The Optimal Monetary Instrument and the (Mis)Use of Causality Tests

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Motivation

- What is the optimal instrument for monetary policy? [Poole (1970)]
- Should central bank's remain focused on using interest rates or should they consider switching to a monetary aggregate? [Woodford (2003)]
- We study these and related questions in light of a standard New-Keynesian model that allows for multiple types of monetary assets. [Belongia and Ireland (2014)]
- We also examine whether causality tests are helpful in answering these questions in the context of our DSGE economy. [Granger (1969), Sims (1972), Geweke, Meese, and Dent (1983)]

Welfare Analysis

- First, this paper investigates the optimal monetary instrument in a New-Keynesian model with two types of monetary assets: deposits which pay interest and currency which does not.
- We compare a standard interest rate rule [Taylor (1993)] to fixed growth rate rules for 3 alternative monetary aggregates.
- The interest rate rule dominates k-percent rules for both the monetary base and simple sum money
- However, the Divisia k-percent rule outperforms the interest rate rule.
- We conclude Divisia is superior to the typical choices for policy instrument in this (essentially) standard New-Keynesian model.

Implications for Causality Tests

- Then, we examine causality testing based on data generated from our model, under the normative assumption that monetary policy follows a standard Taylor Rule.
- Causality tests for each of our 4 potential monetary instruments are performed for output and the price level
- We find the interest rate causes both variables at extremely high significance levels.
- We find monetary base and the simple-sum monetary aggregate also cause output and the price level
- Divisia causes output, however, it fails to cause prices.
- Thus, if the choice of instrument is based solely on its propensity to statistically cause macroeconomic targets, a central bank may choose an inferior policy instrument.
- Econometrics Result: We prove that the Geweke, Meese, and Dent (1983) test is immune to issues associated with integrated regressors (which Granger's test is not immune to)

The DSGE Set-up

The Variables

Variables in levels are upper case, while lower case indicates logarithms (or log deviations from steady state)

- c_t is consumption
- π_t is inflation rate
- r_t is the nominal interest rate on one-period bonds
- m_t is real money balances
- y_t is real output
- N_t is currency
- D_t is deposits
- R_t is the gross benchmark interest rate
- R_t^D is the gross interest rate on deposits

The Shocks

- ε_t^a is a shock to preferences (a)
- ε_t^z is a shock to technology (z)
- ε_t^ν is a shock to money demand (ν)
- ε_t^r is a shock to monetary policy (r)
- ε_t^x is a shock to financial intermediation (x)
- ε_t^τ is a shock to bank reserves (τ)

- These are white noise shocks.
- Except for the monetary policy shock, each of these white noises drives an AR(1) process.
- The monetary policy shock is a shock to the Taylor (1993) Rule.

The Usual Equations - with Habit Persistence

- Euler Equation:

$$c_t = \frac{1}{1+h}\mathbb{E}_t c_{t+1} + \frac{h}{1+h} c_{t-1} - \frac{1-h}{1+h}(r_{t+1} - \mathbb{E}_t \pi_{t+1} - (1-\rho_a)a_t)$$

- Money Demand Function:

$$m_t = \frac{1+\chi(1-h)}{(1+\chi)(1-h)} c_t - \frac{h}{(1+\chi)(1-h)} c_{t-1} - \eta r_t - \eta_\tau \tau_t - \eta_x x_t + \upsilon_t$$

- Phillips Curve:

$$\pi_t = \pi_{t-1} + \kappa(\frac{1}{1+h} c_t - \frac{h}{1+h} c_{t-1} - z_t) + \beta \mathbb{E}_t(\pi_{t+1} - \pi_t)$$

Taylor Rule

- New-Keynesian Models are typically closed by a Taylor-type rule:

$$r_t = \rho_r r_{t-1} + (1-\rho_r)(\rho_\pi \pi_t + \rho_y (y_t - z_t)) + \varepsilon_t^r$$

- In addition to this rule, we will also consider money growth (Monetary Base, Simple Sum Money, or Divisia Money) as a possible policy instrument

The "True" Monetary Aggregate

Is assumed to be a constant elasticity of substitution (CES) function:

$$M_t = \left[\nu^{\frac{1}{\omega}} N_t^{\frac{\omega-1}{\omega}} + (1-\nu)^{\frac{1}{\omega}} D_t^{\frac{\omega-1}{\omega}} \right]^{\frac{\omega}{\omega-1}}$$

where N_t and D_t are non-interest bearing currency and interest bearing deposits, respectively.

- $\omega > 0$ is the elasticity of substitution between currency and deposits
- $0 < \nu < 1$: governs the steady-state shares of each asset.
- $\omega \to \infty \Rightarrow M_t = N_t + D_t$. (i.e. the simple-sum monetary aggregate is the appropriate monetary aggregate when currency and deposits are perfect substitutes.)
- $\omega < \infty$, i.e. currency and deposits are not perfect substitutes, then a simple-sum aggregate will not equal the true aggregate.

Growth Rate of Divisia Monetary Aggregate

- The weighted Divisia aggregate, $M_t^{\mathcal{D}}$, of Barnett (1980) is one non-parametric measure of money.
- The growth rate of Divisia is defined as:

$$\ln\left(\frac{M_t^{\mathcal{D}}}{M_{t-1}^{\mathcal{D}}}\right) = \left(\frac{S_t^N + S_{t-1}^N}{2}\right) \; ln\left(\frac{N_t}{N_{t-1}}\right) + \left(\frac{S_t^D + S_{t-1}^D}{2}\right) ln\left(\frac{D_t}{D_{t-1}}\right)$$

- where S_t^N is the share of spending on monetary assets allocated to currency:

$$S_t^N = (R_t - 1)N_t/((R_t - 1)N_t + (R_t - R_t^D)D_t)$$

- and $S_t^D = 1 - S_t^N$ is the share allocated to deposits.

