Stochastic Forecasting of New Product Diffusion

With Adherence to Historical Data

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About AQS

- A consultancy specializing in quantitative management/marketing sciences since 1999
  - Forecasting
  - Market simulation
  - Valuation analysis
  - Supply chain analysis/optimization
  - Portfolio modeling & analysis
  - Statistical analytics
- Products
  - Model Builder for Excel/@Risk
  - Model Builder Enterprise

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2

AQS Clients

- Johnson & Johnson Global Business Development
- Ethicon Endo-Surgery
- LifeScan
- Ethicon, Inc.
- Ortho-McNiel-Janssen
- Cordis
- Codman
- Depuy Spine
- Vistakon
- Roche
- Easton Associates
- Metaphor, Inc.
- Smith & Nephew
- Reliant Pharmaceuticals
- Endo Pharmaceuticals
- Eisai Pharmaceuticals
- J&J Pharmaceutical Group Strategic Marketing
- Merial, LTD
- Cryonics Medical
- Anika Therapeutics
- Breathe Technologies
- Deloitte
- Magellan Health Services
- Proctor & Gamble - MDVIP
- Florida Department of Children & Families

The Bass Diffusion Model

- Developed by Frank Bass
- Published in Marketing Science, 1969
- Mathematical representation of the social process underlying innovation and social contagion
- Selected in 2004 as one of the most influential papers in the 50 year history of Management Science
- Originally formulated to forecast durable goods, but has been successfully generalized to numerous product categories across many industries

4

The Continuous Bass Equation

$$N(t) = m(t)\frac{1 - e^{-(p+q)t}}{1 + \frac{q}{p}e^{-(p+q)t}}$$

Where:
N(t) = Sales at time t
m(t) = maximum organic adoption
p = Coefficient of innovation
q = Coefficient of contagion

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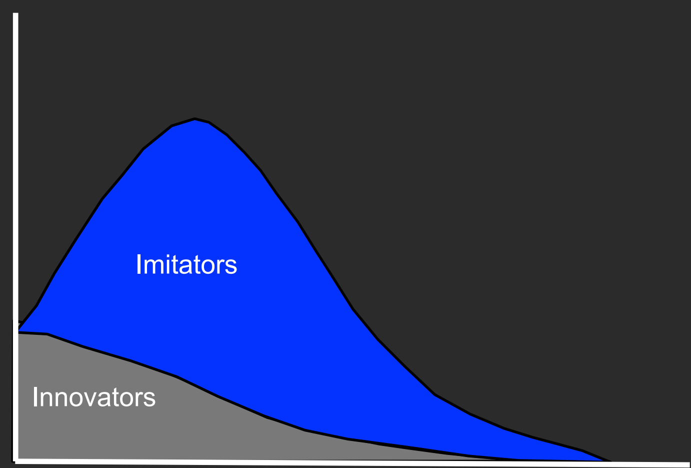
The AQS Experience Using the Bass Model

- Early experimentation in the life sciences industry
  - Medical device
  - Pharmaceutical
  - Biotechnology
  - Clinical practice guidelines
- Conversations with Frank Bass
- Problems with absence of data
  - Original parameters not amenable to expert elicitation or market research
  - Re-parameterization of p and q

6

Diffusion as a Social Process



- Early adoption is driven by innovators who adopt the technology as a direct function exposure via marketing (the p coefficient)
- As time passes the role of innovation becomes less important than that of social contagion, where adoption is driven by those that adopt as a function of exposure to others who have adopted (the q coefficient)
  - The role of risk

