

Computational Learning in Macroeconomics: Evolving Models and Methods

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Outline

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Dynamic Models

- We are interested in dynamic models: $\Delta x_t = \alpha x_{t-1} + \beta z_t$
- The symbol Δ is the first difference operator, with $\Delta x_t = x_t - x_{t-1}$
- The symbols α and β are coefficients or parameters
- x_t is the state variable or endogenous variable, while z_t is an exogenous variable
- For stability, we require that $|1 - \alpha| < 1$. Otherwise, the sequence x_t will explode
- For systems of two or more variables, the roots must be less than one
- If only one or two roots are greater than one, we can pick one variable as a jumper and solve it as a function of other current variables using the stable root
- Bottom line: if we have an unstable root, we must make it a current variable determined by the rest of the system

The Quantity Theory of Money

- $MV = PY$, where M is money, P is the price level, V is velocity, and Y is output or real income. PY is nominal income
- Pure tautology as written: If nominal income is high and money supply is low, then velocity must be high
- Cambridge (Alfred Marshall) interpretation as a theory of money demand: $\frac{M}{P} = \frac{1}{V} Y$. Real money demand is proportional to real income
- Yale (Irving Fisher) interpretation: $P = \frac{MV}{Y}$
- With $V = \bar{V}$ and $Y = \bar{Y}$ in the long run, $P = kM$, where $k = \frac{\bar{V}}{\bar{Y}}$
- In log first differences, inflation equals money supply growth:
$$\pi = \Delta p = \Delta m$$
- This is a theory of long-run adjustment and the long-run *neutrality* of money

Money in the Short Run vs. Long Run

- Double the money, double the price level in the long run, but in the short run we can see a boom
- Reverse: Cut the money, cut the price level, but in the short run, a recession
- Increase the rate of growth of money, increase inflation, but expect a boom in the short run
- Decrease the rate of growth of money, lower inflation, but with a recession during adjustment
- We only get real effects of money if prices are sticky
- One specification: $\pi_t = \gamma(p_t^* - p_{t-1})$, where p_t^* is the long-run price level, $\pi = \Delta p_t$, and γ is a price stickiness coefficient
- Bottom line: If all prices were flexible, there would be no need for monetary policy and macroeconomic stabilization

What is the Right Inflation Target?

- Monetary machismo: Target 2% annual inflation. New Zealand's Central Bank Governor can be fired by law if inflation exceeds 2% in two consecutive years
- Debate: Should central banks also target asset price inflation (share prices, commercial real estate)?
- Once high inflation sets in, indexation systems are adopted and people learn to live with it, as seen in Brazil and Israel
- Brazil never qualified for hyperinflation; they averaged around 30%
- Some inflation helps reduce debt burdens, but how much is too much?
- A 2% target vs. 4%? Keeping inflation too low means interest rates are constrained near zero, limiting monetary policy effectiveness

Transmission of Monetary Policy

- What is the right definition of Money: Base, M1, M2, M3?
- How does monetary policy work?
- Helicopter drops: literally drop money on streets or send checks to people
- Buy stocks and target equity indices (Roger Farmer's proposal)
- Older instruments: change reserve requirements on banks
- Present approach: target the risk-free interest rate and buy or sell Treasury securities to achieve target
- People now focus on the short-term risk-free interest rate, not money supply figures

The Interest Rate Channel

- Targeting the interest rate has advantages: it is a clear and transparent signal
- It is a tax on holding money but also discourages investment in stocks or risky ventures
- Problem: interest rates cannot fall below zero, so the Fed is constrained when stimulus is needed near zero rates
- The ECB has experimented with negative interest rates, essentially a tax on deposits, but there are limits
- When conventional policy fails, the Fed must return to "old time religion" and just create money
- It can transfer money by purchasing domestic assets or government bonds, thus financing public spending by printing money
- Built-in conflict between Treasury and Fed: Why?

