Granger-causality of real oil prices after the Great Recession

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Summary

- Oil prices surged to a sustained high level from 2009 through 2014.
  - "Shock" compares to height of 1970's "oil shocks"; Explanation?
- 1970's: US inflation rate at highest level since 1946;
  - Post-2008 inflation rate subdued. No Monetary Cause?
- Paper shows strong Granger causality of nominal & real oil prices
  - by nominal factors.
- Key: Subtract Fed Res Liq. Swaps (SWP) from MB, M1, M1 Divisia.
- Strong Granger causality for MB-SWP, M1-SWP, M1Div-SWP
  - for post 1947 sample, various sub-periods, including post-2008.
  - Without adjustment, no causality results.
- CPIE index Granger causes real & nominal oil price.
- Money & Inflation also Granger Cause Gold Prices,
  - & oil to gold price ratio, & US dollar exchange rate index.
- Demonstrates importance of monetary factors
  - for benchmark international commodity markets.

Literature

- Oil shocks caused by no Macroeconomic data series (Hamilton, 1983),
  - uses data up to 1972;
- by episodes of unrest (Baumeister and Kilian, 2016),
- by OPEC monopoly power (Silbur, 2009; Mankiw, 2014),
- by inflation (Gillman and Nakov, 2009, of oil & gold prices).
- by inflation & M1 money supply growth
  - Alquist, Vigussen & Kilian, 2013, using data up to 2009.
- Conventional: AS-AD analysis with Nominal Price,
  - cost-push inflation, & stagflation: Mankiw
  - Silbur '09: "1970s witnessed greatest peactime US inflation"
- Convention not applicable in 2009-2014 oil price rise,
  - stagnating growth, but low Inflation Rate.
- A mystery: Except Monetary Base Shot upwards.

Monetary Thesis of Oil, Gold Prices

- 1970s: When Pres. Nixon ended Bretton Woods, 1971-1973;
  - exchange rates began floating more freely;
  - US dollar price of gold shot up by similar percent
  - as did US dollar price of oil.
  - Hamilton '83 data ended '72: oil prices fixed to gold standard.
- Built up money supply, financing Vietnam, broke Bretton Woods;
  - Real Oil prices falling from 1957 to 1973: 16 years.
  - Johnson put Social Security on-budget, 1968, hid deficits.
- Post-2009: Monetary base built up after 2008-09 Recession,
  - but not lent out. Kept as Excess Reserves.
  - Because IOER: Fed paid Interest on Excess Reserves.
- 1st Problem: Monetary Base, M1, M1 Divisia, M2, M2 Divisia
  - do not Granger cause oil prices or gold prices.
- 2nd Problem: CPI Inflation does not Granger cause Oil or Gold Price
  - in post 2009-2017 sample period.

Fed's Use of Swaps: June 2008-Dec 2008

- Excess Reserves hit $-\$50$ Billion in May 2008
- Fed borrowed Reserves from other Central Banks.
- For Liquidity Crisis, during run on Non-FDIC insured.
- Investment Banks.
- Swaps rose from \$50 Billion in May 2008
- to \$580 Billion in Dec 2008, & back to 0: Feb 2010.
- A Look at Data

