To Explain
To Predict
or
To Describe?

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ISBIS: International Society for Business and Industrial Statistics

An Association of the International Statistical Institute

Definitions: Explain

Explanatory modeling

theory-based, statistical testing of causal hypotheses

Explanatory power

strength of relationship in statistical model

Definitions: Predict

Predictive modeling

empirical method for predicting new observations

Predictive power

ability to accurately predict new observations

Definitions: Describe

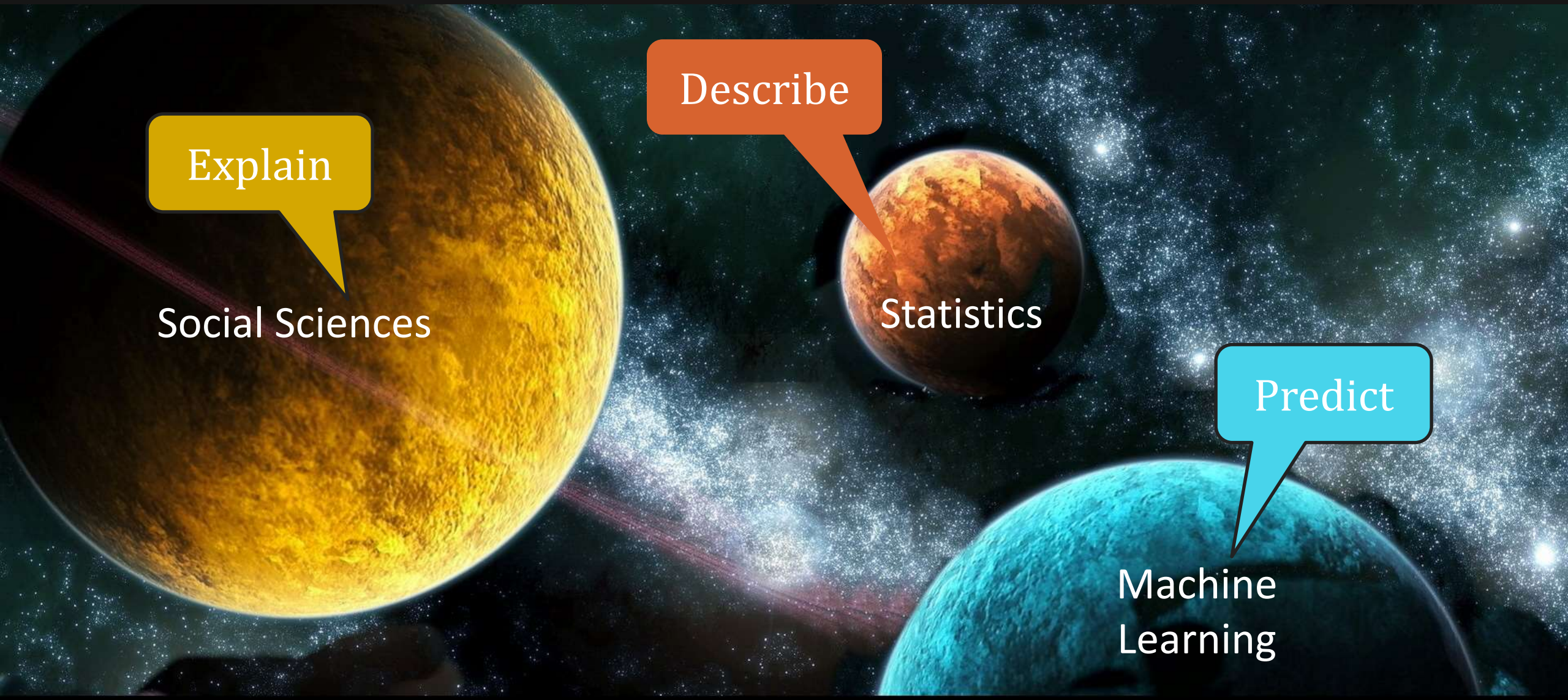
Descriptive modeling

statistical model for approximating a distribution or relationship

Descriptive power

goodness of fit, generalizable to population

Monopolies in Different Fields



Misconception #1:
The same model is best for explaining, describing, predicting

Social Sci & Mgmt: Build explanatory model and use it to "predict"

"A good explanatory model will also predict well"

