

# Introduction

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Doug Gray

# Motivation (See Forbes Article)

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- *Critical and urgent need for GM/senior executives to understand how to **practically apply data science (analytics and optimization)** to their businesses to address:*
  - Competition and creating strategic competitive advantage (strategy)
  - Customer service, satisfaction and loyalty (market share)
  - Significant, tangible, measurable economic impact and business value
  - Financial performance improvement (revenue, cost, profit)
  - Shareholder value creation (stock price, market cap)
- How to leverage **data availability and computing power, in conjunction with analytics and optimization, to drive significant, tangible, and measurable economic, financial, and business value, and achieve strategic, competitive advantage**

# Course Overview

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- Offer a course featuring real-world cases illustrating how to ***apply analytics strategically to create competitive advantage***
- Focus on real-world problem solving applications of analytics and optimization, from the data scientist as well as the GM/senior executive perspective: this includes implications for IT
- Balance of quantitative techniques and real world problem analysis/solutions
  - Modeling/number crunching, applying what students have learned previously
  - Focus on *problem definition/structure, modeling frameworks, solution approaches, business benefits of quantification, analytics implementation, and execution approaches*
  - Incorporate elements of strategy, finance, economics, operations management, marketing, and organizational behavior
- Study optimization techniques and applications

# Course Objectives

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- Students should be able to practically identify and implement a **strategy** to leverage analytics, optimization, and IT approaches, methods, and techniques, working alongside OR/OM/IT/analytics professionals/specialists
  - *Data requirements*
  - *Enterprise orientation*
  - *Leadership from executives*
  - *Targets, i.e., revenue drivers, cost drivers, market share drivers*
  - *Technology platforms*
  - *Analysts and analytical methods*
- Students should understand how and be able to practically:
  - Lead and drive the creation of an analytics and optimization organizational capability
  - Create an organization driven by analytics and optimization

# Course Objectives

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- Students should be able to practically identify and implement **tactics** to leverage analytics, optimization, and IT approaches, methods, and techniques, working alongside OR/OM/IT/analytics professionals/specialists
  - **Frame** the problem and define the problem statement
    - Conceptualize a solution approach
  - **Analytically model** and **solve** the problem
    - Develop, test, and implement a solution
  - **Communicate** and **act** on the results, i.e., “telling a story”
    - Estimate/calculate benefits in terms of economic and financial impact
  - **Embed models inside enterprise processes and systems**
    - “Models make the enterprise smarter, models embedded within processes and systems make the enterprise more efficient (economically, financially)”  
— Davenport

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# Tip

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**Google** and **Wikipedia** are your friends.

- If you are not familiar with or don't understand something, **google** it and read the **Wikipedia** entry... this will give you a quick introduction to the topic and references to get a better idea.
- Google will also refer you to a host of academic papers, news articles, books, and other published material on the topic at hand.
- Google and Wikipedia are often a great start to find the references to become an expert as well as a good source of quick information/overviews/quick review.

# Who Is Using BA?

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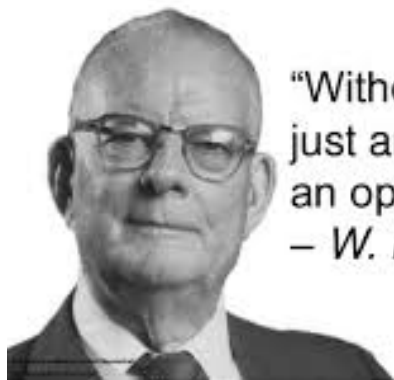
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# Course Motivation: Mini-Cases

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***Using data and analytics strategically to transform an entire nation's industrial base***



"Without data you're  
just another person with  
an opinion."  
– W. Edwards Deming



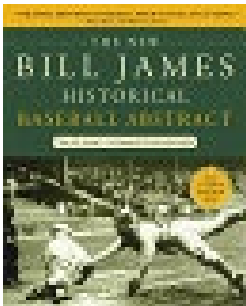
***"In God we trust.  
All others bring data."***

W. E. Deming

# Analytics Is Mainstream in Baseball and Popular Culture

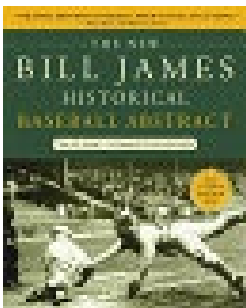
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## *Sabermetrics*



# Analytics Is Mainstream in Baseball and Popular Culture

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# Analytics Is Mainstream in Business Media

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**Forbes** article: [Data Analytics Is No Longer a Nice Option – It's the Core of the Enterprise](#)

**Bloomberg**      **THE WALL STREET**  
**Businessweek**      **JOURNAL**

**FINANCIAL**  
**TIMES**

**Forbes**

**InformationWeek**

**The**  
**Economist**

# Analytics Is Mainstream in Business

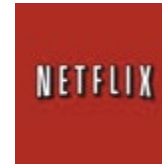
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# Small to Big: Growth Using Analytics

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amazon.com.



Revenue growth

\$5M (1999) → \$1B+ (2006) → \$8.3B+ (2016)



EPS and ROE  
increased 20% per  
year each year for  
10 years post-IPO



Family-owned  
trucking company to  
a multi-billion dollar  
international logistics  
company



Market share growth

36% (1998) → 43% (2004)

same store sales gains 23/24  
quarters prior, failed to meet R  
and P goals for seven years

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# Why Are We Here?

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Doug Gray



# Why Are We Here?

## (If You Don't Believe Me, Then...)

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- “**Analytics** will be the gold rush of the next several years, and many companies will be assiduously panning their data for treasure.”

— Michael Treacy, author of *Double Digit Growth*

- **Analytics** is the **number one issue** for Global CIOs (3,000 surveyed) annually 2012–16.
  - *Global CIO: The Top 10 Issues for 2015, January 2015, InformationWeek*
  - *The 2016 CIO Agenda*, Gartner Report
- **Analytics** is performance-wise measurably transformational.
  - Figure 3-1 page 76; Figure 3-2 page 78

# Why Should You Care?

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- C-level executives can leverage **analytics** to significantly, tangibly, and measurably improve the economic performance and competitive market position of their firms
- **Big takeaway:**
  - ***Analytics*** looks *forward* into the *future* to *anticipate* and *predict* what is *going to happen*, *optimize* what *should* happen, not just look back at what happened
- Customer behaviors/competitor actions/internal operations

# How Does It Work?

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- Understand and appreciate analytics as a **competitive weapon**.
- Embed analytics in your **strategic/tactical/operational decision-making**.
- Identify and collect the **data** required to support analytics.
- Identify and install the appropriate analytics **methodologies and technologies**.
- Identify and execute **high-impact, high value-added** analytics projects.
- Develop an **internal** analytics organization and capability.

