# Assessing and Improving the Accuracy of Estimators from Blended Data

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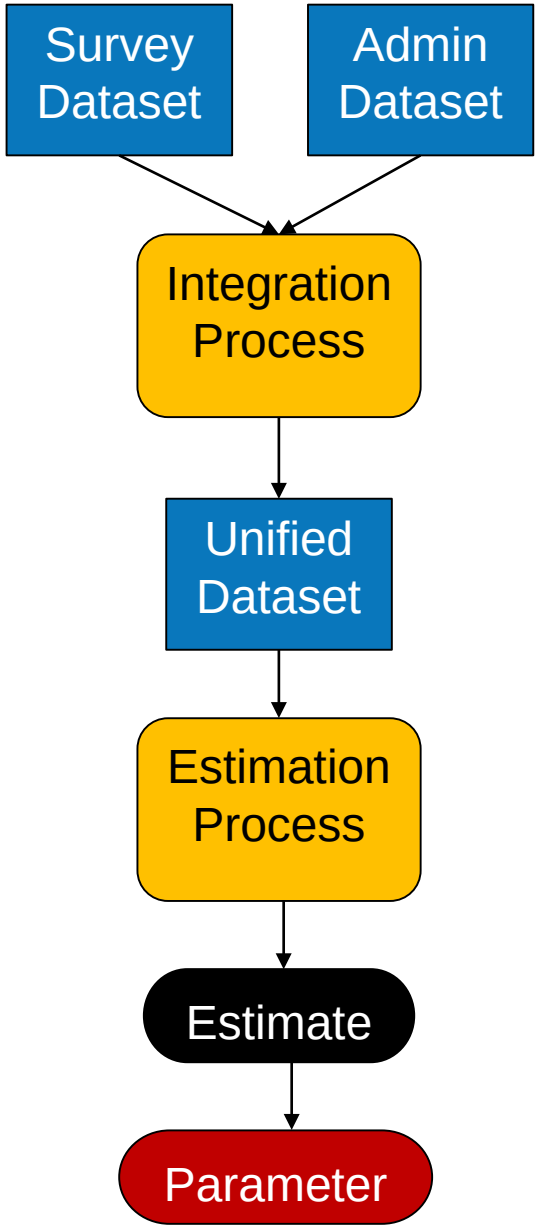
# Outline

- Hybrid estimators
- An total error framework for datasets
- An total error framework for hybrid estimators
- Types of error risks
- Error risk profiles
- Illustration of the concepts

# The Hybrid Estimation Process



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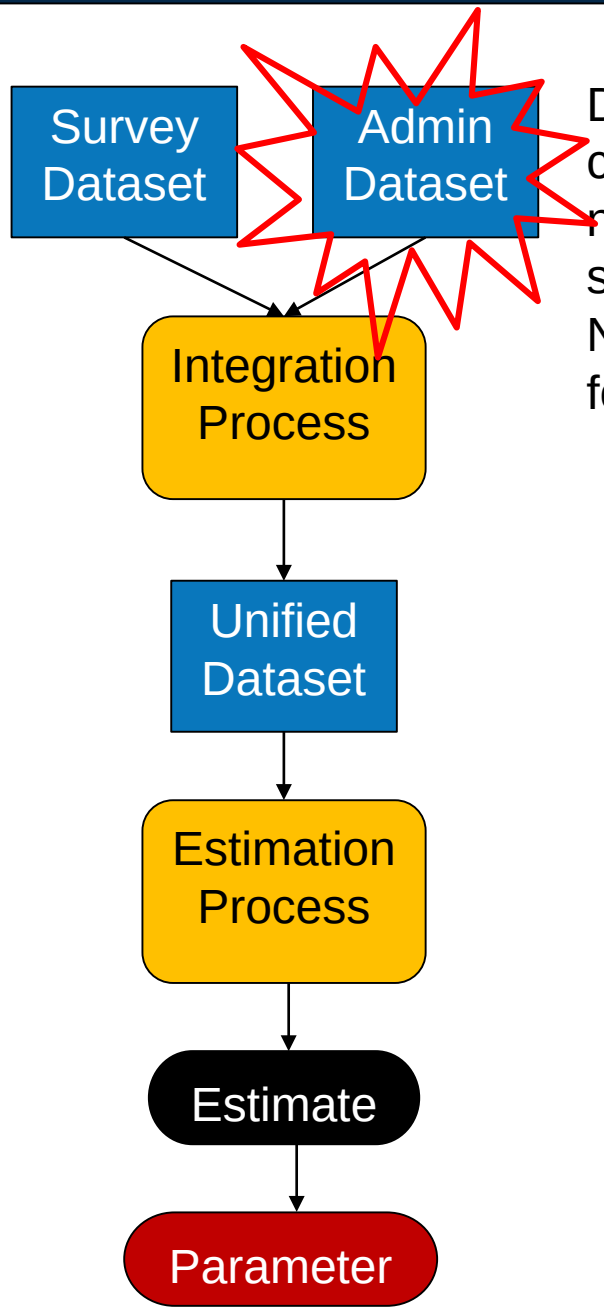


Definition: “data holdings containing information which is not primarily collected for statistical purposes.” United Nations Economic Commission for Europe, 2011

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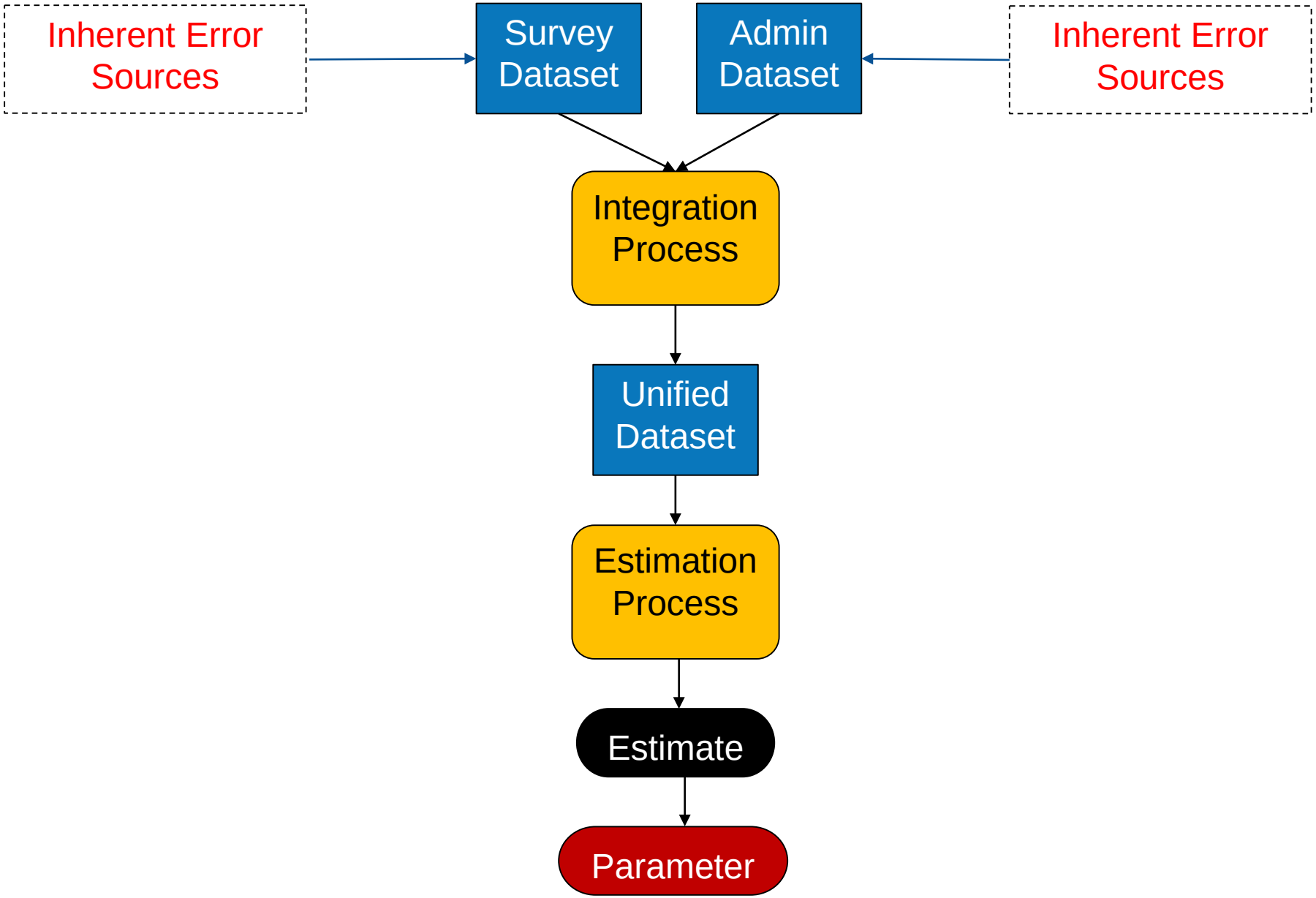

