DATA SCIENCE

DATA-INFORMED SUPPLY CHAIN DECISIONS

Bradley C. Boehmke, Ph.D.

September 14, 2016

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AGENDA

- What is data science?
- Why do you care
- How is it different
- Air Force examples
- How do you grow this capability

INTRODUCTION

A little about me.

HELLO

my name is

Brad

bradley.boehmke.4@us.af.mil

bradleyboehmke@gmail.com

LinkedIn

@bradleyboehmke

I AM WHO I AM

I'm a computational economist focused on applying data science to provide decision makers robust understanding of economic behavior, performance, and potential policy impacts across an organization.

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I'm a computational economist focused on applying data science to provide decision maker economic behavior, performance, and pote an organization.

THIS TIME WITH PICTURES

computational economist

economics

management science

computers

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computational economist

economics

management science

computers

I study human and organizational interactions to reveal how and why they behave in particular ways.

THIS TIME WITH PICTURES

computational economist

economics

management science

computers

I apply statistical & analytical methods to analyze and solve organizational problems.

THIS TIME WITH PICTURES

computational economist

economics

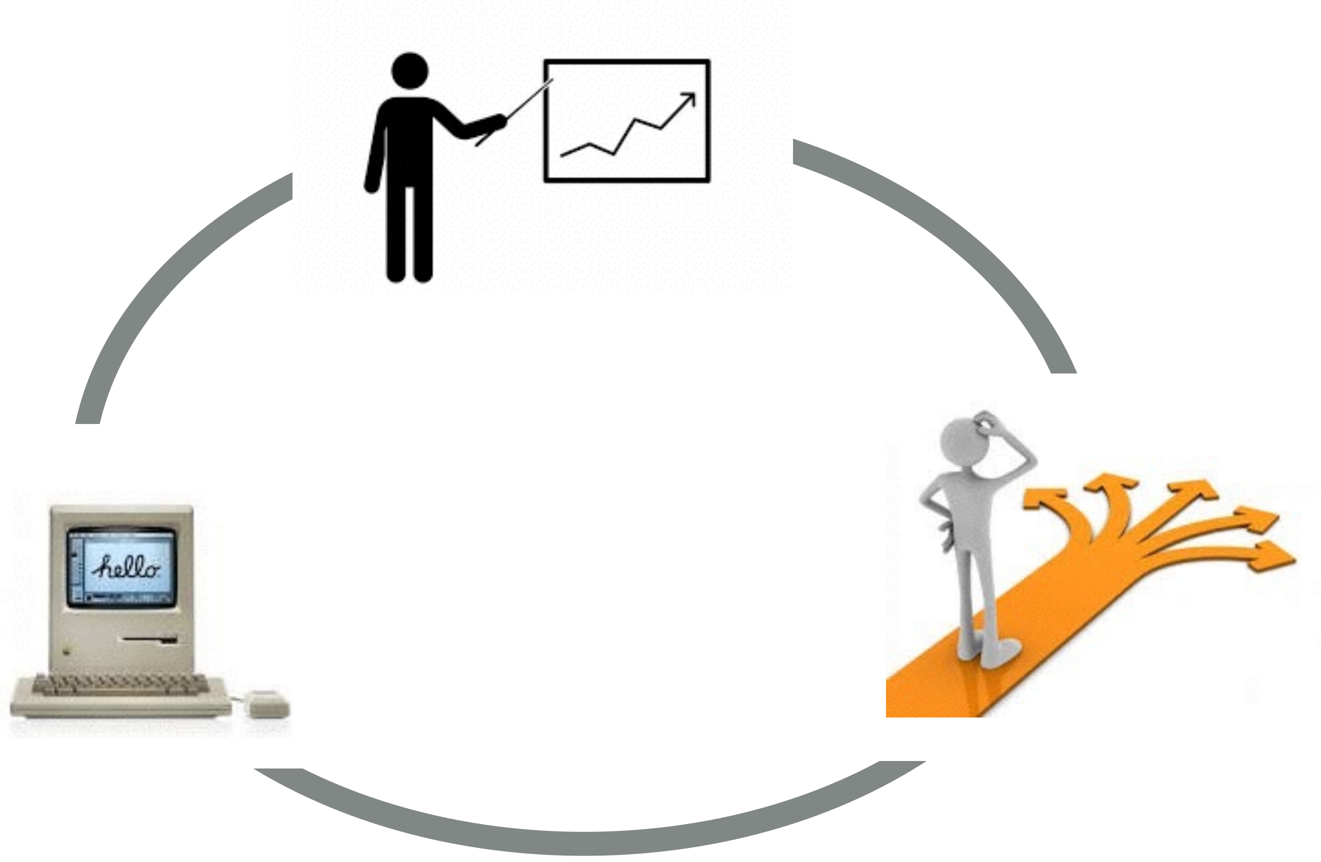
management science

computers

I use computer programming to get, clean, manipulate, analyze, and visualize data for economic and management science purposes and develop products to communicate my results.

MY RELATION TO YOU

me



you

DATA SCIENCE

So what is it?

WHAT IS DATA SCIENCE?

Statistics

Big data

Data mining

Artificial intelligence

Data science

Business intelligence

Machine learning

Predictive analytics

Interactive data visualization

WHAT IS DATA SCIENCE?

Statistics

Big data

Data mining

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Interactive data visualization

__Science__ *is the investigative process used to extract knowledge, information and insights about reality through observation and experiment.*

Statistics

WHAT IS DATA SCIENCE?

Big data

Data mining

Artificial intelligence

Data science

Data science *is the investigative process used to extract knowledge, information and insights about reality by examining data.*

Business intelligence

Machine learning

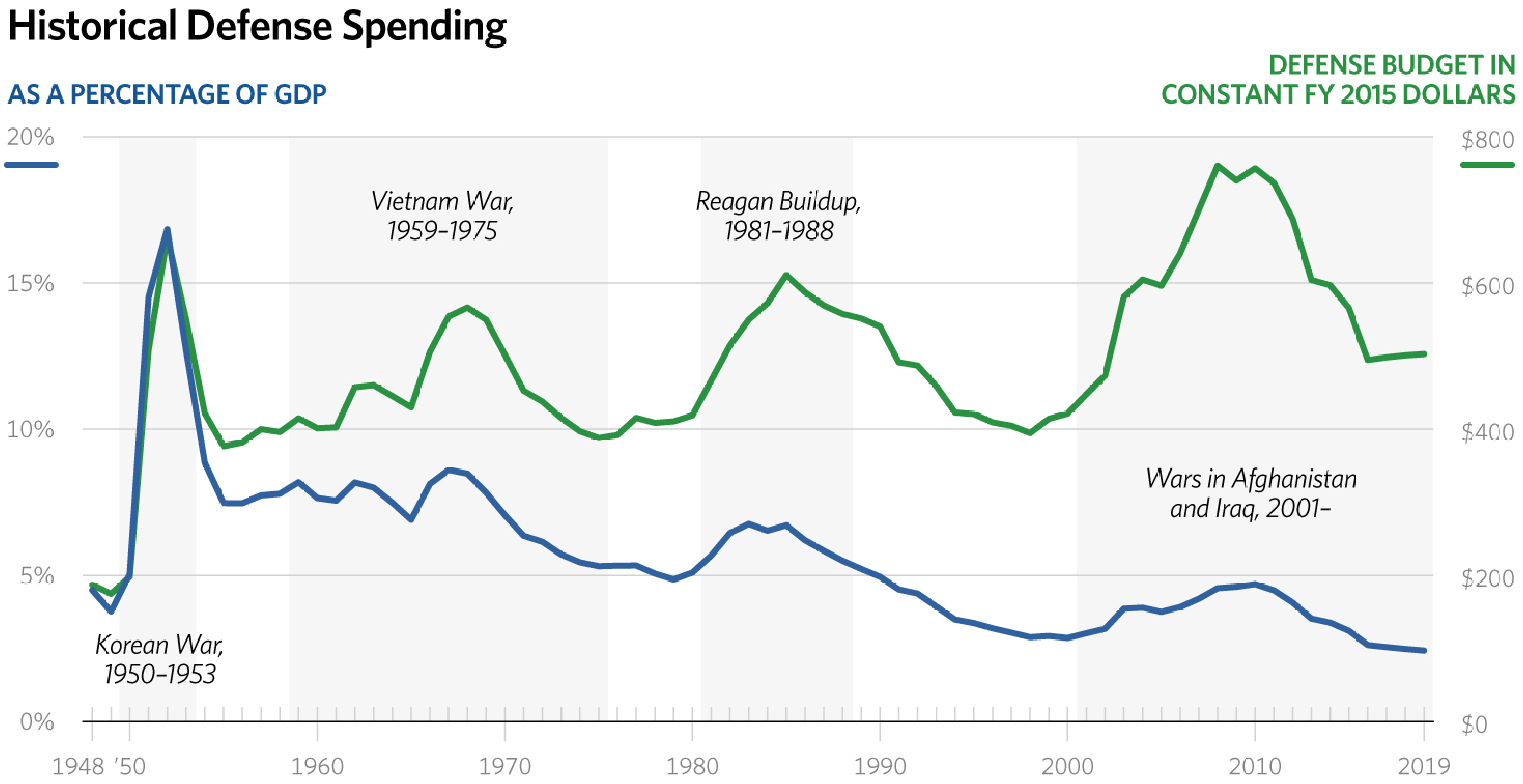
Predictive analytics

Interactive data visualization

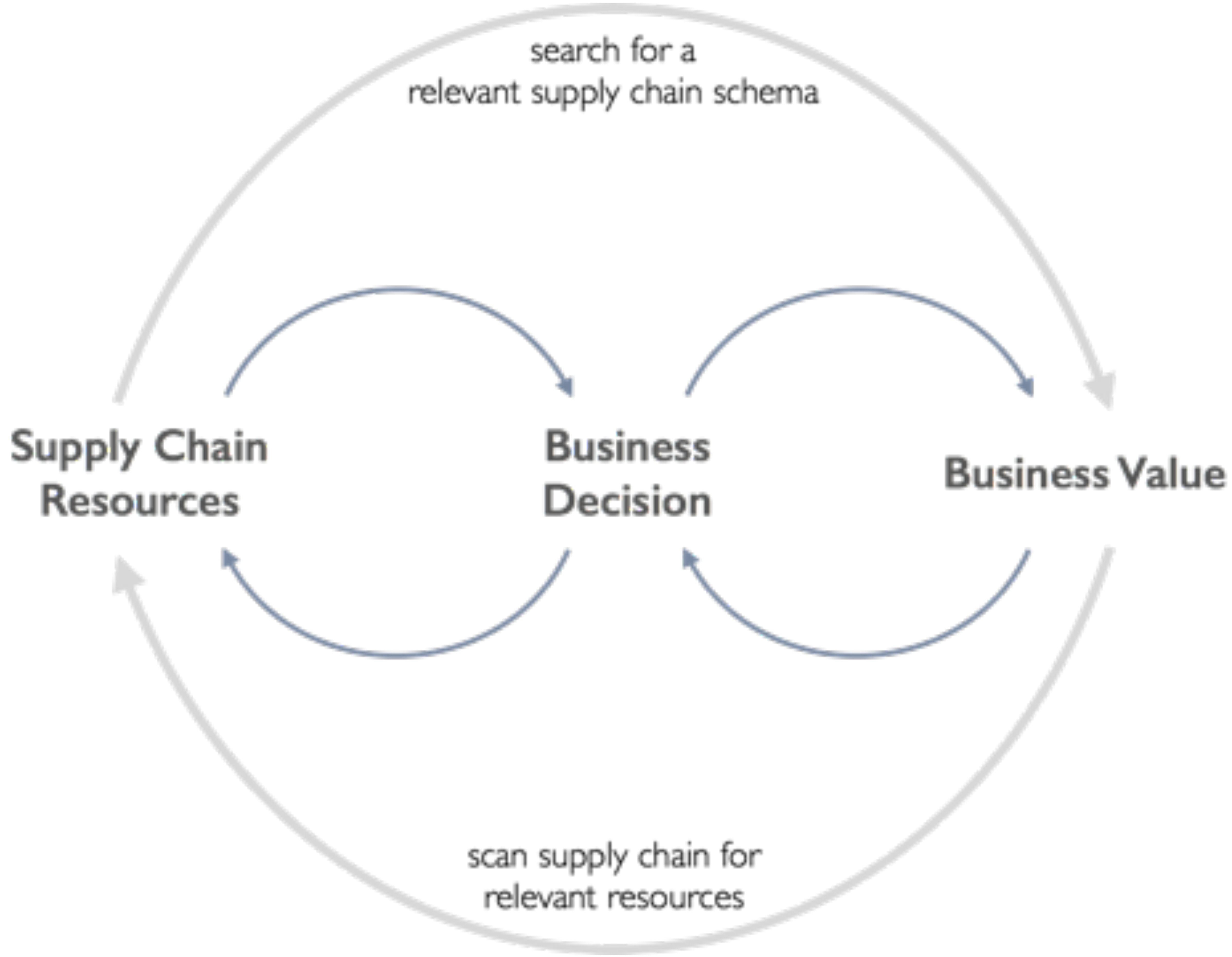
DATA SCIENCE

Ok, so why do I care?

THE ONLY CONSTANT IS NOTHING IS CONSTANT



YOU WILL NEED TO MAKE RESOURCE DECISIONS



YOU WILL NEED TO MAKE RESOURCE DECISIONS

Reducing F-35 lot size

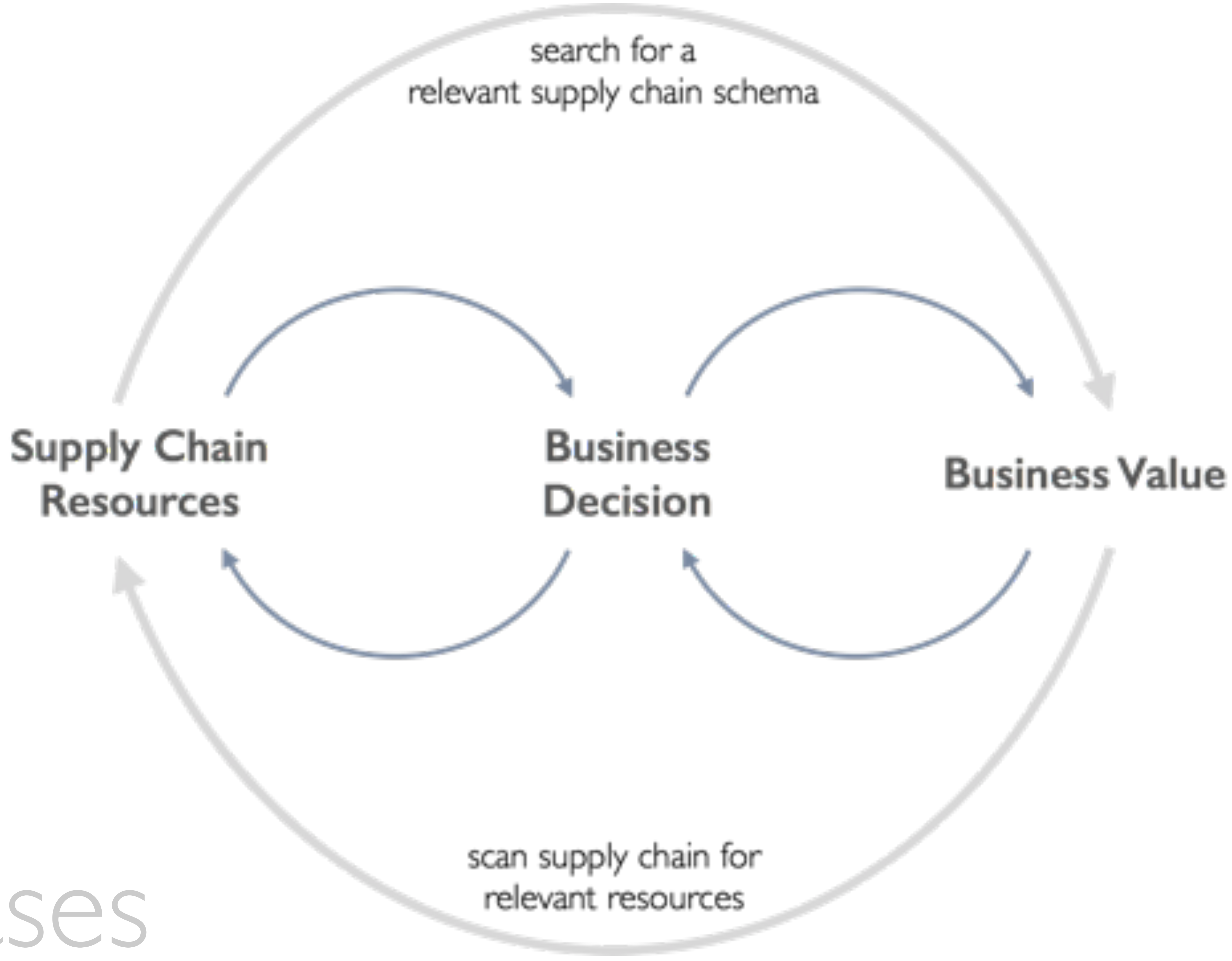
A-10 fleet reduction

Divesting GH block 40

Scrapping KC-10 fleet

Reduce ICBM force by 50

Eliminating Reaper purchases



YOU WILL NEED TO MAKE RESOURCE DECISIONS

Security Forces

Civil Engineering

Utilities

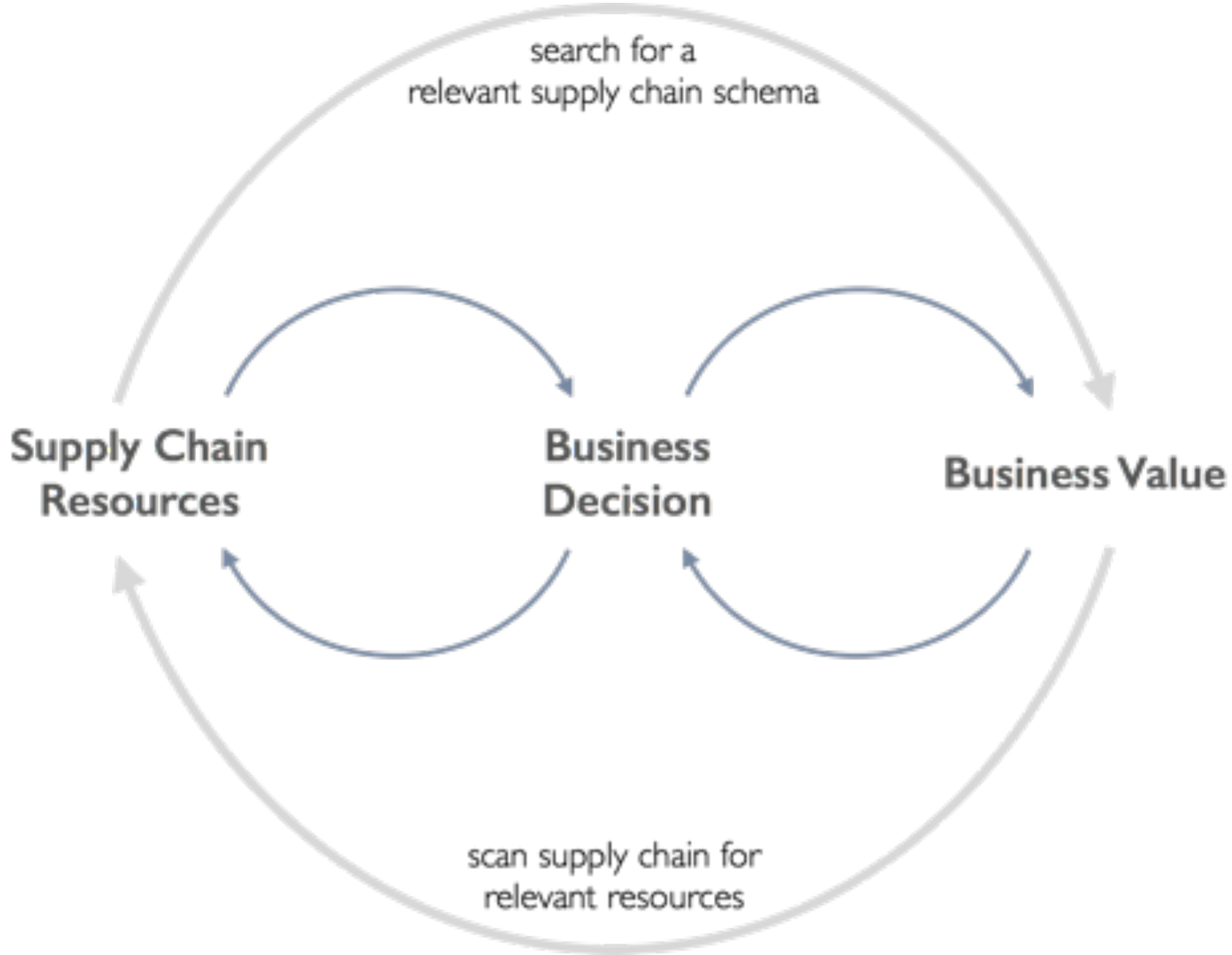
Facility Sustainment

Contracting

Utilities

Personnel Services

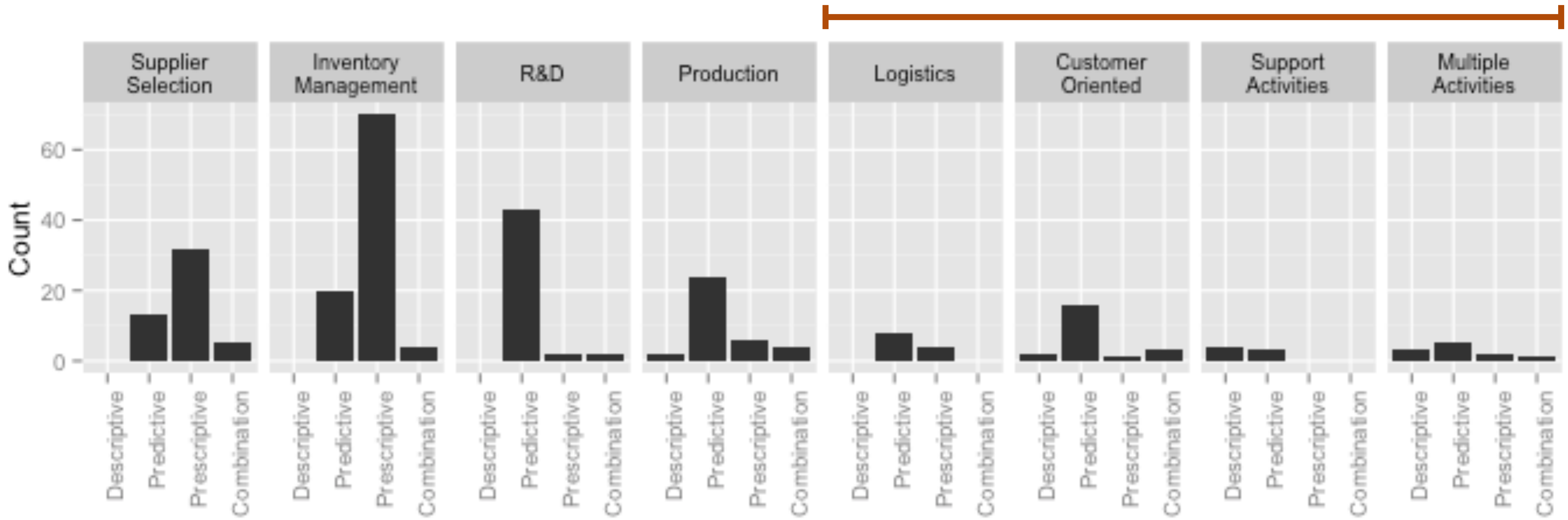
MWR



TOOTH vs. TAIL

AN UNBALANCED ANALYTIC FOCUS

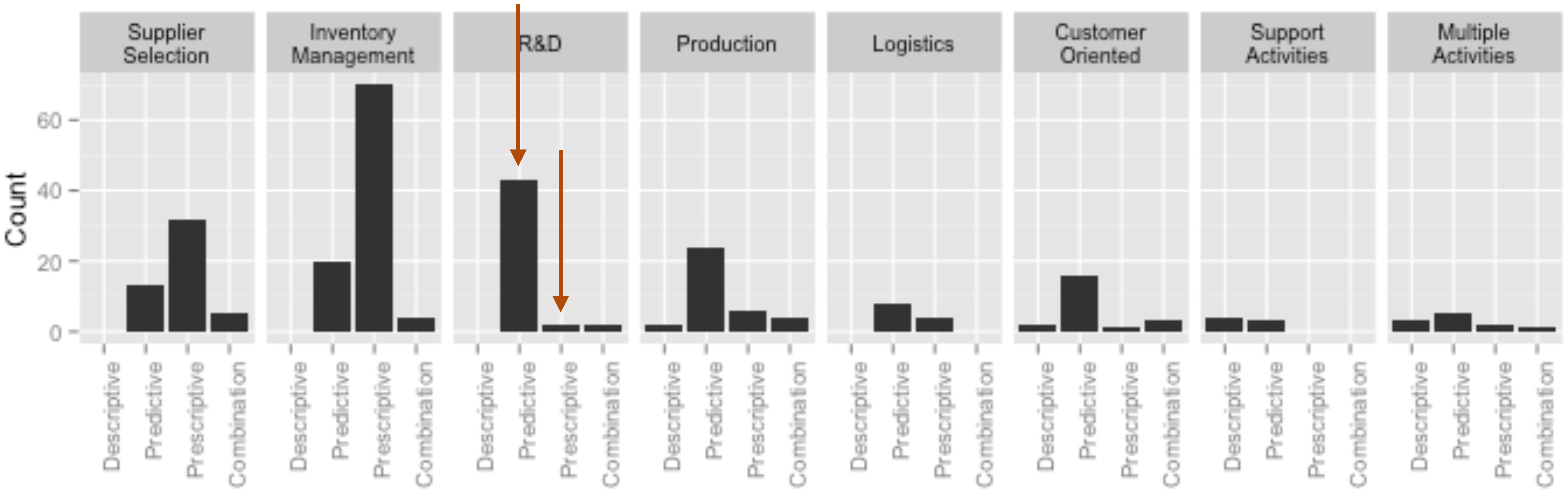
Problem: *The "long tail" of supply chain data science is a systemic problem; many decisions in the tail appear to not be data informed.*



