

Improving the Accuracy of Economic Measurement with Multiple Data Sources: The Case of Payroll Employment Data

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How can one combine official and alternative data to improve the accuracy of economic measurement?

Our approach for the case of payroll employment data:

- ▶ Build a payroll employment index (ADP-FRB) using alternative, private-source microdata (ADP)
- ▶ Compare official and alternative data in benchmarking and forecasting
- ▶ Use a state-space model to combine the information in CES and ADP-FRB (treat both as noisy indicators of true employment)

CES, QCEW important in our application: not about replacing government statistics.

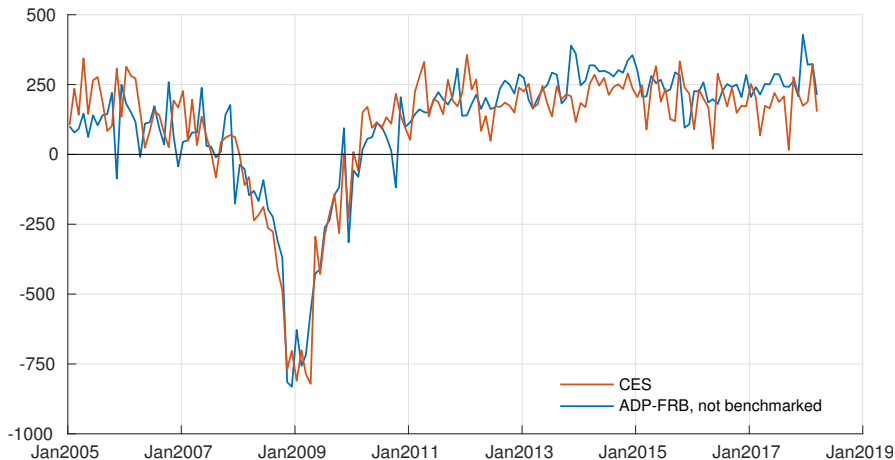
Our data based on records from the payroll processor ADP (July 1999-present):

- ▶ ADP processes paychecks for 20 percent of private US workers
- ▶ Every pay period: client firm sends ADP data on the number of workers to pay
- ▶ We process microdata data into aggregate private employment estimates using methodology analogous to CES

Strengths and weakness of our data:

- ▶ We observe all pay periods, not just a reference period
- ▶ Not a probability sample, but approximately representative [More](#)
- ▶ Real-time measurement: we get data updates weekly

CES and ADP-FRB Payroll Employment Gains (in thousands)



ADP-FRB tracks the business cycle very well (even without benchmarking).

Comparing CES and ADP-FRB Payroll Employment Data

CES and ADP-FRB data are annually benchmarked to QCEW data:

- ▶ Over the last 10 years, root-mean-squared benchmark revision is 0.49 percent for ADP-FRB data and 0.36 for CES data
- ▶ In 4 out of last 10 years ADP-FRB had a smaller benchmark revision, including during the Great Recession [Table](#) [Great Recession Real-Time Chart](#)
- ▶ In annual regressions CES data outperform ADP-FRB data [Regression Results](#)

Evaluate the ability of ADP-FRB data to predict the final print of monthly CES data:

- ▶ ADP-FRB data are statistically significant for predicting final CES data, even after controlling for market expectations [Regression Results](#)
- ▶ Improvement in terms of RMSE decline is modest

What is the Best Use of ADP-FRB Data?

Is forecasting the best use of ADP-FRB data?

CES data are subject to measurement imprecision due to:

- ▶ sampling error
- ▶ birth-death adjustment
- ▶ nonresponse
- ▶ reference period concept

We proceed by combining the information in CES and ADP-FRB data within a state-space framework.

State Space Model

Kalman filter assumptions:

- ▶ Unobserved state (true employment growth) follows an AR(1):

