Predicting recessions with leading indicators: An application of the Stock and Watson methodology on the Icelandic economy

Work in progress

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1 Outline of seminar

1. What is a business cycle?
2. General idea of the Stock and Watson method
3. Choice of coincident and leading variables
4. Model specification
5. Estimating recession and expansion probabilities
6. Results
7. Conclusions

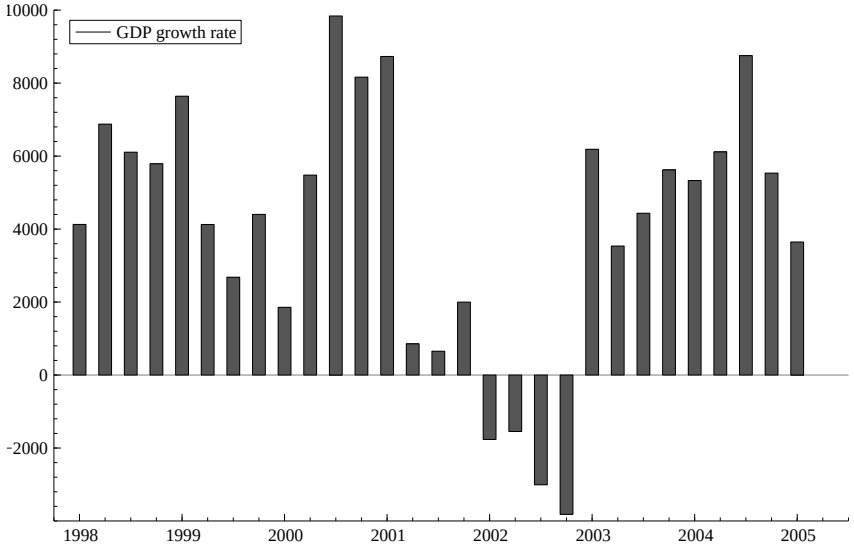
2 What is a business cycle?

- Burns and Mitchell's (1946) defined a business cycles to represent co-movements in a set of macroeconomical series. They proposed that:

"... a cycle consists of expansions occurring about the same time in many economic activities, followed by similarly general recessions, contractions, and revivals ..."

"Aggregate activity can be given a definite meaning and made conceptually measurable by identifying it with gross national product."

- The cycle thus reflects co-movements in a broad range of macroeconomical aggregates such as output, employment, and sales.


GDP growth rate
10000
8000
6000
4000
2000
0
-2000
1998
1999
2000
2001
2002
2003
2004
2005

3 General idea of the Stock and Watson method

- Stock and Watson formalized Burns and Mitchell's (1946) notion that business cycles represent co-movements in a set of macroeconomical series.
- GDP could provide a reliable summary of the current economical conditions if it were available on a monthly basis.

GDP can thus not be used directly in the modeling procedure.

- Choose a number of proxy variables that mimics the cyclical behavior of GDP, called *Coincident variables*.
- Assume that a single common variable drives the evolution of many of the macroeconomical variables, called the "*state of the economy*"
- Choose a number of variables that mimics the cyclical behavior of GDP but with a lead, called *Leading variables*.

4 Choice of coincident and leading variables

- The choice of coincident and leading variables can be done by estimating the correlation structure.
- 104 of Icelandic macroeconomical variables have been considered, some in both level and in growth rate.
- Sample size: January 1999 - July 2005

Total number of observations: 79

- Consider as an example the variable Creditcards, total number of transactions.

Summary of Coincident and Leading variables:

Exports, total, food and beverages	level	lag 1	$r =$	-0.62
Exports, marine products	level	lag 1	$r =$	-0.69
Trade balance total	level	lag 1	$r =$	-0.62
Imports, consumer goods, semi-durable	g.r.	lag 0	$r =$	0.72
Imports, totals food and beverages	g.r.	lag 0	$r =$	0.67
Creditcards, total number of transactions	g.r.	lag 3	$r =$	0.64
Creditcards, total number of transactions in Iceland	g.r.	lag 3	$r =$	0.63
Number of new work permits	g.r.	lag 0	$r =$	0.72
Number of vacancies	g.r.	lag 1	$r =$	0.65
Number of vacancies in greater Reykjavik area	g.r.	lag 0	$r =$	0.69
Oil price	g.r.	lag 2	$r =$	0.60
Cement sales	g.r.	lag 0	$r =$	0.68
Real exchange rate	level	lag 3	$r =$	0.70
Real exchange rate	g.r.	lag 0	$r =$	-0.64
Yield spread of treasury bonds 5 years and 20 years	g.r.	lag 0	$r =$	0.66