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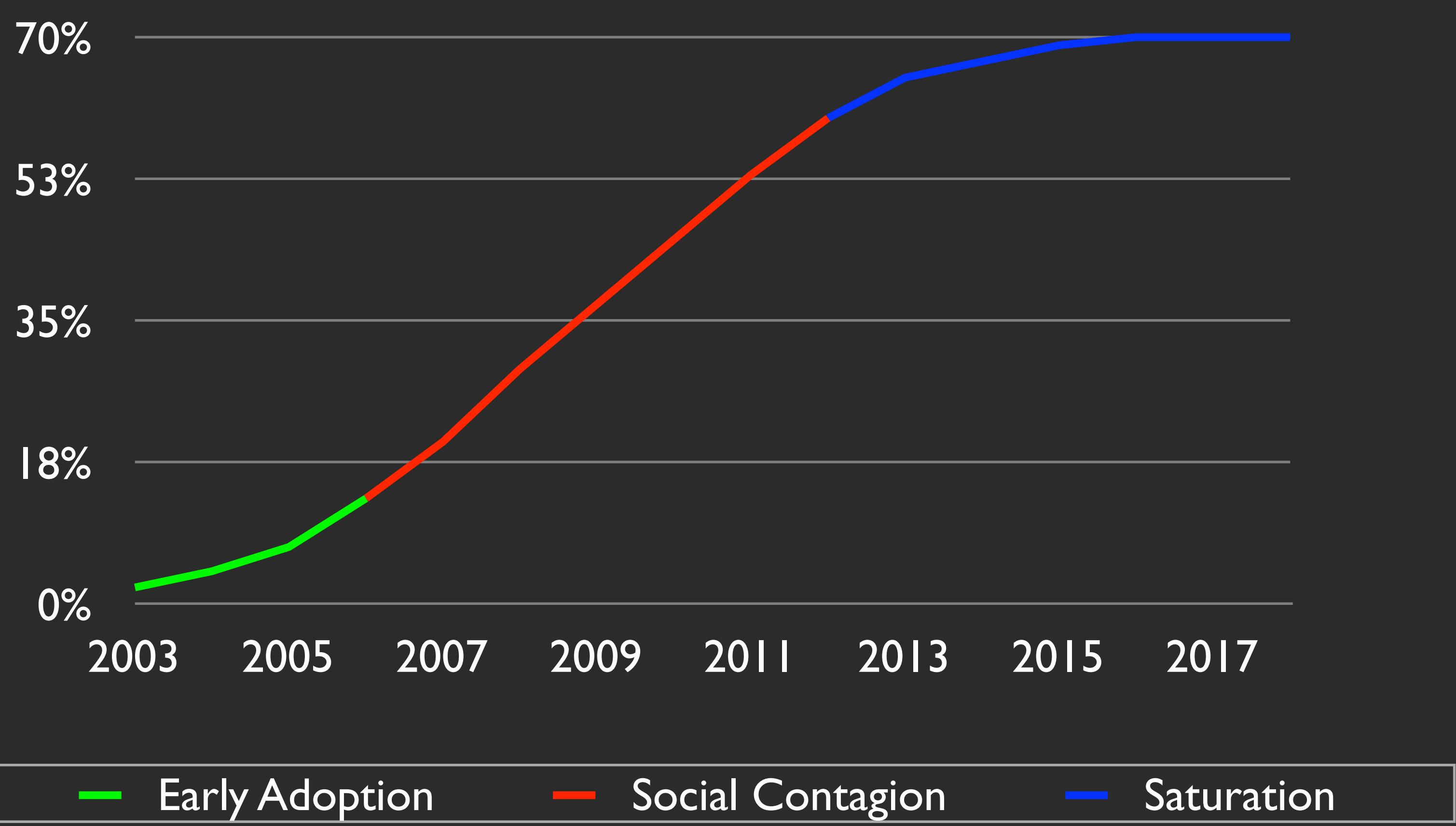
Time Series of Adoption



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Organic versus Disrupted Diffusion

- We model organic diffusion and disruptions to this organic process as unique phenomena
- Organic refers to an unimpeded natural process of diffusion
  - Systematic
  - Monotonically increasing
- Disruption is any perturbation to the organic diffusion process

Fitting Bass Equation Parameters (Non-Stochastic) to Forecast Organic Diffusion Using Microsoft Excel

- Plot historical segment adoption units
- Convert to percentage of segment
- Construct Bass model with visual approximation for input parameters
- Calculate squared error for Bass model relative to history
- Calculate Mean for time series of squared error (MSE)
- Establish a best estimate for m (maximum adoption)
- Using Solver, minimize MSE by varying p and q

Risks and Benefits of Using This Method

- Benefits
  - Relatively simple
  - Tools are readily accessible
  - Defensible (Volumes of support in the literature)

- Risks
  - Single point estimation of future
    - The earlier in the diffusion process the more risky this is
    - With each passing year of history the organic futures become more prescribed