TOOTH vs. TAIL

AN UNBALANCED ANALYTIC FOCUS

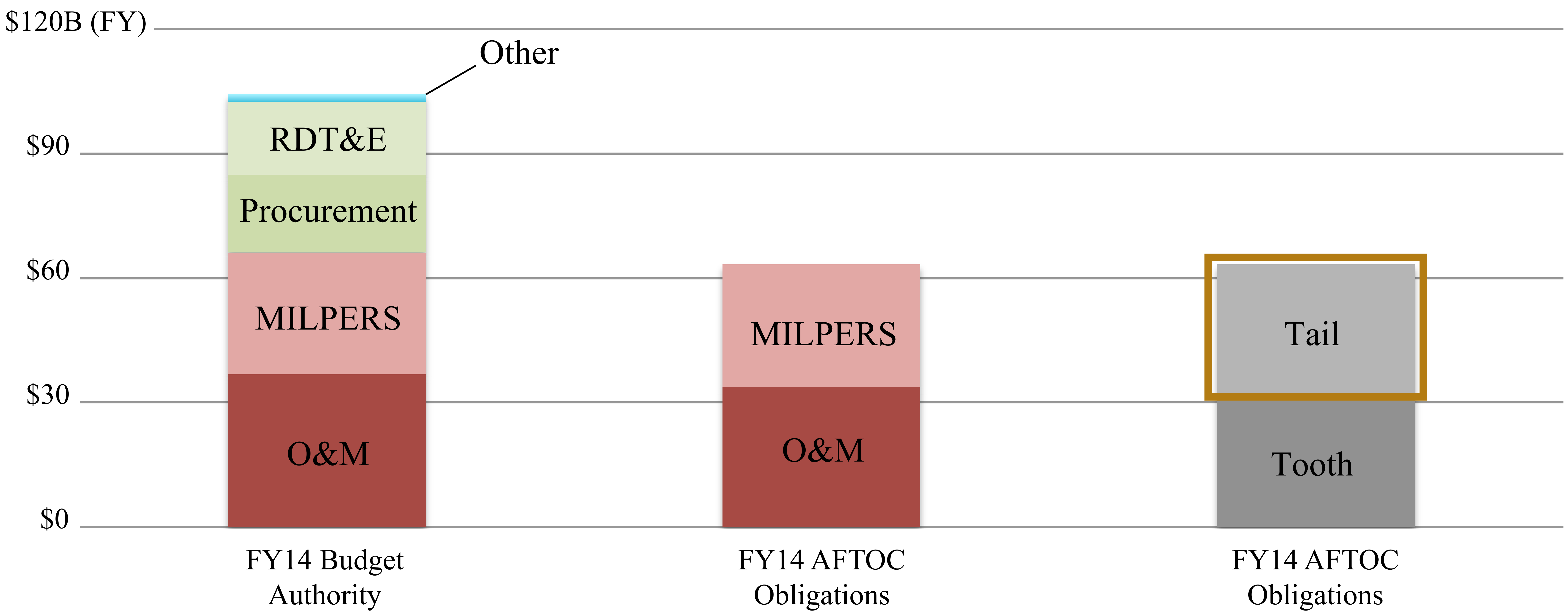
Problem: *Significant imbalances exist in how we apply different data science methodologies across and even within supply chain domains.*



TOOTH vs. TAIL

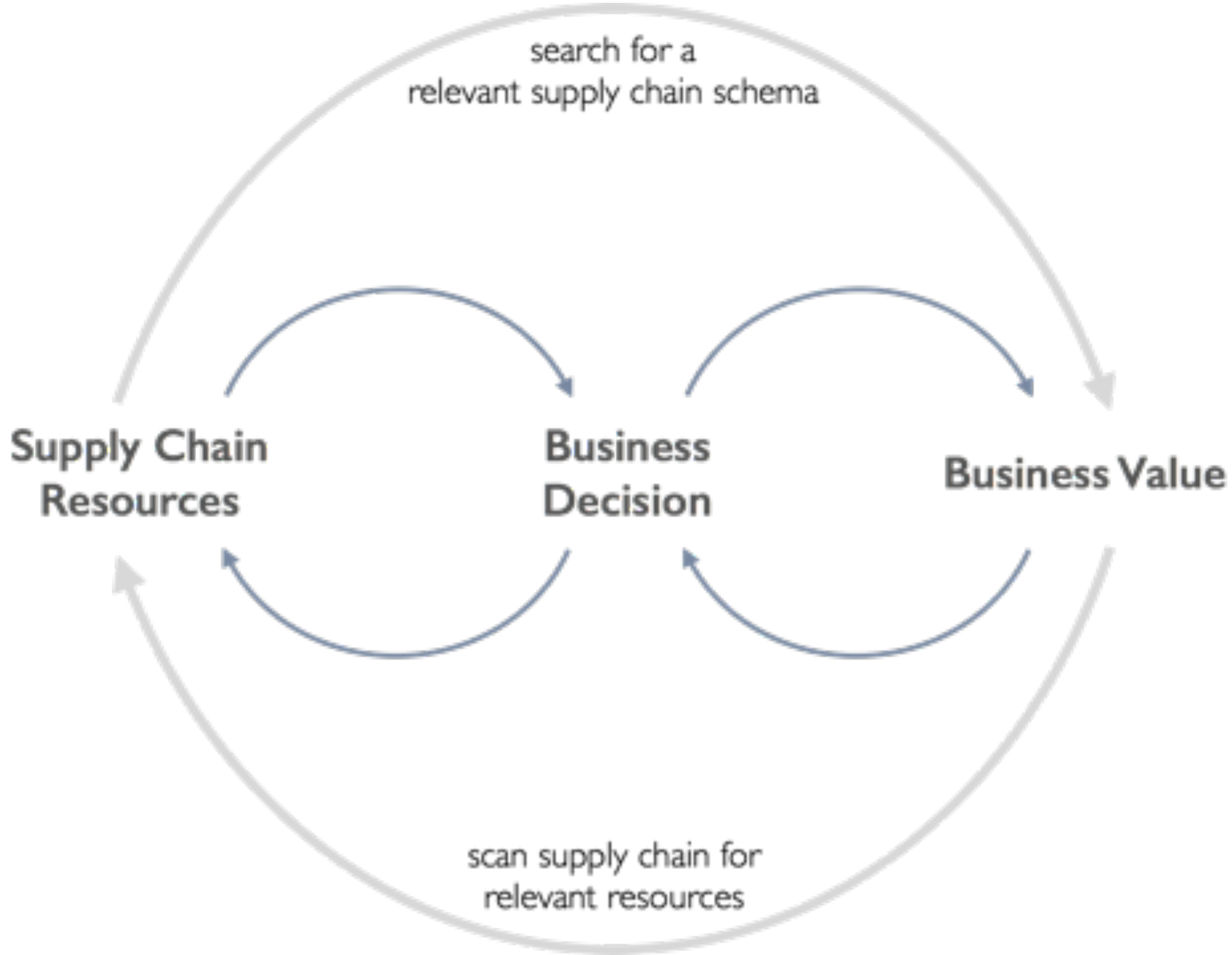
AN UNBALANCED ANALYTIC FOCUS

Problem: *Lack of research focusing on the economics of, and data science approaches applied to, tail activities for resource management purposes.*