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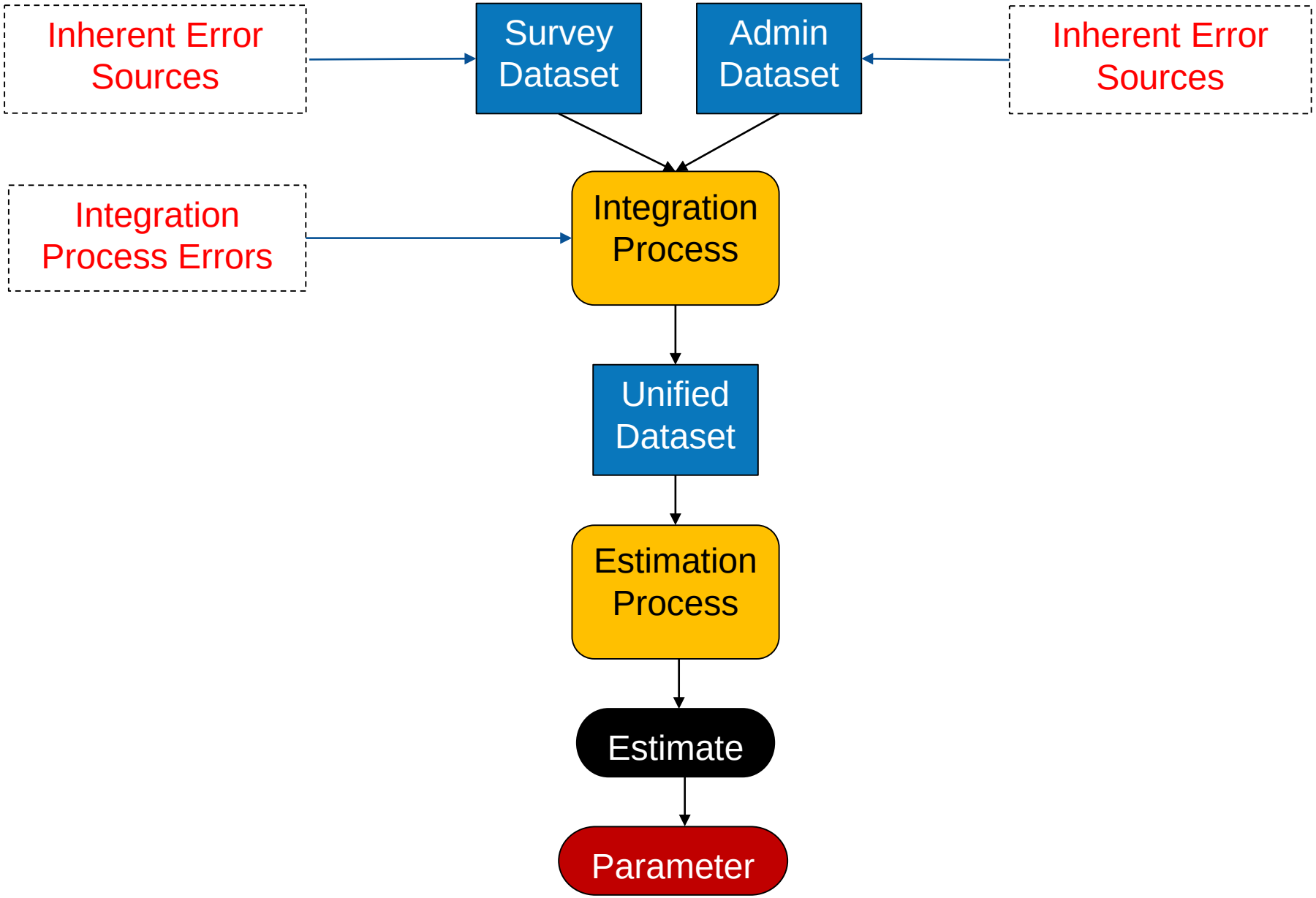