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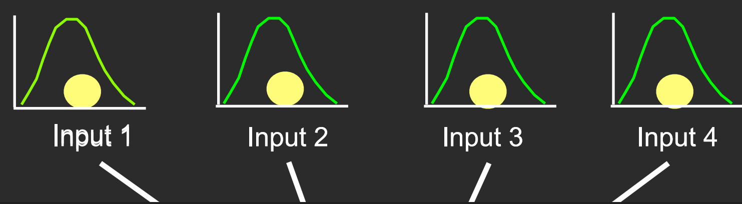
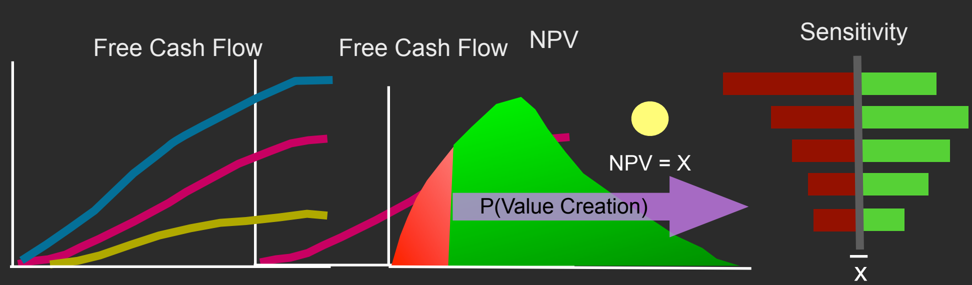
Traditional vs. Monte Carlo Method



"Any realistic model of a real-world phenomena must take into account the possibility of randomness."

--- Sheldon M. Ross



Modeling Stochastic Organic Diffusion with the Bass Equation to Forecast Organic Diffusion Using Microsoft Excel and @Risk: The Case With No History

- Simplest form of stochastic diffusion model
- m, p, and q are independent uncertainties
- Use of analogs may inform choice of input parameters
- However, virtually impossible to rely on expert elicitation for shaping parameters (p, q)

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Modeling Stochastic Organic Diffusion with the Bass Equation to Forecast Organic Diffusion Using Microsoft Excel and @Risk: The Case With History

- History creates a host of issues in ensuring a plausible forecast
- m, p, and q are no longer independent uncertainties
  - Modeling them as such will establish forecast futures that are implausible given history ("can't get there from here")
- Common (problematic) work-arounds
  - Correlation of input parameters
  - Force to history

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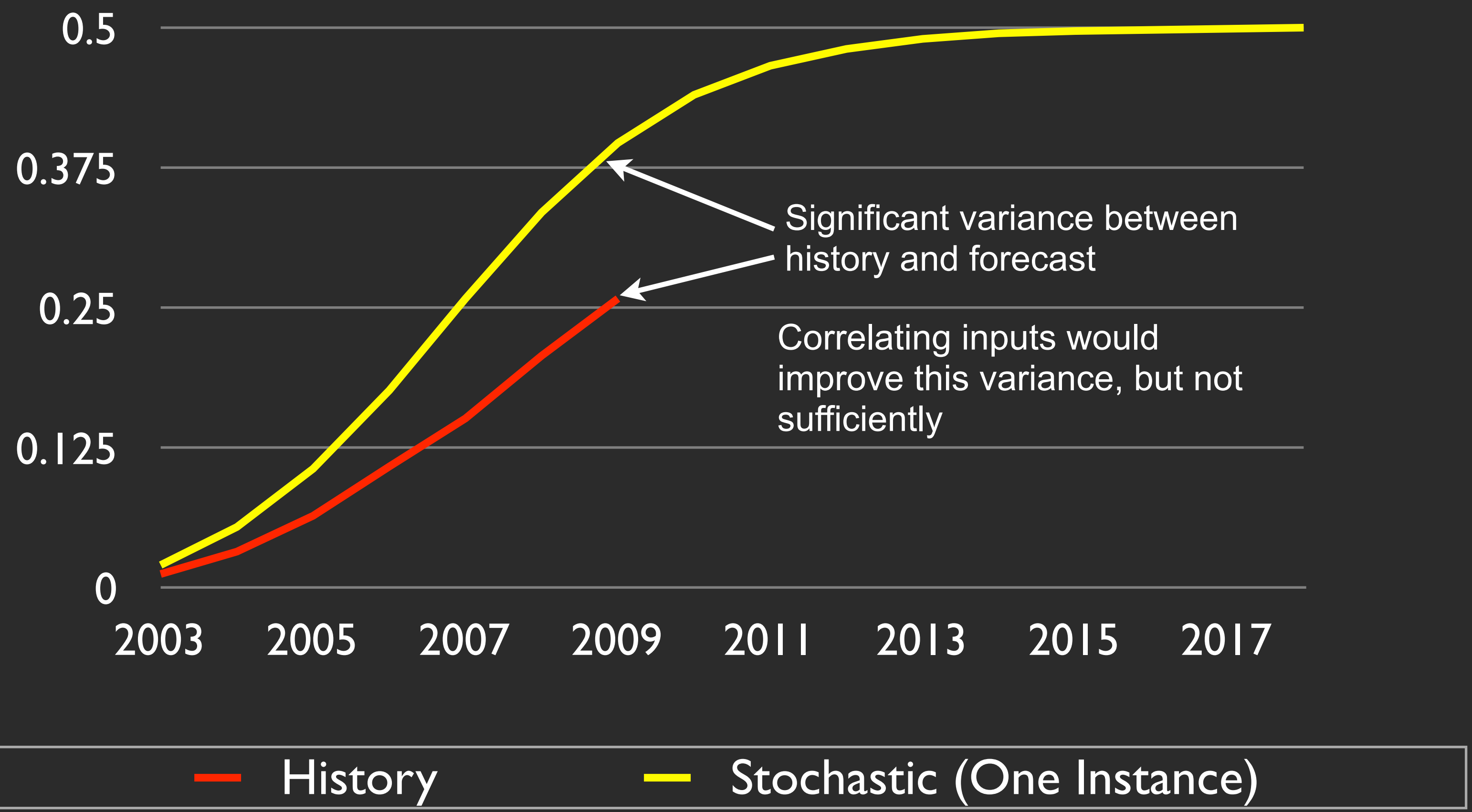
Stochastic Independent Inputs