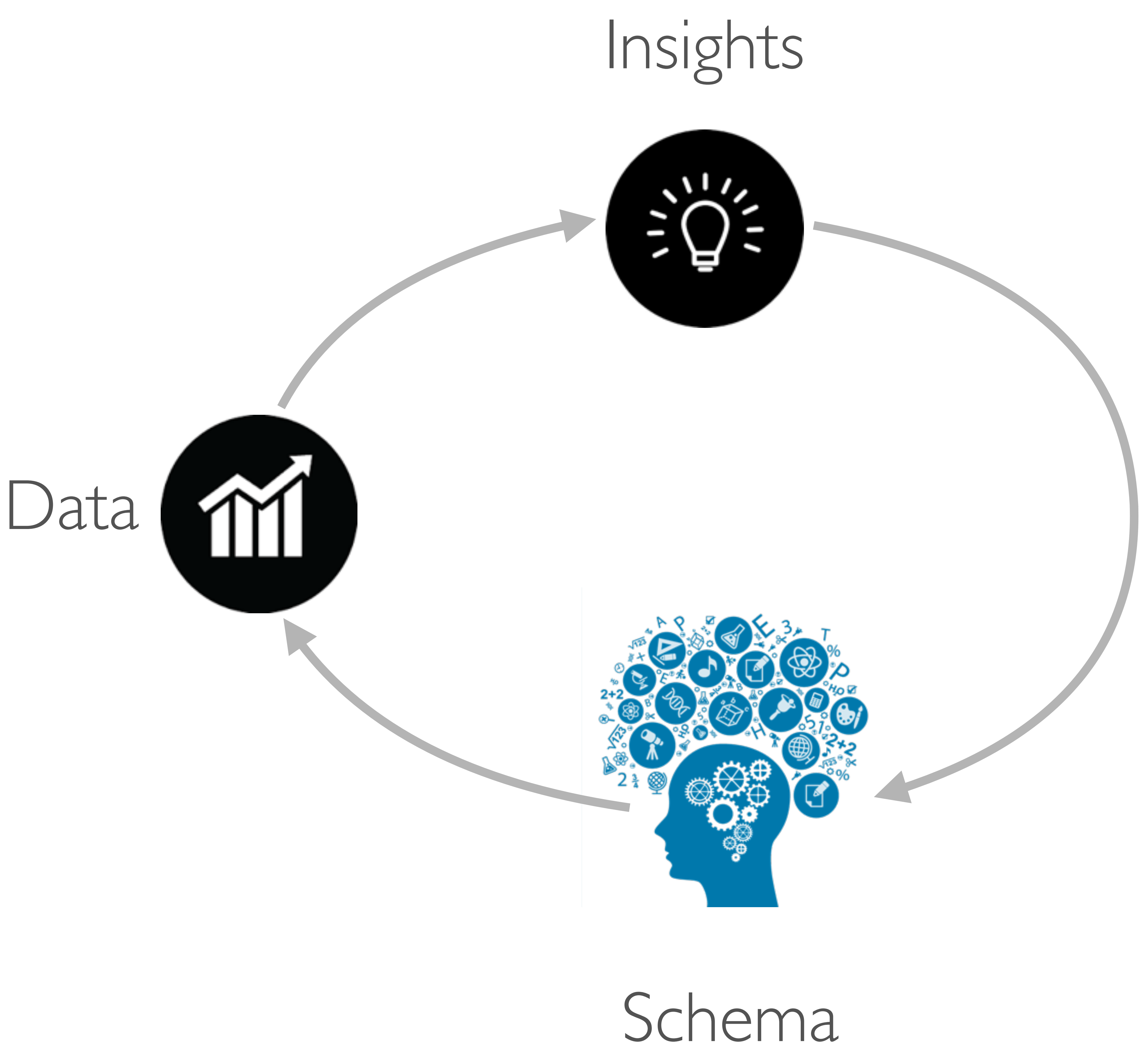


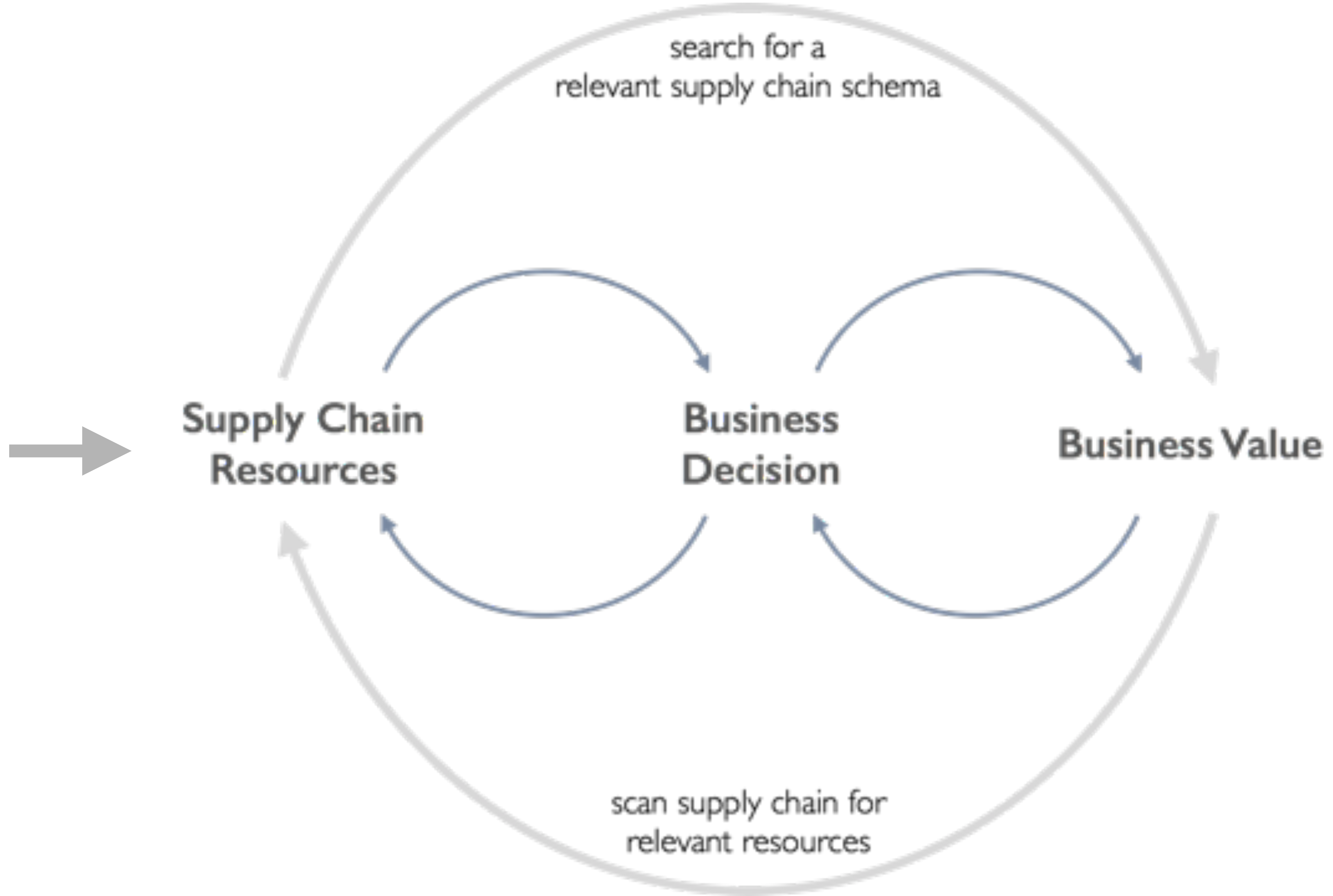
WE NEED TO GO FROM THIS TO…

PMJ

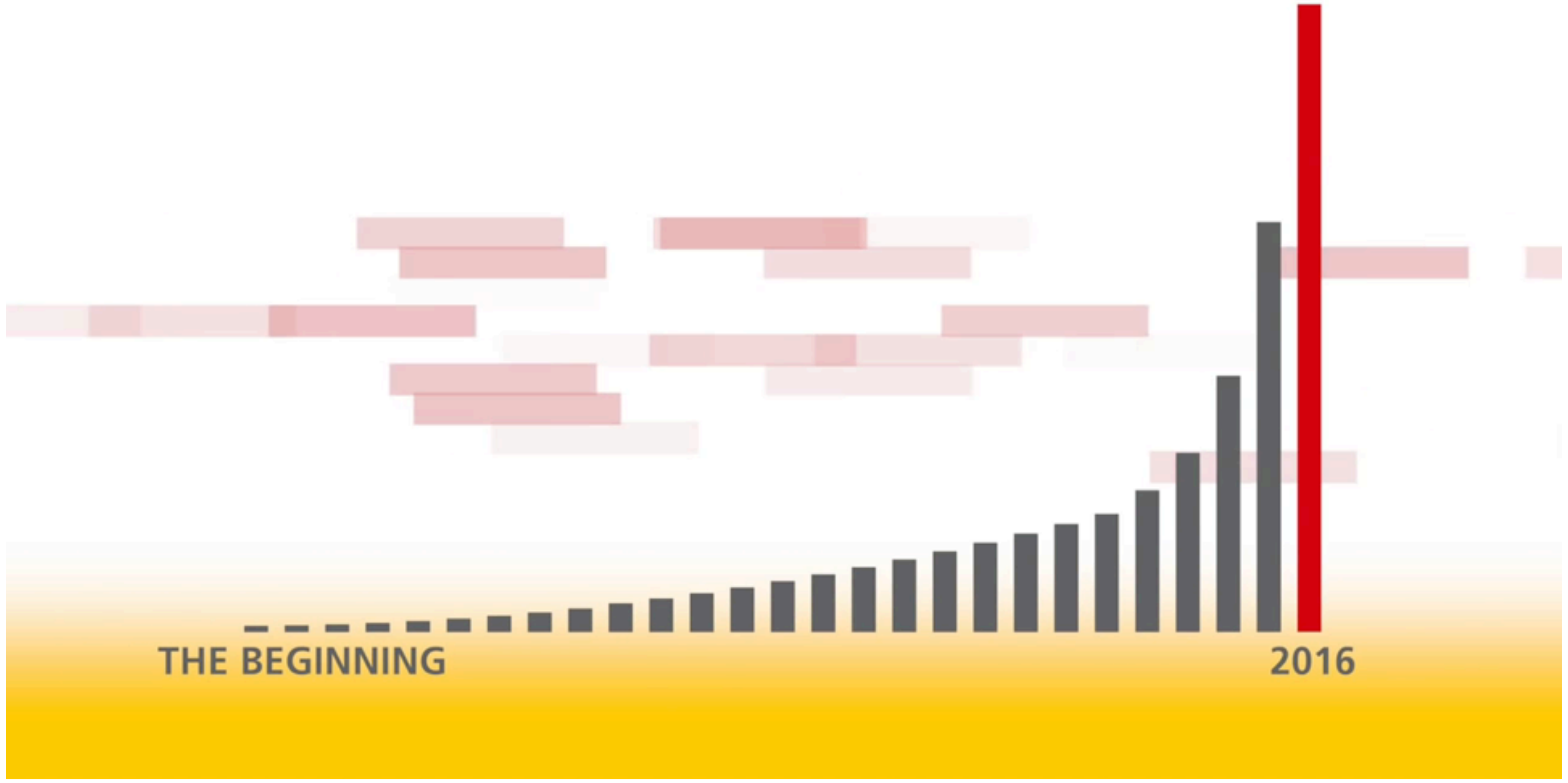


DATA ~~DRIVEN~~ INFORMED DECISIONS





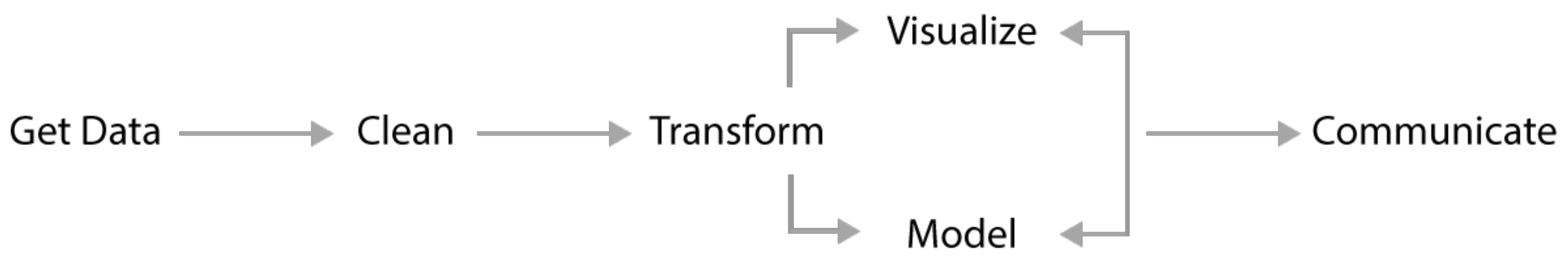
DATA INFORMED SUPPLY CHAIN DECISIONS

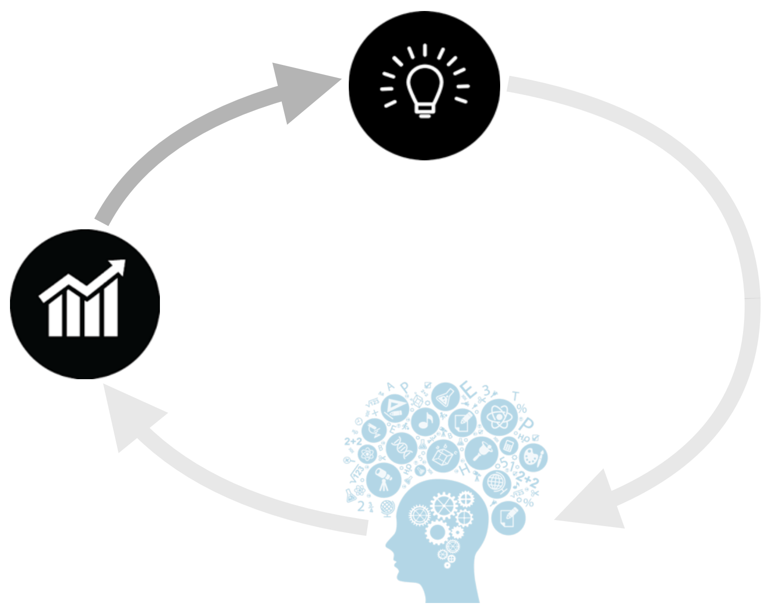


DATA SCIENCE

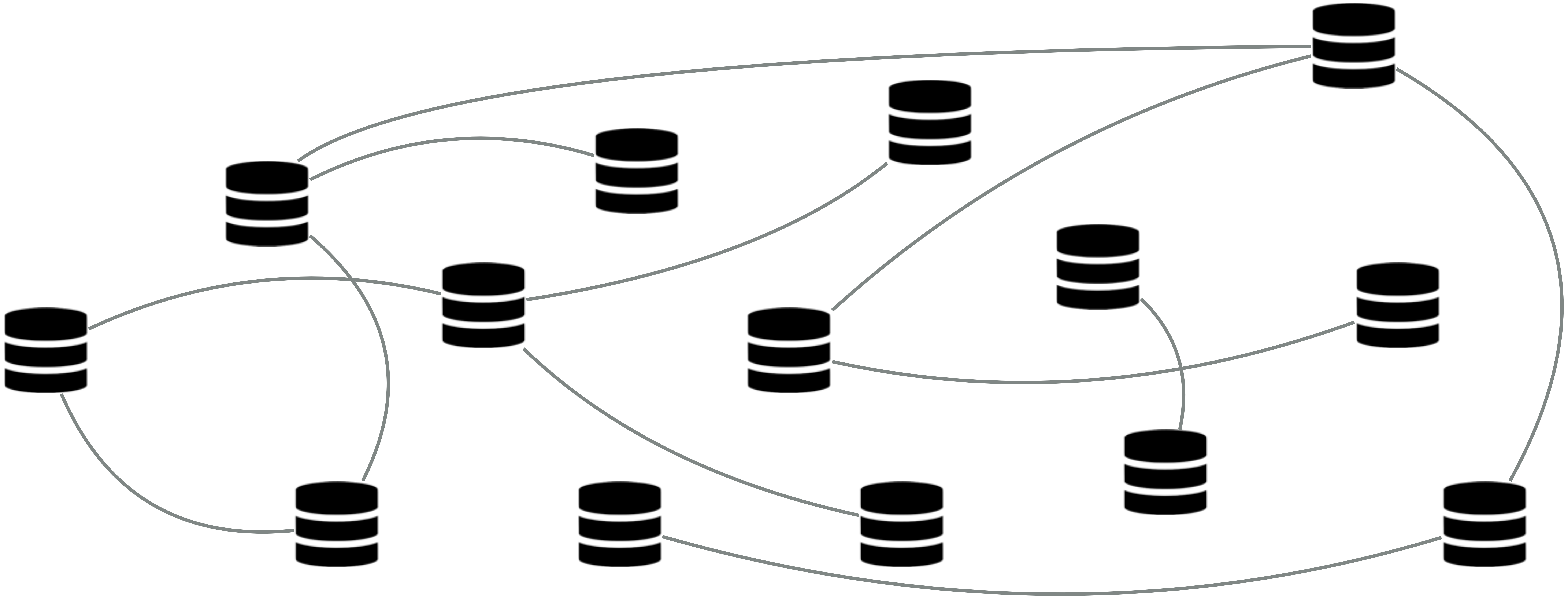
Why do you call it data science rather than analytics?

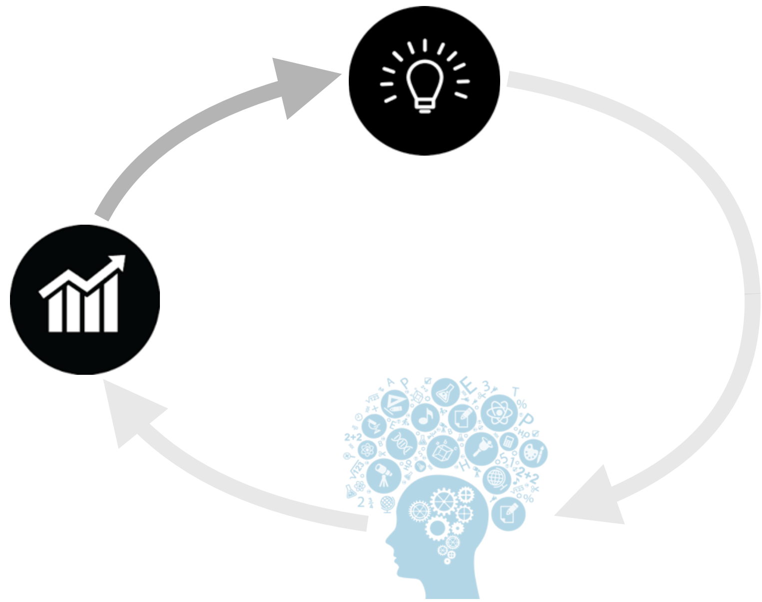
THE DATA SCIENCE PROCESS





THE DATA SCIENCE PROCESS





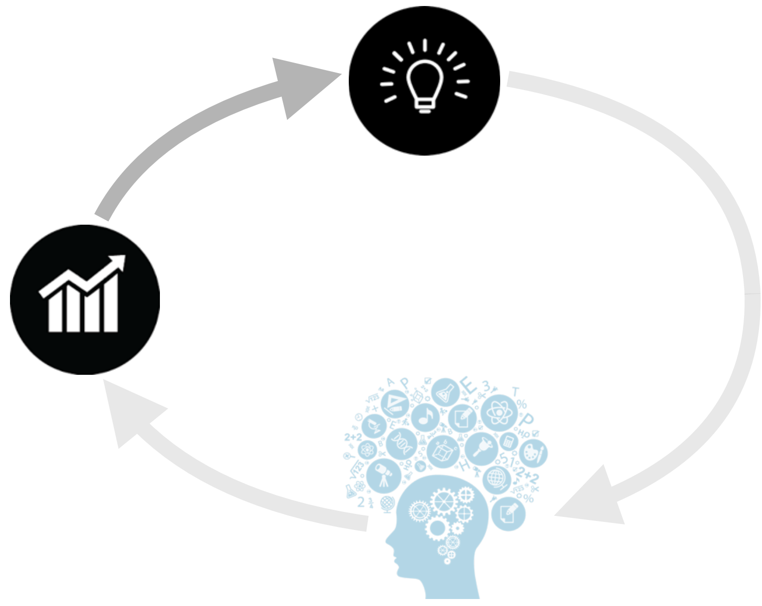
THE DATA SCIENCE PROCESS

Get Data → Clean → Transform → Visualize / Model → Communicate

Text analysis
Pareto analysis
Linear regression
Time series modeling
Survival analysis
Simulation

Cluster analysis
Data envelopment analysis
Factor analysis
Support vector machines
Risk modeling
Linear programming

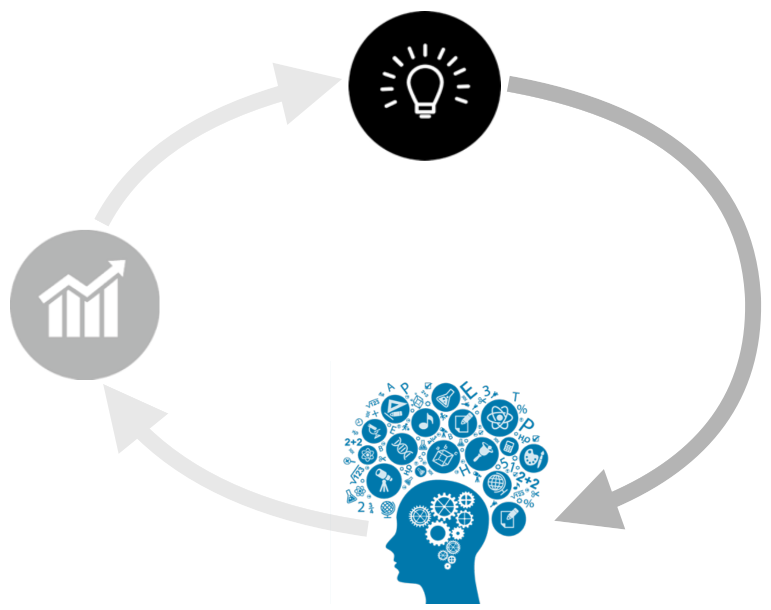
Neural networks
Correlation analysis
Anomaly detection
Bayesian networks
Multilevel modeling
Analytical hierarchy proce



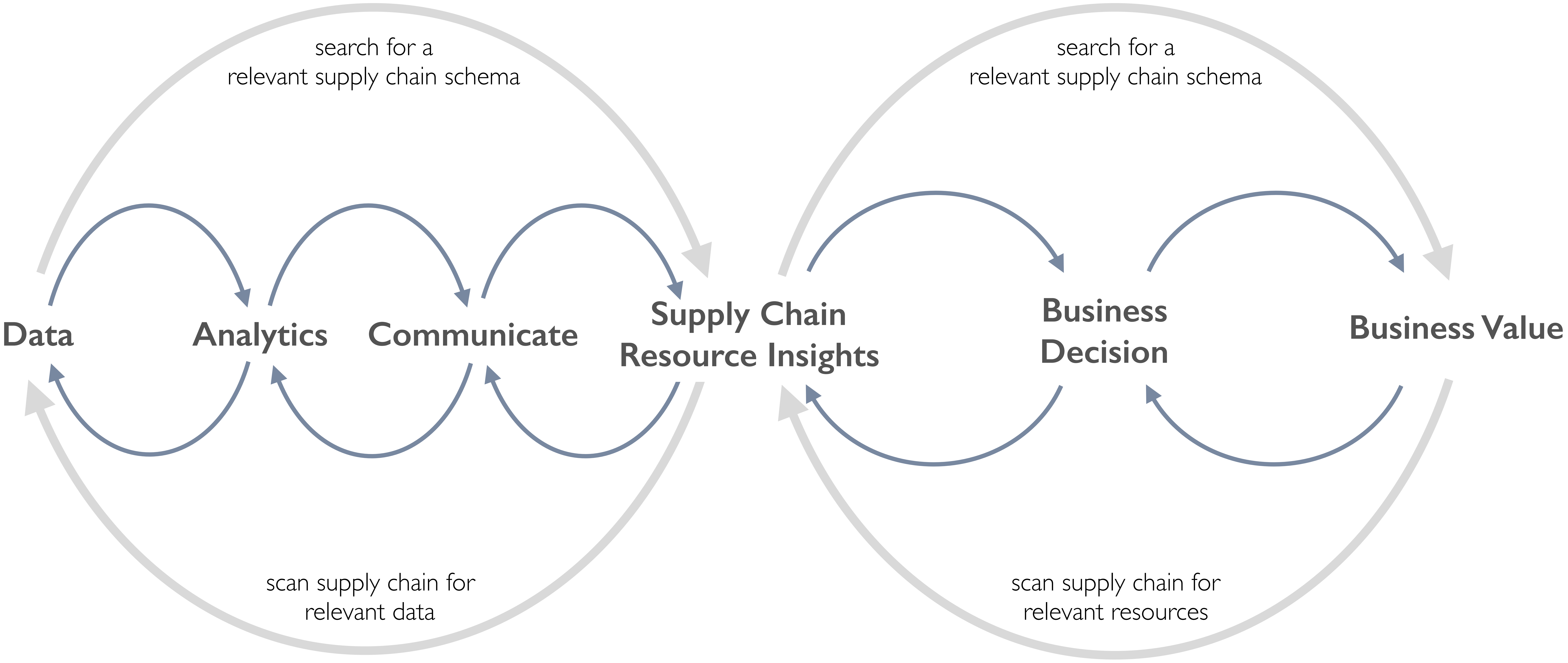
THE DATA SCIENCE PROCESS

Get Data → Clean → Transform → Visualize / Model → Communicate

PowerPoint	Tufte-style handouts	Shared Dashboards
Technical Docs	Interactive HTML reports	Vignettes
Bullet point memos	Shiny applications	Scientific
Dashboards	Literate statistical programming	
Interactive graphics	Interactive storyboards	
Analytic packages	Electronic books	



AN INTEGRATED DATA SCIENCE PROCESS



DATA SCIENCE

Can I get some examples?

AGGREGATED PERFORMANCE METRICS

BETTER AWARENESS OF TRENDS & PATTERNS

Resource Problem

Organizations love metrics but often base decisions on aggregated values

AGGREGATED PERFORMANCE METRICS

BETTER AWARENESS OF TRENDS & PATTERNS

Objective

Establish an approach to identify underlying metric trends, and the pervasiveness of the behavior, across an enterprise:

- Identify the existence of homogenous base-level metric trends
- Identify the bases affiliated with these trends
- Identify the magnitude of these cost trends

Key Data Science Components

Acquired, cleaned and combined data from two different organizations and three databases.

Results

Insights

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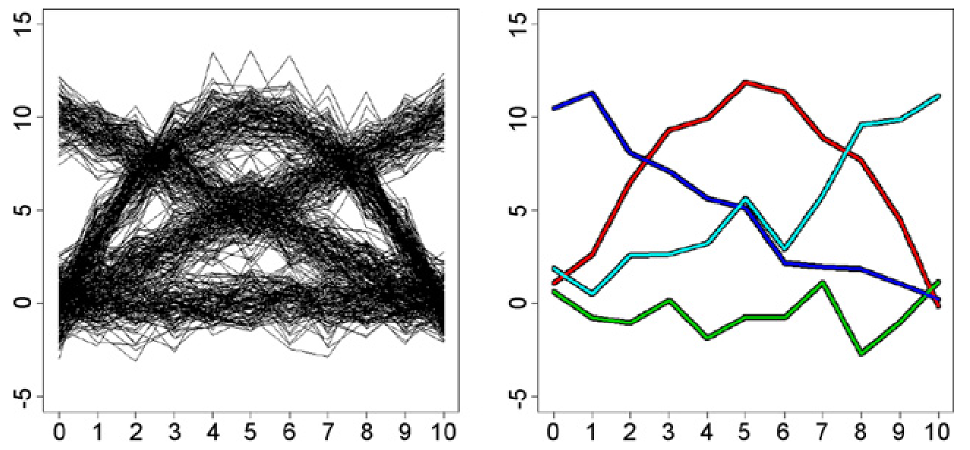
Non-parametric k-means clustering algorithm for longitudinal data

$$Dist^{E}(y_i, y_m) = \sqrt{\sum_{j=1}^{t} (y_{ij} - y_{mj})^2}$$

$$C(k) = \frac{SS_B}{SS_W} \times \frac{(N-k)}{(k-1)}$$



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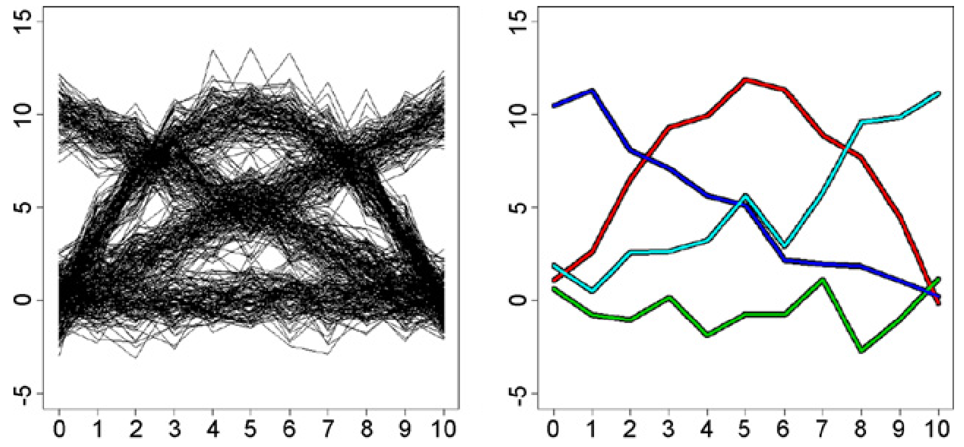

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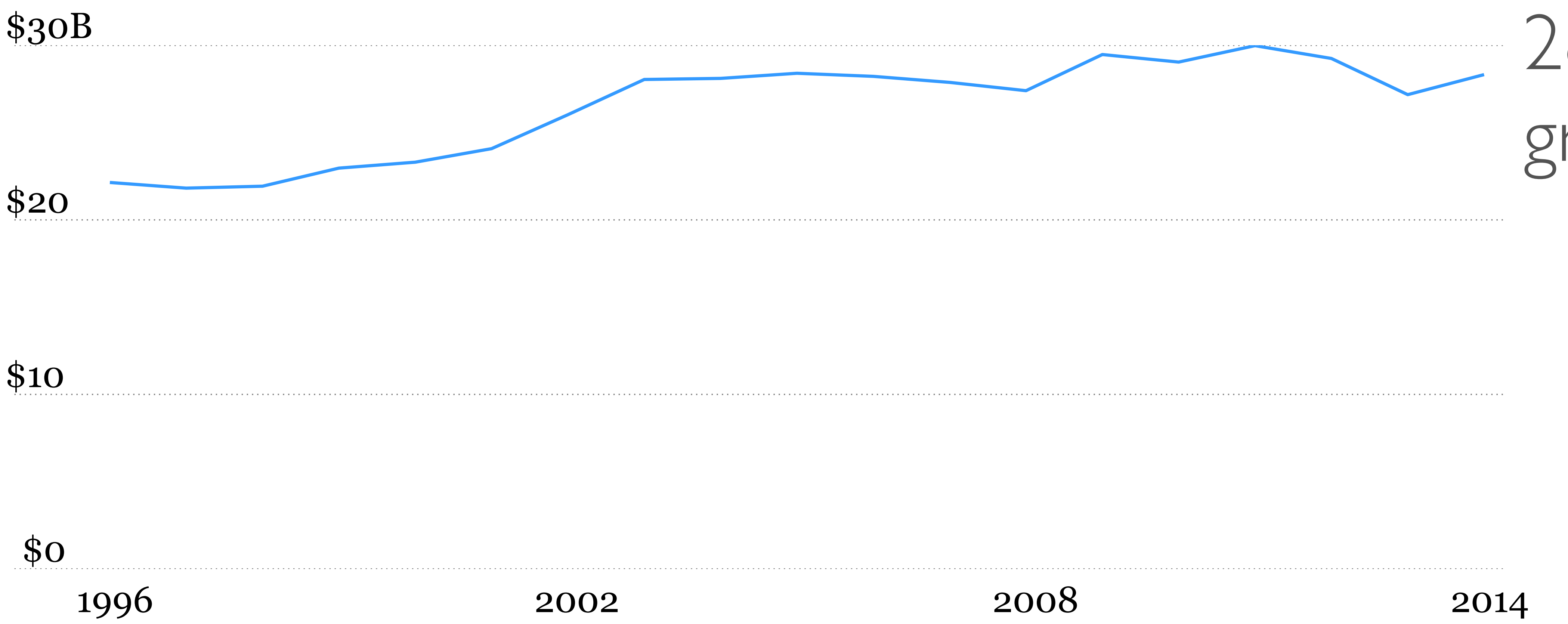

28% growth

Insights

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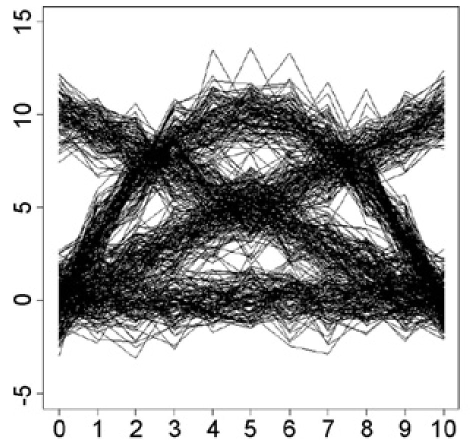
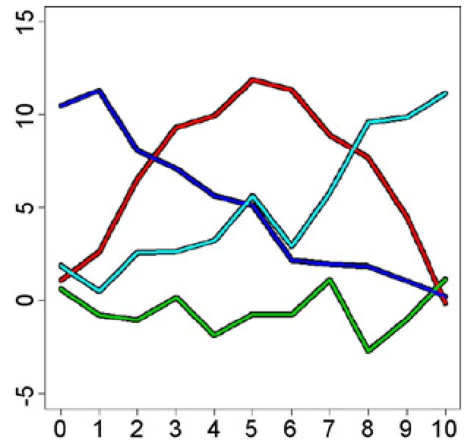
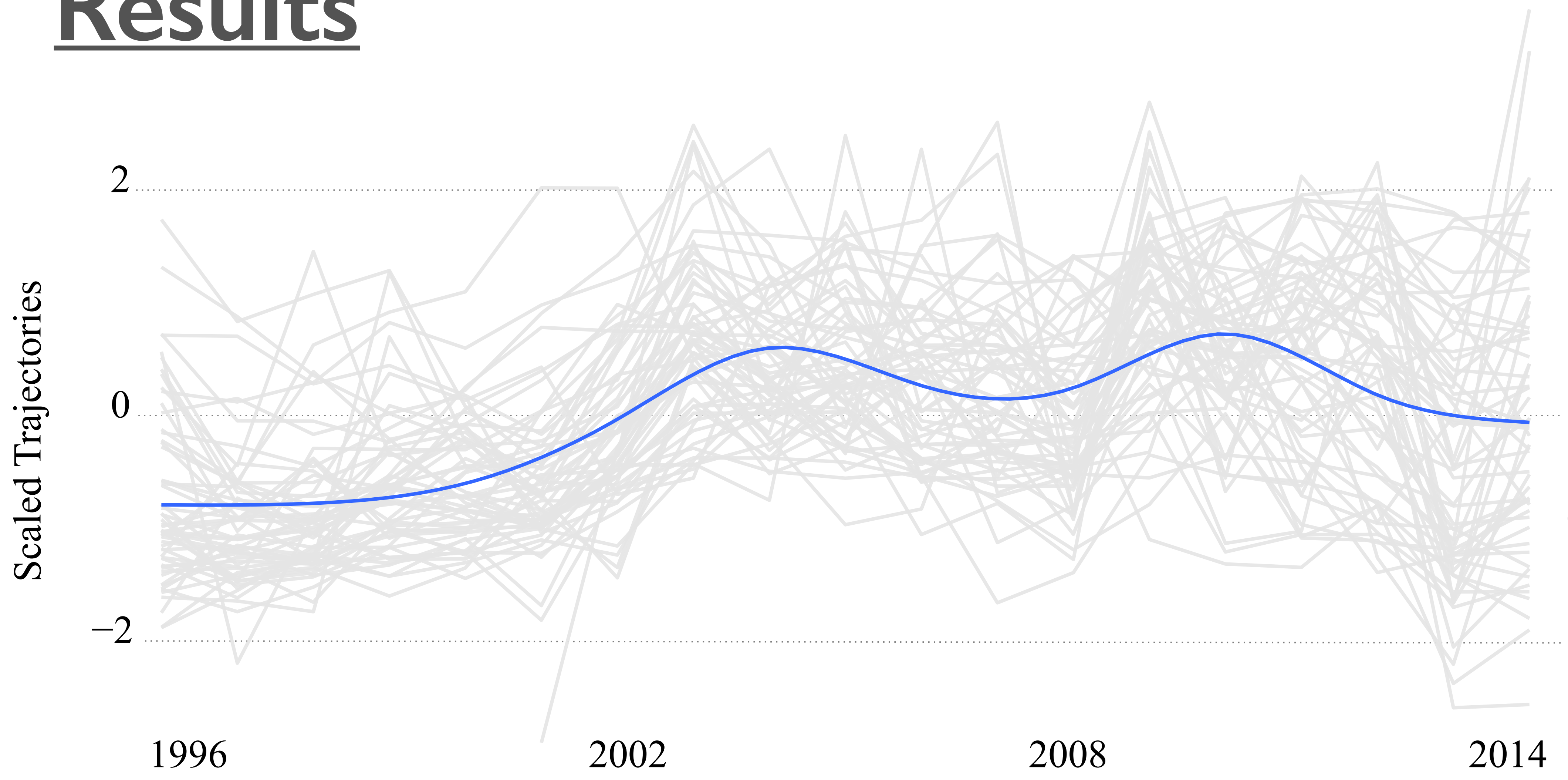