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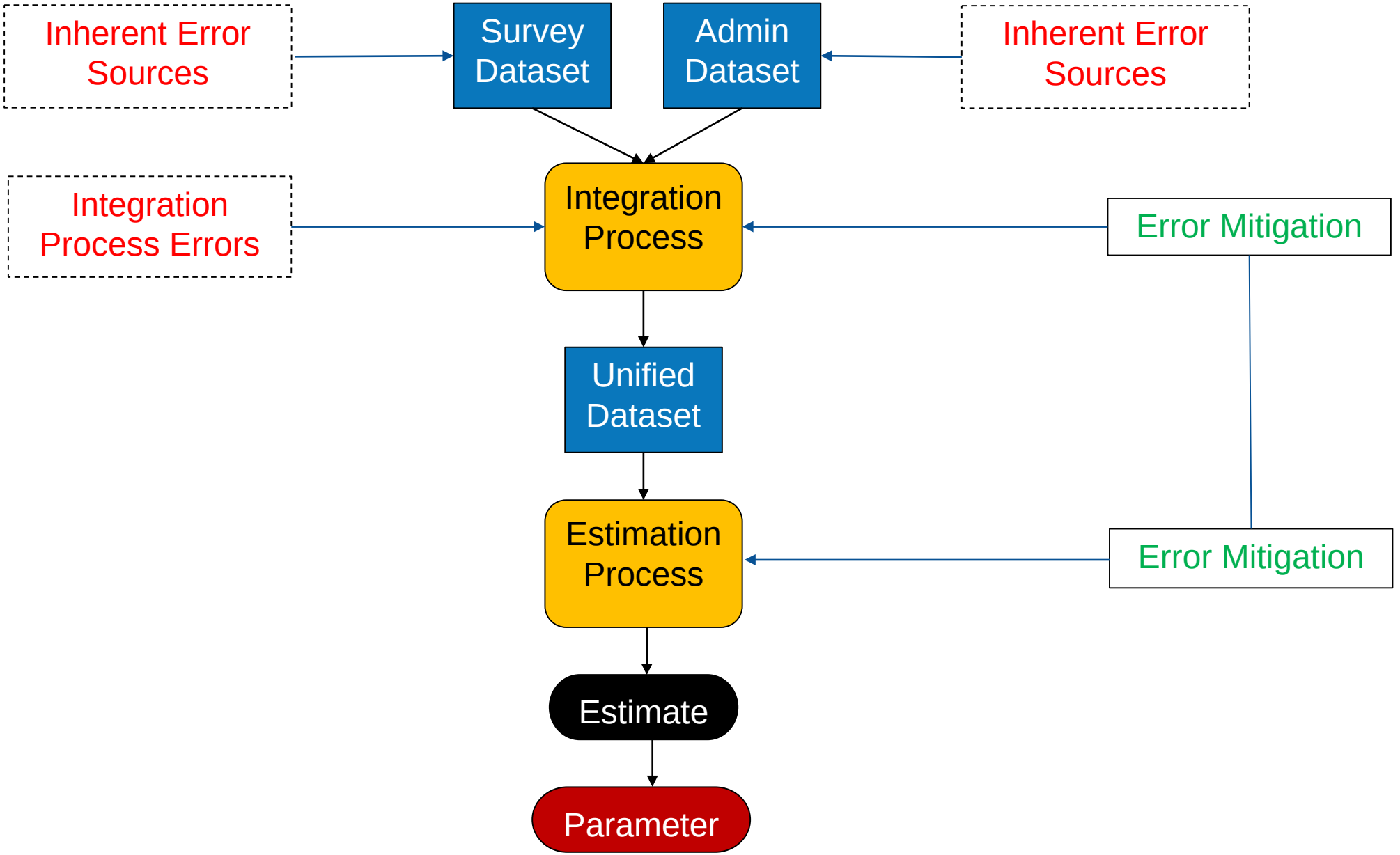

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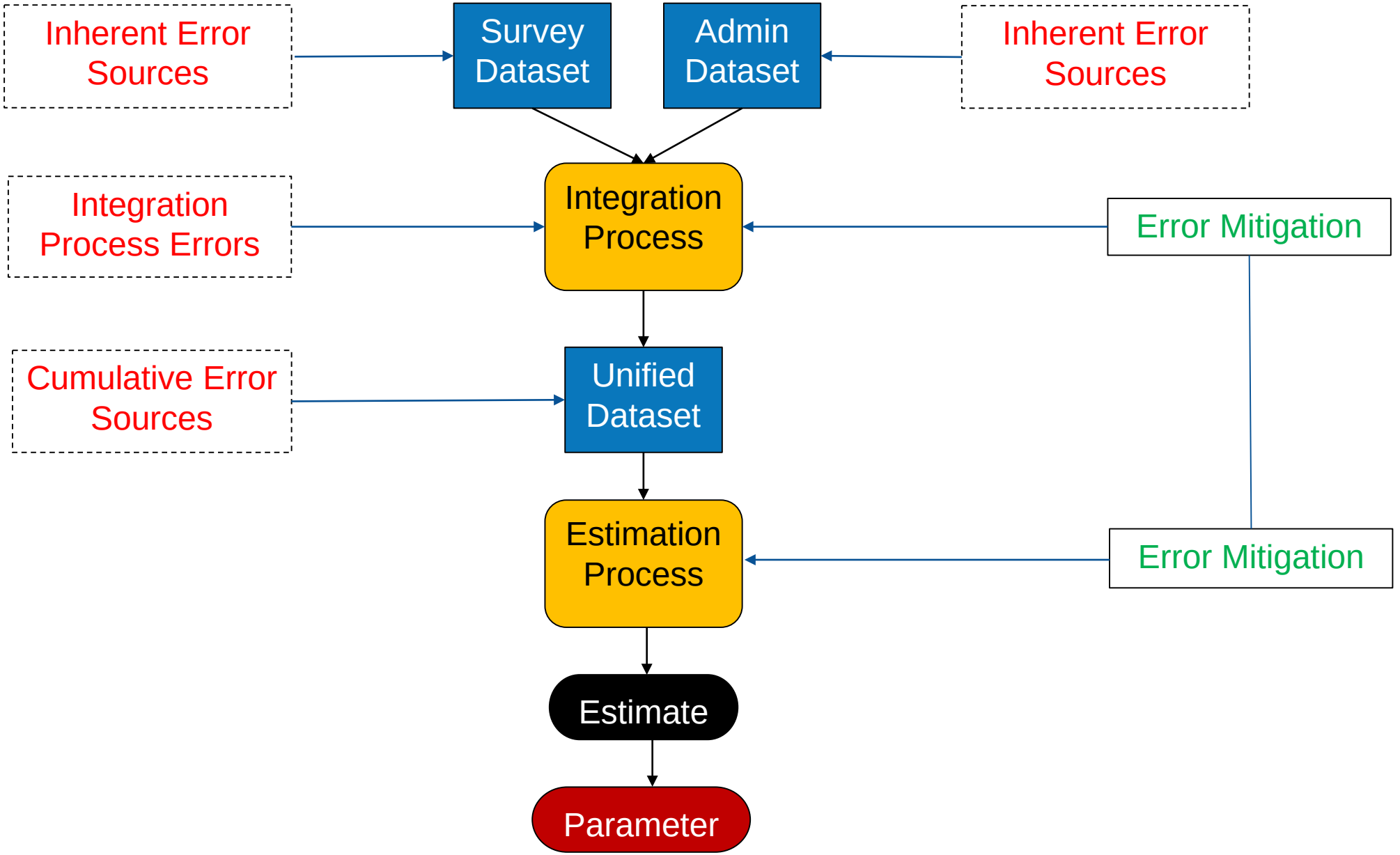