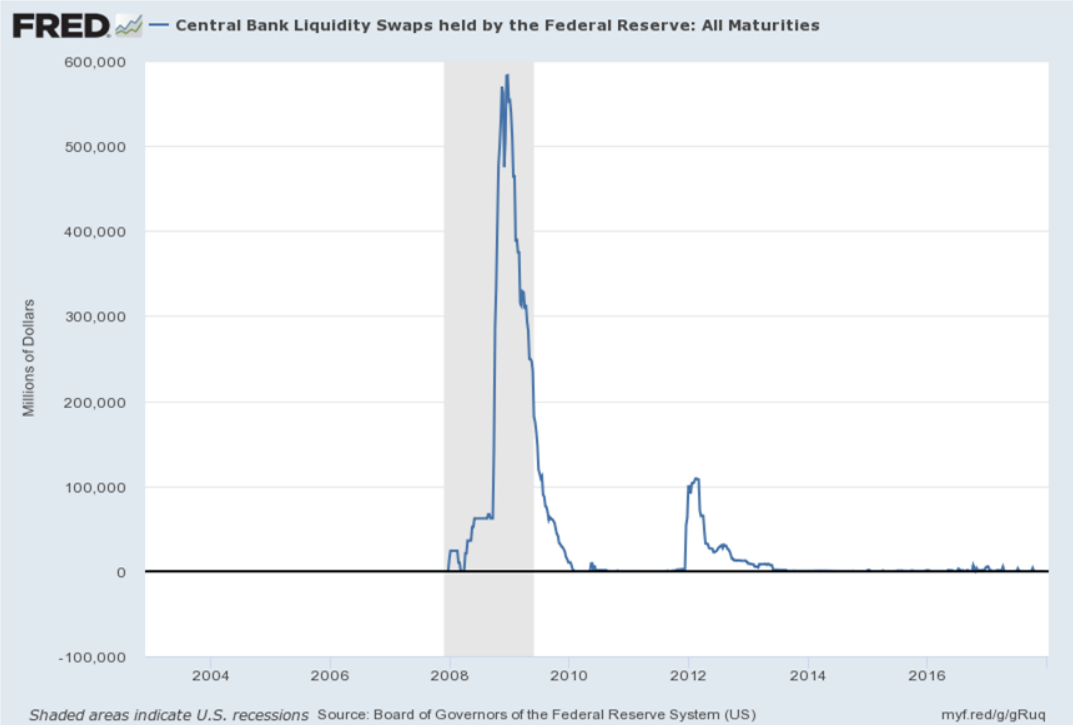

Figure: Central Bank Liquidity Swaps; Peak at $580 Billion in December 2008

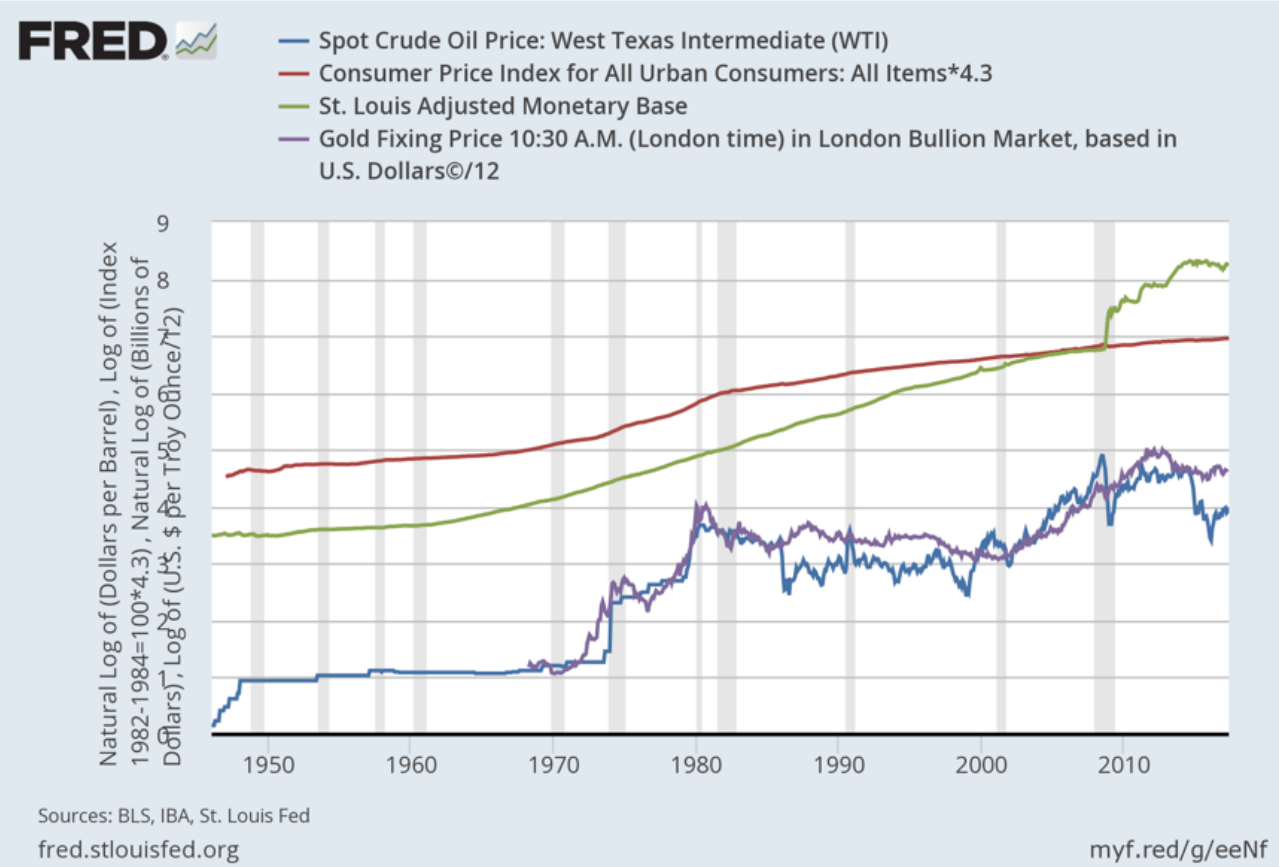

Figure: Oil, CPI, Monetary Base, and Gold post-WWII Data Series.