Results



26% growth

Insights

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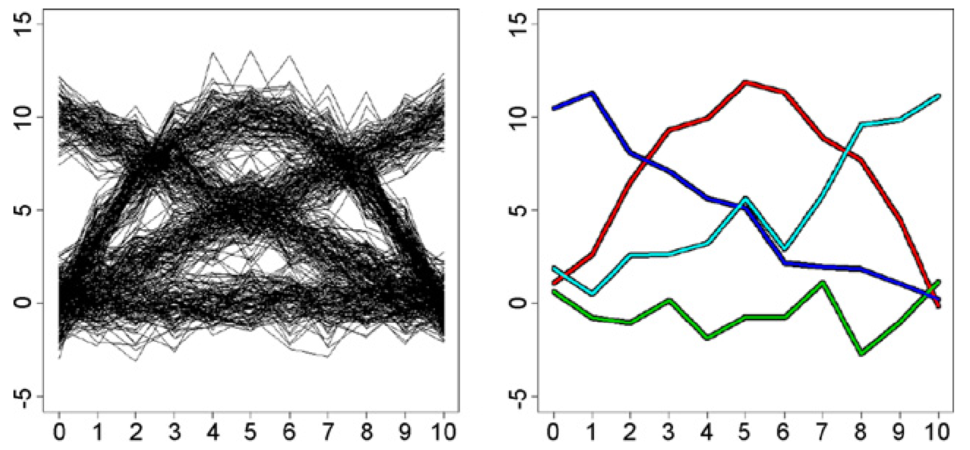
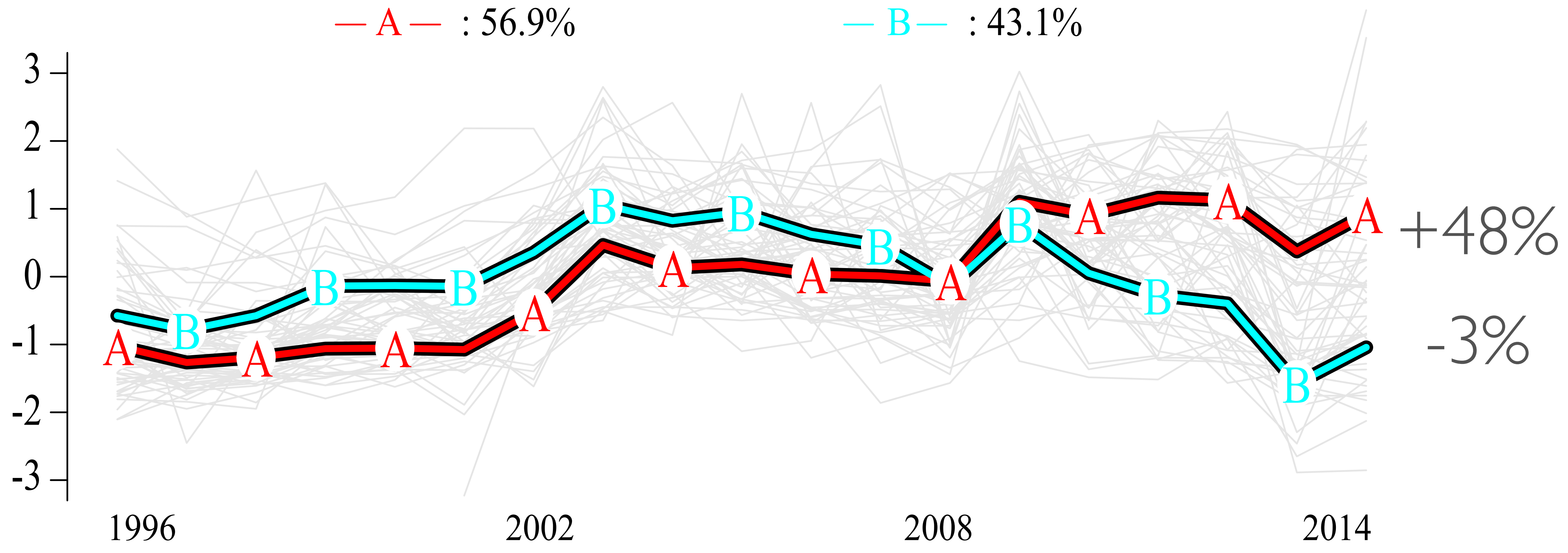


Results



Insights

1. Illustrates micro vs macro level trends

AGGREGATED PERFORMANCE METRICS

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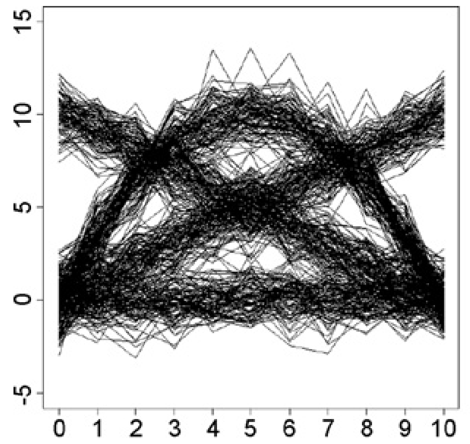

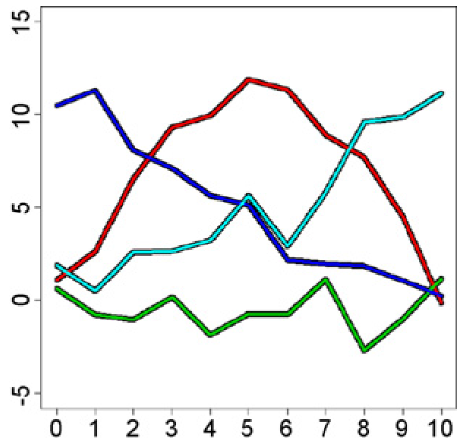

Results

	Increasing Cost Curves			Decreasing Cost Curves		
Metric	Percent of Bases	Cost Curve	Percent Growth	Percent of Bases	Cost Curve	Percent Growth
Total Support Costs	57%		48%	43%		-3%
Total Manpower Costs	62%		30%	38%		-15%
Indirect-to-Direct Headcount Ratio	52%		129%	48%		-58%
Per Support Person Costs	62%		15%	38%		-13%
Total Facility Sustainment Costs	38%		182%			
	62%		36%			
Facility Sustainment Cost per PRV	29%		144%	26%		-42%
	45%		29%			
Facility Sustainment Cost per SqFt	62%		70%			
	38%		162%			
Total Utility Costs	38%		123%	31%		-26%
	31%		11%			
Utility Cost per PRV	60%		75%	40%		-71%
Utility Cost per SqFt	76%		105%	24%		-16%
Total Discretionary Costs	28%		137%	72%		-35%
Discretionary Cost per Support Person	36%		100%	64%		-44%

Insights

1. Illustrates micro vs macro level trends
2. Identifies common themes across the enterprise

AGGREGATED PERFORMANCE METRICS

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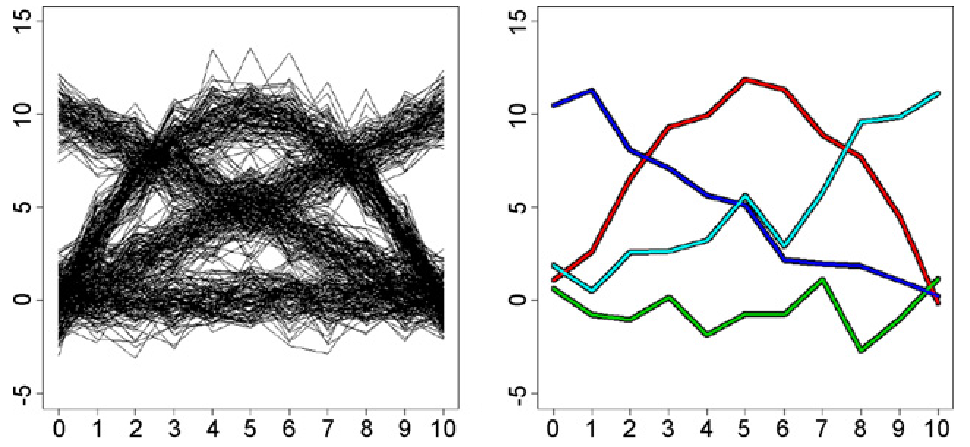
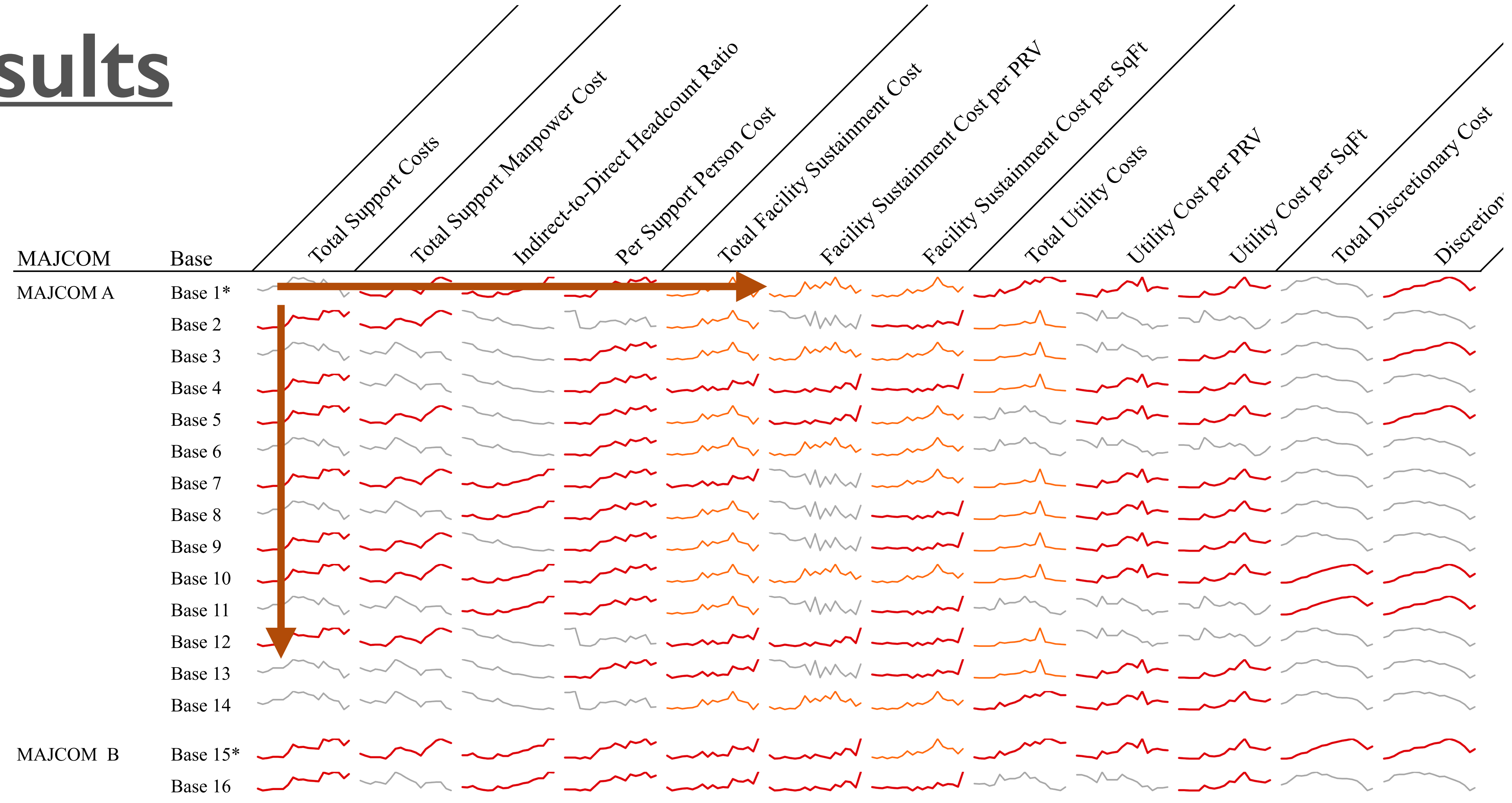


Results



Insights

1. Illustrates micro vs macro level trends
2. Identifies common themes across the enterprise
3. Directs decision-makers' focus

PERFORMANCE ASSESSMENTS

MEASURING EFFICIENCY TO GUIDE RESOURCE ALLOCATION

Resource Problem

The current performance assessment process for installation support activities fails to inform resource allocation decisions

PERFORMANCE ASSESSMENTS

MEASURING EFFICIENCY TO GUIDE RESOURCE ALLOCATION

Objective

Improve the performance assessment process for installation support activities:

- Benchmark performance
- Identify potential cost savings
- Identify potential performance improvements

Key Data Science Components

Acquired, cleaned and combined data from two different organizations and three databases.

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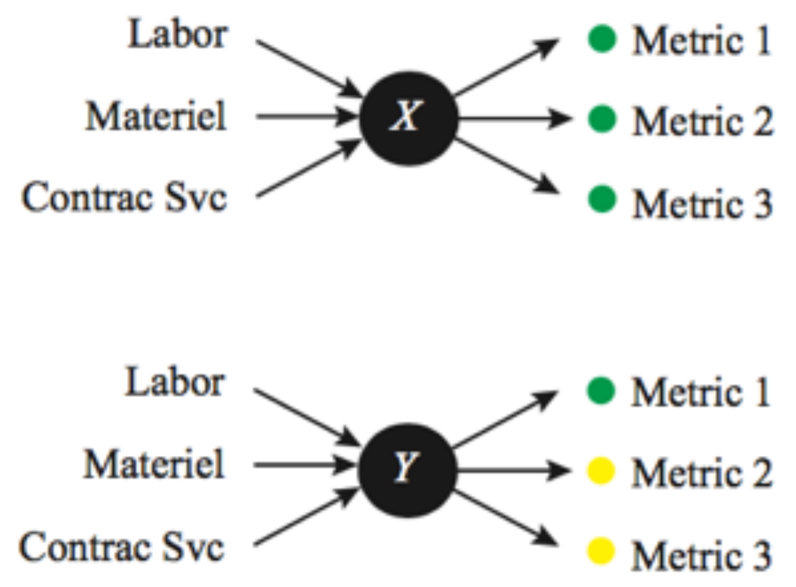
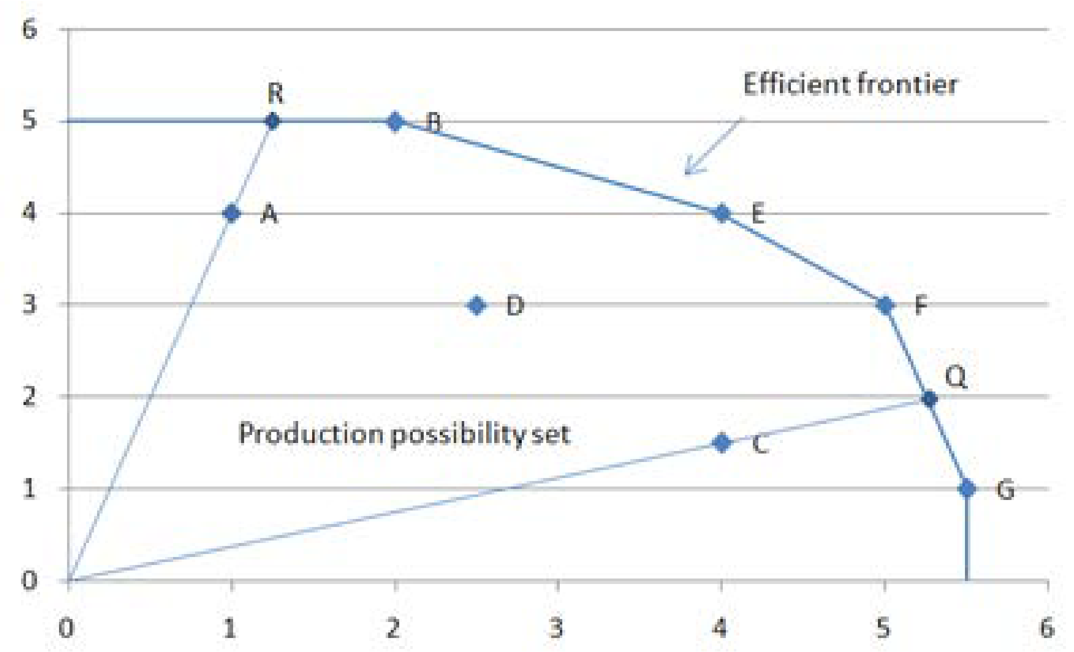
Key Data Science Components

