International Statistical Institute

Statistical Thinking & Methodology: Pillars For Quality In The Big Data Era

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(Big) Data Era

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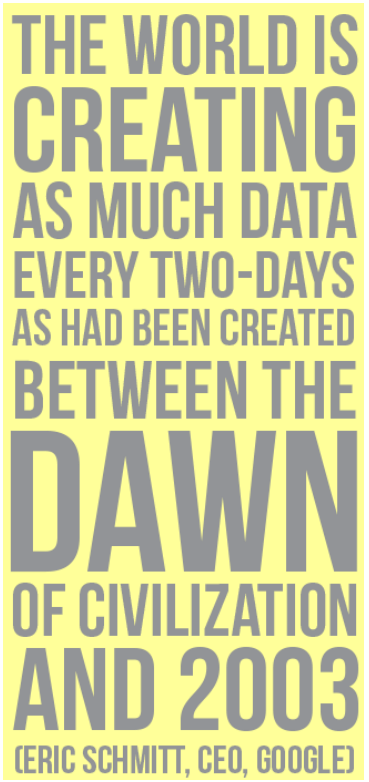
Global Partnership for Sustainable Development Data (GPSDD)

http://www.data4sdgs.org/#news



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We live in an era of unprecedented volume, availability and access to data.

“Data in the world is doubling every 18 months.”

IBM

http://www-01.ibm.com/software/data/demystifying-big-data/

Data Gaps

Despite this *data deluge*, there are glaring **data gaps**.

> "For example, in low-income countries more than 70% of births – almost 20 million children annually – are not registered."

Paris21: http://datarevolution.paris21.org/the-project

Data & Development

"On September 27th 2015, 193 world leaders committed to 17 Global Goals to achieve 3 extraordinary things in the next 15 years.

- End extreme poverty.
- Fight inequality & injustice.
- Fix climate change."

Data & Development

"To reach these Sustainable Development Goals (SDGs), we will need to confront **a crisis** at the heart of solving many of the world's most pressing issues - a crisis of **poor use, accessibility, and production of high quality data** that is stunting the fight to overcome global challenges in every area—from health to gender equality, human rights to economics, and education to agriculture.

The availability and access to **high quality data** is essential to measuring and achieving the SDGs."

http://www.data4sdgs.org/#intro

Central Banks

Play a key role in **shaping policy**.

Understand the role of **relevant**, **accurate and timely data** for:

- Informed debate;
- Policy making;
- Policy evaluation & monitoring.

Operate both as **data producers** and **data consumers**.

Official and Public Statistics

Typical data sources (observational studies):

- **Censuses**
  - Data obtained from **every unit** in the target population.
- **Sample surveys**
  - Data obtained from **samples of units** in the target population.
- **Administrative records**
  - Data obtained for admin purposes, but later used for statistical purposes.

Big Data

New and emerging **data sources**:

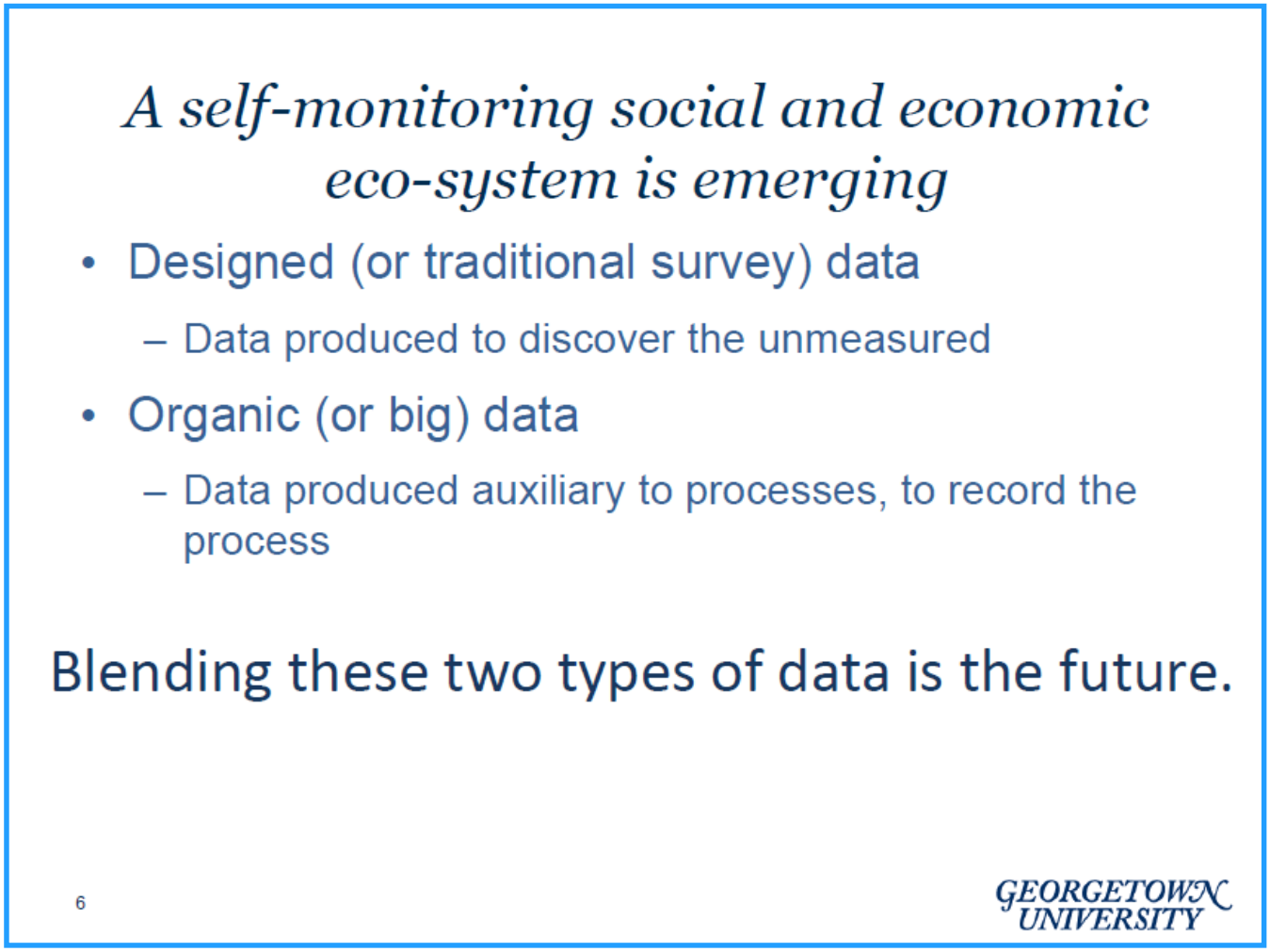
"Big Data are data sources that can be – generally – described as: high **volume**, **velocity** and **variety** of data that demand cost-effective, innovative forms of processing for enhanced insight and decision making."

UNECE Definition 2013

Types of sources:

Social networks (communications; images; searches);
Traditional business data (transactions; records);
'Internet of things' (sensor data).

UNECE Classification:
http://www1.unece.org/stat/platform/display/bigdata/Classification+of+Types+of+Big+Data



Robert Groves

http://directorsblog.blogs.census.gov/2011/05/31/designed-data-and-organic-data/

Big Data Quality Issues

Variability or Volatility

Inconsistence and/or instability of data across time.

Veracity

Ability to trust that data is accurate and/or complete.

Complexity

Need to link multiple data sources.

Accessibility

Need to ensure that data is and will remain available.

Data Quality in the Big Data Era

More data **does not** necessarily **mean** good or better data!

Many of the data available **lack the quality** required for its safe use in many applications.