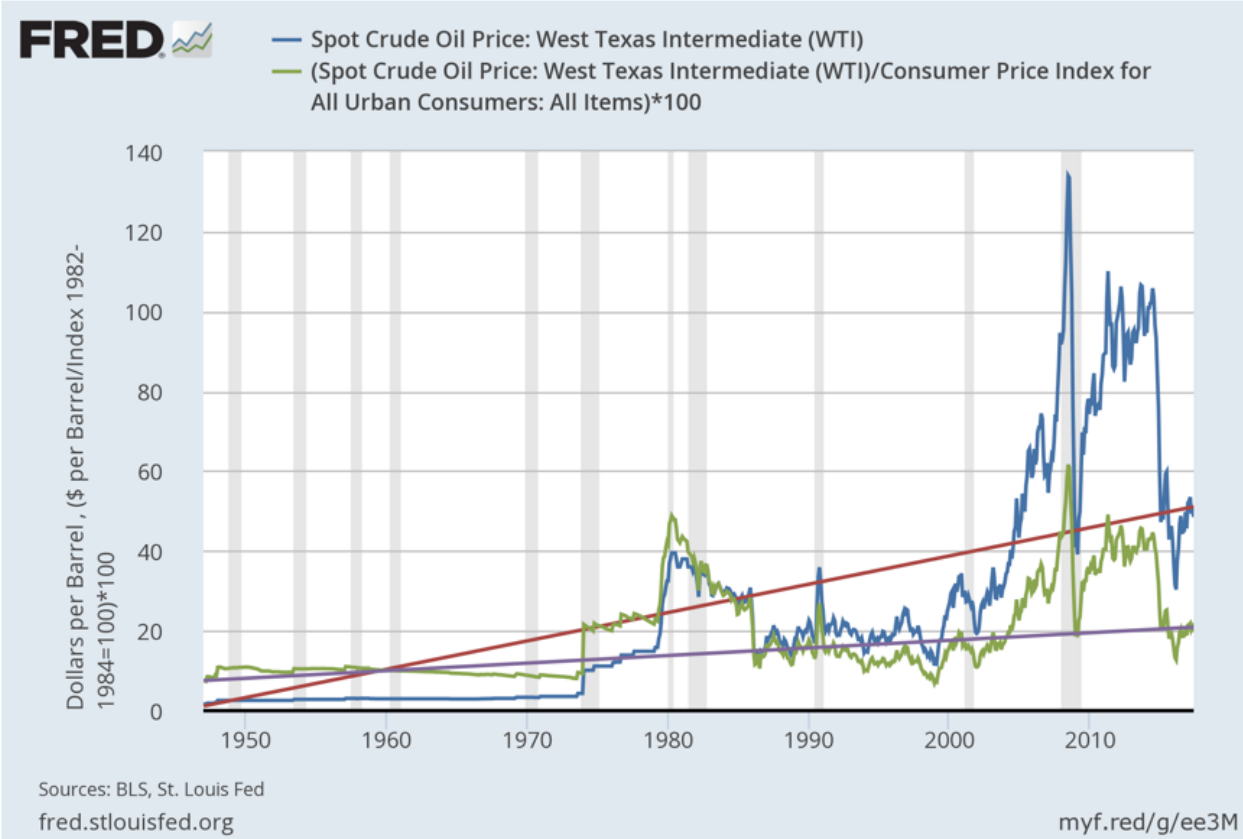

Figure: Nominal and Real WTI Oil Prices, with trend lines.

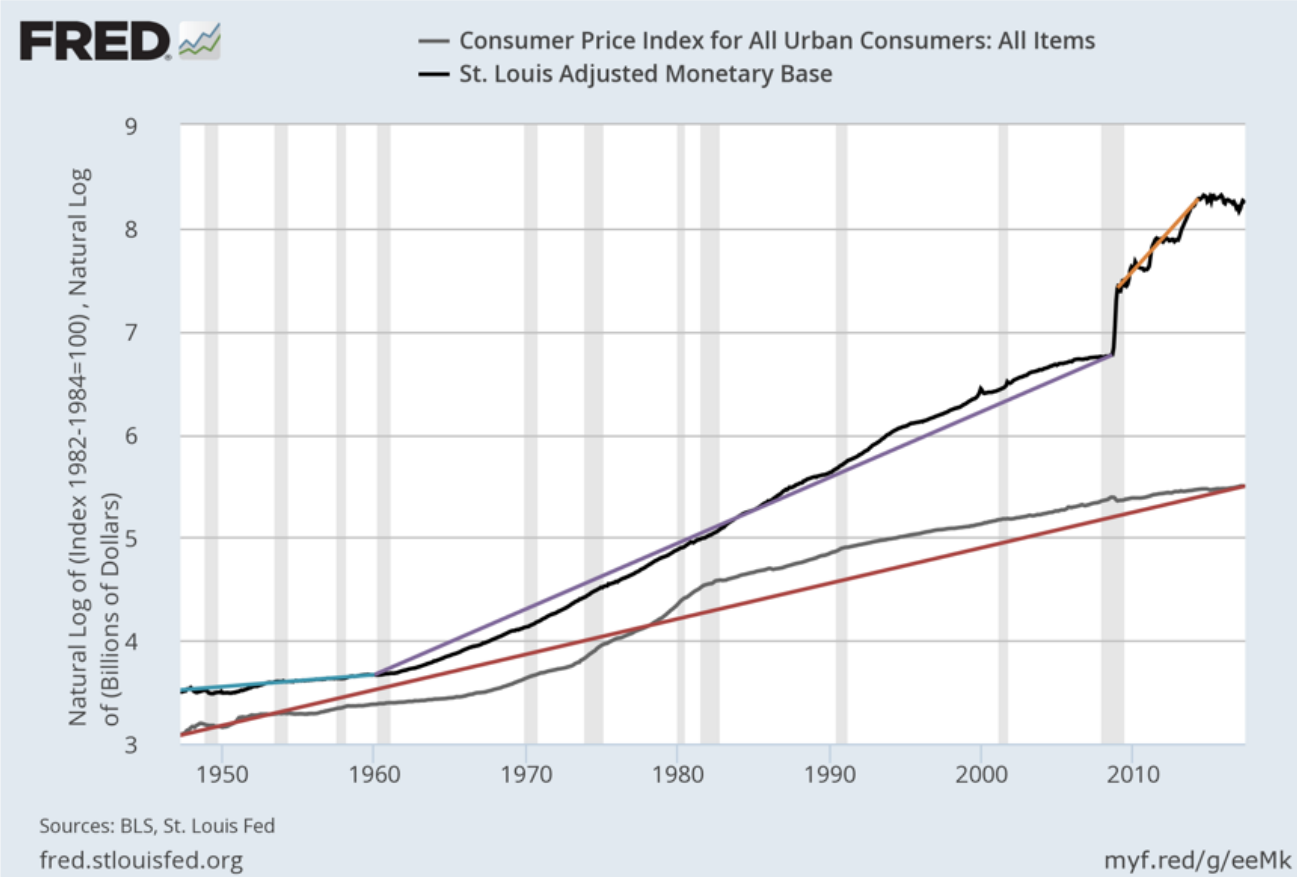

Figure: Natural Log of CPI and Monetary Base, 1947-2017.