Data Envelopment Analysis





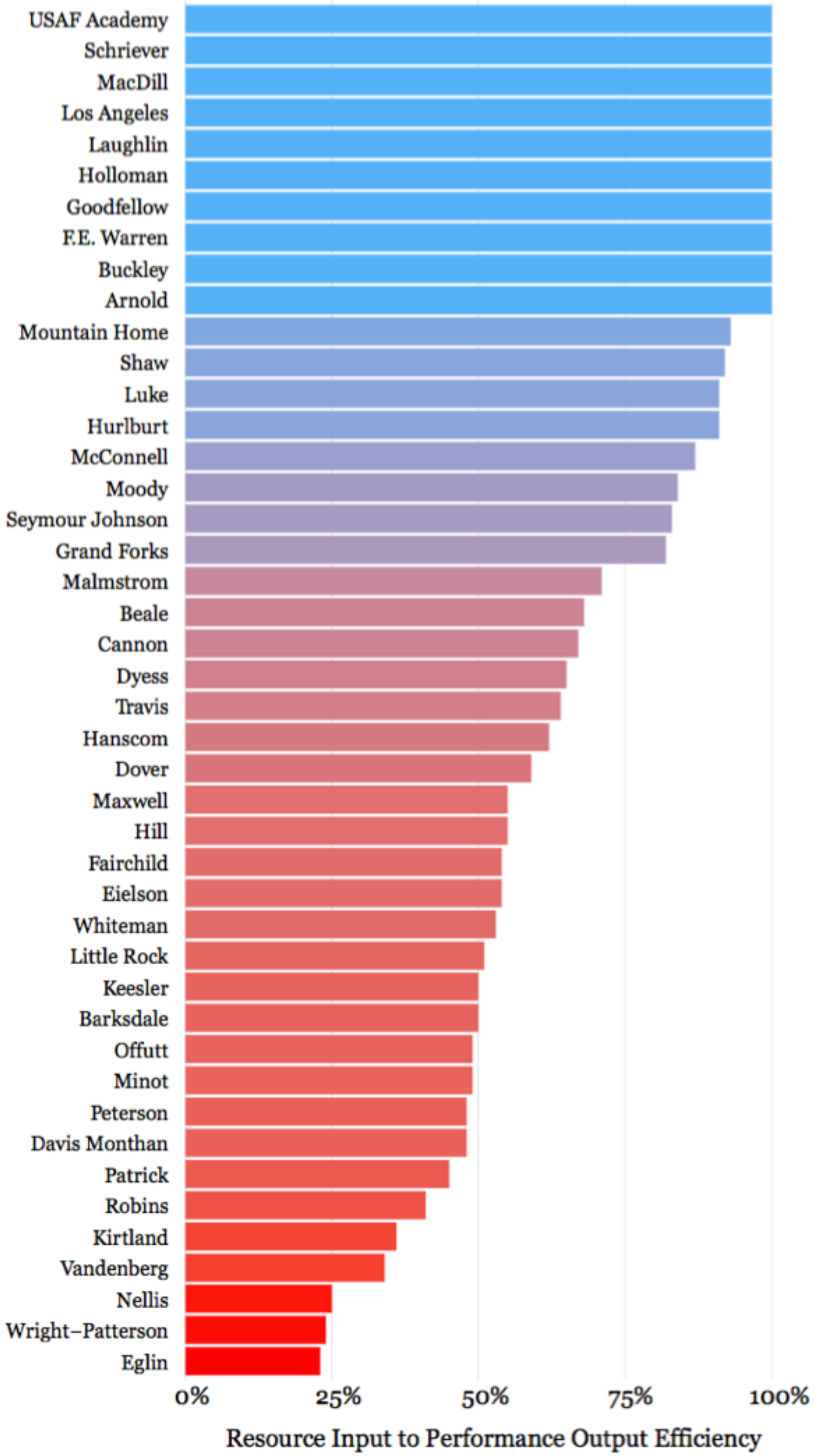
Results

Insights

CE ASSESSMENTS

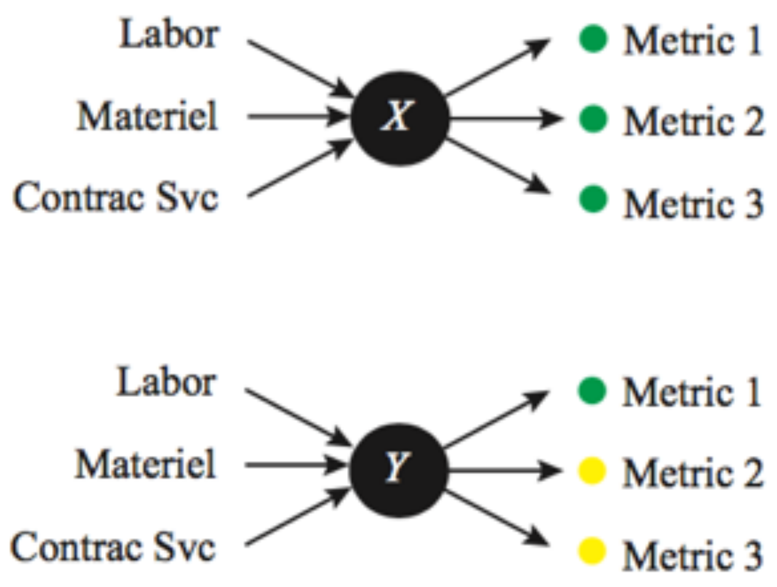
GUIDE RESOURCE ALLOCATION

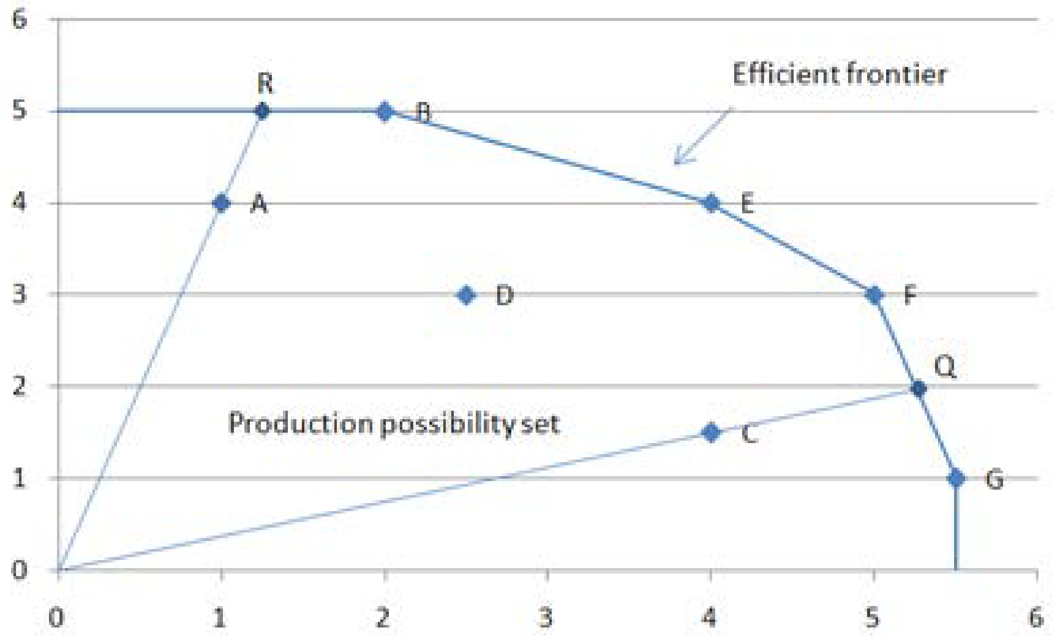
Results



Key Data Science Components

Data Envelopment Analysis





Insights

1. Measured the efficiency of bases across the enterprise

PERFORMANCE ASSESSMENTS

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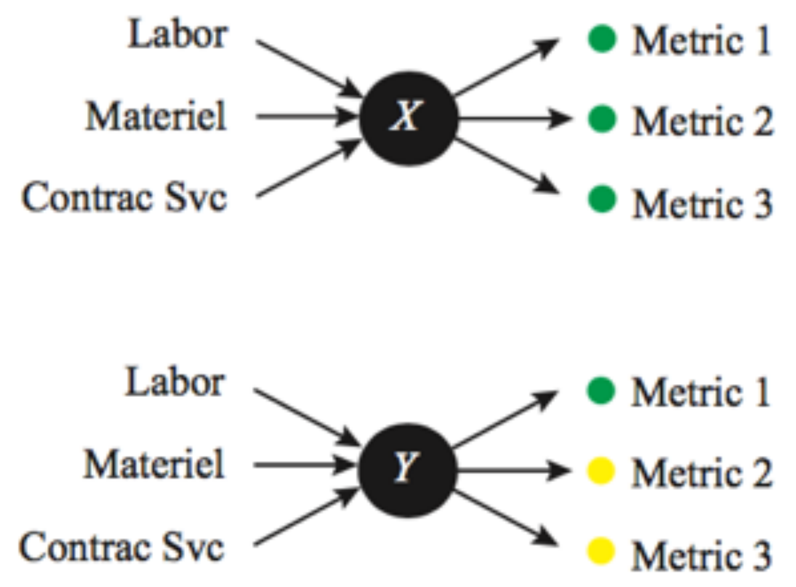

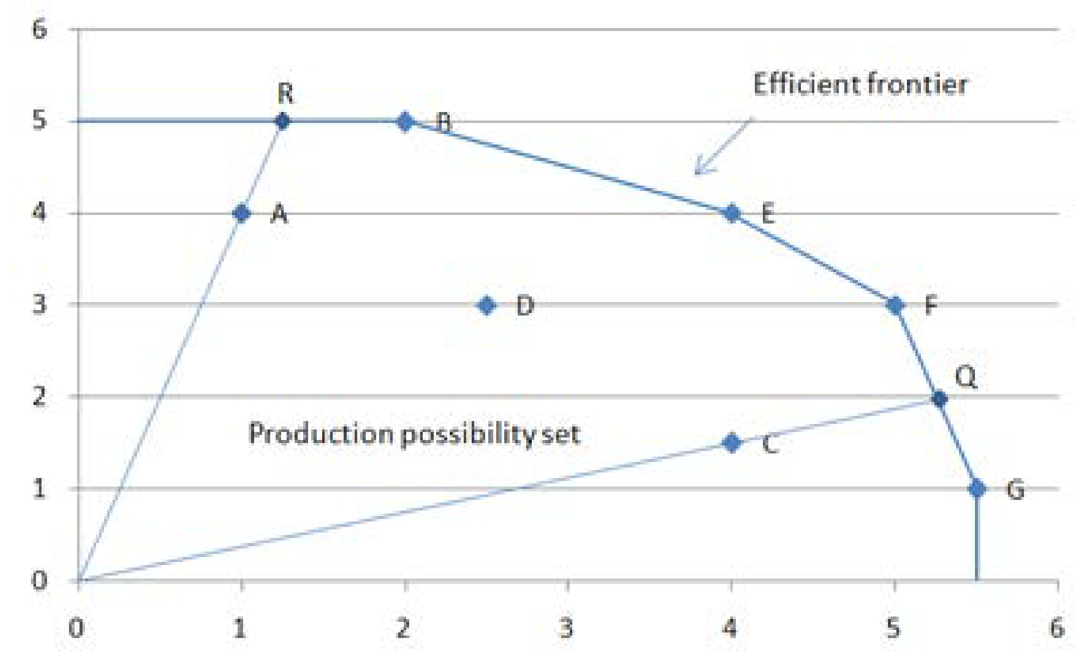

Results

Performance	SBM	CRS	VRS	Potential Slack Range	
Installations achieving a "Green" risk rating:					
S^-_{Labor}	\$18.83	\$1.03	\$0.48	\$0.48-18.83	(1-8%)
S^-_{CS}	\$7.65	\$4.42	\$0.00	\$0.00-7.65	(0-5%)
$S^-_{M\&R}$	\$26.38	\$8.54	\$4.04	\$4.04-26.38	(1-3%)
S^-_{Supply}	\$10.04	\$1.98	\$1.85	\$1.85-10.01	(2-12%)
Total	\$62.90	\$15.97	\$6.37	\$6.37-62.90	(1-5%)
minus M&R	\$36.52	\$7.43	\$2.33	\$2.33-36.52	(1-7%)

Insights

1. Measured the efficiency of bases across the enterprise
2. Identifies potential cost savings across the enterprise

PERFORMANCE ASSESSMENTS

MEASURING EFFICIENCY TO GUIDE RESOURCE ALLOCATION

Objective

Improve the performance assessment process for installation support activities:

- Benchmark performance
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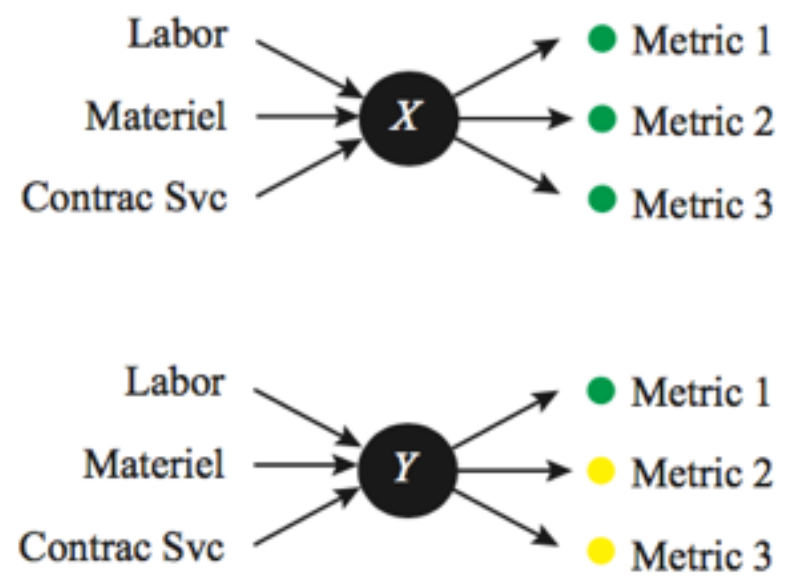
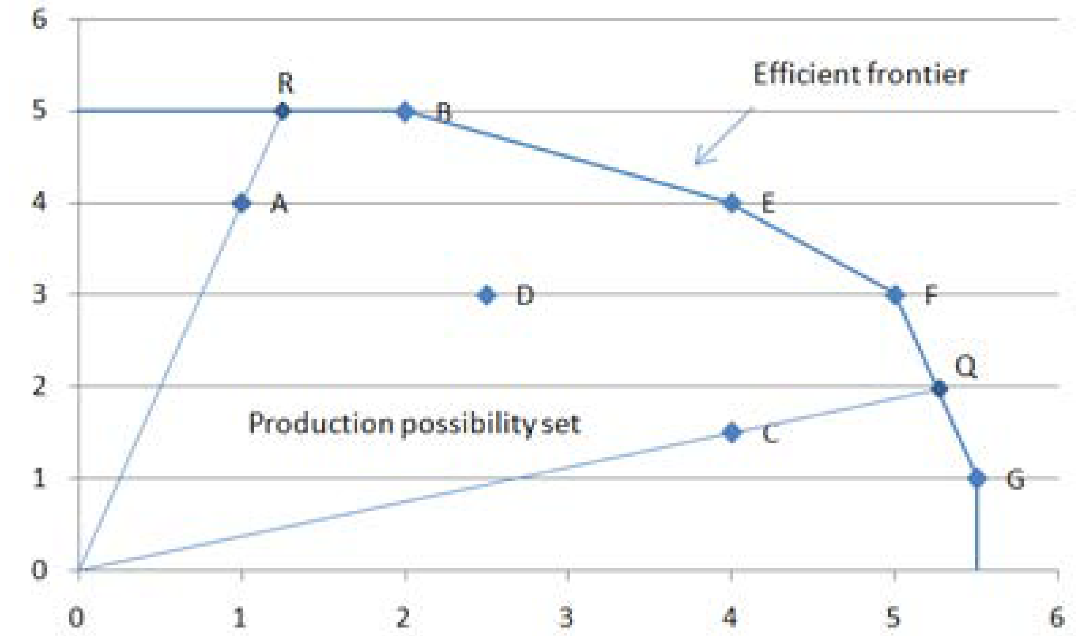




Results

Performance	SBM	CRS	VRS	Efficient Performance Range
Installations achieving a "Yellow" risk rating:				
s^+_{EM}	99% (+6pp)	108% (+16pp)	99% (+6pp)	99-100% (+6-7pp)
s^+_{HP}	88% (+8pp)	96% (+17pp)	87% (+7pp)	87-96% (+8-17pp)
s^+_{LP}	78% (+5pp)	79% (+6pp)	79% (+6pp)	78-79% (+5-6pp)
s^+_{PM}	91% (+9pp)	95% (+12pp)	90% (+7pp)	90-95% (+7-12pp)
Installations achieving a "Red" or "Yellow" risk rating:				
s^+_{EM}	98% (+9pp)	102% (+12pp)	98% (+9pp)	98-100% (+9-12pp)
s^+_{HP}	85% (+10pp)	89% (+14pp)	84% (+9pp)	84-89% (+9-14pp)
s^+_{LP}	80% (+7pp)	81% (+9pp)	81% (+8pp)	80-81% (+7-9pp)
s^+_{PM}	86% (+7pp)	92% (+14pp)	85% (+6pp)	85-92% (+6-14pp)

*pp values listed represent the percentage point(s) increase gained if the installations would have operated efficiently.

Insights

1. Measured the efficiency of bases across the enterprise
2. Identifies potential cost savings across the enterprise
3. Identifies potential performance improvements

PERFORMANCE ASSESSMENTS

MEASURING EFFICIENCY TO GUIDE RESOURCE ALLOCATION

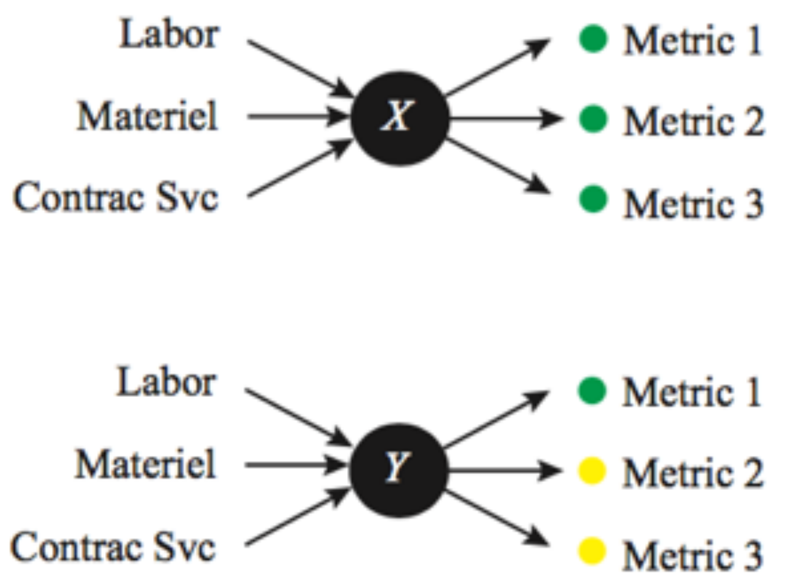
Objective

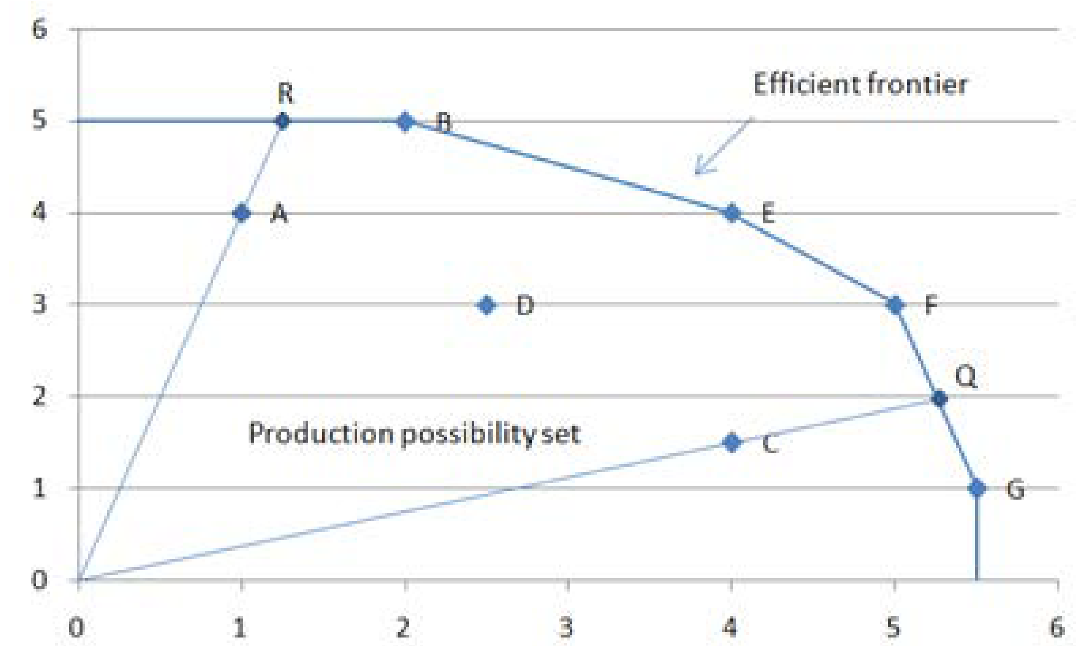
Improve the performance assessment process for installation support activities:

- Benchmark performance
- Identify potential cost savings
- Identify potential performance improvements

Key Data Science Components

Data Envelopment Analysis





Results

	Subject Base	Benchmark Bases	
	McConnell AFB	Travis AFB	USAF Academy
Efficiency:	0.43	1.00	1.00
Weights:		0.64	0.36
Inputs*:			
x_{Labor}	0.0050	0.0031	0.0004
x_{CS}	0.0025	0.0008	0.0016
$x_{M\&R}$	0.0313	0.0055	0.0125
x_{Supply}	0.0043	0.0010	0.0001
Outputs:			
y_{EM}	● 100%	● 100%	● 100%
y_{HP}	● 100%	● 100%	● 100%
y_{LP}	● 91%	● 87%	● 100%
y_{PM}	● 95%	● 97%	● 100%
Slacks:			
$S^{-}_{M\&R}$	\$4.04M		
S^{-}_{Supply}	\$0.83M		

*Inputs are presented as cost per plant replacement value
*Slacks are presented in FY14 \$M

Insights

1. Measured the efficiency of bases across the enterprise
2. Identifies potential cost savings across the enterprise
3. Identifies potential performance improvements
4. Provides base-level resource tradeoffs

CATEGORY MANAGEMENT

GREATER FIDELITY FOR STRATEGIC SOURCING

Resource Problem

We don’t track lower levels of procurement; therefore, we cannot benchmark and improve product sourcing across the Air Force.

CATEGORY MANAGEMENT

GREATER FIDELITY FOR STRATEGIC SOURCING

Objective

1. Improve understanding of what is being procured
2. Improve visibility of what is being procured

Key Data Science Components

Applied text analytics

Results

Figure 3: Most Frequent Purpose Classifications Found in Clothing & Insignia CLIN Description

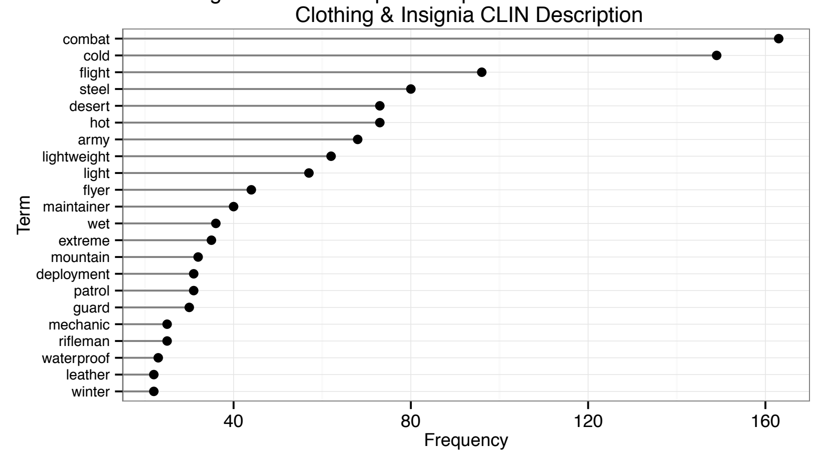


Figure 4: Most Frequent Gender & Size Descriptions Found in Clothing & Insignia CLIN Description

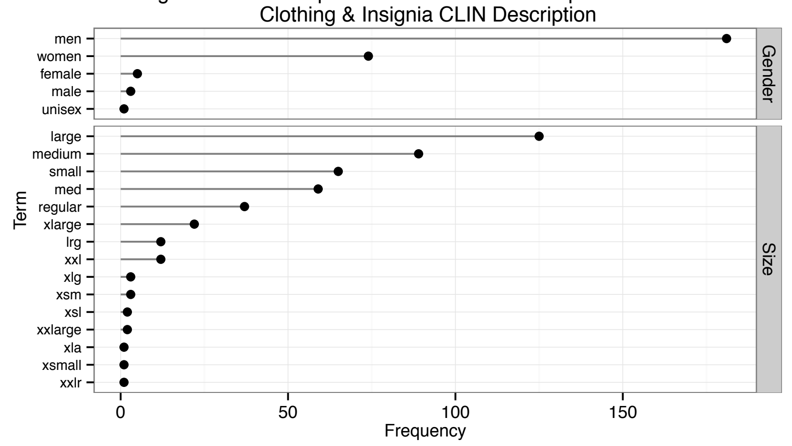


Figure 11a: Top 50 Most Frequent Words Found in Vehicle CLIN Description

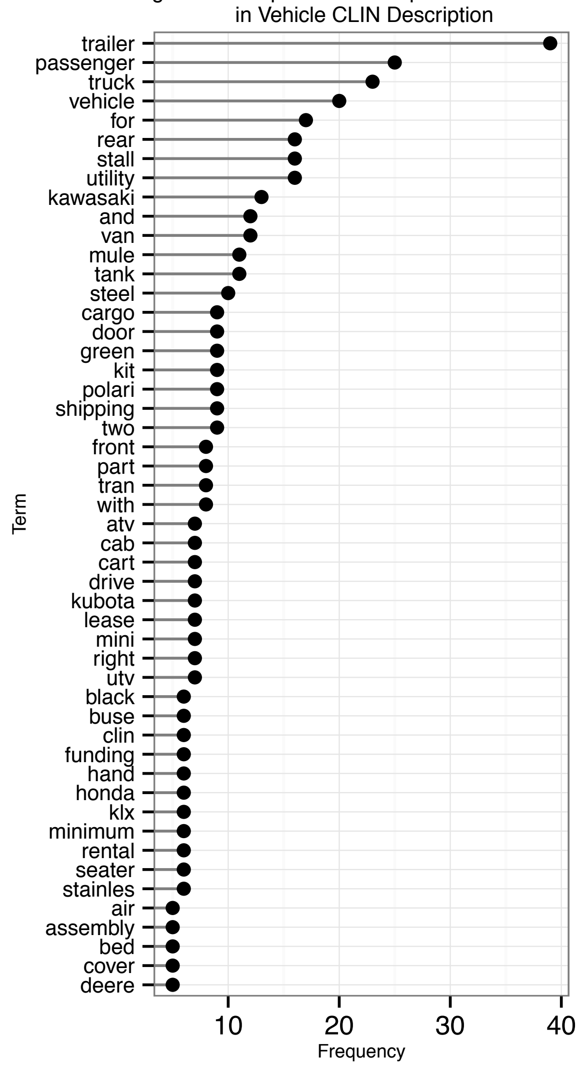
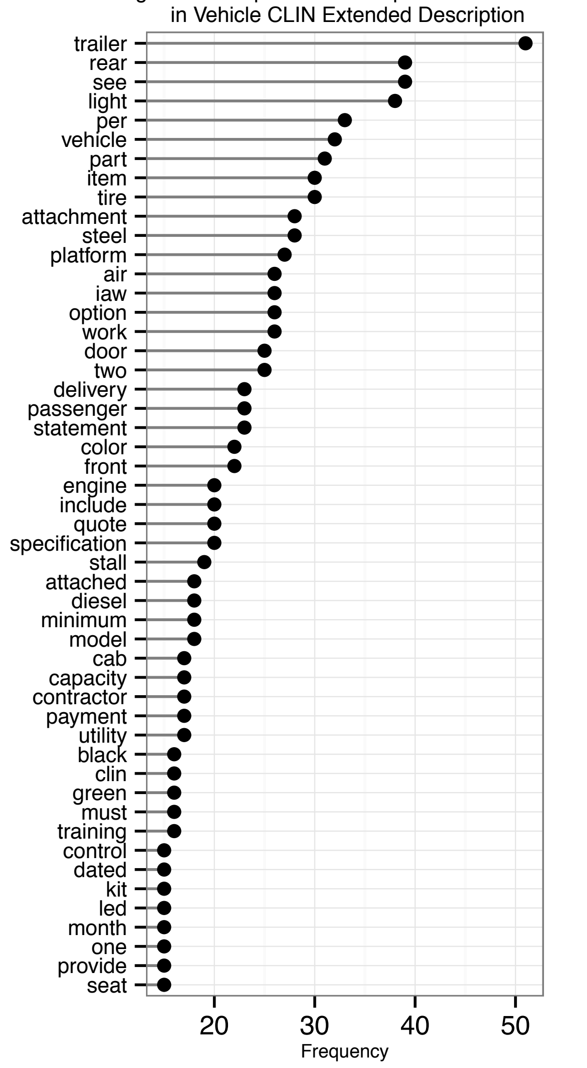