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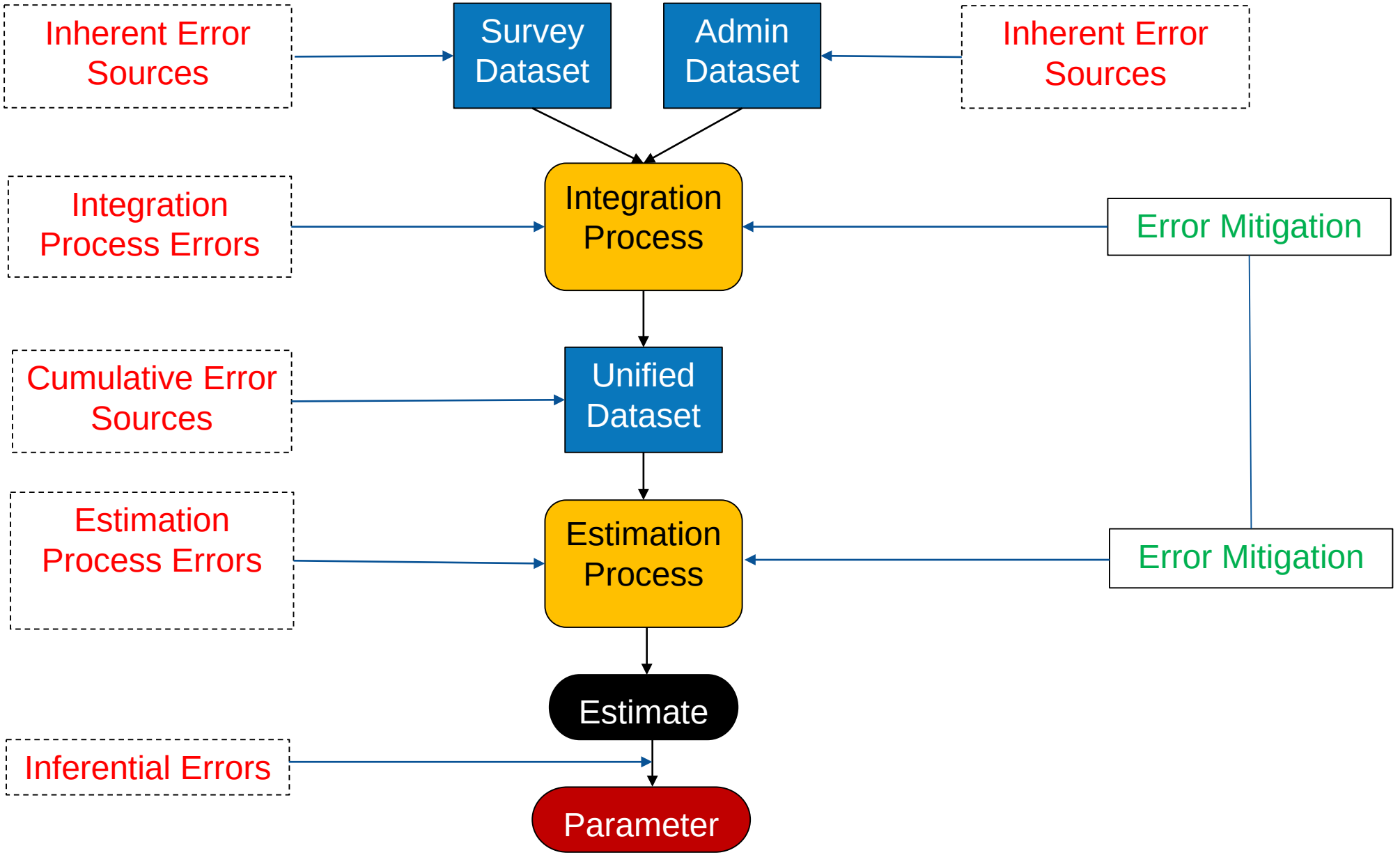
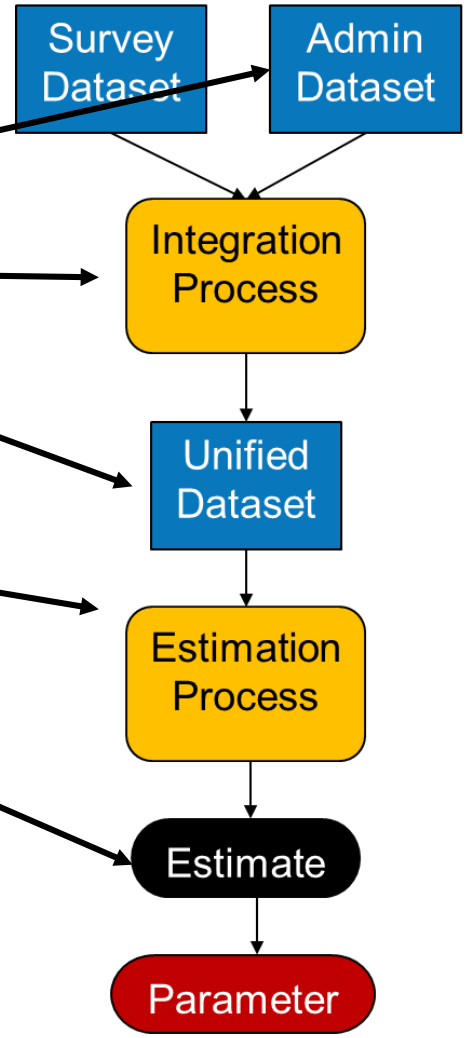


# Questions Regarding Hybrid Estimator Accuracy

- What error sources are associated with the unified dataset?
- Which of these pose the greatest *intrinsic* risks to data accuracy?
- Among the hybrid estimators that might be constructed from the unified dataset, which estimator minimizes the *total error risk*?
- What are the major *intrinsic* and *residual* error risks associated with the **hybrid** estimator?
- Which of these error risks could be further mitigated to maximally increase the accuracy of the hybrid estimator?

# A Total Error Framework Can be Specified for Each Stage of the Process

- Inherent errors associated with survey dataset
- Inherent errors associated with administrative dataset
- Integration processing errors
- Cumulative errors associated with the unified dataset
- Estimation processing errors
- Final errors associated with the estimate




Error mitigation can occur at various stages of each the process

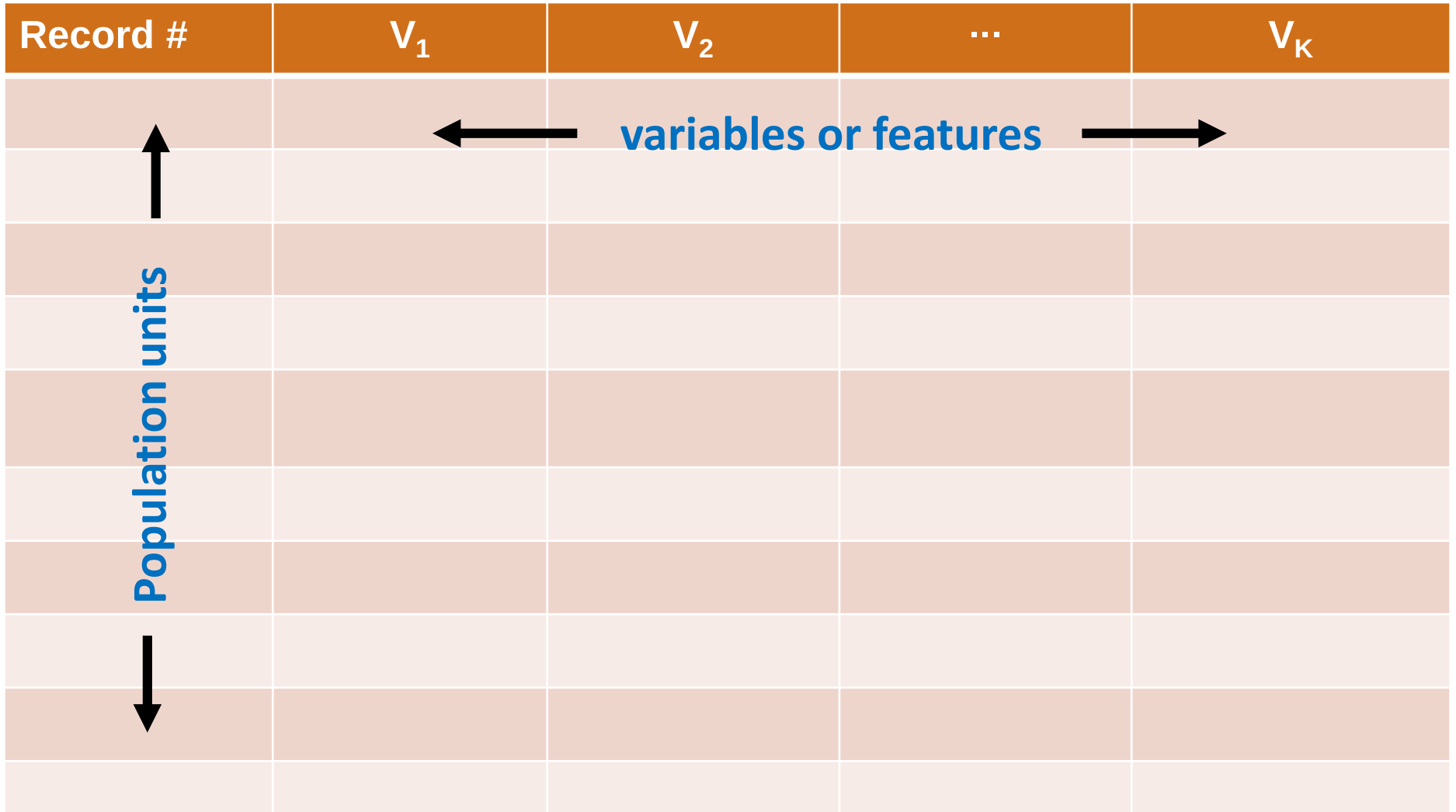
(see, for example, 3 stage framework of Reid, et al, 2017)

