Money in the Production Function
Some Policy Implications

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Microeconomic Science

• Microeconomics and Macroeconomics are different Sciences
• Microeconomics is a powerful science for addressing micro issues
• But in addressing macro problems it has failed spectacularly (Lucas and Sargent)
Macroeconomic Science

- It is a unified hard quantitative science
- Conceptually it is simple
  - Smart undergraduates can master the basic concepts in a single course
  - Supply and demand are not used in this science
  - General equilibrium reasoning is used with agents on both sides of every transaction
  - All accounting identities must hold for the model economy being used to address the given question
• To answer the question: What is the aggregate consequences of some interest rate targeting regime?

• Until recently when the President of the Minneapolis Federal Reserve Bank asked me what the Fed should do, my answer was that economic theory does not provide an answer.

• Today I will report on a recent advance of macro theory that can be helpful to answer such questions.
Motivation

• Technology is rapidly advancing in the information processing area

• This is changing the monetary/payment system

• A currency–less fiat monetary system is now feasible (Sweden)

• U.S. is moving in this direction
History of Aggregate Monetary Theory

• Using the Stokey and Lucas (1981) framework, money was introduced into dynamic macroeconomics

• The finding was that with this household transaction framework monetary policy had virtually no consequences for real output and employment (Cooley and Hansen, 1989)
History of Value

• The price of a good is in units of value

• Commodity value system
  • Value is in units of a commodity, e.g. ounces of gold/silver
  • Used in U.S. before 1933
• Fiat currency value system
  • Value is in units of currency, e.g. dollar, pound, etc.
  • Its use economizes on resources needed to acquire gold
  • Used in U.S. after 1933

What is the unit of value in a currency-less system?
Fiat Value System

- Fiat value is a form of government debt
- Prices are in units of **fiat value**
- Name of units of value is unimportant
Fiat Value System

- Use valuation equilibrium theory of Debreu (1954)
  - Commodity space is a linear topological space
  - “Value services” is a commodity
- Use sequence of valuation equilibria
  - This is the way statistics are collected (quarterly)
• Fiat value is the numeraire
  • GE theory prior to Debreu had finite number of goods and only *relative* values of commodities were determined
  • In fiat value system, prices are in units of fiat value
Traditional and Commercial Banks

• Traditional Banks
  • Played important role in commodity value system
  • Fractional reserves reduced the amount of commodity used by the payment system
• Commercial Banks
  • Play important role in fiat currency value system
  • Accept demand deposits, originate loans, and have fractional reserves
  • But, managing assets is their major activity
Banks in a Fiat Value System

Proposal: totally separate transaction services from asset management services
Transaction Services

• Businesses hold large amounts of cash reserves

• Businesses hold over $10 trillion in highly liquid assets that earn zero real return

• Services of these “cash reserves” are a factor of production

• Just like human capital and other capital services
Asset Management

• Trusts that do not accept demand deposits

• They pool savings and make investments

• This is the way most lending to finance business is done
  • Checkable deposits only 0.08 annual GNP
  • Time and savings deposits only 0.57 GNP
  • Yet business borrowing is 2.5 GNP (*Flow of Funds L104, L105*)

• BlackRock alone manages 0.25 GNP of debt assets
Key Features of System

• Fiat value is a form of government debt
• Prices are in units of fiat value
• Fiat value is a capital stock
• It is rented to the business sector

Note: Money is short for fiat value in what follows
The Model Used to Explore How Such a System Would Operate
Aggregate Production Properties

• Want marginal product of money to be zero if money services input is large enough

• Want standard production function properties (McKenzie)
  • Constant returns to scale (CRS)
  • Concavity
  • Increasing
  • Differentiable

• An isoquant defines a production function, given CRS
Technology

- $h$ labor, $k$ capital services, $m$ money services, $y$ output, $A$, $\lambda$ and $\theta$ parameters, and $z_t = k_t^\theta h_t^{1-\theta}$