Government Budget Constraint

- Formula: $\frac{B_t}{P_t} = (1 + r_t) \frac{B_{t-1}}{P_t} + G_t - T_t$
- The balance $G_t - T_t$ is the primary deficit
- The fiscal deficit is the primary deficit plus interest payments: $r_t \frac{B_{t-1}}{P_t}$
- B_t, r_t, G_t, T_t, P_t represent government bonds, interest rates, real government spending, real tax revenue, and price level
- The government can limit debt growth by cutting spending, raising taxes, reducing interest rates, or raising the price level
- Raising taxes or cutting spending is politically unpleasant
- 1993 Clinton administration raised taxes to reduce debt; Gore broke the tie in Senate
- Democrats lost both houses of Congress in 1994 elections for the first time since 1952

Unpleasant Monetarist Arithmetic: Sargent and Wallace (1981)

- Classic paper: "Some Unpleasant Monetarist Arithmetic"
- Key insight: Fiscal policy dominates monetary policy when government is determined to maintain deficits
- If the Treasury continues to run deficits with a positive interest rate, debt accumulates
- The central bank faces a choice: tighten money now or tighten money later
- But if fiscal authority won't adjust, monetary restraint now just postpones inflation
- Eventually, the debt must be monetized or defaulted upon

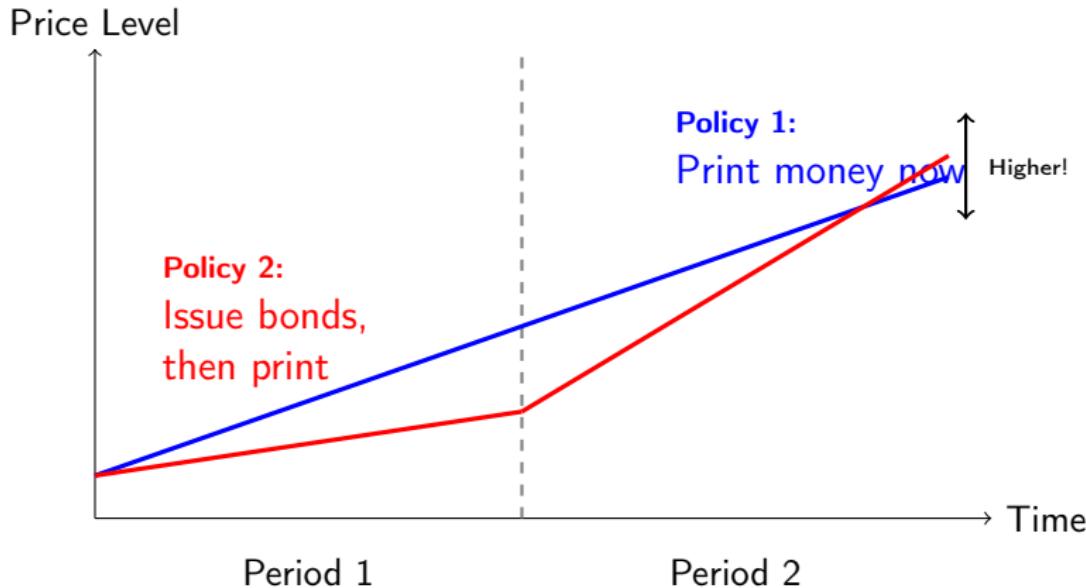
The Sargent-Wallace Mechanism

- Government budget constraint: $\Delta B_t + \Delta M_t = r_t B_{t-1} + (G_t - T_t)P_t$
- Central bank can control money growth temporarily, but cannot control it forever if fiscal authority is uncooperative
- Paradox: Tight money today (low ΔM_t) forces more bond issuance (ΔB_t rises)
- Higher debt means higher future interest payments ($r_t B_{t-1}$ grows)
- This requires even *more* money creation in the future to service the debt
- Result: Delaying monetization leads to *higher* eventual inflation
- Why? Compound interest on bonds exceeds the "tax" the government would pay by printing money immediately

Unpleasant Arithmetic: The Bottom Line

- Inflation rate when government eventually monetizes debt will be higher than if deficits were financed by printing money from the start
- Why? The government doesn't pay interest on money, but it does on bonds
- The longer you wait, the more interest accumulates, the more money must eventually be printed
- Policy implication: An "independent" central bank cannot control inflation if fiscal policy is unsustainable
- Message: Sooner or later, large debt causes problems, unless you have:
 - "Exorbitant privilege" (USA with dollar as reserve currency)
 - Patriotic citizens holding debt at low rates (Japan)
 - Credible commitment to fiscal discipline

Visualizing Unpleasant Monetarist Arithmetic



The Paradox: Delaying monetization (Policy 2) leads to *higher* eventual prices because interest on bonds compounds during the delay.