Challenges are even bigger with Big Data!

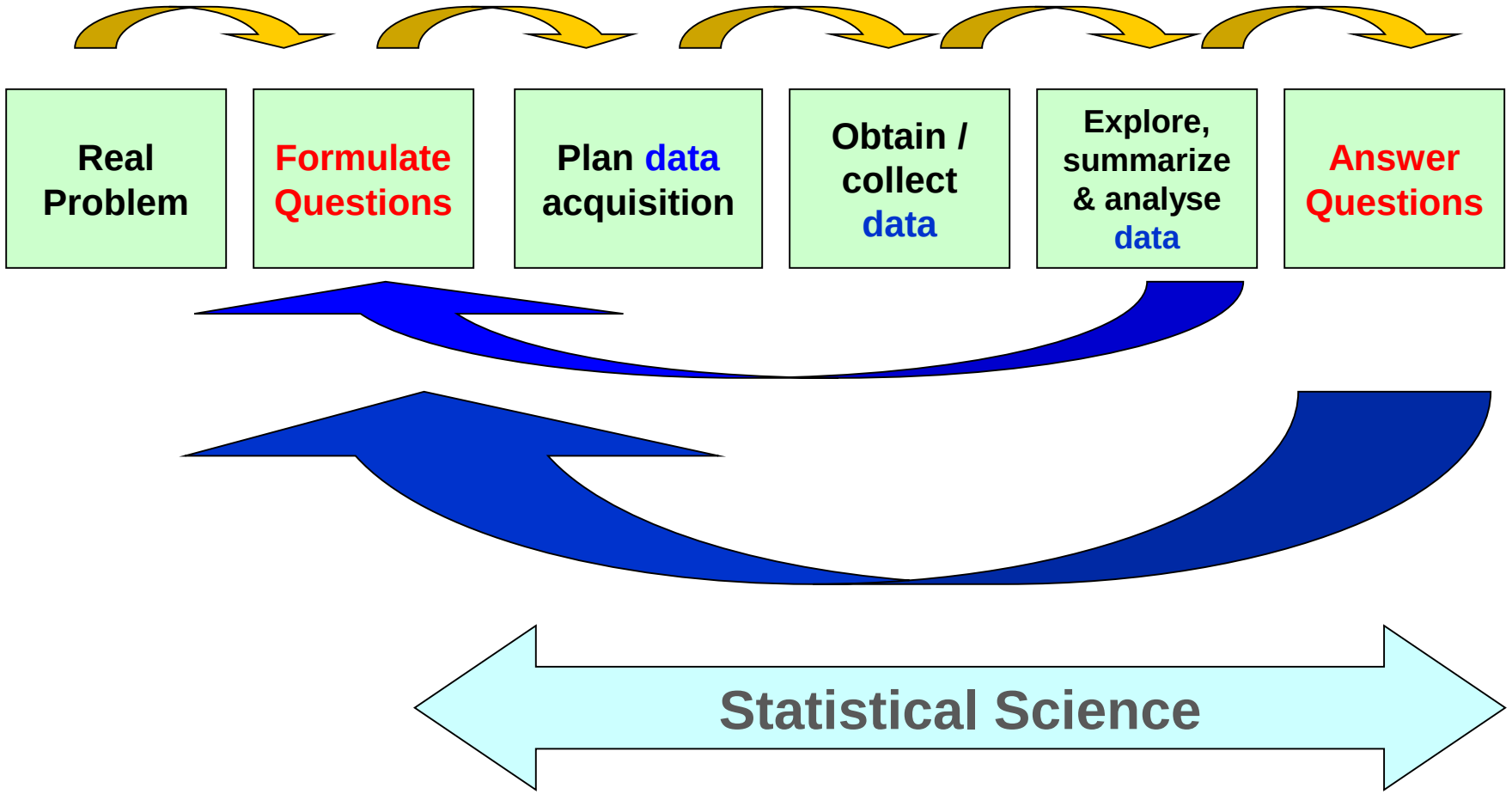
Statistical Science

For all the above reasons, **Statistical Science** has never been in such **evidence** and in such **high demand**.