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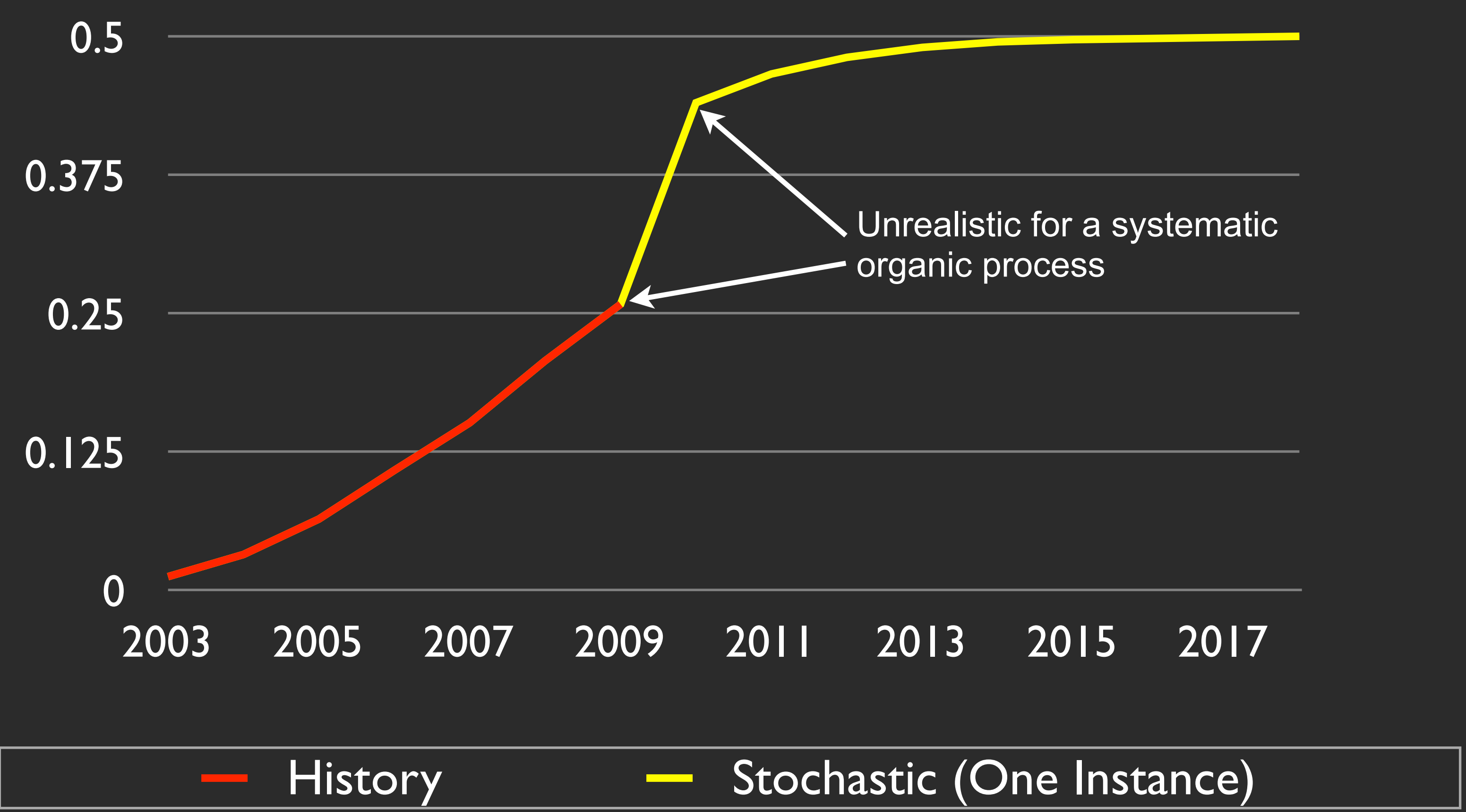
Stochastic Independent Inputs



