

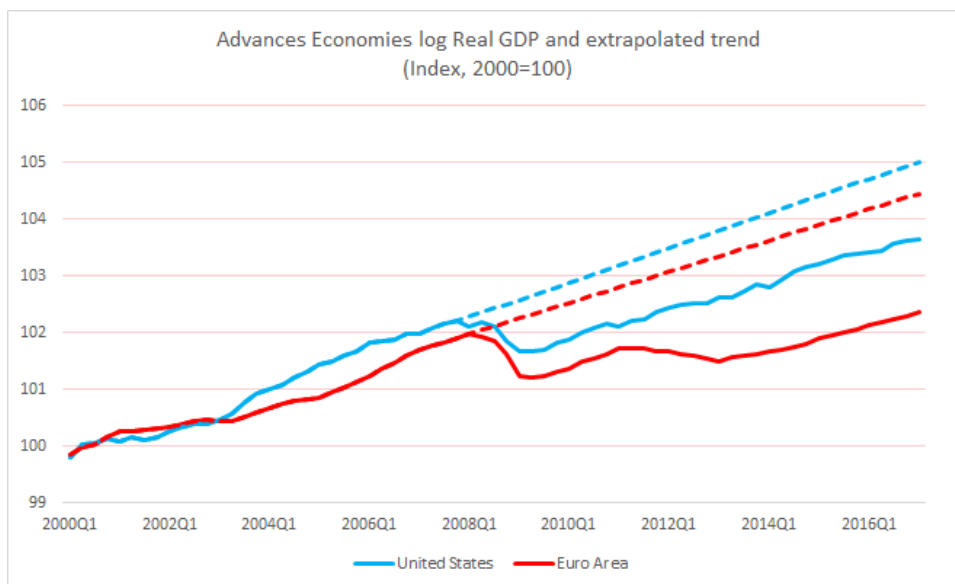
Should we reject the natural rate hypothesis?

Appendix

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Figure 1.



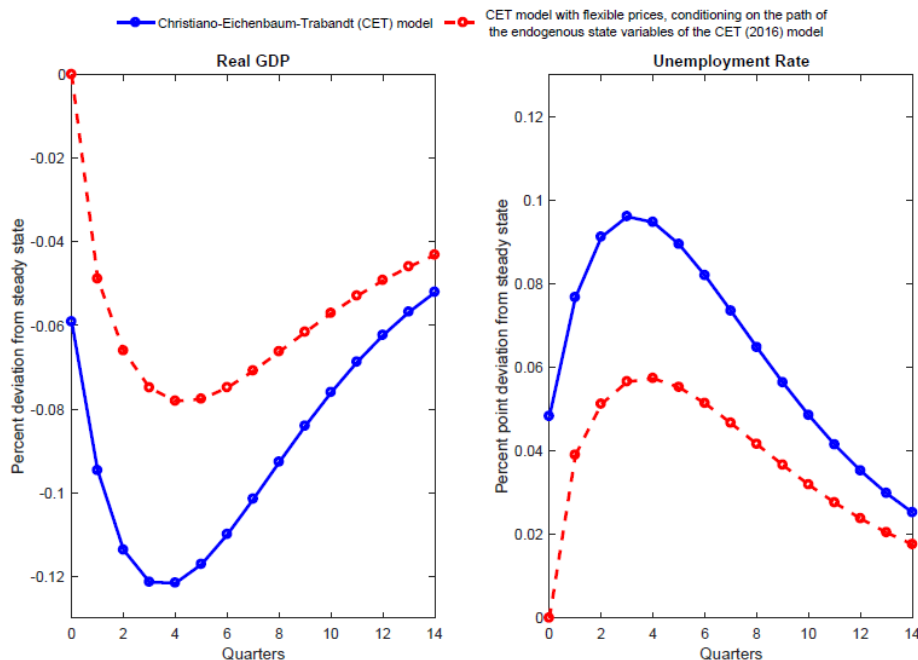
Excel file: Appendix_NaturalRate_temp.xlsx, sheet "Fig1."

Source: Bureau of Economic Analysis, Eurostat

Figure 2.