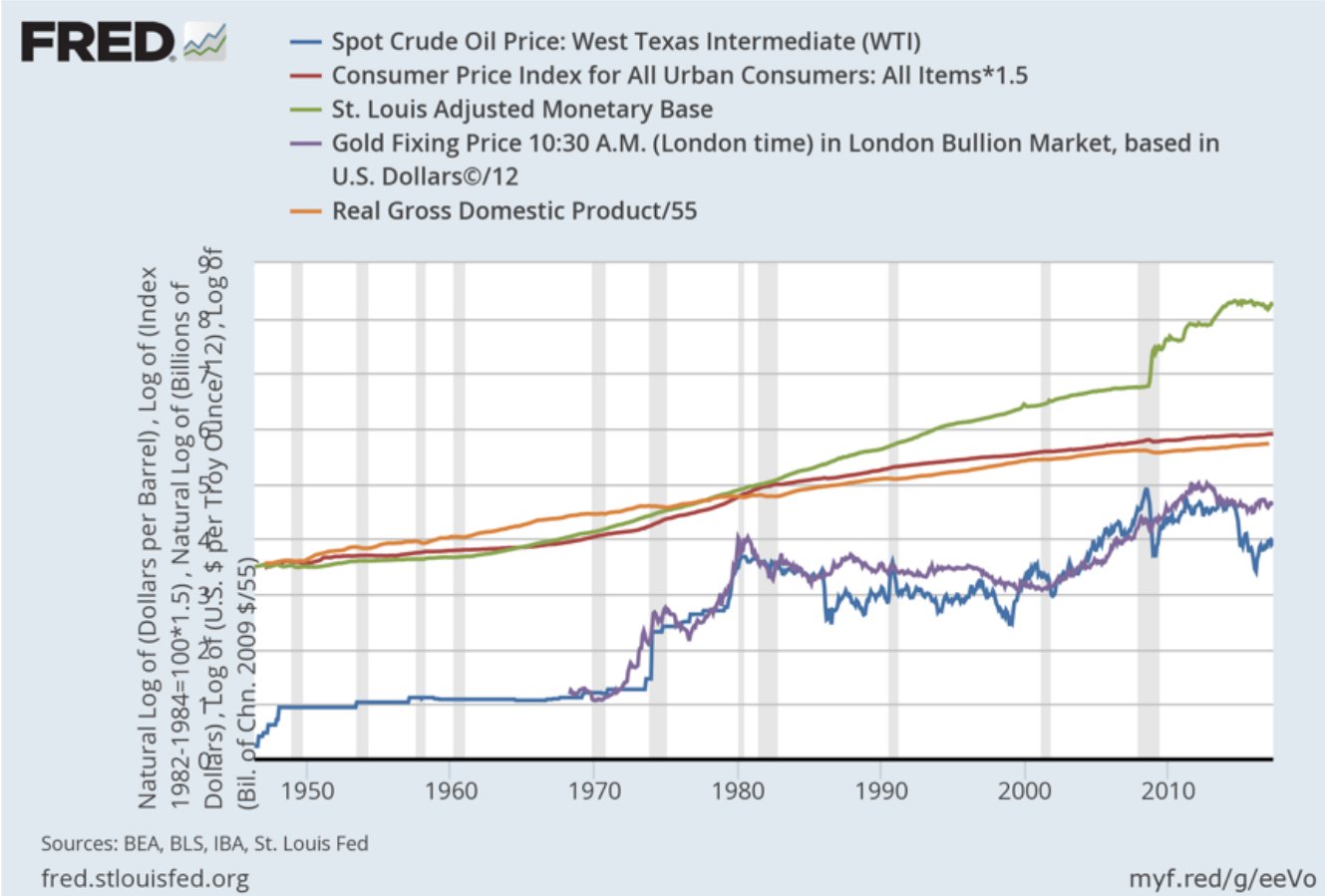

Figure: Natural Log of Real GDP lags the Natural Log of the Monetary Base.

