

The Natural Gas Paradox

Is there a “Moore’s Law” in Unconventional
Production?

SPE Gulf Coast Northside Study Group

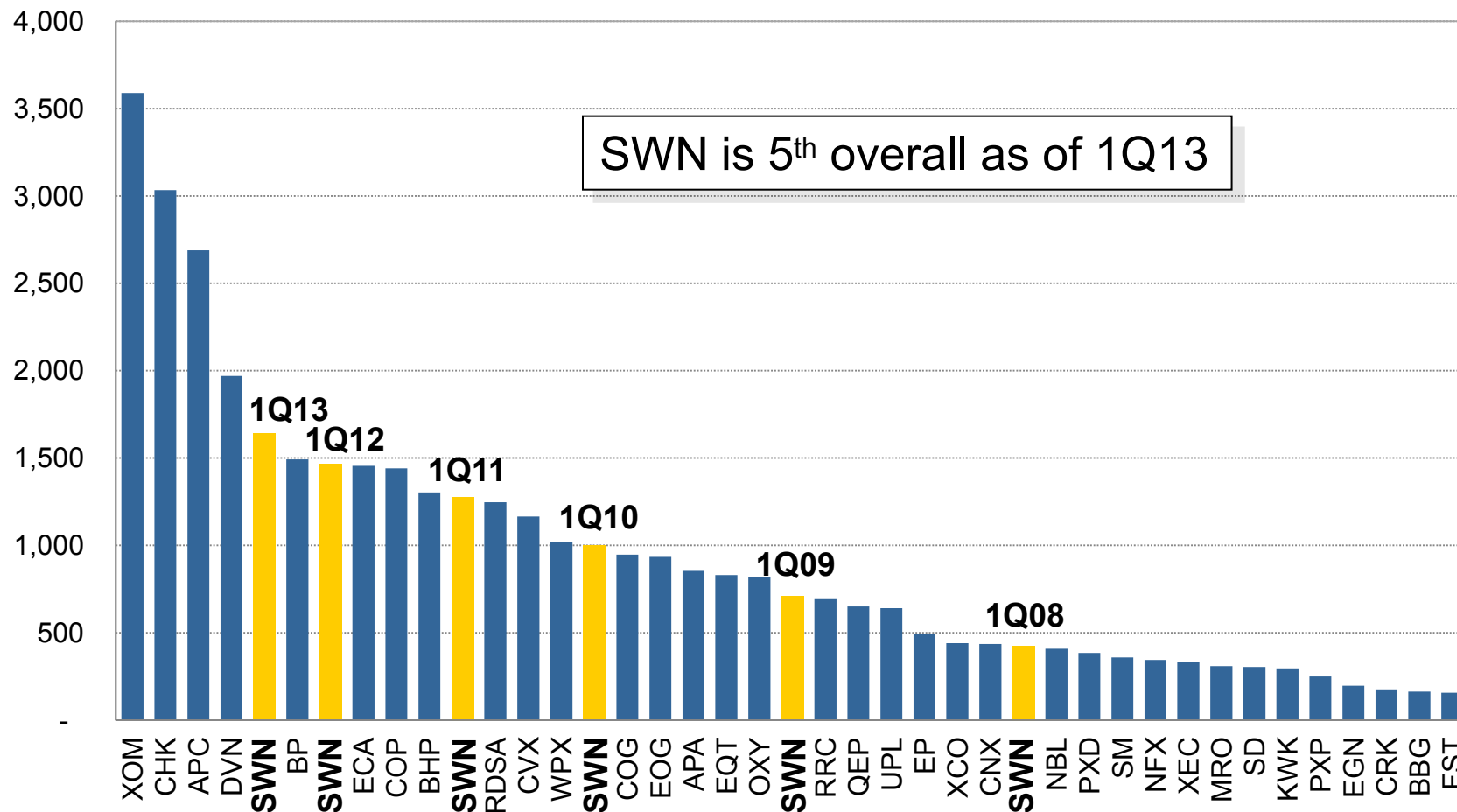
November 13, 2013

$$\frac{R^2}{A} \rightarrow V^+$$

$$\frac{R^2}{A} \rightarrow V^+®$$

US Lower 48 Gas Production

Sorted by 1Q13 (MMcf/d)

