2.5-4 years



Geography of Shale Boom



Project Design and Geography



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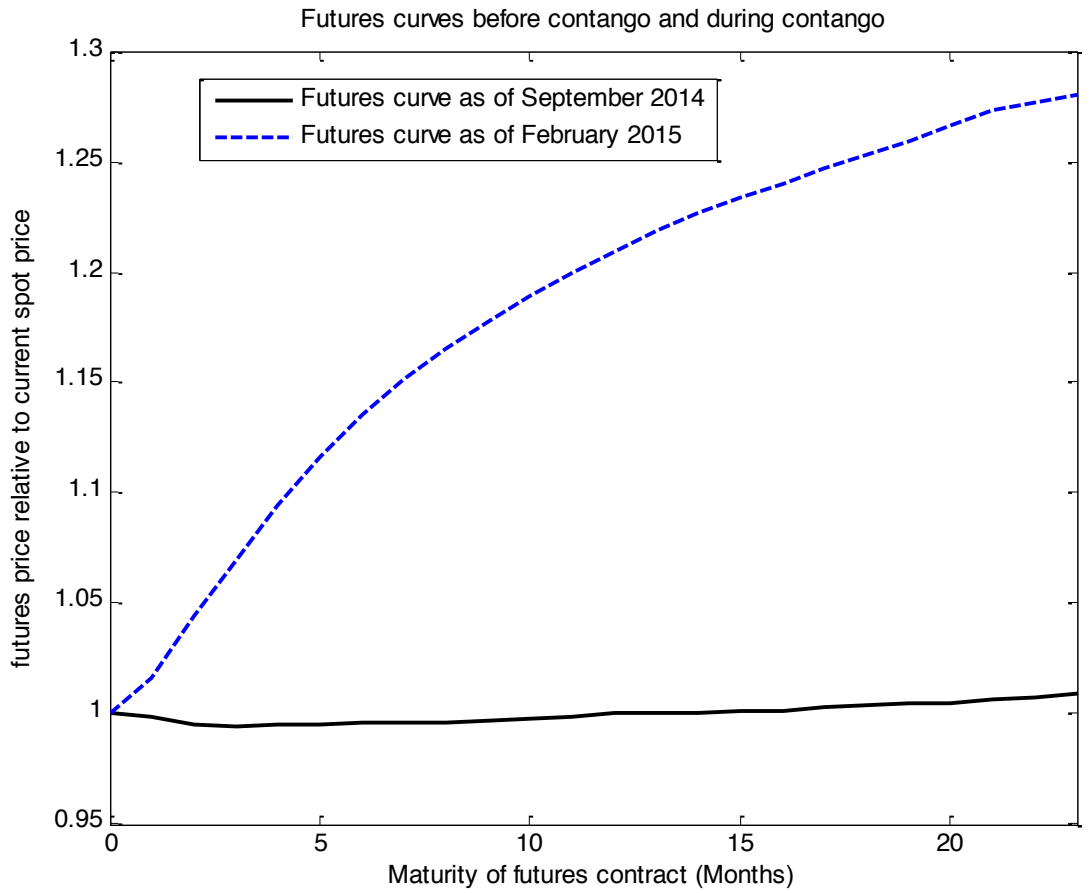
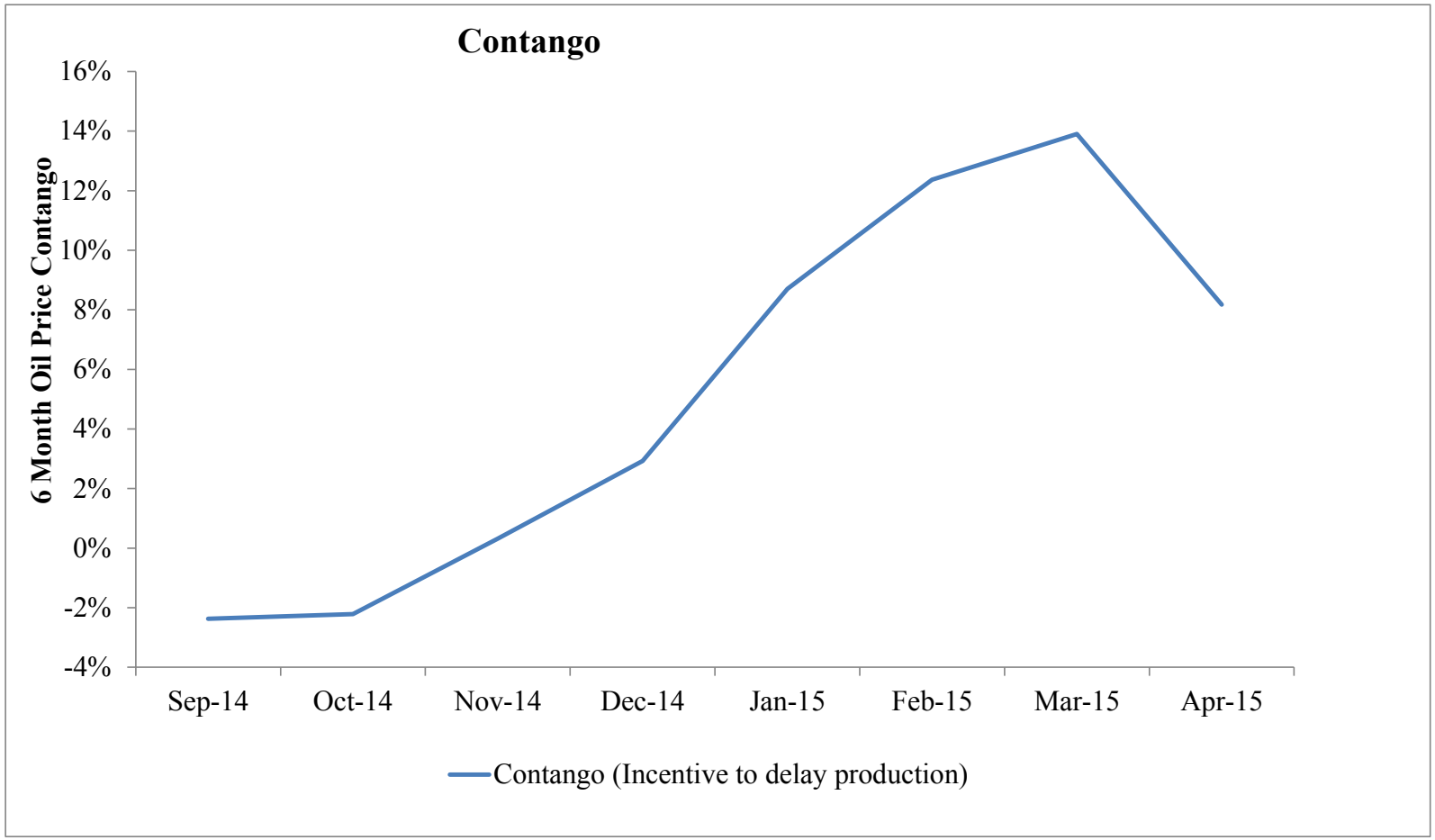
II. Contango Episode: Clear Counterfactual