# What's in It for You? For Your Company?

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- Improve managerial **decision-making (based on data, facts, and analysis) and performance**
  - Increase **your** career success, fulfillment, compensation, and advancement (**ten- vs. nine- vs. eight-figure impact**)
- More efficiently and effectively **identify, acquire, satisfy, and retain profitable customers**
- Increase **revenues**, decrease **costs**, and increase **profitability and margins**
- Increase **efficiency** in internal operational processes and resource allocation and utilization
- Increase **returns** for investors and shareholders
- Increase **agility** in dealing with and responding to competitor actions

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# Evolution of and Revolution in Business Analytics

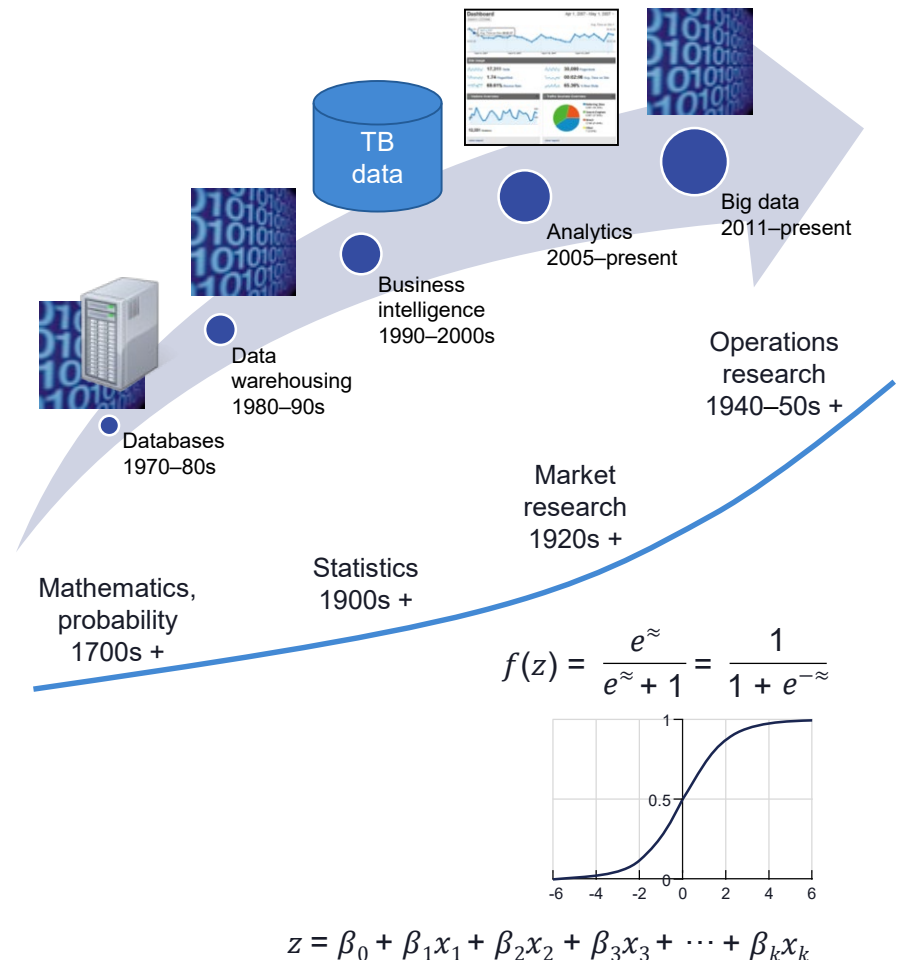
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# Evolution of Analytics

## “Lever to move the needle on economic performance”

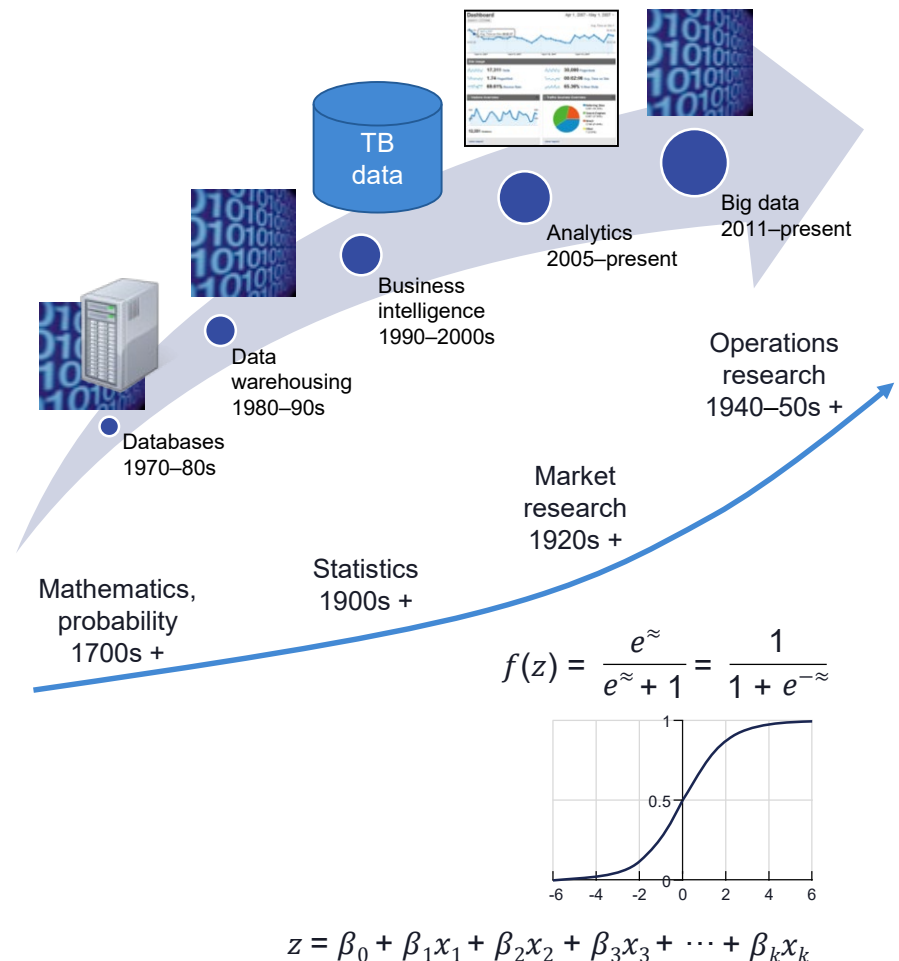
- Predictive and marketing analytics
- Customer intelligence and social media
- Cross- and up-sell loyalty and retention
- Customer profiling, segmentation, targeting, consumption propensity, and lifetime value
- Supply chain, process operational, analysis, and optimization