"You must understand the underlying causes in order to predict"

JOURNAL ARTICLE

Understanding and Predicting Electronic Commerce Adoption: An Extension of the Theory of Planned Behavior

Paul A. Pavlou and Mendel Fygenson
MIS Quarterly
Vol. 30, No. 1 (Mar., 2006), pp. 115-143

"To examine the **predictive** power of the proposed model, we compare it to four models in terms of **R^2 adjusted**"

HEALTH PSYCHOLOGY REVIEW
Taylor & Francis

Health Psychol Rev. 2016 Apr 2; 10(2): 148–167. PMCID
Published online 2014 Sep 17. doi: 10.1080/17437199.2014.947547

How well does the theory of planned behaviour predict alcohol consumption? A systematic review and meta-analysis

Richard Cooke, [a,*] Mary Dahdah, [a] Paul Norman, [b] and David P. French [c]

Journal of Applied Social Psychology
Explore this journal >

Predicting and Explaining Intentions and Behavior: How Well Are We Doing?

Stephen Sutton

First published: August 1998 Full publication history

DOI: 10.1111/j.1559-1816.1998.tb01679.x View/save citation

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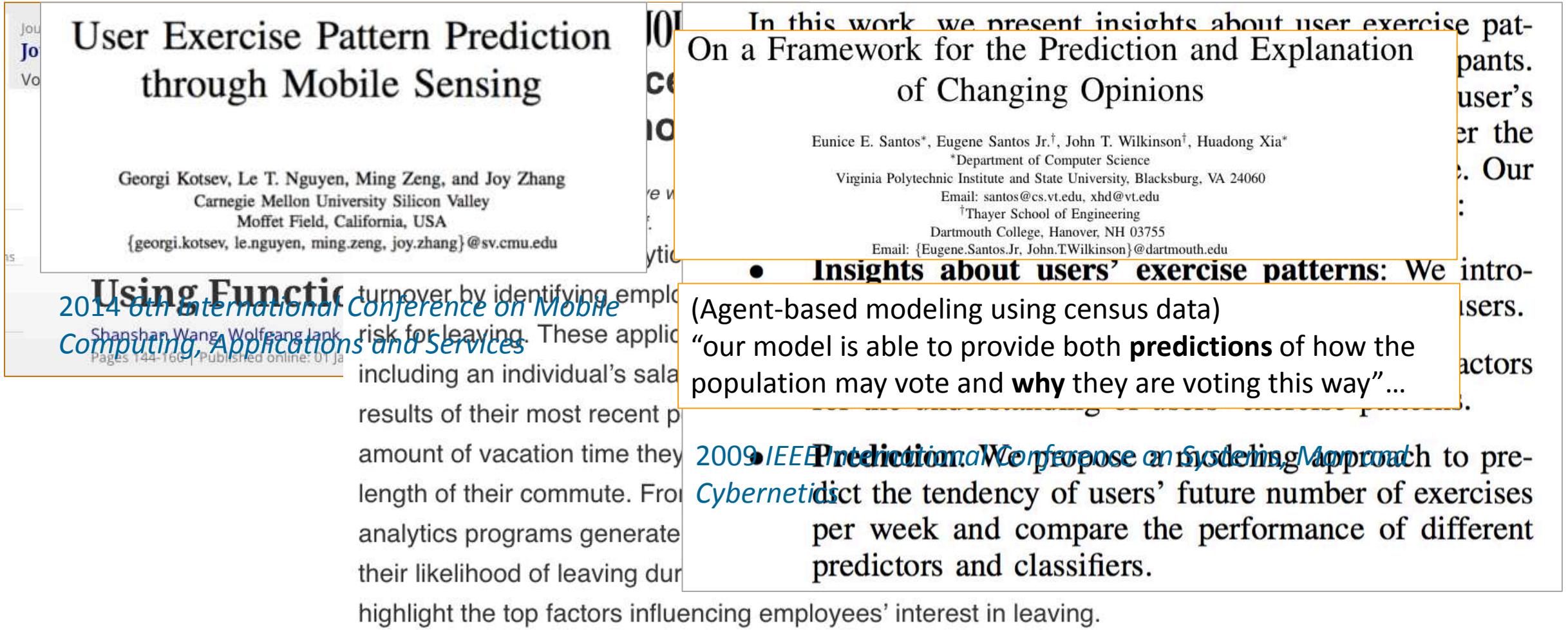
View issue TOC
Volume 28, Issue 15
August 1998
Pages 1317–1338