$$\Delta EMP_t^U = \mu(1 - \rho) + \rho \Delta EMP_{t-1}^U + \epsilon_t^U$$

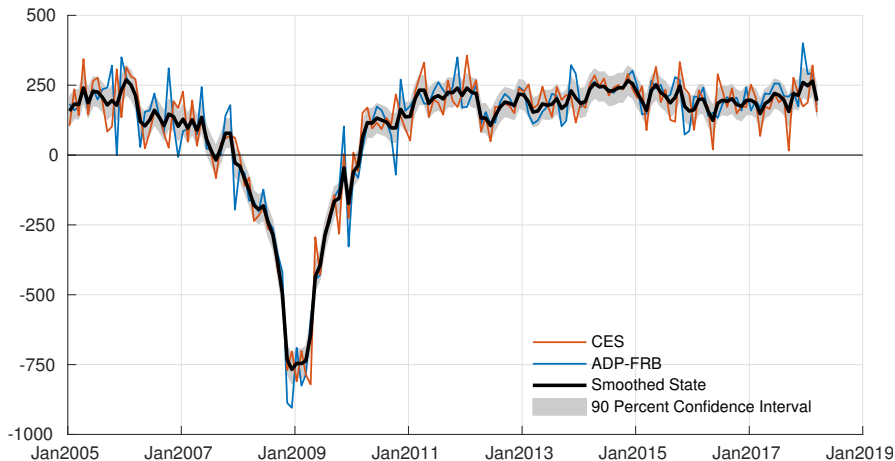
- ▶ CES and ADP-FRB are noisy signals of truth:

$$\begin{bmatrix} \Delta EMP_t^{CES} \\ \Delta EMP_t^{ADP-FRB} \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \end{bmatrix} \Delta EMP_t^U + \begin{bmatrix} \epsilon_t^{CES} \\ \epsilon_t^{ADP-FRB} \end{bmatrix}$$

Feed in the data:

- ▶ Extract estimates of observation noise
- ▶ Extract estimates of true employment growth

State Space Estimate of Payroll Employment Gains (in thousands)



State estimate combines the noisy information in both series.

Interpretation of State Space Results

State-space estimates:

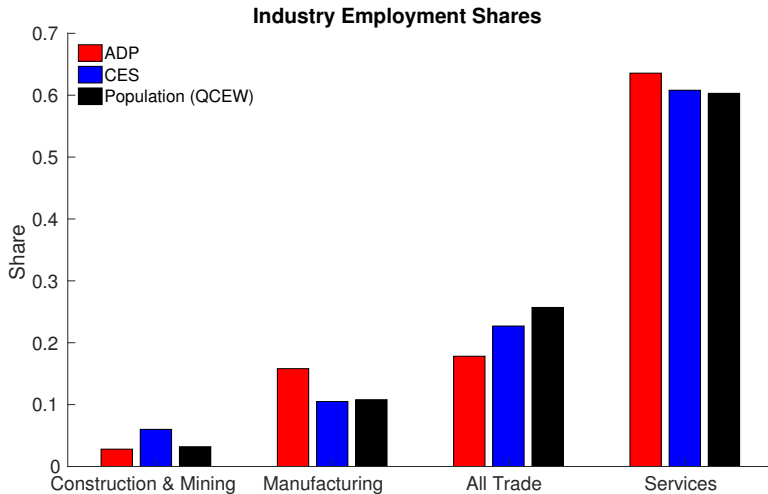
- ▶ Model puts roughly equal weight on CES, ADP-FRB (Kalman gains are similar)
- ▶ Robust to changes in assumptions: AR(1), random walk, correlation of observation noise
- ▶ Adding CPS series, adjusted to match CES scope, yields similar results (very low weight on CPS data)

In a forecasting regression, the state-space estimate outperforms CES and ADP-FRB data (and the state-space estimate based on CES data only). [Regression Results](#)

Conclusions

- ▶ Alternative data can improve the accuracy of payroll employment estimates
- ▶ ADP-FRB data contain similar amount of information as CES data (intuition: roughly similar sample size)
- ▶ Statistical agencies could potentially use data from payroll processors to increase their sample size

Representativeness



Representativeness

Pay frequency	ADP emp.	ADP estabs.	QCEW estabs.
Weekly	23.4	22.4	32.2
Biweekly	55.1	45.8	40.0
Semimonthly	17.5	20.6	18.5
Monthly	4.0	11.2	9.3

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Representativeness

Census Region	ADP emp.	ADP estabs.	QCEW emp.
Northeast	28.2	28.1	18.2
South	29.4	30.2	34.9
Midwest	20.2	16.6	20.1
West	22.2	25.2	26.8