- CRS aggregate production function

\[
y_t = f(m_t, z_t) = \begin{cases} 
A\lambda^{1-f}z_t & \text{if } m_t = \lambda z_t \\
A z_t^f m_t^{1-f} & \text{if } m_t < \lambda z_t
\end{cases}
\]
A Production Function Isoquant

\[ z = \frac{m}{\lambda} \]
Technology

• When \( \frac{m}{z} = \lambda \), the marginal product of money is zero

• We term this “satiation”

• When satiation, the marginal product of money is zero
Households and Their Preference Ordering

- Measure one of identical households

- Preferences ordered by

\[
\sum_{t=0}^{\infty} (1 + \rho)^{-t} \left[ \log c_t + \alpha \log(1 - h_t) \right]
\]

- \( h \) is the fraction of time allocated to the market
Government Policy Variables

• Variables
  
  • $\pi$ : inflation rate
  • $\tau$ : labor tax rate
  • $g$ : gov’t purchases of final product
  • $\psi$ : transfers to household
  • $m$ : stock of money
  • $b$ : stock of gov’t bonds issued
  • $i_m$ : interest rate on money
  • $i_b$ : interest rate on gov’t bonds
Government

- Government pays interest on two types of debt:
  - \( i_m \): nominal interest paid on money
  - \( i_b \): nominal interest paid on bonds
- Absent monetary satiation \( i_b \) is the bigger

Note

- An equilibrium condition is \( r_m + i_m = i_b \)
- When monetary satiation, the rental price of money services is zero and \( i_m = i_b \)
Budget Constraints

• All quantities are real

• All prices are nominal
Budget Constraints

• Household budget constraint is
  \[ c + [k' - (1 - \delta)k] + [(1 + \pi)m' - m] + [(1 + \pi)b' - b] = (1 - \tau)wh + r_k k + r_m m + i_m m + i_b b + \psi \]

• HH consume and invest in capital, money, and bonds

• HH income from business sector (wage, capital rental, money rental) and from government (interest received on money and bonds, transfers)
Budget Constraints

• Firm budget constraint is

\[ y = wh + r_k k + r_m m \]

• Constant returns to scale so no economic profits in equilibrium
Budget Identity

• Government budget identity is

\[ g + \psi + i_m m + i_b b = \tau w h + \left[ m'(1 + \pi) - m \right] + \left[ b'(1 + \pi) - b \right] \]

• Gov’t consumes, transfers to HH and pays interest on \( m \) and \( b \)

• Gov’t finances its expenditures from labor taxes, producing money (inflation tax), and new debt.
• Dynasty and overlapping generations in our model economies are essentially equivalent

• We use dynasty because it simplifies the presentation

• In balanced growth, stocks are constant relative to output, so we will drop the prime on beginning of next period’s stocks
A Note on Government Financing

• In balance growth, the government budget constraint is

\[ g + \psi + i_m m + i_b b = \tau wh + \pi m + \pi b \]

• Government revenue is from the labor tax and from the inflation “tax”

• Money production is a government monopoly
Equilibrium

• Prices are \( \{w_t, r_{kt}, r_{mt}, i_{mt}, i_{bt}\}_{t=0}^{\infty} \)

• Equilibrium conditions are

  – Given prices and budget constraint, **household** chooses its best \( \{c_t, h_t, k_{t+1}, m_{t+1}, b_{t+1}\}_{t=0}^{\infty} \)

  – Given prices, **firm** chooses \( \{k_t, h_t, m_t\} \) that maximizes its value for every \( t \)

  – The **government** selection of \( \{g_t, \psi_t, b_{t+1}, m_{t+1}, \pi_t, \tau_t\}_{t=0}^{\infty} \)
    are such that its budget identity is satisfied for all \( t \)

• We study balanced growth only
Baseline Economy

• We have specified a parametric set of economies

• We choose a set of parameters so that model matches selected U.S. National Income and Product Account data (following Larry Klein)

• Targets:
  – Consumption/investment shares
  – Fraction of time worked
  – Asset stocks to output ratios
  – Factor income shares
Baseline Economy: *Parameters*