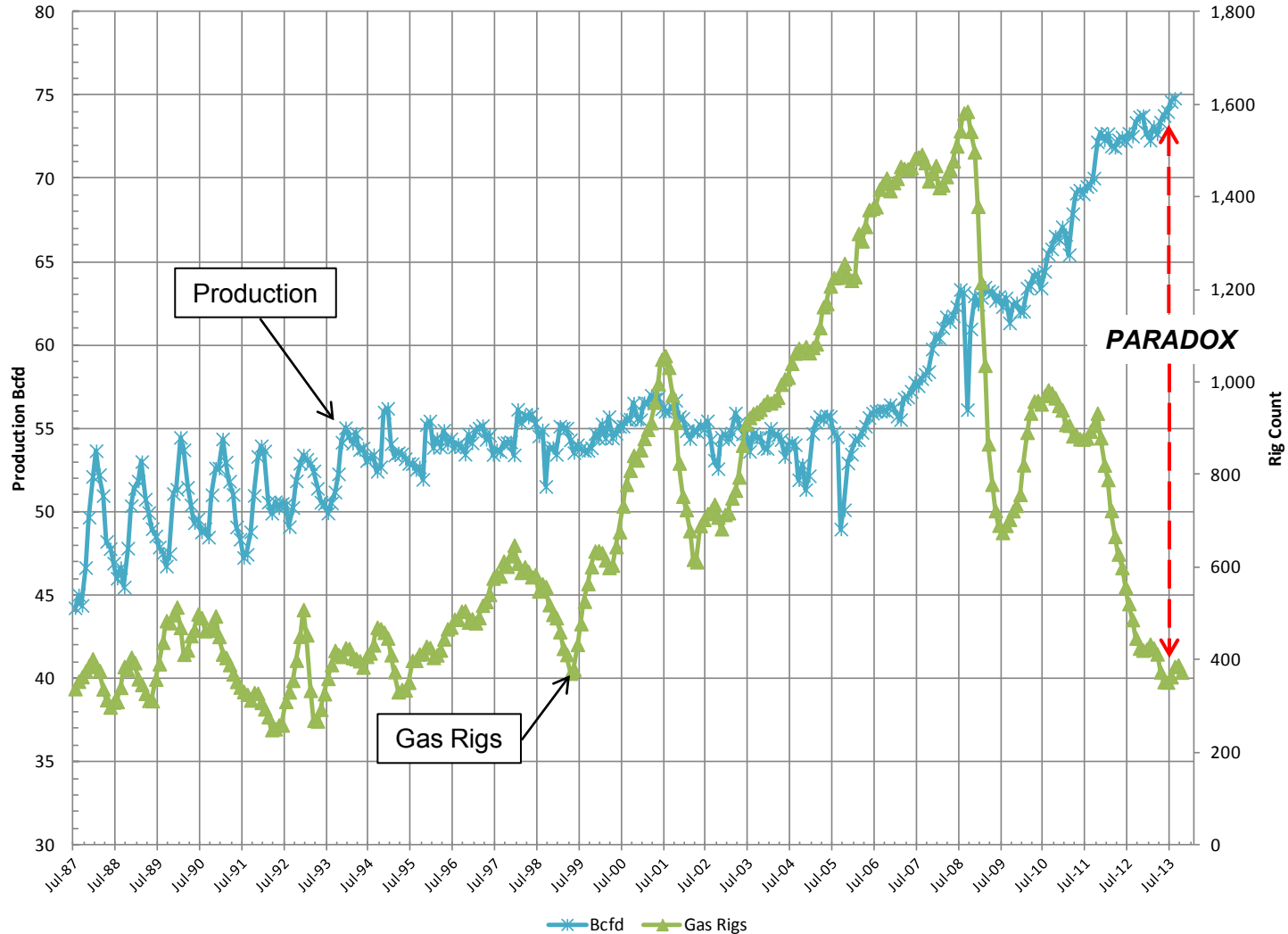


Source: Public company reports, Southwestern Energy

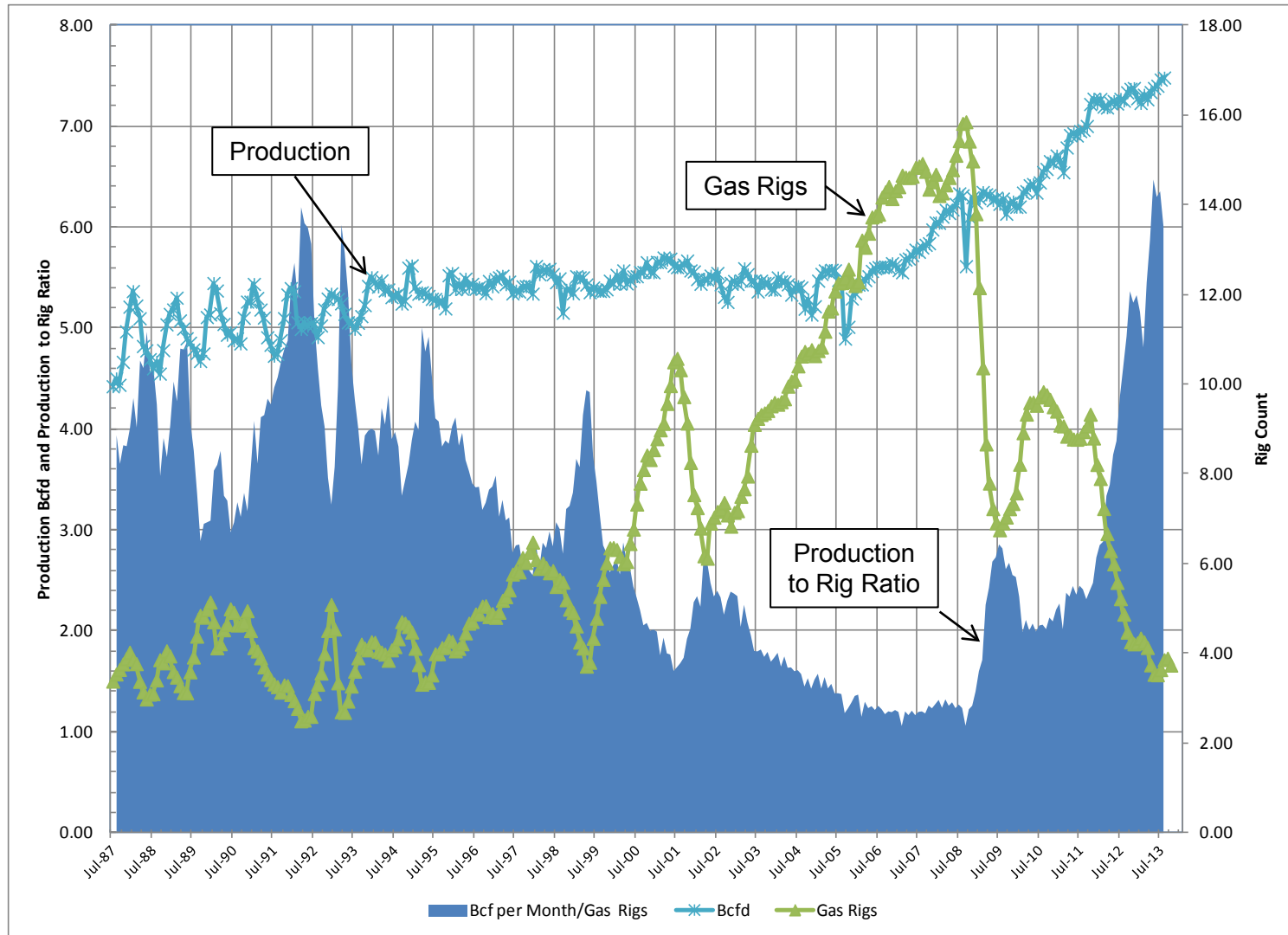


The Paradox

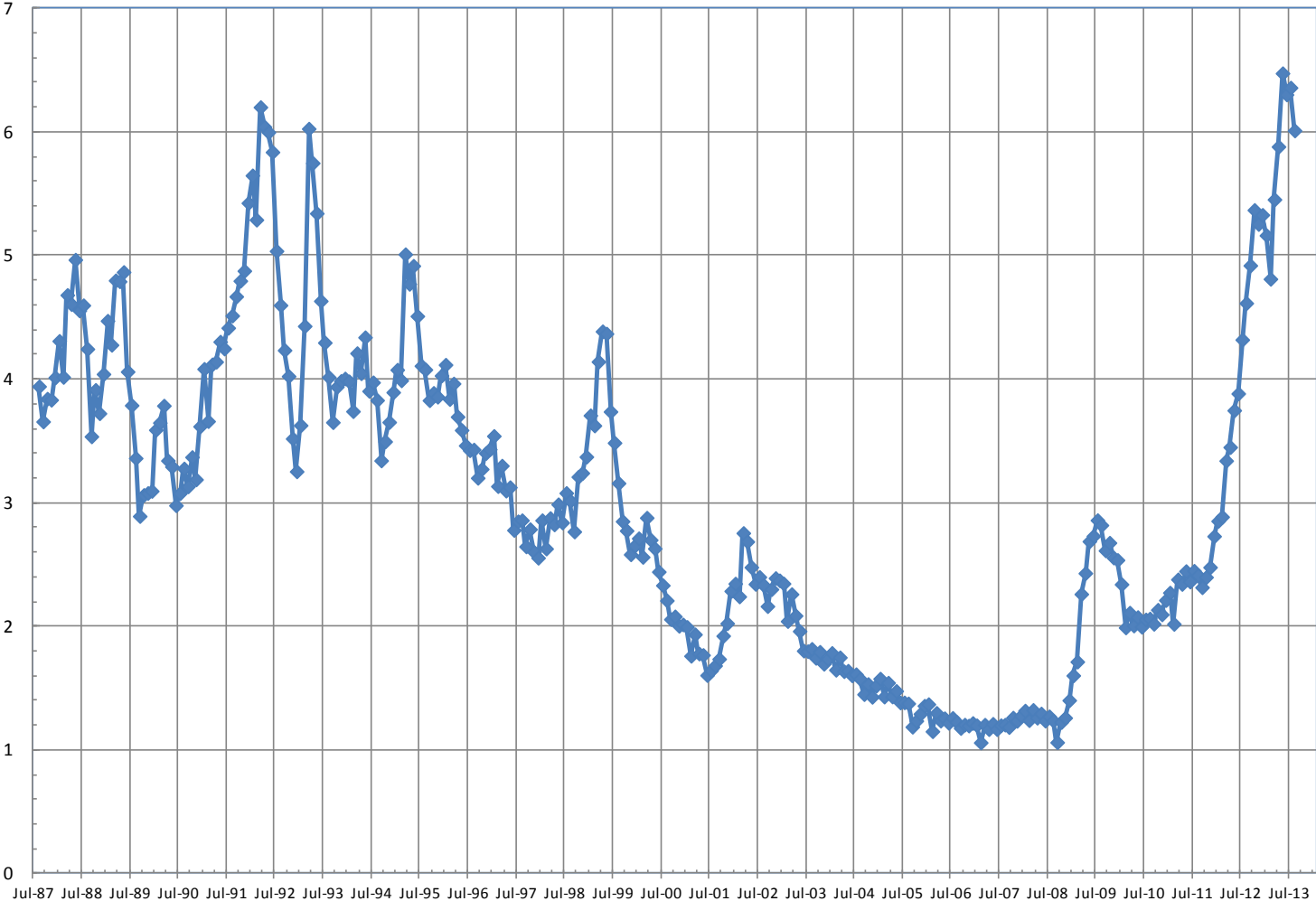
Gas Rigs Compared Production



Gas Production to Rig Count Ratio