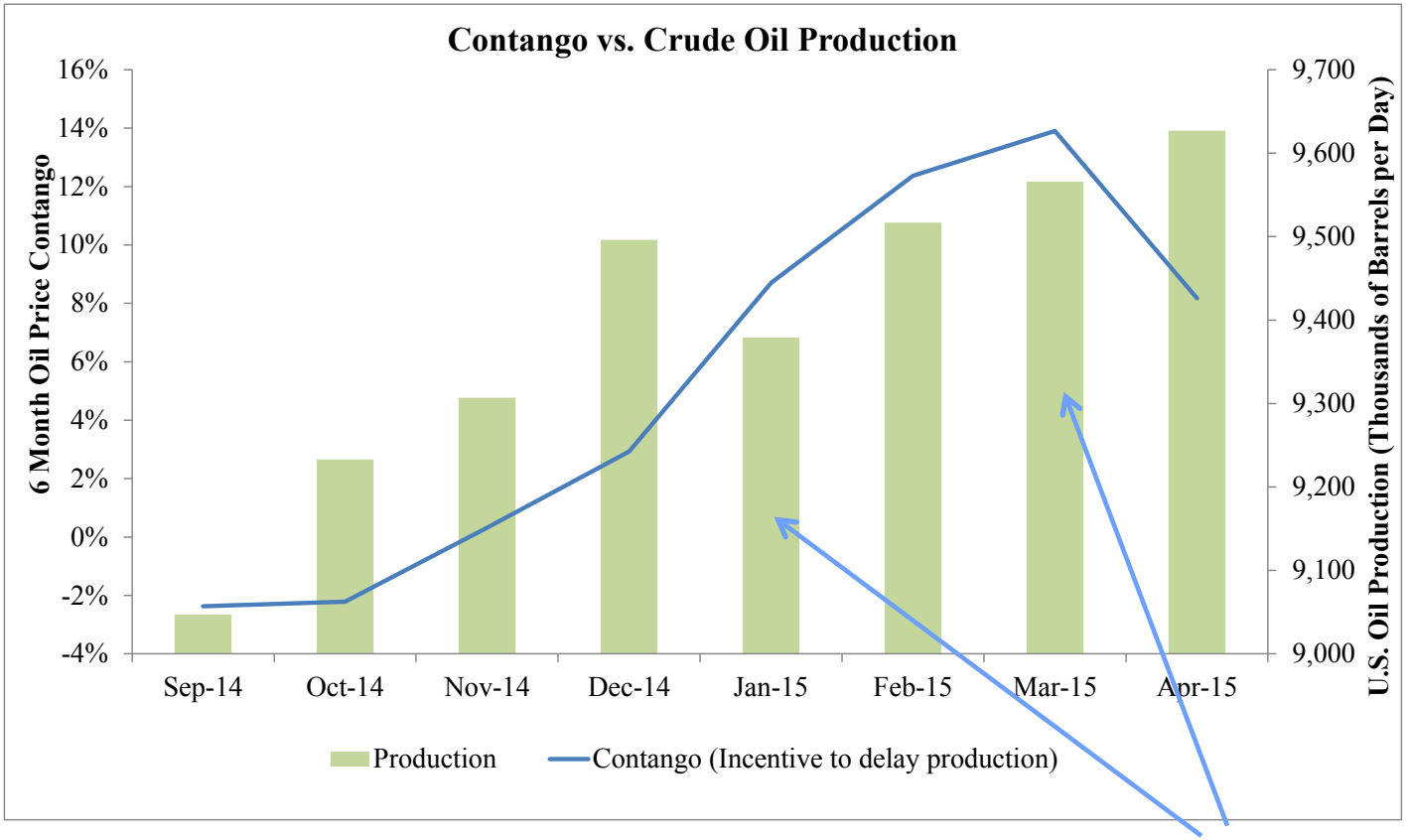
- Should changes incentives on timing to complete wells and start production