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Benchmark Revisions

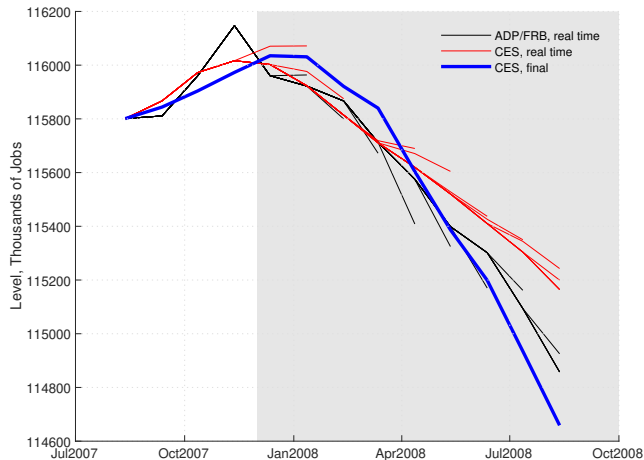
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
ADP-FRB	-173	-451	12	709	283	-230	-1030	-853	-322	-623
CES	-137	-933	-391	229	481	340	105	-259	-151	136
CES No BD	645	-216	-55	561	972	975	874	638	737	1066

Notes: Units: Thousands of jobs. CES revisions are the post-benchmark (QCEW-based) March estimate less the pre-benchmark estimate. ADP-FRB revisions are calculated in a similar fashion. CES no BD are the CES benchmark revisions that would have occurred excluding net birth-death adjustment.

Source: <https://www.bls.gov/web/empsit/cesbmart.pdf>, authors' calculations.

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Real-Time vs. Current Vintage Estimates



During Great Recession ADP-FRB data outperformed CES data.

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Forecasting Annual Employment Changes

	(1)	(2)	(3)	(4)	(5)
CES	1.126*** (0.0316)			1.104*** (0.142)	
CES excl. Birth-Death		1.154*** (0.0235)			0.927*** (0.0847)
ADP			0.976*** (0.0543)	0.0197 (0.121)	0.199** (0.0818)
Constant	-163.7* (76.93)	604.5*** (75.29)	-135.1 (172.8)	-163.6* (82.61)	452.5*** (79.37)
Observations	10	10	10	10	10
Adj. R-squared	0.989	0.993	0.965	0.988	0.994
RMSE	299.2	243.3	535.9	319.7	224.2

Notes: Dependent variable is benchmarked annual change in private nonfarm employment, March to March. Years 2008-2017. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Robust standard errors in parentheses.

Forecasting Monthly Employment Changes

	(1)	(2)	(3)	(4)	(5)
ADP-FRB active employment			0.29** (0.11)	0.39*** (0.11)	0.16** (0.07)
Lagged private CES employment	0.82*** (0.07)	-0.13 (0.15)	-0.21 (0.14)	0.51*** (0.12)	
Lagged UR change	-156.73** (61.56)	-45.66 (52.17)	-43.05 (46.84)	-123.09** (58.02)	
Unemployment expectations	39.17*** (11.82)	30.95*** (11.01)	14.08 (12.29)	16.55 (12.74)	15.21 (10.88)
Initial UI claims	-3.10*** (0.74)	-0.91 (0.71)	-0.79 (0.72)	-2.52*** (0.83)	-0.56 (0.52)
CES employment expectations		1.15*** (0.16)	0.98*** (0.15)		
Private CES employment					0.97*** (0.07)
UR change					33.12 (36.03)
Constant	4.87 (9.36)	-17.77* (10.40)	-24.39** (11.58)	-7.48 (10.77)	-17.85** (8.98)
RMSE	99	84	80	92	58

Notes: Dependent variable is final print of CES private employment. ADP series are real-time vintage, as of 5 weeks after the start of the month (i.e., the week before or week of the Employment Situation release). Unemployment expectations are from the Michigan survey. CES employment expectations are eve-of-release median markets expectations. Lagged private CES employment refers to pre-Employment Situation release. Robust standard errors in parentheses. RSMES are calculated in-sample. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Estimation period: 2007m1-2018m9.

Forecasting Monthly Employment Changes with State Estimate

	(1) CES employment	(2) CES employment	(3) 3-month average CES employment
Constant	-28.14 (19.43)	-28.52 (18.78)	-17.05 (20.35)
ADP-CES State	1.43*** (0.49)	1.50*** (0.55)	1.69*** (0.44)
ADP-FRB Emp.	-0.18 (0.15)	-0.19 (0.16)	-0.30** (0.15)
CES Emp.	-0.18 (0.34)	-0.11 (0.55)	-0.41 (0.31)
CES State		-0.12 (0.68)	-0.04 (0.42)

Notes: The dependent variable in columns 1 and 2 is the fully revised change in CES private employment at time $t + 1$; in column 3 the dependent variable is the average of the fully revised change in CES private employment for $t + 1$, $t + 2$ and $t + 3$. ADP series are real-time vintage, as of 5 weeks after the start of the month. CES series appearing as independent variable or in state-space estimates are real-time vintage. Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Estimation period: 2007m1-2018m9.