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The Disappointing Recovery of Output after 2009

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Supplementary Econometric Appendix

A.1. The partially linear trend, its standard error, and state-space alternative (Section II.A)

As discussed in Section **Error! Reference source not found.**, we estimate μ_t using the partially linear regression model. An alternative would be to make an explicit parametric assumption about the process followed by μ_t and z_t. For example, Gordon (2014) estimates cyclically adjusted trends by modeling μ_t as a Gaussian random walk and z_t as serially uncorrelated and Gaussian, with μ and z being independent. This gives a fully specified likelihood that can be maximized using state space methods. Gordon (2014) then estimates μ_t using the Kalman smoother.

Although these two approaches sound different, in the end they both involve estimation of μ_t by smoothing $y_t - \hat{\beta}(L)\Delta u_t$ as in (9). As a matter of econometric theory, when the variation in μ_t is small, the following three estimators of β(L) are asymptotically equivalent: (i) OLS estimation of y_t on leads and lags of U_t; (ii) the two-step partially linear regression method, in which y_t and U_t are both detrended using the low-frequency smoother κ(L); and (iii) joint estimation of state space parameters and β(L) by maximizing the Gaussian likelihood computed using the Kalman filter, as in Gordon (2014). Stock and Watson (2016, Figure 2) compare the lag weights for the biweight filter and the implied filter from the Kalman smoother for the random-walk model of μ_t. On a series-by-series basis, the Kalman smoother and partially linear regression approaches often give quite similar results. However, because the state-space approach entails estimation of different model parameters (different variances for the latent disturbances) for each series, the implied smoothing filters differ across series so the useful additivity property discussed in Section II does not hold for the state space approach.

The use of the OLS estimator of β(L) in equation (9) (that is, estimator (i) in the previous paragraph) to estimate the trend departs from standard practice in partially linear regression, in which β(L) is estimated by regressing prefiltered (1-κ(L))y_t on leads and lags of prefiltered (1-κ(L))Δu_t. As mentioned, this departure is justified theoretically when the variation in μ_t is small compared with the variation in Δu_t and z_t, as it is here, and in any event the two estimation methods yield virtually identical results. We use the simpler approach (i) here for transparency and to stay as close as possible to conventional implementations of Okun's Law.

HAC standard errors for $\hat{\mu}_t$ are computed as follows. With some abuse of notation, write $\hat{\mu}_t = \kappa_t' v$, where κ_t is a T-vector of weights associated with κ(L) and v is the T-vector with $v_t = y_t - \hat{\beta}(L)\Delta u_t$. Then $\mathrm{var}(\hat{\mu}_t) = \mathrm{var}(\kappa_t' v) = \kappa_t'\Sigma_v\kappa_t$, where Σ_v is the $T\times T$ covariance matrix of v. If κ_t were the vector of ones, then $\mathrm{var}(\hat{\mu}_t)$ is the HAC estimation problem of estimating the variance of the mean. The problem here is closely related in that κ_t has many very similar values. There are many ways to address the HAC problem. Here, we chose a simple method for reliably computing positive semidefinite inner products by approximating the stochastic process for v_t as a first order autoregression, then estimating $\kappa_t'\Sigma_v\kappa_t$ using the implied parametric covariance matrix.

A.2 Variables used to construct factors for the DFM (Section II.C)

The DFM factors were estimated using principal methods surveyed in Stock and Watson (2016) and 123 time series from an updated version of the dataset described in that paper. The variables are from 12 broad categories shown in text Table 1. The specific series are listed in Appendix Table A-1. The transformation applied to each series, for example growth rates at an annual rate for NIPA expenditure series, is given in the final column of the table, and the codes are defined in the table notes.

A.3. Computation of the factor forecasts (Section II.C)

To fix concepts, write the dynamic factor model (DFM) as,

$$X_t = \Lambda F_t + e_t \tag{A-1}$$

$$F_t = \Phi(\mathrm{L})F_t + \eta_t, \tag{A-2}$$

where Λ is the $N\times r$ matrix of factor loadings, Φ(L) is the vector autoregression lag polynomial for the factors, X_t is the $N\times 1$ vector of series, F_t is the $r\times 1$ vector of factors, and η_t are the innovations to the factors. The term ΛF_t is referred to as the common component of X_t and e_t is the idiosyncratic component.

The factor forecasts described in Section **Error! Reference source not found.** are computed as follows.

(i) All 123 series used to estimate the factors are transformed to approximate stationarity. Real activity variables are transformed to (annualized) growth rates, inflation is transformed to first differences, interest rates and unemployment rates appear in first differences, spreads and ratios that are approximately cointegrating appear as differences of levels or log levels. (The specific transformation applied to each series is listed in the data appendix.) Any remaining near-zero frequency variation is removed by local demeaning using a biweight kernel with 25-year bandwidth. See Stock and Watson (2016).

(ii) The factors are estimated by principal components (computing using least squares on the unbalanced panel of data) over the period 1959, third quarter through 2016, second quarter.

(iii) The DFM parameters Λ and Φ(L), with 4 factors and 4 VAR lags, are estimated by OLS, using data from 1984, first quarter, to 2009, second quarter, treating the estimated factors $\hat{F}_t$ as data. The start date of 1984, first quarter, is chosen to align with standard estimates of the start of the Great Moderation period. There is evidence of a break in the factor loadings around this date, see Stock and Watson (2016) for a review of this literature. As discussed there, even if there are structural breaks in the dynamic factor model coefficients it can be desirable to estimate the factors over the full sample (here 1959-2016), and this appears to be the case for this data set.

(iv) Given the factors through the trough quarter, forecasts of the factors, $\hat{F}_{t|2009q2}$, are computed for succeeding quarters using the factor vector autoregression and history of the factors through the 2009 trough date.

(v) Given the factor forecasts, forecasts of the detrended variables are computed as $X_{t|2009q2} = \hat{\Lambda}\hat{F}_{t|2009q2}$ for the succeeding period, where the estimated value of Λ is computed by using data from 1984, second quarter, through the 2009 trough date.

(vi) Forecasts for the original series (not detrended) are computed by adding the forecast of the detrended variable to the trough value of the trend, adjusted as appropriate for the demographic trend in the labor force participation rate (details discussed below). The results are robust to variations in the benchmark model, including shifting the jumping-off date to 2009, fourth quarter. For the main series, including output and employment, and productivity, they are also robust to using a low-dimensional vector autoregression.

In the context of the trend-cycle-irregular decomposition, the forecast from (v) is the estimated cyclical component of the series c_t, the forecast from (vi) is the estimated trend + cyclical component $\mu_t + c_t$, and the forecast error—the unexpected shortfall or exceedance of y_t—is the irregular component z_t.

Section **Error! Reference source not found.** estimated the decline in the labor force participation rate (LFPR) associated with changing demographics in the population. Because these changing demographics were largely known or could have been accurately forecast over the 2009-2016 period, we incorporate these changes in the forecast of the growth rate for LFPR. These demographic adjustments to the LFPR growth rate forecast are included one-for-one in the forecast growth rate of employment and hours, and in the various output measures after multiplying by labor's share. Forecasts for the trends in capital, TFP, and labor quality are left unchanged. To maintain adding-up for the expenditure decomposition of GDP in **Error! Reference source not found.**, the trend in each expenditure component is adjusted by its share in GDP multiplied by the LFPR demographic trend adjustment in GDP.

A.3. Full set of figures of DFM forecasts and actuals (Section III.C).

Text Figure 6 shows the predicted and actual values of selected variables and their forecasts, computed using the dynamic factor model as described in Section II. These plots are provided in Appendix Figure A-2 for all the growth decomposition variables in Table 4; in Figure A-3 for the expenditure variables in Table 5; and Figure A-4 presents the forecasted and actual plots for some additional employment variables. Figures A-3 – A-5 are the complete set of forecast/actual figures so these figures include the series presented in text Figure 6.

A.4. Sensitivity analysis for Okun's law coefficients and Table 3 decomposition (Section III.D).