5 Model specification

A simple example of the model:

$$
\begin{aligned}
y_{1t} &= \mu_1 + \alpha_1 c_t + \alpha_2 c_{t-1} + u_{1t} \\
y_{2t} &= \mu_2 + \beta_1 c_t + u_{2t} \\
x_{1t} &= \mu_3 + \gamma_1 c_{t-1} + \gamma_2 c_{t-2} + \gamma_3 x_{1t-1} + \gamma_4 x_{1t-2} + \gamma_5 x_{2t-1} + \varepsilon_{x_1 t} \\
x_{2t} &= \mu_4 + \lambda_1 c_{t-2} + \lambda_2 x_{1t-1} + \lambda_3 x_{2t-1} + \lambda_5 x_{2t-3} + \varepsilon_{x_2 t} \\
c_t &= \mu_5 + \delta_1 c_{t-1} + \delta_2 c_{t-3} + \delta_3 x_{1t-1} + \delta_4 x_{2t-2} + \varepsilon_{ct} \\
u_{1t} &= \theta_1 u_{1t-1} + \theta_2 u_{1t-2} + \varepsilon_{u_1 t} \\
u_{2t} &= \varepsilon_{u_2 t}
\end{aligned}
$$

or expressed in state space form, the Kalman filter, as:

$$
\begin{aligned}
y_t &= z h_t + A x_t + \varepsilon_t \\
h_t &= F h_{t-1} + B x_{t-1} + w_t.
\end{aligned}
$$

The model is estimated, using the Kalman filter, under the assumption that the error vectors, ε_t and w_t, are normally distributed.

6 Estimating recession and expansion probabilities

6.1 Stock and Watson's approach

- Define two elementary recession patterns.

1. c_t falls below a limit $b_{r,t}$ for six consecutive months
2. c_t falls below a limit $b_{r,t}$ for seven of nine consecutive months including the first and last months

$$D_{1t} = \left\{ \; c_s, \quad s = t-5, ..., t : \quad c_s \leq b_{r,s}, \quad s = t-5, ..., t \; \right\}$$

$$\begin{aligned} D_{2t} \quad = \quad & \left\{ \; c_s, \quad s = t-8, ..., t : \quad c_{t-8} \leq b_{r,t-8}, \quad c_t \leq b_{r,t}, \right. \\ & \left. \# \left(\; c_s \leq b_{r,s}, \quad s = \tau - 7, ..., t-1 \; \right) \geq 5 \right\} \end{aligned}$$

Analogous for expansion. c_t increase above a limit $b_{e,t}$.

- Analyzing c_t for each time point t, the indicator vector R_t can be defined as the recession event at time t. The expansion event, the indicator vector E_t can be defined in the same fashion.

- Estimation of recession probabilities

1. Stock and Watson suggests a resampling scheme by drawing $\widetilde{c}_t$ from a $N(m_t, \Omega_t)$, where $\widetilde{c}_t = (c_{t-8}, ..., c_t, ..., c_{t+8})$.
2. Draw a realization of $b_{r,t}$ and $b_{e,t}$.
3. Evaluate R_t and E_t for each realization.
4. The probability of a recession is then defined as

$$P_{r,t} = \frac{\#(R_t)}{\#(R_t) + \#(E_t)}.$$

- The limits $b_{r,t}$ and $b_{e,t}$ are modeled as

$$b_{r,t} = \mu_{r,t} + \varepsilon_t, \qquad b_{e,t} = \mu_{e,t} + \varepsilon_t, \qquad \text{where } \varepsilon_t \sim Nid\left(0, \sigma^2\right)$$

- Stock and Watson propose to estimate the three parameters $\mu_{r,t}$, $\mu_{e,t}$ and σ^2 by minimizing the mean squared error $\sum_t (R_t - P_{r,t})^2$.

6.2 Alternative approach to Stock and Watson

- Draw a large number of realization c_t^* from the estimated model of c_t, that is

$$c_t^* = \widehat{\mu}_5 + \widehat{\delta}_1 c_{t-1} + \widehat{\delta}_2 c_{t-3} + \widehat{\delta}_3 x_{1t-1} + \widehat{\delta}_4 x_{2t-2} + \varepsilon_{ct}.$$

- The empirical distribution of c_t can now be estimated at each time point t.