# In many cases it suffices to simply describe the errors in the final output

- Total error model for registers, frames and other datasets
- Total error model for survey point estimates
- Total error model for hybrid estimates
- Total error models for compilations such as the GDP and various price indexes

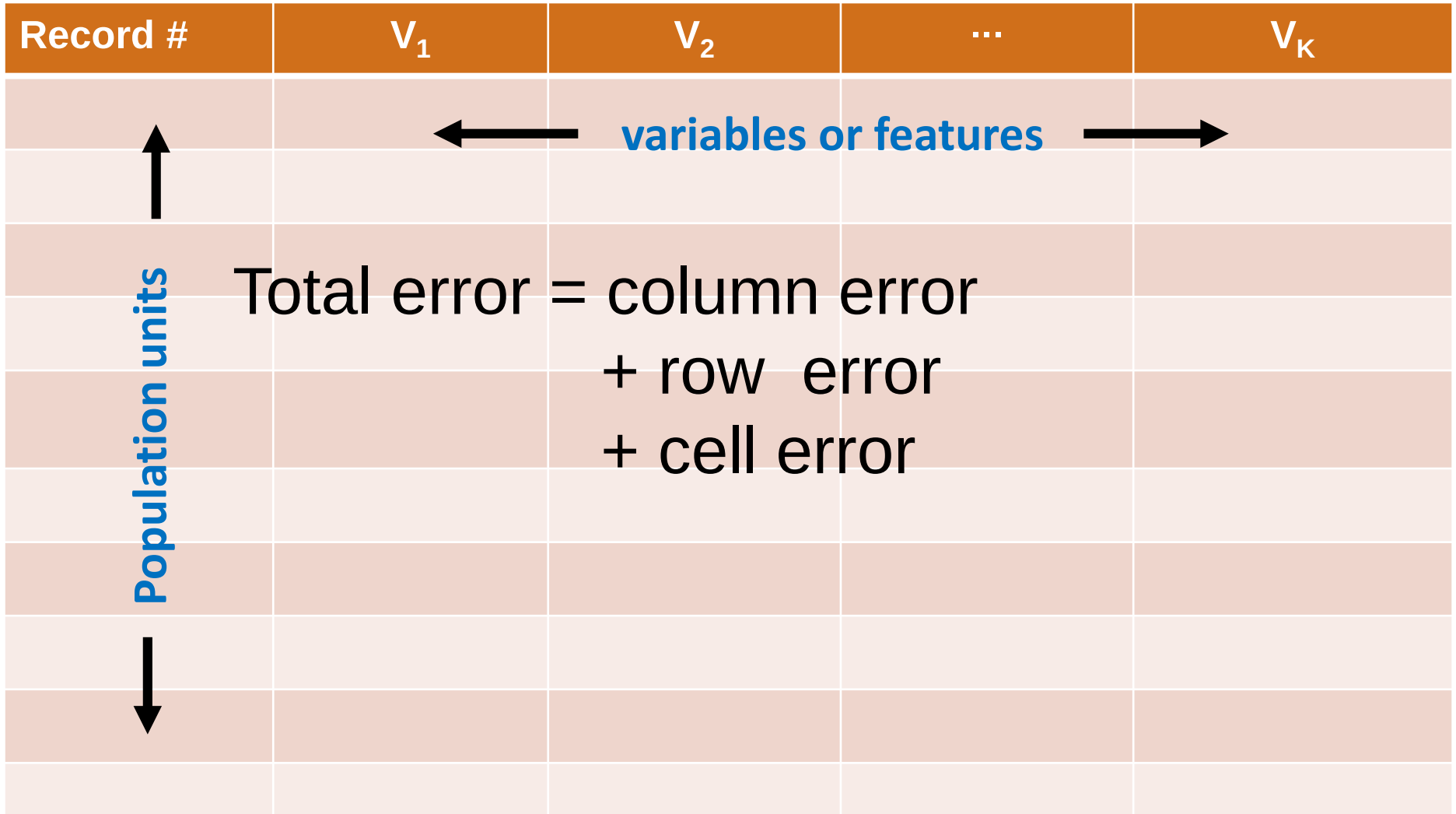
# A Total Error Framework for a Generic Dataset

## Typical File Structure



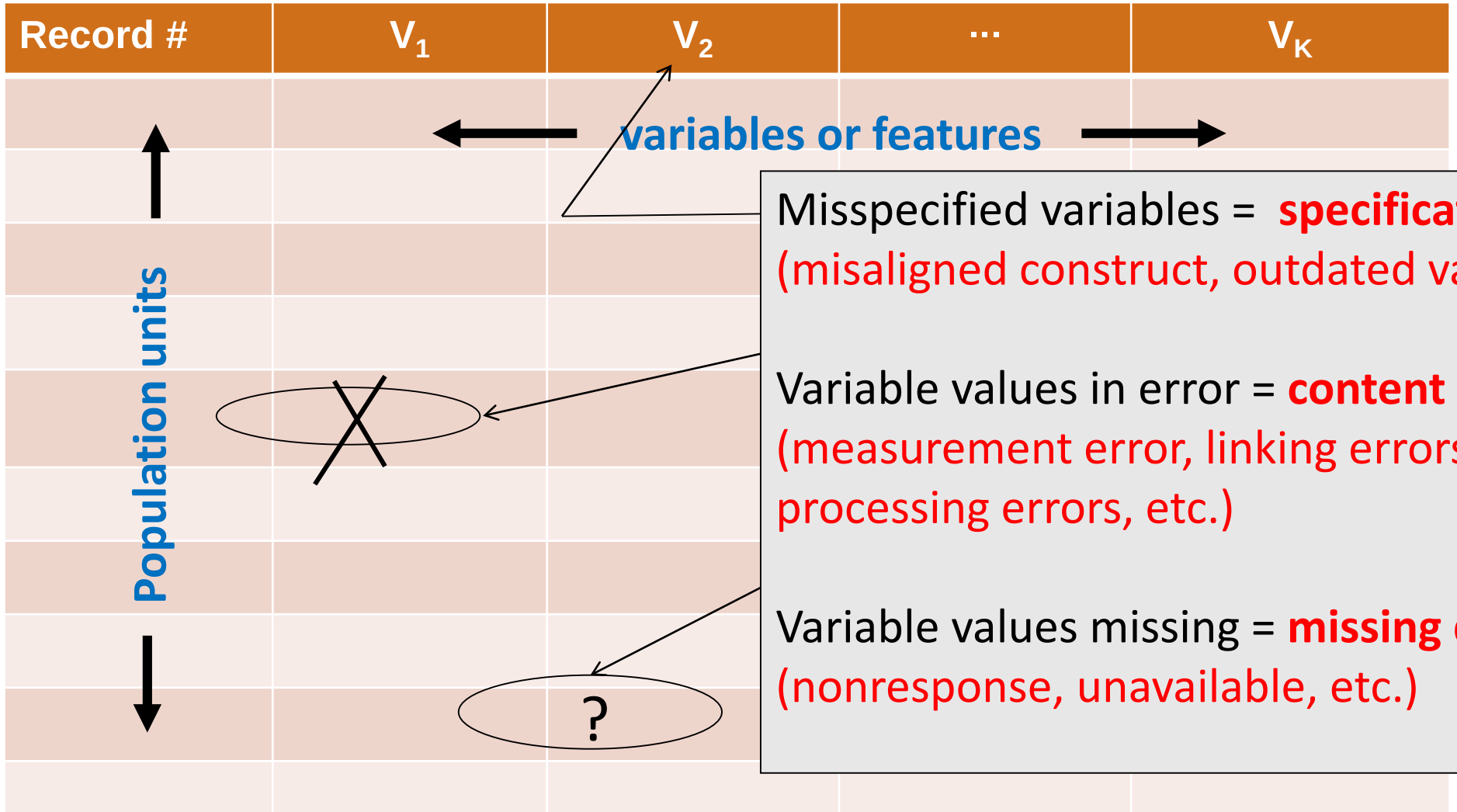
# A Total Error Framework for a Generic Dataset