# Evolution of Analytics

## “Lever to move the needle on economic performance”

- CHAID and latent class models
- Linear and logistic regression
- Time series analysis and forecasting
- Simulation and scenario analysis
- Mathematical programming
- Big data
  - Social media, text, video, audio
- Pattern recognition and trend analysis
- Machine learning, deep learning, AI

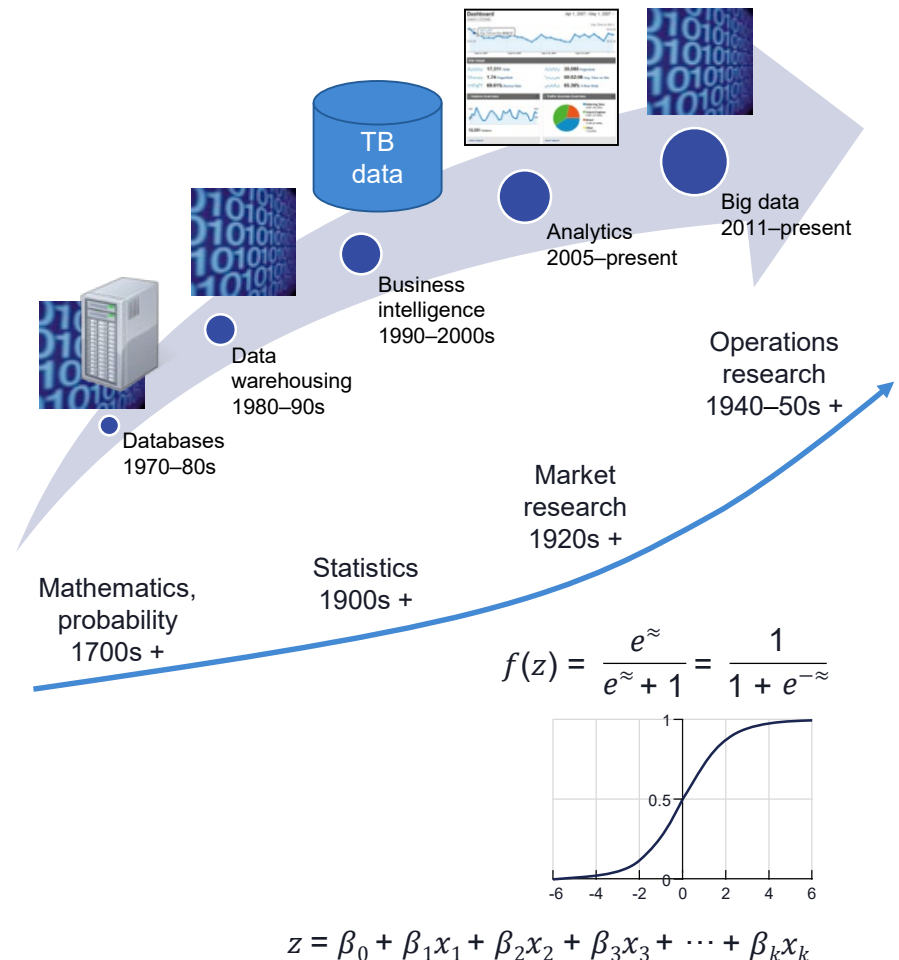




# Revolution in Analytics

## “Four eras in 10 years 2007–2017”

1. Heavy on reports; light on prediction
2. Silicon Valley: open source tools/visualization
3. Mainstream: big (and small) data for big companies; “*operational analytics*”, e.g., UPS ORION, GE Predix “*digital industrial*”/ *organizational change management*
4. Autonomous analytics: AI, cognitive technologies, e.g., neural networks, machine learning, deep learning



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# *Moneyball*

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# Acquiring Players with “Affordable Skills”

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- **Moneyball** asserts that **OBP** is *most highly correlated* with **runs scored**; number of **runs scored** determines **wins**.
- If you can't afford “big money players” who hit **lots** of home runs, or have a high batting average (BA), then you acquire players with “affordable skills,” like high OBP and OPS (OBP plus slugging percentage).
  - Scott Hatteberg was signed by the A's in 2002 to a one-year contract (high OBP).
    - **Annual salary: \$950,000**
  - He helped lead the A's to the playoffs in 2002–03.
  - He hit a total of 49 home runs with a BA of 0.269 over the period 2002–05.
    - *Not exactly Hall of Fame performance, by anyone's estimation.*

# Expected Runs Scored Matrix (Up through 2007)

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**Moneyball** highlights the *long-run average risk* of **stealing** and **bunting**, as they both present a higher risk of making an **out**, and risk reducing the **expected runs scored** in an inning.

Runners	Outs		
1 <sup>st</sup> , 2 <sup>nd</sup> , 3 <sup>rd</sup>	0	1	2
---	0.5165	0.2796	0.1075
1--	<b>0.8968</b>	<b>0.5487</b>	0.2370
-2-	<b>1.1385</b>	0.6911	0.3502
12-	1.4693	0.9143	0.4433
--3	1.5120	0.9795	0.3718
1-3	1.8228	1.1830	0.4931
-23	2.0363	1.4144	0.6073
123	2.3109	1.5279	0.7485

# Expected Runs Scored Matrix (Up through 2007)

---

**Moneyball** also focuses on situational batting statistics, like BA with RISP (Runners in Scoring Position), BA with certain ball-strike counts, and hitter's spray pattern against specific pitchers and pitch types, to optimally place fielders.

Runners	Outs		
1 <sup>st</sup> , 2 <sup>nd</sup> , 3 <sup>rd</sup>	0	1	2
---	0.5165	0.2796	0.1075
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# Obstacles and Skepticism

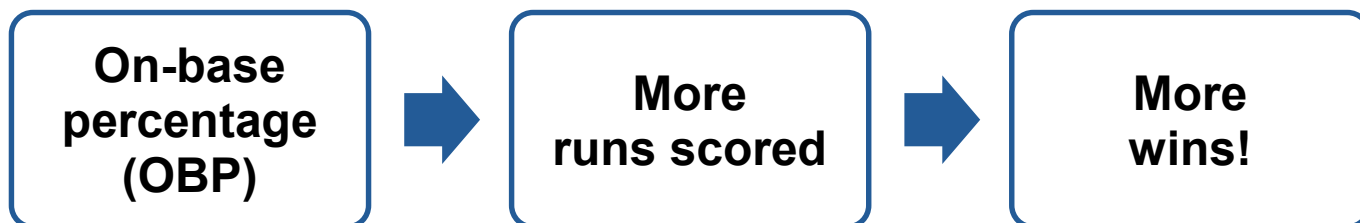
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# Problem, Solution, Outcome

- Billy Beane wants to win the **World Series** (objective).
- Billy only has a budget of **around \$40 million** (constraint).
- His **competition** has a budget of **around \$160 million** (problem).
- Billy must **maximize** the collective output of the players he can **afford** within his budget to “level out the playing field,” and increase his odds of winning.

