Modeling State Business Cycles: a dynamic single factor model for Hawaii

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Overview

Develop Coincident and Leading Indicator for Hawai‘i:

Philly Fed CEI are based on a fixed set of indicators similar to conference board national coincident index:

- non-farm payroll employment
- unemployment rate
- hours in manufacturing
- real wage and salary disbursements

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Evaulate usefulness of new CEI/LEI:

- Compare with Philadelphia CEI/LEI
- Evaluate turning point prediction

Key papers in literature which develops and evaluates regional CEI/LEI

Stock, James H., and Mark W. Watson. "New Indexes of Coincident and Leading Economic Indicators," NBER Macroeconomics Annual (1989), pp. 351-94.

Clayton-Matthews, Alan, and James H Stock. An Application of the Stock/Watson Index Methodology to the Massachusetts Economy. Journal of Economic and Social Measurement (1989), pp. 183-233.

Crone, Theodore M., and Alan Clayton-Matthews. Consistent Economic Indexes for the 50 States, Review of Economics and Statistics, 87 (2005), pp. 593-603.

Crone, Theodore M. "What a New Set of Indexes Tells Us About State and National Business Cycles," PDF Business Review, Federal Reserve Bank of Philadelphia (First Quarter 2006).

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Following the literature, we use the Kalman Filter to estimate a dynamic single-factor, multiple-indicator model.

$$y_t = \alpha + \beta(L)s_t + \mu_t, \tag{1}$$

$$\phi(L)\mu_t = \epsilon_t, \tag{2}$$

$$\rho(L)s_t = \gamma + \eta_t, \tag{3}$$

where

y_t is an (nx1) vector of differenced logs of monthly indicators,

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and ϵ_t, η_t are vector and scalar (assumed) white noise processes, respectively.

The Model
Assumptions and restrictions

$$y_t = \alpha + \beta(L)s_t + \mu_t, \quad (1)$$
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Assumptions/Restrictions:

The idiosyncratic error vector, μ_t is modeled as an AR(2) process.

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We write the state space form by treating both equations (2) and (3) as the transition equation and including both μ_t and s_t in the state vector.

The Model

Our State Space Form: Measurement Equation

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$$\begin{bmatrix} y_{1t} \\ y_{2t} \\ y_{3t} \\ y_{4t} \end{bmatrix} = \begin{bmatrix} 0 & \beta_{11} & \phi_1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \beta_{21} & 0 & 0 & \phi_2 & 0 & 0 & 0 & 0 & 0 \\ \beta_{30} & 0 & 0 & 0 & 0 & 0 & \phi_3 & 0 & 0 & 0 \\ \beta_{40} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \phi_4 & 0 \end{bmatrix} \begin{bmatrix} s_t \\ s_{t-1} \\ \mu_{1t} \\ \mu_{1,t-1} \\ \mu_{2t} \\ \mu_{2,t-1} \\ \mu_{3t} \\ \mu_{3,t-1} \\ \mu_{4t} \\ \mu_{4,t-1} \end{bmatrix}$$

The Model

Our State Space Form: Transition Equation

$$\begin{bmatrix} s_t \\ s_{t-1} \\ \mu_{1t} \\ \mu_{1,t-1} \\ \mu_{2t} \\ \mu_{2,t-1} \\ \mu_{3t} \\ \mu_{3,t-1} \\ \mu_{4t} \\ \mu_{4,t-1} \end{bmatrix} = \begin{bmatrix} \rho_1 & \rho_2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & d_{11} & d_{12} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & d_{21} & d_{22} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & d_{31} & d_{32} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & d_{41} & d_{42} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} s_{t-1} \\ s_{t-2} \\ \mu_{1,t-1} \\ \mu_{1,t-2} \\ \mu_{2,t-1} \\ \mu_{2,t-2} \\ \mu_{3,t-1} \\ \mu_{3,t-2} \\ \mu_{4,t-1} \\ \mu_{4,t-2} \end{bmatrix} + \begin{bmatrix} \eta_t \\ 0 \\ \epsilon_{1t} \\ 0 \\ \epsilon_{2t} \\ 0 \\ \epsilon_{3t} \\ 0 \\ \epsilon_{4t} \\ 0 \end{bmatrix}$$