Contango


Contango
6 Month Oil Price Contango
16%
14%
12%
10%
8%
6%
4%
2%
0%
-2%
-4%
Sep-14
Oct-14
Nov-14
Dec-14
Jan-15
Feb-15
Mar-15
Apr-15
Contango (Incentive to delay production)

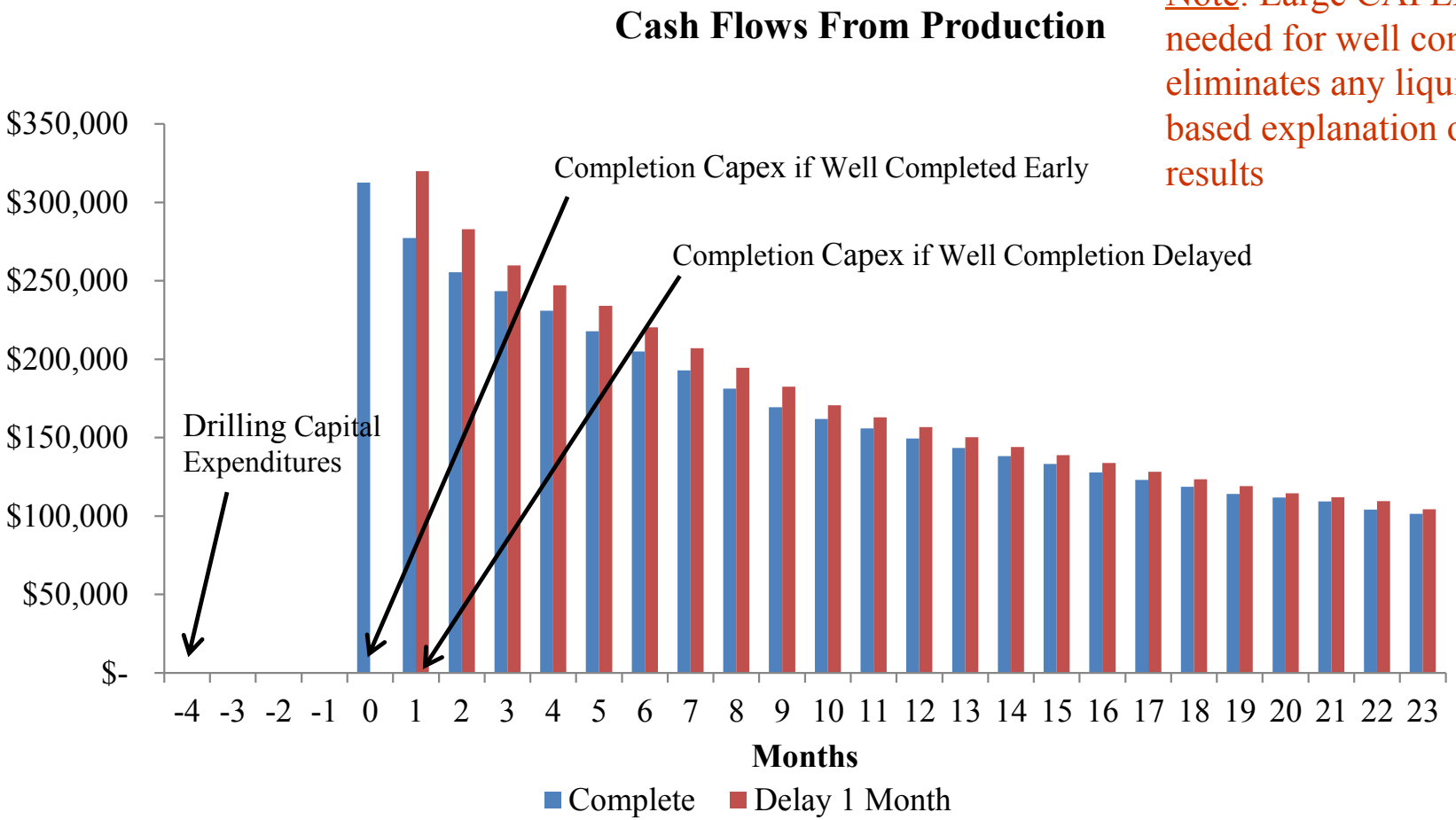
Puzzle



