Users Guide for Macro-Economic Model with Prices, Money Supply, Inventory Cycles, Random Shocks

Description of the Macro-Economic Model

This model simulates the evolution of a national economy using one of four economic models of increasing complexity from "A Dynamic Synthesis of Basic Macroeconomic Theory: Implications for Stabilization and Policy Analysis," by Nathan B. Forrester, thesis at M.I.T. Sloan School of Management, 1982. URL: http://hdl.handle.net/1721.1/15739

ModelSheet Software is solely responsible for any errors in this derivative work.

The second model extends the first macro-economic model by adding a rudimentary financial market to the production economy. It has a variable interest rate and a variable demand for capital. The financial market model is based on the IS-LM model presented by Hicks in 1937.

The third model extends the second model by adding a variable price level with a constant money supply to the production and financial markets. It is based on the aggregate supply aggregate demand model.

This fourth model adds an inventory adjustment mechanism. Adjustment of inventory is a significant factor in short-term business cycles. Meltzer outlined early macroeconomic inventory adjustment models in 1941.
This model also includes a lagged unemployment variable which does not affect the rest of the model and is used only for analysis.

As you explore the model, we suggest that you

- Read some of the Excel comments that are attached to Analysis Variables throughout the workbook. These comments also appear in ModelSheet in convenient places.
- View worksheet "Formulas" which shows the named variables and symbolic formulas of the model in a compact and readable form. The symbolic formulas are not active in this Excel workbook, but they give you some idea how the model works, and how it looks in ModelSheet.

Technical Notes: Overview of Modified Multiplier-Accelerator Model

Purple indicates a change in the second model compared to the first model.
Green indicates a change in the third model compared to the second model.
Red indicates a change in the fourth model compared to the third model.

1. Ten time-evolution variables

employment(t)
demand_expected_short(t)
income_permanent(t)
demand_expected_long(t)
capital(t)
demand_expected_long(t)
output_average(t)
prices(t)
money_supply(t)
inventory(t)
unemployment_rate_lagged(t)

2. Ten time-evolution equations

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- d employment(t) /dt = (employment_desired(t) - employment(t)) / time_adjust_employment
- d demand_expected_short(t) / dt
  = (demand_aggregate(t) - demand_expected_short(t)) / time_smooth_short_demand
- d income_permanent(t) / dt =
  (income_current_disposable(t) - income_permanent(t))/ time_smooth_income
- Δ capital(t) = capital_investment(t) - capital_depreciation(t)
- d demand_expected_long(t) / dt =
  (demand_aggregate(t) - demand_expected_long(t)) / time_smooth_long_demand
- **d output_average(t) / dt = (output(t) - output_average(t)) / time_smooth_output_average**
- **d prices(t) / dt = prices(t)* Phillips_slope * (unemployment_rate_natural / unemployment_rate(t) - 1)**
- **d money_supply(t) / dt = 0**
- **Δ inventory(t) = output(t) - final_sales(t)**
- **d unemployment_rate_lagged(t) / dt =**
  (unemployment rate(t) - unemployment rate lagged(t)) / time smooth unemployment

3. Five types of auxiliary functions appear in the evolution equations

- Output
  output(t) := output_potential(t) * (1-flexibility_capacity_utilization) + demand_expected_short(t) *
  flexibility_capacity_utilization + output_noise(t)
  output_potential(t):=
  output_equilib * (employment(t) / employment_equilib) ^ (1-capital_expon) *
  (capital / capital_equilib) ^ capital_expon
  desired inventory(t) := natural_inventory_coverage * long_expected_demand
  desired inventory_investment(t) := (desired inventory - inventory) / time_adjust_inventory
  The inventory variables are added in this fourth Forrester model.
- Labor Market
  employment_desired(t) :=
  (1-capital_expon) * demand_expected_short(t) / real_wage
  unemployment_rate(t):= (employment_equilib / (1 – unemployment_rate_natural) - employment) /
  (employment)equilib / (1 – unemployment rate natural))
- Demand
  demand_aggregate(t):= final_sales(t) + desired_inventory_investment(t) + demand_aggregate_noise(t)
  Aggregate demand is altered to include desired inventory investment in this fourth Forrester model.
  final_sales(t) :=consumption(t) + capital_invest(t) + gov_spending(t)
  consumption(t) := consumption_avg_propensity * income_permanent
  income_current_disposable(t):=output(t) - (tax(t) - gov_transfers(t))
- Capital Investment
  interest_rate(t) := interest_rate_long *
  ((output / output average) ^ (- money income elasticity)) ^ (1/money interest elasticity)
  The time-varying interest rate is added in the second Forrester model.
  interest_rate(t) := interest_rate_long *
  (money_supply * (money_equilib_velocity/output_equilib/prices)
  *** ((output equilib / output average) ^ money income elasticity) ^ (1/money interest elasticity)**
  The time-varying interest rate is changed in the third model to use prices and money supply.
  capital_investment(t) :=capital_depreciation(t) + (capital_desired(t) – capital(t)) / time_adjust_capital
  capital_depreciation(t) := capital / capital_avg_life
  capital_desired(t) :=
  capital_expon * demand_expected_long(t) / (1/capital_avg_life + interest_rate)
  Desired capital is changed in the second Forrester model to use time-varying interest rate.
- Government Sector

