Towards a Quality Framework for Blends of Designed and Organic Data

Robert M. Groves

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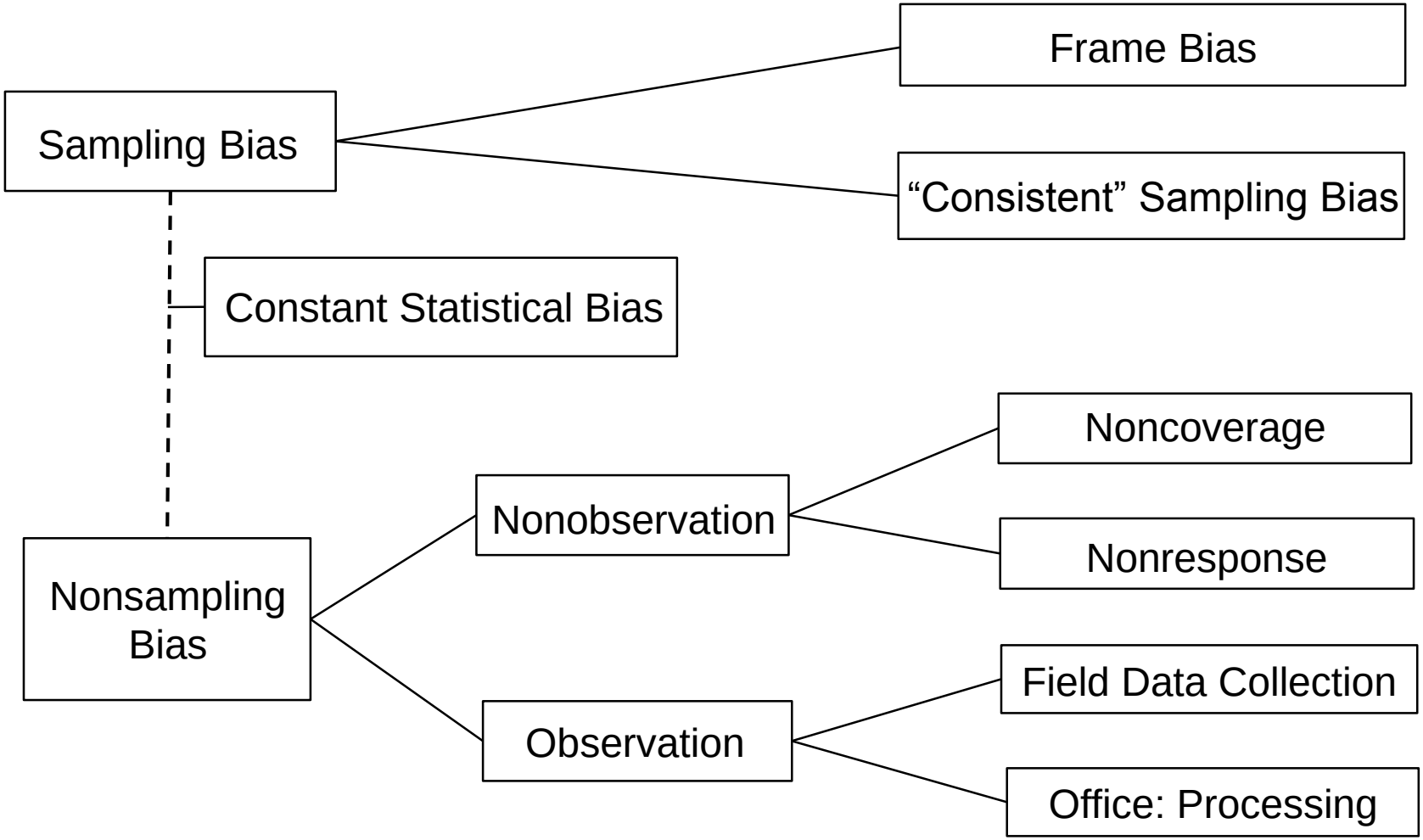
Outline

1. Evolution of concepts of statistical quality
2. Alternative taxonomies of quality
3. The rise of organic data, the demise of designed data
4. Blending organic and designed data
5. The need for a new quality framework for organic data
6. Blending models

Sampling and Nonsampling Bias



Adapted from Deming (1943) and Kish (1965)

Total Survey Error

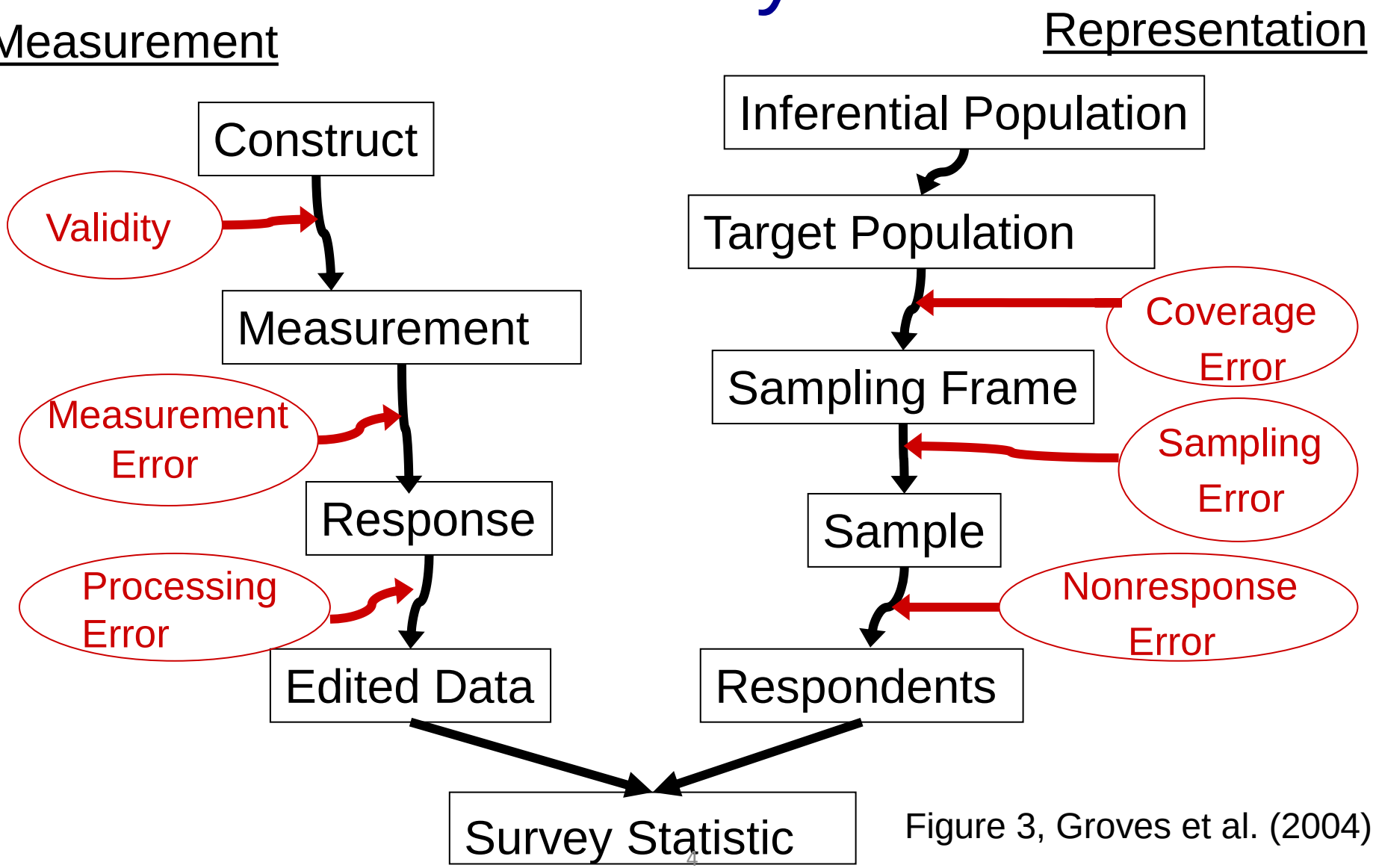


Figure 3, Groves et al. (2004)