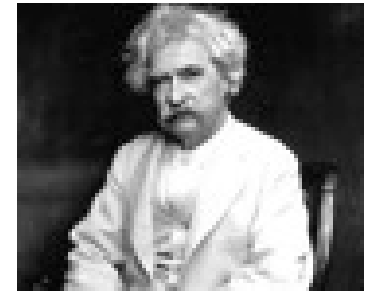


# Skepticism from Critics

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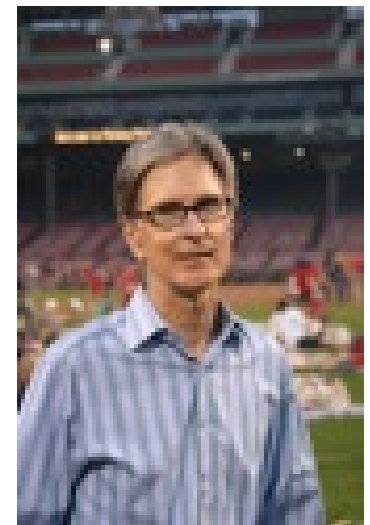
- “There are three kinds of lies: lies, damned lies, and statistics.”

—Mark Twain, attributed to  
*Benjamin Disraeli, British PM*



- Baseball scouts, commentators, former and current players, sports media, all criticized the **Moneyball** principles and concepts.
- “The first guy through the wall always gets bloody.”

—John Henry, in **Moneyball**, owner,  
*Boston Red Sox, billionaire commodities  
futures, and FX trader (“Quant”)*



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# The Outcome

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# Billy's Moneyball Outcome

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- Using **Moneyball** principles, Billy Beane's Oakland A's:
  - Set the American League record for 20 consecutive wins in 2002
    - Hatteberg had the game-winning home run in game 20 in the streak!
  - Made the playoffs in 2002, 2003, and 2006
  - Failed to win the **World Series (bummer!)**



# Billy's Moneyball Outcome

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- Billy was offered the Boston Red Sox GM position for an ***annual salary of \$12 million (ka-ching!)***
  - Red Sox had already hired Bill James to apply Sabermetrics
- Red Sox owner and GM applied **Moneyball** aggressively and won the ***World Series*** in ***2004, 2007, 2013, and again in 2016 with the Cubs!***
  - Keeping in mind they had payrolls of \$125 million and \$143 million, in 2004 and 2007, respectively
  - Sabermetrics and money meant ***World Series*** wins (two) (franchise ***first*** in 86 years!)



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# What It Is and What It Is Not

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# “We Were into Analytics Before Analytics Was Cool”

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1980s–90s

**American Airlines**  
**Decision Technologies**



2002: A's true story

2011: **Moneyball**, movie  
starring Brad Pitt and  
Jonah Hill

# Analytics: What It Is

- ***Analytics leverages historical and real-time operational data to significantly improve an enterprise's economic performance***
  - ***Descriptive*** What happened?  
(Reports, dashboards, scorecards)
  - ***Diagnostic*** Why did it happen?  
(Pattern recognition, trend analysis)
  - ***Predictive*** What's going to happen?  
(Forecasting, outcome prediction)
  - ***Prescriptive*** What should happen?  
(Optimizing against targets, metrics)



$$f(z) = \frac{e^z}{e^z + 1} = \frac{1}{1 + e^{-z}}$$

$$z = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \cdots + \beta_k x_k,$$

$$\begin{aligned} &\text{maximize} && \mathbf{c}^\top \mathbf{x} \\ &\text{subject to} && \mathbf{A}\mathbf{x} \leq \mathbf{b} \\ &\text{and} && \mathbf{x} \geq \mathbf{0} \end{aligned}$$



# Analytics: What It Is

- Applying ***mathematics, statistics, and computer science***-based techniques to solve problems and make *optimal* business decisions, using operational data—a specialized part of ***business intelligence***
- Discovering historical patterns and future trends in order to more accurately forecast, predict, and improve future business performance, and make more informed, more sound decisions about customers, competitors, and internal operations



$$f(z) = \frac{e^z}{e^z + 1} = \frac{1}{1 + e^{-z}}$$

$$z = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \cdots + \beta_k x_k,$$

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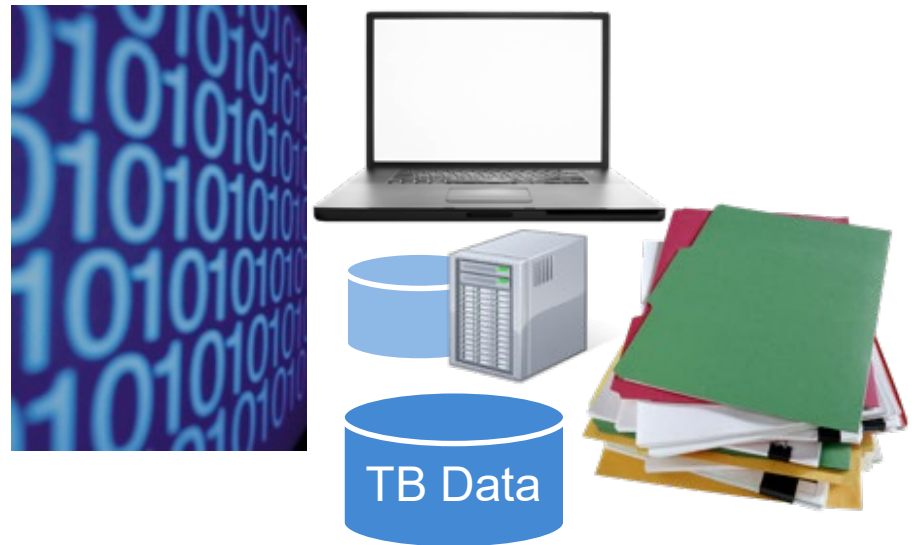


# Analytics: What It Is Not

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## **Analytics is *not*:**

- Databases, data warehouses, or data marts
- Ad hoc queries
- Rules of thumb
- Gut instinct or intuition alone



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# Where Is It Applied?