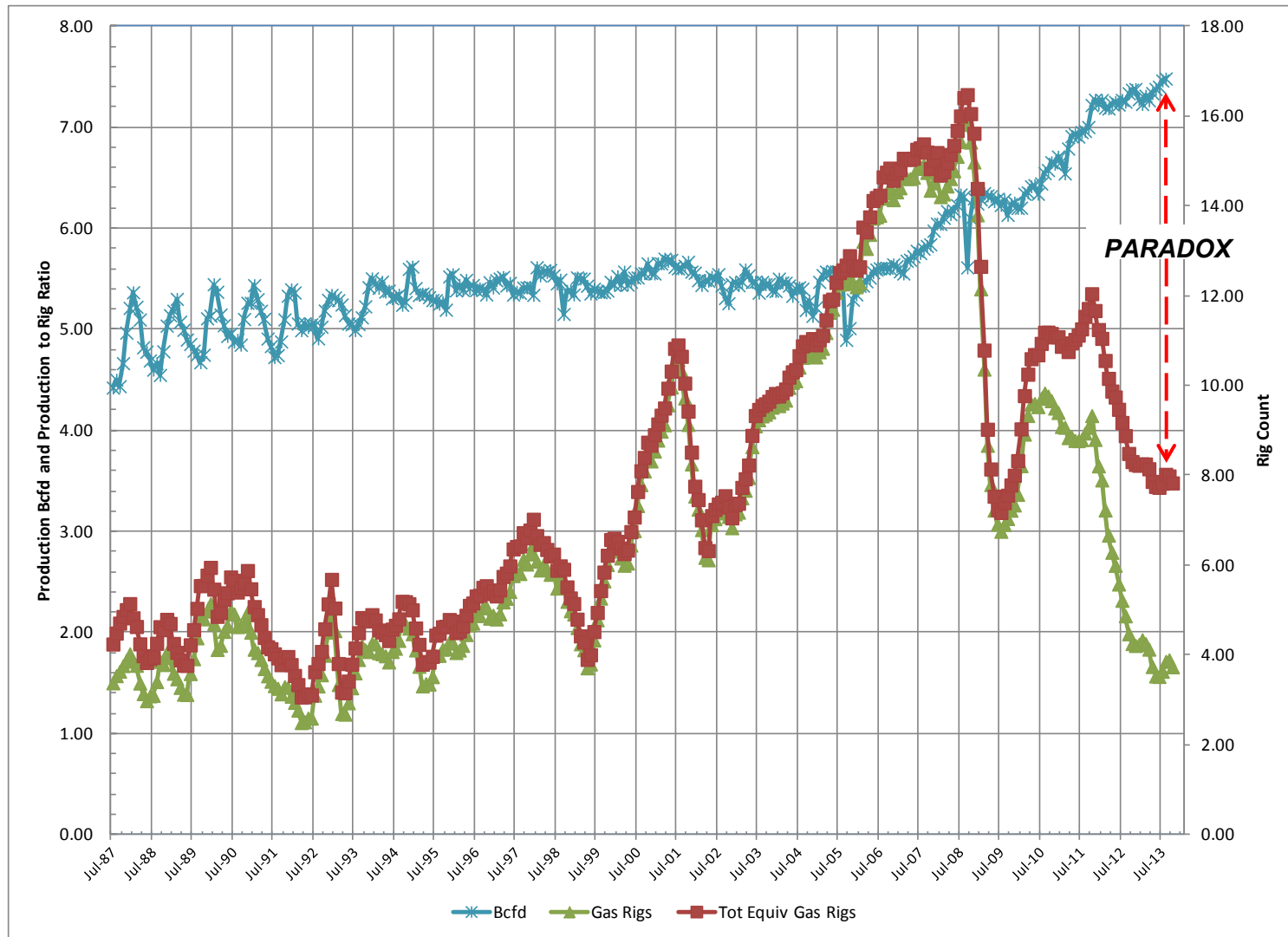


Gas Production to Rig Count Ratio

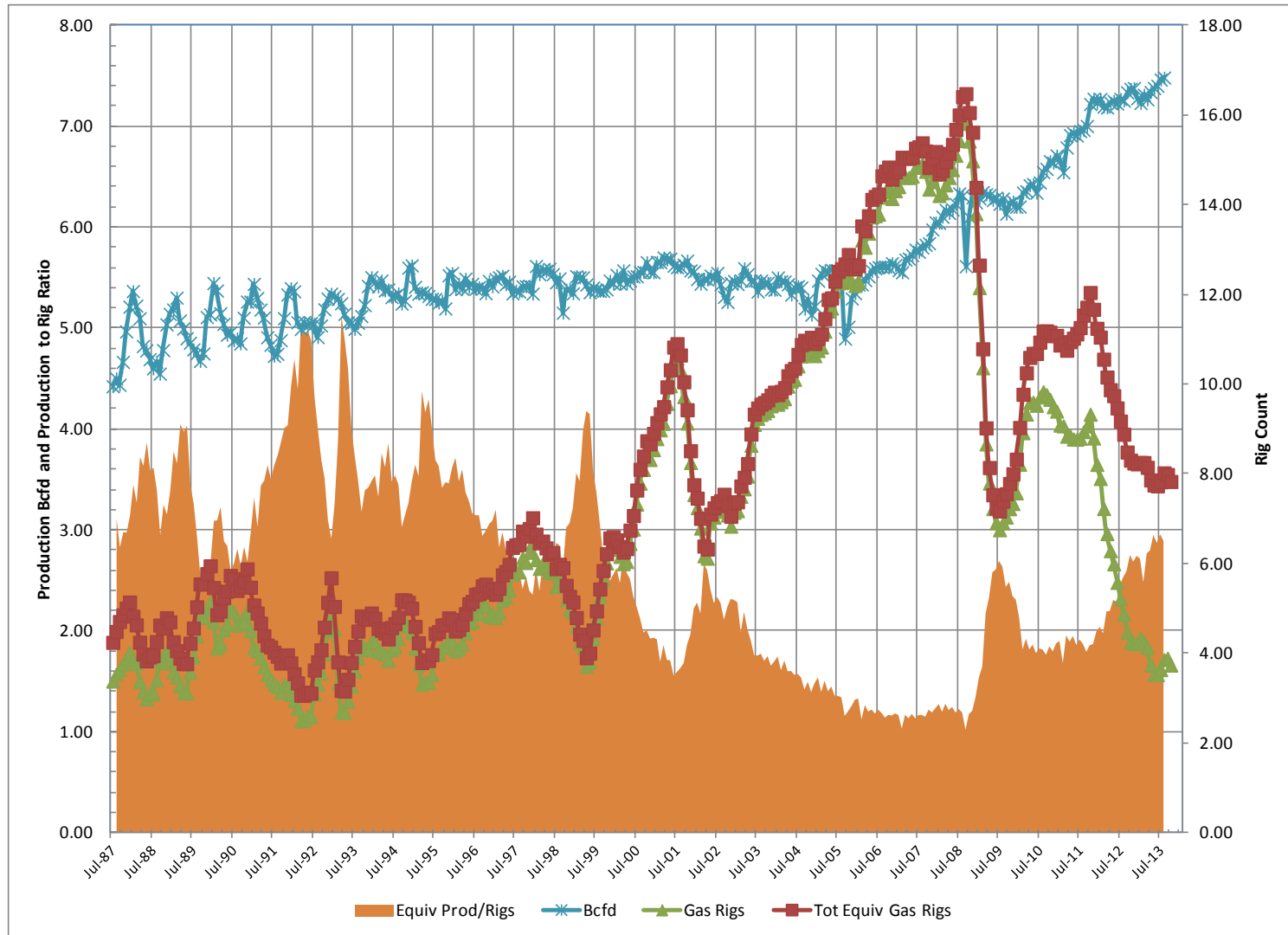


—◆— Bcf per Month/Gas Rigs

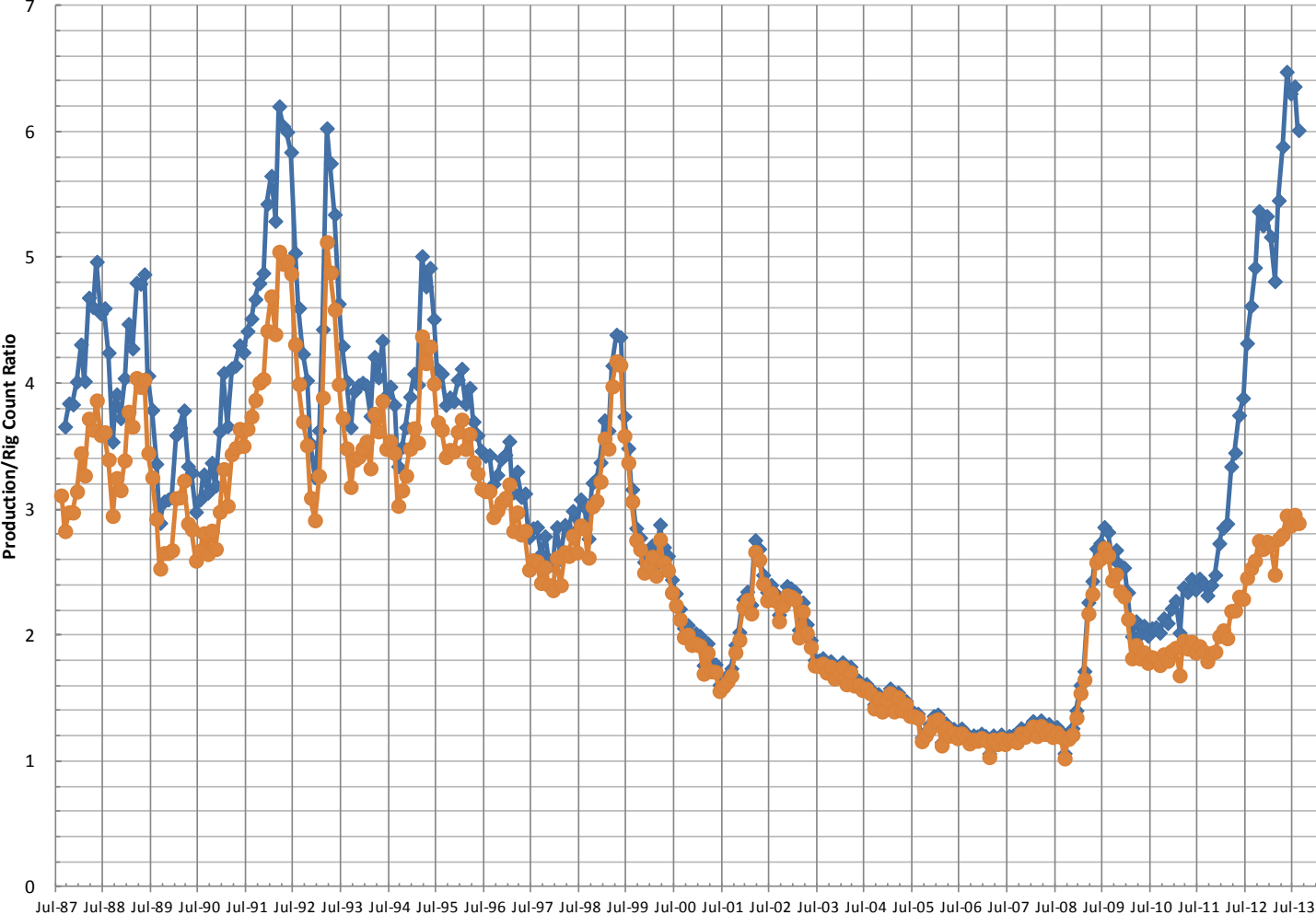
Accounting for Associated Gas Equivalent Gas Rigs