Fitness for Use

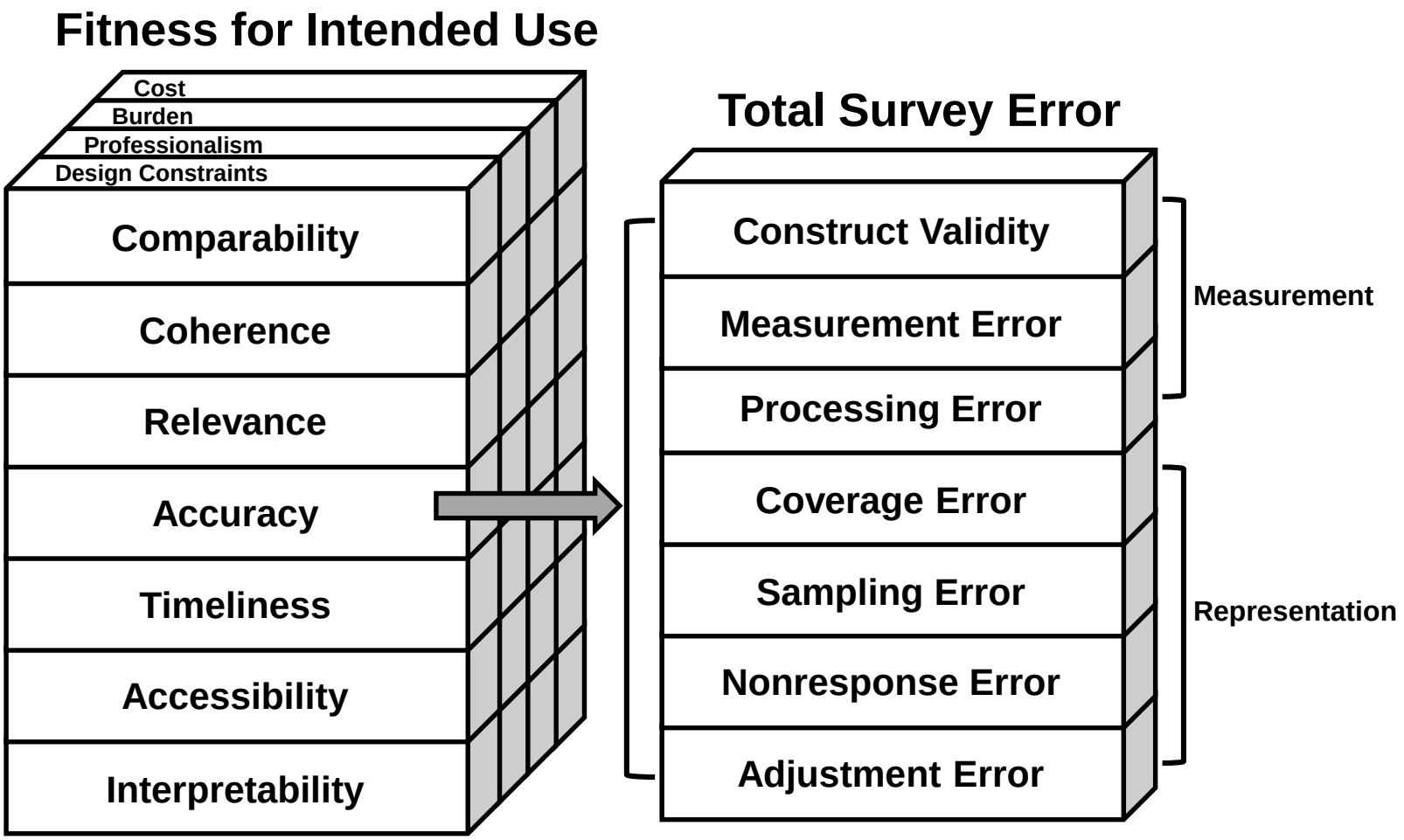


Figure 2, Hansen et al. (2010)

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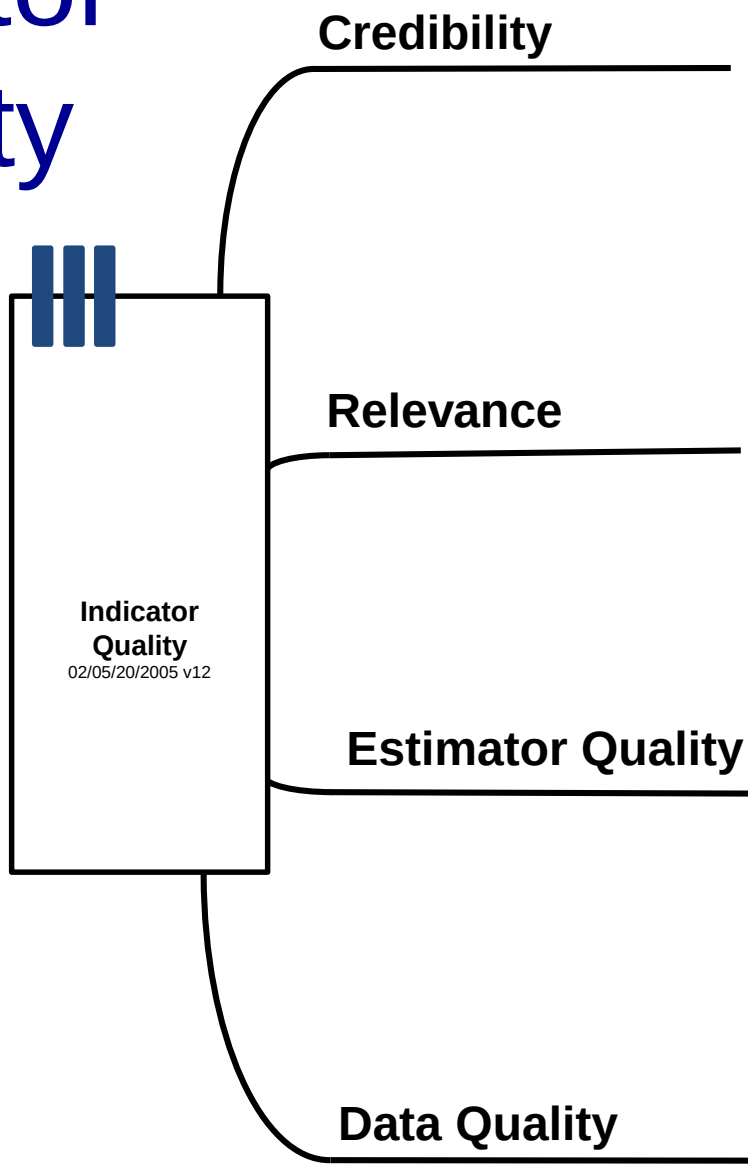
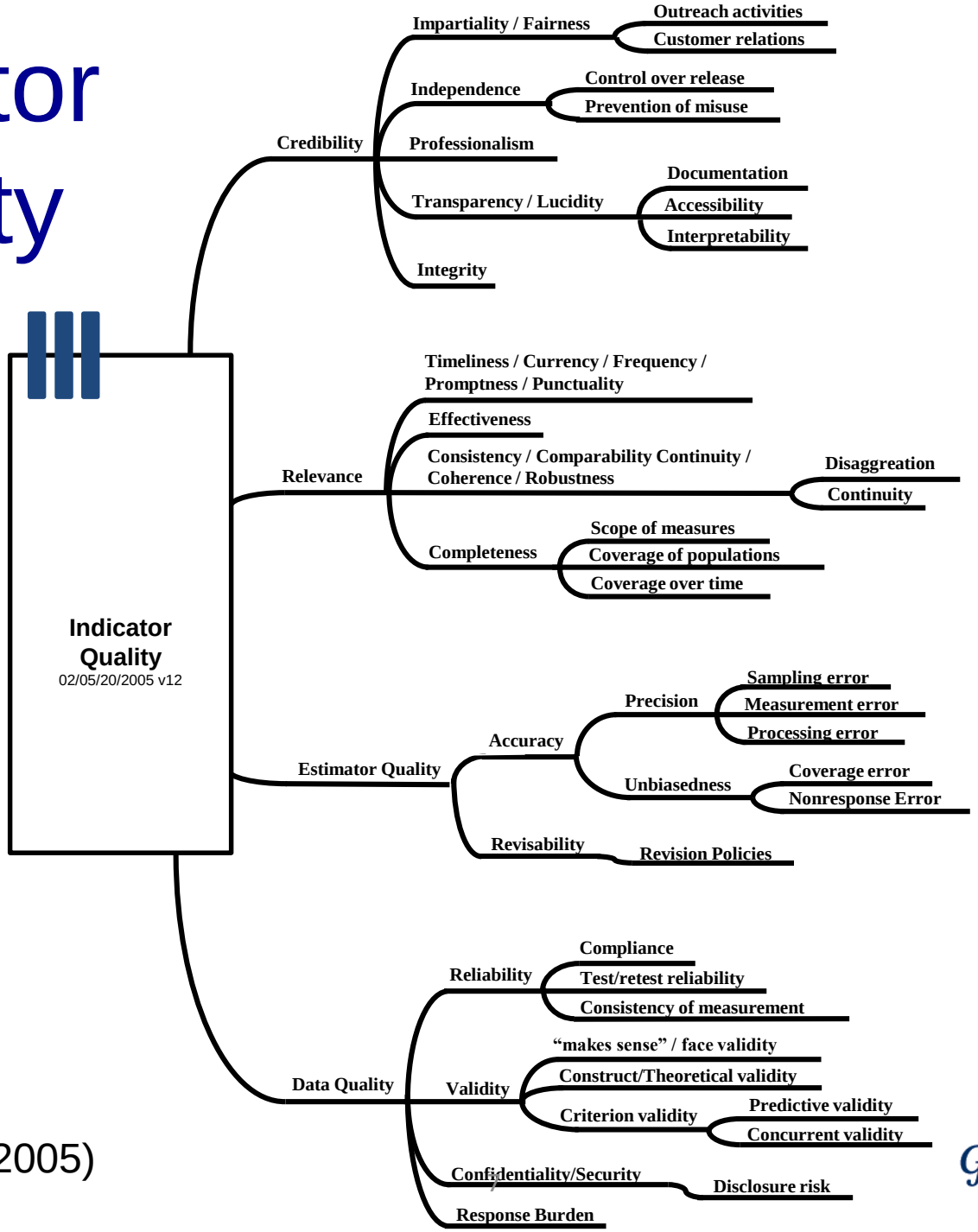
Indicator Quality



Groves (2005)

Indicator Quality



Groves (2005)