Figure 11b: Top 50 Most Frequent Words Found in Vehicle CLIN Extended Description



Insights

1. Identified most common clothing characteristics: items, purposes, sizes and gender
2. Identified most common types of vehicles

CATEGORY MANAGEMENT

GREATER FIDELITY FOR STRATEGIC SOURCING

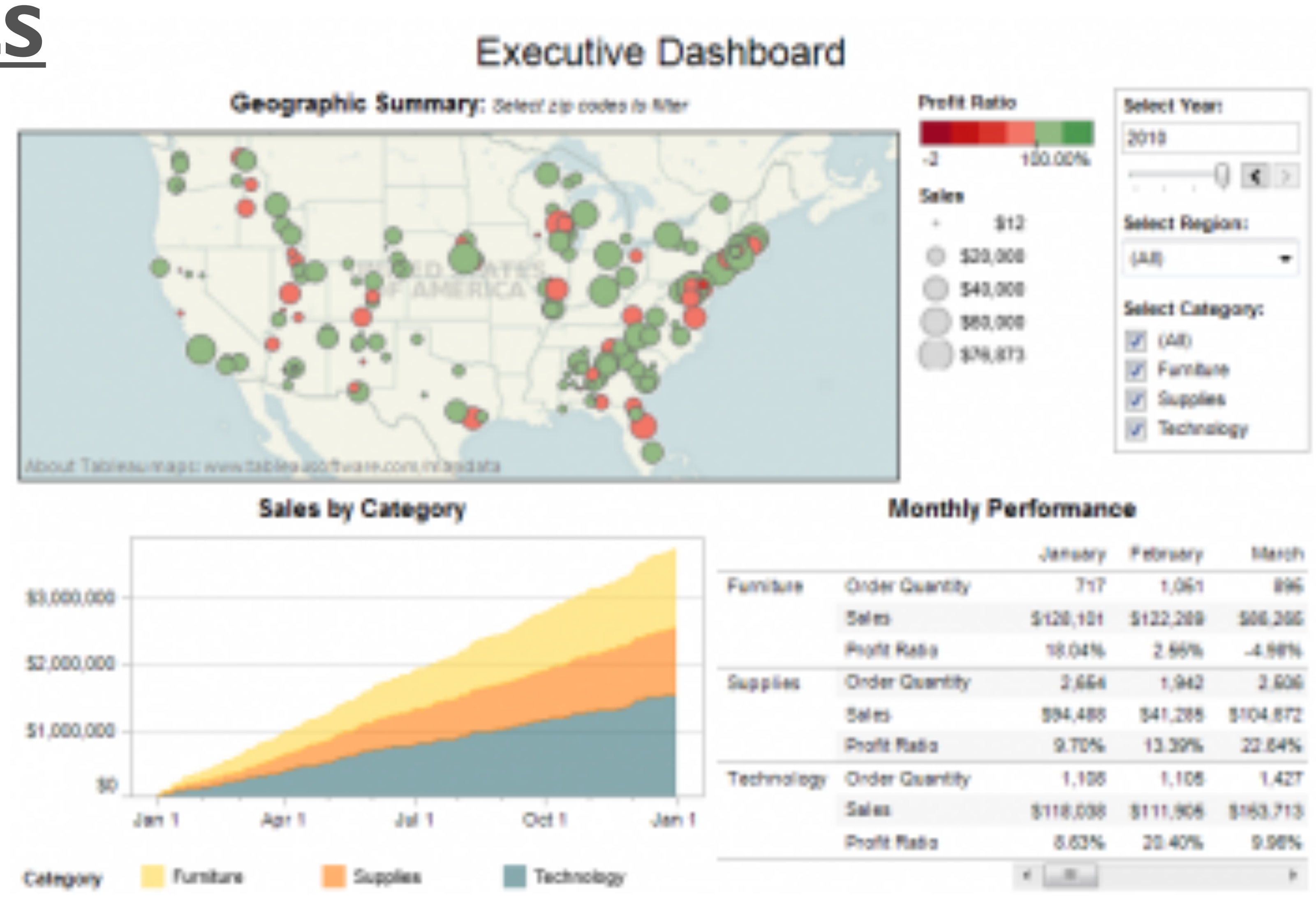
Objective

1. Improve understanding of what is being procured
2. Improve visibility of what is being procured

Key Data Science Components

Created interactive dashboard for AF-wide consumption

Results



Insights

1. Identified most common clothing characteristics: items, purposes, sizes and gender
2. Identified most common types of vehicles
3. Provides insights regarding sourcing trends to all installations creating common understanding.

AIR FORCE "REQUIREMENTS"

AIRCRAFT AVAILABILITY AND THE SEARCH FOR SIGNIFICANCE

Resource Problem

Aircraft availability is the Air Force's primary metric for aircraft performance. Although the conceptual linkage is clear the evidence is not.

AIR FORCE "REQUIREMENTS"

AIRCRAFT AVAILABILITY AND THE SEARCH FOR SIGNIFICANCE

Objective

Understand the relationship between AA and aircraft performance

Key Data Science Components

Data quality and disorganization

Results

Figure: Association Between AA and Mission Performance

The relationships between AA and near–term mission performance attributes are nominal at best. A weapon system's utilization, sortie execution, and adjusted flying hour requirement execution rate are not influenced by the weapon system's percent of AA standard achieved. The only statistically significant relationship observed is the relationship between AA and the President's Budget flying hour requirement execution. However, this relationship is weak with a correlation of .42, which suggests about 15% of the variance in executing the PB flying hour requirement is explained by a weapon system's ability to achieve its AA standard.

Insights

1. Illustrated the apparent lack of relationship between AA and near-term aircraft performance
2. Suggests that AA may not be appropriate for near-term, programmatic and enterprise decisions

FINDING $2B IN ERRORS…

AND $4.4B IN REDUCTIONS!

Resource Problem

In 2014, Air Force leaders expressed concern over the rising cost of Weapon System Sustainment (WSS) and the co-occurring increase of WSS requirements.

FINDING $2B IN ERRORS…

AND $4.4B IN REDUCTIONS!

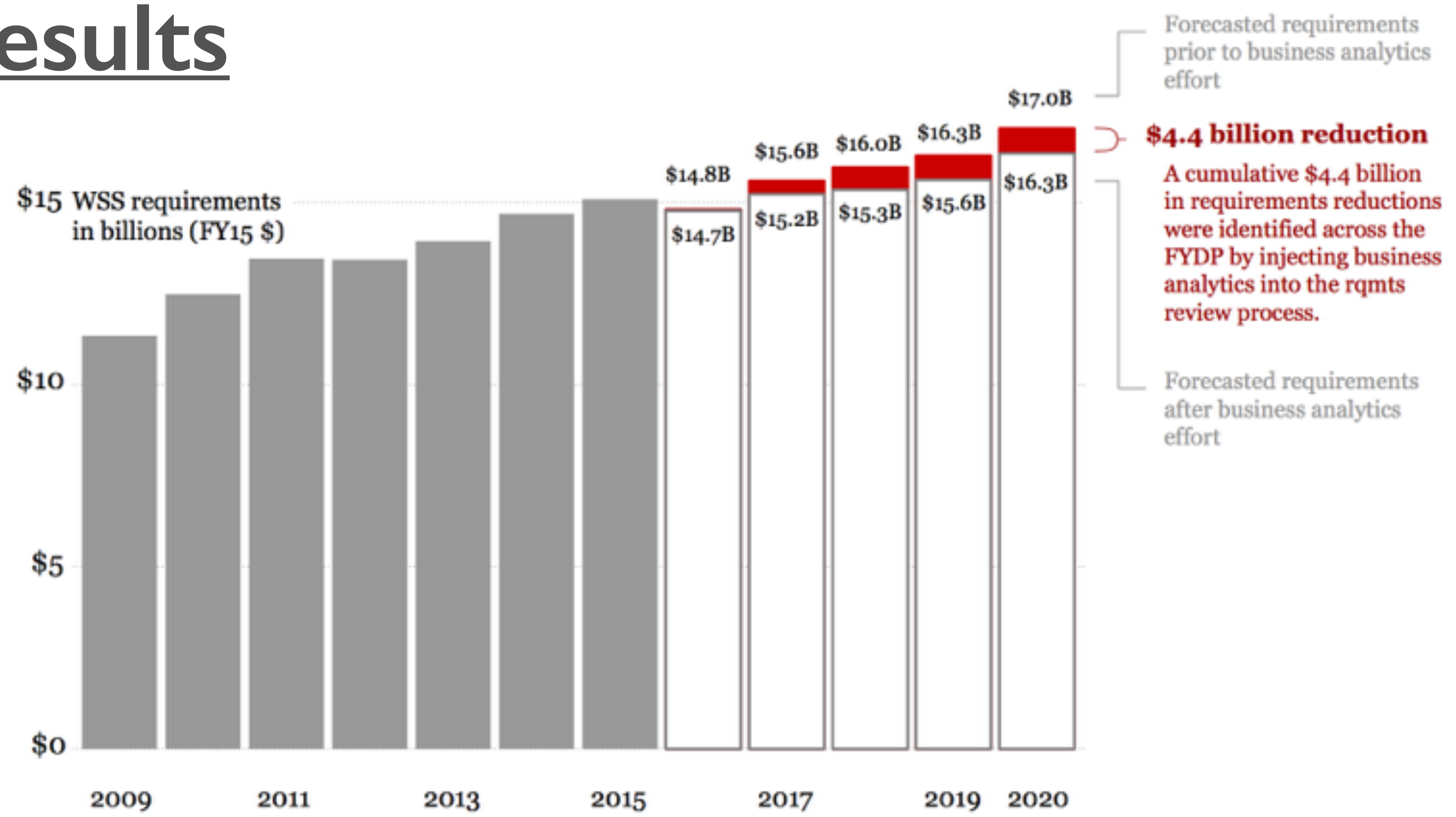
Objective

1. Improve visibility into WSS requirements and cost increases
2. Help speed up the validation process

Key Data Science Components

1. Applied data mining techniques
2. Integrated interactive visualization capabilities so CAM leadership could "cut-n-slice" as needed

Results



Insights

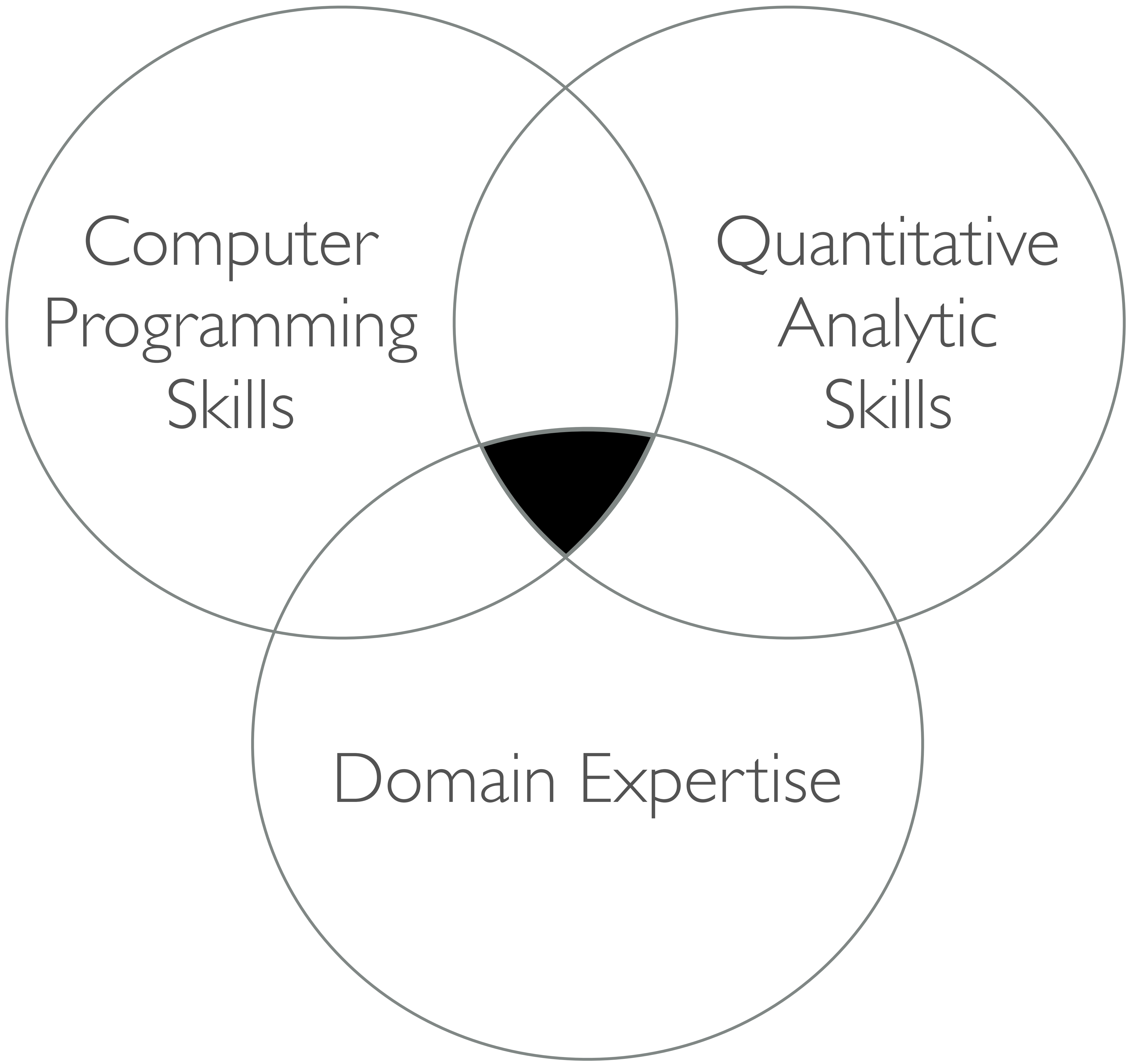
1. Identified a $2.2B requirement error after it had been overlooked by CAM's normal validation process
2. Identified a total of $4.4B in reductions over the FYDP

DATA SCIENCE

How do we grow this capability?