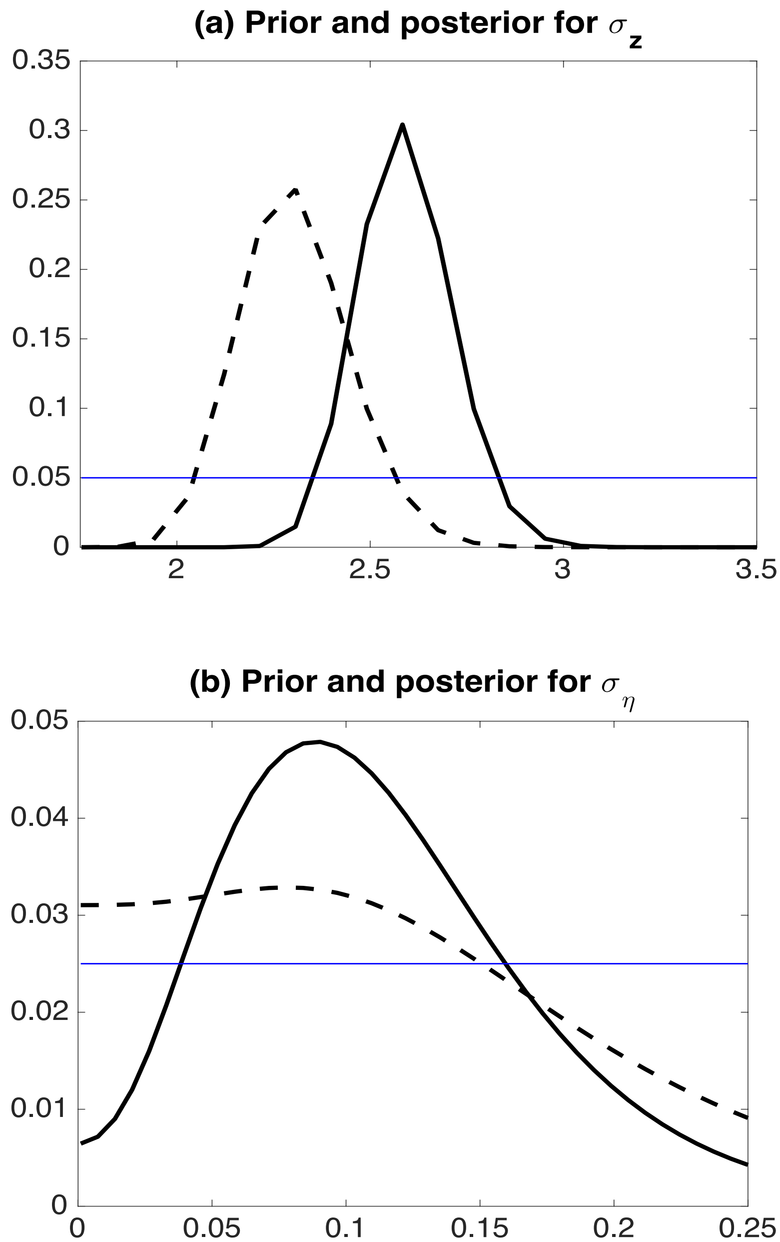
Section III.D briefly summarizes results from sensitivity analysis, in which different lag lengths and/or leads and lags are used to estimate the Okun's law coefficients. Changing these choices yields different numerical values for the decompositions in text Table 3, however the sensitivity of the Table 3 results to these changes is very small. Appendix Table A-2 provides results for four different choices of lag lengths (including the 12-lag specification discussed in the text in the context of the LFPR cyclical sensitivity) and estimation samples.

A.5. Bayesian random-walk-plus noise model for TFP growth rates (Section IV.A).

Text Figures 8 and 9 show results from a model for TVP growth in which the growth rate of TFP, say y_t, follows the model $y_t = \beta(L)\Delta U_t + \mu_t + z_t$, where $\Delta\mu_t = \eta_t$ and $\{z_t\}$ and $\{\eta_t\}$ are mutually independent Gaussian white noise processes that are independent of Δu_t. We fixed $\beta(L)$ at its OLS estimate and estimated σ_z, σ_η, and the time path of $\{\mu_t\}$ using Bayes methods using independent priors for σ_z, σ_η, and μ_0. Specifically, $\mu_0 \sim N(1,10)$, $\sigma_z \sim u[0.67s,1.33s]$ where s is the sample standard deviation of

$y_t - \beta(L)\Delta u_t$, and $\sigma_\eta \sim U[0,0.25]$. Posteriors for $\{\mu_t\}$, σ_z and σ_η, were computed using $y_t - \beta(L)\Delta u_t$ for $t\in[1956{:}q3,2016{:}q2]$ and $t\in[1981{:}q3,2016{:}q2]$. Posterior quantiles for $\{\mu_t\}$ are shown in Figure 8 based on the 1956-2016 sample. The marginal posteriors for σ_z and $\sigma_{\Delta\eta}$ are shown in Appendix Figure A-1.

Figure A-1: Priors and Posteriors for Random-walk + white noise model for TFP growth rates



Notes: 1956-2016 posterior (solid black), 1981-2016 posterior (dashed), prior (thin solid blue).

Figure A-2: Forecasted and Actual Paths from the Factor Model: Growth Accounting Variables