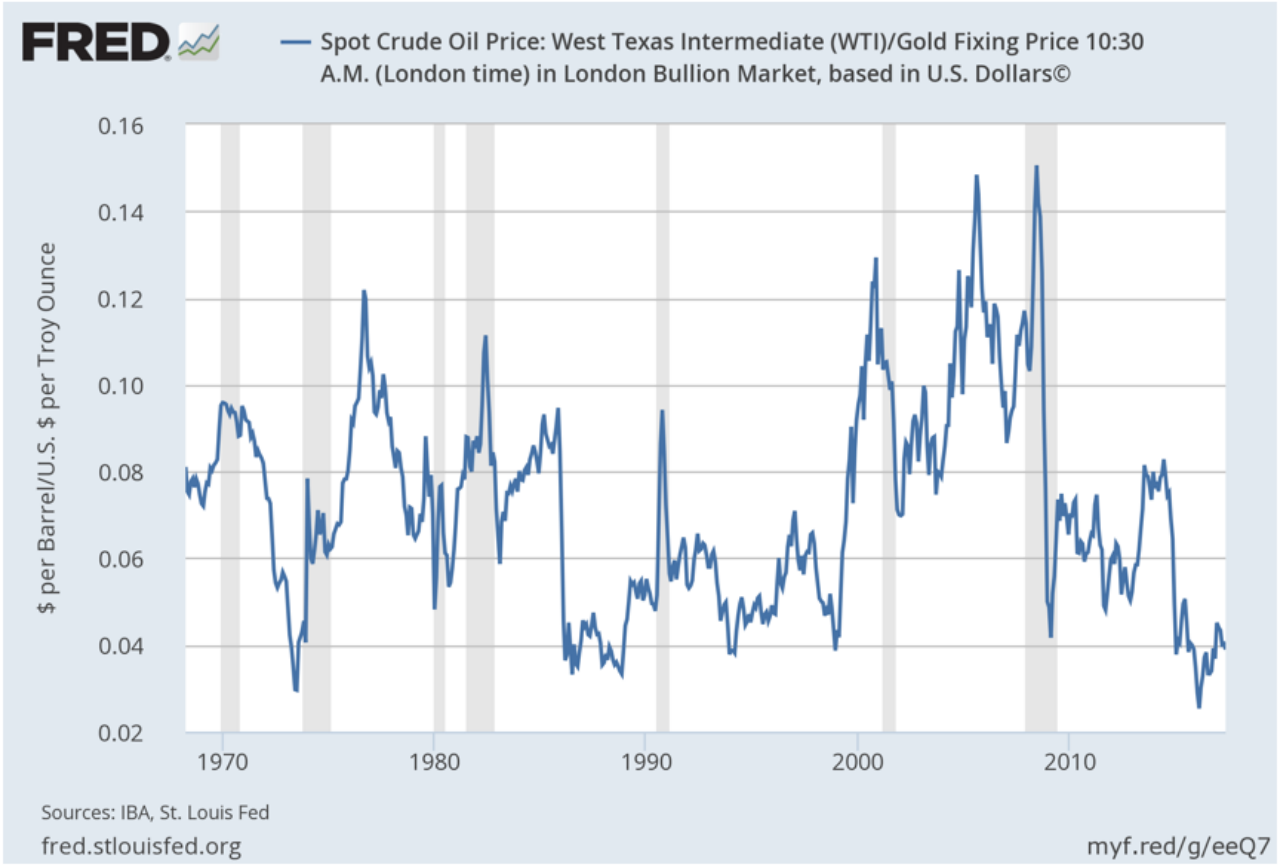

Figure: Oil to Gold Price Ratio

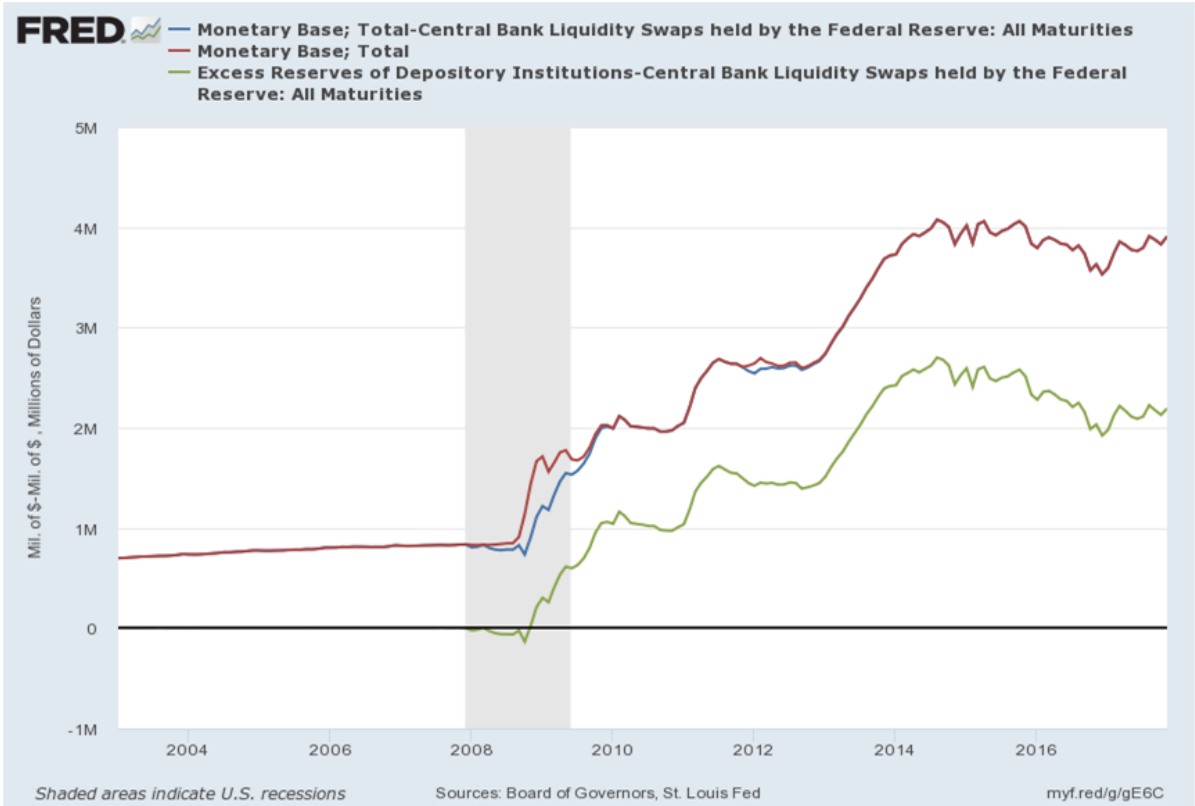

Figure: Monetary Base; Monetary Base minus Swaps; Excess Reserves minus Swaps turned Negative in 2008.

Data:FRED

- MB: Money Base (AMBSL, 1946m1 - 2017m4)
- SWP: Central Bank Liquidity Swaps (SWPT, 2003m1 - 2017m5)
- DEMDEP: Demand deposits (DEMDEPSL, 1959m1 – 2017m4)
- M1: M1 Money Stock (M1SL, 1959m1 – 2017m4)
- M2: M2 Money Stock (M2SL, 1959m1 – 2017m4)
- CPIE: CPI less Energy (CPILEGSL, 1957m1 – 2017m4)
- CPI: CPI for all urban consumers (CPIAUCSL, 1947m1 – 2017m4)
- WTI: Spot Crude Oil Price WTI (WTISPLC, 1946m1 – 2017m4)
- GOLD: Gold fixing price in London Bullion Market (GOLDPMGBD228NLBM, 1950m1 – 2017m5)
- M1 Divisia: Monetary services Index M1 (MSIM1P, 1967m1 – 2013m12)
- M2 Divisia: Monetary services Index M2 (MSIM2, 1967m1 – 2013m12)
- EXCH: Trade Weighted U.S. Dollar Index: Broad (TWEXB, 1973m1 – 2017m4)

Testing Methodology

- Granger (1969), Hamilton (1983),
  - Gillman-Nakov (2009), Alquist et al.(2013).
  - Tests for endogeneity of oil prices by estimating VAR model:
- $Y_t = c_0 + c_1 Y_{t-1} + ... + c_p Y_{t-p} + d_1 X_{t-1} + ... + d_p X_{t-p} + v_t$
  - X "Granger-cause" Y if Y can be better predicted using
  - histories of both X and Y than
  - by using the history of Y alone.
- Reduces to testing null hypothesis $H_0 : d_1 = d_2 = ... = d_p = 0$,
  - against H_A: 'Not H_0'.
  - Rejection of null equivalent to saying X does Granger-cause Y.
- Requires X & Y to be stationary.
  - If X and Y are of a different order of integration, differentiate
  - X and Y by the necessary amount of times so stationary.
- If different orders of integration, Toda-Yamamoto 1995 (Giles 2011)
  - Giles (2011) offers a set of instructions on applying Toda-Yamamoto.