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# Where Analytics Is **Most** Often Applied

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- External: consumer marketing analytics
  - Customer segmentation and propensity to consume and customer lifetime time value
  - Dynamic, variable pricing and optimal capacity allocation to create sales revenue and profit lift\*
  - Big data text analytics to find out what consumers are saying about your brand, products, and company

\* For example, AZ Diamondbacks vs. KC Royals: **walk-up ticket discount night**—6,000 (22%) more seats sold over 27,000 pre-paid seats, Einstein Bros. Bagel Box \$6 Mondays

# Where Analytics Is **Most** Often Applied

---

- Internal: operations management and business process
  - Optimizing performance of productive units, e.g., retail stores, factories, hospitals, hotels, cruise ships
  - Factoring in the effect of variable factors, like weather, promotions, competition, on sales and labor staffing
  - Managing inventory matching supply with dynamic demand while balancing shortage costs with holding costs

\* For example, AZ Diamondbacks vs. KC Royals: **walk-up ticket discount night**—6,000 (22%) more seats sold over 27,000 pre-paid seats, Einstein Bros. Bagel Box \$6 Mondays



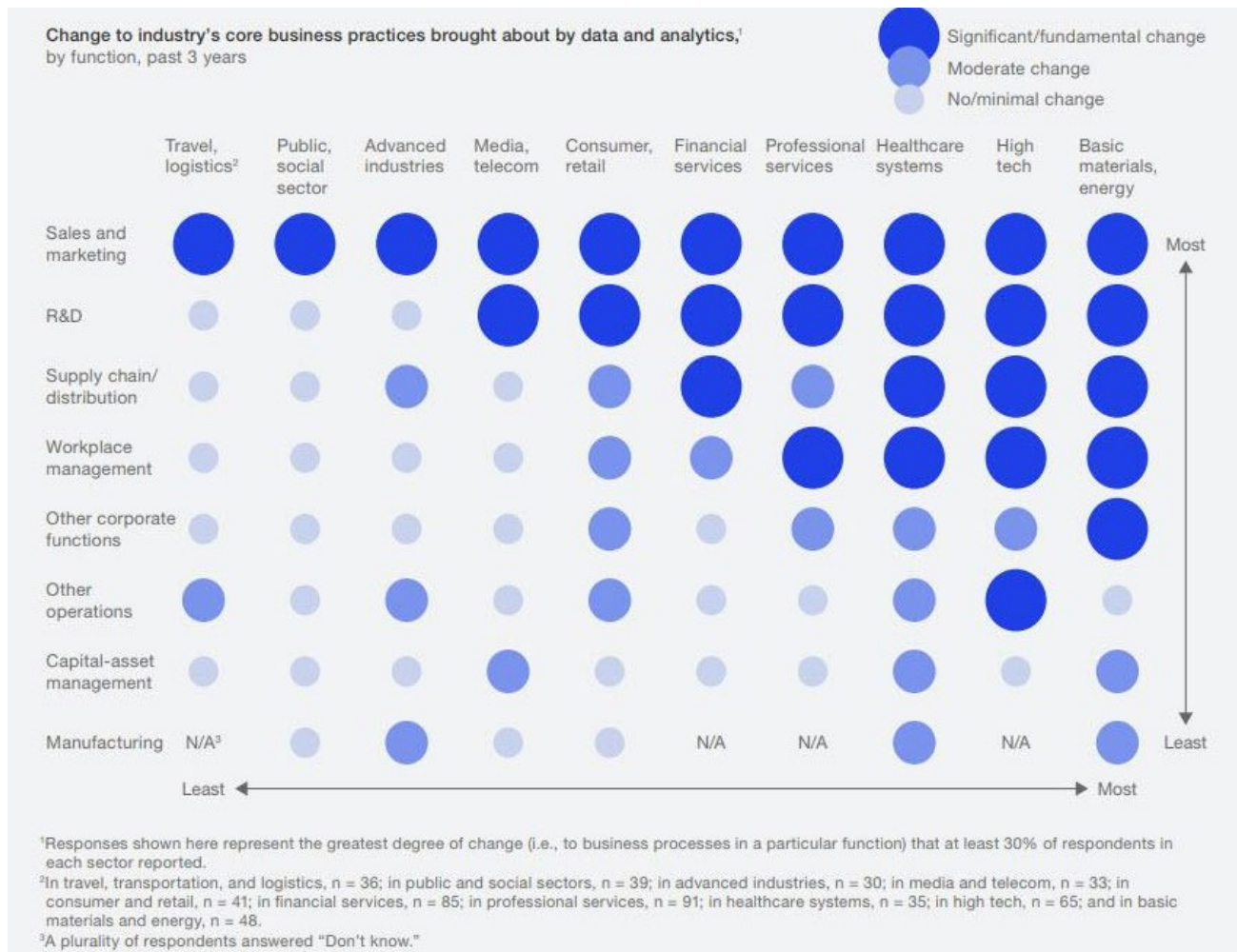
# Where Analytics Is Least Often Applied\*

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- When there is little or no time to do the analysis, e.g., firefighting (e.g., FDNY)
- When there is simply too little, insufficient, or no data to analyze
- When there is no historical precedent
- One-time decisions that do not warrant in-depth analysis
- When gut instinct or intuition ***based on years of identically similar circumstances and experience*** is deemed sufficient

*\* Not to say that analytics can't be applied in these situations, it just isn't very often; but, still could be ☺*

# Change to Industry's Core Business Practices Brought about by Data and Analytics



Source: <https://blogs-images.forbes.com/louiscolumbus/files/2018/05/McKinsey-Analytics-Comes-Of-Age.jpg> (Forbes, May 2018)

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# The ROI

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# Analytics Projects ROI\*

## (Show Me the Money!)

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- Improving production: median ROI of 277%
- Improving financial management: median ROI of 139%
- Improving customer relationship: median ROI of 55%
- BI projects using predictive analytics technologies: median ROI of **145%**
- BI projects **not** using predictive analytics technologies: median ROI of **89%**
- Offers backed up by analytics are **ten times** more likely to be redeemed
- Nucleus study (2014): every dollar spent on analytics returned \$13.