Misconception #1:
The same model is best for explaining, describing, predicting

CS/eng/stat: Build a predictive model and use it to ”explain”



User Exercise Pattern Prediction through Mobile Sensing

Georgi Kotsev, Le T. Nguyen, Ming Zeng, and Joy Zhang
Carnegie Mellon University Silicon Valley
Moffet Field, California, USA
{georgi.kotsev, le.nguyen, ming.zeng, joy.zhang}@sv.cmu.edu

2014 *6th International Conference on Mobile Computing, Applications and Services*

On a Framework for the Prediction and Explanation of Changing Opinions

Eunice E. Santos*, Eugene Santos Jr.†, John T. Wilkinson†, Huadong Xia*
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(Agent-based modeling using census data)
“our model is able to provide both **predictions** of how the population may vote and **why** they are voting this way”…

2009 *IEEE International Conference on Systems, Man and Cybernetics*

Misconception #2:

explain > predict or predict > explain

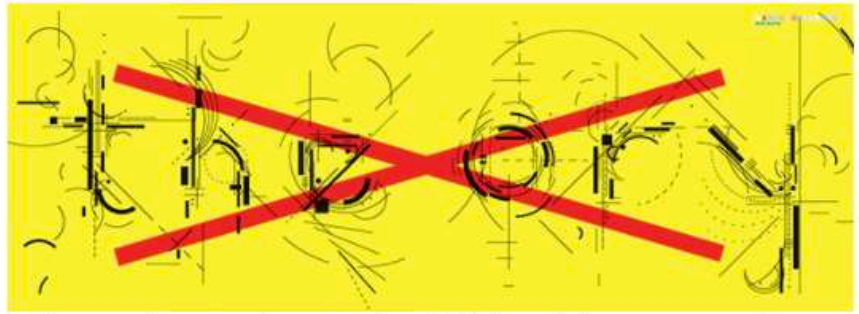
Emanuel Parzen, Comment on "Statistical Modeling: The Two Cultures" *Statistical Science* 2001

The two goals in analyzing data which Leo calls prediction and information I prefer to describe as "management" and "science." Management seeks *profit*, practical answers (predictions) useful for decision making in the short run. Science seeks *truth*, fundamental knowledge about nature which provides understanding and control in the long run.