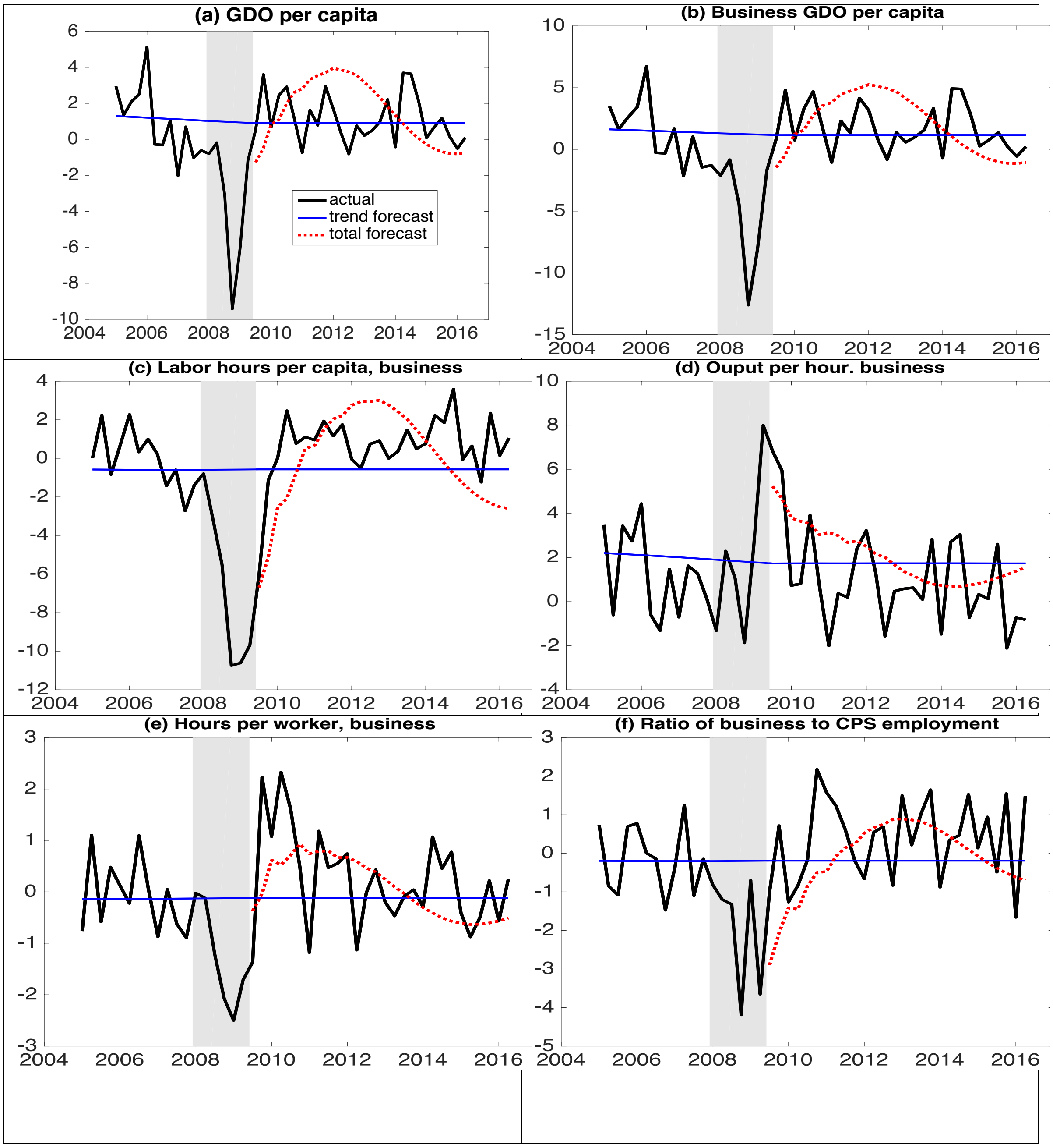
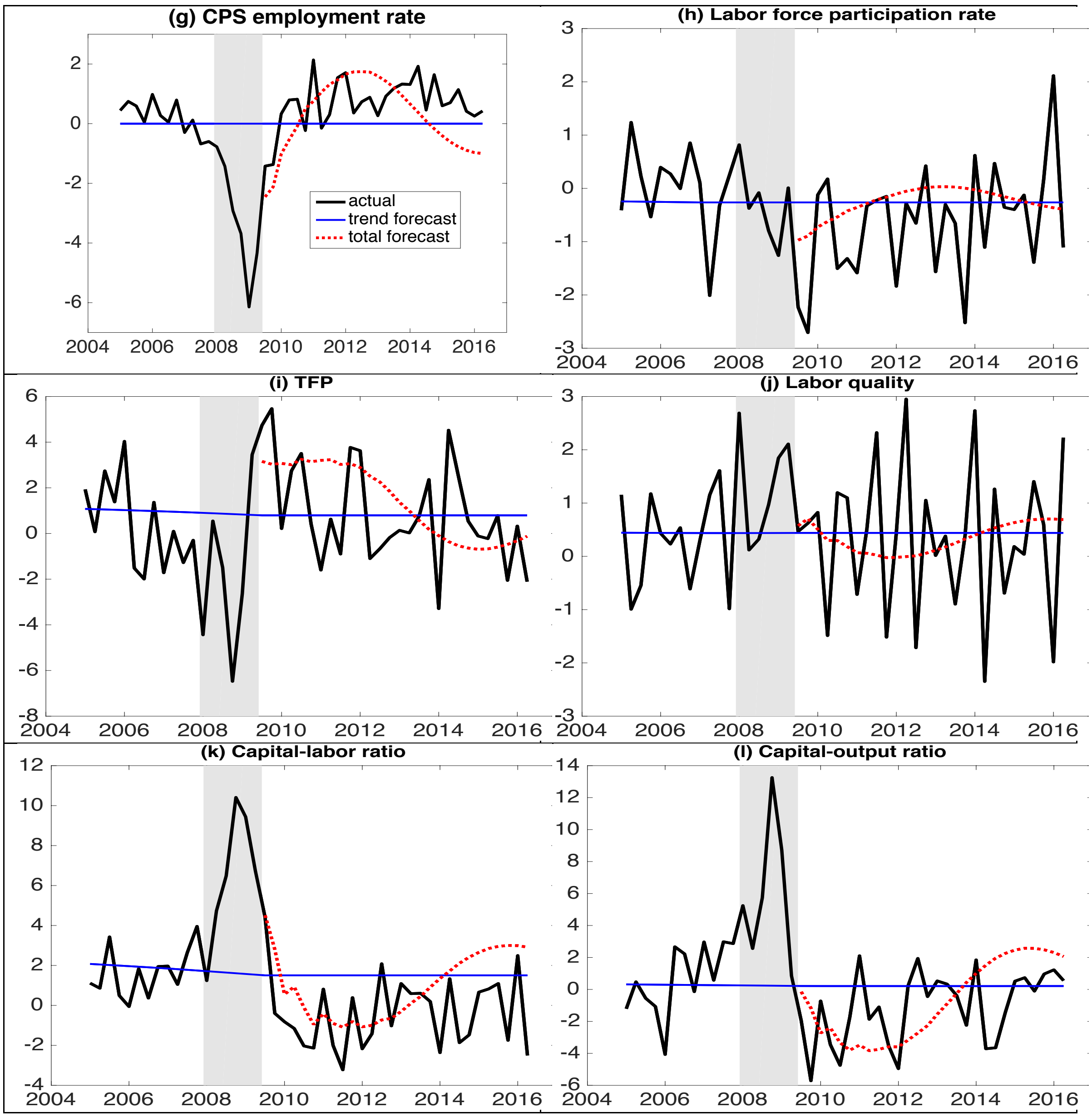


Figure A-2, continued



Notes to Figure: Black line is the actual growth rate of the variable, red line is its forecast based on the 6 factors, and the blue line is the long-term growth trend.

Figure A-3. Forecasted and Actual Paths from the Factor Model: Expenditure Variables (not share-weighted)

