Analytic Tools for Evaluating Variability of Standard Errors in Large-Scale Establishment Surveys

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The views expressed in this paper are those of the authors and do not necessarily reflect the policies of the U.S. Bureau of Labor Statistics

Outline

Large-scale **establishment surveys** exhibit temporal or cross-sectional **variability** in their published **standard errors**.

Use **generalized variance function** framework to provide tools to evaluate these patterns of variability.

Outline (continued)

- Establishment Survey
- Generalized Variance Functions (GVFs)
- Current Employment Statistics Program (CES)
- Numerical Results

Establishment Survey

- Many survey variables are continuous, heavily **skewed population distribution**.
  In our example, individual employment counts range from single digits to tens of thousands. Most units have counts in the single or double digits.
- Initiation of new sample units can be expensive, and time consuming.
  Slow initiation and **attrition** may lead to increased variability.

Sources of Variability

1. Changes in factors **controllable** (e.g. realized sample size)
2. Changes in factors **observable** but not controllable (e.g. the true population parameter)
3. Changes in factors neither observable nor controllable (e.g. short-term local changes in economic conditions)
4. Sampling variablity of the variance estimator

explore sources of variability using GVF models

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Generalized Variance Function Model

Johnson and King (1987, JOS), Valliant (1987, JASA), Wolter (2007, Ch 7)

Mathematical model describing the relationship between variance of a survey estimator and predictors

Generalized Variance Function Model

$$log(V_{p\,j}) = f(\theta_j, X_j, \gamma) + q_j$$

Given a domain j,

$V_{p\,j}$: true design-based variance
θ_j: a finite population mean or total
X_j: a vector of predictor variables
γ: a vector of function parameters
q_j: a random error with the mean 0

Current Employment Statistics Program

collects data on employment, hours and earnings of nonfarm establishments

- Active CES sample includes approximately one third of all nonfarm payroll employees
- When firms are sampled, they are retained for two years or more

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Sample Design and Special Features

- Sample Unemployment Insurance (**UI**) accounts
- **Stratification** by state, industry and employment size class
- Complete **universe employment counts** of the previous year become available from the **Quarterly Census of Employment and Wages** employment total on a lagged basis
- **Benchmark** the sample estimates annually

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Point Estimators

Given a domain j and a month t,

$$\hat{\theta}_{jt,total} = x_{j0}\,\hat{R}_{jt}$$

$\hat{\theta}_{jt,total}$:	estimator of total employment
x_{j0}:	known total at benchmark month 0
$\hat{R}_{jt}$:	growth ratio estimator from 0 to month t

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Point Estimators (continued)

$$\hat{\theta}_{jt,change} = \hat{\theta}_{jt} - \hat{\theta}_{j,t-1}$$

$$\hat{\theta}_{jt,ratio} = \hat{\theta}_{jt} \,/\, \hat{\theta}_{j,t-1}$$

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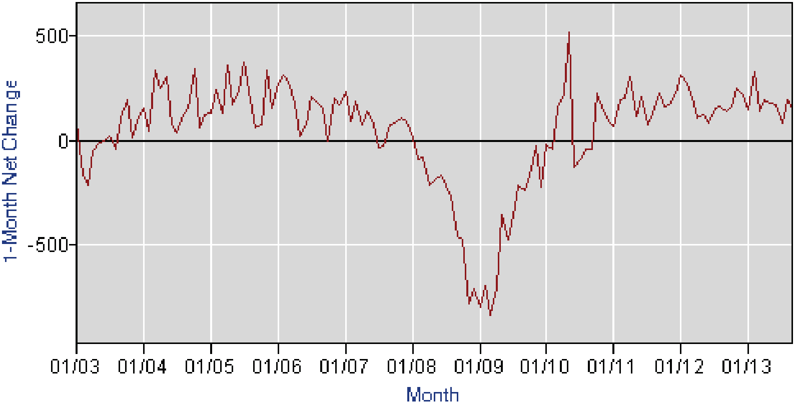
One-Month Employment Change



THOUSANDS; Seasonally Adjusted; http://www.bls.gov/

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Use **generalized variance function** framework
to evaluate **temporal**
or **cross-sectional variability**
in design variance of the CES

Common Group

Find groups of domains with similar GVF coefficients γ
(Wolter, 2007, Section 7.3)

- In CES application, group by years or industries
- Empirical evidence of equality or inequality of coefficients across groups
- Need satisfactory estimator of $V(\hat{\gamma})$