**Typical File Structure**



# Column and Cell Errors

## Typical File Structure



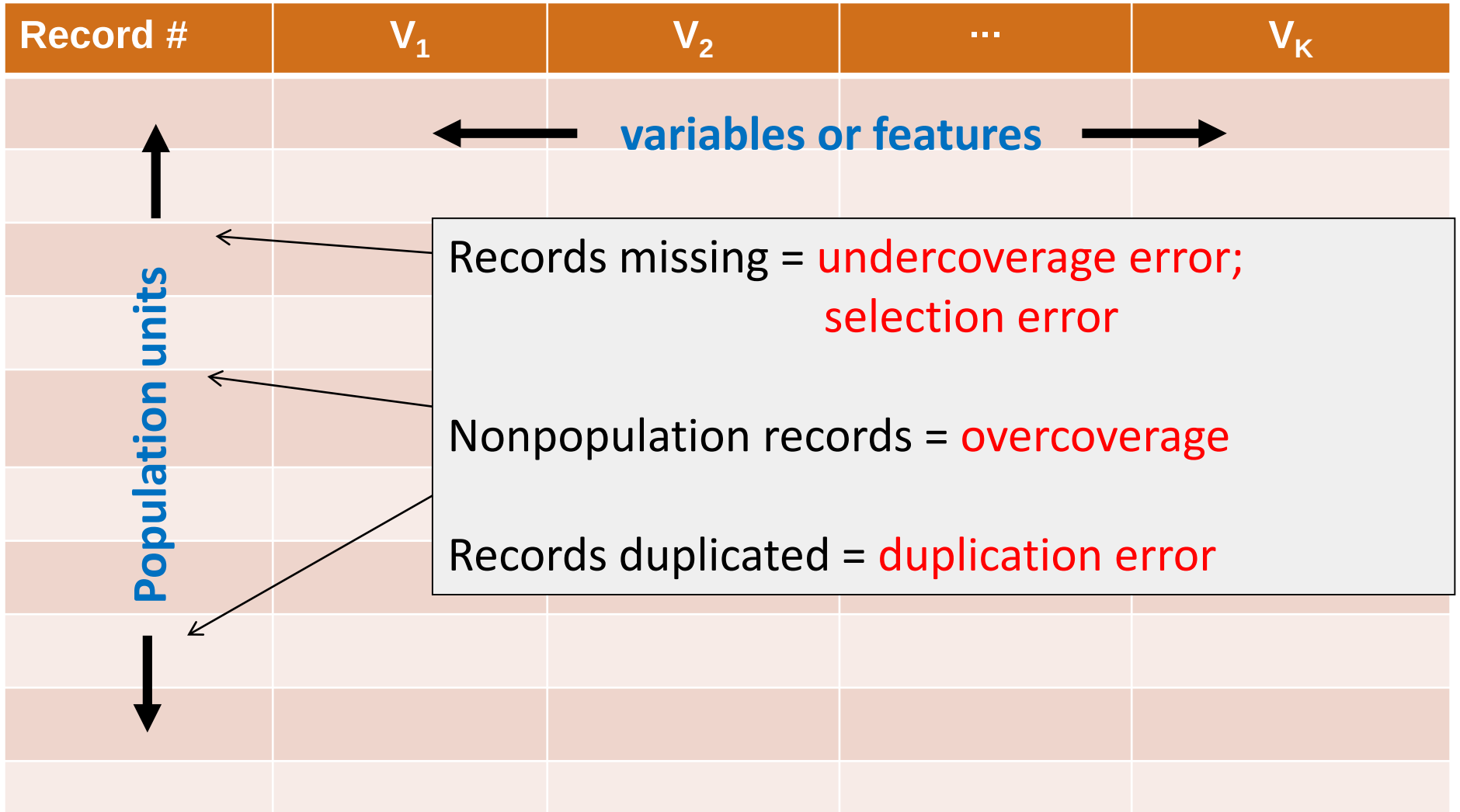

Misspecified variables = **specification error** (misaligned construct, outdated value, etc.)

Variable values in error = **content error** (measurement error, linking errors, data processing errors, etc.)