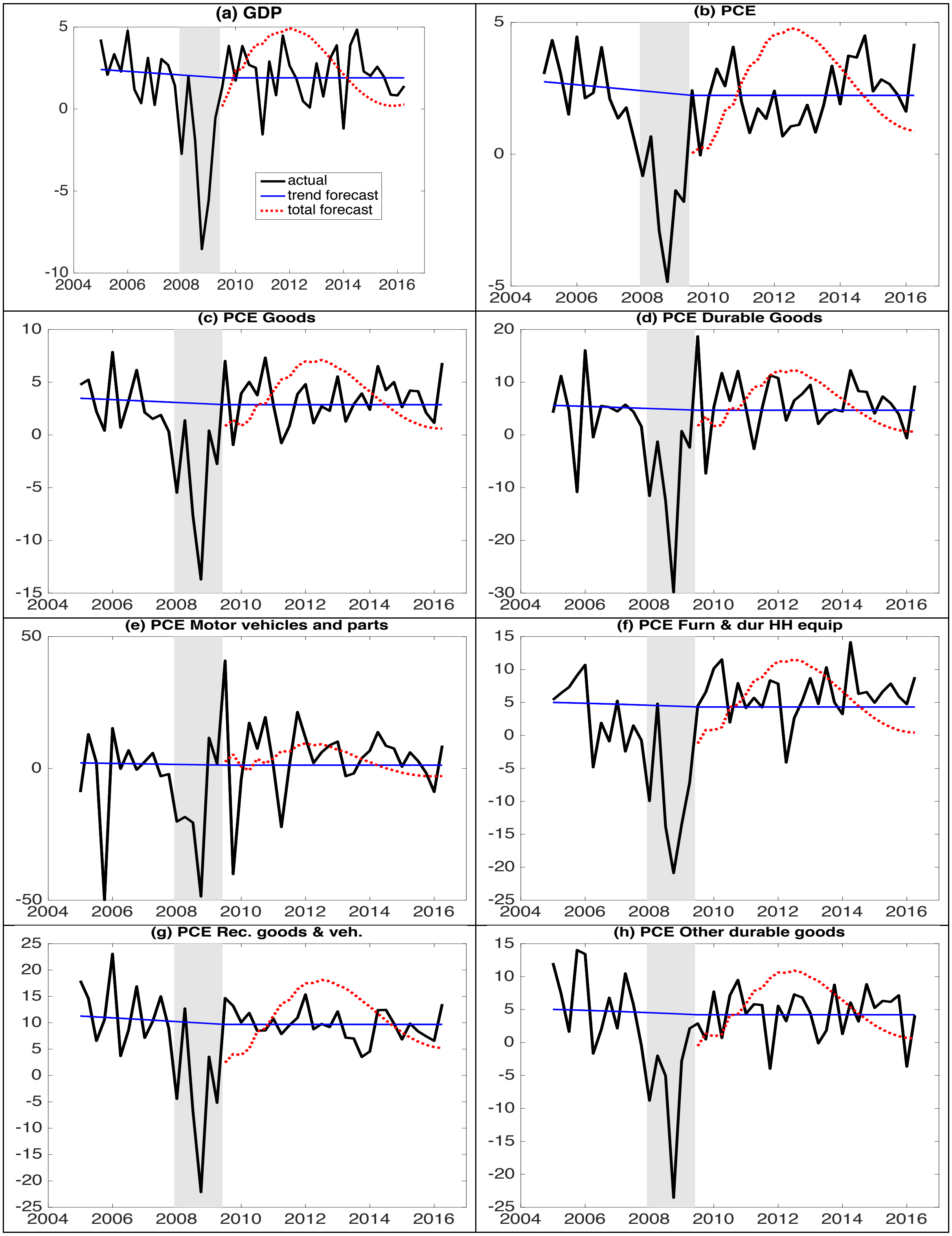


Figure A-3, continued

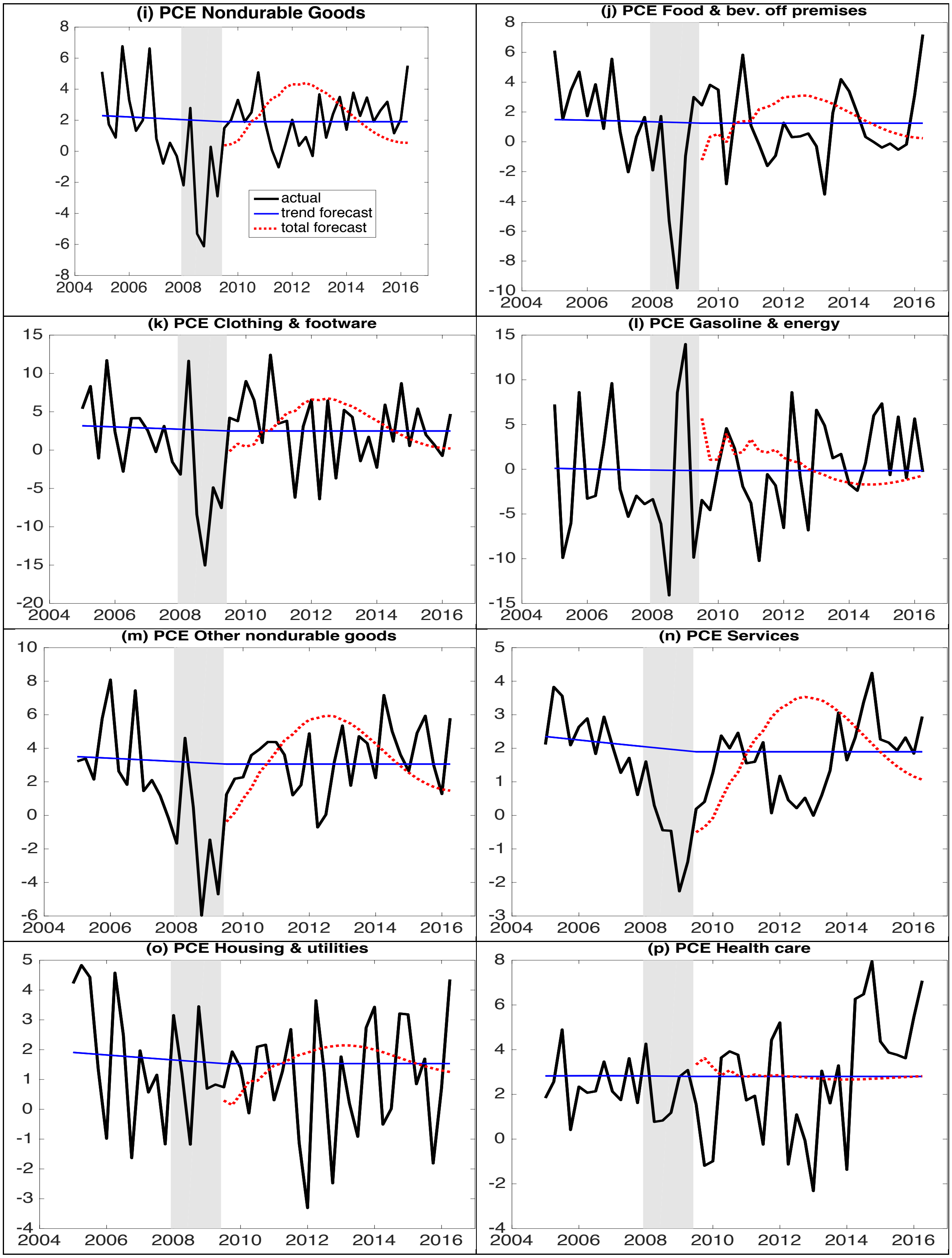


Figure A-3, continued

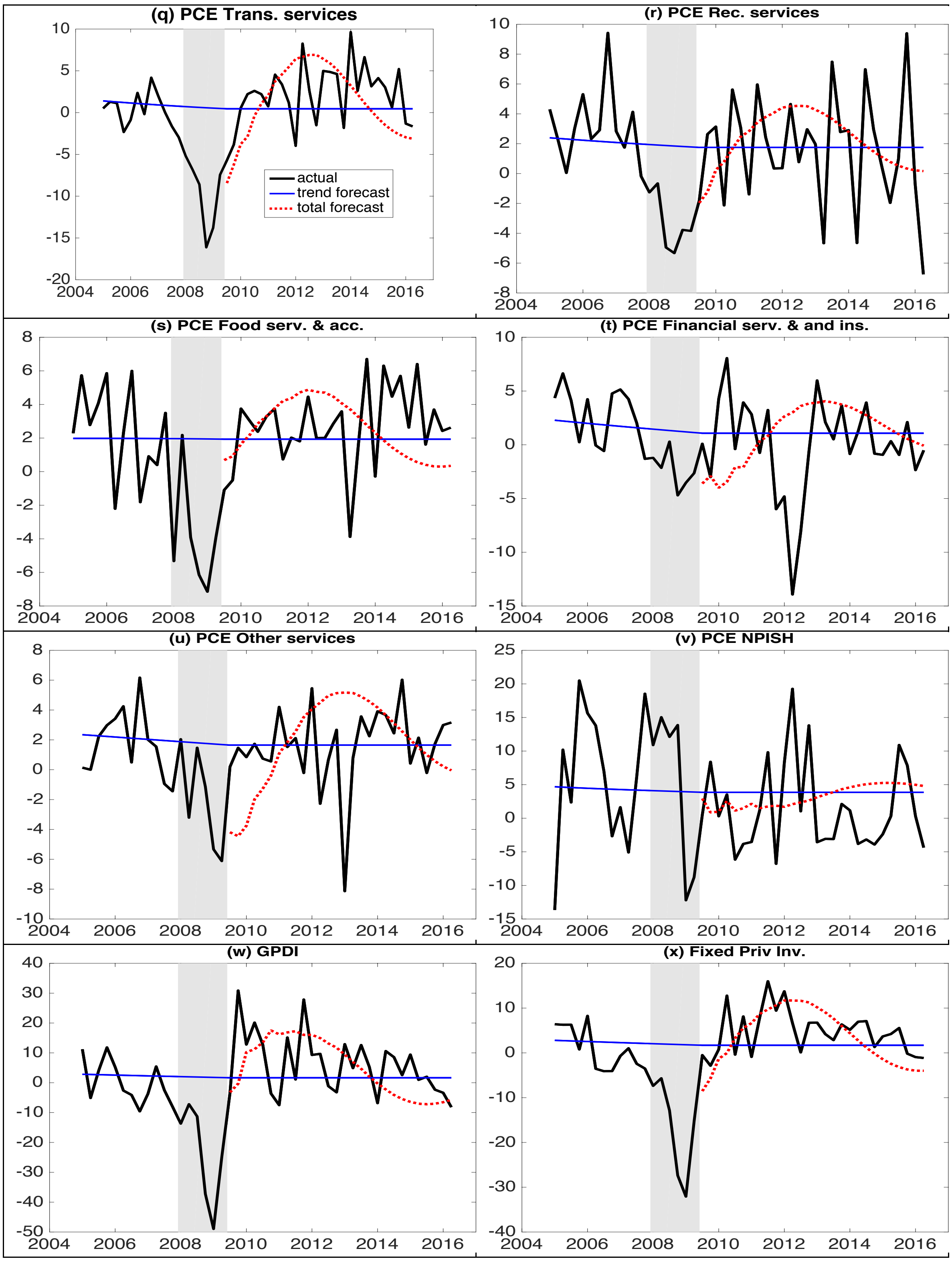