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# Obstacles

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# Obstacles to Reaching Analytics Maturity

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- Executive leadership needs to understand the **business value** and the **level of investment** needed
- Extreme reliance on access to **clean, relevant, and organized sources of operational data**
- Requires **specialists**, often PhD/MS statisticians and mathematicians, to build complex models or use specialized tools to address complex business problems and questions
- Several niche and some large players fragment the market for analytics tools and solutions.
- Models are industry or problem specific, **difficult to generalize**, require unique types of data, and are not fully applicable across industries.
- Analytic **models** are **inexpensive** to develop, but **real-time embedded analytics systems** are generally **expensive** and require upfront and ongoing investment, similar to operational systems.\*

\* Design, engineer, develop, test, deploy, operate, support, maintain, upgrade <repeat> (No free lunch! ☹)



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# Option 1

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# How Do You Start Doing Analytics?

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## ***Option 1: Top-down approach (Davenport's "Full Steam Ahead")***

- Executive sponsors and stakeholders, e.g., CEO, COO, CFO, CMO, CIO, division GM
- Analytics strategic readiness assessment and roadmap
- Analytics strategy and approach

# How Do You Start Doing Analytics?

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## ***Option 1: Top-down approach (Davenport's "Full Steam Ahead")***

- Select a *few key problems* suited for analytics solutions (see bottom-up approach)
  - Problems that involve core business processes and high business value add significant economic impact
    - Situations in which the “economic impact multipliers” are the greatest
  - *Start with a critical, complex business problem, decision, or opportunity that must be solved, but cannot be resolved otherwise, or in a spreadsheet*

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# Option 2

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# How Do You Start Doing Analytics?

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- ***Option 2: Bottom-up approach (Davenport's "Prove-It")***
  - What are the *most complex, pressing problems and challenges facing your business today* that SAP and spreadsheets, data warehouses, and dashboards alone cannot solve?
  - Isolate one-two problems and conduct analytics projects to solve them
    - Department, division, or business unit level
    - Marketing, finance, and operations are typical starting points
      - KPIs: revenue, costs, profit, market share, inventory, purchasing

# How Do You Start Doing Analytics?

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- ***Options 1 and 2:*** Iterate between a top-down and bottom-up approach.



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# Analytics Hierarchy

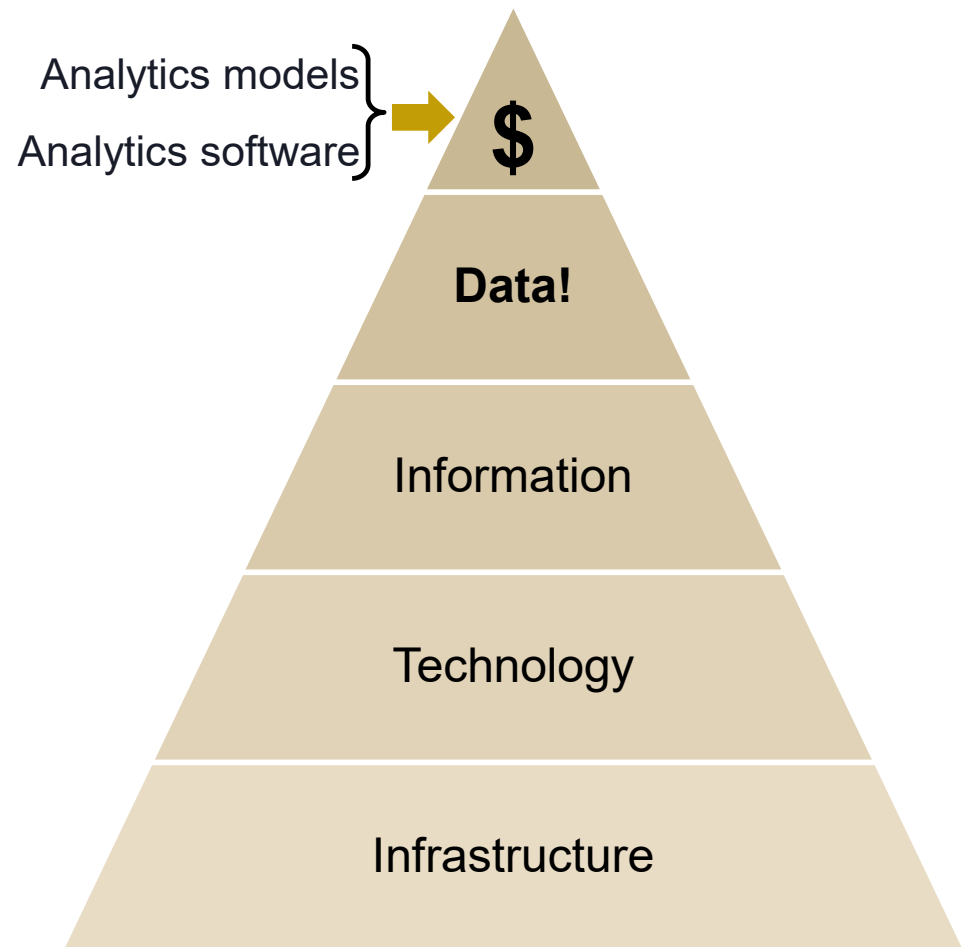
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# What Does an Analytics-IT Hierarchy Look Like?

