Rule-Based Data Validation and Reconciliation of Survey Responses

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Disclaimer

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Road map

- **Introduction and Motivation**
- **Error-correction process**
  - Defining error-correction rules
  - Automated error corrections
- **Transforming data to improve error correction**
  - Imputing missing values
  - Augmenting edit rules
- **Error-correction performance**

Introduction and motivation

- Each year, the U.S. Department of Agriculture's National Agricultural Statistics Service (NASS) conducts more than 100 surveys to understand and enumerate every aspect of agriculture in the United States.

- Ensuring that survey responses are **valid, reliable, and internally consistent** is vital to publishing accurate official statistics:
  - The quality of survey responses varies with survey and respondent.
  - A significant amount of **manual labor is required to edit and impute** missing or incorrect survey responses.

- As part of an agency-wide modernization effort, NASS is looking at **automating the editing and imputation processes** to improve the quality, consistency, and efficiency of its survey data processing.

Benefits to NASS

- **Saves time**
  - Automates many edits that analysts routinely and consistently make.
  - Frees NASS analysts to pursue more difficult cases—further improving data quality.
- **Improves consistency**
  - Uses an algorithm in comparison to personalized edits and imputations.
  - Allows for consistency across surveys, regions, administrators, and time.
- **Makes rules catalog explicit to more users**
  - Condenses entire rules universe into a singular file with consistent structure.
  - Centralizes and organizes each rule catalog to facilitate consistent updates and management.

Before error correction—deterministic edits and imputation

- **Deterministic edits**
  - Each survey has a host of edit rules, for example:
    - "If I know how many acres are owned and rented but the total land is missing, I can calculate it."
    - LAND_OWNED > 0 & LAND_RENTED > 0 & LAND_TOTAL == MISSING
      THEN LAND_TOTAL := LAND_OWNED + LAND_RENTED

- **Imputation**
  - The goal is to have values in the ballpark, which are then fixed in error correction.
  - Mean imputation using one draw from a multivariate normal.
    - Uses historical information

Defining error-correction rules

These rules are conditional statements in the USDA code that signal to an analyst that something is logically incorrect about the dataset.

Examples:

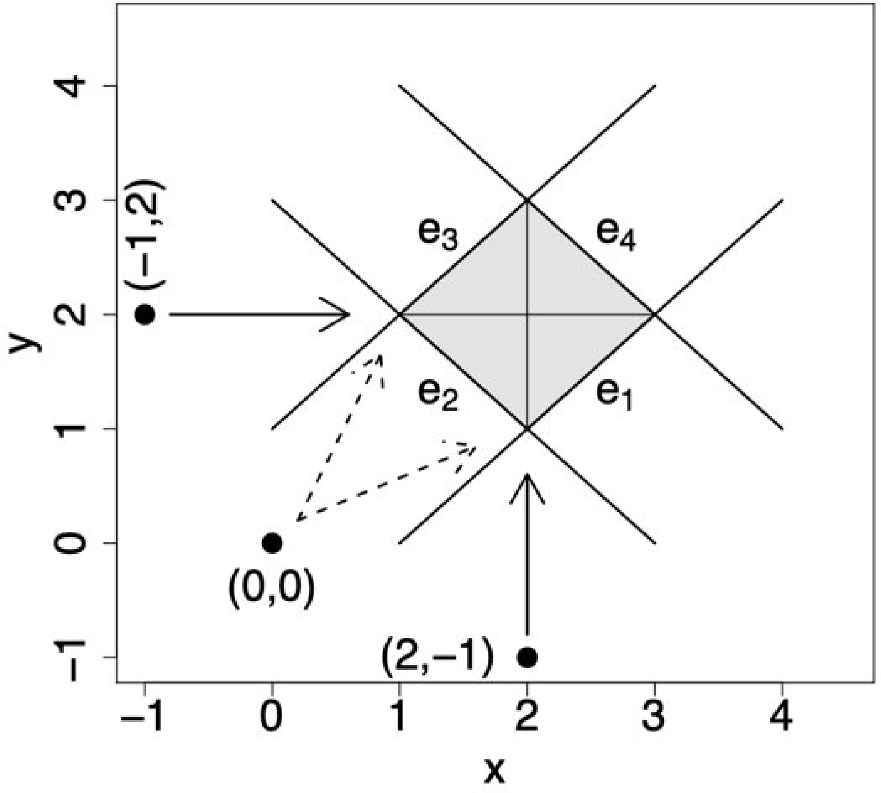
```
If Farm planted Crop A
Then
Acres_Planted_CropA >= Acres_Harvested_CropA
```

or

```
If Farm has rented acreage
Then
Acres_Cultivated <= Acres_Owned + Net_Acres_Rented
```

Fellegi-Holt's principle of parsimony

Implement an edit by correcting the smallest number of items possible by the smallest amount.



Source: Statistics Netherlands (2011)

R packages and implementation

- **R package**
  - *Validate*
    - Used to declare data validation rules and confront data to find violated rules in records.
  - *Errorlocate*
    - Uses the *lpSolveAPI* to solve the liner problem and output solution values.

- **Implementation**
  - Issues
    - Linear rules are required for R packages.
    - Rules must be explicit.
    - Nonlinear functions including rounding.
  - Solutions
    - Multiplication: Log values.
    - Range Check.

Error-correction performance

- **Dataset**
  - Over 30,000 Records
  - 150 + Variables
- **Results from error correction**
  - 151,000 + values that get an error correction
  - 21% of values dirty before error correction
  - 7% of values dirty after error correction

Further thoughts

- **Repeatable process**
- **Interplay between academic ideals and practical challenges:**
  - Speed and timing of process / availability of rules.
- **Lessons learned**
  - Business rule management is difficult, especially over more than 30 years and many analysts.
    - Code parsers are necessary but not sufficient.
    - Error rules are frequently not independent of deterministic edits.
  - With human editors, code is not only source of rules.
  - Automatic error correction is very good, but analysts are needed for the worst cases.

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