Econometrics

- unit root tests & Granger causality tests: on full sample, & subsamples.
- Subsamples chosen various reasons.
  - post-1973 & post-1975 replication of Alquist et al. 2013
  - 2008 breakpoint separates pre- and post-crisis periods.
- Data Properties
  - p-values of ADF unit root test for first differences.
  - All series integrated of order 1 (I(1)); use Granger 69,
  - except for the CPIE, which is I(2); use Toda & Yamamoto (1995).

	full sample	1973-2017	1975-2017	1991-2017	Data Start- 2008m9	2008m10-2017
MB	0	0	0	0	0	0
MB-SWP	0	0	0	0	0	0
MB+DEMDEP	0	0	0	0	0	0
MB-SWP+DEMDEP	0	0	0	0	0	0
M1	0	0	0	0	0	0
M1-SWP	0	0	0	0	0	0
M2	0	0	0	0	0	0
M2-SWP	0	0	0	0	0	0
CPIE	0.2185	0.3369	0.0278	0.0023	0.2332	0
CPI	0	0	0	0	0.0001	0
WTI	0	0	0	0	0	0
GOLD	0	0	0	0	0	0
realOil	0	0	0	0	0	0
realGold	0	0	0	0	0	0
M1 Divisia	0	0	0	0	0	0
M2 Divisia	0	0	0	0	0	0
EXCH	0	0	0	0	0	0

Note: for p>0.05 the stationarity hypothesis is rejected

Table: p values for ADF test on the first difference of the series

Results of Granger causality

- MB-SWP Granger causality of (nominal & real) Oil prices
  - for all subperiods but 1918; p-value < 0.002 post war.
- M1 minus Swaps (M1-SWP): causality stronger:
  - p-value below 1% for all post-WWII subperiods.
- M1 Divisia minus Swaps: Granger causality
  - p-values at less than 3% for all post WWII subperiods.
- No Granger causality for MB, M1, M1 Divisia or M2, M2 Divisia.
- MB-SWP+DD: Results similar to MB-SWP.
- MB+DD Granger causes Oil Prices in 1918-2017 sample:
  - only exception; p-value is 7.6%.
- CPI minus Energy prices (CPIE) causes Oil Prices.
  - CPI (all urban) similar results; but not for 2008-2017.
  - CPIE Granger causes oil prices in 2008-2017.

causality to $WTI		full sample	1973-2017	1975-2017	1991-2017	Start -2008.9	2008.10-2017
MB	1946	0.1425	0.5046	0.4216	0.5773	0.8911	0.7593
MB-SWP	1946	**0.0017**	**0.0607**	**0.0068**	**0.024**	0.9852	**0.0483**
MB+DD	1959	**0.0755**	0.2289	0.1348	0.1243	0.8518	0.325
MB-SWP+DD	1959	**0.0159**	**0.0846**	**0.0102**	**0.0253**	0.9035	**0.0231**
M1	1959	0.4826	0.6716	0.4199	0.2152	0.8273	0.3679
M1-SWP	1959	**0.0003**	**0.0053**	**0.0005**	**0.0011**	0.8111	**0.0011**
M2	1946	0.7509	0.8688	0.797	0.3413	0.8273	0.5959
M2-SWP	1946	0.8698	0.9141	0.8126	0.5564	0.8297	0.1404
CPIE	1957	**0.0014**	**0.0001**	0.7814	0.5171	**0.0003**	**0.0173**
CPI	1947	**0.0931**	**0.0154**	0.1439	**0.0488**	**0.032**	0.6129
M1Divisia	1967	0.6818	0.7172	0.372	0.3499	0.8846	0.7799
M1Divisia-SWP	1967	**0.0124**	**0.0271**	**0.0041**	**0.0045**	0.9134	**0.0017**
M2Divisia	1967	0.6253	0.6649	0.3832	0.1915	0.8801	0.5889
M2Divisia-SWP	1967	0.855	0.8743	0.7058	0.718	0.8893	0.322

Note: p values in bold (<0.10) indicate the presence of causality

Table: Causality to nominal oil price (WTI)

causality to real Oil		full sample	1973-2017	1975-2017	1991-2017	Start-2008.9	2008.10-2017
MB	1947	0.1305	0.4985	0.4065	0.5728	0.7909	0.7486
MB-SWP	1947	**0.0019**	**0.0602**	**0.0066**	**0.0241**	0.9545	**0.0538**
MB+DD	1959	**0.075**	0.2299	0.1288	0.1227	0.852	0.299
MB-SWP+DD	1959	**0.0151**	**0.0816**	**0.0095**	**0.0246**	0.9064	**0.0244**
M1	1959	0.4581	0.6533	0.4001	0.1983	0.8001	0.3475
M1-SWP	1959	**0.0004**	**0.0067**	**0.0006**	**0.0011**	0.793	**0.0013**
M2	1947	0.7671	0.8821	0.8119	0.3224	0.8405	0.5765
M2-SWP	1947	0.8882	0.9326	0.8412	0.5326	0.8432	0.1393
CPIE	1957	**0.0021**	**0.0001**	0.8309	0.4942	**0.0003**	**0.0169**
CPI	1947	0.1605	**0.0187**	0.1521	**0.0462**	**0.0572**	0.5931
M1Divisia	1967	0.664	0.7003	0.3634	0.3257	0.8704	0.7573
M1Div-SWP	1967	**0.0151**	**0.0323**	**0.0048**	**0.0046**	0.9024	**0.0016**
M2Div	1967	0.6046	0.6439	0.3758	0.165	0.8704	0.5612
M2Div-SWP	1967	0.8466	0.8679	0.7038	0.6873	0.8803	0.3214

