Fiscal Policy and Learning

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Introduction

- Interest in effectiveness of fiscal policy has been revived as a result of governments' measures against the "Great Recession".

- The subject is not new, early studies: Barro and King (1984), Baxter and King (1993) etc.

- Recently many studies: Hall (2009), Barro and Redlick (2011), Ramey (2011a, b), etc.

- A central focus has been measurement of the multiplier effects of exogenous government spending.

- The basic neoclassical or RBC model has been one of the frameworks used.

- **Conundrum:** The output multiplier in an RBC model is very small and outside the range found in empirical studies.

- One response**:** employ New Keynesian models with aggregate demand channels.

- **Our approach**: Relax the rational expectations (RE) hypothesis.
  - The RE assumption is very strong when one analyzes policy changes.
  - Economic agents are required to know completely the economic structure before and after the change.
  - Agents must, moreover, assume that all other agents are equally knowledgeable and rational.

- After structural changes information and understanding become imperfect.
  - Agents try to improve their knowledge.
  => Learning behavior becomes a major driver of economic dynamics.

- Implications of learning have been analyzed a lot in the past 20 years or so.

- Messages from learning:
  - Standard rational expectations (RE) may emerge if the agents' environment remains stationary for sufficiently long period.
  - The learning process has a big impact on dynamics of the economy. (e.g. Sargent's studies of inflation dynamics, persistence of output and inflation dynamics in NK model, expectations shocks and business cycle, RBC dynamics,.asset price dynamics,...)

- **This paper**: How does relaxing the RE hypothesis influence the magnitude of the multiplier?
  - We analyze this question using the standard RBC model.
  - We use an RBC model, not because of strong belief in it, but because the neoclassical mechanisms are one part of most DSGE models.

- We replace RE with agents learning adaptively over time in the standard RBC model with lump-sum taxes.
  - Agents forecast wages and interest rates using a statistical model with parameters updated over time.
  - To forecast future taxes agents use credible announcements of policy changes.

- **Result 1**: output multipliers of a temporary change in government purchases are much higher than under RE.

- **Result 2**: multipliers continue to be high in times of deer recessions.

- **Result 3**: RBC model with learning can account for episodes of expansionary fiscal consolidations whereas RBC model under RE cannot.

The Model

- Representative households with preferences over consumption c_t and leisure $1 - n_t$, where n_t is labor supply:

  $$\hat{E}_t\{\sum_{s=t}^{\infty} \beta^{s-t} U(c_s, 1-n_s)\}, \text{ where } U(c_s, 1-n_s) = \ln c_s + \zeta \ln(1-n_s).$$

  $\hat{E}_t$ denotes potentially subjective expectations at time t for the future. Household flow budget constraint is

  $$\begin{aligned} a_{t+1} &= w_t n_t + r_t a_t - c_t - \tau_{h,t}, \text{ where} \\ r_t &= 1 - \delta + r_{k,t}. \end{aligned}$$

  a_t is per capita household wealth, $a_t \equiv k_t - b_{pt}$, where k_t is capital and b_{pt} is debt (to other households). r_t is the gross interest rate, w_t is the wage rate, and $\tau_{h,t}$ is per capita lump sum taxes. $r_{k,t}$ is the rental rate on capital goods and δ is the depreciation rate.

- Utility maximization gives the Euler equation for consumption and leisure consumption trade-off

$$c_t^{-1} = \beta \hat{E}_t r_{t+1} c_{t+1}^{-1} \text{ and } \zeta(1-n_t)^{-1} = w_t c_t^{-1}.$$

With the transversality condition we get the intertemporal budget constraint (IBC) in realized terms:

$$\begin{aligned} 0 &= r_t a_t + \sum_{j=1}^{\infty} (D_{t,t+j}(t))^{-1} \chi_{t+j} + \chi_t, \\ \text{where } D_{t,t+j} &= \prod_{i=1}^{j} r_{t+i},\ j \geq 1 \text{ and } \chi_t \equiv w_t n_t - c_t - \tau_{h,t}. \end{aligned}$$

and an expected value IBC

$$0 = r_t a_t + \chi_t + \sum_{j=1}^{\infty} \hat{E}_t (D_{t,t+j})^{-1} \{w_{t+j} - (1+\zeta) c_{t+j} - \tau_{h,t+j}\}.$$