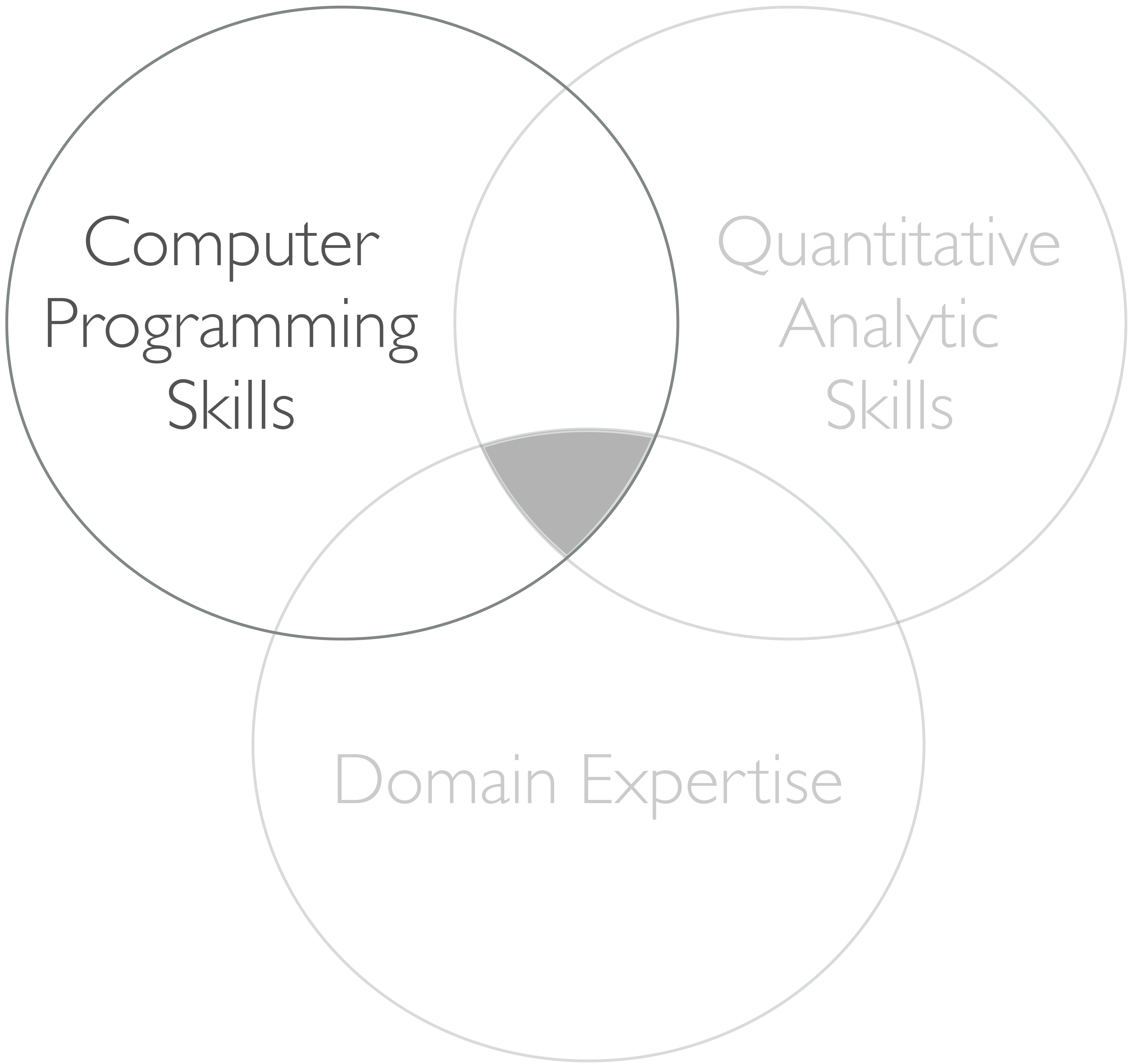
PEOPLE WITH THE RIGHT SKILLS

PEOPLE WITH THE RIGHT SKILLS

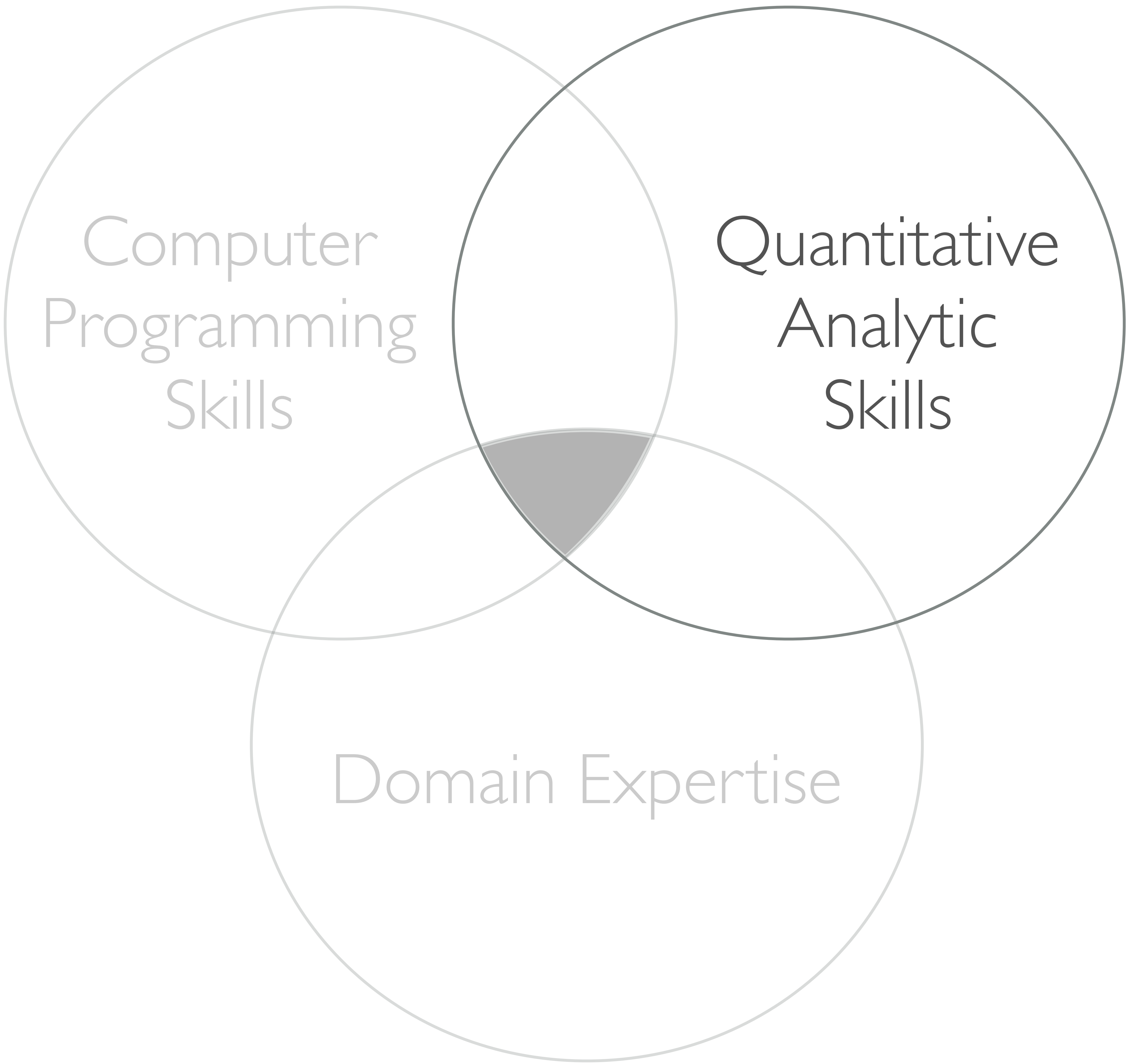


PEOPLE WITH THE RIGHT SKILLS

- Computer science basics
- Hacker mindset
- Statistical computing
- Data base

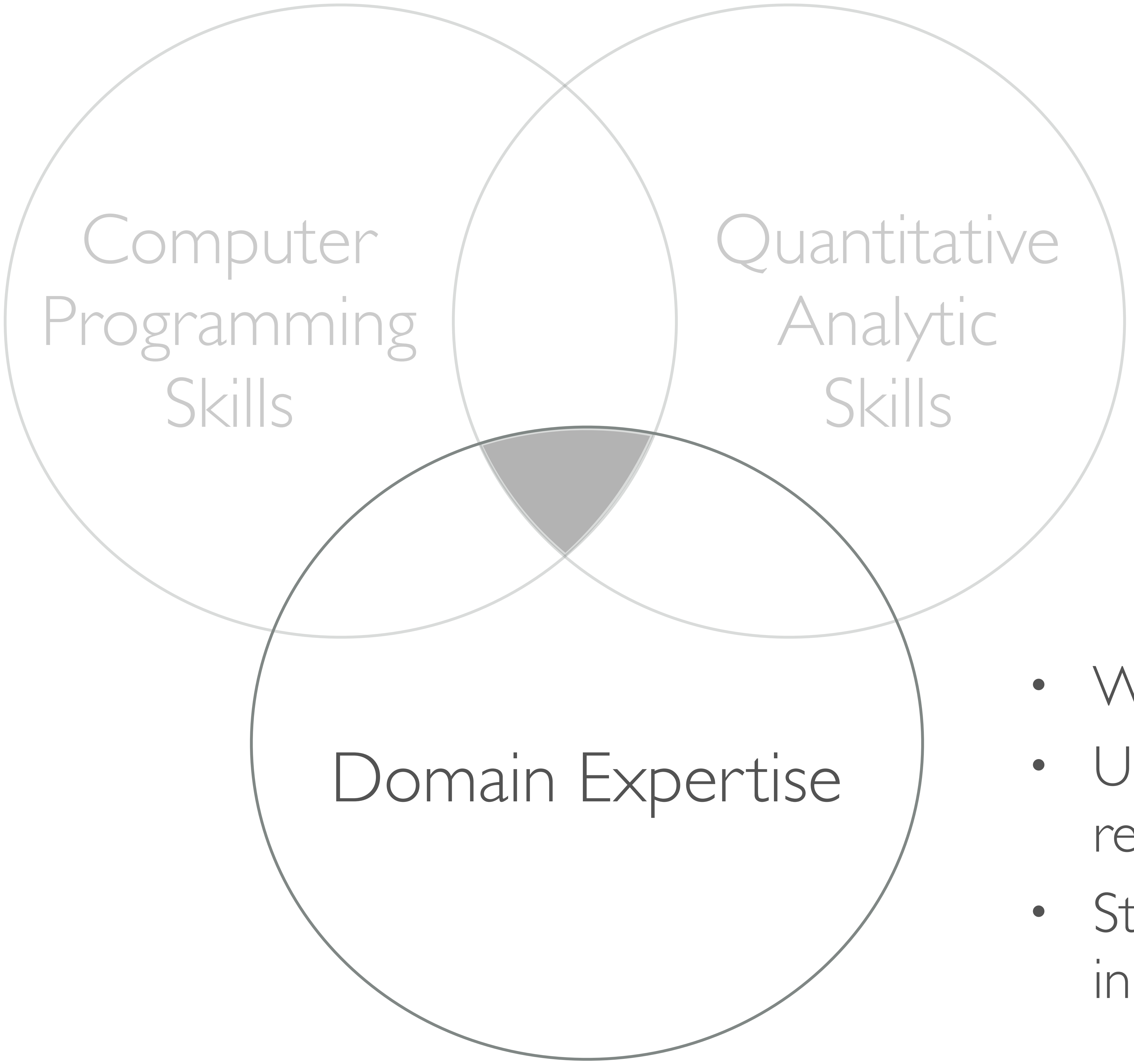


PEOPLE WITH THE RIGHT SKILLS



- Statistical modeling
- Decision analysis
- Experimental design
- Machine learning
- Text analysis
- Optimization techniques

PEOPLE WITH THE RIGHT SKILLS



- Willing to learn the AF business
- Understand supply chain relationships & implications
- Strategic, proactive, creative, innovative and collaborative

PROVIDE THE RIGHT TOOL SET

PROVIDE THE RIGHT TOOL SET

- R
- Python
- Tableau
- SQL
- ARENA
- Mathematica
- DesignExpert
- Analytica
- VBA
- Solver
- JMP
- Crystal Ball

PRE-DECISIONAL // AF/A9 WORKING PAPER

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS UNITED STATES AIR FORCE
WASHINGTON, DC

(Date)

MEMORANDUM FOR AIR FORCE ANALYTIC COMMUNITY

FROM: HQ USAF/A9
1570 Air Force Pentagon
Washington, DC 20330-1570

SUBJECT: Baseline Software Suite for Operations Research Analysis

In order to minimize costs, increase productivity, and foster a more productive environment for Operations Research (OR) in the Air Force, all OR analysts (AFSC 61A, civilian occupational series 1515, and others practicing OR in support of the Air Force mission) in the Air Force should have access to a baseline suite of software. After careful study, AF/A9 compiled the list of software for this suite, detailed in Appendix I. AF/A9 will review this software suite annually to ensure its currency.

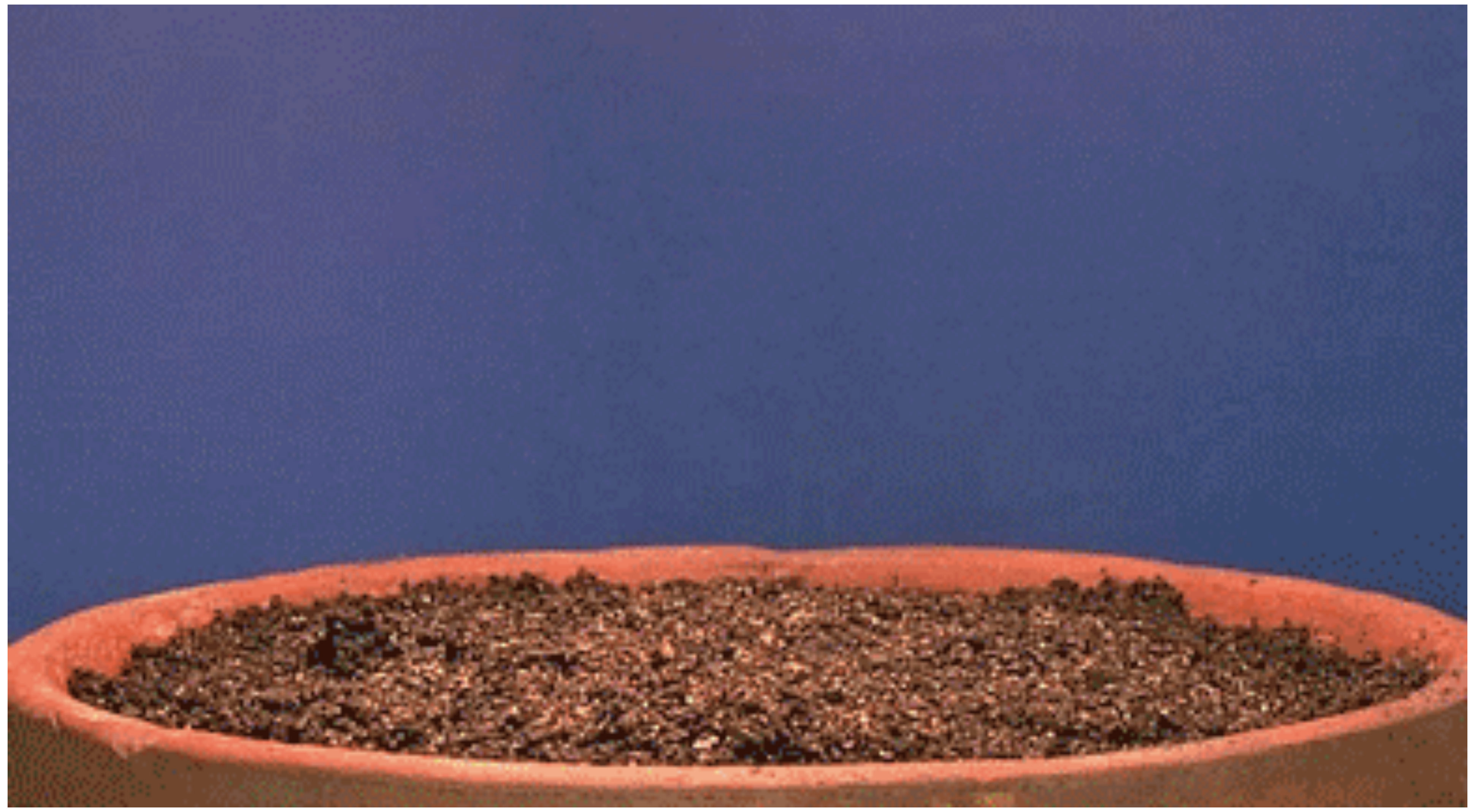
Institutions responsible for training and educating 61As or 1515s shall ensure their curriculums prepare analysts to use these software tools effectively in order to produce gold-standard analyses for the Air Force.

Currently not all of the products or latest product versions on this list are on the Air Force Evaluated Products List (EPL). AF/A9 is working on a longer term solution with the Air Force and Space Authorizing Official to gain accessibility of these products to all AFAC members. In the meantime, units are encouraged to pursue procurement of these tools through their local communications process.

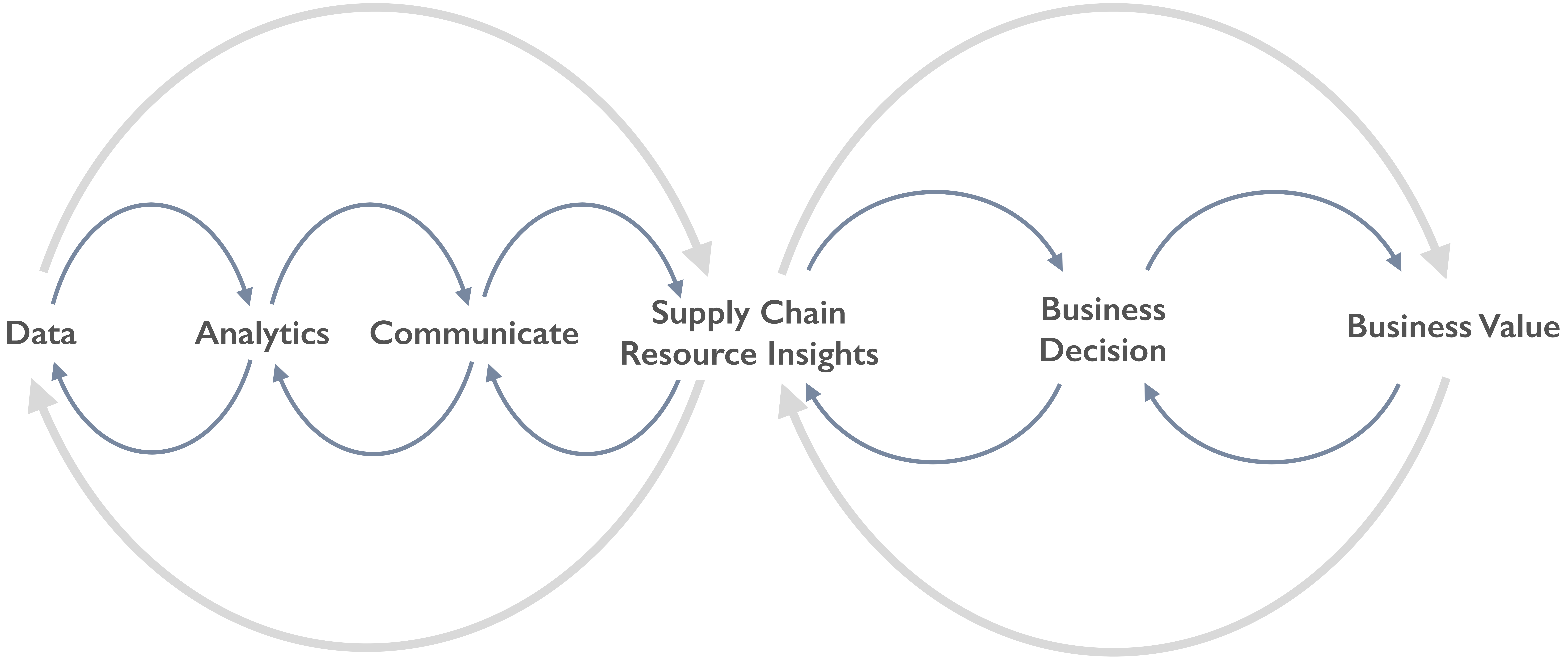
This policy does not prohibit analysts from using software outside of Appendix I. However, analysts are encouraged to use this suite as much as possible in order to reap the benefits of standardization.

KEVIN E. WILLIAMS, SES, DAF
Director, Studies, Analyses and Assessments

PROVIDE THE RIGHT ENVIRONMENT



PROVIDE THE RIGHT ENVIRONMENT



PROVIDE THE RIGHT ENVIRONMENT

U.S AIR FORCE

AFMC Business Analytics Working Group

Guidance Document

This document serves as general guidance for the intentions and operations of the AFMC Business Analytics Working Group.

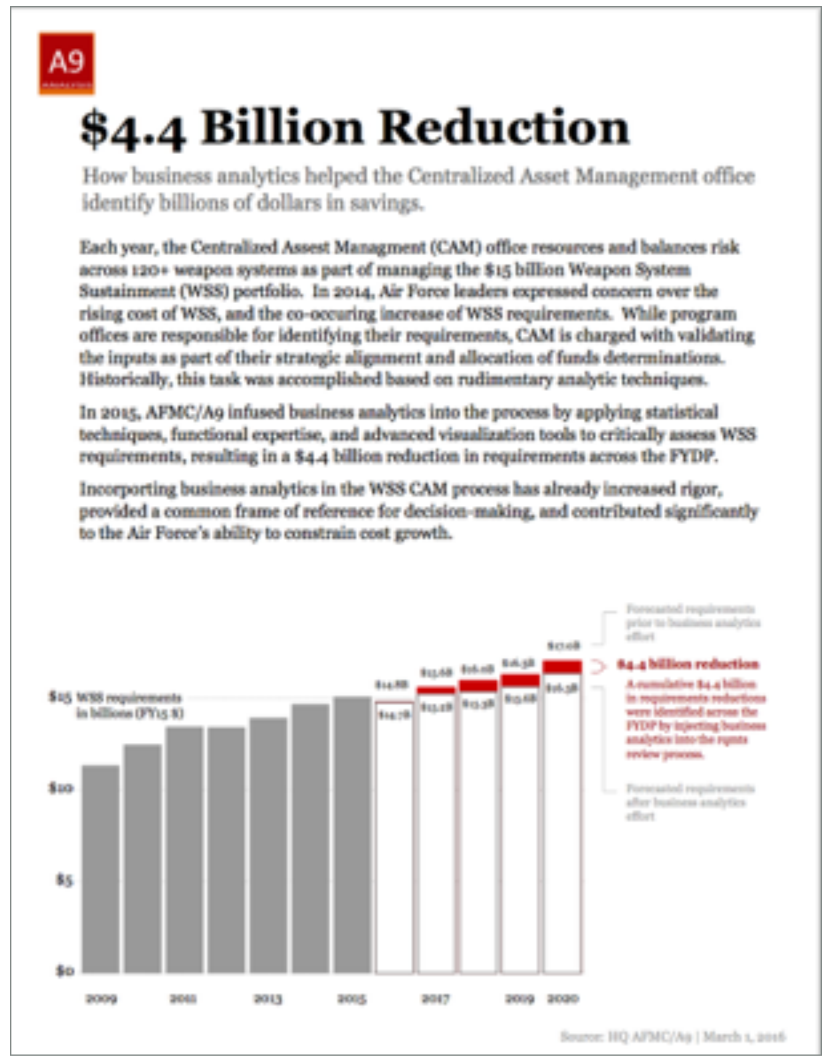
Second

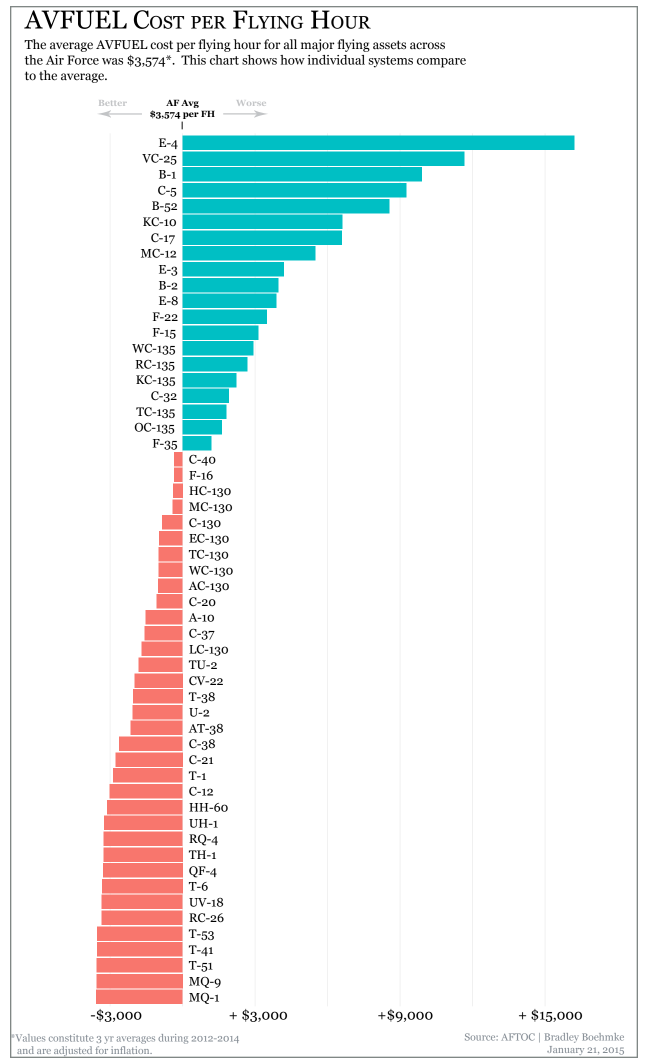
Wright-Patterson Tableau User Group (Wright-Patt TUG) Meeting