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tax(t) := tax_rate * output(t)
gov_transfers(t) := gov_transfers_equilib
gov_spending(t) := gov_spend_equilib

4. Numerical parameters

- Demand
  - Average propensity to consume: consumption_avg_propensity = 0.78
  - Time to smooth income: time_smooth_income = 2.5
  - Time to smooth short run demand: time_smooth_short_demand : 0.5
  - Time to smooth long run demand: time_smooth_long_demand : 3.0
- Labor
  - Expected labor (million man-years per year): employment_equilib = 100
  - Real wage $ million per million-man-year (set so that wages are 75% of national income):
    real_wage = 0.75 * output_equilib / employment_equilib
  - Time to adjust employment : time_adjust_employment = 0.4
  - Time to smooth unemployment: time_smooth_unemployment = 1.0
    Time to smooth unemployment is added in this fourth Forrester model.
- Capital Investment
  - Exponent on capital in the production function: capital_expon = 0.25
  - long run interest rate: interest_rate_long = 3.0%
  - Average life of capital: capital_avg_life = 14.0
  - **Equilibrium capital: capital_equilib =**
    capital_expon * output_equilib / (1/capital_avg_life + interest_rate_long)
  - Time to adjust capital: time_adjust_capital = 3.0
  - Flexibility of capacity utilization: flexibility_capacity_utilization = 3.0
  - **Income elasticity of money demand: demand_income_elasticity = 0.7**
  - **Interest elasticity of money: money_interest_elasticity = -1.0**
- Output
  - Annual equilibrium national output: output_equilib = $ 14.0 * 10^6 millions
  - **Time to smooth average output: time_smooth_output_average = 3.0**
    (Added in the second Forrester model)
  - **Ratio of inventory to sales: net_inventory_coverage = 0.3**
  - **Time to adjust inventory: time_adjust_inventory = 0.4**
- Government Spending
  - Equilibrium government spending pct: gov_spend_equilib_pct = 20% (gov_spend_equilib : 0.2 * output_equilib)
  - Equilibrium government transfers pct: gov_transfers_equilib_pct = 10% (gov_transfers_equilib : 0.1 * output_equilib)
  - Tax rate (set to cover government spending and transfers with no surplus or deficit):
    tax_rate : (equilibrium_govt_spend+equilibrium_govt_transfers) / output_equilib
- Prices and Money
  - **natural rate of unemployment: unemployment_rate_natural = 5%**
  - **slope of the Phillips curve: phillips_slope = 0.175**
  - **equilibrium income velocity of money: equilib_velocity_money = 6.0**
  - **The equilibrium price level determines the ratio of the money to output: prices_equilib = 1.0**

5. Initial conditions

Average output: output_average(t=0) = output_equilib
output_average was added in the second Forrester model.
Employment: employment(t=0) = employment_equilib
Short run equilibrium demand: demand_expected_short(t=0) = output_equilib

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Permanent income: income_permanent(t=0) = output_equilib - equilibrium_govt_spend
Capital: capital(t=0) = capital_expon * output_equilib * (1/capital_avg_life +interest_rate_long)

The initial condition for capital is changed to include the interest rate in the second Forrester model.

Long run equilibrium demand: demand_expected_long(t=0) = output_equilib
Prices: prices(t=0) = prices_equilib
Money supply: money(t=0) = income_equilib * prices_equilib / equilib_velocity_money
Inventory: inventory(t=0) = output_equilib * net_inventory_coverage

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