Simulation by Mathias Trabandt, based on the model in Trabandt and al. (2016). The model was modified so as to allow quantities and inflation to respond within the quarter to a monetary policy shock.

Impulse Responses to a Contractionary Monetary Policy Shock (50 Annual Basis Points)



Figures 3, 4 and related

Data from 22 advanced countries, using quarterly data starting in 1960 (or whenever data starts being available). The list of countries consists of Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, and the United States.

Stata data file: FinalData_c225_new.dta

Source: OECD

Identification of recessions

I identify recessions using the methodology and algorithm of Harding and Pagan (2002). Roughly speaking, the method identifies peaks and troughs as local maxima and minima in the log level real GDP series, and, with some exceptions, defines recessions as times between a peak and a trough. This leaves 122 recessions. (The list of recessions is given in Excel file Appendix_NaturalRate_temp.xlsx, sheet "List episodes".)

Stata program: Figure 3.do and Figure 4.do

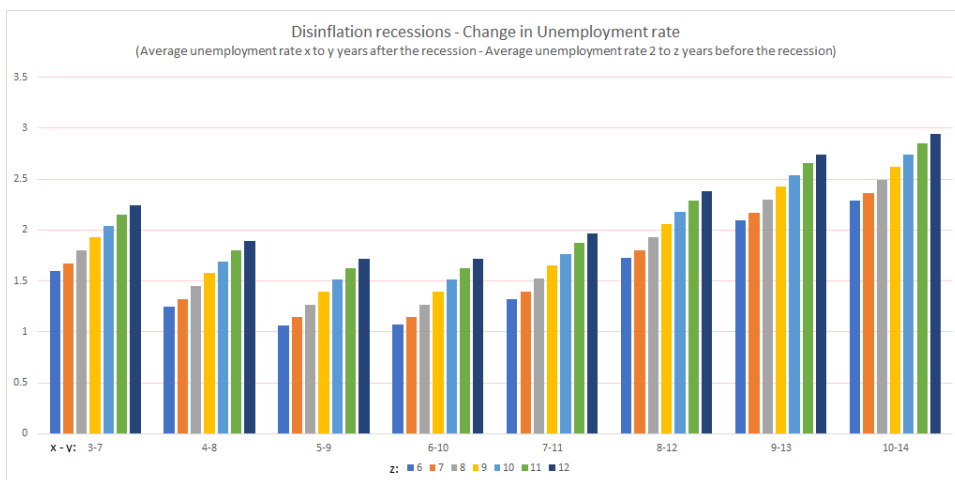
Identification of recessions by type

Recessions associated with a large increase in the price of oil, all associated

with the 1974 and 1979 oil price increases. Recessions associated with financial crises: Recessions coinciding with financial crises as defined by Laeven and Valencia (2013). Recessions associated with intentional disinflations. The specific assumption is that the recession be associated with a large increase in policy rates, and a subsequent large decrease in inflation (and a qualitative check that the intent of the central bank was to decrease inflation).

(The list of recessions by type is given in Excel file Appendix_NaturalRate_temp.xlsx, sheet "List episodes".)

Figure 3. Construction of average unemployment rates, pre-recession, and post-recession, for recessions associated with disinflations



The economy may have been in a boom, and thus above trend, before the recession started. To deal with this issue, I exclude the 8 quarters preceding the start of the recession from the computation of the pre-recession trend.

For each country, averages pre-recession are computed using quarters $t_0 - 8$ to $t_0 - 8 - x$, with x from 16 (4 years) to 40 (10 years), and t_0 being the first quarter of the recession (so, stated more simply, 2 to 6 years before the recession, 2 to 7 years, up to 2 to 12 years).

Averages post-recession are computed over quarters $t_1 + x$ to $t_1 + x + 16$, with x increasing from 12 (3 years) to 40 (10 years), and t_1 being the last quarter of the recession (so stated more simply, 3 to 7 years after the recession, 4 to 8 years, all the way to 10 to 14 years).