- Agents linearize the expected value IBC and the Euler equation around the initial steady state $\bar{c}, \bar{a}, \bar{w}, \bar{\tau}_h$ and $\bar{r} = \beta^{-1}$. One obtains the consumption function

$$\begin{aligned} (c_t - \bar{c})\frac{(1+\zeta)}{(1-\beta)} &= \bar{a}(r_t - \bar{r}) + \beta^{-1}(a_t - \bar{a}) - (\tau_{h,t} - \bar{\tau}_h) \\ &\quad + (w_t - \bar{w}) - (\bar{w} - \bar{\tau}_h)Sr_t^e - S\tau_{h,t}^e + Sw_t^e, \end{aligned}$$

where

$$\begin{aligned} Sr_t^e &\equiv \sum_{j=1}^{\infty} \beta^{j+1} \sum_{i=1}^{j} (r_{t+i}^e - \bar{r}),\ S\tau_{h,t}^e \equiv \sum_{j=1}^{\infty} \beta^j (\tau_{h,t+j}^e - \bar{\tau}_h), \\ Sw_t^e &\equiv \sum_{j=1}^{\infty} \beta^j (w_{t+j}^e - \bar{w}). \end{aligned}$$

denote “present value” type expressions.

- Households require forecasts r^e_{t+i}, w^e_{t+j}, and $\tau^e_{h,t+j}$:
  - $\tau^e_{h,t+j}$ is obtained from "structural knowledge" that government has balanced budgets $\tau_{h,t+j} = g_{t+j}$ and announces that the path of spending.
  - r^e_{t+i}, w^e_{t+j} are obtained as forecasts from an estimated VAR-type model in $k_t, w_t, r_{k,t}$ and v_t, with coefficients updated over time by RLS.

- Firms' behavior: households rent capital and labor services. The firm produces according to

$$y_t = v_t k_t^{\alpha} n_t^{1-\alpha},$$

where v_t is the technology shock following $\hat{v}_t = \rho \hat{v}_{t-1} + \tilde{u}_t$ with $\hat{v}_t = (v_t - \bar{v})$, and $\tilde{u}_t$ is an iid zero-mean normal variable with variance σ_u^2.

- Profit maximization by firms implies

$$w_t = (1-\alpha) v_t (\frac{k_t}{n_t})^{\alpha} \text{ and } r_{k,t} = \alpha v_t (\frac{n_t}{k_t})^{1-\alpha}.$$

- In equilibrium, aggregate private debt $b_{pt} = 0$, so that $a_t = k_t$, and market clearing gives

$$k_{t+1} = v_t k_t^{\alpha} n_t^{1-\alpha} + (1-\delta)k_t - c_t - g_t,$$

where g_t is per capita government spending.

- Without policy change and under RE the endogenous variables can be written as an (approximate) linear function in the state $\hat{x}_t' \equiv \left(\hat{k}_t, \hat{v}_t\right)$:

$$\begin{pmatrix} \hat{k}_{t+1} \\ \hat{v}_{t+1} \end{pmatrix} = B \begin{pmatrix} \hat{k}_t \\ \hat{v}_t \end{pmatrix} + \begin{pmatrix} 0 \\ 1 \end{pmatrix} \tilde{u}_{t+1}, \text{ where } B = \begin{pmatrix} \lambda_2 & f_{kv} \\ 0 & \rho \end{pmatrix}.$$

Here $\hat{k}_t = k_t - \bar{k}$ etc. are deviations from the deterministic steady state.
- Under RE forecasts of future $\hat{w}_{t+j}$ and $\hat{r}_{k,t+j}$ are given by linear combinations of $\hat{x}_{t+j}^e = B^j \hat{x}_t$.

Learning Dynamics

- Assume an immediate temporary policy change (a *surprise* change in g):

$$g_t = \tau_t = \begin{cases} \bar{g}',\ t = 1, ..., T_g - 1 \\ \bar{g},\ t \geq T_g, \end{cases}$$

and in a later example we set $T_g = 9$, i.e., a two-year increase in g.