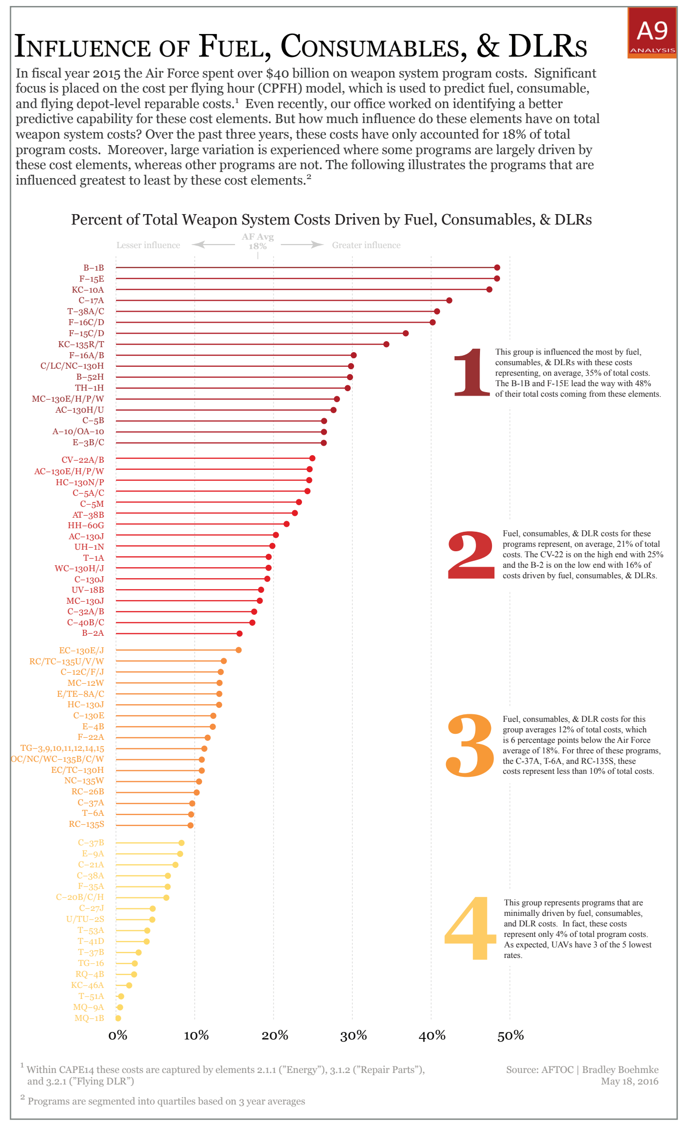
15 July 2016
13:00H
Tec^Edge

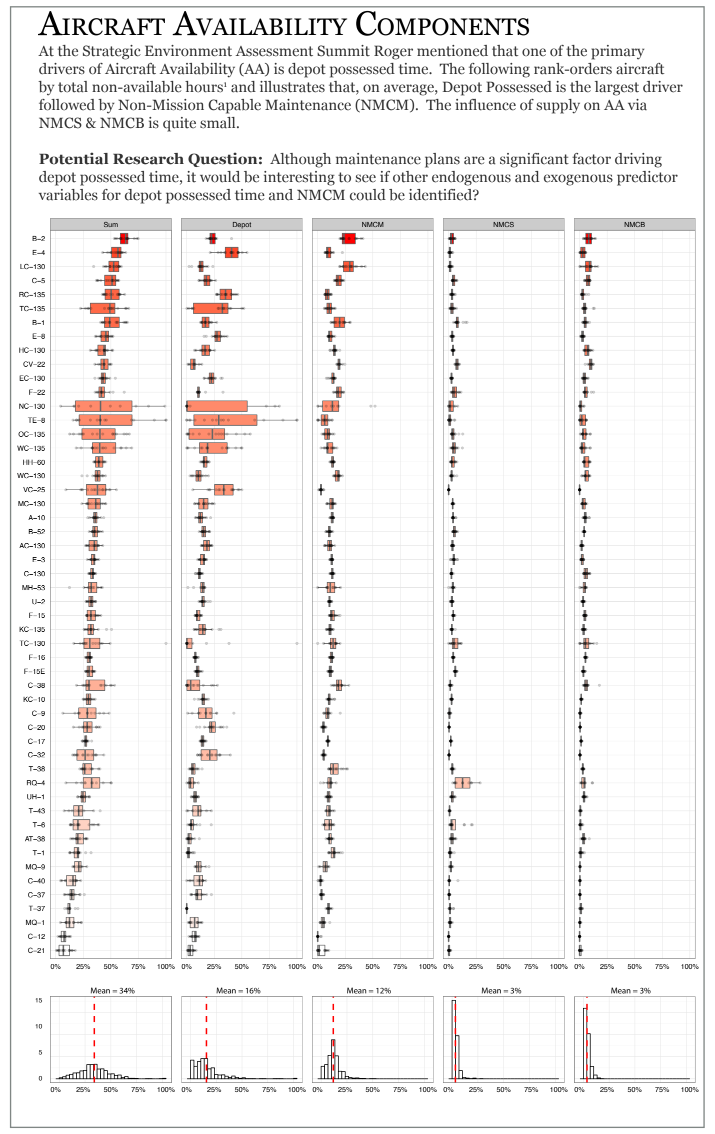
Wright-Patterson AFB useR Group

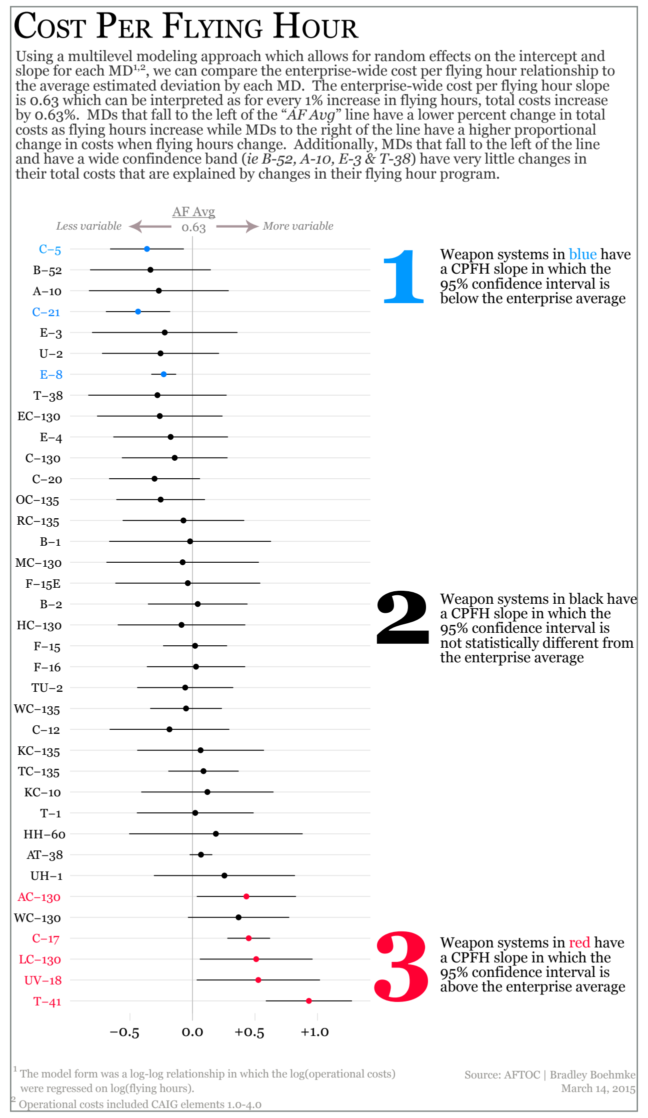
PROVIDE THE RIGHT ENVIRONMENT

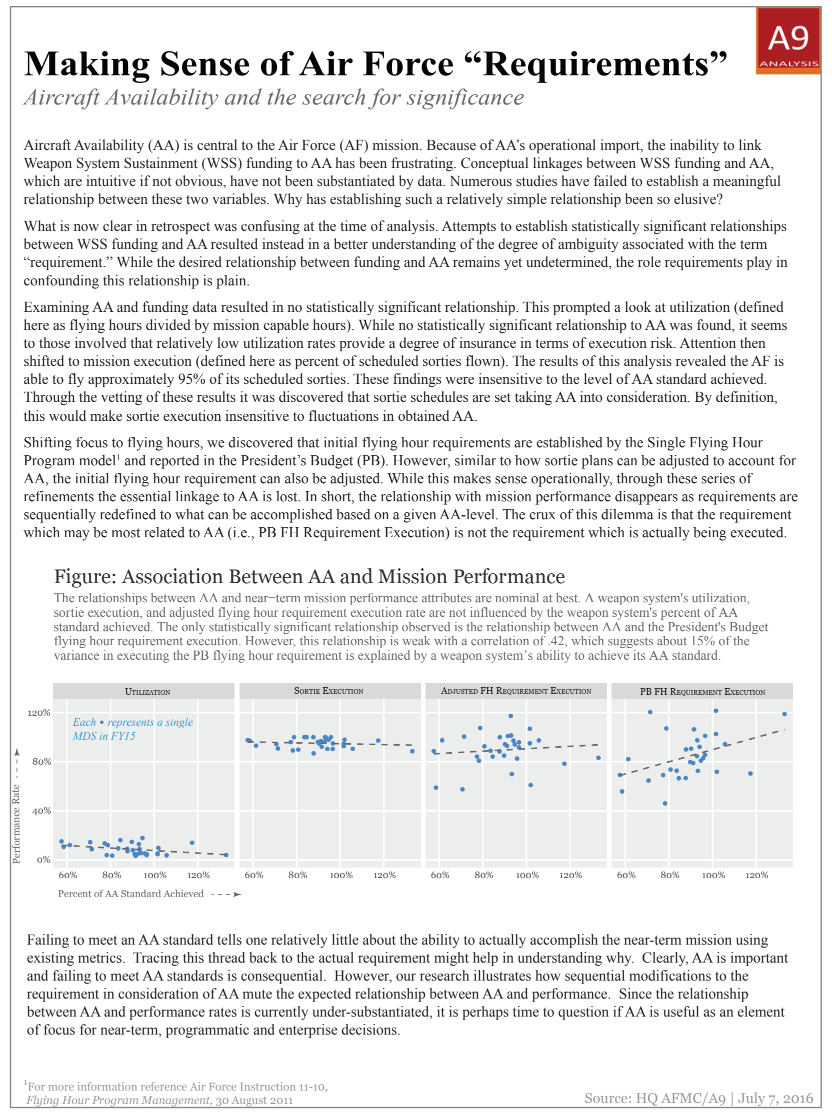


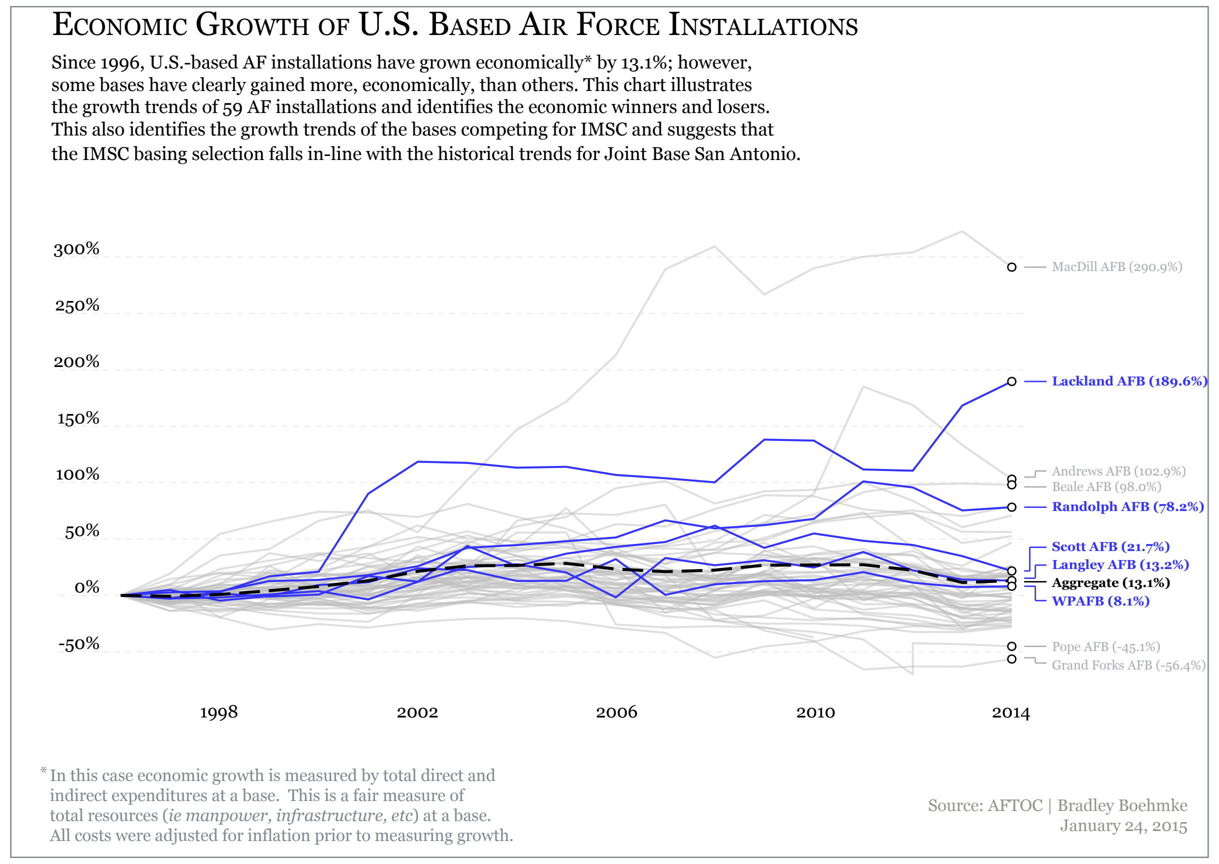


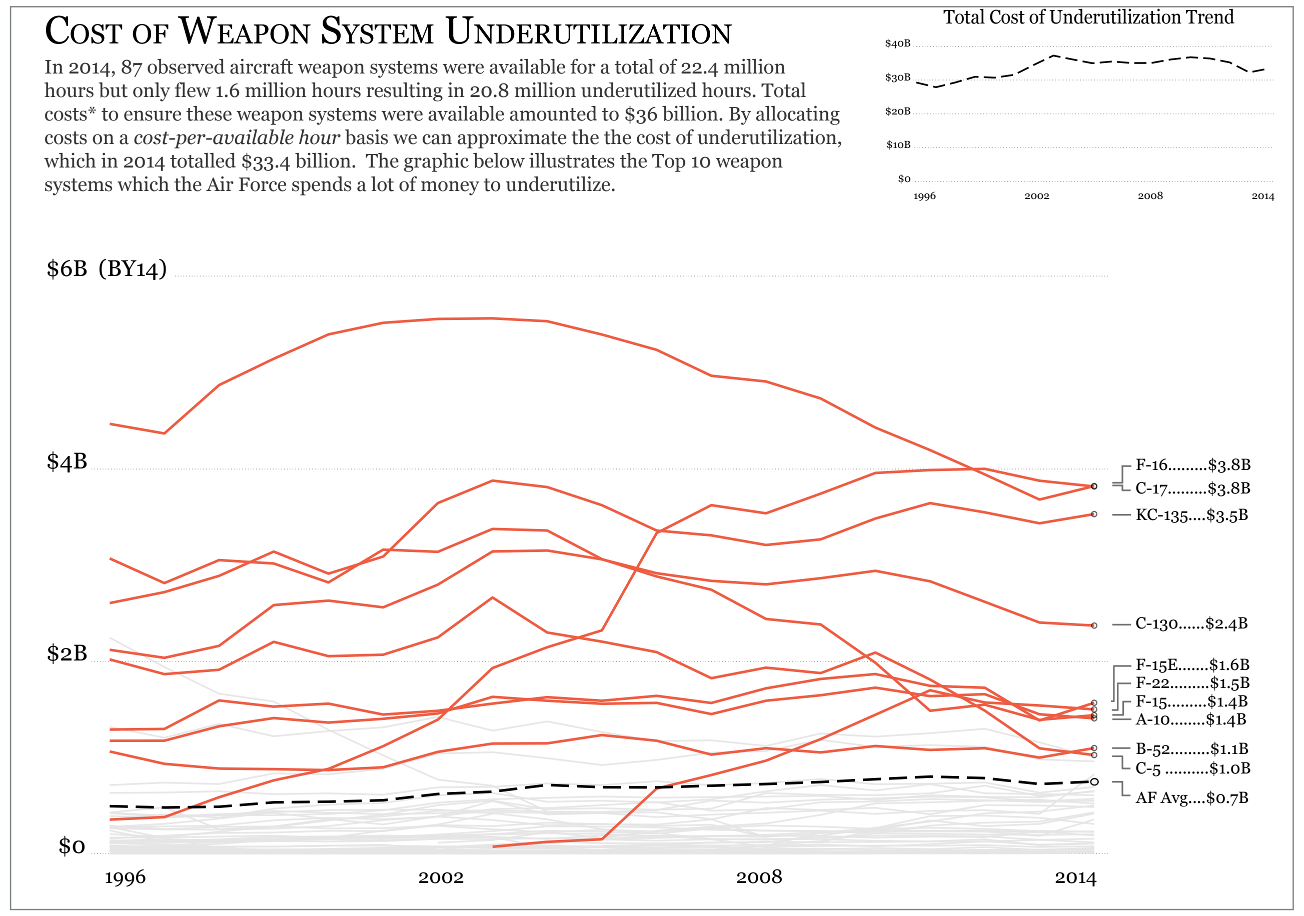


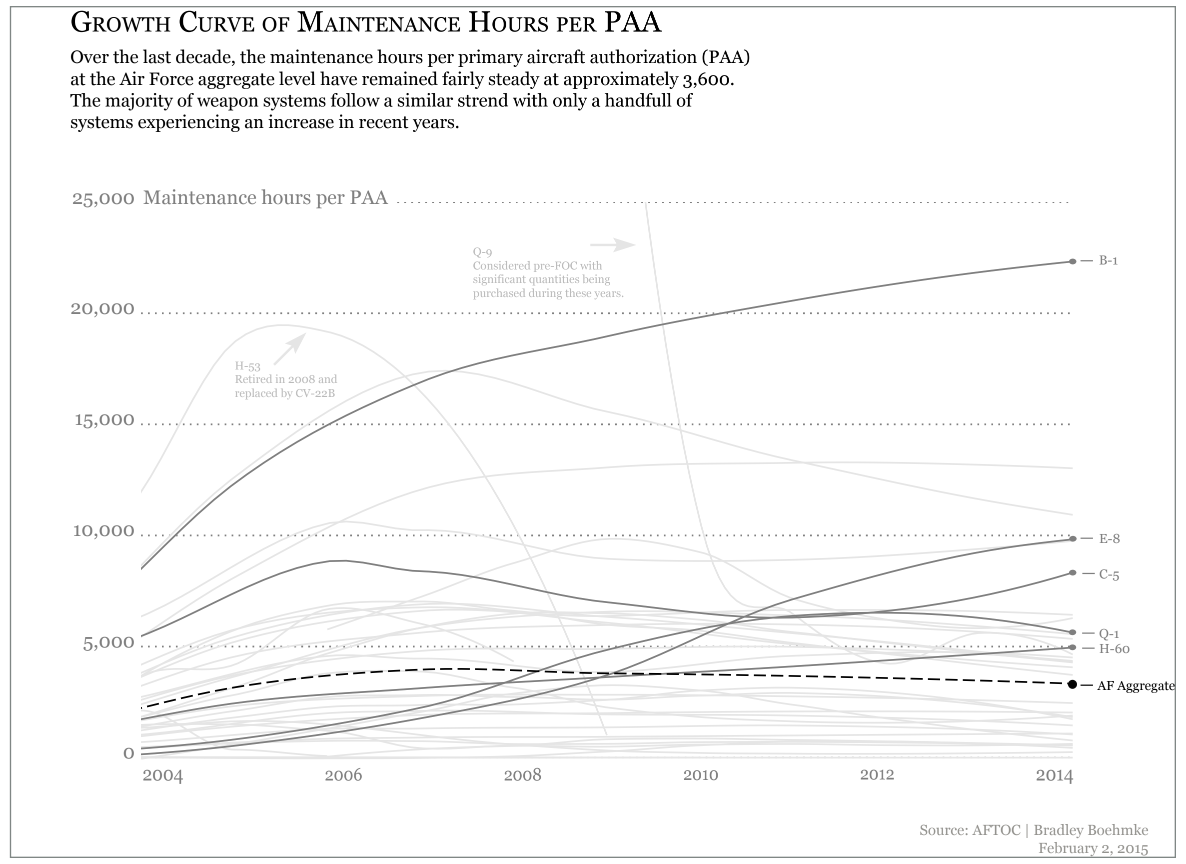


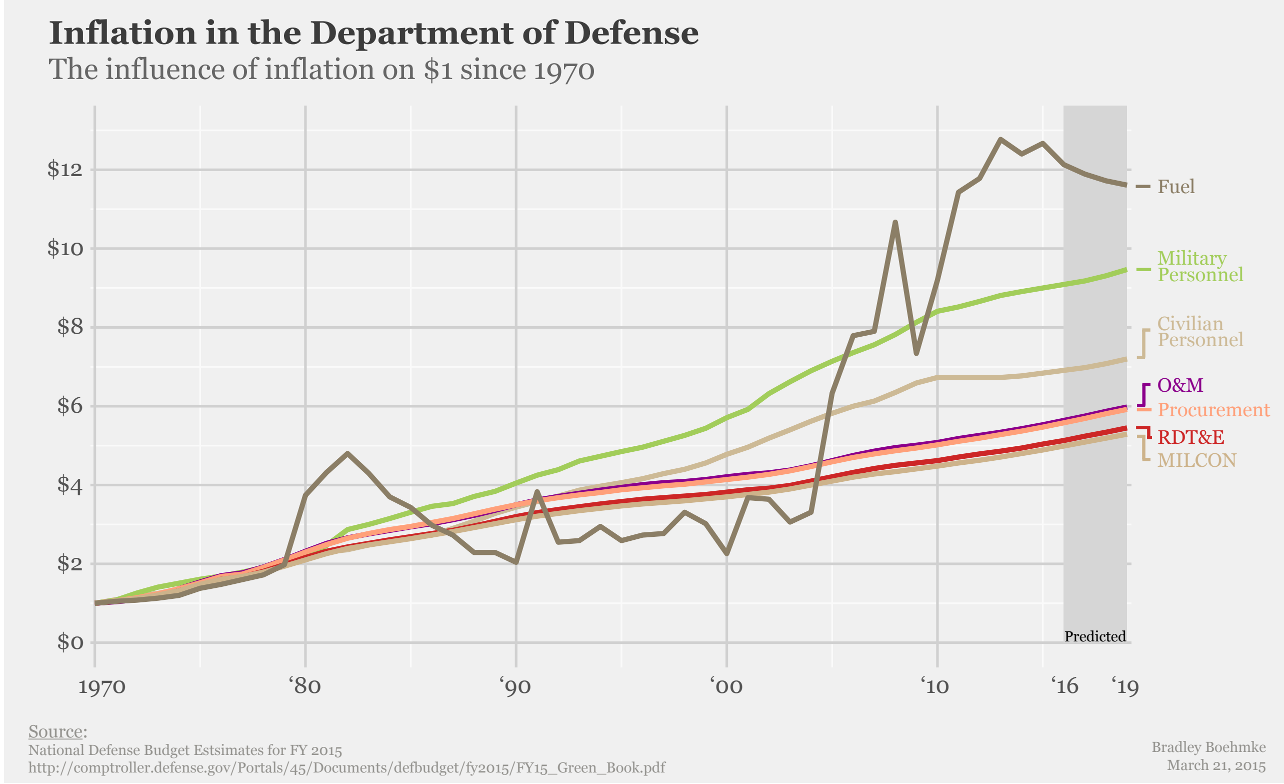










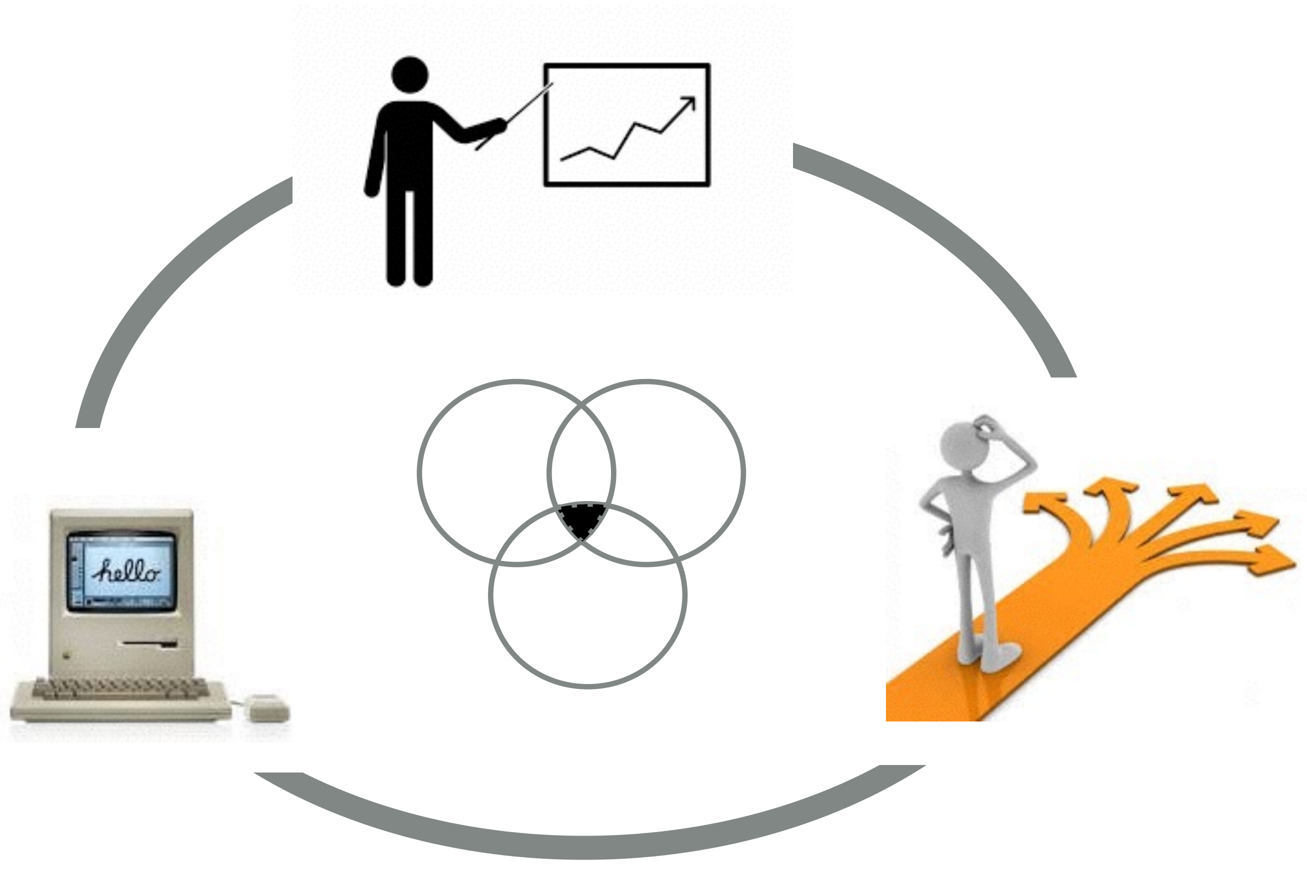


CONCLUDING REMARKS

Go forth and conquer

THEIR RELATION TO YOU

data scientist



you

CONCLUDING REMARKS

QUESTIONS?

BRADLEY C. BOEHMKE

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