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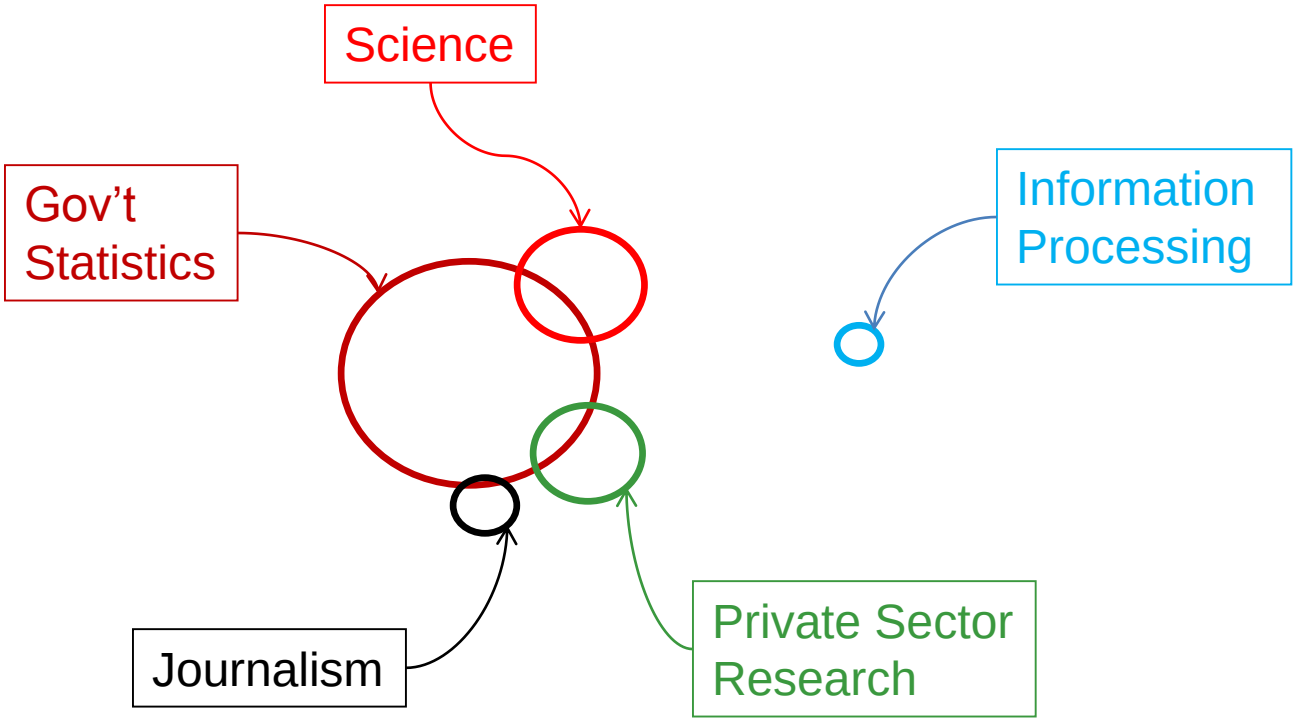
Summary of Quality Frameworks

- They offer a language
- They offer a conceptual framework, relating components to one another
- They permit focused design of data evaluation
- But, they have not in general yielded measureable error components

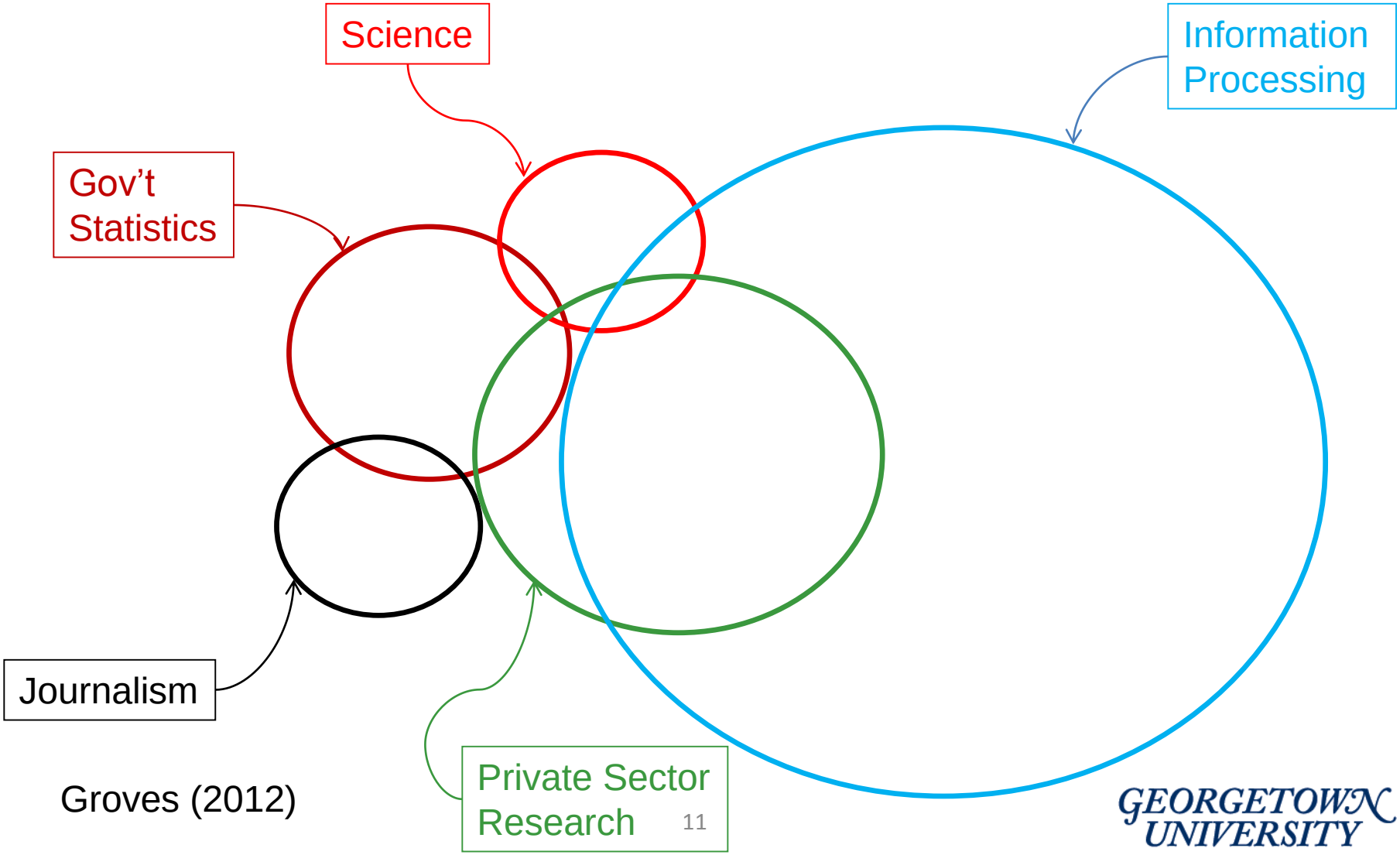
THE RISE OF ORGANIC DATA

Relative Sizes of Digital Data Production, c.1960



Groves (2012)

Relative Sizes of Digital Data Production, c.2010



Groves (2012)

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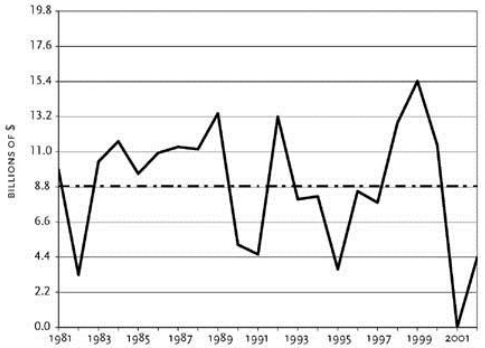
Types of Organic Data

- Transaction data (scanner, credit card, utility usage, health service, tweets)
- Social network communication data (Twitter, instagram)
- Data from software agents in mobile devices (GPS-associated data)
- Data from the internet of things (weather sensors)
- Biometric data
- Communication data (blogs, texts, emails)
- Internet search data
- CCTV digital data
- Data scraped from websites

Credit Card and Nielsen Scanner Data

12/5/2016	8:13 AM	Giant	$2.07
12/5/2016	8:46 AM	Giant	$4.35
12/5/2016	9:16 AM	Safeway	$2.31
12/5/2016	9:31 AM	Giant	$4.92
12/5/2016	11:15 AM	Costco	$1.31
12/5/2016	12:47 PM	Costco	$3.11
12/5/2016	12:58 PM	Safeway	$3.01
12/5/2016	1:38 PM	Costco	$2.17
12/5/2016	2:24 PM	Safeway	$1.32
12/5/2016	2:51 PM	Costco	$3.05
12/5/2016	4:05 PM	Giant	$4.78
12/6/2016	9:38 AM	Safeway	$3.03
12/6/2016	10:35 AM	Giant	$1.57
12/6/2016	1:15 PM	Giant	$2.70
12/6/2016	2:42 PM	Safeway	$1.57
12/7/2016	11:11 AM	Costco	$2.80
12/7/2016	1:45 PM	Safeway	$4.41
12/7/2016	3:41 PM	Safeway	$2.76



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Organic Data from Mobile Devices