- Popular press suggests debt may have a role
  - "Debt and alive" – The Economist
  - "As Oil Prices Plummet Mounting Debt Catches up with Producers" – New York Times

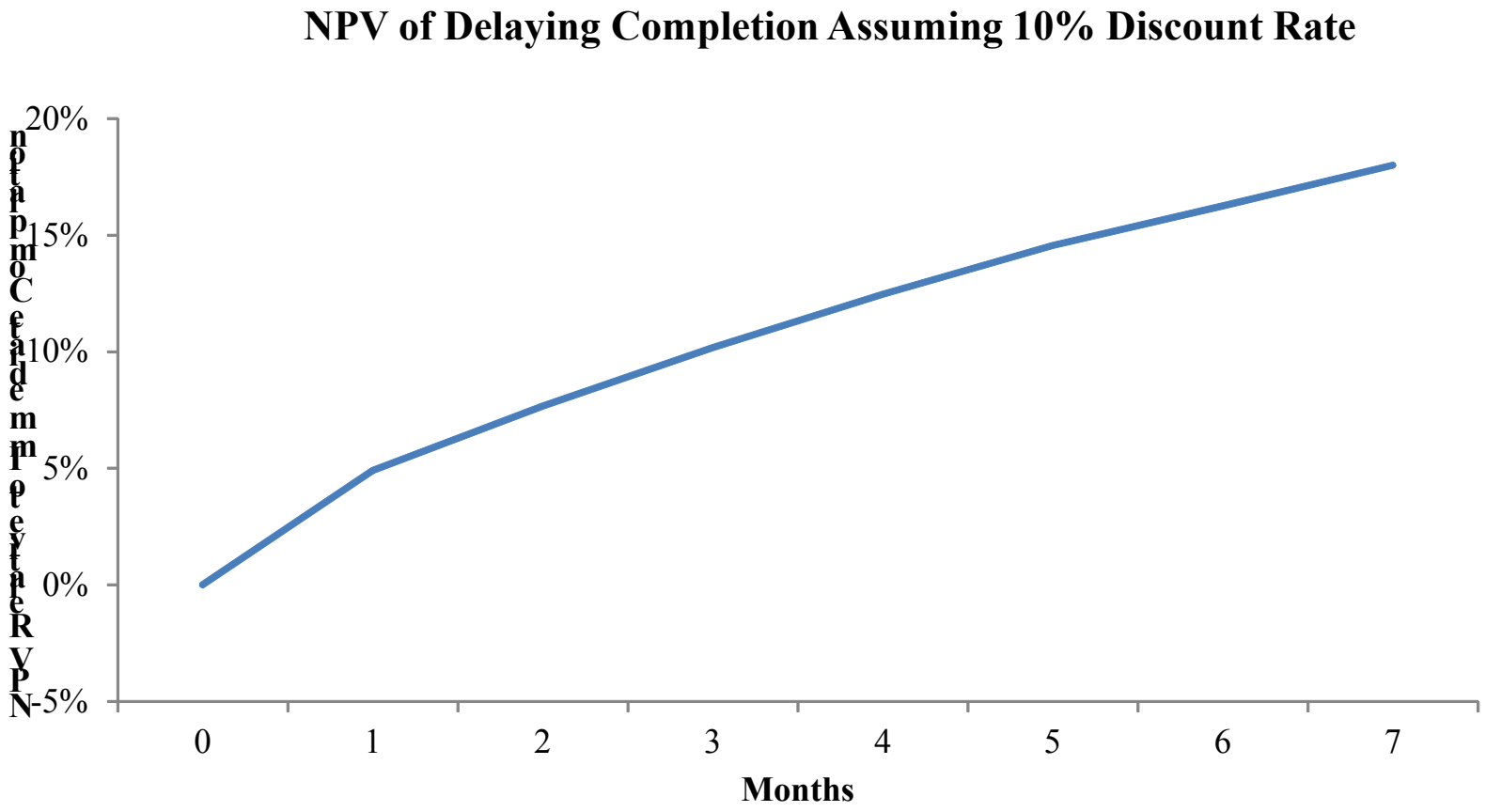
Margin of adjustment is completing new wells