Gas Production to Equivalent Rig Count Ratio



Gas Production to Rig Count Ratio

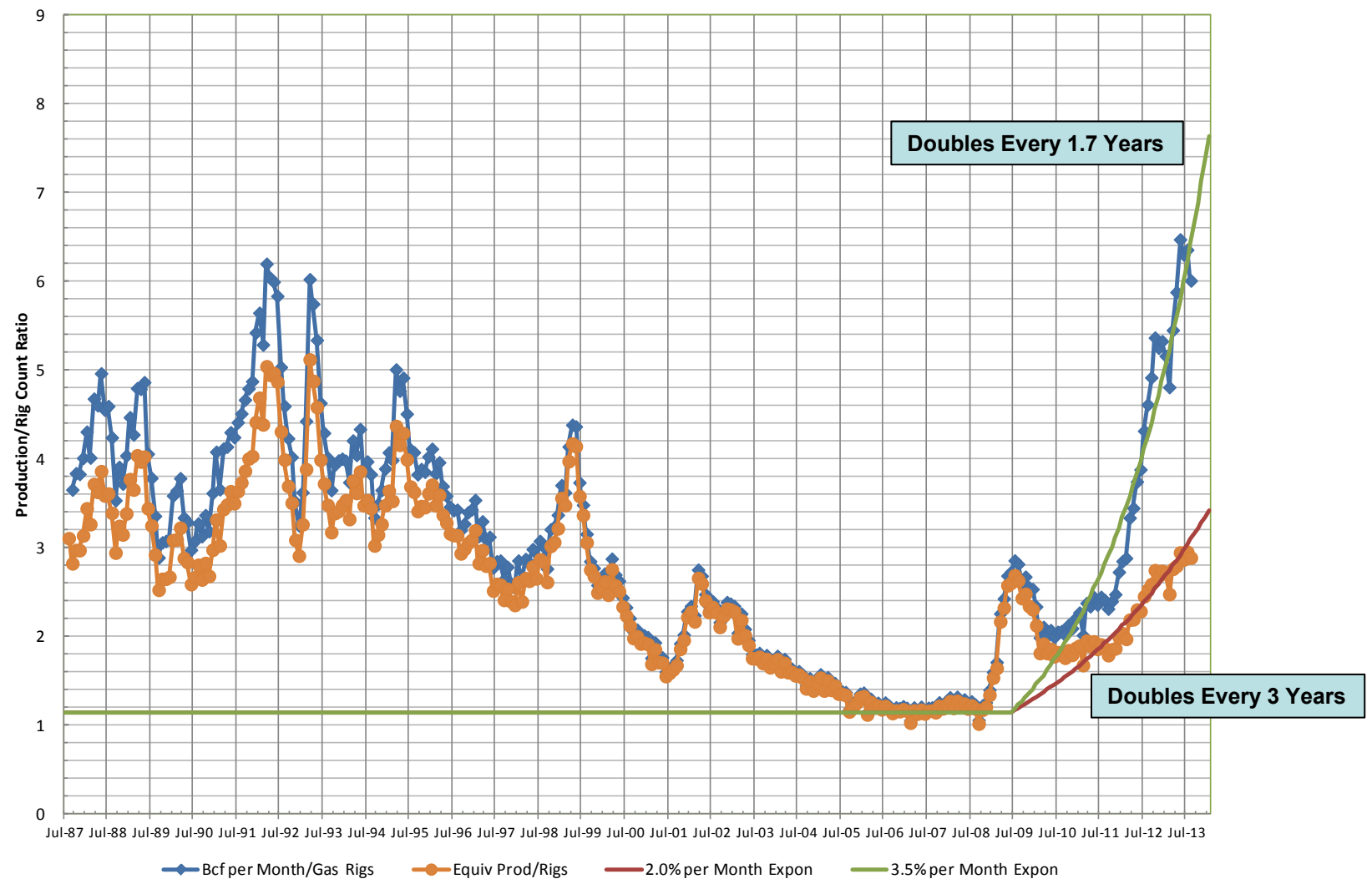


◆ Bcf per Month/Gas Rigs ● Equiv Prod/Rigs



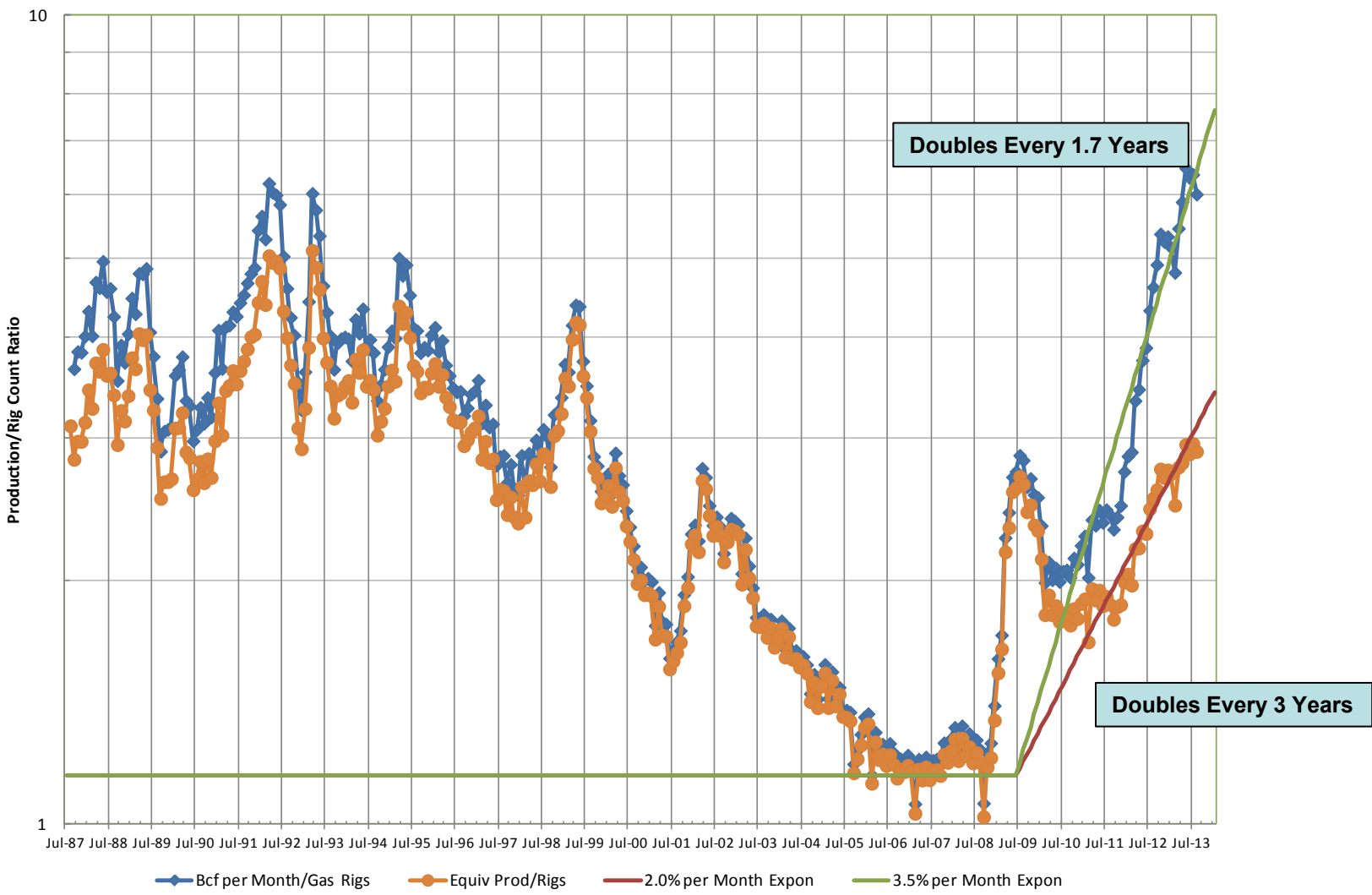
Gas Production to Rig Count Ratio

Is there a Moore's Law?