Figure A-3, continued

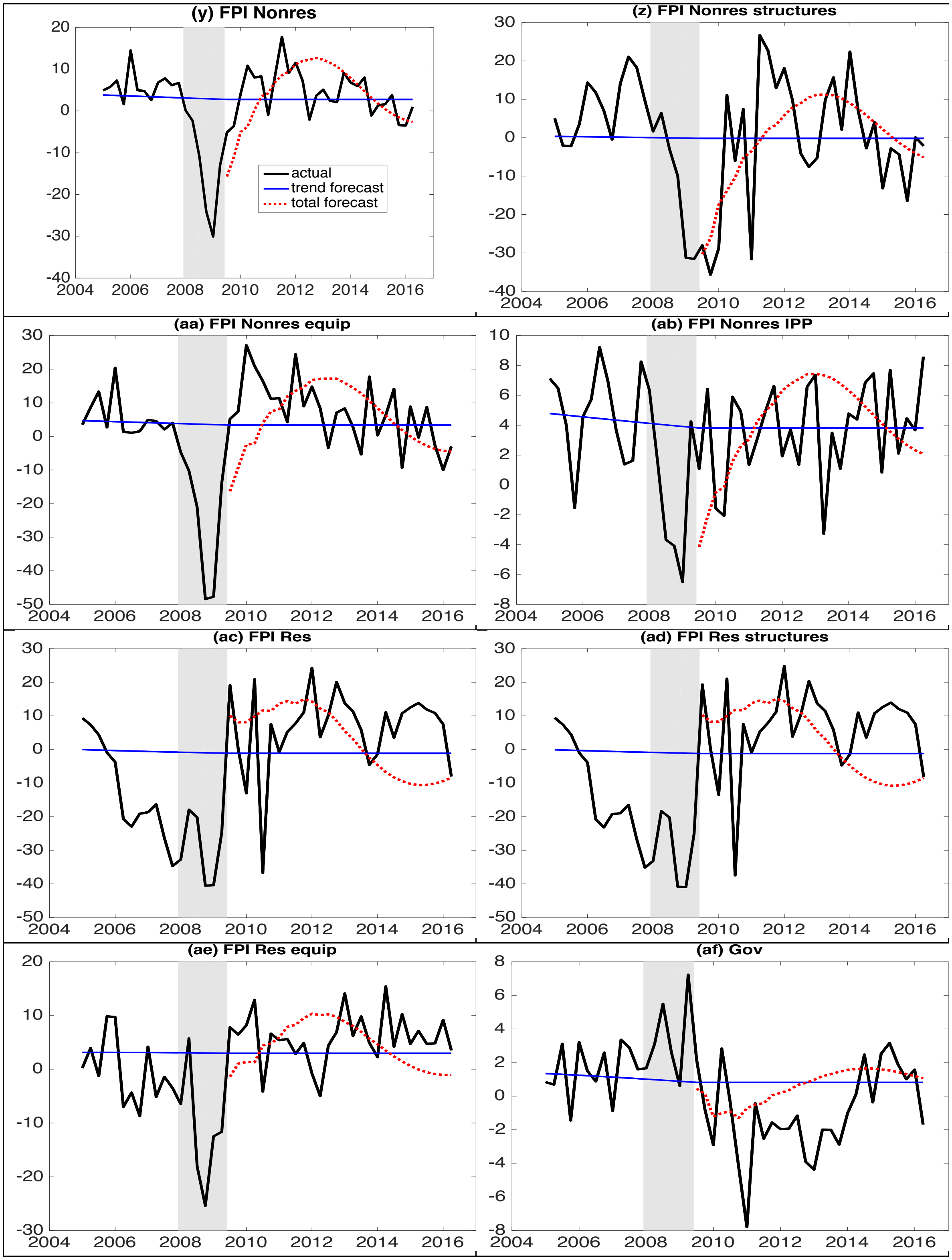
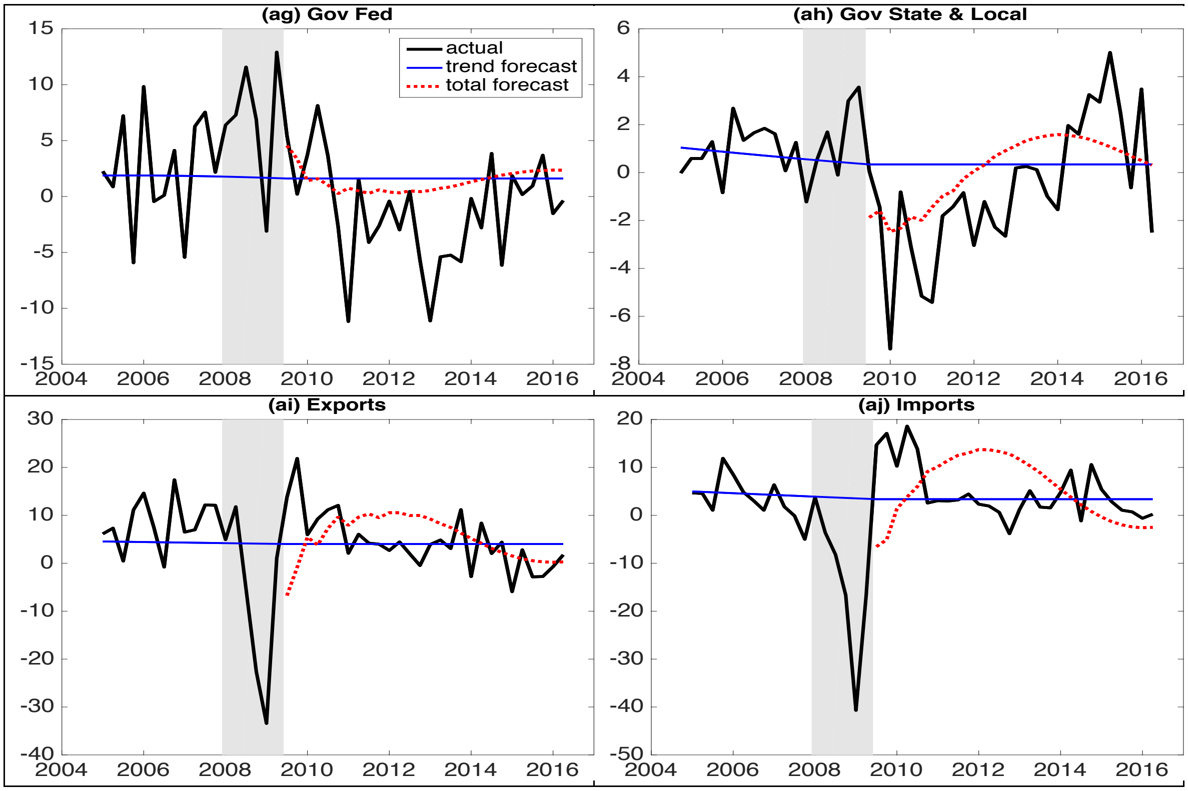
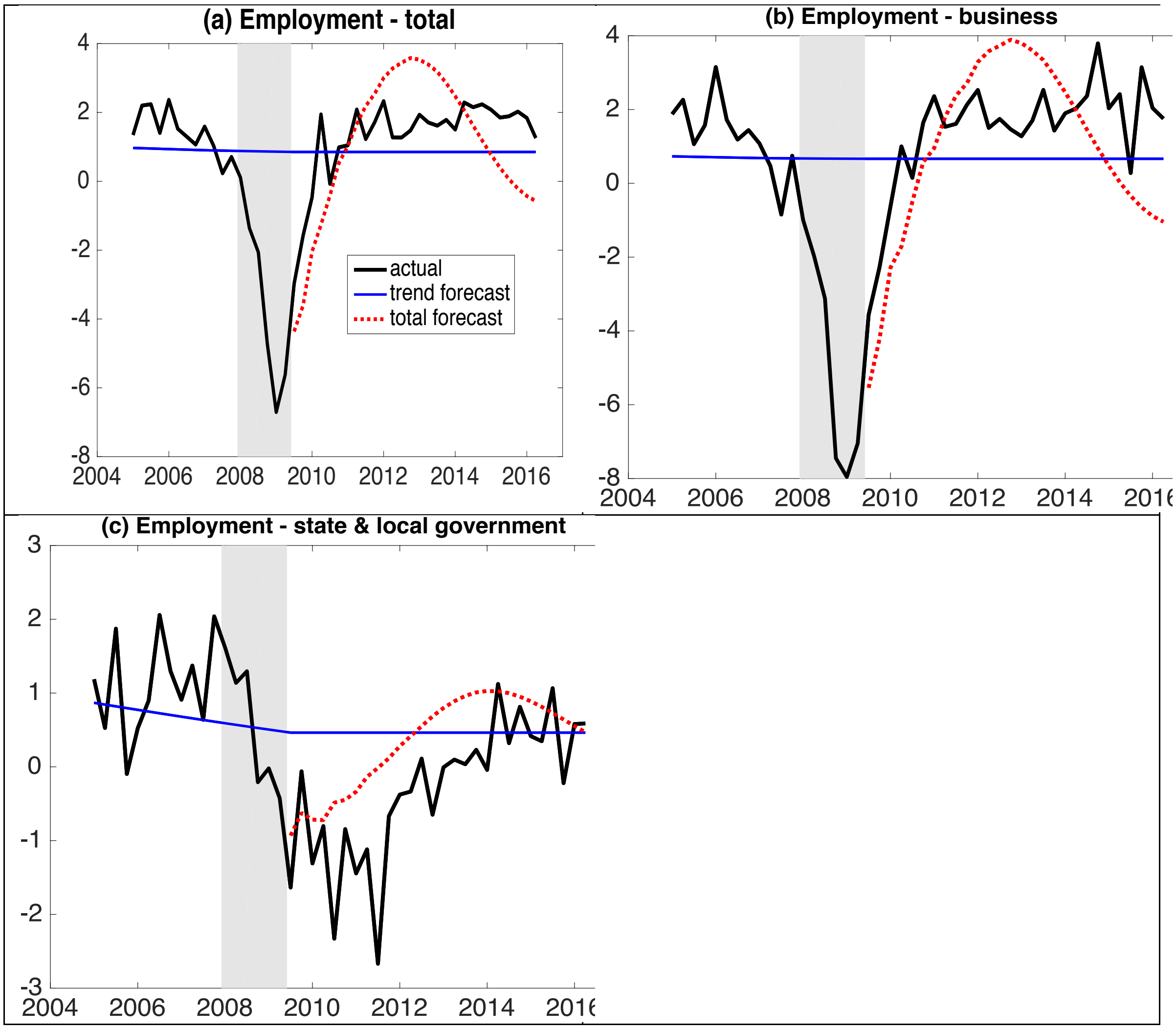