The Data
Choice of Indicators

A first reaction to the Philadelphia Fed indicators. Are hours in manufacturing really useful in forming a CEI for Hawai‘i:

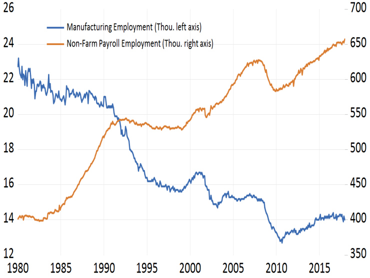

Figure: Manufacturing vs Non-farm Jobs

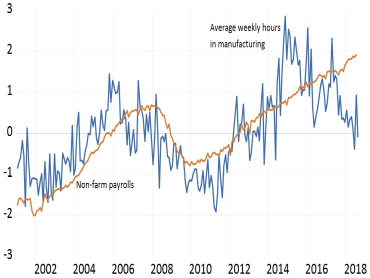

Figure: Manufacturing Hrs. vs Non-farm Jobs

The Data

Choice of Indicators

Conference Board	Crone (2000)	Hawaii CEI
		Model 1
Employees on non-agricultural payrolls	Employees on non-agricultural payrolls	Employees on non-agricultural payrolls
Real personal income minus transfer payments (monthly)	Real wage & salary disbursements (quarterly)	Real wage & salary disbursements (interpolated)
Real manufacturing and trade sales	Avg. hours worked in manufacturing	Visitor arrivals
Industrial production	Unemployment rate	Unemployment rate
		Model 2
		Real withholding tax revenue instead of wage & salary disbursements
		Real General Excise tax base instead of visitor arrivals

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Sample starts in January of 1982 and runs through July 2017 (model 1), or January 2018 (model 2) after smoothing.

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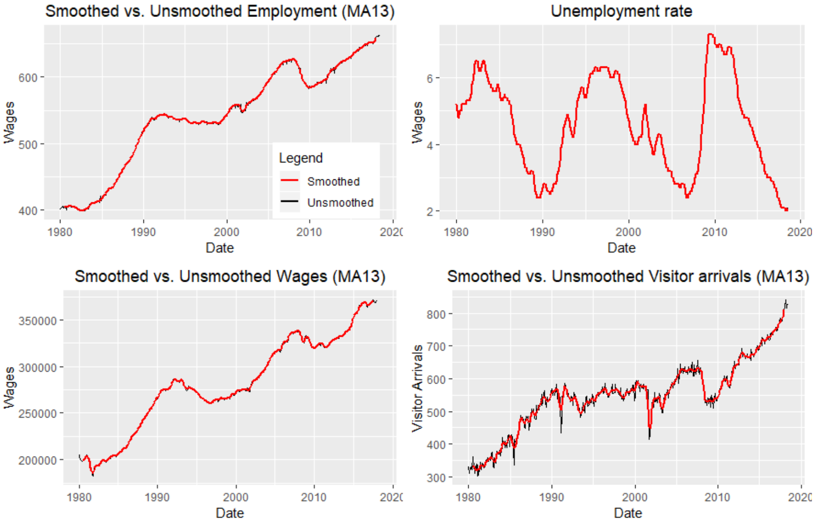
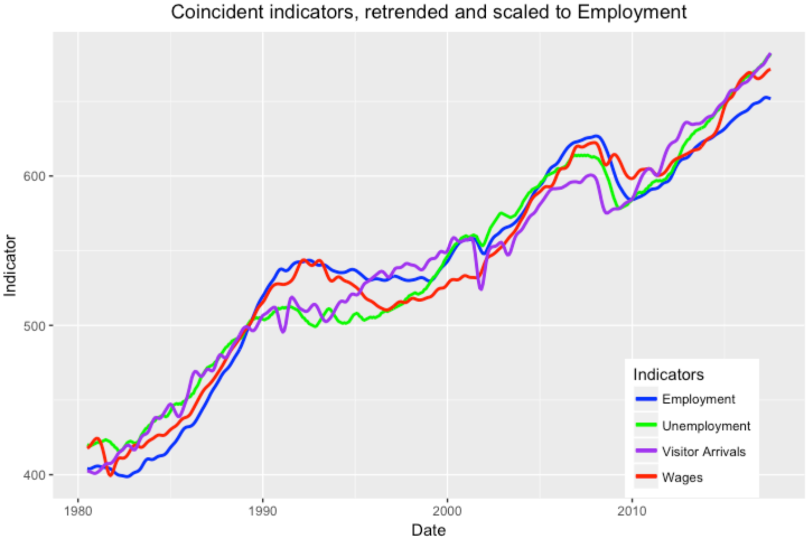
Similar to the Philadelphia state CEI models, we use non-farm payroll employment and the unemployment rate.