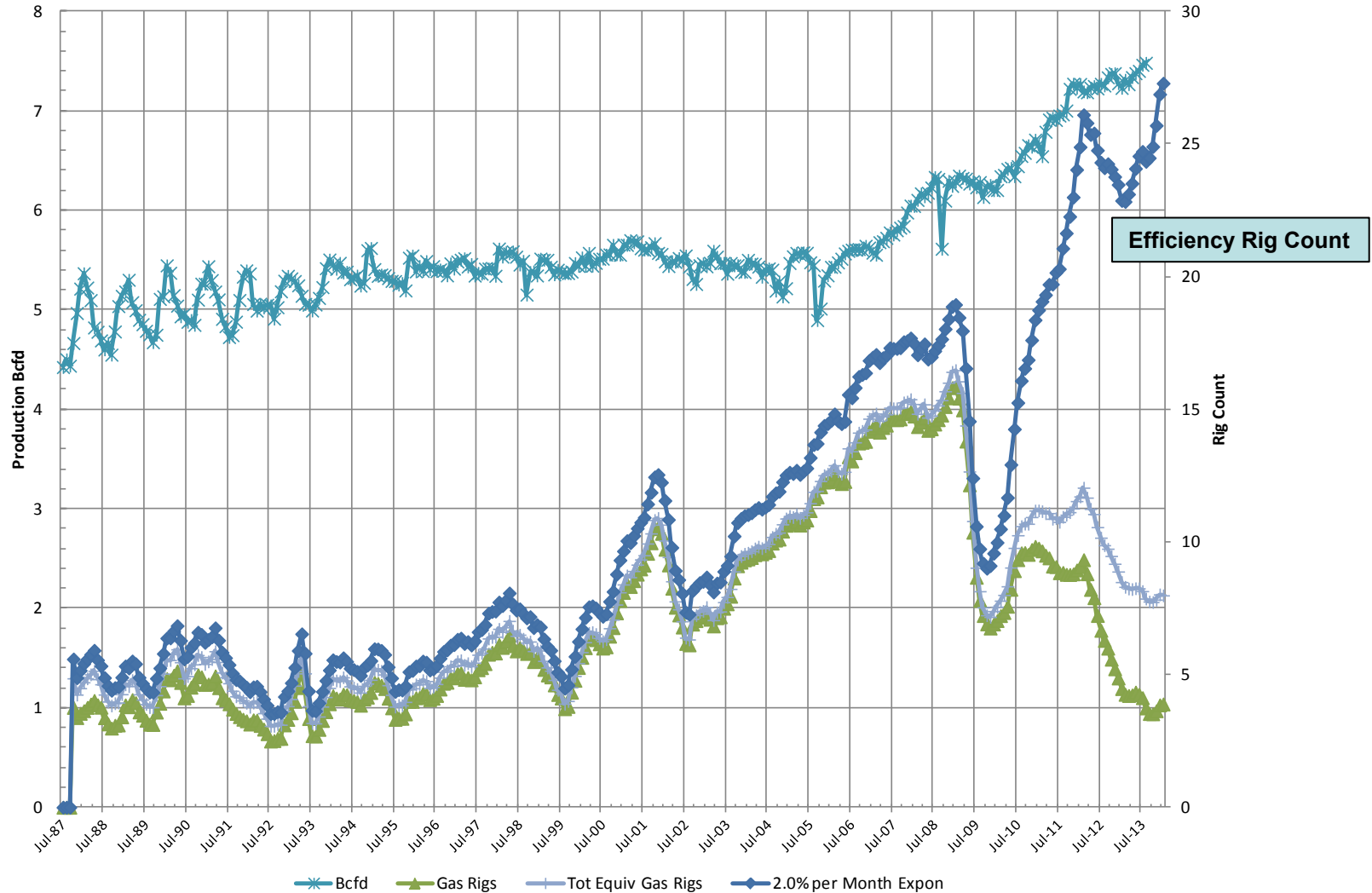


Gas Production to Rig Count Ratio

Is there a Moore's Law?