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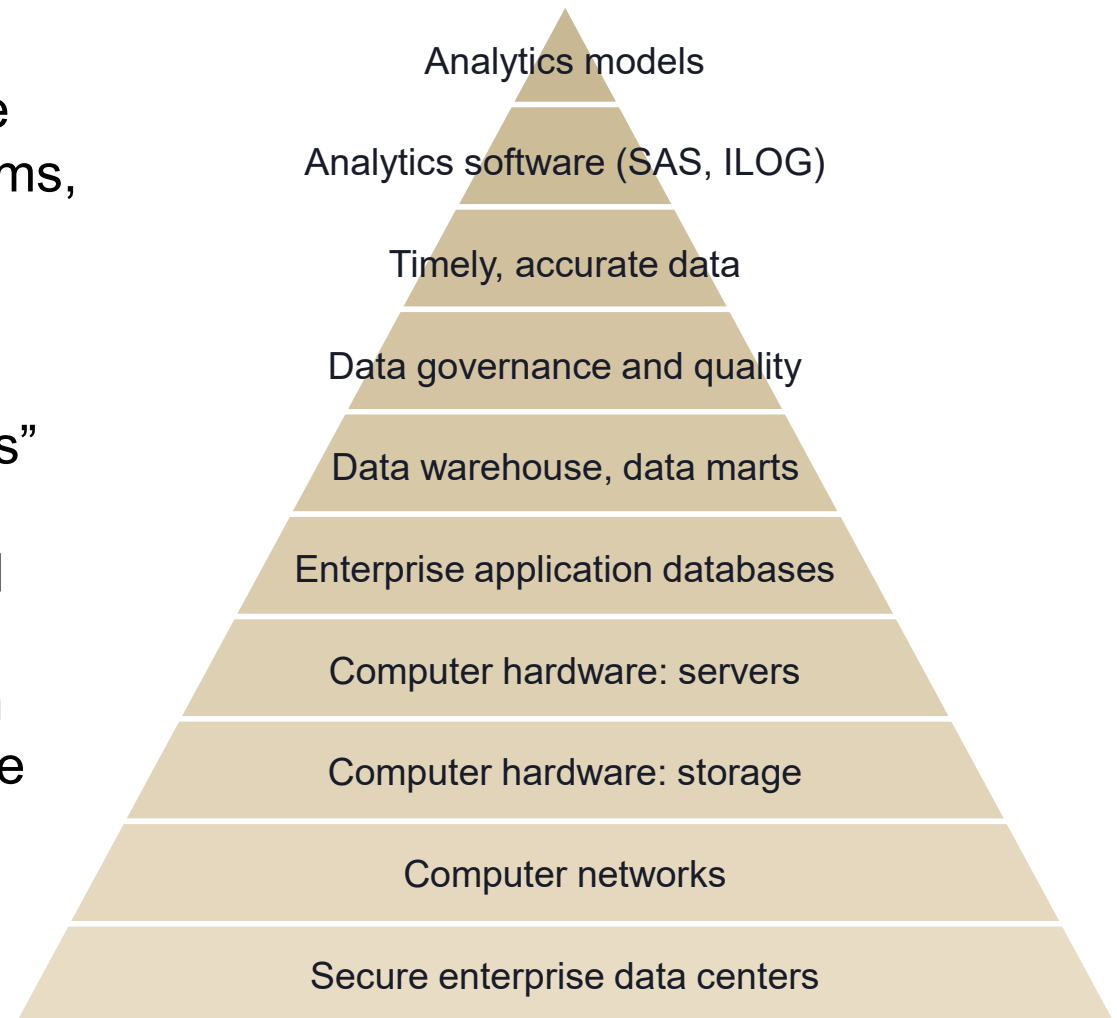
- Analytics is the “tip of iceberg” relative to the enterprise data, systems, and IT infrastructure required to support it perpetually
- “Analytical competitors” make the investment since they understand that ***analytics*** is what ***moves the needle*** on economic performance and market competitiveness



# What Does an Analytics-IT Hierarchy Look Like?

---

- Analytics is the “tip of iceberg” relative to the enterprise data, systems, and IT infrastructure required to support it perpetually
- “Analytical competitors” make the investment since they understand that ***analytics*** is what ***moves the needle*** on economic performance and market competitiveness



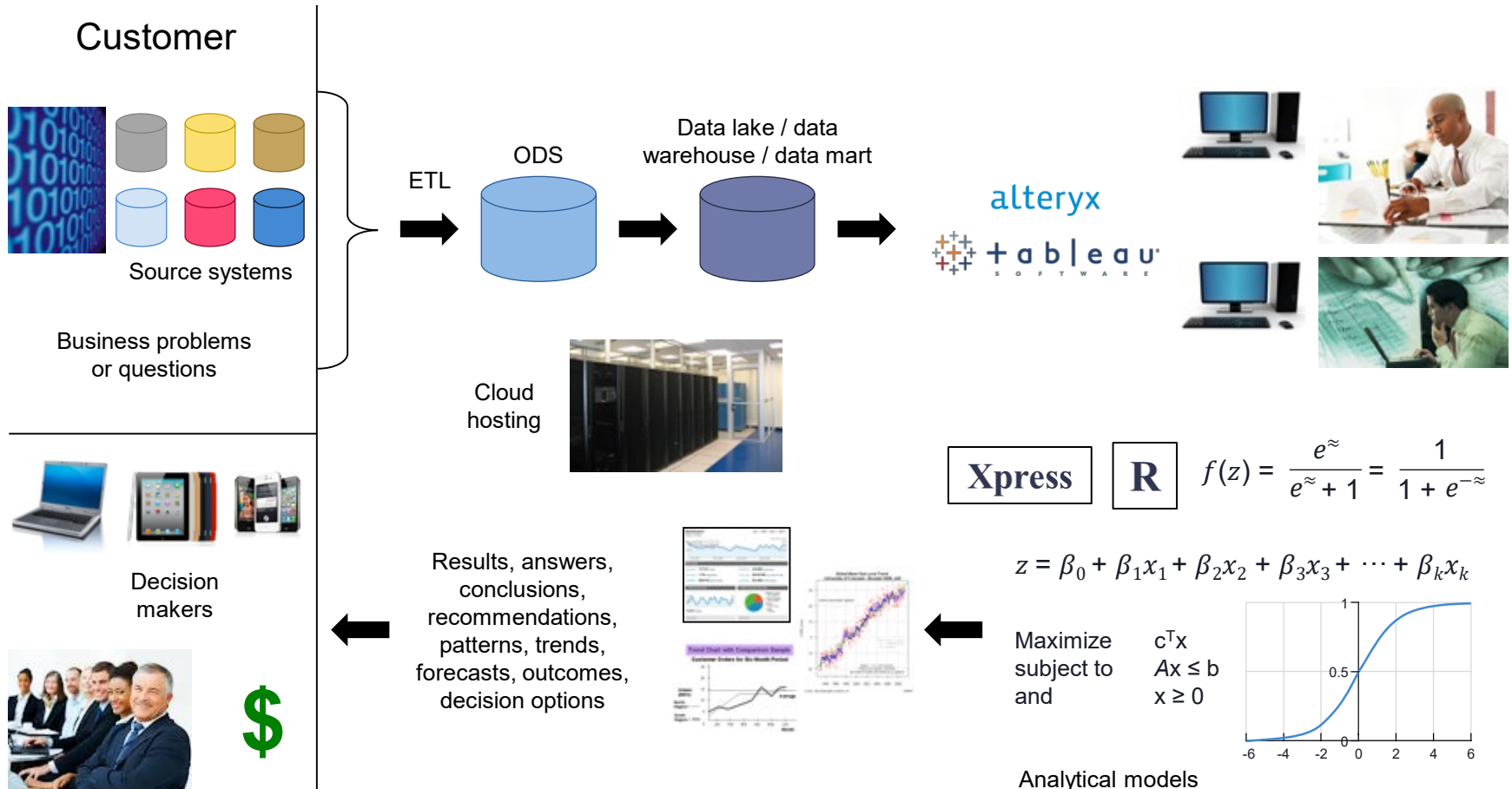
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# Analytics Architecture Flow

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# Analytics Architecture Flow