12/5/2016	8:13 AM	Airtel	23292 miles	24576 miles	22045 miles	8°30'26"N 13°15'01"W
12/5/2016	8:19 AM	Airtel	23291 miles	24573 miles	22045 miles	8°29'71"N 13°14'31"W
12/5/2016	8:26 AM	Airtel	23290 miles	24574 miles	22046 miles	8°29'97"N 13°15'37"W
12/5/2016	8:37 AM	Airtel	23289 miles	24575 miles	22045 miles	8°28'79"N 13°15'57"W
12/5/2016	8:41 AM	Airtel	23296 miles	24570 miles	22047 miles	8°30'25"N 13°15'48"W
12/5/2016	8:46 AM	Airtel	23294 miles	24579 miles	22043 miles	8°28'38"N 13°14'46"W
12/5/2016	8:55 AM	Airtel	23292 miles	24581 miles	22045 miles	8°28'88"N 13°14'98"W
12/5/2016	9:03 AM	Airtel	23289 miles	24569 miles	22043 miles	8°29'26"N 13°14'75"W
12/5/2016	9:12 AM	Airtel	23297 miles	24575 miles	22045 miles	8°29'53"N 13°14'75"W
12/5/2016	9:18 AM	Airtel	23288 miles	24579 miles	22043 miles	8°29'57"N 13°14'84"W
12/5/2016	9:31 AM	Airtel	23291 miles	24569 miles	22046 miles	8°30'09"N 13°14'91"W
12/5/2016	9:36 AM	Airtel	23298 miles	24573 miles	22044 miles	8°28'48"N 13°14'37"W
12/5/2016	9:40 AM	Airtel	23297 miles	24576 miles	22045 miles	8°28'18"N 13°14'88"W
12/5/2016	9:47 AM	Airtel	23297 miles	24574 miles	22042 miles	8°29'99"N 13°15'13"W
12/5/2016	9:59 AM	Airtel	23290 miles	24571 miles	22046 miles	8°29'52"N 13°14'38"W
12/5/2016	10:02 AM	Airtel	23288 miles	24570 miles	22047 miles	8°29'25"N 13°14'50"W
12/5/2016	10:09 AM	Airtel	23294 miles	24571 miles	22043 miles	8°29'88"N 13°15'68"W
12/5/2016	10:16 AM	Airtel	23293 miles	24576 miles	22042 miles	8°28'49"N 13°15'99"W

Bus Route Image from: Wakefield (2013)
http://www.bbc.com/news/technology-22357748

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Provost of Georgetown's main campus, professor in mathematics and statistics, and sociology. His blog can be found at blog.provost.georgetown.edu

Bio

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106K Tweets

#HowIStaySaneInMyWorkspace
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#NationalPopcornDay
Trending for 5 hours now

Ice Prince
12K Tweets

#TravelTuesday
Trending for 5 hours now

#GrantsNotDebt
Trending for 2 hours now

Edgar Allan Poe
10.1K Tweets

Pete Rose
Started trending in the last hour

Adapted from Daas, et al. (2015)

Robert M. Groves
@RobertMGroves

Provost of Georgetown's main campus, professor in mathematics and statistics, and sociology. His blog can be found at blog.provost.georgetown.edu

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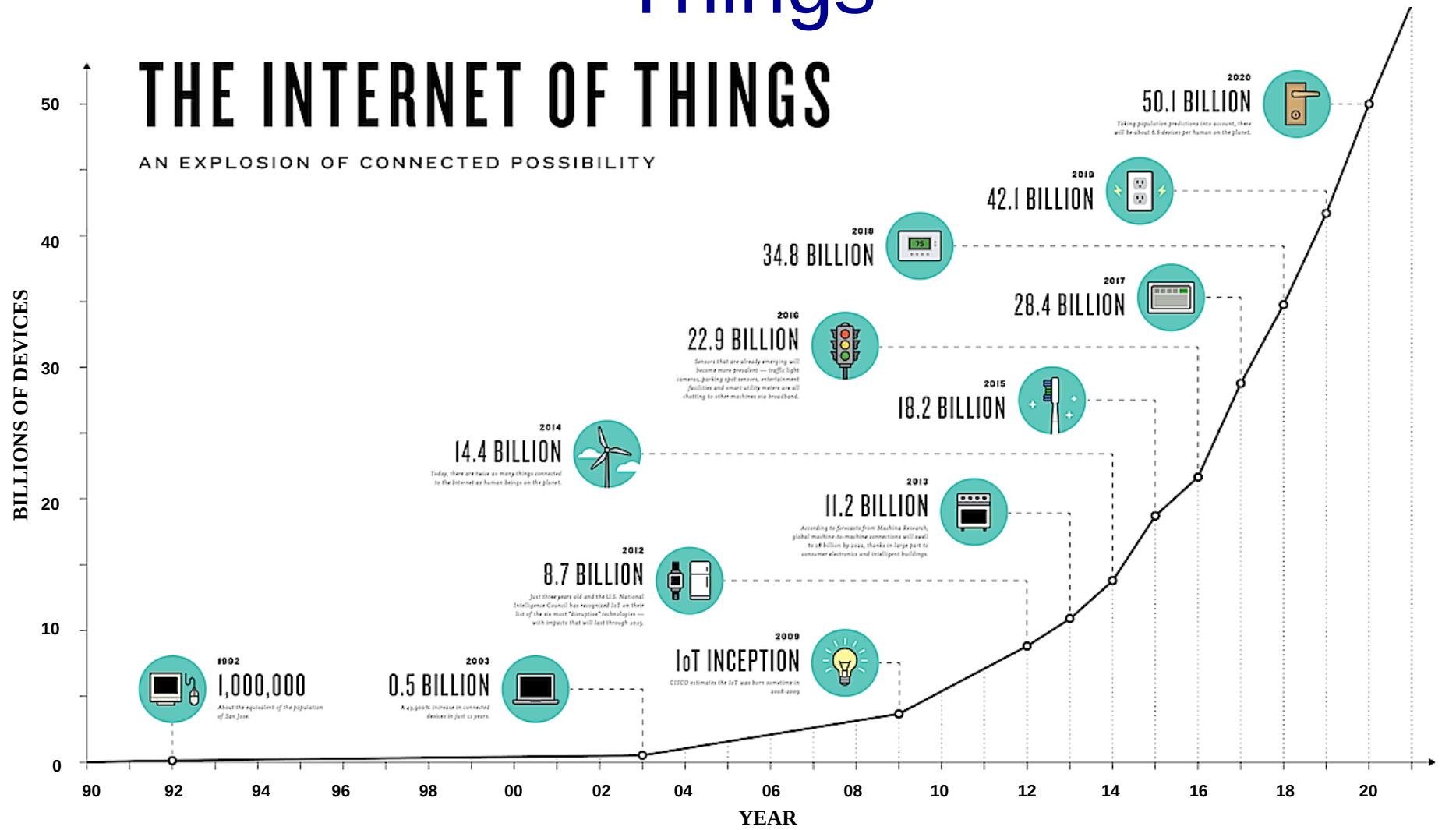
Exponential Growth of Internet of Things



De Clerck (2015) http://www.i-scoop.eu/internet-of-things/

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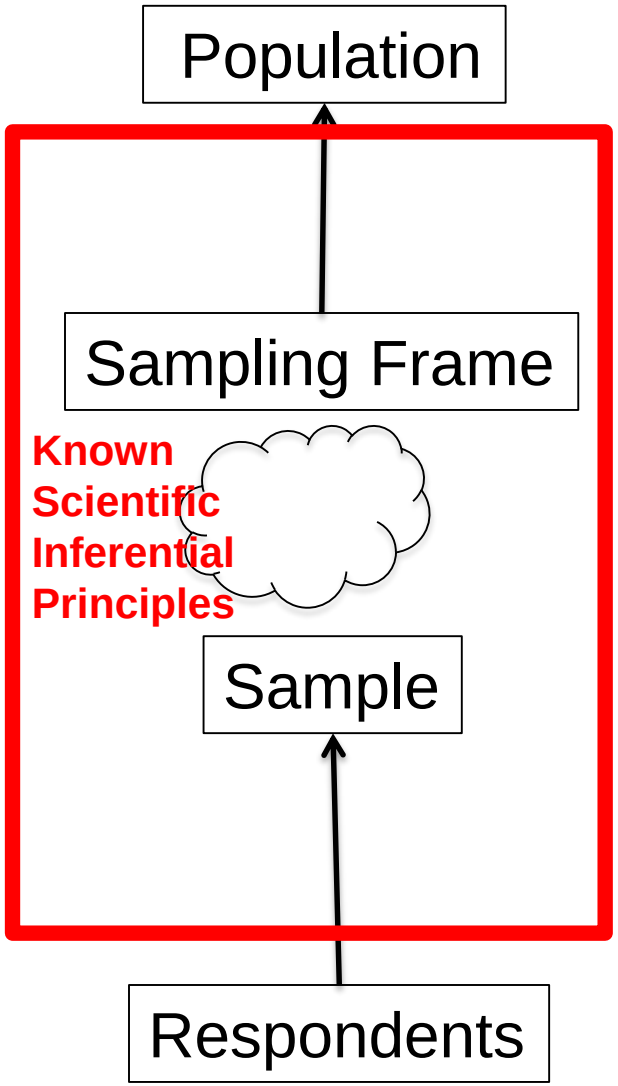
Organic data strengths

- They measure novel behaviors
- Frequency is near real-time
- High spatial granularity
- Ability to measure networks