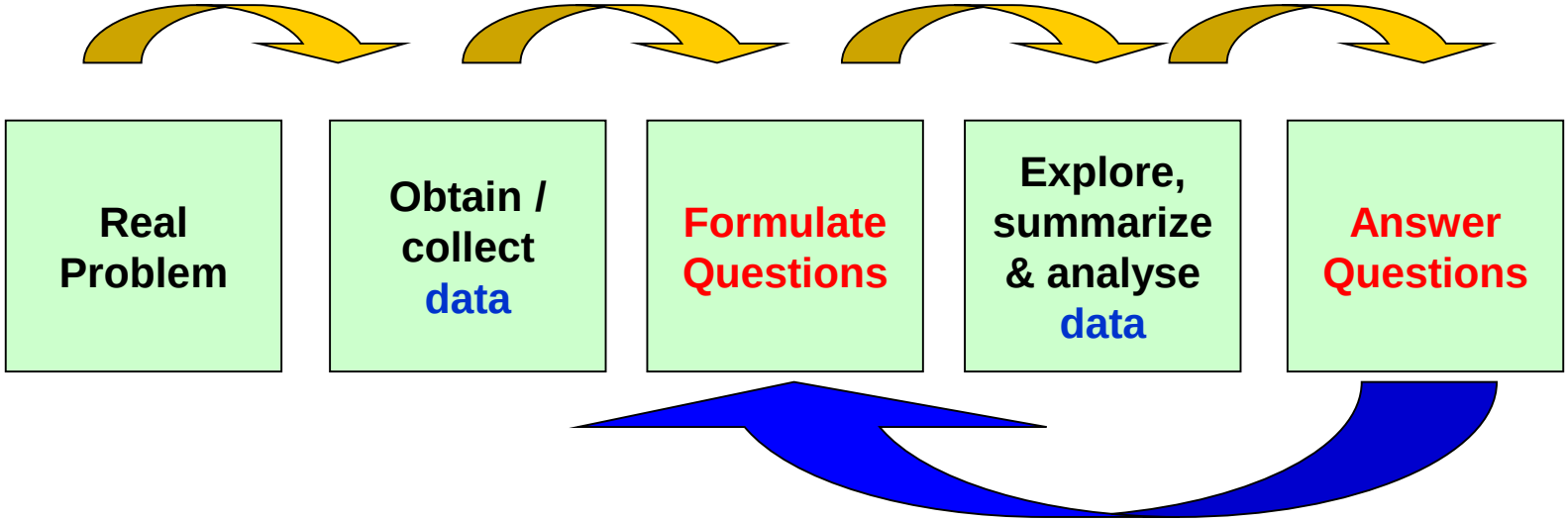
Statistical thinking & methodology offer the essential guidance to obtaining relevant, accurate, current, and cost-effective data.

It also guides the **extraction of useful knowledge from data**, to support decision making.