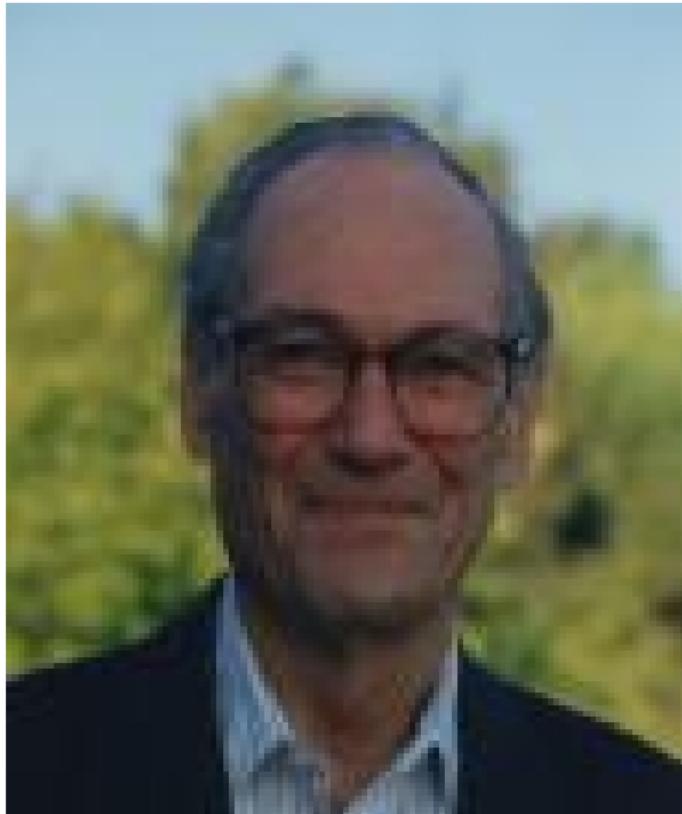
The Trouble with Debt

- A country can tighten its belt and debt can still continue to increase
- Even when the deficit shifts to a surplus after belt-tightening, debt can continue to rise despite austerity programs
- Why? Interest payments accumulate faster than primary surpluses can offset them
- Some inflation and low interest rates help reduce debt
- Jumping interest rates even slightly can lead to debt explosion
- Inflation erodes the real value of debt, helping to stabilize it
- Early 1990s Brazil realized its debt was growing despite primary deficit austerity

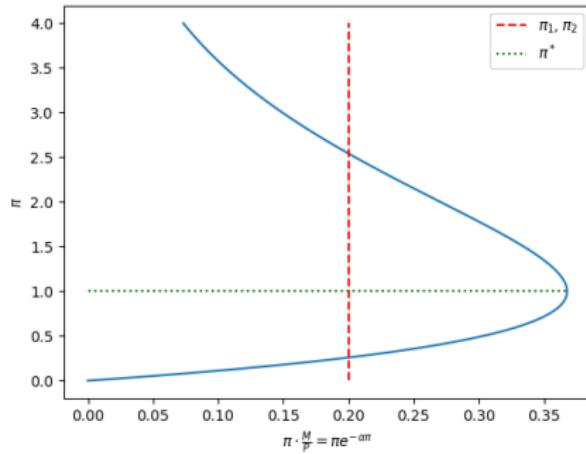
Seigniorage

- Inflation is a way to tax money holders to finance a deficit:
$$SR_t = \pi_t \frac{M_t}{P_t}$$
- Seigniorage revenue is the amount by which inflation reduces the real value of money holdings
- In times of high inflation, only π matters for money demand:
$$m_t - p_t = -\alpha\pi$$
- m_t, p_t are log values of money and prices: $\frac{M_t}{P_t} = \exp^{-\alpha\pi}$
- Seigniorage or inflation tax revenue: $SR_t = \pi \exp^{-\alpha\pi}$
- This has interesting implications for policy

Phillip Cagan, 1927-2012



Inflation Laffer Curve



Seigniorage Maximizing Inflation

- What rate of inflation π maximizes revenue from inflation:
$$\pi \frac{M}{P} = \pi \exp^{-\alpha\pi}$$
- Optimal inflation: $\pi^* = \frac{1}{\alpha}$
- The optimal inflation has a *closed-form solution*
- It is inversely related to α , the semi-elasticity of money demand with respect to inflation
- Beyond this point, higher inflation actually reduces revenue (wrong side of Laffer curve)

Plan Collor in Brazil (1990)

- Fernando Collor de Mello elected President, appointed Zelia Cardoso de Mello as Economics Czarina
- Brazil was getting primary deficits in order, but debt was still increasing
- If Brazil defaults, banks would have no assets since they were primary debt holders
- Banks bought debt using ON (Overnight deposits) indexed to inflation. Most Brazilians kept money in ONs
- Government froze ONs for 18 months as debt was eliminated
- New currency introduced and deposits converted with a loss in value