Figure A-3, continued



See the notes to Figure A-2.

Figure A-4. Forecasted and Actual Paths from the Factor Model: Employment variables



See the notes to Figure A-2.

Table A.1: Data Series

	Name	Description	Sample Period	T
(1) NIPA				
1	Cons:Dur	Real personal consumption expenditures: Durable goods	1959:Q1, 2016:Q3	5
2	Cons:Svc	Real personal consumption expenditures: Services	1959:Q1, 2016:Q3	5
3	Cons:NonDur	Real personal consumption expenditures: Nondurable goods	1959:Q1, 2016:Q3	5
4	Inv:Equip	Real Gross Private Domestic Investment: Fixed Investment: Nonresidential: Equipment	1959:Q1, 2016:Q3	5
5	FixInv:NonRes	Real private fixed investment: Nonresidential	1959:Q1, 2016:Q3	5
6	FixedInv:Res	Real private fixed investment: Residential	1959:Q1, 2016:Q3	5
7	Ch. Inv/GDP	Change in Inventories /GDP	1959:Q1, 2016:Q3	1
8	Gov:Fed	Real government consumption expenditures and gross investment: Federal	1959:Q1, 2016:Q3	5
9	Real_Gov Receipts	Government Current Receipts (Nominal) Defl by GDP Def	1959:Q1, 2016:Q3	5
10	Gov:State&Local	Real government consumption expenditures and gross investment: State and local	1959:Q1, 2016:Q3	5
11	Exports	Real exports of goods and services	1959:Q1, 2016:Q3	5
12	Imports	Real imports of goods and services	1959:Q1, 2016:Q3	5
(2) Industrial Production				
13	IP: Dur gds materials	Industrial Production: Durable Materials	1959:Q1, 2016:Q3	5
14	IP: Nondur gds materials	Industrial Production: nondurable Materials	1959:Q1, 2016:Q3	5
15	IP: Dur Cons. Goods	Industrial Production: Durable Consumer Goods	1959:Q1, 2016:Q3	5
16	IP: Auto	IP: Automotive products	1959:Q1, 2016:Q3	5
17	IP:NonDur Cons God	Industrial Production: Nondurable Consumer Goods	1959:Q1, 2016:Q3	5
18	IP: Equip	Industrial Production: Equipment, total, Index 2012=100, Monthly, Seasonally Adjusted	1959:Q1, 2016:Q3	5
19	Capu Tot	Capacity Utilization: Total Industry	1967:Q1, 2016:Q3	1
(3) Employment and Unemployment				
20	Emp: DurGoods	All Employees: Durable Goods Manufacturing	1959:Q1, 2016:Q3	5
21	Emp: Const	All Employees: Construction	1959:Q1, 2016:Q3	5
22	Emp: Edu&Health	All Employees: Education & Health Services	1959:Q1, 2016:Q3	5
23	Emp: Finance	All Employees: Financial Activities	1959:Q1, 2016:Q3	5
24	Emp: Infor	All Employees: Information Services	1959:Q1, 2016:Q3	5
25	Emp: Bus Serv	All Employees: Professional & Business Services	1959:Q1, 2016:Q3	5
26	Emp:Leisure	All Employees: Leisure & Hospitality	1959:Q1, 2016:Q3	5
27	Emp:OtherSvcs	All Employees: Other Services	1959:Q1, 2016:Q3	5
28	Emp: Mining/NatRes	All Employees: Natural Resources & Mining	1959:Q1, 2016:Q3	5
29	Emp:Trade&Trans	All Employees: Trade Transportation & Utilities	1959:Q1, 2016:Q3	5
30	Emp:Retail	All Employees: Retail Trade	1959:Q1, 2016:Q3	5
31	Emp:Wholesal	All Employees: Wholesale Trade	1959:Q1, 2016:Q3	5
32	Emp: Gov(Fed)	Employment Federal Government	1959:Q1, 2016:Q3	5
33	Emp: Gov (State)	Employment State government	1959:Q1, 2016:Q3	5
34	Emp: Gov (Local)	Employment Local government	1959:Q1, 2016:Q3	5
35	Urate: Age16-19	Unemployment Rate - 16-19 yrs	1959:Q1, 2016:Q3	2
36	Urate:Age>20 Men	Unemployment Rate - 20 yrs. & over Men	1959:Q1, 2016:Q3	2
37	Urate: Age>20 Women	Unemployment Rate - 20 yrs. & over Women	1959:Q1, 2016:Q3	2
38	U: Dur<5wks	Number Unemployed for Less than 5 Weeks	1959:Q1, 2016:Q3	5
39	U:Dur5-14wks	Number Unemployed for 5-14 Weeks	1959:Q1, 2016:Q3	5
40	U:dur>15-26wks	Civilians Unemployed for 15-26 Weeks	1959:Q1, 2016:Q3	5
41	U: Dur>27wks	Number Unemployed for 27 Weeks & over	1959:Q1, 2016:Q3	5
42	U: Job losers	Unemployment Level - Job Losers	1967:Q1, 2016:Q3	5