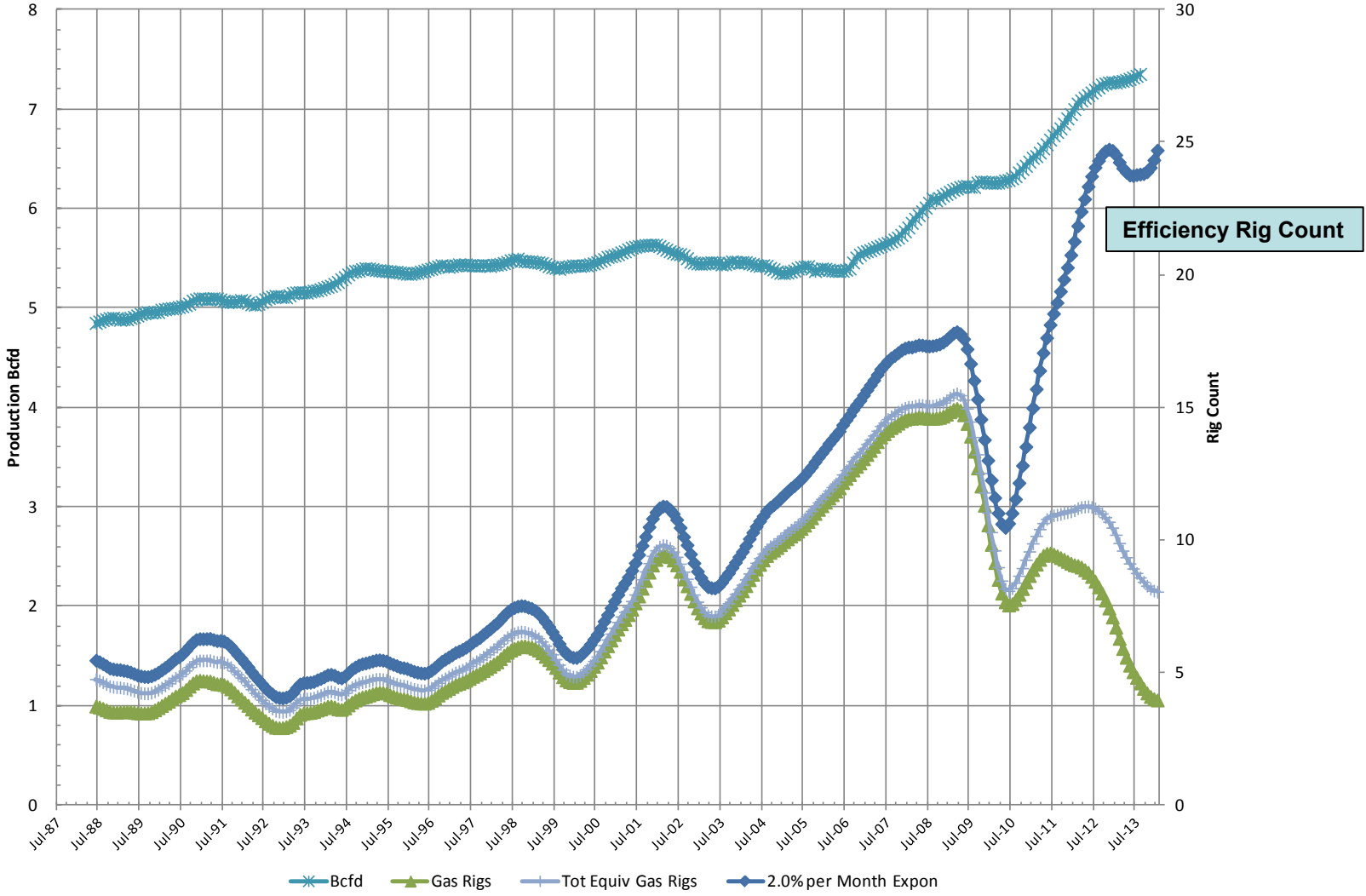


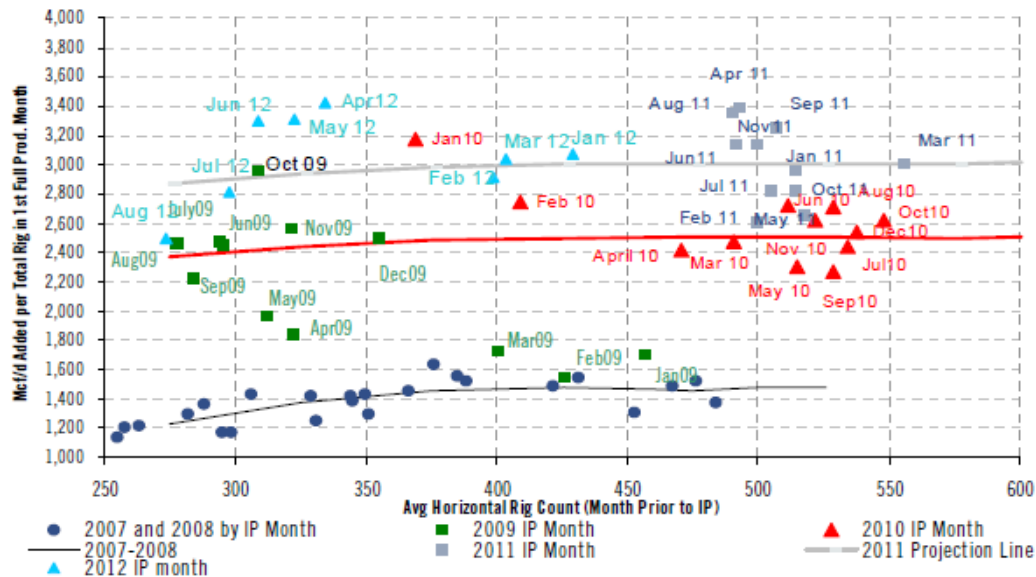
Rig Count with Exponential Efficiency



Rig Count with Exponential Efficiency

12 Month Rolling Average of Data





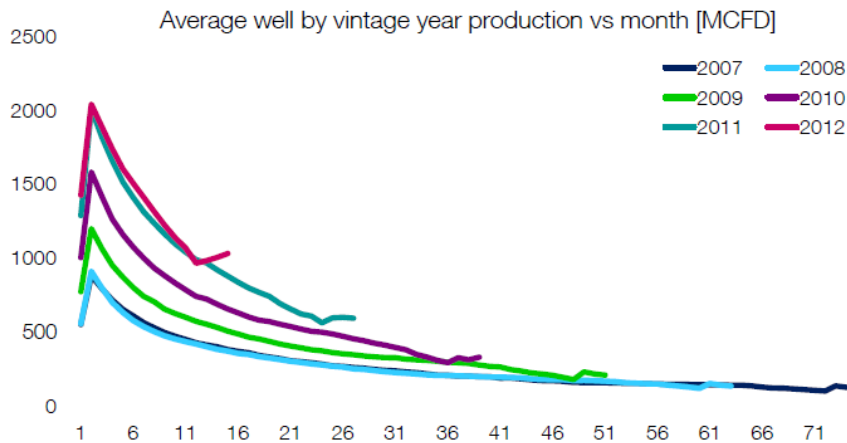
Production per Rig up 2.5x 2008 to 2012

Citi April 2013

The technology revolution

Technology drives massive per well production growth