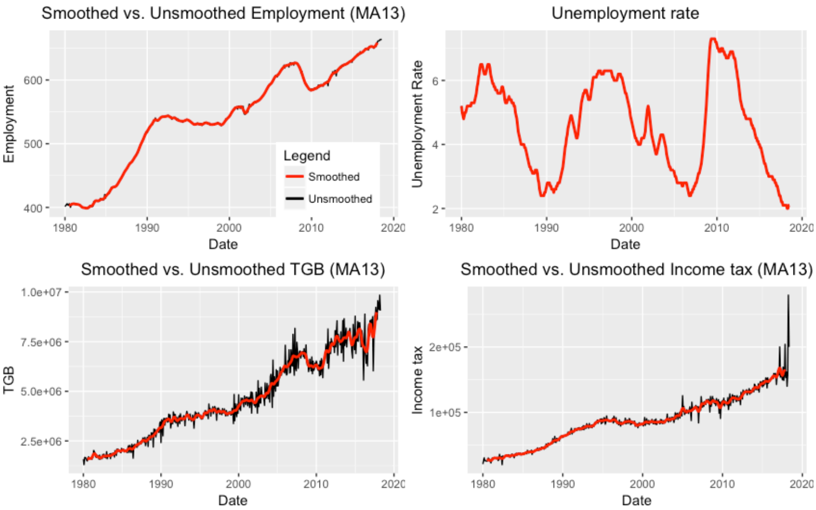
The Data
Model 1



The Data
Model 1: retrended and scaled



The Data
Model 2



The Data
Model 2: retrended and scaled

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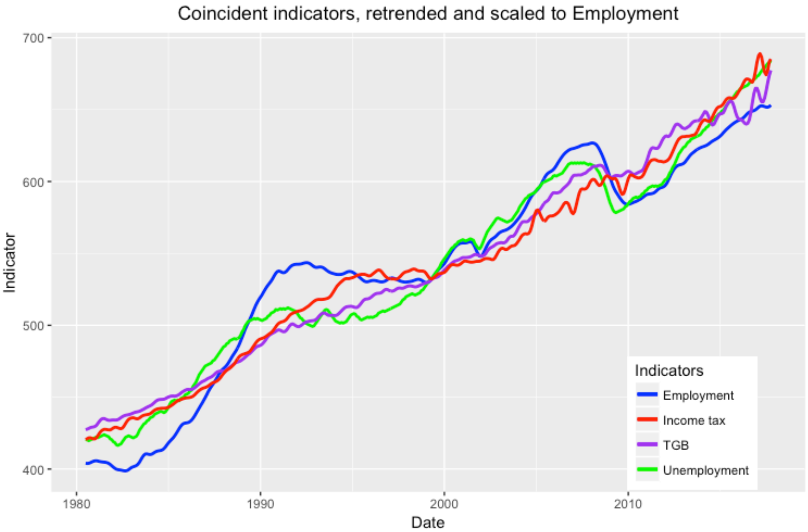