Conventional Knowledge Generation Process



Knowledge Generation Process in the Big Data Era



Statistical Thinking

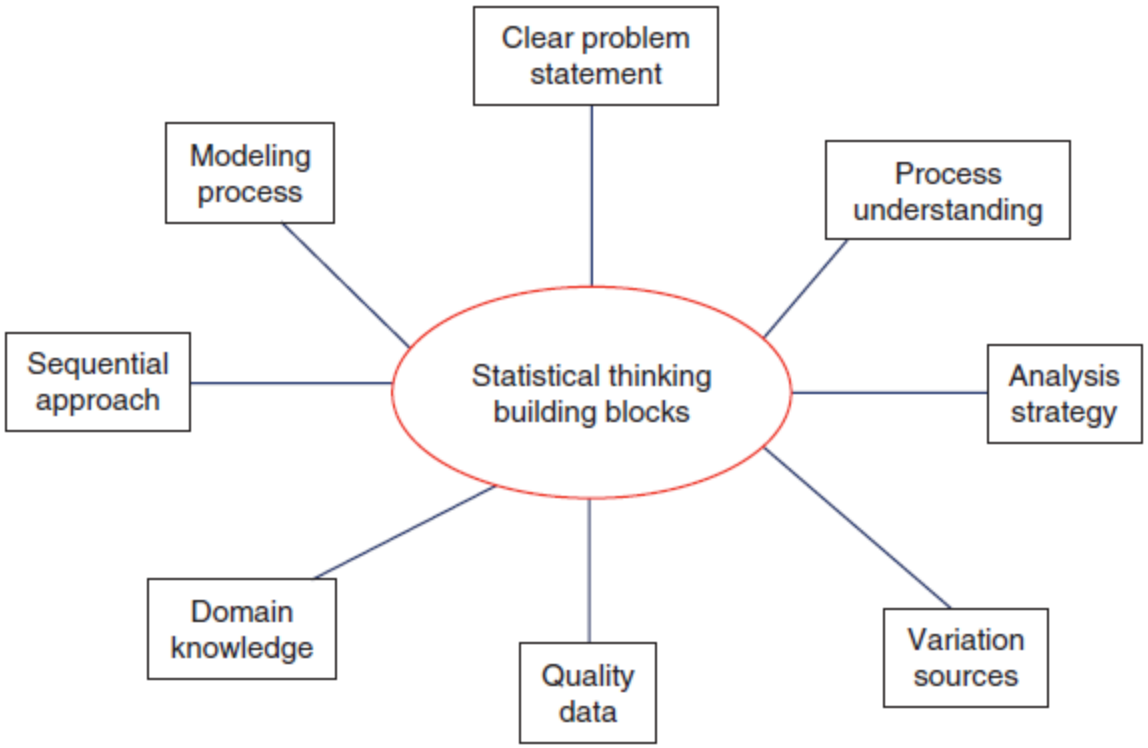


FIGURE 1 | The building blocks of statistical thinking.

Source: Hoerl, Snee & De Veaux (2014)

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- Creating visual displays of data, summaries and key findings revealed from the data.

Obtaining Data

Methods for careful planning and conducting of cost-effective **data gathering** studies:

- Sampling;
- Design of experiments;
- Design for observational studies;
- Measurement protocols (questionnaires, instruments, record keeping protocols, etc.)
- Data checking, cleaning, storage and sharing protocols.

Analysis / discovery

Methods for exploratory and confirmatory data analysis:

- Exploratory data analysis;
- Data mining;
- Hypothesis formulation and testing;
- Model formulation, fitting, selection, diagnostics and interpretation;
- Data summarization, presentation & visualization.

Data Quality

Quality is desirable attribute of all data.

Data quality derives from **quality of the source**(s), **measurement instruments** & **methods**.

Vague concept: **what is data quality**?

Must be defined, so that it can be planned, measured and evaluated.

Data Quality Frameworks

Several important organizations have invested in developing frameworks for data quality:

- ✓ US Office of Management and Budget (2006);
- ✓ Statistics Canada (2009);
- ✓ International Monetary Fund (2012);
- ✓ OECD (2012);
- ✓ UN (2012);
- ✓ IBGE (2013).