Empirical Design: Contango and Project Cash Flow



Note: Large CAPEX needed for well completion eliminates any liquidity based explanation of our results

Empirical Design: Contango and Project NPV



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Observe a Clear Unambiguous Counterfactual

- Super-contango episode:
  - Futures prices are much higher than spot prices
  - Delaying production is NPV>0

- Detailed geographic data on projects
  - Tight geography fixed effects eliminate alternative explanation stemming from well quality

Exogenous variation in leverage

- Leverage is not randomly assigned
  - No instrument for leverage

- BUT
  - Decline in oil prices created an exogenous shock to firm debt capacity and operational leverage
  - Evaluate the behavior within individual firm
    - September - November 2013 **VS** September - November 2014
    - Explore the well completion behavior around debt renegotiations

Empirical Design Summary

- Exploit super-contango as a natural experiment: Diff-in-Diff
  - First Diff: Before "super-contango" vs. after "super-contango"
  - Second Diff: Compare high-leverage vs. low leverage

Unit of observation: Well *j*, firm *i,* time *t*

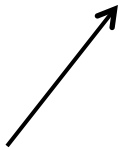
Dependent variable = months from project start to project completion

$$TimeToComp_{i,j,t} = \alpha + \beta_1 \text{Contango}_t + \beta_2 HighLev_i + \beta_3 HighLev_i * \text{Contango}_t + GeogFE_k + FirmFE_i + \varepsilon_{i,j,t}$$

Effect of Leverage on Production Decisions

- Univariate results

	Pre-Super Contango	Super Contango	Difference
Leverage Quintile 5 (Highest Leverage)	3.57	3.75	0.18
Leverage Quintile 4	3.53	5.19	1.66***
Leverage Quintile 3	4.02	5.13	1.11***
Leverage Quintile 2	4.18	4.76	0.58***
Leverage Quintile 1 (Lowest Leverage)	4.04	5.07	1.03***



Economic Interpretation: Firms delay beginning of well production by **1.03 months**, or **25.7%** relative to sample median

Effect of Leverage on Production Decisions

Unit of observation: well *j*, firm *i,* time *t*

$$TimeToComp_{i,j,t} = \alpha + \beta_1 Contango_t + \beta_2 HighLev_i + \beta_3 HighLev_i * Contango_t + YearFE_t + GeogFE_k + FirmFE_i + \varepsilon_{i,j,t}$$