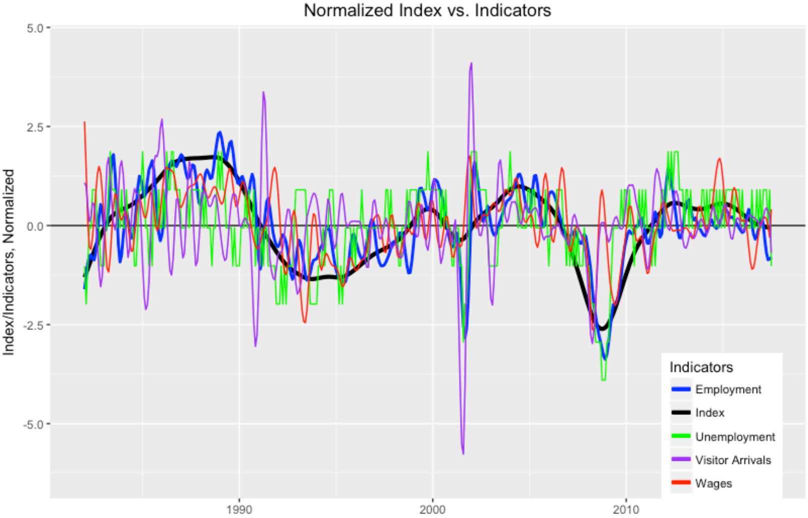
Results

Model 1: Coefficient Estimates

Parameters	Employment	Unemployment	Wages	Visitors
β_0			**0.0191**	**0.0066**
β_1	**0.0274**	**-0.0177**		
ϕ	-3.27e-7	3.70e-4	-2.79e-5	-2.35e-7
d_1	-0.1950	0.0017	0.0060	0.0706
d_2	0.3592	0.0111	0.220	0.0080

Autoregressive coefficients for the state variables	
ρ_1	1.8519
ρ_2	-0.8574

Results
Model 1: Normalized Index



Results

Model 1: re-trended and scaled to real GSP

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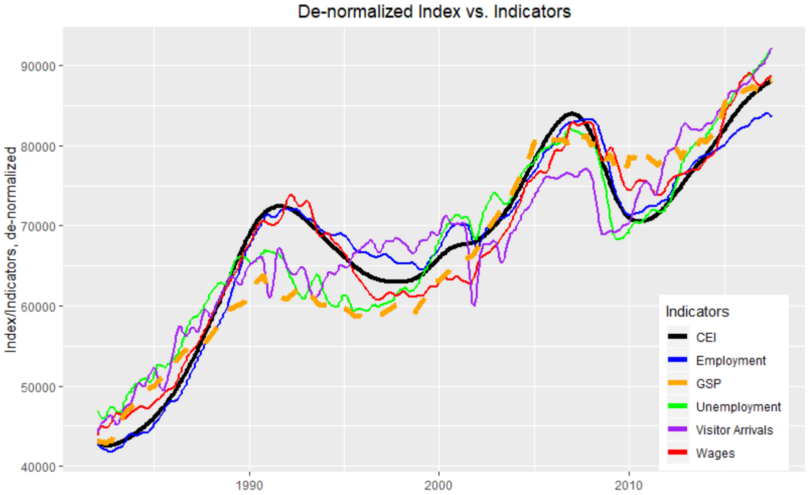