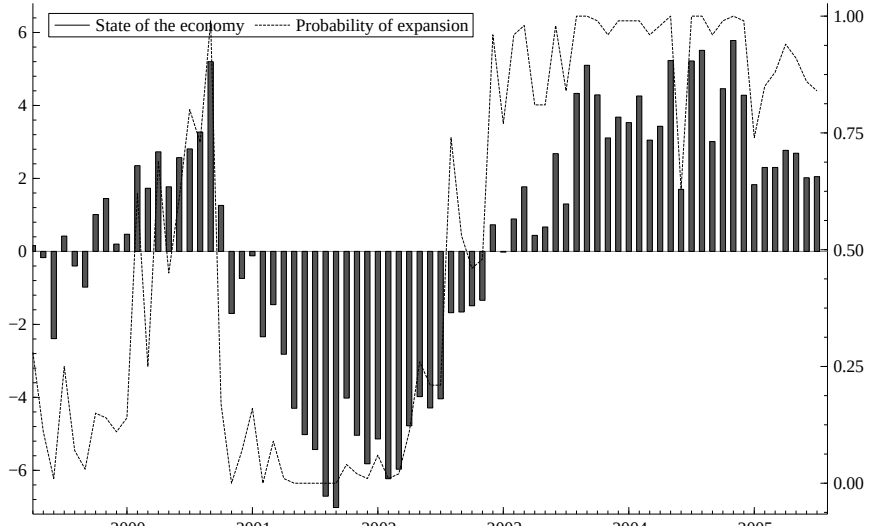
- Define the probability of a recession as

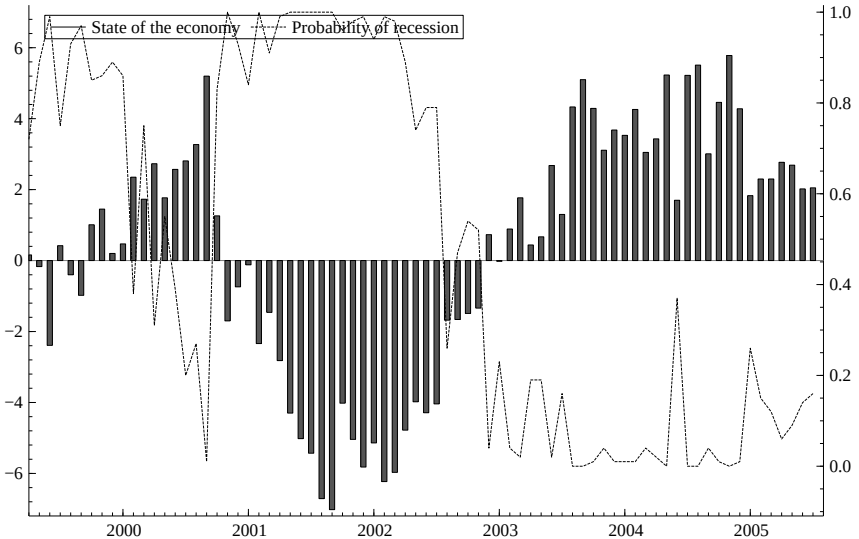
$$P_{r,t} = \frac{P\left(c_{obs,t} \geq c_t^*\right) P\left(c_{obs,t} \geq c_s\right)}{P\left(c_{obs,t} \geq c_t^*\right) P\left(c_{obs,t} \geq c_s\right) + P\left(c_{obs,t} \leq c_t^*\right) P\left(c_{obs,t} \leq c_s\right)},$$

  where $s = 1, ...T$ and $c_{obs,t}$ is the observed value at t.

- Main advantage over Stock and Watson is that it is no need for estimating any extra parameters.

7 Results


State of the economy
Probability of expansion
6
4
2
0
−2
−4
−6
1.00
0.75
0.50
0.25
0.00
2000
2001
2002
2003
2004
2005


State of the economy
Probability of recession
6
4
2
0
−2
−4
−6
1.0
0.8
0.6
0.4
0.2
0.0
2000
2001
2002
2003
2004
2005

8 Conclusions

- Several other models can be considered
- Estimation of several alternative model specifications should be performed
- Even with this simple model, the cyclical behavior of the Icelandic economy has been estimated with relatively good fit.