	Dependent Variable = Months to Production		
	(1)	(2)	(3)
$Contango_t$	1.077***	1.077***	1.093***
	(0.310)	(0.202)	(0.203)
$Contango_t \times$ Leverage p20 p40 D_i	-0.269		
	(0.611)		
$Contango_t \times$ Leverage p40 p60 D_i	0.174		
	(0.530)		
$Contango_t \times$ Leverage p60 p80 D_i	0.196		
	(0.405)		
$Contango_t \times$ Leverage p80 and up D_i	-1.001**	-1.002***	
	(0.419)	(0.369)	
$Contango_t \times$ Asset Based Lending Leverage p80 and up D_i			-1.198***
			(0.308)
$FirmFE_i$	Yes	Yes	Yes
6 Sq Mile Geog FE	Yes	Yes	Yes
N	3300	3300	3300
R^2	0.50	0.50	0.50

Differences in Observables

	Dependent Variable = Months to Production			
	(1)	(2)	(3)	(4)
$Contango_t$	0.542	2.130*	0.790	1.793
	(0.519)	(1.206)	(0.720)	(1.193)
$Contango_t \times$ Leverage p80 and up D_i	-0.916**	-1.196***	-0.896*	-1.124**
	(0.386)	(0.378)	(0.478)	(0.456)
$Contango_t \times Profitability_i$	11.988			6.779
	(9.667)			(12.472)
$Contango_t \times Log\ Assets_i$		-0.105		-0.103
		(0.123)		(0.111)
$Contango_t \times$ Market to $Book_i$			0.198	-0.025
			(0.483)	(0.573)
$FirmFE_i$	Yes	Yes	Yes	Yes
6 Sq Mile Geog FE	Yes	Yes	Yes	Yes
N	3233	3233	2930	2930
R^2	0.51	0.51	0.52	0.52

Production Decisions and Debt Renegotiation: Number of Wells

Does well *j* from firm *i* begin to produce in month *t: 0/1 Dummy Dep Variable*

	Probability of Well Starting Production							Difference
	Time 0 = month of debt renegotiation							Well Starts$_{t=-1}$ - Well Starts$_{t=0}$
	-3	-2	-1	0	1	2	3+	
High Leverage	0.22	0.18	0.21	0.08	0.08	0.04	0.05	0.12***
N	129	238	238	238	238	238	238	
Low Leverage	0.15	0.18	0.12	0.07	0.03	0.03	0.11	0.05***
N	626	640	640	640	640	640	640	
							Difference$_{High}$ - Difference$_{Low}$	0.08**
							p-value	0.02

Economic Interpretation: if high leverage firm has 100 wells it started in Fall of 2014, it begins production from 21 of them in the month before it amends its credit agreement

Production Decisions and Debt Renegotiation: Number of Wells

Does well *i* from firm *i* begin to produce in month *t: 0/1 Dummy Dep Variable*

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N	129	238	238	238	238	238	238

$\text{Difference}_{\text{High}} = \text{High Leverage}_{t=-1} - \text{High Leverage}_{t=0}$	0.12***
p-value	0.00
$\text{Difference}_{\text{Low}} = \text{Low Leverage}_{t=-1} - \text{Low Leverage}_{t=0}$	0.05***
p-value	0.00
Difference-in-Differences = $\text{Difference}_{\text{High}} - \text{Difference}_{\text{Low}}$	0.08**
p-value	0.02

Economic Interpretation: if high leverage firm has 100 wells it started in Fall of 2014, it begins production from 21 of them in the month before it amends its credit agreement

	Dependent Variable = Well Start (1 if well starts producing in month, 0	
	High Leverage	Low Leverage
	(1)	(2)
Month T=-2 to Renegotiation D_t	-0.062	0.017
	[0.061]	[0.039]
Month T=-1 to Renegotiation D_t	-0.022	-0.007
	[0.049]	[0.031]
Month T=0 to Renegotiation D_t	-0.135**	-0.006
	[0.050]	[0.037]
Month T=1 to Renegotiation D_t	-0.107**	-0.034
	[0.046]	[0.030]
Month T=2 to Renegotiation D_t	-0.111***	-0.015
	[0.037]	[0.031]
Month T≥3+ to Renegotiation D_t	-0.092*	0.074
	[0.046]	[0.052]
$FirmFE_i$	Yes	Yes
$MonthFE_t$	Yes	Yes
6 Sq Mile Geog FE_j	Yes	Yes
N	15,051	18,755
R^2	0.056	0.049

Mechanism at work

- "Liquidity Hypothesis"
  - Firms need to complete wells to avoid liquidity shortfalls and/or cover interest payments
    - Unlikely given significant CAPEX needed to complete wells

- "Collateral Hypothesis"

  - Firms need to meet their covenants or maintain their collateral value backing existing credit agreements.
    - Should be most pronounced before renegotiations

Are wells being completed for liquidity reasons?