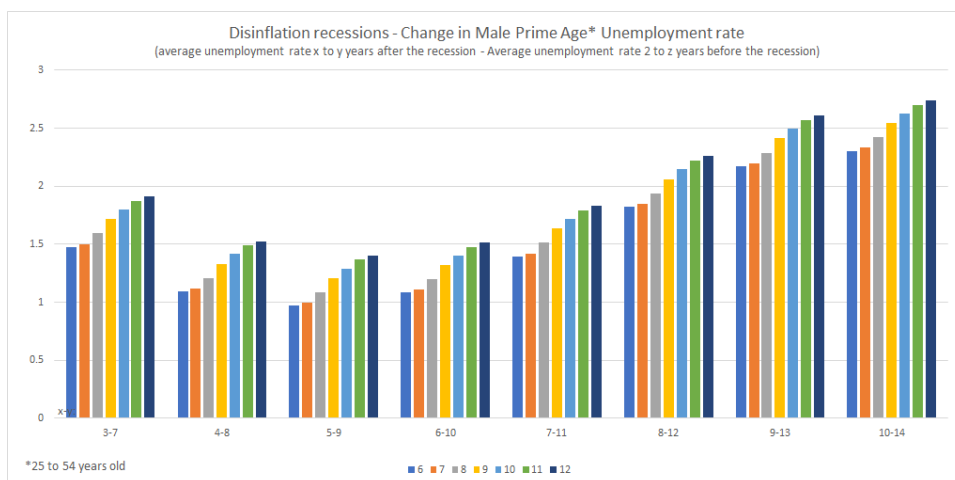
Data for pre-recession and post-recession averages, for each recession, and the average for the different recession types are given in Excel file Appendix_NaturalRate_temp.xlsx,

sheet "Table2.")

Stata program: Figure 3.do

Excel sheet and figure: Appendix_NaturalRate_temp.xlsx, sheets "Fig3." and "Fig3. data"

Figure 3a. (not shown in the text)



Same as Figure 3, but looking at prime age male unemployment rates. Data available for 14 countries out of 22. Computed using the same pre-recession and post-recession intervals, but using annual data as quarterly data are typically not available (so, 2 to 6 years before the recession, 2 to 7 years, up to 2 to 12 years).

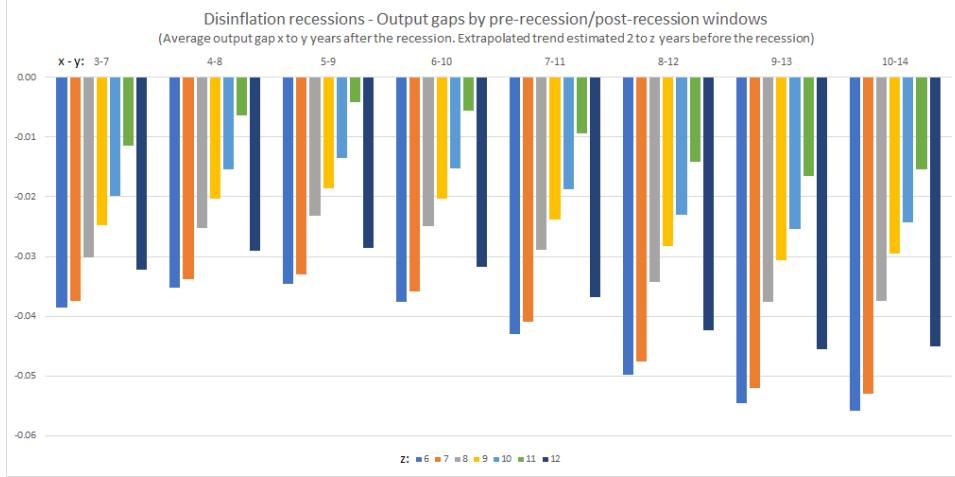
Stata program: Figure 3a.do

Excel sheet and figure: Appendix_NaturalRate_temp.xlsx , sheets "Fig3a." and "Fig3a. data"

Figure 4. Construction of average output gaps post-recession, for recessions associated with disinflations:

The identification of recessions is the same as for Figure 3. The general approach is presented in the figure below:

Construction of pre-recession trends: The time intervals used for estimation of output trend are the same as the time intervals used to compute average unemployment rate above. Shorter time intervals can capture underlying changes in trend, but may be influenced by cyclical fluctuations. Longer time intervals will be less influence, but may not capture recent underlying changes



in trend. In each case, the trend is estimated as a log linear trend for GDP, using quarterly data.