Note: p values in bold (<0.10) indicate the presence of causality

Table: Causality to real oil price (WTI/CPI)

Granger Causality of Gold Prices

- M1 minus Swaps, M1 Divisia minus Swaps, M2 minus Swaps,
- & M2 Divisia minus Swaps:
- Granger cause nominal & real gold prices
  - for some of the post-WWII subperiods.
- M2-SWP causality for entire post 1950 "full sample" period,
  - as well as for 1991-2017 and 2008-2017.
- M1-SWP causality for 1991-2017 and 2008-2017.
- M1 Divisia minus Swaps shows causality only for 1991-2017.
- CPI Granger causes gold prices in all subperiods except for 2008-2017.
  - Norm of inflation Granger-causing gold prices fell apart post 2008
  - when the expected inflation did not actually materialize.

causality to GOLD		full sample	1973-2017	1975-2017	1991-2017	Start-2008.9	2008.10-2017
MB	1950	0.8764	0.9723	0.9213	0.7626	0.7871	0.7878
MB-SWP	1950	0.6631	0.895	0.8815	0.486	0.4564	0.7802
MB+DD	1959	0.8798	0.9501	0.8886	0.6053	0.811	0.6083
MB-SWP+DD	1959	0.5147	0.7108	0.724	0.3426	0.7685	0.5197
M1	1959	0.7509	0.8441	0.878	0.5101	0.8141	0.1387
M1-SWP	1959	0.3909	0.5935	0.5222	0.0619	0.8361	0.0886
M2	1950	0.3451	0.4633	0.6182	0.6526	0.2214	0.58
M2-SWP	1950	0.0489	0.1143	0.1719	0.0362	0.2521	0.0263
CPI	1950	0.0254	0.047	0.0082	0.0102	0.0142	0.6118
M1Div	1967	0.5263	0.5086	0.6597	0.8013	0.4483	0.9496
M1Div-SWP	1967	0.3506	0.411	0.3505	0.0346	0.5093	0.3074
M2Div	1967	0.2818	0.3018	0.4588	0.9093	0.1473	0.8601
M2Div-SWP	1967	0.0913	0.113	0.2029	0.2032	0.1692	0.2994

Table: Causality to nominal gold price

causality to real gold		full sample	1973-2017	1975-2017	1991-2017	Start-2008.9	2008.10-2017
MB	1950	0.8887	0.9705	0.9045	0.7706	0.8020	0.834
MB-SWP	1950	0.7126	0.906	0.8844	0.4962	0.4959	0.82
MB+DD	1959	0.8374	0.9239	0.8286	0.6155	0.7484	0.6548
MB-SWP+DD	1959	0.4822	0.6748	0.6781	0.3253	0.7122	0.5551
M1	1959	0.7128	0.8077	0.8456	0.4755	0.7948	0.108
M1-SWP	1959	0.4588	0.6514	0.5491	**0.0889**	0.8300	0.1145
M2	1950	0.3291	0.4372	0.5991	0.6677	0.2165	0.5908
M2-SWP	1950	**0.0619**	0.1291	0.1819	**0.0578**	0.2481	**0.0339**
CPI	1957	**0.0234**	**0.0506**	**0.0089**	**0.0155**	**0.0146**	0.6753
M1Div	1967	0.4462	0.4292	0.5826	0.7558	0.3841	0.9539
M1Div-SWP	1967	0.4001	0.4585	0.3652	**0.048**	0.4441	0.3705
M2Div	1967	0.2206	0.2414	0.3916	0.9125	0.1181	0.8967
M2Div-SWP	1967	**0.0902**	0.1111	0.1993	0.2562	0.1372	0.3816

Note: p values in bold (<0.10) indicate the presence of causality

Table: Causality to real gold price

Granger Causality of Oil/Gold Price Ratio

- Results quite similar to tests on oil prices alone.
  - M1 minus Swaps (M1-SWP) & M1 Divisia minus Swaps,
  - results same, with causality of all post-WWII subperiods.
  - For the Monetary Base minus Swaps & (MB-SWP+DEMDEP)
  - a lack of causality in 1973-2017 and 2008-2017 subperiods.
- M1 shows causality for 1991-2017, unlike previous oil price results,
  - and M2 minus Swaps shows causality for the 2008-2017 subperiod.
- CPIE causality results are similar to Oil tables
- CPI: causality only for 1918-2008 subperiod.
- Allow possible new "oil price shock" definition
  - that shows broader monetary causality in the 2008-2017
  - because of added M2-SWP causality, compared to Oil tables.