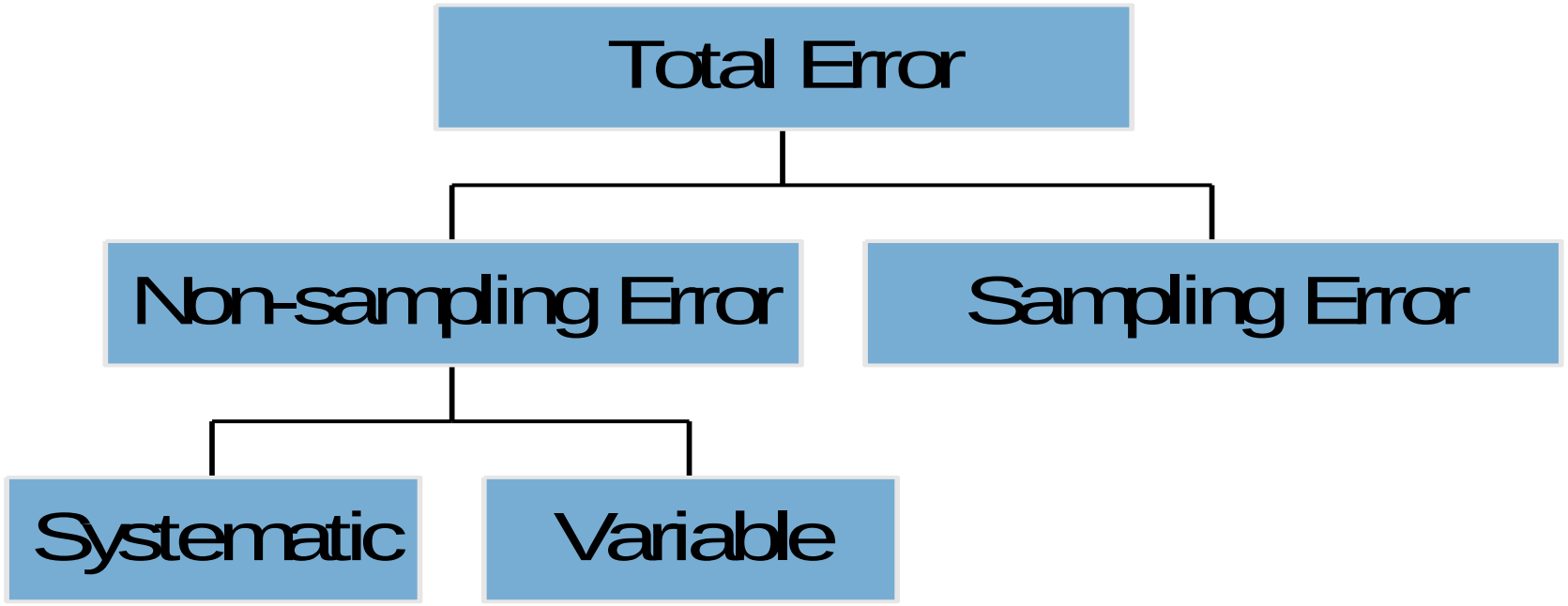
UNECE Framework for the Quality of Big Data

- Institutional / business environment (agency providing the data)
- Privacy and Security
- Complexity
- Relevance
- Time factors

- Accessibility and Clarity
- Usability
- **Accuracy**
- Completeness
- Coherence
- Validity

“Error” in Estimates

Error = Estimate – True Value



Source: United Nations (2005).

Sampling Error

Errors arising due to sampling for observation.

Easier to control.

Bias (systematic error) may be avoided ➔ use **probability sampling.**

Sample design, sample size and **estimator** defined to make **variable sampling error** as small as required.

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With '**Big Data**', there may no longer be sampling error in many applications!

Non-Sampling Error

Two broad classes of **non-sampling errors**.

Errors due to '**non-observation**':

- Coverage (frames, populations);
- Non-response (collection).

Errors in **observations**:

- Specification;
- Measurement;
- Linking, processing & estimation.

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With '**Big Data**', non-sampling errors dominate!

Even worse: they may not vanish with large n!

Summarizing

Data quality remains fundamental concern.

Statistical thinking & methodology are essential pillars for promoting:

- **data quality**;
- sound evidence-based decision making.

Big data era will require **more statistical development**, not less.

ISI
Statistical Science for a Better World

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