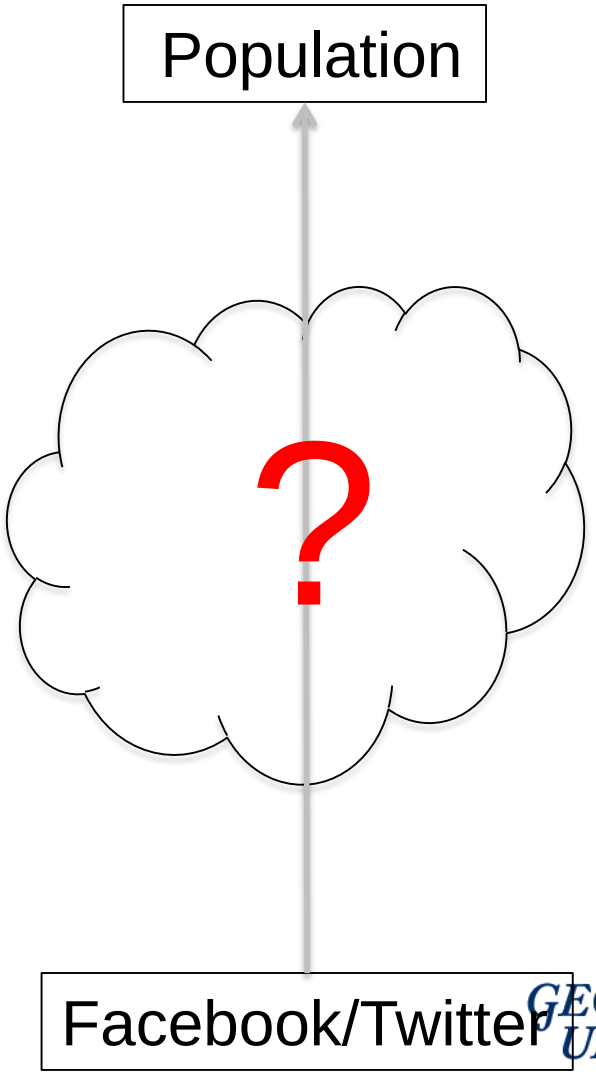
Organic data weaknesses

- Not all members of the population are covered
- Not multivariate; lean in variables
- Identifying who supplied the data is difficult
- The structure of the data is hostile to analysis
- Access and content are controlled by owners of the data

The Sample Survey Paradigm



The "Big Data" Paradigm



THE NEED FOR A QUALITY FRAMEWORK FOR ORGANIC DATA

Four Examples of Organic Data Problems Needing a Quality Framework

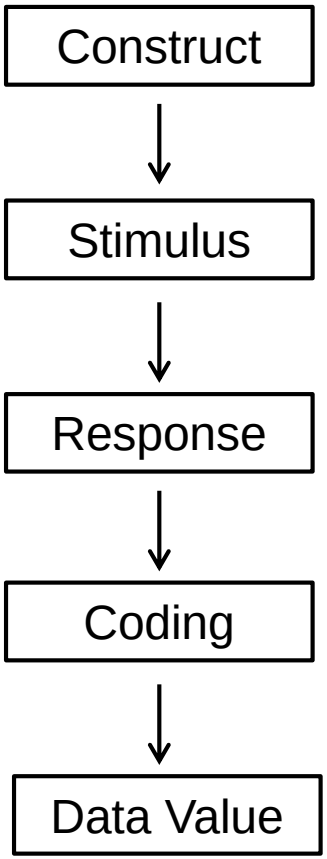
1. Organic data generated without a known external stimulus
2. Organic data stimulated by a single process that is not known by the statistician
3. Organic data that are products of models themselves
4. Organic data from text

The Absence of a Measurement Stimulus

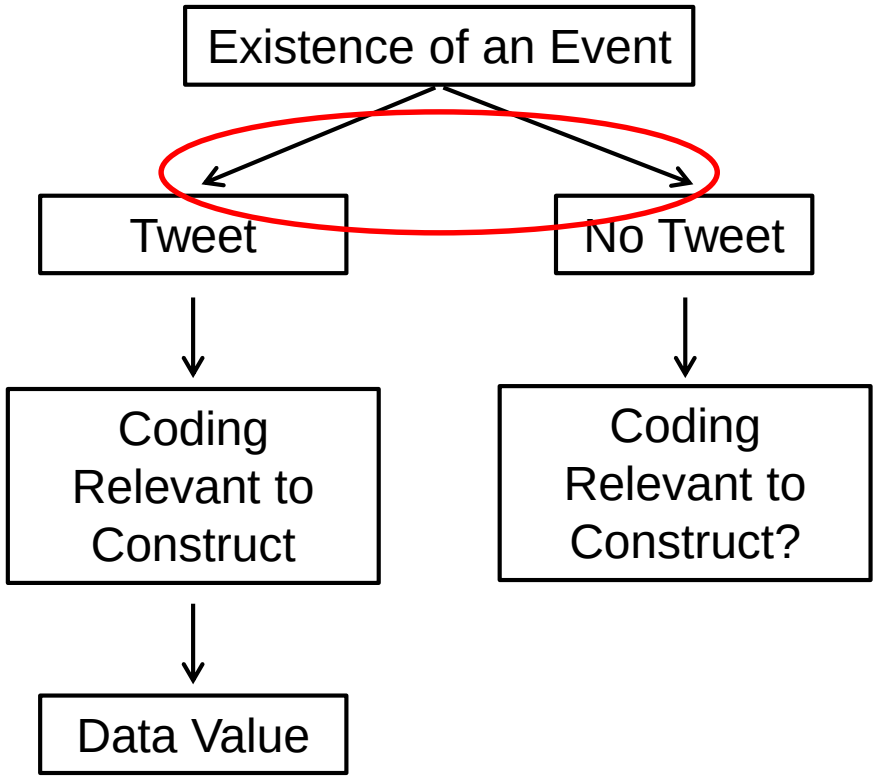
- Many sources of organic data do not arise in reaction to a uniform stimulus applied to all measurement units
- Examples:
  - Tweets
  - Blogs

The Absence of a Measurement Stimulus

Designed Data



Organic Data



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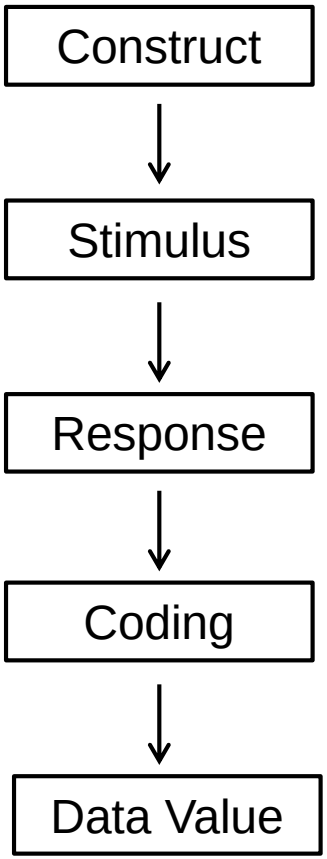
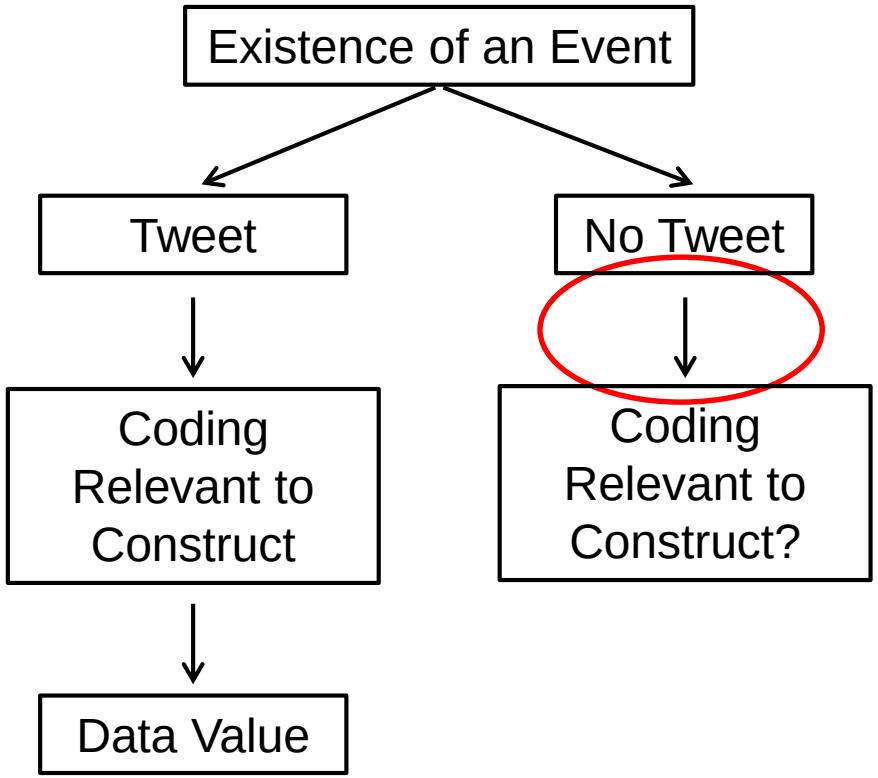
A Measurement Stimulus that is a Known Unknown