<table>
<thead>
<tr>
<th>Preference and Technology Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$ relative preference for leisure</td>
<td>0.68</td>
</tr>
<tr>
<td>$\beta$ discount rate (annual)</td>
<td>0.98</td>
</tr>
<tr>
<td>$\delta$ depreciation rate (annual)</td>
<td>0.04</td>
</tr>
<tr>
<td>$\theta$ capital cost share</td>
<td>0.35</td>
</tr>
<tr>
<td>$\varphi$ money cost share</td>
<td>0.01</td>
</tr>
<tr>
<td>$A$ TFP</td>
<td>1.13</td>
</tr>
<tr>
<td>$\lambda$ money satiation parameter</td>
<td>2</td>
</tr>
</tbody>
</table>
## Baseline Economy: Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Definition</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$g / y$</td>
<td>gov’t public goods share</td>
<td>0.05</td>
</tr>
<tr>
<td>$\psi / y$</td>
<td>transfer share</td>
<td>0.25</td>
</tr>
<tr>
<td>$m / y$</td>
<td>money output ratio</td>
<td>1.50</td>
</tr>
<tr>
<td>$b / y$</td>
<td>gov’t privately held debt to output</td>
<td>0.50</td>
</tr>
<tr>
<td>$\tau$</td>
<td>labor tax rate</td>
<td>0.52</td>
</tr>
<tr>
<td>$i_m$</td>
<td>interest rate on money</td>
<td>6.54%</td>
</tr>
<tr>
<td>$i_b$</td>
<td>interest rate on gov’t bonds</td>
<td>7.21%</td>
</tr>
<tr>
<td>$\pi$</td>
<td>inflation rate (annual %)</td>
<td>2.00%</td>
</tr>
</tbody>
</table>
Baseline Economy: *National Accts*

• This theory necessitates a change in how National Accounts are constructed
### National Accounts

<table>
<thead>
<tr>
<th>Product</th>
<th>1.08</th>
</tr>
</thead>
<tbody>
<tr>
<td>HH Consumption</td>
<td>0.68</td>
</tr>
<tr>
<td>Gov’t C &amp; Invest.</td>
<td>0.05</td>
</tr>
<tr>
<td>HH Invest. in k</td>
<td>0.27</td>
</tr>
<tr>
<td>Money Production</td>
<td>0.08</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Income</th>
<th>1.08</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wages</td>
<td>0.64</td>
</tr>
<tr>
<td>Depreciation of Capital</td>
<td>0.15</td>
</tr>
<tr>
<td>Capital Rental Income</td>
<td>0.19</td>
</tr>
<tr>
<td>Money Rental Income</td>
<td>0.01</td>
</tr>
<tr>
<td>Central Bank Profits</td>
<td>0.08</td>
</tr>
</tbody>
</table>
# Government Accounts

<table>
<thead>
<tr>
<th>Receipts</th>
<th>0.44</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tax Revenue</td>
<td>0.33</td>
</tr>
<tr>
<td>Money Issuance</td>
<td>0.08</td>
</tr>
<tr>
<td>Debt Issuance</td>
<td>0.03</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Expenditures</th>
<th>0.44</th>
</tr>
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<tbody>
<tr>
<td>Gov’t Consumption</td>
<td>0.05</td>
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<td>Transfers to HH</td>
<td>0.25</td>
</tr>
<tr>
<td>Bond Interest Payments</td>
<td>0.04</td>
</tr>
<tr>
<td>Money Interest Payments</td>
<td>0.10</td>
</tr>
</tbody>
</table>
Three Explorations
• Government policy variables \( \{\pi, \tau, i_m, \frac{m}{y}, \frac{b}{y}, \frac{\psi}{y}, \frac{g}{y}\} \)

• We are concerned with MONETARY policy not FISCAL policy.

• Therefore, fix government debt, spending, and transfers relative to output \( y \)

• Gov’t policy variables \( \{\pi, \tau, i_m, \frac{m}{y}\} \)

• Restriction on two MONETARY policy variables
  – interest on money and money stock cannot both be fixed.
1. Monetary Policy with Endogenous Tax Rate

- What consequences do money supply policies have?