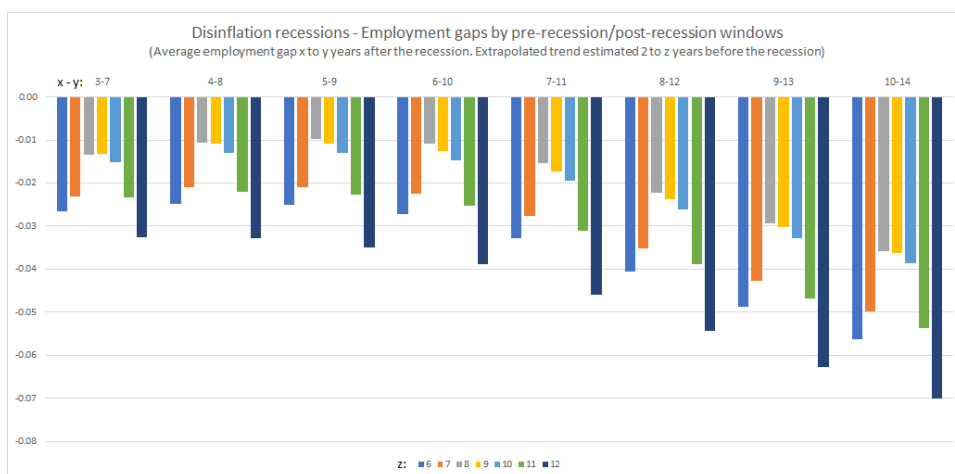
An issue comes from the fact that, since the 1960s, most countries have experienced declining growth. Most of this decline reflects a secular decrease in growth, which has little or nothing to do with the potential after-effects of recessions. This implies that, on average, log linear time trends estimated on earlier data will tend to overpredict later output, and, thus, will generate spurious negative gaps between later output and the time trend estimated on earlier data. To account for this, I first regress log GDP on linear and quadratic time trends over the whole sample. Then, for each recession, and for each post-recession quarter, I adjust down the estimated pre-recession trend by a factor equal to the coefficient on the quadratic term times the square of the difference between the mid range of the trend estimation period. This adjustment turns out to be empirically important, and to substantially reduce the number of cases where one finds post-recession output to be below the adjusted pre-recession trend.

I then construct output gaps as the difference between the adjusted pre-recession trend and actual log GDP after the recession. Here again, one faces a trade-off. Computing the output gap soon after the recession may lead to finding an output gap which is in fact largely temporary. Computing the output gap much further out introduces the risk that the permanent effect of the recession, if any, is hard to detect, as many other shocks have taken place. Again, the results are presented for a number of post-recession time intervals. For each time interval, the average output for each recession is given by the average of the output gaps during the post-recession time interval.

Stata program: Figure 4.do

Excel sheet with estimated trends and output gaps for different pre- and post-recession time intervals are given for each recession in Excel file Appendix_NaturalRate_temp.xlsx, sheet "gdp", together with the average by recession type.

Figure 4a. Output, employment, and productivity gaps for recessions associated with disinflations. (not shown in the text).



Using the fact that log output is equal to the sum of log employment and log productivity, I use the same approach as for output to estimate employment and productivity gaps.