Prospective Models (f)

$$log(V_{jt}) = \gamma_0 + \gamma_1 log(x_{j0}) + \gamma_2 log(t) + \gamma_3 log(n_{jt}) + q_{jt}$$

x_{j0}: known total employment at benchmark month 0

t: distance from 0 to reference month t

n_{jt}: sample size

q_{jt}: a random univariate "equation error" reflecting lack of model fit

estimated γ by OLS regression

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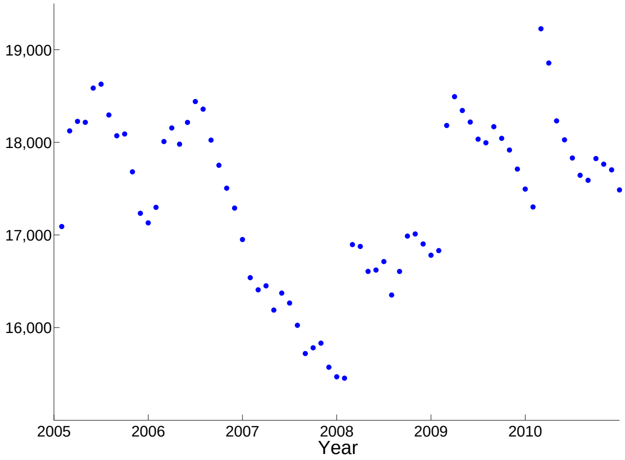
Observed Patterns in n_{jt}

number of responding sample units

- Substantial variability across industries
- "Saw tooth" patterns due to periodic initiation of new units and continuing attrition of current units

Number of Responding Sample Units across Years: Construction



Coefficient Estimates for Model (f)

$$log(V_{jt}) \quad = \quad \gamma_0 + \gamma_1 log(x_{j0}) + \gamma_2 log(t) + \gamma_3 log(n_{jt}) + q_{jt}$$

	intercept γ_0	$\log(x_{j0})$ γ_1	$\log(t)$ γ_2	$\log(n_{jt})$ γ_3
EST.	**-1.43**	**1.16**	**1.17**	**0.22**
s.e.	0.66	0.09	0.07	0.12
t_γ	-2.17	12.77	16.72	1.78

confounding of x_{j0} with n_{jt}

$\log(n_{jt})$ *provided very limited additional value*

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Final Model

$$log(V_{jt}) \;=\; \gamma_0 + \gamma_1 log(x_{j0}) + \gamma_2 log(t) + q_{jt}$$

x_{j0}: known total employment at benchmark month
t: distance from 0 to reference month t
q_{jt}: a random univariate “equation error” reflecting lack of model fit

Testing Homogeneity of Coefficient γ: Estimating Equation Approach (cf. Binder, 1983)

- **Sample design** and **estimation** features are important
- Dependent variables $\hat{V}_{jt}$ may be strongly **correlated** across months, due to the **form of the estimators** as well as the use of a **rotation** sample design
- Sampling is essentially **independent across domains**
- Thus, decompose estimating equation into sum of terms across independent domains

test temporal and cross sectional homogeneity in the CES

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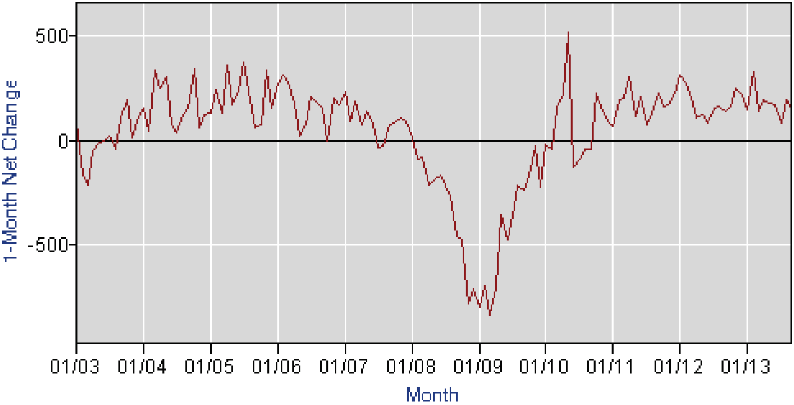
One-Month Employment Change



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Temporal homogeneity

$$log(V_{jt}) = \begin{cases} \gamma_{10} + \gamma_{11} log(x_{j0}) + \gamma_{12} log(t) + q_{jt} & \text{if 2005-2007} \\ \gamma_{20} + \gamma_{21} log(x_{j0}) + \gamma_{22} log(t) + q_{jt} & \text{if 2008-2010} \end{cases}$$

Test homogeneity of coefficients across year groups:

$$H_0 : (\gamma_{10}, \gamma_{11}, \gamma_{12}) = (\gamma_{20}, \gamma_{21}, \gamma_{22})$$

$$W = (A\,\hat{\gamma})' \, [(A\,V(\hat{\gamma})\,A')']^{-1} \, (A\,\hat{\gamma})$$

$$\text{where } A = \begin{pmatrix} 1 & 0 & 0 & -1 & 0 & 0 \\ 0 & 1 & 0 & 0 & -1 & 0 \\ 0 & 0 & 1 & 0 & 0 & -1 \end{pmatrix}, \quad \hat{\gamma} = \begin{pmatrix} \gamma_{10} \\ \gamma_{11} \\ \gamma_{12} \\ \gamma_{20} \\ \gamma_{21} \\ \gamma_{22} \end{pmatrix}$$