- Cash flow profile of well

Month	Cash Flow	
0	$ (3,500,000.00)	Well Spud
1	$ -	
2	$ -	
3	$ -	
4	$ -	
5	$ -	
6	$ (2,742,432.23)	Well Completed
7	$ 304,575.63	
8	$ 277,096.46	
9	$ 261,452.69	
10	$ 245,789.72	
11	$ 230,193.24	
12	$ 215,326.93	
13	$ 201,693.72	
14	$ 188,563.25	
15	$ 175,723.45	
16	$ 167,406.12	

- Completing well likely adversely affects Debt/EBITDA and EBITDA to interest metrics

Production Decisions and Collateral Constraints: Production Volume

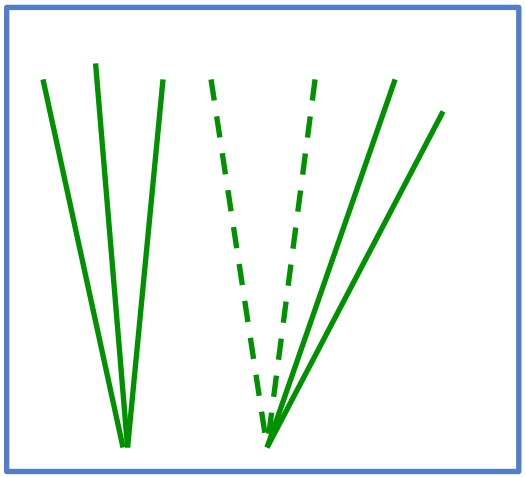
- Initial production of wells started before vs. after debt negotiation

	Initial Production (Barrels of Oil per Day)		
	Before Renegotiation	After Renegotiation	Difference
High Leverage Firms	417.34	291.71	125.64*
N	151	41	

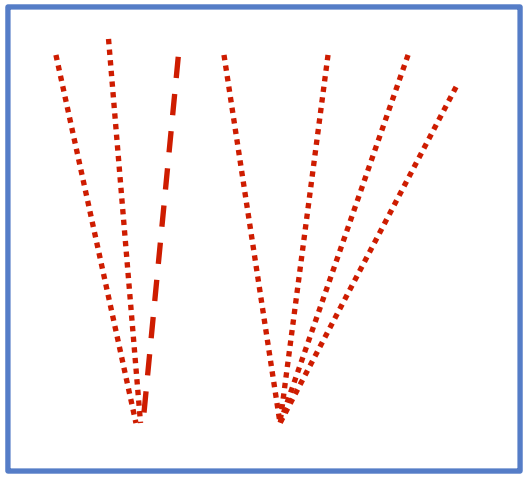
	Initial Production (Log(Barrels of Oil per Day))		
	Before Renegotiation	After Renegotiation	Difference
High Leverage Firms	5.57	5.23	0.34*
N	151	41	

Production Decisions and Collateral Constraints

Multi well producing lease



Single well lease



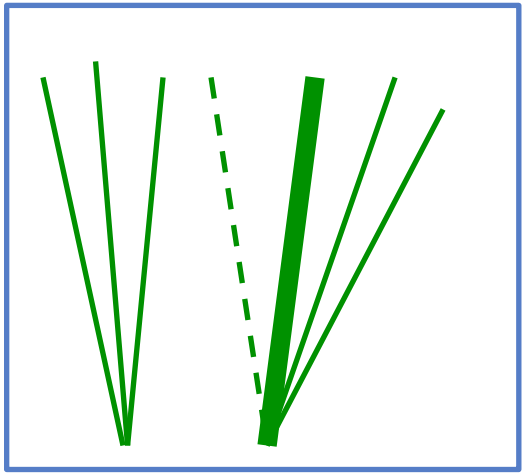
Drilled but not yet producing (not complete) – **60%** or **40%** of NPV as collateral value

Producing well – **100%** of PV collateral value

Prospective location (Drilling not yet begun) – **30%** or **15%** of NPV as collateral if there is producing well on lease