Stata program: Figure 4a.do

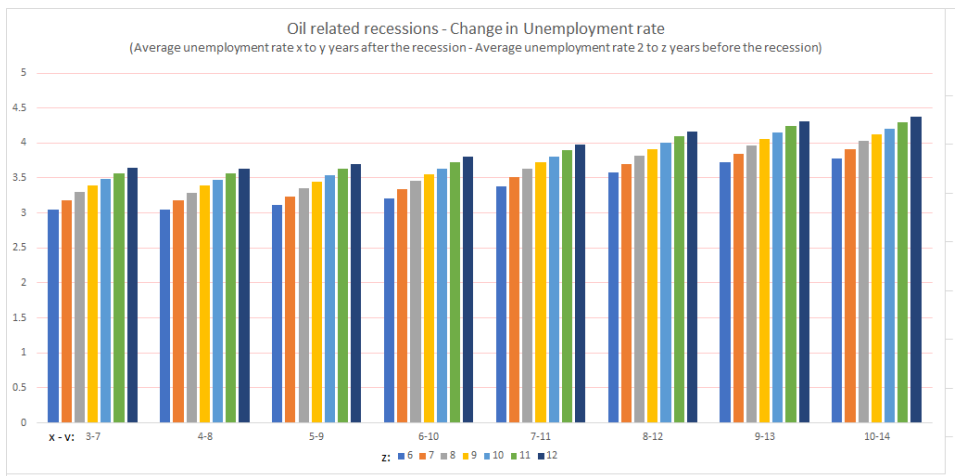
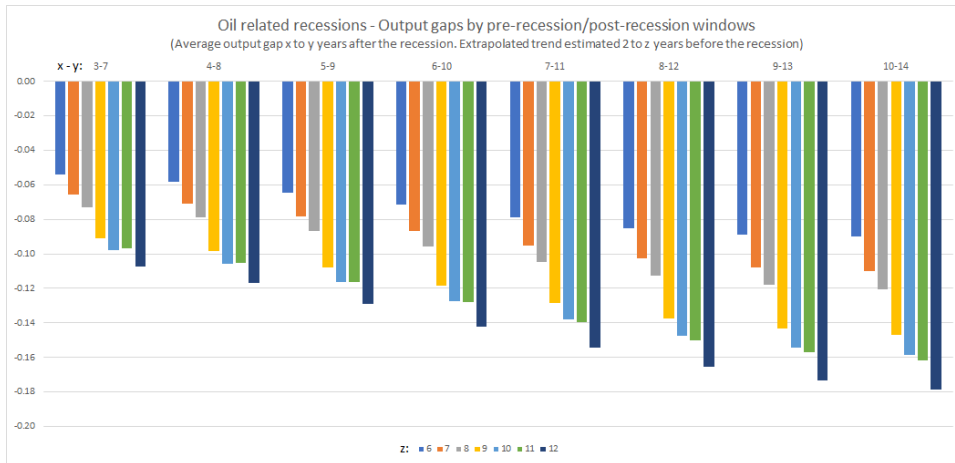
Excel sheet with estimated employment and productivity gaps for different pre- and post-recession time intervals are given for each recession in Excel file Appendix_NaturalRate_temp.xlsx, sheets "Fig4a.", "emp" and "prod"

Figures 4b and 4c. Unemployment and output gaps for oil-price related and financial crisis related recessions. (Not shown in the text)

The methodology is the same as for disinflation-triggered recessions in Figure 3 and 4

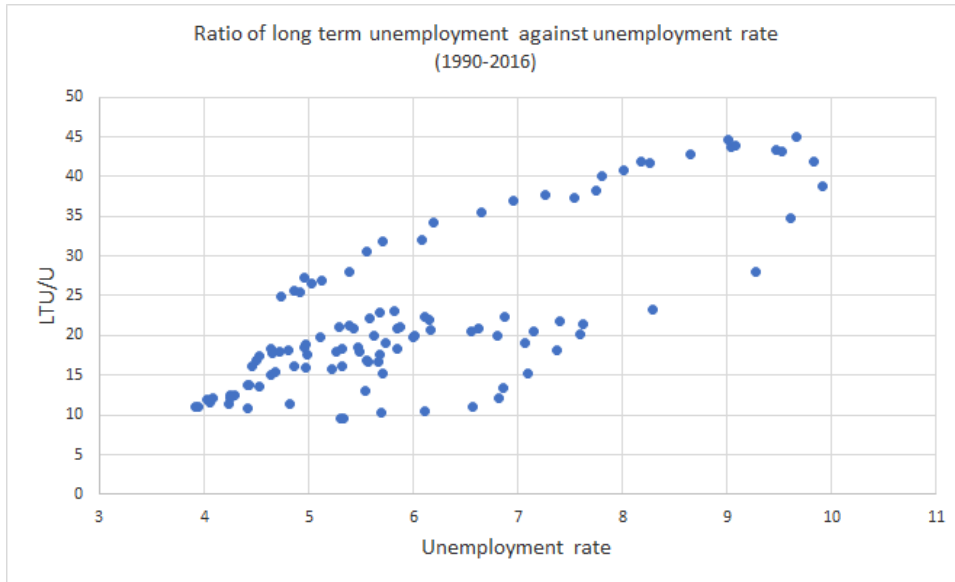
Stata program: Figure 4b.do and Figure 4c.do