Modeling Stochastic Organic Diffusion with the Bass Equation to Forecast Organic Diffusion Using Microsoft Excel and @Risk: Robust Method for the Case With History (Patent Pending)

- Fit the best estimate forecast through history
- Create distribution for probabilistic m (maximum adoption)
- Establish p as a function of m:

$$\frac{p_{BestEst}}{\left(\frac{m_{Stochastic}}{m_{BestEst}}\right)}$$

- Establish a table with increments across the interval of m
- Calculate p for each increment of m
- Varying the m input to the adoption model, with p varying as a proportional function of m, solve for q by minimizing the fitted error as in the best estimate example
- Record the solved-for value of q for each increment of m and record in the table
- Using regress q against p acoss the increments of m
  - Depending on history, the relationship will range from slightly non-linear to significantly non-linear (most of the time a third-order polynomial is optimal)
- Use the regression equation to calculate q as a function of p in the adoption model
- Simulate!

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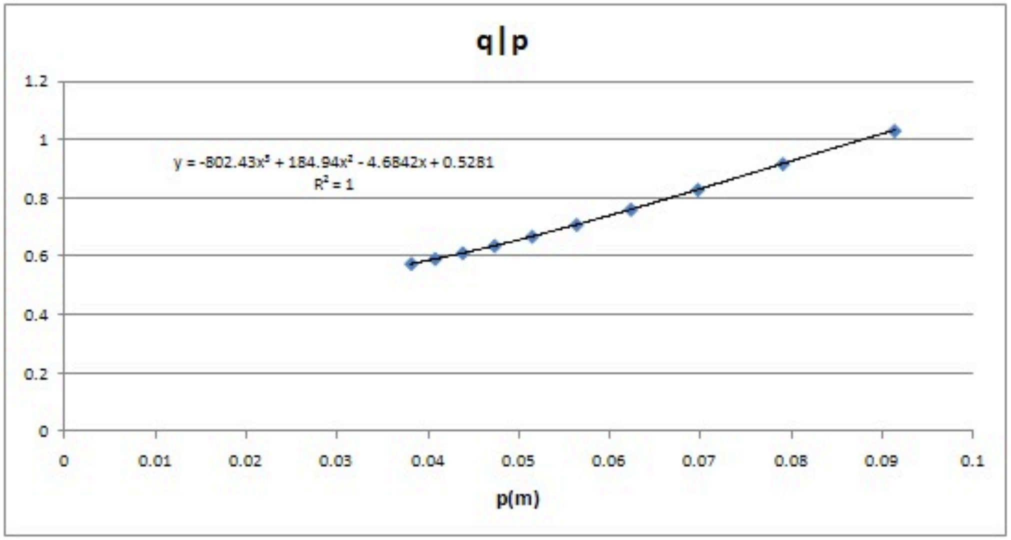
Table of q | p (Example)

m	p|m	q|p
25.0%	0.091363583	1.031962719
28.9%	0.079064639	0.917283966
32.8%	0.069684089	0.828244868
36.7%	0.062293352	0.76002595
40.6%	0.056320017	0.707592003
44.4%	0.051392015	0.666940814
48.3%	0.047257026	0.635101825
52.2%	0.043737885	0.609908812
56.1%	0.040706547	0.589781752
60.0%	0.03806816	0.573559704