Shock Treatment vs. Gradualism

- Issue with defaulting on domestic debt: someone will lose, usually bank depositors
- Brazil canceled debt but froze bank deposits to prevent bank runs
- Mexico permitted dollar-denominated deposits. When defaulting, it confiscated deposits subtly
- Dollar deposits converted to pesos at an unfavorable exchange rate
- Debate: shock treatment vs. gradualism in stabilization programs
- Shock treatment imposes quick but severe costs; gradualism spreads adjustment over time but may lack credibility

Foreign Assets and Liabilities

- Same method for foreign asset/debt dynamics:
$$\Delta F_t = (r_t^* F_{t-1}) + (X_t - \frac{E_t M_t}{P_t})$$
- $F_t, r_t^*, X_t, M_t, E_t, P_t$ represent foreign assets, world interest rates, exports, imports, exchange rate, and price level
- If a country imports more than it exports, it accumulates foreign debt
- The term $(X_t - \frac{E_t M_t}{P_t})$ is the *trade balance*
- Adding interest receipts/payments $r_t^* F_{t-1}$ gives the *current account balance*
- A country can run a positive trade balance but negative current account balance if interest rates are high

Original Sin: International Borrowing in Dollars

- Foreign investment means imports increase (investment goods) and countries assume debt to investors
- 1970s: Large European and US banks eager to invest in Latin America
- Banks awash in Petrodollars from OPEC countries (the "Ayatollah effect")
- Latin America liberalizing trade and opening to foreign investment (often under military governments)
- Lots of money gushed into these countries
- Issue: debts denominated in US dollars at world interest rates (LIBOR), not local currency
- "Original sin": inability to borrow abroad in domestic currency

Debt Resolution: Creditor Countries

- Crisis in creditor countries when debt concentrated in a few key banks (too big to fail)
- When does debt become a crisis? When concentrated. More dangerous to owe one person \$100 than 100 persons \$1 each
- Solutions:
 - Debt syndication or credit risk sharing with cross-default clauses
 - Haircuts and rescheduling
 - Reducing interest rate spreads on outstanding debts relative to LIBOR
 - Buybacks of outstanding debts in secondary markets
 - Brady Bonds: collateralize new investment with long-term Treasury bonds

Debt Resolution: Debtor Countries

- Debt-for-equity swaps
- IMF Medicine: devaluation and fiscal austerity
- Capital controls (Malaysia during Asian Financial Crisis)
- Create conditions for investment and growth:
 - Financial supervision
 - Legal protections for investors
 - Structural reforms

Great Moderation in the United States

- Since late 1980s: stabilization of inflation and moderation of business cycle
- Reagan era: attributed to his leadership
- Fed: attributed to great monetary policy
- Alternative explanation: Advent of IT allowed firms to better forecast demand
- Move to "just in time production" cut costs of carrying inventory
- Previously, inventory changes were leading indicators of business cycle

Twin Deficits: Savings-Investment Imbalances

- Both fiscal and current account deficits turned negative
- Relationship not one-to-one: Even as fiscal deficits improved, current account balances continued to plunge
- Not twins but distant cousins at best
- National income identity: $Y = C + I + G + X - M$
- Rearranging: $S - I = X - M$, where S is total saving
- Fiscal deficit represents public-sector dissaving, but private saving changes too
- Net hypothesis: trade imbalances reflect Savings-Investment imbalances
- High surplus countries (Singapore, Taiwan, Korea): high personal savings, twice as high as USA

Implications for US Policy

- To reduce trade deficit: increase domestic savings, not bash foreigners
- Reduce fiscal deficit (negative saving)
- Federal consumption tax (GST or VAT): increases saving but politically suicidal
- Privatize social security or make it fully-funded (not pay-as-you-go)
- Norway and Singapore have successful Sovereign Wealth Funds
- Problem: At time of switch, one generation has double burden
- Best time to switch was during Roaring 90s under Clinton administration
- Unlikely that big trade deficits and negative Net Foreign Asset position will change soon

Feldstein-Horioka and Capital Mobility

- Is capital really mobile?
- Fast international financial arbitrage in stocks and bonds exists
- But does swapping Singapore Airlines for All Nippon stock in London mean capital flows from Singapore to Japan?
- Capital mobility means counterpart to savings-investment balances
- Feldstein and Horioka: With high capital mobility, there should be little correlation between savings and investment across countries
- They found much higher correlation, suggesting capital not as mobile as thought
- World of real investment, not financial arbitrage, less globalized than assumed
- New buzzword: on-shoring with tax incentives to invest at home
- Globalization is diminishing