Designed Data



Organic Data



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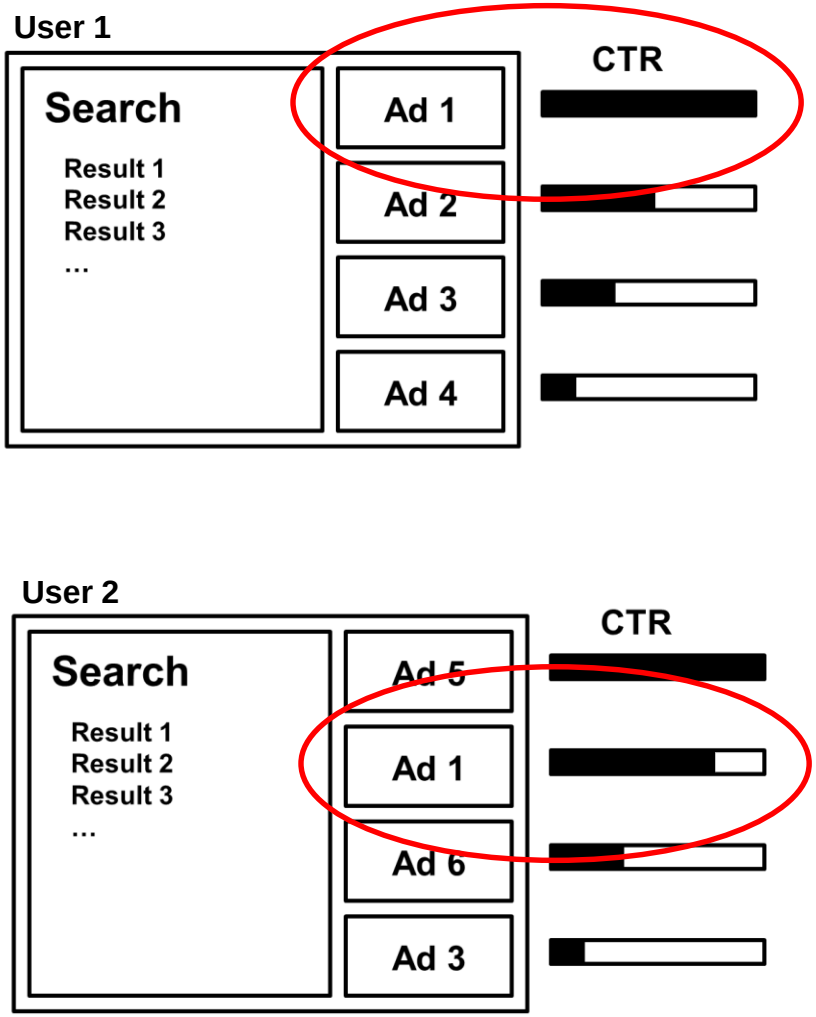
Organic Data With Intermediate Measurement Error Features

- Organic data created by multi-step processes affecting measurement error properties
- Example:
  - Click data on web-page advertisements that were displayed based on predictive models of user interest

Advertisement Location Affects Click Through Rate



Adapted from Figure 1, Richardson et al. (2007)

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Data Generated from Models using Unstructured Data

- Some organic data come from model-based coding
- Example:
  - Facial recognition
  - Traffic data from CCTV
  - GPS

Measurement Error Estimates Included with Data Items

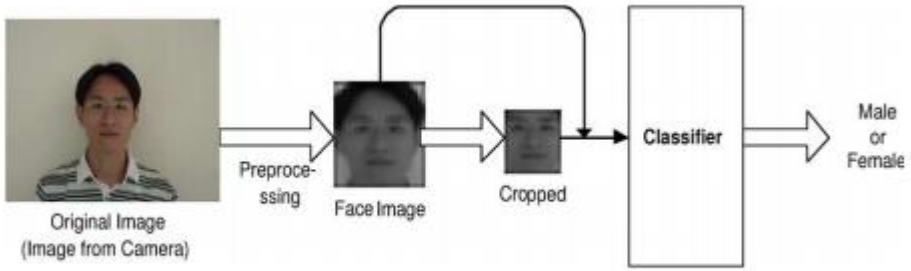

Fig. 1. The process of appearance-based gender classification.

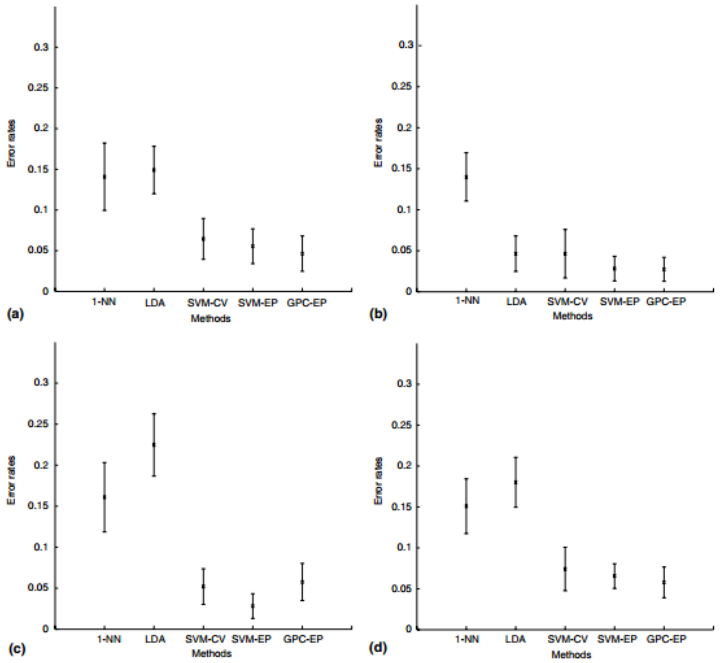

Fig. 5. Classification error rates of various methods for four kinds of gender classification data sets (PF'01 DB): (a) data set P-I, (b) data set P-II, (c) data set P-III, (d) data set P-IV.

Figure 1 and Figure 5
Kim et al. (2006)

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Text to Number Translation

- Organic data based on coding from text data
- Example:
  - Twitter text coding
  - Blog coding
  - LinkedIn coding

Coding in Sample Survey

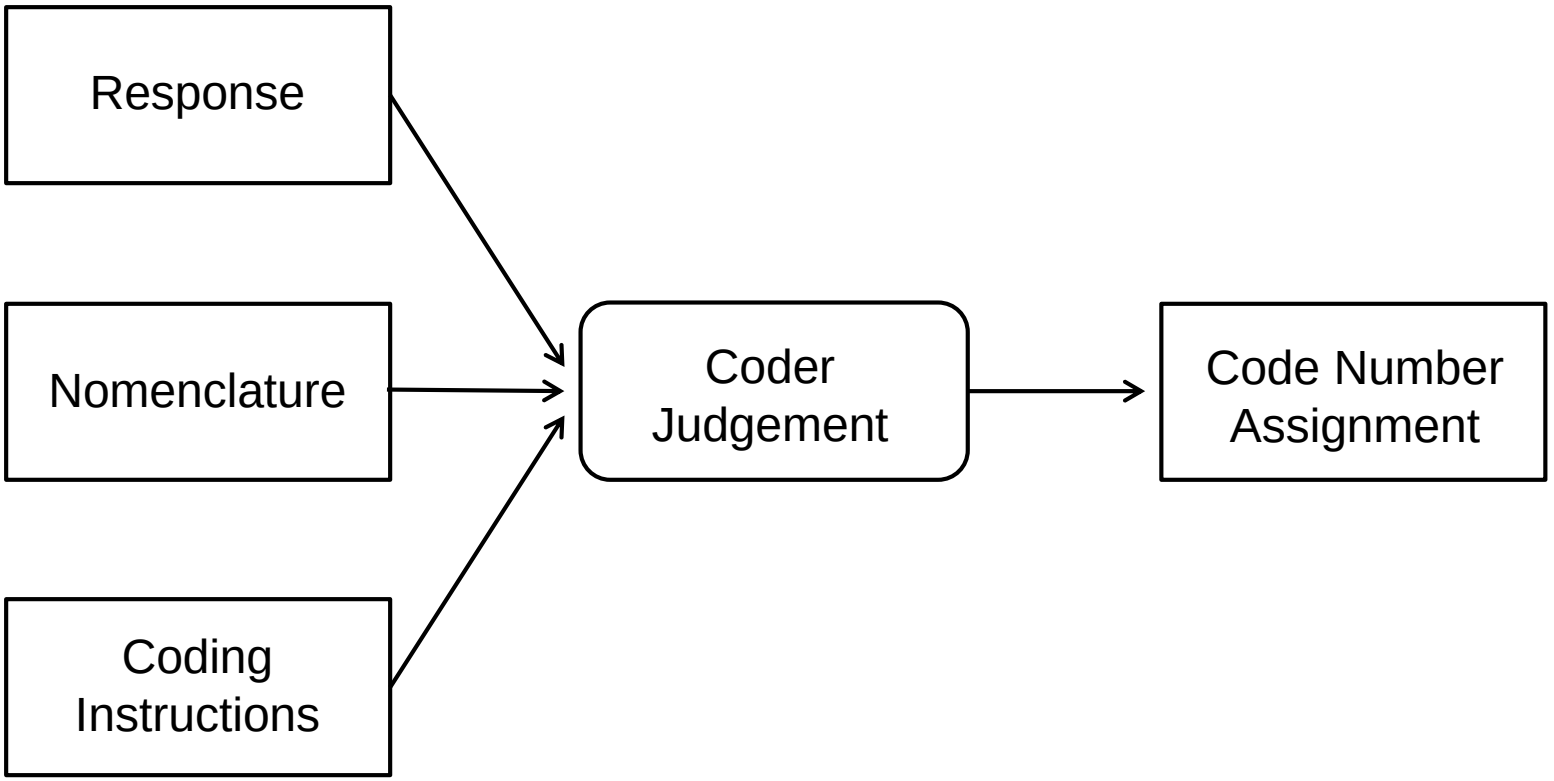

Figure 7.1, Biemer & Lyberg (2003)

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Sources of Coding Errors from Lexical Polysemy

I don't want to get back at him for it though.
We are so backed up at work I get overtime.
I wish my baby would get back to normal.
I have to get back to work one of these days.
My back hurts all the time.
I have a bad back.
The ceiling in the back of the house is falling in.
I called her back and said I was sorry.
I have to go back to the store and get food.
This morning the cars were so backed up for miles and I was late to work.
I never had these problems back in Alabama.