Results

Model 2: Coefficient Estimates

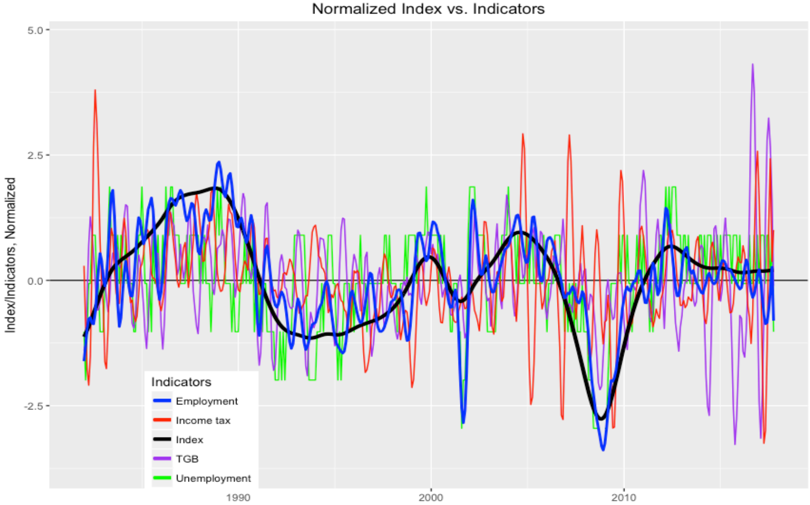
Coef.	Employment	Unemployment	GE Tax Base	Withholding Tax
β_0			0.0091	0.0070
β_1	0.0274	-0.0174		
ϕ	4.83e-5	3.35e-7	-2.59e-7	2.62e-8
d_1	0.0041	-0.3948	0.1488	0.5636
d_2	0.0022	0.0376	0.4029	-0.0698

Autoregressive coefficients for the state variables

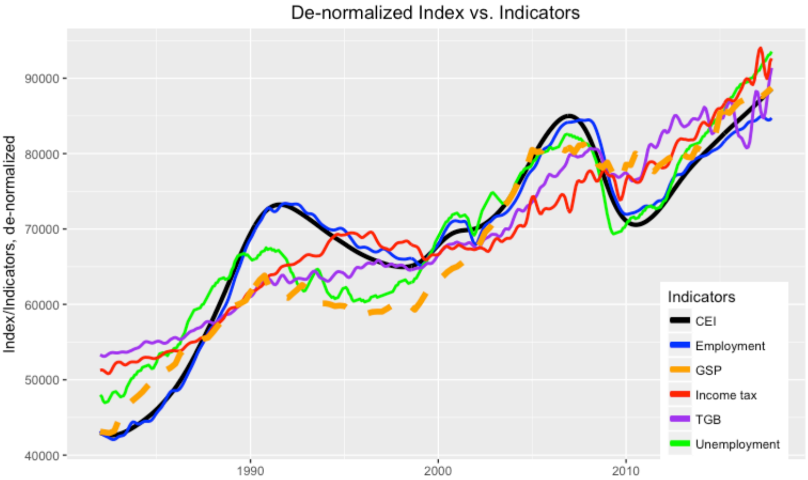
ρ_1	1.8556
ρ_2	-0.8608

Results

Model 2: Normalized Index



Results
Model 2: retrended and saled to real GSP



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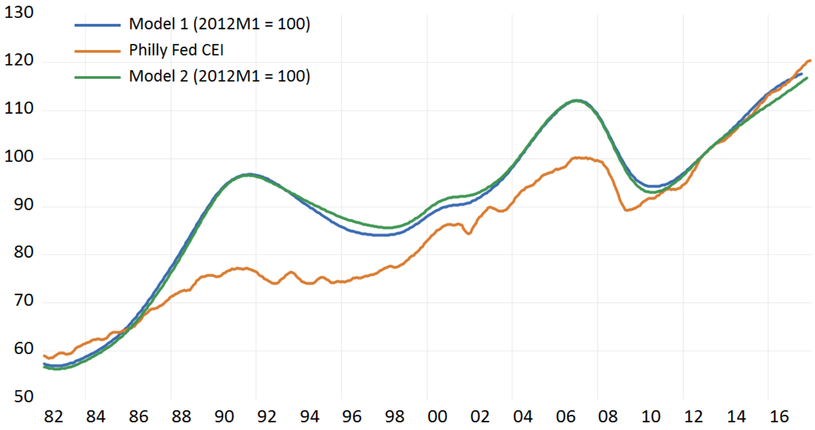
Comparing CEI



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Explore optimal variance for added noise when dealing with corner solutions.

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Test for single factor and explore specification.

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Test for single factor and explore specification.

Once satisfied with CEI, move on to LEI and evaluate.