Production Decisions and Collateral Constraints

Multi well producing lease



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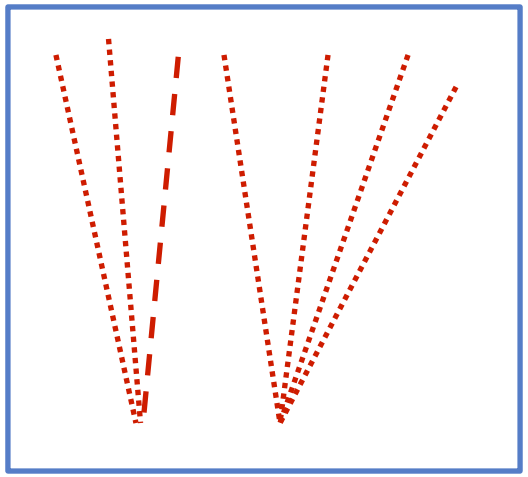

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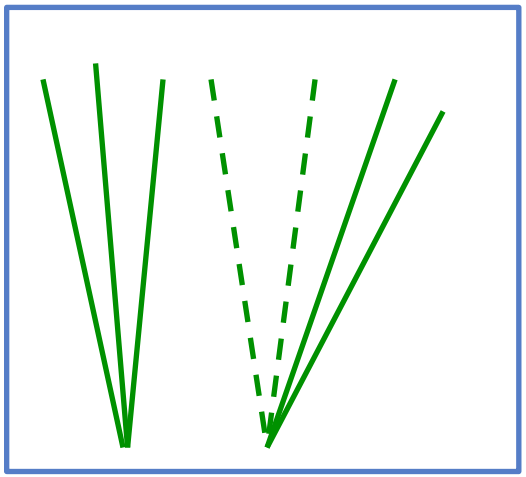

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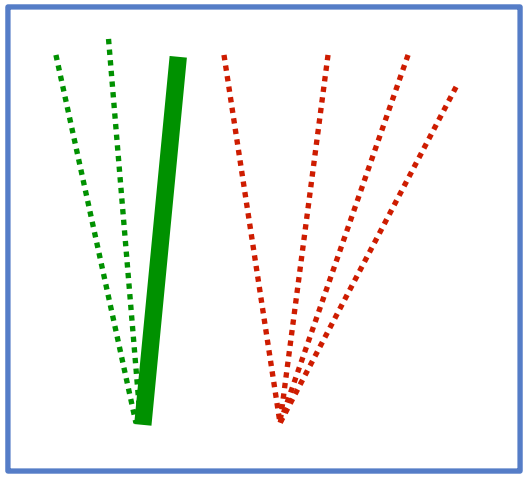

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Producing well – **100%** of PV collateral value

Prospective location (Drilling not yet begun) – **30%** or **15%** of NPV as collateral if there is producing well on lease

	Probability of Well Starting Production Time 0 = month of debt renegotiation							Difference $Starts_{t=-1}$ - Well
	-3	-2	-1	0	1	2	3+	
Single Well Lease (High Collateral Impact)								
High Leverage	0.26	0.19	0.24	0.08	0.08	0.05	0.03	0.16
Low Leverage	0.14	0.16	0.12	0.09	0.04	0.05	0.13	0.03
							$Difference_{High}$ - $Difference_{Low}$	0.13***
							p-value	0.01

	Probability of Well Starting Production Time 0 = month of debt renegotiation							Difference $Starts_{t=-1}$ - Well
	-3	-2	-1	0	1	2	3+	
Multi Well Lease (Low Collateral Impact)								
High Leverage	0.17	0.18	0.14	0.10	0.07	0.02	0.07	0.05
Low Leverage	0.17	0.19	0.12	0.06	0.03	0.01	0.09	0.06
							$Difference_{High}$ - $Difference_{Low}$	-0.01
							p-value	0.87

Findings

- **Empirical evidence**
  - High leverage firms engage in actions to pull forward cash flows
    - These actions are at the expense of higher return long term cash flow decisions
    - Estimated that this costs firms 4.8% of project NPV or $124,000 per project
    - 1.2% of equity value

- **Mechanism**
  - High leverage firms pull forward cash flows just before debt renegotiations/credit amendments
    - Estimated enhanced collateral value from early project completion increases debt capacity by 6.9%, and increases slack in financial covenants
  - Collateral Value: Projects completed before renegotiations
    - Have characteristics that are more likely to enhance collateral value
    - Produce more oil than projects that firms delay