Growth Rate of Simple Sum Money

Simple Sum money, M_t^S, is another non-parametric aggregate, and its growth is given by:

$$ln\left(\frac{M_t^{\mathcal{S}}}{M_{t-1}^{\mathcal{S}}}\right) = ln\left(\frac{N_t + D_t}{N_{t-1} + D_{t-1}}\right)$$

Growth Rate of the Monetary Base

The monetary base, A_t, is calculated by adding together currency and bank reserves, hence its growth rate is:

$$\ln(\frac{A_t}{A_{t-1}}) = ln(\frac{N_t + exp(\tau_t)D_t}{N_{t-1} + exp(\tau_{t-1})D_{t-1}})$$

A Simple Model of Banks

- Assume profit maximizing banks under perfect competition
- τ_t and x_t are exogenous financial disturbances, to bank reserves and the cost of financial intermediation, respectively.
- each shock follows a stationary stochastic processes
- the resulting first order condition for the bank:

$$R_t - R_t^d = (R_t - 1)\tau_t + x_t$$

- affects S_t^N and S_t^D

Calibrated Model Parameters

Parameter	Value
β	0.99
Π	$1.02^{\frac{1}{4}}$
$exp(z)$	$1.02^{\frac{1}{4}}$
$exp(\tau)$	0.03
$exp(x)$	0.01
$exp(\upsilon)$	2.65
η	16.61
ν	0.275
ω	0.5
θ	6
ϕ	50
b	0.85
ρ_r	0.79
ρ_π	2.15
ρ_y	0.93

Estimated Model Parameters

Parameter	Value
ρ_a	0.3981
σ_a	0.0433
ρ_υ	0.3701
σ_υ	0.0014
σ_z	0.0086
ρ_τ	0.8557
σ_τ	0.0526
ρ_x	0.7430
σ_x	0.0031
σ_r	0.0015
χ	27

Model Fit: Moment Matching Results

Variable		Data	Model
Real GDP Growth	ρ	0.320	0.312
	σ	0.008	0.006
Inflation	ρ	0.983	0.861
	σ	0.006	0.006
Federal Funds Rate	ρ	0.962	0.879
	σ	0.010	0.006
Divisa M2 Growth	ρ	0.481	0.481
	σ	0.009	0.011
Divisa M2 User Cost	ρ	0.915	0.879
	σ	0.100	0.123
Monetary Base Growth	ρ	0.336	0.338
	σ	0.039	0.040

Welfare Comparison of Monetary Policy Instruments

Policy Instrument	Welfare
Interest Rate Rule	-1.0759
Constant Divisia Growth Rule	-0.5929
Constant Simple-Sum Growth Rule	$-\infty$
Constant Monetary Base Growth Rule	-1.4877

Results:

- Simple Sum yields indeterminacy.
- The other 3 are determinate.
- Divisia obtains the lowest loss.

Granger Causality Tests: p-Values

Causal Variable	Real GDP		Price Level	
Divisia	0.008	0.108	0.116	0.427
Simple-Sum	0.018	0.105	0.000	0.435
Monetary Base	0.000	0.294	0.000	0.449
Interest Rate	0.000		0.000	
Interest rate included in VAR?	No	Yes	No	Yes

When interest rates are not included in the VAR (the second and fourth columns), all VAR models are bivariate. When interest rates are included in the VAR (the third and fifth columns) then all VAR models are trivariate.

Sims (lagged-dependent variable) Causality Tests: p-Values

Causal Variable	Real GDP	Price Level
Divisia	0.001	0.363
Simple-Sum	0.064	0.000
Monetary Base	0.000	0.000
Interest Rate	0.000	0.000

- These bivariate causality tests are performed using the Geweke, Meese, and Dent (1983) version of Sims (1972).
- In the paper we show that this test has the same asymptotic distribution whether or not one or more of the regressors has a unit root.

Conclusion

- The common belief that an interest rate is a superior monetary policy instrument is refuted in a New Keynesian model with multiple types of monetary assets
- A weighted monetary aggregate outperforms the interest rate, the monetary base, and the simple sum measure of money as the policy instrument.
- In spite of its welfare advantages, causality tests find that overall Divisia has the weakest relationship with two important policy goal variables.
- Choosing an instrument based on causality test results would yield an inferior outcome in a standard New-Keynesian model with multiple types of monetary assets.

Conclusion

- Christiano and Ljungqvist (1988) state that Eichenbaum and Singleton (1986) "conjecture that it would be difficult to construct a business cycle model which (a) assigns an important role to monetary factors, (b) is empirically plausible and (c) has the implication that money fails to Granger-cause output."
- The model we use finds such as model: it satisfies Points(a) and (b), in general, and satisfies Point (c) when the interest rate is included in the VAR.
- Our model is also consistent with another finding in the literature [e.g. Sims (1980)]: money causes output in the bivariate relationship, but not when the interest rate is added to the VAR.
- Thus, we conclude the Belongia and Ireland (2014) framework has a number of interesting features and deserves further study.