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Grouping by Years: cutoff=9.69

Year Group 1 : 2005-2007
Year Group 2 : 2008-2010

Estimator	$\gamma_{1,0}$	$\gamma_{1,1}$	$\gamma_{1,2}$	$\gamma_{2,0}$	$\gamma_{2,1}$	$\gamma_{2,2}$	*W*
Total	0.26	1.08	1.33	0.38	1.15	0.87	11.14
(s.e.)	(4.46)	(0.27)	(0.12)	(2.50)	(0.16)	(0.09)	
Change	-2.18	1.27	0.32	-1.45	1.29	-0.12	6.95
(s.e.)	(2.65)	(0.17)	(0.13)	(2.84)	(0.18)	(0.11)	
Ratio	-2.27	-0.72	0.30	-1.60	-0.71	-0.09	5.73
(s.e.)	(2.59)	(0.17)	(0.13)	(2.75)	(0.17)	(0.10)	

significant coefficients for $\log(x_{j0})$
test statistic for total is larger than cutoff point at $\alpha = 0.05$

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Description of Industries

Industry	Description	Classification
1	Mining and logging	Goods-producing
2	Construction	Goods
3	Durable goods manufacturing	Goods
4	Non-durable goods manufacturing	Goods
5	Wholesale trade	Service-providing
6	Retail trade	Service
7	Transportation and warehousing	Service
8	Utilities	Service
9	Information	Service
10	Financial activities	Service
11	Professional and business services	Service
12	Education and health services	Service
13	Leisure and hospitality	Service
14	Other services	Service

Cross-Sectional Homogeneity (cutoff=12.72)

$$log(V_{jt}) = \begin{cases} \gamma_{10} + \gamma_{11} log(x_{j0}) + \gamma_{12} log(t) + q_{jt} & \text{if Goods} \\ \gamma_{20} + \gamma_{21} log(x_{j0}) + \gamma_{22} log(t) + q_{jt} & \text{if Service} \end{cases}$$

Test statistic similar to year-group case

Estimator	$\gamma_{1,0}$	$\gamma_{1,1}$	$\gamma_{1,2}$	$\gamma_{2,0}$	$\gamma_{2,1}$	$\gamma_{2,2}$	*W*
Total	6.69	0.69	1.15	-2.35	1.29	1.08	15.94
(s.e.)	(2.17)	(0.16)	(0.10)	(3.02)	(0.18)	(0.12)	
Change	4.87	0.90	-0.25	-4.73	1.44	0.23	65.33
(s.e).	(1.61)	(0.12)	(0.07)	(1.86)	(0.13)	(0.12)	
Ratio	4.27	-1.07	-0.21	-4.68	-0.56	0.23	53.52
(s.e.)	(1.64)	(0.12)	(0.08)	(1.90)	(0.13)	(0.12)	

strong indication of differences in the Goods and Services coefficients

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Quantiles of Residuals from Two Groups of Industries

(for total employment)

$$\hat{q}_{jt} = log(\hat{V}_{jt}) - X_{jt}\,\hat{\gamma}$$

Group	0.01	0.10	0.25	0.50	0.75	0.90	0.99	IQR
Goods	-0.98	-0.69	-0.52	-0.23	0.65	1.07	1.52	1.17
Services	-1.63	-0.79	-0.42	-0.02	0.38	0.84	2.26	0.80

Goods-producing industries have a wider IQR

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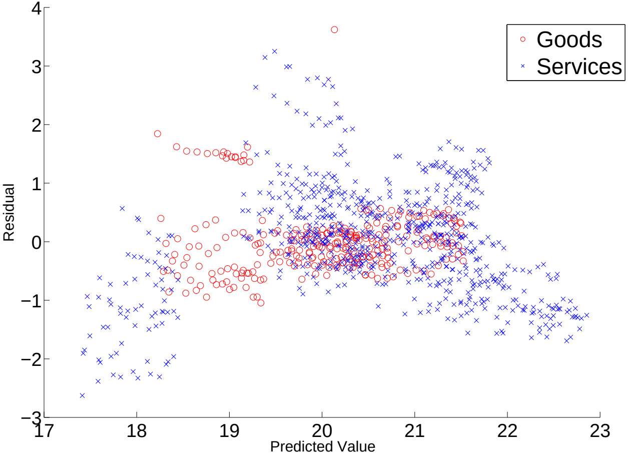
Log-Scale Residuals against Predicted Values $(X_{jt}\hat{\gamma})$



Summary

- Presented tools to evaluate patterns of variability using generalized variance function framework
- Evaluated temporal and cross-sectional variability by examining GVF coefficients across groups
- For GVF coefficients, estimated their variance estimators using estimating-equation to take into account for clustering

THANK YOU.

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