Oil/Gold price ratio		full sample	1973-2017	1975-2017	1991-2017	Start-2008m9	2008m10-2017
MB	1950	0.149	0.4696	0.3808	0.5503	0.5377	0.7825
MB-SWP	1950	**0.02**	0.1707	**0.0342**	**0.0923**	0.6695	0.2309
MB+DD	1959	**0.0481**	0.1601	**0.0879**	0.1321	0.4415	0.2015
MB-SWP+DD	1959	**0.0366**	0.1383	**0.023**	**0.0524**	0.5073	**0.0693**
M1	1959	0.1507	0.3089	0.1367	**0.0713**	0.6941	0.2947
M1-SWP	1959	**0.0004**	**0.0057**	**0.0005**	**0.0016**	0.7207	**0.0031**
M2	1950	0.6722	0.796	0.813	0.2315	0.8291	0.4188
M2-SWP	1950	0.4433	0.5443	0.3823	0.3026	0.8184	**0.0427**
CPIE	1957	**0.0321**	**0.0014**	0.5804	0.8658	**0.0063**	**0.0516**
CPI	1950	0.1048	0.1072	0.3225	0.0903	**0.0152**	0.6126
M1Div	1967	0.5318	0.6001	0.3863	0.2475	0.6241	0.7606
M1Div-SWP	1967	**0.0087**	**0.0175**	**0.0019**	**0.0014**	0.6538	**0.0018**
M2Div	1967	0.5808	0.6847	0.6058	0.121	0.8882	0.3128
M2Div-SWP	1967	0.6857	0.7416	0.5621	0.4088	0.8861	**0.0704**

Note: p values in bold (<0.10) indicate the presence of causality

Table: Causality to Oil/Gold price ratio

Granger Causality: Money to Inflation

Both to Exchange Rate

- MB & MB-SWP cause CPI Inflation.
- Causality of US dollar trade-weighted Exchange Rate index.
  - MB & MB-SWP cause exchange rate index only in 2008-2017.
  - M1-SWP, M2 Divisia & M2Div-SWP all Granger cause index;
  - for "Full Sample", 1975-2017 & 1991-2017.
  - M1Divisia-SWP causality for Full Sample and 1975-2017.
  - M1Divisia: causality for 1991-2007.
- CPI causality of Exch Rate is robust for all subperiods.

Frame Title

Money to Prices		full sample	1973-2017	1975-2017	1991-2017	Start-2008m9	2008m10-2017
MB to CPI	1947	0.0029	0.0013	0.001	0.0013	0.0237	0.0929
MB-SWP to CPI	1947	0.0011	0.0073	0.0026	0.0076	0.0044	0.0245

Note: p values in bold (<0.10) indicate the presence of causality

Table: Causality of Base Money to Inflation

to Exch rate		full sample	1975-2017	1991-2017	Start-2008m9	2008m10-2017
MB	1973	0.1862	0.2221	0.1557	0.8803	**0.0285**
MB-SWP	1973	0.4269	0.4725	0.496	0.6024	**0.0752**
MB+DEMDEP	1973	0.3385	0.3642	0.3496	0.9056	0.1049
MB-SWP+DEMDEP	1973	0.3987	0.4205	0.6351	0.7276	0.1432
M1	1973	0.2451	0.1882	0.2745	0.8167	0.7234
M1-SWP	1973	**0.0233**	**0.0408**	**0.0786**	0.5833	0.2508
M2	1973	0.2447	0.156	0.123	0.5582	0.9102
M2-SWP	1973	0.163	0.1298	0.1178	0.4786	0.5678
CPI	1973	**0.0488**	**0.0571**	**0.0227**	**0.0825**	**0.0000**
M1Divisia	1967	0.2039	0.1336	**0.0314**	0.9214	0.2844
M1Divisia-SWP	1967	**0.049**	**0.0803**	0.1338	0.7689	0.7387
M2Divisia	1967	**0.0962**	**0.059**	**0.0289**	0.3907	0.5327
M2Divisia-SWP	1967	**0.0522**	**0.0444**	**0.0602**	0.3122	0.8328

Note: p values in bold (<0.10) indicate the presence of causality

Table: Causality to the Exchange rate

Discussion

- Strong evidence of Money & Inflation Granger causing oil prices
  - for narrower monetary aggregates.
- Given Key role of Swaps.
- Money strongly Granger causes inflation, as typically found.
- Money and Inflation causes gold prices, oil to gold price ratio,
  - and US dollar exchange rate index.
  - Robust set of monetary facts reinforce nominal factors.
  - Oil price not special, as international commodity in US dollars.
- Granger causality results for gold prices,
  - by broader M2 minus Swaps (M2-SWP).
  - Gold different in that oil used for production of output.
  - Gold is more of an investment hedge.
- inference: gold price builds in longer term expectations

of inflation; oil price shorter term inflation expectations.

Conclusion

- Inflation expected after 2009 because Fed bought lots T-debt.
- Expected inflation built into oil price expectations,
  - causing the 2009-2014 oil "shock".
- When excess reserves stopped rising in April 2014,
  - expectations of future inflation collapsed & so did oil prices.
- Jump in monetary base & excess reserves after 2008
  - worthy of Friedman (1994) *Money Mischief.*
  - Money causing inflation, oil & gold prices reflect this expectation,
  - & if expectations not met, then prices might fall precipitously.
- Post-2008 "interest on excess reserves" kept reserves in Fed
  - so did not cause new loan & demand deposit creation.
  - Caused "stagnation" of investment & growth, without inflation
- Fed's new 2008 policy of paying interest on reserves
  - induced an unpredicted oil shock because
  - expectations of inflation that were not realized.
  - Friedman might have guessed.

Gramm and Saving

"Today, banks hold $12 of excess reserves for every dollar they are required to hold, and the Fed balance sheet contains 20% of all publicly held federal debt and 34% of the value of all outstanding government-guaranteed mortgage-backed securities....While the initial injection of liquidity into the economy in 2008 clearly helped stabilize the financial market and was a classic central-bank response to a financial crisis, the monetary easing program of the Obama era was unprecedented... To maintain price stability in an environment of rising interest rates, the Fed would not only have to soak up existing excess reserves; it would also have to reduce bank reserves to prevent the increase in velocity from inflating demand and igniting inflation."