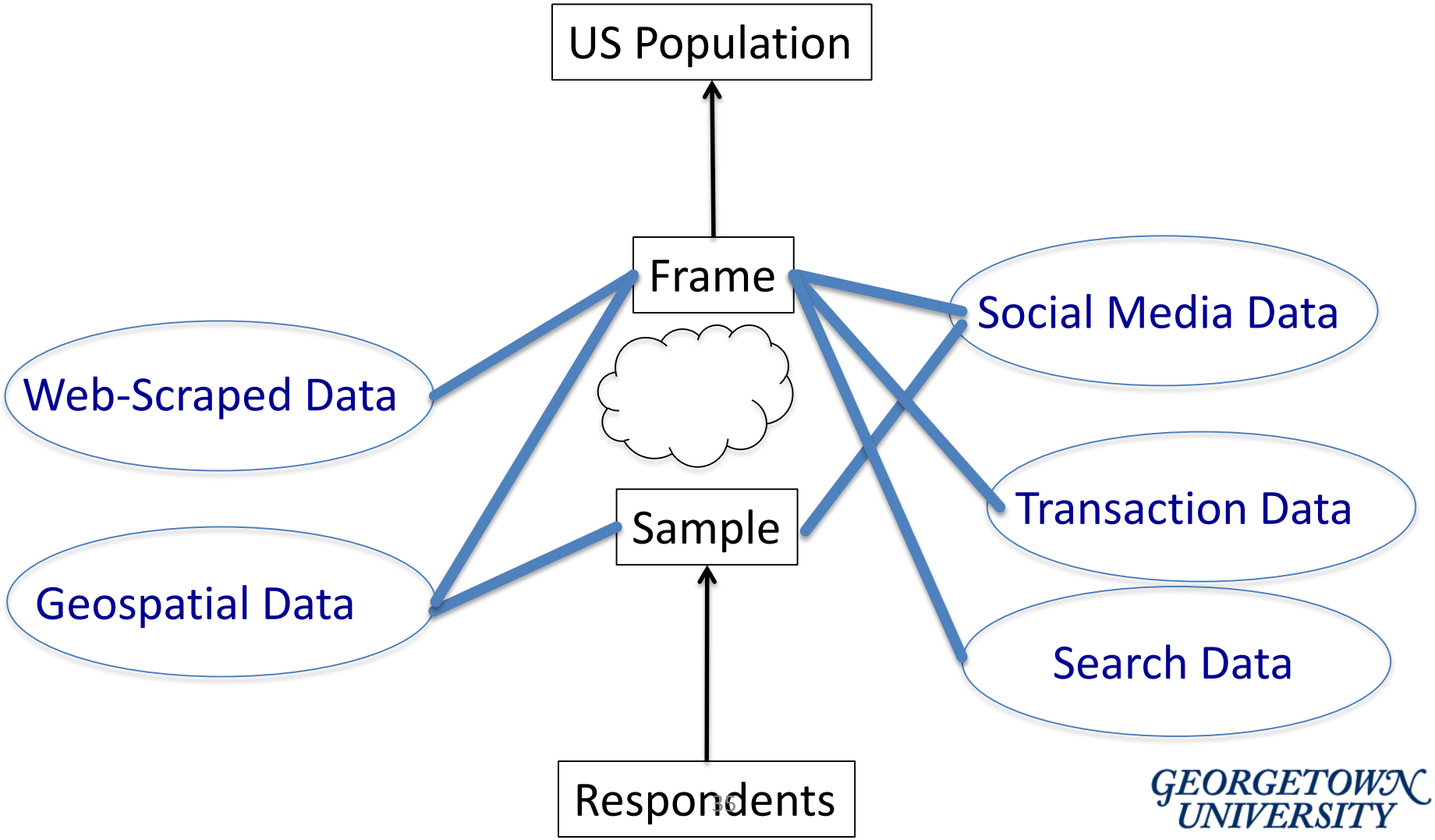
Adapted from Frisbie & Sudman (1968)

BLENDING ORGANIC AND DESIGNED DATA

Blending organic and survey data combines the temporal and spatial granularity of organic data with the inferential power of survey data

- Statistical models are key
- Shared covariates across data sets are desirable
- Focusing on coverage and measurement errors is critical

The Blended Paradigm



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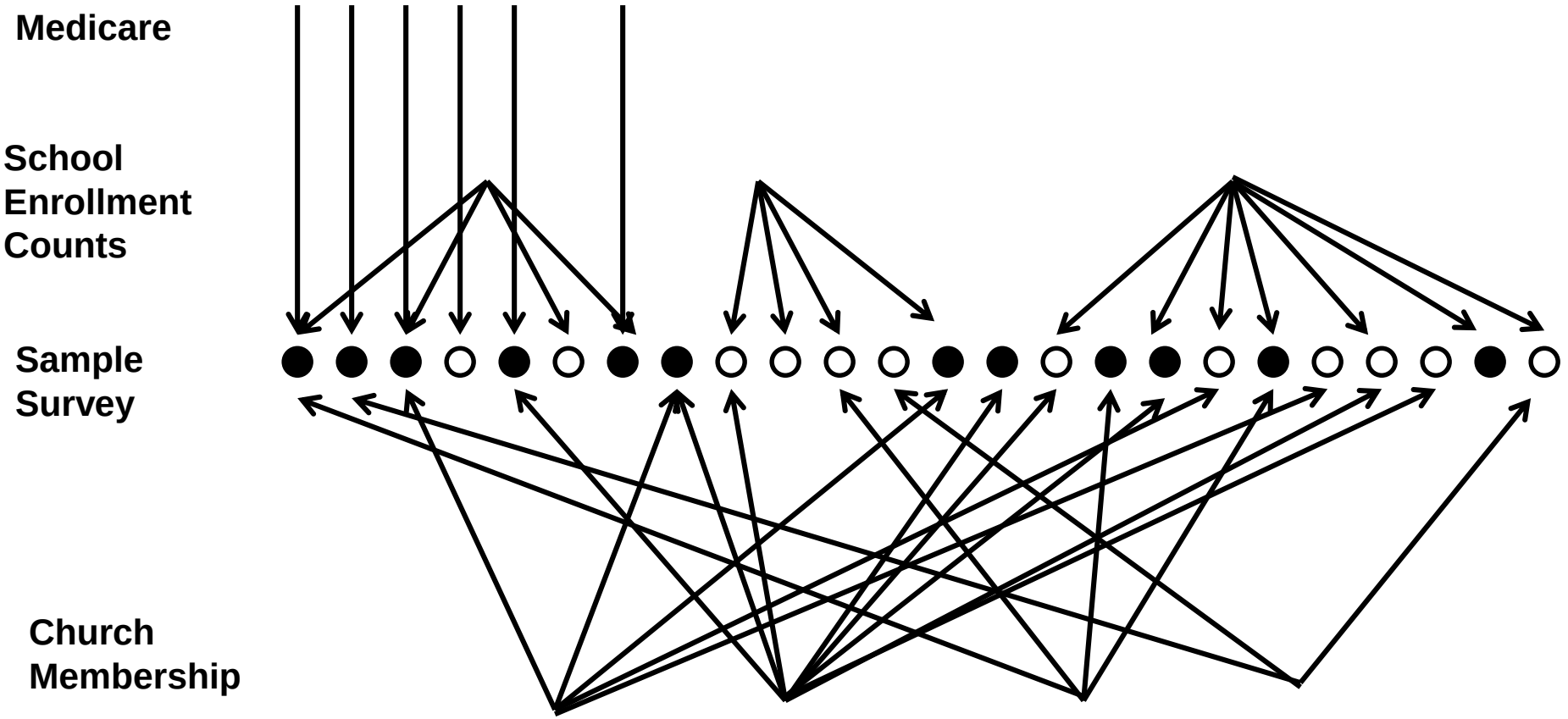
Organic Data as Covariate Source

- Problem: estimation of statistic for many small domains
- Data resources:
  - National survey with designed data on sample of PSUs
  - Most recent census data
  - Organic data as a covariate of the key quantity to be estimated
- Example: Marchetti *et al.*(2015) for income using mobile phone GPS traffic as covariate