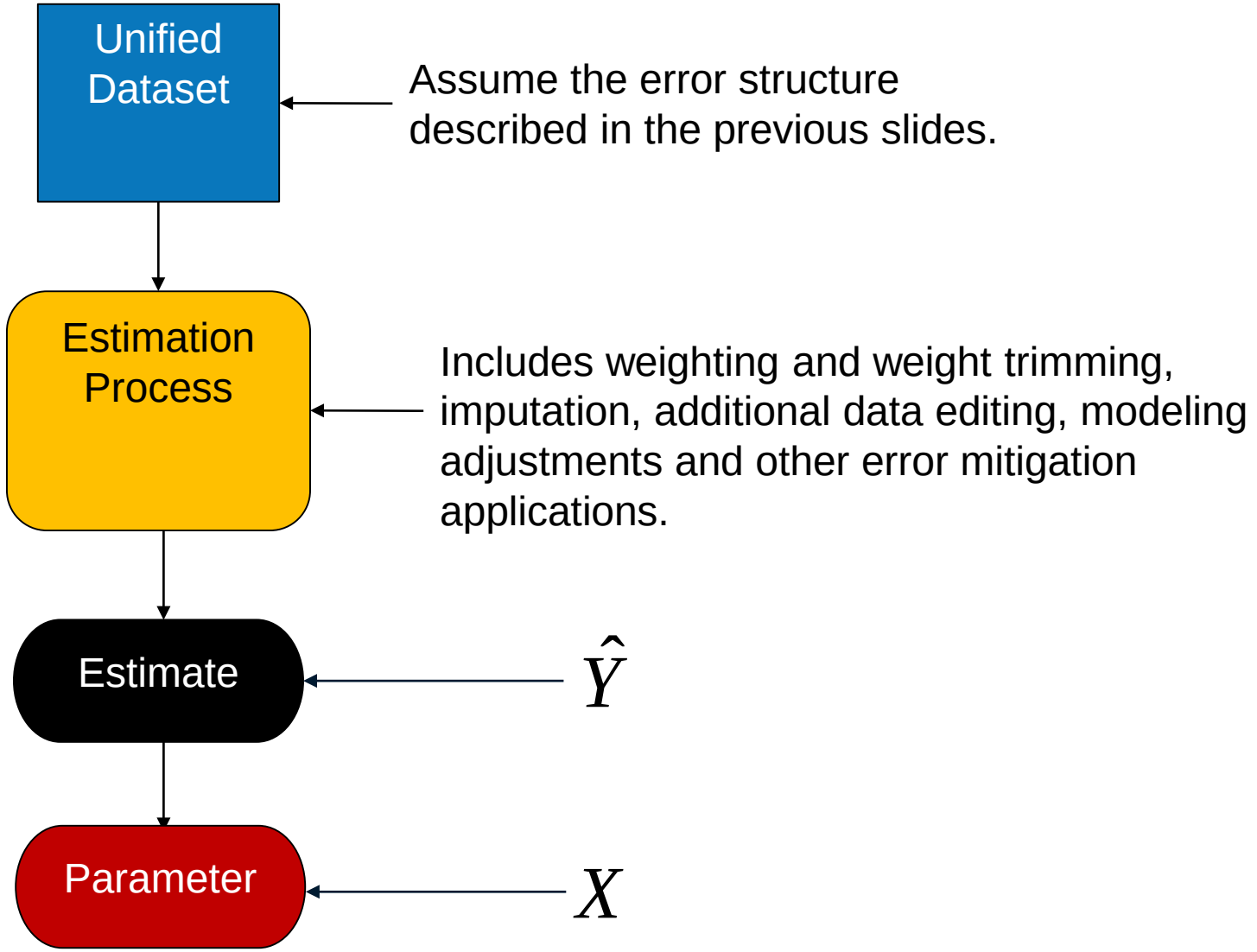
Variable values missing = **missing data** (nonresponse, unavailable, etc.)

# Row errors

## Typical File Structure



# Errors Associated with the Hybrid Estimation Process



# Total Error Model for Hybrid Estimators

$$\underbrace{\hat{Y} - X}_{\text{total error}} = \underbrace{(\hat{Y} - Y)}_{(\varepsilon_1 + \mathsf{L} + \varepsilon_6)} + \underbrace{(Y - X)}_{\varepsilon_7}$$

$\varepsilon_1 =$ Selection error
$\varepsilon_2 =$ Coverage error (over-, under-, duplication)
$\varepsilon_3 =$ Missing data error
$\varepsilon_4 =$ Content error
$\varepsilon_5 =$ Data processing error
$\varepsilon_6 =$ Model/estimation error
$\varepsilon_7 =$ Specification error

# Assessing Error Risk

**Types of Error Risks**

- Intrinsic risk – risk that an error source poses if no steps are taken to reduce the error; error risk of "doing nothing."
  - Example: The intrinsic risk of nonresponse bias in an linear estimator is

$$B_I = \frac{\mathrm{cov}(y_i, \rho_i)}{\bar{\rho}}$$

- Residual risk – risk of error for a source that remains after mitigation strategies have been applied.
  - Example: After nonresponse weighting adjustments have been applied, the residual risk of bias is

$$B_R \leq B_I$$

# Risk Profile Comparing Survey, Administrative and Unified Datasets: Either Intrinsic or Residual Risks

| *Error Sources* | *Survey Dataset* | *Administrative Dataset* | *Unified Dataset* |
|---|---|---|---|
| ***Specification*** | Risk level (1, 2, 3) | Risk level (1, 2, 3) | Risk level (1, 2, 3) |
| ***Coverage: Undercoverage*** | Risk level (1, 2, 3) | Risk level (1, 2, 3) | Risk level (1, 2, 3) |
| ***Coverage: Overcoverage*** | Risk level (1, 2, 3) | Risk level (1, 2, 3) | Risk level (1, 2, 3) |
| ***Coverage: Duplication*** | Risk level (1, 2, 3) | Risk level (1, 2, 3) | Risk level (1, 2, 3) |
| ***Selection*** | Risk level (1, 2, 3) | Risk level (1, 2, 3) | Risk level (1, 2, 3) |
| ***Content*** | Risk level (1, 2, 3) | Risk level (1, 2, 3) | Risk level (1, 2, 3) |
| ***Missing Data*** | Risk level (1, 2, 3) | Risk level (1, 2, 3) | Risk level (1, 2, 3) |

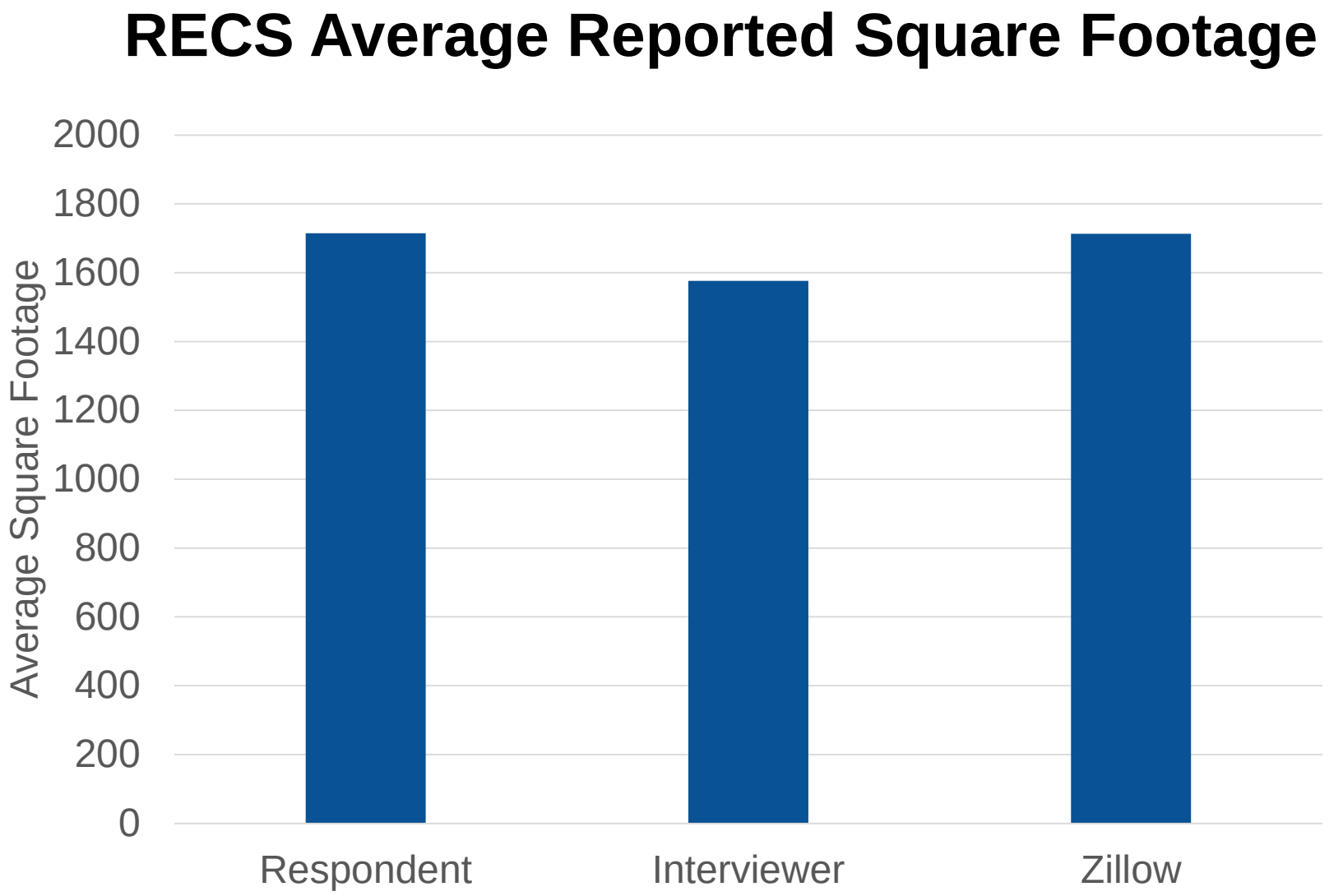
# Intrinsic Error Risk Profile Comparing Survey and Hybrid Estimates