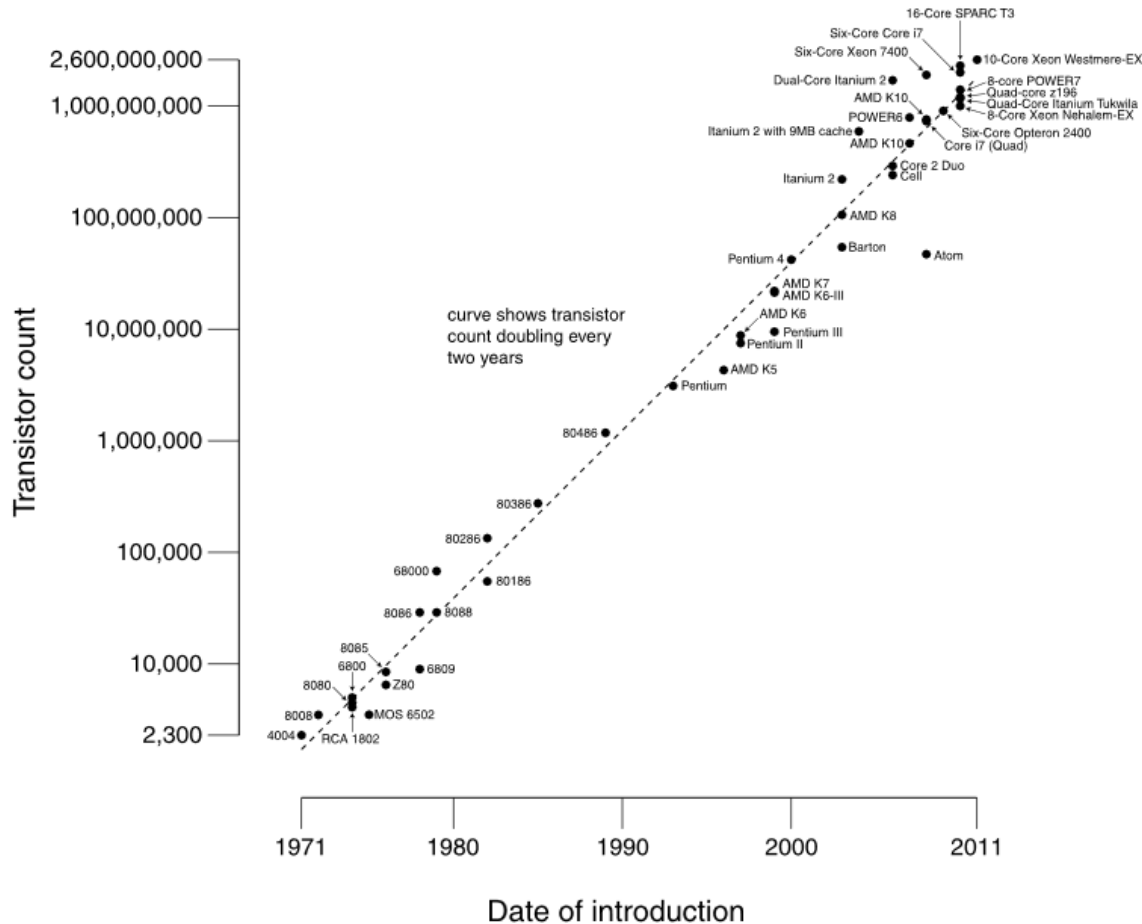
Production up 2x 2008 to 2012



$$\frac{R^2}{A} \rightarrow V^+$$

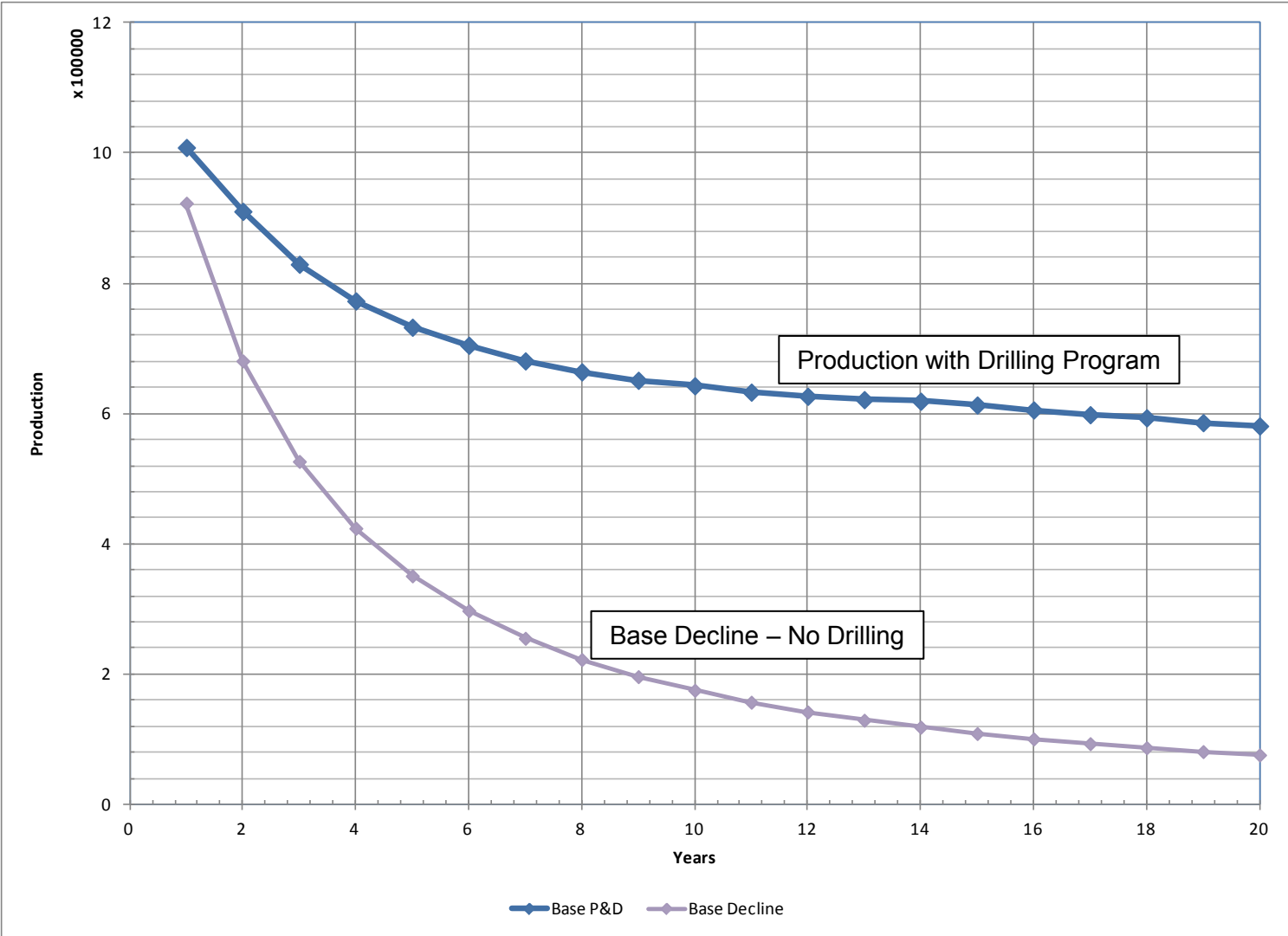
Why is Moore's Law Exponential

Microprocessor Transistor Counts 1971-2011 & Moore's Law

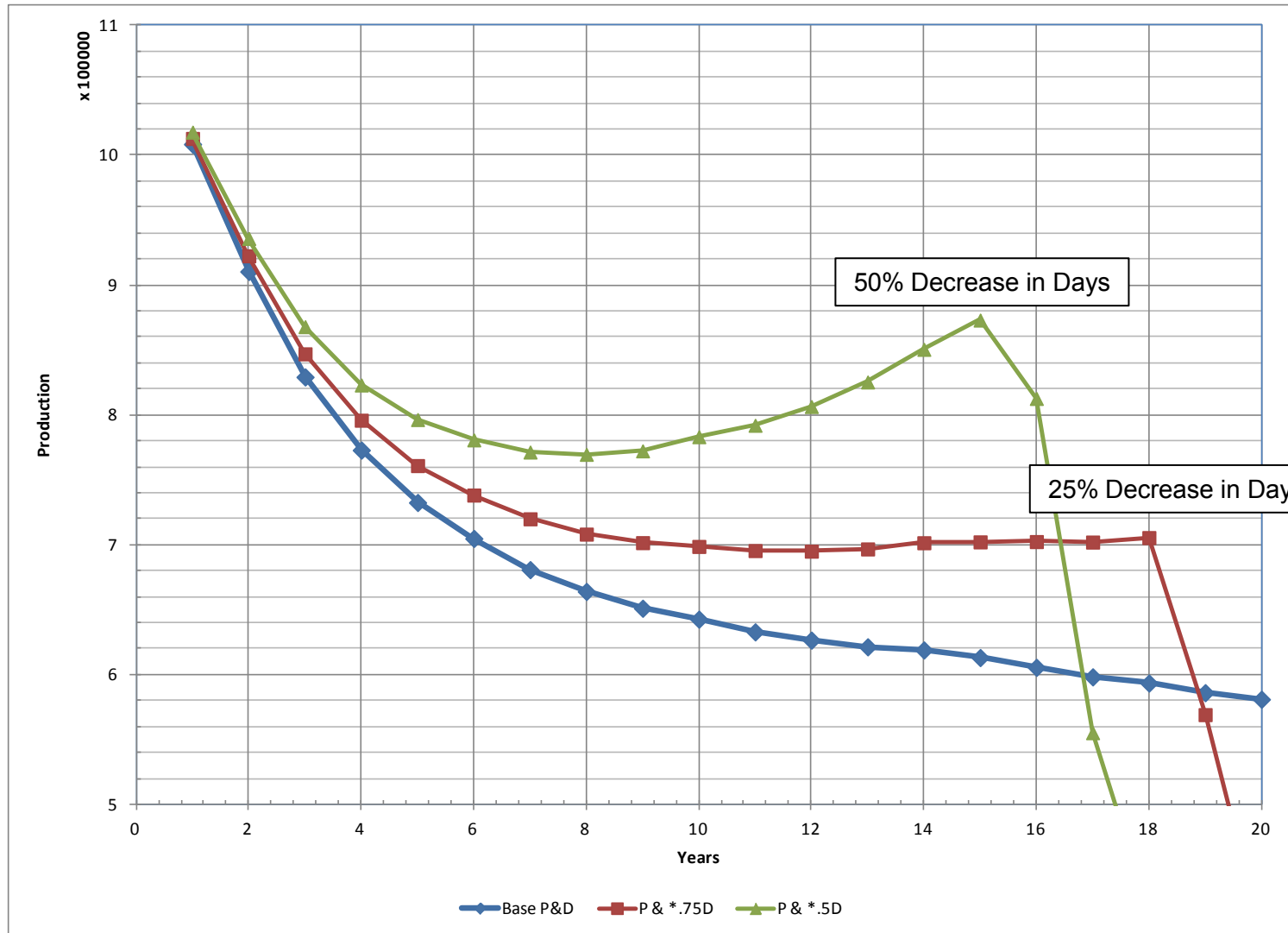


Many small improvements concentrated on a single goal create a net multiplicative effect rather than linear.