Small Area Estimation



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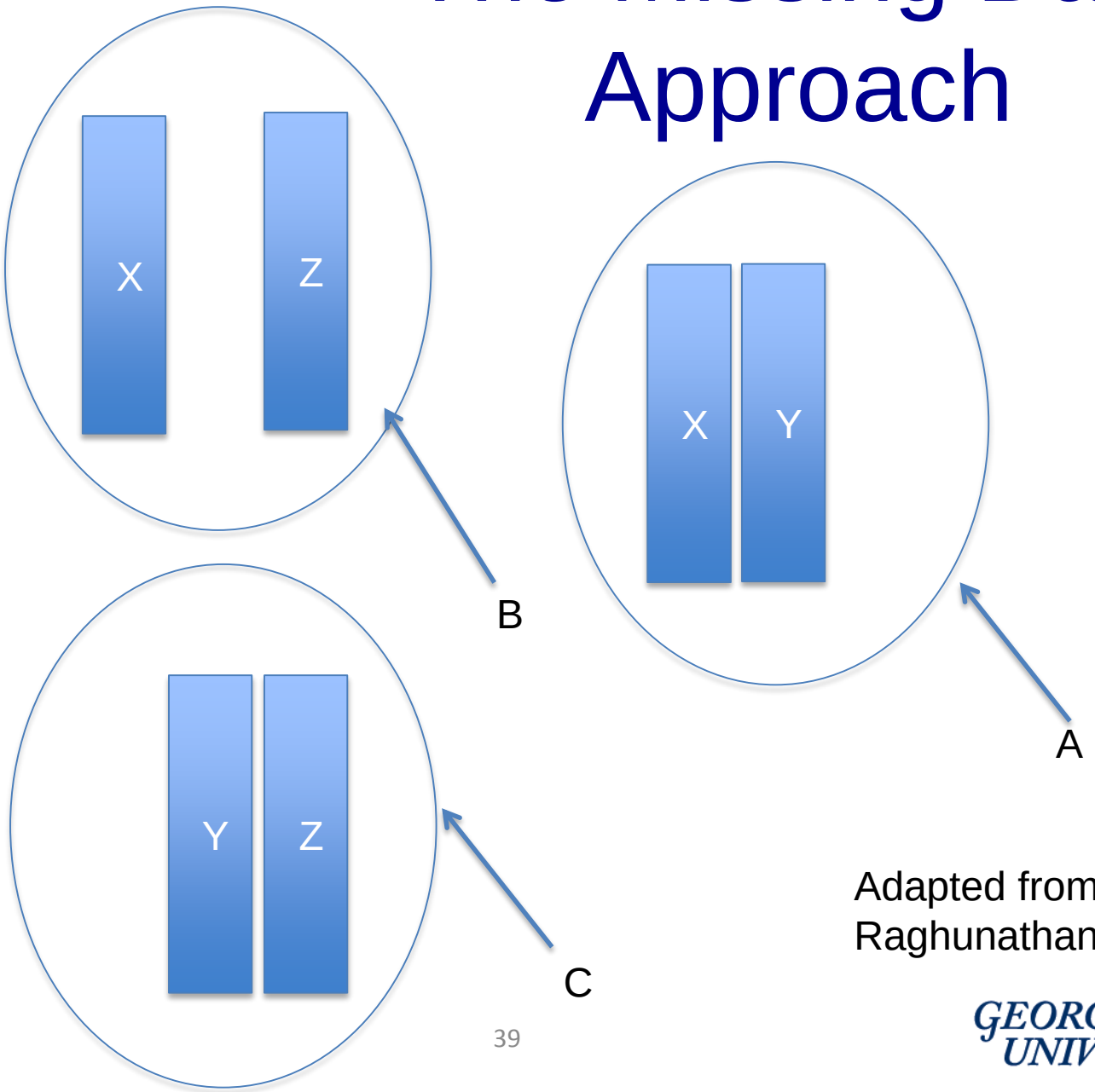
Blending in a Missing Data Framework

- Problem: Improved estimation borrowing strength from multiple data sources
- Data resources:
  - National survey with designed data on some measures (X,Y)
  - Organic data sources with other variables (X,Z), (Y,Z)
- Example: Schenker and Raghunathan *et al.* (2006, 2007, 2010)

The Missing Data Approach



Adapted from:
Raghunathan (2015)

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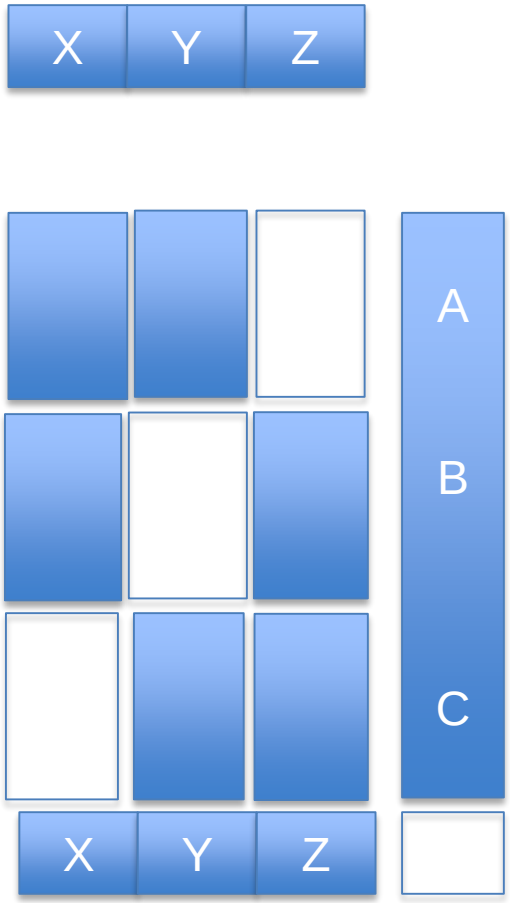
The Missing Data Approach



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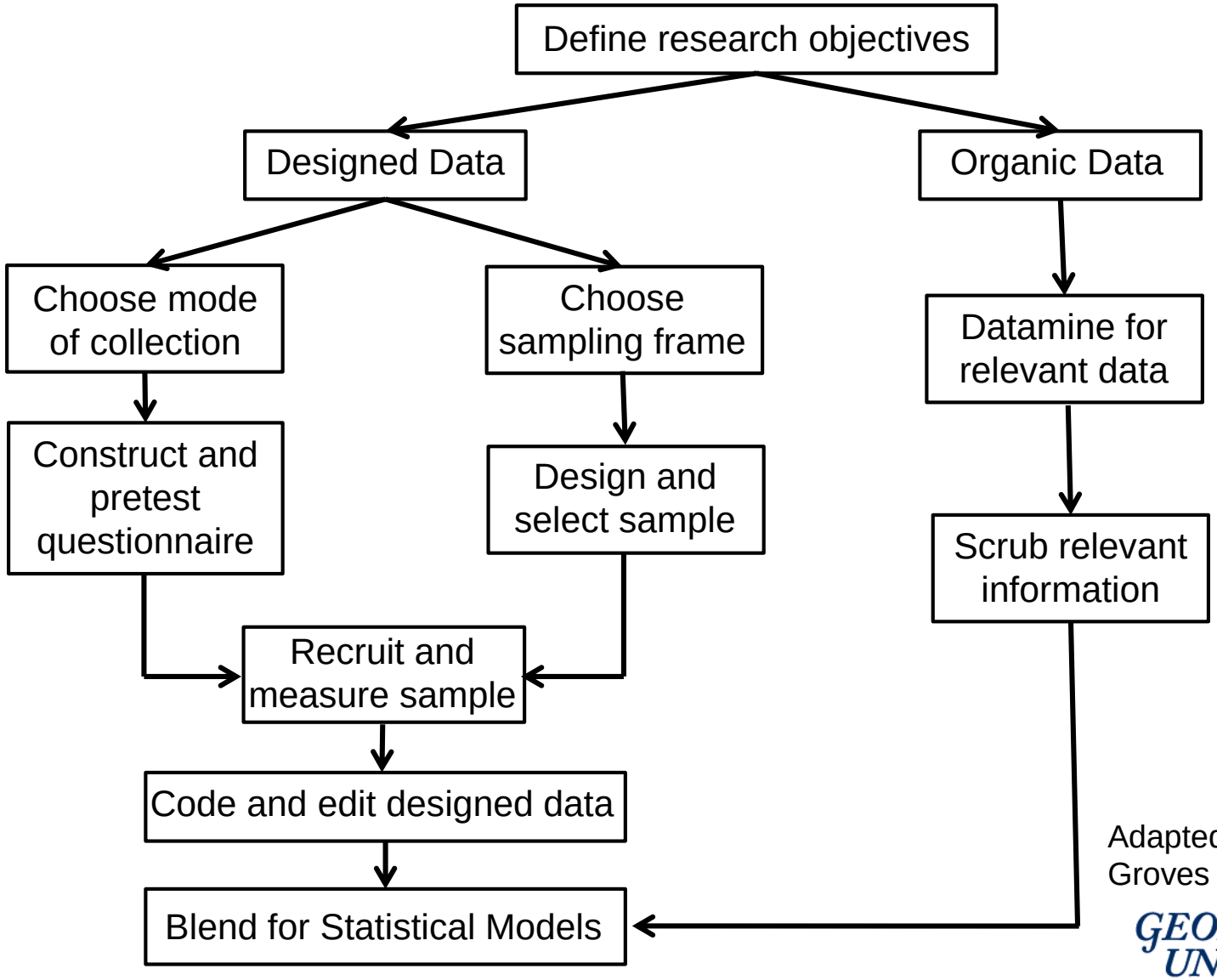
MOVING FORWARD

A New World for Official Statistics



Adapted from Figure 2.4, Groves et al. (2009)

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Model Based World

In order to move to a fully model based world, we must:

- Develop standards of transparency
- Invent simple statistics understandable by large groups
- Faithfully display uncertainty of estimates
- Develop standards of sensitivity analysis.