# Analytics Is Mainstream in Business

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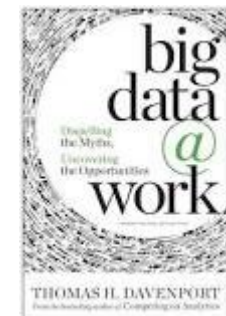
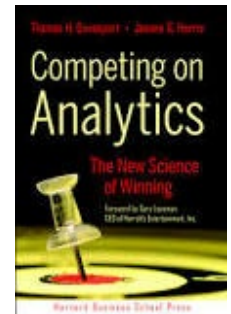
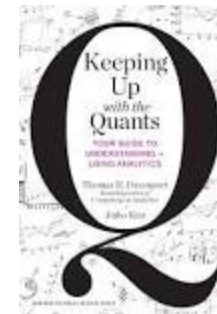
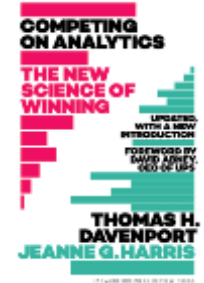
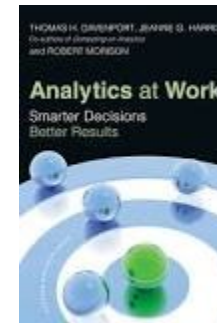
# Books and Resources

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# Supporting Material: Books

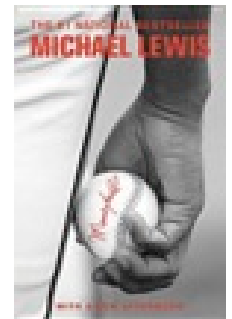
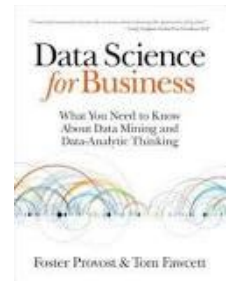
- ***Competing on Analytics: The New Science of Winning***  
— Thomas H. Davenport and Jeanne G. Harris
- ***Analytics at Work: Smarter Decisions, Better Results***  
— Thomas H. Davenport, et al.
- ***Keeping Up with the Quants***  
— Thomas H. Davenport, et al.
- ***Big Data @ Work***  
— Thomas H. Davenport



# Supporting Material: Books

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- ***Data Science for Business***  
— Foster Provost and Tom Fawcett
- ***Revenue Management: Hard-Core Tactics for Market Domination***  
— Robert G. Cross
- ***Moneyball: The Art of Winning an Unfair Game***  
— Michael M. Lewis: *Liar's Poker*,  
*The Big Short*, *The Blind Side*



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# Case Studies

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# Case Studies in Analytics: Travel and Transportation (See T&T Survival Guide)

Problem	Business impact	Analytics approach
Perishable, commodity inventory; high fixed costs	<b>4–10% increase in hotel, cruise line, rental car, airline revenue</b>	Customer segmentation, variable pricing; demand forecasting, imputing product utility
Slow tour package sales; natural complement to leisure ACH sales	<b>100% increase in tour package sales and online ad click-through</b>	Customer preferences, customer web site click-through context data, CART/CHAID
Low yields on heavy aircraft maintenance checks; each check \$1 million	<b>\$300 million in superfluous aircraft maintenance costs avoided</b>	Interactive optimization-based scheduling hangar capacity allocation model and algorithm

***Who is the customer? What do they want to buy, when, why, at what price?***

# Case Studies in Analytics: Media and Entertainment/Gaming (See Harrah's Revival)

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Challenge	Business impact	Analytics approach
Loyalty, cross-market play is a challenge in the gaming industry	<b>Increase in market share from 36% to 43% in six years</b>	Customer segmentation, variable pricing, game location, targeted marketing programs
Single largest theme park variable cost is labor	<b>Reduced labor costs 20% optimizing staff tasking</b>	Statistical analysis to track guest activity at attractions; weather
What are consumers, critics saying online about your company, brand, and products?	<b>Identifying trending and feedback on social media re brand and product topics</b>	"Big data" text analysis using Hadoop and cloud computing



# Case Studies in Analytics: Financial Services

## (See JP Morgan \$6–7 Billion Trading Loss)

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Challenge	Business impact	Analytics approach
Credit card business became commoditized, tough to differentiate	<b>Increasing credit card revenue; reducing credit risk of loss</b>	Customer segmentation; predictive modeling to anticipate customer behavior, e.g., default
Fraud and identity theft are multi-billion dollar problems	<b>Reducing fraud in online checking and credit card usage</b>	Transaction data mining; pattern recognition; matching algorithms
Too many products, too many customers, commodity pricing	<b>Matching financial research products with investment managers</b>	Correlating product usage patterns with investor attributes; heat maps; Pareto analysis

***Who is the customer? What do they want to buy, when, why, at what price?***

## Case Studies in Analytics: Retail [See “True Cost of Inventory Shortages” (In *The Choice* by Eli Goldratt)]

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Challenge	Business impact	Analytics approach
Desire for a <b><i>single metric</i></b> to measure store performance	<b>Optimizing retail store performance; best practices</b>	Data envelopment analysis (DEA): application of linear programming
Sales drop during a weather event; excess staff kills profitability	<b>Quantifying impact of weather on retail sales and staffing</b>	Correlation analysis, multiple regression analysis, time series analysis (forecasting)
Inventory management balancing shortage and holding costs	<b>Minimizing inventory costs while stocking what customers want</b>	Mathematical modeling, computer simulation modeling, real-time POS-driven supply chain signals

# Case Studies in Analytics: Healthcare (See Real-Time Insurance Claim Scoring for Fraud, Waste, and Abuse)

Challenge	Business impact	Analytics approach
Post-operative patient readmissions are a <i>huge</i> problem for insurers	<b>Predicting patient hospital readmission rates to reduce costs</b>	Bayesian Inference applied to 10 years of healthcare insurance claim data
Spinal surgery frequency and costs are skyrocketing	<b>Predicting propensity for spinal surgeries to improve QPC</b>	CHAID and logistic regression analysis applied to 10 years of healthcare insurance claim data
Health insurance profit margins average between 2–7%	<b>20% increase in ancillary insurance product cross/up-sell</b>	Customer profiling and predicting propensity to consume; CHAID, logistic regression
Inside telephone sales close rate below 10%	<b>Three times increase in sales close rate on Medicare insurance</b>	Customer demographic profiling and predicting propensity to consume, CART/CHAID
Failure to understand linkage between customer satisfaction, employee satisfaction, and EBITDA	<b>90% correlation between EBITDA and customer/employee satisfaction</b>	Pearson's correlation coefficient analysis applied to 7 years of data for a major hospital

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