CHRIS ANDERSON SCIENCE 06.23.08 12:00 PM

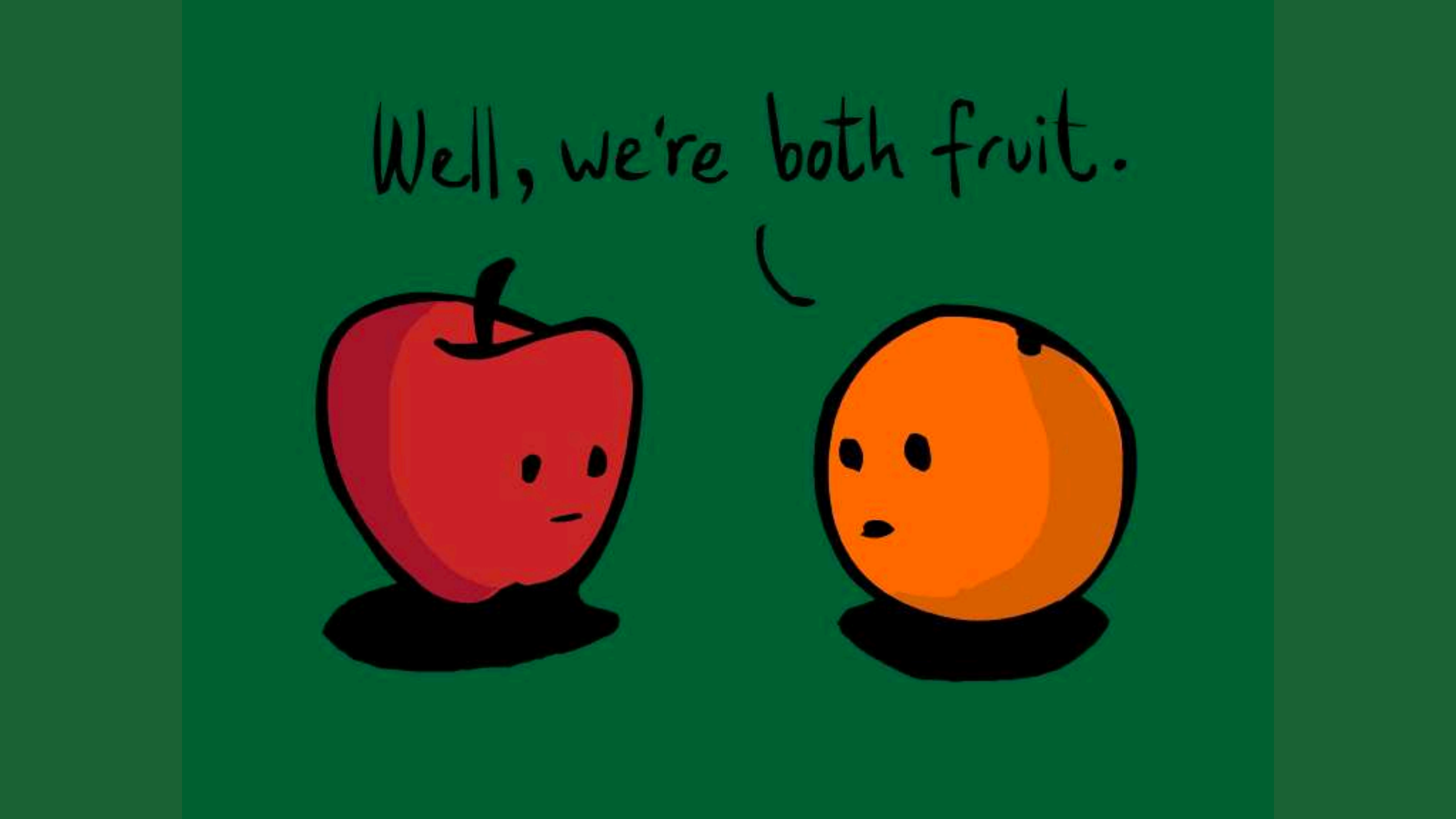
THE END OF THEORY: THE DATA DELUGE MAKES THE SCIENTIFIC METHOD OBSOLETE

*Chris Anderson is the editor in chief of Wired



* Illustration: Marian Bantjes * **"All models are wrong**, but some are useful."

"Correlation supersedes causation, and science can advance even without coherent models, unified theories, or really any mechanistic explanation at all"


Well, we're both fruit.

Why statistical

explanatory modeling

predictive modeling

descriptive modeling

are different

Different Scientific Goals

Different ***generalization***

Explanatory Model:

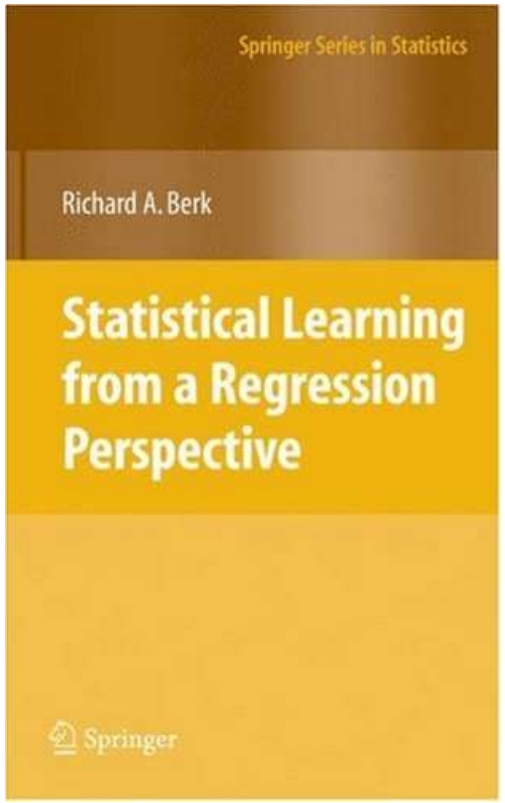
test/quantify causal effect between *constructs* for "average" unit in population

Descriptive Model:

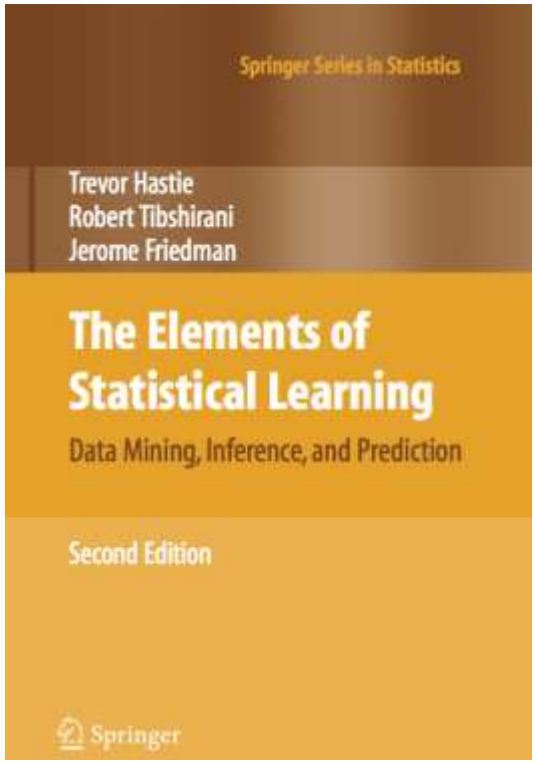
test/quantify distribution or correlation structure for *measured* "average" unit in population

Predictive Model:

predict *values* for new/future individual units



"The goal of finding models that are predictively accurate differs from the goal of finding models that are true."



$$
\begin{aligned}
\mathrm{Err}(x_0) &= E[(Y - \hat{f}(x_0))^2 | X = x_0] \\
&= \sigma_\varepsilon^2 + [\mathrm{E}\hat{f}(x_0) - f(x_0)]^2 + E[\hat{f}(x_0) - \mathrm{E}\hat{f}(x_0)]^2 \\
&= \sigma_\varepsilon^2 + \mathrm{Bias}^2(\hat{f}(x_0)) + \mathrm{Var}(\hat{f}(x_0)) \\
&= \text{Irreducible Error} + \mathrm{Bias}^2 + \text{Variance}.
\end{aligned}
$$

But there's **more** than bias-variance

Example: Regression Model for Explanation

Underlying model: X → Y

Measures of X, Y constructs

Danger: endogeneity

$$y_i | x_i = \beta_0 + \beta_1 x_i + \beta_2 x_{controls} + \varepsilon_i$$

parameter of interest (inference)

Chosen to avoid Omitted Var Bias and backdoor/spurious paths

Example: Regression Model for Description

All variables treated/interpreted as observable

Remain in model only if statistically significant

$$y_i | x_i = \beta_0 + \beta_1 x_{1i} + \ldots + \beta_p x_{pi} + \varepsilon_i$$

parameters of interest (inference)

Chosen b/c related to Y
Danger: multicollinearity

Residual analysis for GoF & test assumptions

Example: Regression Model for Prediction

All variables treated as observable,
available at time of prediction

Retain only if improve out-of-sample prediction

$$y_i | x_i = \beta_0 + \beta_1 x_{1i} + \ldots + \beta_p x_{pi} + \varepsilon_i$$

Quantity of interest for new i's (prediction)

Chosen b/c possibly correlated with Y
Danger: over-fitting

Evaluate overfitting (train vs holdout)

Point #1

best explanatory model

best predictive model

best descriptive model

Predict ≠ Explain

"we tried to benefit from an extensive set of attributes describing each of the movies in the dataset. Those attributes certainly carry a significant signal and can ***explain some of the user behavior****. However… they could not help* ***at all*** *for improving the [predictive] accuracy."*

Bell et al., 2008

Predict ≠ Describe

Election Polls

"There is a subtle, but important, difference between reflecting current public sentiment and predicting the results of an election. Surveys have focused largely on the former… [as opposed to] survey based prediction models [that are] focused entirely on analysis and projection"

Kenett, Pfefferman & Steinberg (2017) "Election Polls – A Survey, A Critique, and Proposals", *Annual Rev of Stat & its Applications*

Goal Definition

Design & Collection

Data Preparation

EDA

Variables? Methods?