| *Error Sources* | *Survey Estimator* | *Hybrid Estimator* |
|---|---|---|
| ***Specification*** | Risk level (1, 2, 3) | Risk level (1, 2, 3) |
| ***Coverage: Undercoverage*** | Risk level (1, 2, 3) | Risk level (1, 2, 3) |
| ***Coverage: Overcoverage*** | Risk level (1, 2, 3) | Risk level (1, 2, 3) |
| ***Coverage: Duplication*** | Risk level (1, 2, 3) | Risk level (1, 2, 3) |
| ***Sampling/Selection*** | Risk level (1, 2, 3) | Risk level (1, 2, 3) |
| ***Measurement/Content*** | Risk level (1, 2, 3) | Risk level (1, 2, 3) |
| ***Data Processing*** | Risk level (1, 2, 3) | Risk level (1, 2, 3) |
| ***Nonresponse/Missing data*** | Risk level (1, 2, 3) | Risk level (1, 2, 3) |
| ***Modeling/estimation*** | Risk level (1, 2, 3) | Risk level (1, 2, 3) |

# Case Study: Error Mitigation for Energy Use Survey Square Footage Data using Unified Data

- Data sources
  - Survey data: 2015 Residential Energy Consumption Survey (RECS)
    - n ≈ 2,400 completed cases
  - Big Data (data pulled from various sources)
    - Zillow
    - Acxiom
    - CoreLogic
- Variable of interest: housing unit square footage
- **Goal: Integrate the external data sources with the survey data to improve and/or evaluate the accuracy of survey square footage data**

# Evidence of Nonsampling Error from the RECS



# More Evidence of Intrinsic Error Risks

| | Survey (R) | Zillow |
|---|---|---|
| **NR/Missing** | | |
| Unit NR/missing rate | 58.2% | 22.0% |
| Item NR rate | 19.2% | |
| **Overcoverage rate** | 11.8% | ~0 |
| **Undercoverage rate** | ~0 | 15.3% |
| **Reliability** | 50% | 68% |

# Intrinsic Error Risk Profile for the RECS, Zillow and Unified Datasets

| *Error Sources* | *RECS* | *Zillow* | *RECS U Zillow* |
|---|---|---|---|
| *Specification* | 2 | 2 | 2 |
| *Coverage: Undercoverage* | 1 | 2 | 1 |
| *Coverage: Overcoverage* | 2 | 1 | 1 |
| *Coverage: Duplication* | 2 | 1 | 1 |
| *Selection* | 3 | 1 | 3 |
| *Content* | 3 | 3 | 3 |
| *Missing Data* | 3 | 2 | 1 |
| *Average* | **2.3** | **1.7** | **1.7** |

# Intrinsic Error Risk Profile for the RECS, Zillow and Unified Datasets

| *Error Sources* | *RECS* | *Zillow* | *RECS U Zillow* |
|---|---|---|---|
| ***Specification*** | 2 | 2 | 2 |
| ***Coverage: Undercoverage*** | 1 | 2 | 1 |
| ***Coverage: Overcoverage*** | 2 | 1 | 1 |
| ***Coverage: Duplication*** | 2 | 1 | 1 |
| ***Selection*** | 3 | 1 | 3 |
| ***Content*** | 3 | 3 | 3 |
| ***Missing Data*** | 3 | 2 | 1 |
| ***Average*** | **2.3** | **1.7** | **1.7** |

Unified data offers no advantage to Zillow only dataset.

# Intrinsic Error Risk Profile RECS and RECS/Zillow Hybrid Estimates

| *Error Sources* | *RECS Estimator* | *RECS/Zillow Hybrid Estimator* |
|---|---|---|
| ***Specification*** | 1 | 2 |
| ***Coverage: Undercoverage*** | 2 | 1 |
| ***Coverage: Overcoverage*** | 1 | 1 |
| ***Coverage: Duplication*** | 2 | 1 |
| ***Sampling/Selection*** | 3 | 1 |
| ***Measurement/Content*** | 3 | 2 |
| ***Data Processing*** | 2 | 2 |
| ***Nonresponse/Missing data*** | 3 | 1 |
| ***Modeling/estimation*** | 3 | 3 |
| ***Average*** | **2.2** | **1.6** |

Initial evaluations suggest a total error reduction with the hybrid estimator even before error mitigation efforts have been fully exploited.

# Illustration 2 – Market Research Client

- Currently conducting a large scale survey to evaluate market share for it customers products about 300 markets
- Quarterly estimates tend to be unstable in some markets
- Various administrative sets have been identified that would improve estimator stability, but each brings with it other error risks that have been fully investigated

**Question:**

Can a hybrid estimator be constructed having greater stability than the current survey estimator without increasing total error?

# Intrinsic Risk for the Hybrid Estimator Compared to Estimators Based on the Survey and Administrative Data

| Quality Component | Survey | Admin Data | Hybrid Estimator |
|---|---|---|---|
| **Specification** | **3** | **2** | **3** |
| **Coverage** | **2.7** | **2.0** | **2.7** |
| Undercoverage | 3 | 1 | 3 |
| Duplication | 3 | 3 | 3 |
| Within unit | 2 | 2 | 2 |
| **Selection** | **2.5** | **3** | **1.5** |
| Sample size | 2 | N/A | 1 |
| Weight variation | 3 | 3 | 2 |
| **Nonresponse/Missing Data** | **1.5** | **2** | **2** |
| Unit | 1 | 3 | 2 |
| Item | 2 | 1 | 2 |
| **Measurement** | **2** | **3** | **3** |
| **Data processing** | **2** | **1** | **2** |
| Keying/editing | 1 | 1 | 1 |
| Design weighting | 3 | N/A | 3 |
| **Estimation/modeling** | **1** | **1** | **1** |
| **Analysis** | **1** | **3** | **1** |
| ***Overall assessment*** | ***2.0*** | ***2.1*** | ***2.0*** |

# Summary

- A total error framework decomposes total error so that key subcomponents can be identified and addressed.
- A unified error risk framework facilitates comparisons across individual and unified data sources.
- An error risk profile can provide insights regarding the quality implications of unified datasets
  - Assesses intrinsic risks by error source
  - Helps determine whether residual risk can be reduced by data unification.

**Thank you!**

Please direct inquiries to:

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