Excel sheet, with estimated output and unemployment gaps and correspond-



ing figures, by recession, and by recession type, are given in Excel file Appendix_NaturalRate_temp.xlsx, sheet "Fig4b." and "Fig4c."

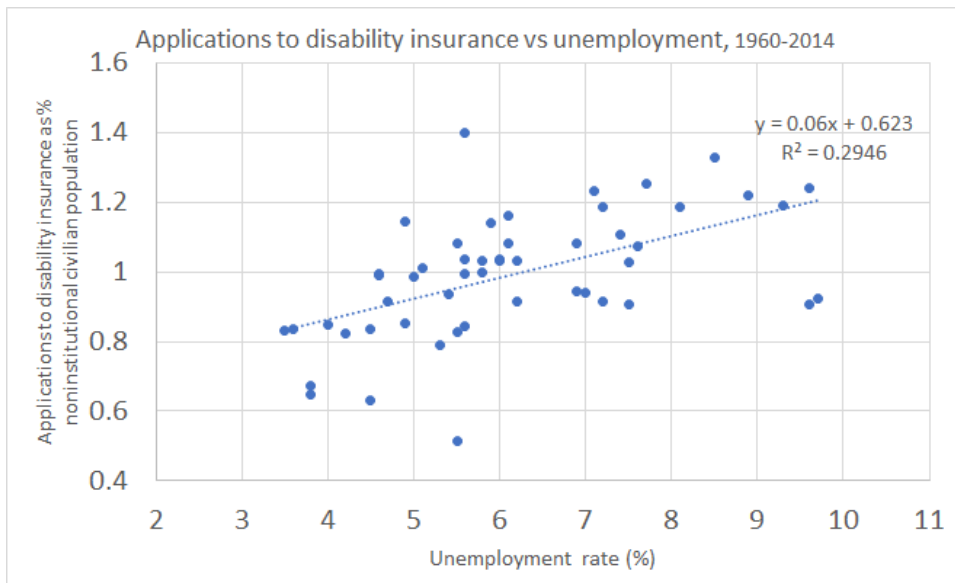
Figure 5. Long term unemployment



Excel file: Appendix_NaturalRate_temp.xlsx, sheet "Fig5."