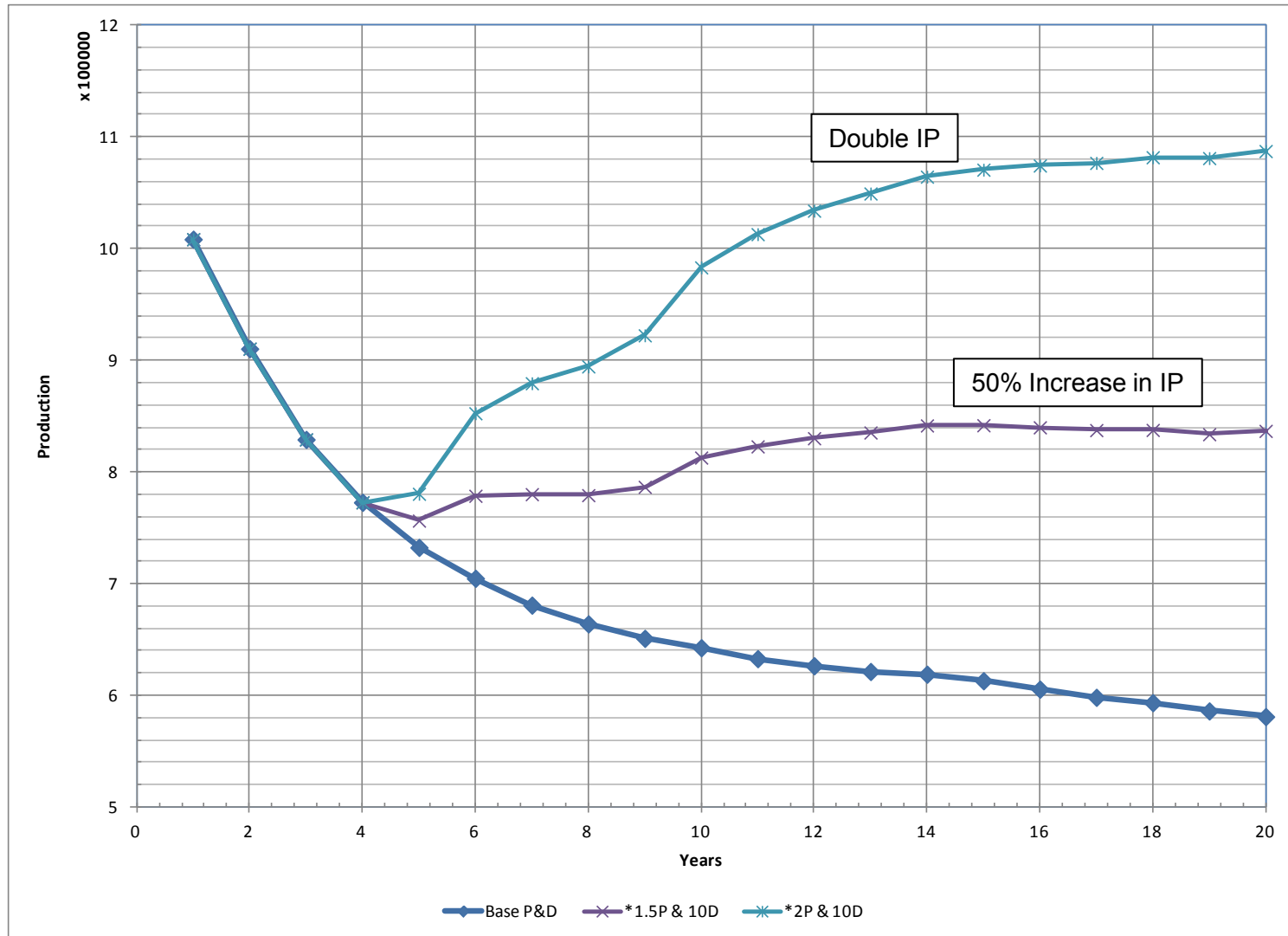
$$\frac{R^2}{A} \rightarrow V^+$$



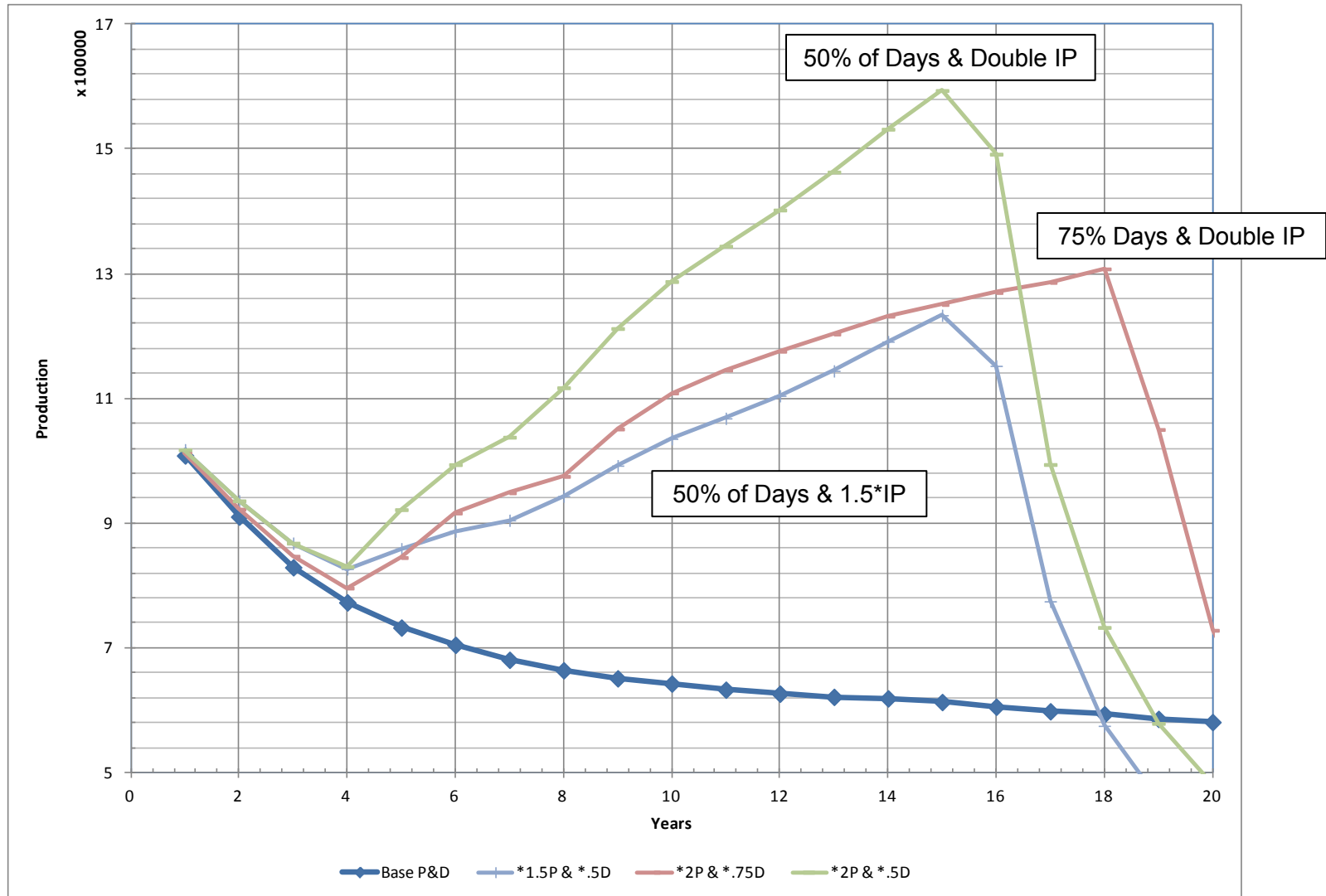
Model – Decreasing Days to Drill



Model – Increasing Well IP



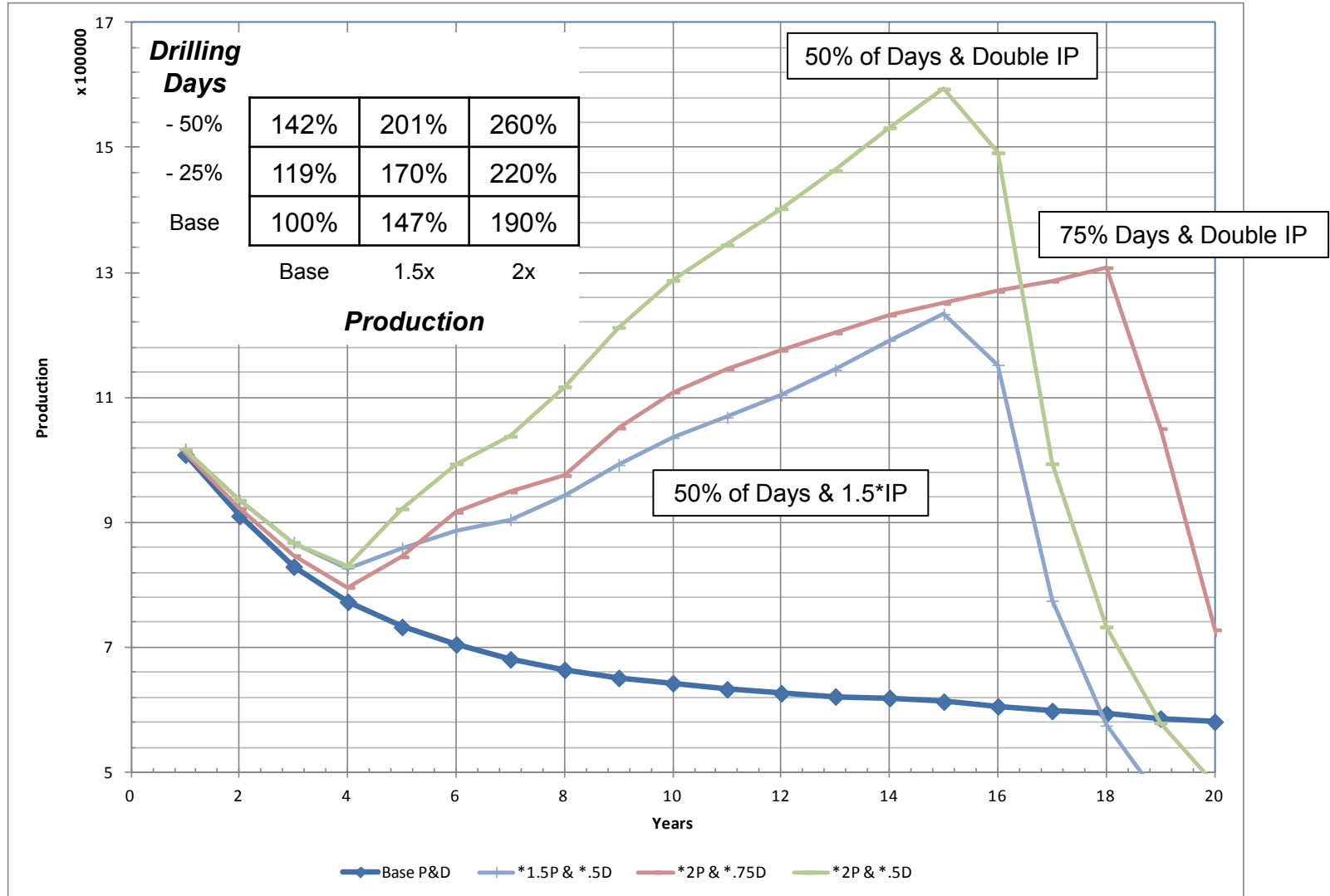
Model Decreasing Days to Drill and Increasing Well IP



$$\frac{R^2}{A} \rightarrow V^+$$

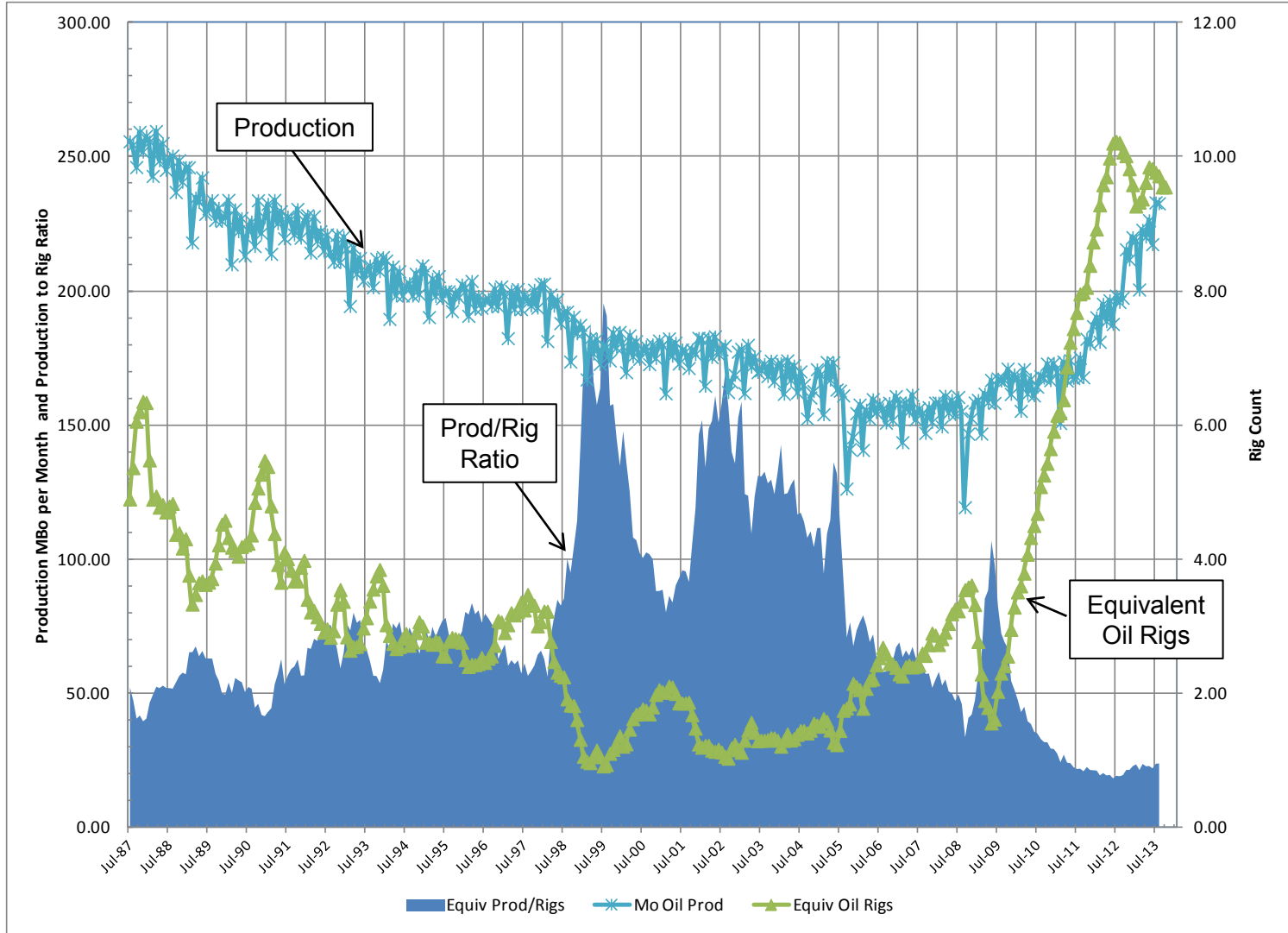
Model

Decreasing Days to Drill and Increasing Well IP



$\frac{R^2}{A} \rightarrow V^+$

Oil Rigs Compared to Production *No Paradox?*



- **Is there a Moore's Law effect on unconventional production?**
 - Is your company up to speed on the current learning?
 - What is the future shape to learning?
 - What does the 3 year doubling of learning mean to E&P's, the service industry, academics, regulators, communities where we work ...?
- **How do you stay in front of the accelerated learning curve?**
 - What do you need to do different?
 - What do you need to do different than the rest of the industry?
- **What does tomorrow's learning organization look like?**

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Appendix

$$\frac{R^2}{A} \rightarrow V^+$$

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The Unconventional Learning Curve or The Natural Gas Paradox

“Moore's law” is one of the most famous observations in computer hardware history. The law is based on work by Gordon Moore in 1965 when he noted that transistors on integrated circuits double approximately every two years. While we no longer talk about transistors, this correlation for computing power has continued through almost four decades.

This presentation will discuss the learning curve already established by the unconventional paradigm. The learning pace has some things in common with Moore's law and provides important clues about future unconventional production and how the industry might approach future technologies.