43	U: LF Reenty	Unemployment Level - Reentrants to Labor Force	1967:Q1, 2016:Q3	5
44	U: Job Leavers	Unemployment Level - Job Leavers	1967:Q1, 2016:Q3	5
45	U: New Entrants	Unemployment Level - New Entrants	1967:Q1, 2016:Q3	5
46	Emp:SlackWk	Employment Level - Part-Time for Economic Reasons All Industries	1959:Q1, 2016:Q3	5
47	AWH Man	Average Weekly Hours: Manufacturing	1959:Q1, 2016:Q3	1
48	AWH Privat	Average Weekly Hours: Total Private Industrie	1964:Q1, 2016:Q3	2
49	AWH Overtime	Average Weekly Hours: Overtime: Manufacturing	1959:Q1, 2016:Q3	2
(4) Orders, Inventories and Sales				
50	Orders:Dur Goods	New Orders for Durable Goods Defl by PCE(LFE) Def	1959:Q1, 2016:Q3	5
51	Orders:ConsGoods	New Orders for Consumer Goods Defl by PCE(LFE) Def	1992:Q1, 2016:Q2	5
52	Unfilledorders	Unfilled Orders for Durable Goods Defl by PCE(LFE) Def	1959:Q1, 2016:Q3	5
53	Orders:capgds	New Orders for Nondefense Capital Goods Defl by PCE(LFE) Def	1968:Q1, 2016:Q3	5
54	VendPerf	ISM Manufacturing: Supplier Deliveries Index©	1959:Q1, 2014:Q4	1
55	NAPM:ORD	ISM Manufacturing: New Orders Index©; Index;	1959:Q1, 2014:Q4	1
56	Business Inventory	Total Business Inventories Defl by PCE(LFE) Def	1959:Q1, 2016:Q2	5
57	Inv/Sales	Total Business: Inventories to Sales Ratio	1959:Q1, 2016:Q2	2
(5) Housing Starts and Permits				
58	Hpermits	New Private Housing Units Authorized by Building Permit	1960:Q1, 2016:Q3	5
59	Hstarts:MW	Housing Starts in Midwest Census Region	1959:Q1, 2016:Q3	5
60	Hstarts:NE	Housing Starts in Northeast Census Region	1959:Q1, 2016:Q3	5
61	Hstarts:S	Housing Starts in South Census Region	1959:Q1, 2016:Q3	5
62	Hstarts:W	Housing Starts in West Census Region	1959:Q1, 2016:Q3	5
63	Constr. Contracts	Construction contracts (mil. sq. ft.) (Copyright McGraw-Hill)	1963:Q1, 2014:Q4	4
(6) Prices				
64	GPDI Defl	Gross Private Domestic Investment: Chain-type Price Index	1959:Q1, 2016:Q3	6
65	BusSec Defl	Business Sector: Implicit Price Deflator	1959:Q1, 2016:Q3	6
66	PCED_MotorVec	Motor vehicles and parts	1959:Q1, 2016:Q3	6
67	PCED_DurHousehold	Furnishings and durable household equipment	1959:Q1, 2016:Q3	6
68	PCED_Recreation	Recreational goods and vehicles	1959:Q1, 2016:Q3	6
69	PCED_OthDurGds	Other durable goods	1959:Q1, 2016:Q3	6
70	PCED_Food_Bev	Food and beverages purchased for off-premises consumption	1959:Q1, 2016:Q3	6
71	PCED_Clothing	Clothing and footwear	1959:Q1, 2016:Q3	6
72	PCED_Gas_Enrgy	Gasoline and other energy goods	1959:Q1, 2016:Q3	6
73	PCED_OthNDurGds	Other nondurable goods	1959:Q1, 2016:Q3	6
74	PCED_Housing-Utilities	Housing and utilities	1959:Q1, 2016:Q3	6
75	PCED_HealthCare	Health care	1959:Q1, 2016:Q3	6
76	PCED_TransSvg	Transportation services	1959:Q1, 2016:Q3	6
77	PCED_RecServices	Recreation services	1959:Q1, 2016:Q3	6
78	PCED_FoodServ_Acc.	Food services and accommodations	1959:Q1, 2016:Q3	6
79	PCED_FIRE	Financial services and insurance	1959:Q1, 2016:Q3	6
80	PCED_OtherServices	Other services	1959:Q1, 2016:Q3	6
81	PPI:FinConsGds	Producer Price Index: Finished Consumer Goods	1959:Q1, 2015:Q4	6
82	PPI:FinConsGds(Food)	Producer Price Index: Finished Consumer Foods	1959:Q1, 2015:Q4	6
83	PPI:IndCom	Producer Price Index: Industrial Commodities	1959:Q1, 2016:Q3	6
84	PPI:IntMat	Producer Price Index: Intermediate Materials: Supplies & Components	1959:Q1, 2015:Q4	6
85	P:SensMat	Index of Sensitive Matrerials Prices (Discontinued) Defl by PCE(LFE) Def	1959:Q1, 2004:Q1	5
86	NAPM com price	ISM Manufacturing: Prices Paid Index©	1959:Q1, 2014:Q4	1

87	Price:NatGas	PPI: Natural Gas Defl by PCE(LFE) Def	1967:Q1, 2016:Q3	5
(7) Productivity and Earnings				
88	CPH:NFB	Nonfarm Business Sector: Real Compensation Per Hour	1959:Q1, 2016:Q3	5
89	CPH:Bus	Business Sector: Real Compensation Per Hour	1959:Q1, 2016:Q3	5
90	OPH:nfb	Nonfarm Business Sector: Output Per Hour of All Persons	1959:Q1, 2016:Q3	5
91	ULC:NFB	Nonfarm Business Sector: Unit Labor Cost	1959:Q1, 2016:Q3	5
92	UNLPay:nfb	Nonfarm Business Sector: Unit Nonlabor Payments	1959:Q1, 2016:Q3	5
(8) Interest Rates				
93	FedFunds	Effective Federal Funds Rate	1959:Q1, 2016:Q3	2
94	TB-3Mth	3-Month Treasury Bill: Secondary Market Rate	1959:Q1, 2016:Q3	2
95	BAA_GS10	BAA-GS10 Spread	1959:Q1, 2016:Q3	1
96	MRTG_GS10	Mortg-GS10 Spread	1971:Q2-2016:Q3	1
97	tb6m_tb3m	tb6m-tb3m	1959:Q1, 2016:Q3	1
98	GS1_tb3m	GS1_Tb3m	1959:Q1, 2016:Q3	1
99	GS10_tb3m	GS10_Tb3m	1959:Q1, 2016:Q3	1
100	CP_Tbill Spread	CP3FM-TB3MS	1959:Q1, 2016:Q3	1
101	Ted_spr	MED3-TB3MS (Version of TED Spread)	1971:Q1, 2016:Q3	1
(9) Credit				
102	C&L loans	Commercial and Industrial Loans at All Commercial Banks Defl by PCE(LFE) Def	1959:Q1, 2016:Q3	5
103	ConsLoans	Consumer (Individual) Loans at All Commercial Banks, adjusted for outlier in April 2010 (see FRB H8 Release) Defl by PCE(LFE) Def	1959:Q1, 2016:Q3	5
104	NonRevCredit	Total Nonrevolving Credit Outstanding Defl by PCE(LFE) Def	1959:Q1, 2016:Q3	5
105	LoansRealEst	Real Estate Loans at All Commercial Banks Defl by PCE(LFE) Def	1959:Q1, 2016:Q3	5
106	RevolvCredit	Total Revolving Credit Outstanding Defl by PCE(LFE) Def	1968:Q1, 2016:Q3	5
(10) Exchange Rates				
107	Ex rate: major	FRB Nominal Major Currencies Dollar Index (Linked to EXRUS in 1973:1)	1959:Q1, 2016:Q3	5
108	Ex rate: Euro	U.S. / Euro Foreign Exchange Rate	1999:Q1, 2016:Q3	5
(11) Asset Prices, Wealth, and Household Balance Sheets				
109	S&P 500	S&P's Common Stock Price Index: Composite (1941, 43=10)	1959:Q1, 2016:Q3	5
110	HHW:TL	Real Total Liabilities of Households and Non Profits (billions of $2009) deflated by core PCE .. Fred-QD. Seasonally adjusted using RATS-X11	1959:Q1, 2016:Q3	5
111	HHW:W	Real Net Worth of Households and Non profits (billions of $2009) deflated by core PCE .. FREDQD. Seasonally adjusted using RATS-X11	1959:Q1, 2016:Q3	5
112	HHW:TA_XRE	Real Assets of households and nonprofits, excluding real estate (billions of $2009) def. by core PCE, FredQD . Seasonally adjusted using RATS-X11	1959:Q1, 2016:Q3	5
113	HHW:TA_RE	Real Real Estate Assets of households and and Nonprofits (billions of $2009) defl by core PCE .. FREDQD. Seasonally adjusted using RATS-X11	1959:Q1, 2016:Q3	5
114	DJIA	Common stock prices: Dow Jones industrial average	1959:Q1, 2016:Q3	5
115	VXO	VXO	1962:Q3-2016:Q3	1
116	CS_10	Case-Shiller 10 City Average Defl by PCE(LFE) Def	1987:Q1, 2016:Q3	5
117	CS_20	Case-Shiller 20 City Average Defl by PCE(LFE) Def	2000:Q1, 2016:Q3	5
(12) Asset Prices				
118	IP: Energy Prds	IP: Consumer Energy Products	1959:Q1, 2016:Q3	5
119	Price:Oil	PPI: Crude Petroleum Defl by PCE(LFE) Def	1959:Q1, 2016:Q3	5

120	Crudeoil Price	Crude Oil: West Texas Intermediate (WTI) - Cushing Oklahoma Defl by PCE(LFE) Def	1986:Q1, 2016:Q3	5
121	CrudeOil	Crude Oil Prices: Brent - Europe Defl by PCE(LFE) Def	1987:Q3-2016:Q3	5
122	Price Gasoline	Conventional Gasoline Prices: New York Harbor Regular Defl by PCE(LFE) Def	1986:Q3-2016:Q3	5
123	CPI Gasoline	CPI Gasoline (NSA) BLS: CUUR0000SETB01 Defl by PCE(LFE) Def	1959:Q1, 2016:Q3	5

Notes: The final column "T" indicates how the variable was transformed 1 = no transformation; 2 = first difference; 3 = second difference; 4 = logarithm; 5 = first difference of logarithm; 6 = second difference of logarithm.