Source: Bureau of Labor Statistics

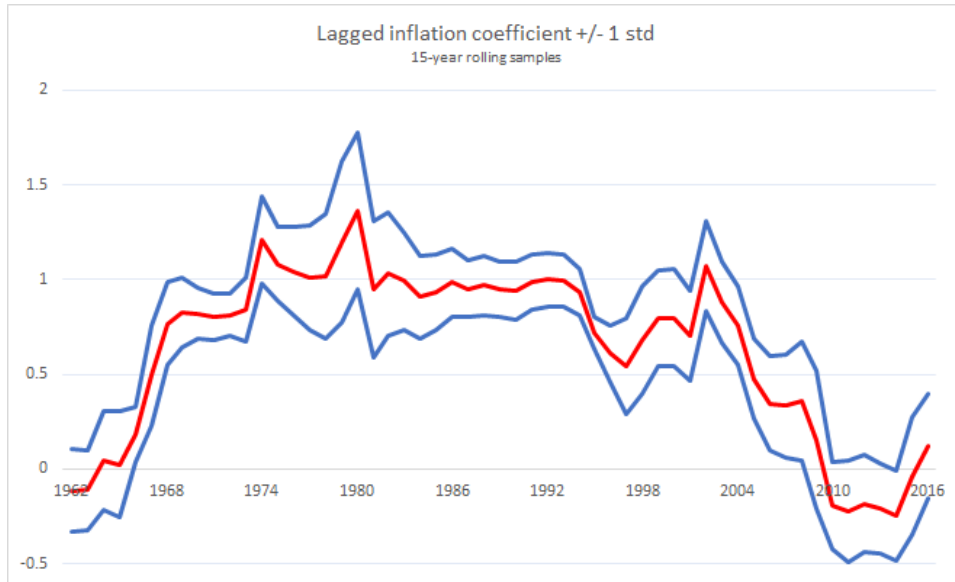
Figure 6. Disability insurance



Excel file: Appendix_NaturalRate_temp.xlsx, sheet "Fig6."

Source: Bureau of Labor Statistics

Figure 7. Coefficient on lagged inflation



Stata program: infl_urate_a_us.do

Stata data file: infl_urate_a_us.results.dta

Excel file: Appendix_NaturalRate_temp.xlsx, sheet "Fig7."

Source: Bureau of Labor Statistics

Table 1. Regressions of inflation forecasts

Table 1: Regressions of professional and consumers' forecasts of inflation				
	1981Q3-1995Q4		1996Q1-2016Q3	
	SPF	Michigan	SPF	Michigan
ma_core	0.498*** [0.038]	0.375*** [0.061]	0.547*** [0.052]	-0.111 [0.125]
ma_inflcore	0.125 [0.099]	0.288*** [0.093]	0.077** [0.029]	0.231*** [0.060]
Constant	2.024*** [0.174]	1.873*** [0.267]	1.098*** [0.103]	3.134*** [0.244]
Observations	58	58	83	83
R-squared	0.746	0.66	0.598	0.19
Robust standard errors in brackets				
*** p<0.01, ** p<0.05, * p<0.1				

Stata program: infl_exp_Q.do

Stata data file: Inflation_expectations_Q.dta

Source: Survey of Professional Forecasters (SPF), University of Michigan

Figure 8. R&D and GDP growth

Expenditures in R&D on distributed lags of GDP - both in first difference, 1953-2013

	est1 b/t	est2 b/t	est3 b/t	est4 b/t	est5 b/t	est6 b/t	est7 b/t	est8 b/t
D.lnGDP	0.82	0.86	1.02*	1.01*	1.08*	1.12*	1.18*	1.13*
	1.95	1.95	2.46	2.41	2.47	2.37	2.43	2.29
LD.lnGDP	0.24	0.24	-0.17	-0.23	-0.23	-0.27	-0.45	-0.41
	0.58	0.56	-0.4	-0.52	-0.53	-0.57	-0.88	-0.77
L2D.lnGDP		-0.34	0.06	0.16	0.2	0.21	0.37	0.41
		-0.83	0.14	0.36	0.45	0.46	0.77	0.79
L3D.lnGDP			-0.3	-0.37	-0.45	-0.48	-0.51	-0.59
			-0.78	-0.89	-1.03	-1.06	-1.11	-1.2
L4D.lnGDP				-0.15	-0.08	-0.05	0.05	0.07
				-0.39	-0.2	-0.12	0.11	0.16
L5D.lnGDP					0.04	0.02	-0.12	-0.22
					0.1	0.04	-0.24	-0.43
L6D.lnGDP						-0.11	0.02	0.01
						-0.24	0.04	0.03
L7D.lnGDP							0.29	0.27
							0.63	0.56
L8D.lnGDP								-0.58
								-1.27
_cons	0.02	0.03	0.03	0.04	0.03	0.04	0.02	0.05
	0.99	1.28	1.28	1.4	1.05	1.05	0.56	1.09
r2	0.08	0.09	0.12	0.13	0.13	0.13	0.15	0.19
N	59	58	57	56	55	54	53	52
dw	1.66	1.5	1.47	1.44	1.44	1.4	1.34	1.44
k	3	4	5	6	7	8	9	10
dL	1.51	1.47	1.43	1.38	1.33	1.29	1.23	1.18
dU	1.65	1.69	1.73	1.77	1.81	1.86	1.92	1.97

Stata program: cyclicality RDv2.do

data file: RD.xlsx

Source: BEA, National Science Foundation