<table>
<thead>
<tr>
<th>Policy Regimes</th>
</tr>
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<tbody>
<tr>
<td><strong>Fixed across regimes</strong></td>
</tr>
<tr>
<td>$\left{ \frac{g}{y} = 0.05, \quad \frac{\psi}{y} = 0.25, \quad \frac{b}{y} = 0.50, \quad \pi = 0.02 \right} $</td>
</tr>
<tr>
<td><strong>Varies across regimes</strong></td>
</tr>
<tr>
<td>$\left{ \frac{m}{y}, i_m, \tau \right} $</td>
</tr>
</tbody>
</table>
Labor tax rates for different interest rate targets
Welfare for interest rate target regimes
Implications

• In a regime with a fixed inflation rate target, FISCAL POLICY must respond to changes in INTEREST RATE POLICY

• Hump shape welfare arises for two reasons
  • Higher interest means more money => more output
  • Higher interest means high labor tax => less output

• Welfare highest when interest on money is 6% in this economy
2. Monetary Policy with Endogenous **Inflation Rate**

• What consequences do money supply policies have?

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<td>( \left{ \frac{g}{y} = 0.05, \quad \frac{\psi}{y} = 0.25, \quad \frac{b}{y} = 0.50, \quad \tau = 0.52 \right} )</td>
</tr>
<tr>
<td>Varies across regimes</td>
</tr>
<tr>
<td>( \left{ \frac{m}{y}, i_m, \pi \right} )</td>
</tr>
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</table>
Welfare for interest rate target regimes

![Graph showing CE (%) vs Money Stock Regime (m/y)]
Friedman Rule

• Friedman Rule calls for nominal return on money equal to social cost of producing money (which is zero for our economies)

• Achieved with deflation equal to real interest rate

• Friedman rule not feasible with a fiat valued currency system (see McAndrews 2015)
Friedman Satiation

• With a fiat value system, **Friedman Satiation** can be implemented with positive inflation!

• With satiation  \( r_m = 0 ; \quad i_m = i_b \)

• Private marginal cost of holding money equals the social cost of producing money
With satiation, rental price of money is zero.
3. Inflation Rate Targeting Regimes

- What are the consequences of different inflation rate targets?

<table>
<thead>
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<th>Policy Regime</th>
<th>Fixed across regimes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \left{ \frac{g}{y} = 0.05, \frac{\psi}{y} = 0.25, \frac{b}{y} = 0.5, i_m = 0.06 \right} )</td>
</tr>
</tbody>
</table>

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</thead>
<tbody>
<tr>
<td></td>
<td>( \left{ \pi, \tau, \frac{m}{y} \right} )</td>
</tr>
</tbody>
</table>
Labor tax rates for inflation rate target regimes

![Graph showing the relationship between tax rates and inflation rate target regimes. The graph displays a downward trend, indicating that as the inflation rate target regime increases, the tax rate decreases.]
Welfare for inflation rate target regimes

![Graph showing the relationship between CE (%) and Inflation Rate Target Regime (%). The graph indicates a peak at around 2.5% inflation rate target regime and a decrease thereafter.]
Implications

• Welfare indicator highest when inflation is 2.5% and labor tax rate is 49.5% (lower than baseline)

• Some inflation is an effective method of financing government consumption

• High inflation is not an effective financing option because labor tax rate decreases very little
Possible Problems and Advantages
Possible Problems with This System

Before initiating this system, should consider:

• Privacy protection and time consistency
  • See work of Rabee Tourky (ANU) who makes a case for privacy protection
  • Will not deal with these big problems here

• Shadow Banking
  • There is a way to deal with this problem
Possible Solution to the Shadow Banking Problem

- Tax net interest income at a 100% rate for limited liability businesses
- This effectively eliminates businesses that borrow low from one group and lend high to another
Advantages of System

- No bank runs
- No too-big-to-fail problem
- No need for costly regulation as with the U.S. deposit insurance system
  - These costs are about one-half a percent per year of deposits at banks
Conclusion

• We explored a fiat value system which is technically possible given the current state of information-processing technology

• We put money services in the aggregate production function
Conclusion Continued

• It is consistent with both traditional money demand functions and with zero nominal interest rates for extended periods (Japan, 1992-2018)

• Much more research is needed

• Whether going to a currency-less system is good or bad is an open question
Conclusion Continued

• We have shown that monetary policy and fiscal policy are not independent, and evaluating a policy regime is an advanced exercise in public finance.