Table A-2. Sensitivity analysis: Okun's law coefficients and Table 3 decomposition using different lag lengths and sample periods.

Leads	2				
Lags	2				
Sample period for OL estimates	1981:Q3 - 2016:Q2				
			Average growth of cyclically adjusted *y*		
Series	$\beta(1)$	SE	3 previous	This recovery	Difference
GDP	-1.4933	0.176	2.9534	0.9637	1.9897
GDO	-1.5308	0.1732	2.9203	1.1063	1.8139
GDO(Bus)	-2.0327	0.2082	3.1816	1.2924	1.8892
GDP-Pop	-1.4822	0.1693	1.8372	-0.0717	1.9089
GDO-Pop	-1.5196	0.1654	1.8041	0.071	1.7331
GDO(bus)-Pop	-2.0215	0.1997	2.0655	0.2571	1.8084
TFP	-0.5011	0.188	0.9937	0.2808	0.7129
kshare*(cap-pop)	-0.091	0.0557	0.7741	0.2447	0.5294
lshare(lq+hours-pop)	-1.4293	0.1372	0.2976	-0.2684	0.566
Hours-Pop	-2.2993	0.1913	-0.0588	-0.7562	0.6974
Hours(bus)-Emp(bus)	-0.3506	0.1038	-0.0997	-0.0657	-0.0339
Emp(bus)-Emp(CPS)	-0.7075	0.0886	-0.1117	0.0072	-0.1189
Emp(CPS)-LF(CPS)	-1.0786	0.0052	0.0002	-0.0033	0.0036
LF(CPS)-Pop(CPS)	-0.1626	0.0957	0.1523	-0.6944	0.8467
GDO(bus)-Hours	0.2777	0.2164	2.1243	1.0133	1.111
TFP/lshare	-0.7545	0.2869	1.4778	0.5138	0.964
(kshare/lshare)*(Capital-Output)	0.901	0.0906	0.157	0.0723	0.0847
LQuality	0.1312	0.0538	0.4894	0.4272	0.0622

Leads	2				
Lags	12				
Sample period for OL estimates	1981:Q3 - 2016:Q2				
			Average growth of cyclically adjusted *y*		
Series	$\beta(1)$	SE	3 previous	This recovery	Difference
GDP	-1.5833	0.346	2.9335	0.9959	1.9376
GDO	-1.5704	0.3358	2.9039	1.127	1.7769
GDO(Bus)	-1.9813	0.3895	3.1651	1.3028	1.8623
GDP-Pop	-1.5385	0.335	1.8223	-0.0578	1.8801
GDO-Pop	-1.5256	0.3205	1.7928	0.0733	1.7195
GDO(bus)-Pop	-1.9365	0.3747	2.0539	0.2491	1.8049
TFP	-0.3549	0.2892	0.9867	0.29	0.6967
kshare*(cap-pop)	-0.2668	0.1091	0.7664	0.2645	0.5019
lshare(lq+hours-pop)	-1.3148	0.1758	0.3008	-0.3055	0.6063
Hours-Pop	-2.2109	0.2404	-0.0571	-0.7972	0.7401
Hours(bus)-Emp(bus)	-0.1086	0.1083	-0.0806	-0.0948	0.0143
Emp(bus)-Emp(CPS)	-0.6667	0.124	-0.1229	-0.0412	-0.0817
Emp(CPS)-LF(CPS)	-1.0684	0.0091	-0.0008	-0.0053	0.0044
LF(CPS)-Pop(CPS)	-0.3672	0.1676	0.1472	-0.6558	0.803
GDO(bus)-Hours	0.2744	0.3435	2.111	1.0462	1.0648
TFP/lshare	-0.5019	0.4326	1.4683	0.5231	0.9452
(kshare/lshare)*(Capital-Output)	0.5565	0.1256	0.1495	0.111	0.0385
LQuality	0.2198	0.0721	0.4933	0.4122	0.0811

Table A-2, continued

Leads		2				
Lags		2				
Sample period for OL estimates		1981:Q3 - 2007:Q4				
				Average growth of cyclically adjusted *y*		
Series		$\beta(1)$	SE	3 previous	This recovery	Difference
GDP		-1.7791	0.1881	2.8586	0.8266	2.032
GDO		-1.876	0.1854	2.8169	0.9679	1.8489
GDO(Bus)		-2.3827	0.2405	3.0805	1.1728	1.9076
GDP-Pop		-1.8167	0.1902	1.7254	-0.2426	1.968
GDO-Pop		-1.9137	0.1883	1.6837	-0.1012	1.7849
GDO(bus)-Pop		-2.4204	0.2442	1.9472	0.1036	1.8436
TFP		-0.7309	0.2477	0.9378	0.2383	0.6995
kshare*(cap-pop)		-0.1078	0.046	0.7685	0.2326	0.5359
lshare(lq+hours-pop)		-1.5817	0.2611	0.2409	-0.3673	0.6082
Hours-Pop		-2.446	0.3593	-0.1072	-0.8466	0.7395
Hours(bus)-Emp(bus)		-0.3736	0.1896	-0.1078	-0.0776	-0.0303
Emp(bus)-Emp(CPS)		-0.7276	0.1601	-0.1109	0.0271	-0.138
Emp(CPS)-LF(CPS)		-1.0799	0.0088	-0.0006	-0.0055	0.0049
LF(CPS)-Pop(CPS)		-0.2649	0.1341	0.1121	-0.7907	0.9028
GDO(bus)-Hours		0.0256	0.3031	2.0544	0.9503	1.1041
TFP/lshare		-1.0999	0.3644	1.3996	0.466	0.9336
(kshare/lshare)*(Capital-Output)		1.0155	0.0996	0.1815	0.0825	0.0991
LQuality		0.11	0.0691	0.4732	0.4018	0.0715

Leads				2		
Lags				2		
Sample period for OL estimates				1960:Q1 - 2016:Q2		
				Average growth of cyclically adjusted *y*		
Series		$\beta(1)$	SE	3 previous	This recovery	Difference
GDP		-1.6732	0.1606	2.8792	0.8119	2.0673
GDO		-1.6846	0.1488	2.8455	0.9542	1.8913
GDO(Bus)		-2.1917	0.177	3.099	1.1224	1.9766
GDP-Pop		-1.7258	0.1463	1.7415	-0.2534	1.9949
GDO-Pop		-1.7373	0.1398	1.7078	-0.111	1.8188
GDO(bus)-Pop		-2.2443	0.1661	1.9613	0.0571	1.9042
TFP		-0.7165	0.153	0.9122	0.1188	0.7934
kshare*(cap-pop)		-0.076	0.0422	0.774	0.2382	0.5358
lshare(lq+hours-pop)		-1.4518	0.0972	0.2751	-0.2999	0.575
Hours-Pop		-2.2821	0.129	-0.0648	-0.7691	0.7043
Hours(bus)-Emp(bus)		-0.3935	0.0773	-0.1117	-0.0787	-0.033
Emp(bus)-Emp(CPS)		-0.7125	0.0756	-0.1282	-0.0266	-0.1016
Emp(CPS)-LF(CPS)		-1.072	0.0049	0.0035	0.0024	0.0012
LF(CPS)-Pop(CPS)		-0.1041	0.0848	0.1715	-0.6662	0.8377
GDO(bus)-Hours		0.0378	0.1687	2.0261	0.8262	1.1999
TFP/lshare		-1.0671	0.2278	1.3653	0.2933	1.072
(kshare/lshare)*(Capital-Output)		0.9906	0.0747	0.1864	0.121	0.0654
LQuality		0.1142	0.0556	0.4744	0.4119	0.0625