Evaluation, Validation & Model Selection

Model Use & Reporting

Which variables?

causal role vs. associations

endogeneity

ex-post availability

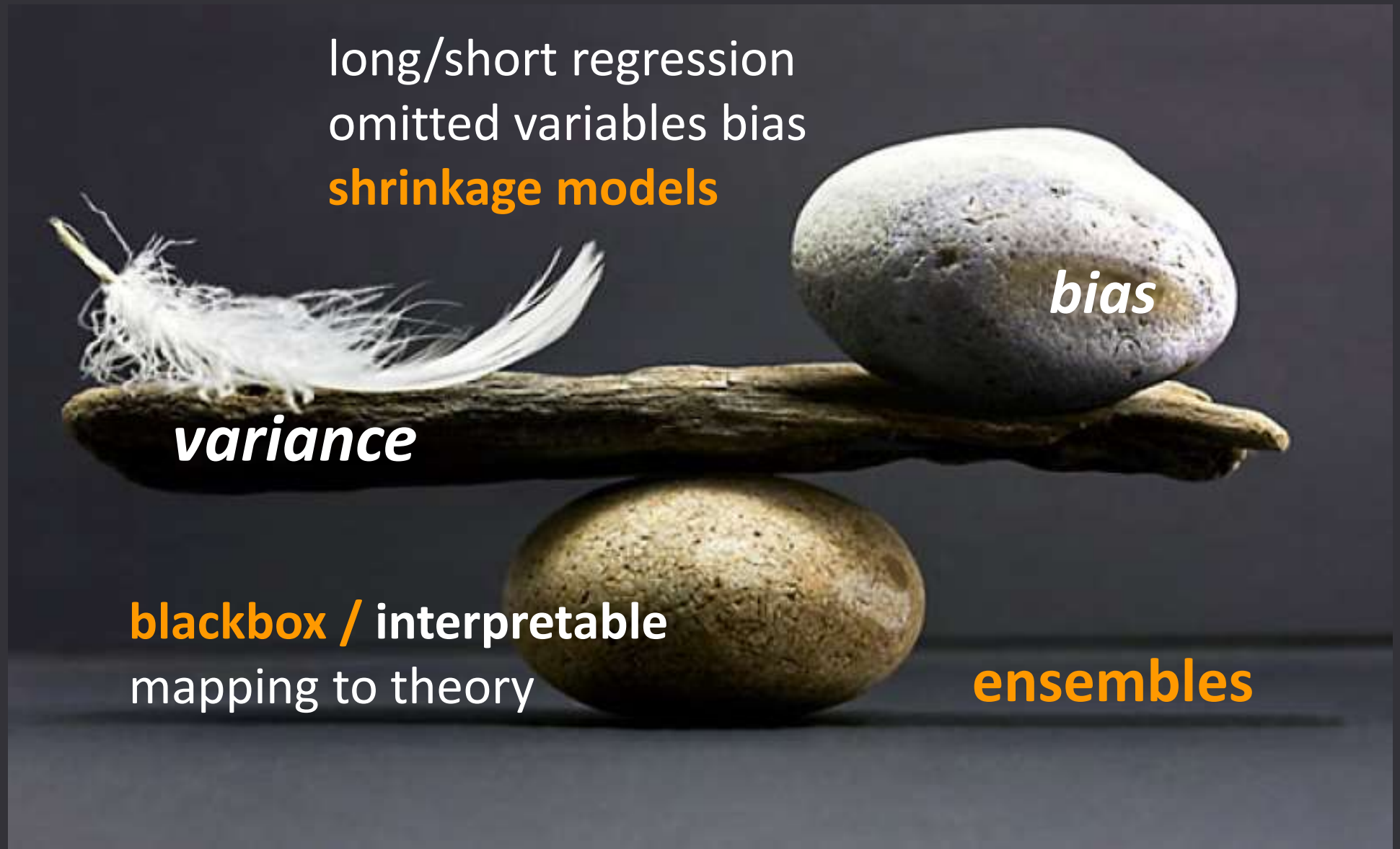
leading, coincident, lagging indicators

multicollinearity

identifiability

A, B, A*B

Methods / Models



Point #2

explanatory power

predictive power

descriptive power

Cannot infer one from the others

interpretation

out-of-sample

p-values
overall, specific

prediction accuracy

Performance Metrics

R^2

costs

goodness-of-fit

training vs holdout

type I,II errors

over-fitting