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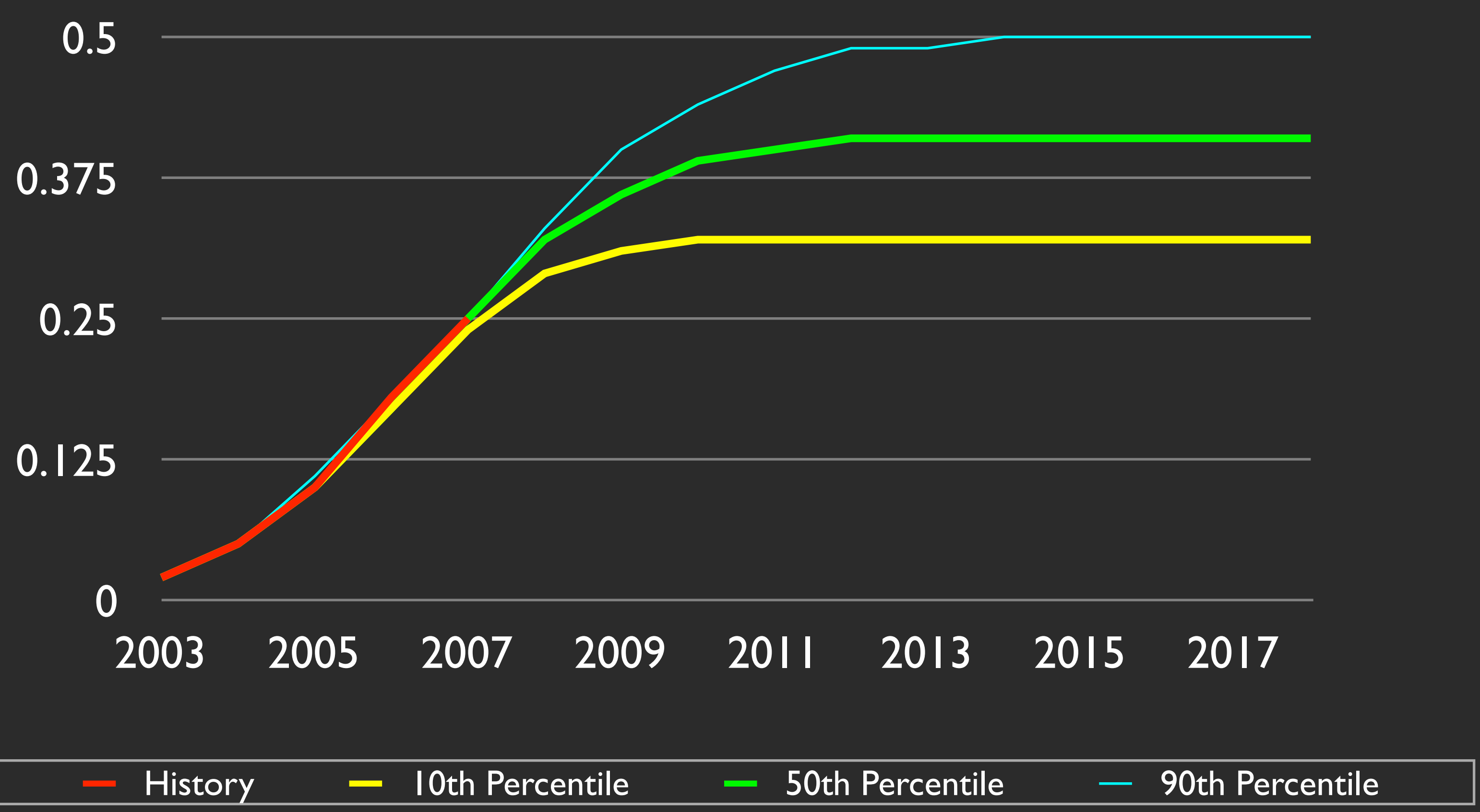
18

Stochastic AQS Method Output



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Thank you

Decide with confidence

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