- The agents compute the present value of the increase in their future taxes as

$$S\tau^e_{h,t} = \sum_{j=1}^{\infty} \beta^j (g_{t+j} - \bar{g}) = \begin{cases} \frac{\beta}{1-\beta}(\bar{g}' - \bar{g})(1 - \beta^{T_g - t - 1}),\ 1 \leq t \leq T_g - 2 \\ 0,\ \text{for } t \geq T_g - 1. \end{cases}$$

- The econometric forecasting model for wages and interest rates is

$$\begin{aligned} k_{t+1} &= b_k + a_{kk} k_t + a_{kv} \hat{v}_t + noise, \\ w_t &= b_w + a_{wk} k_t + a_{wv} \hat{v}_t + noise, \\ r_{k,t} &= b_r + a_{rk} k_t + a_{rv} \hat{v}_t + noise, \\ \hat{v}_t &= \rho \hat{v}_{t-1} + \tilde{u}_t, \end{aligned}$$

  where the parameters b_k, a_{kk}, a_{kv} etc. are estimated on the basis of actual data. Last equation is assumed to be known. Note: the functional form is the same as in RE dynamics.

- Given coefficient estimates and the observed state $(k_t, \hat{v}_t)$, one iterates forward to obtain k^e_{t+j} and $\hat{v}_{t+j}$ for $j = 1, 2, \ldots$. Wage and rental rate forecasts $w^e_{t+j}, r^e_{k,t+j}$ are obtained using the above relationships and $r^e_{t+j} = 1 - \delta + r^e_{k,t+j}$. Sw^e_t and Sr^e_t are then computed and these are used in the consumption function.

- Parameter updating by agents using (discounted) RLS learning: define the time t parameter estimates as

$$\phi_{k,t} = \begin{pmatrix} b_{k,t} \\ a_{kk,t} \\ a_{kv,t} \end{pmatrix}, \phi_{w,t} = \begin{pmatrix} b_{w,t} \\ a_{wk,t} \\ a_{wv,t} \end{pmatrix}, \phi_{rk,t} = \begin{pmatrix} b_{r,t} \\ a_{rk,t} \\ a_{rv,t} \end{pmatrix}, z_t = \begin{pmatrix} 1 \\ k_t \\ \hat{v}_t \end{pmatrix}.$$

The (discounted) RLS formulas are

$$\begin{aligned} \phi_{k,t} &= \phi_{k,t-1} + \gamma R_t^{-1} z_{t-1}(k_t - \phi'_{k,t-1} z_{t-1}), \\ \phi_{w,t} &= \phi_{w,t-1} + \gamma R_t^{-1} z_{t-1}(w_{t-1} - \phi'_{w,t-1} z_{t-1}), \\ \phi_{rk,t} &= \phi_{rk,t-1} + \gamma R_t^{-1} z_{t-1}(r_{k,t-1} - \phi'_{rk,t-1} z_{t-1}). \\ R_t &= R_{t-1} + \gamma(z_{t-1} z'_{t-1} - R_{t-1}). \end{aligned}$$

The constant gain γ is assumed to be the same in all of the regressions, the initial values of ϕ and R are set to the initial steady state values under RE.

Multipliers for Government Purchases

- In period $t = 0$ all variables are in the steady state. Assume the parameter values $\zeta = 4$, $\delta = 0.025$, $\alpha = 1/3$, $\beta = 0.985$, $\rho = 0.95$, $\bar{v} = 1.359$, $\bar{g} = 0.20$, and $\gamma = 0.04$. $\tilde{u}_t$ is normal with zero mean and $\sigma_u = 0.007$.
  $\bar{v} = 1.359$ normalizes output to approximately one.
  The gain parameter $\gamma = 0.04$ is in line with most of the learning literature.

- The policy exercise: increase in government purchases from $\bar{g} = 0.20$ to $\bar{g}' = 0.21$ that takes place at $t = 1$, and lasts until $T_g = 9$. We plot the mean time paths for each endogenous variable over $100,000$ replications.

- Figure 1 compares the dynamics under RE and learning for key variables. All variables are measured in percentage deviations from the (unchanged) steady state.

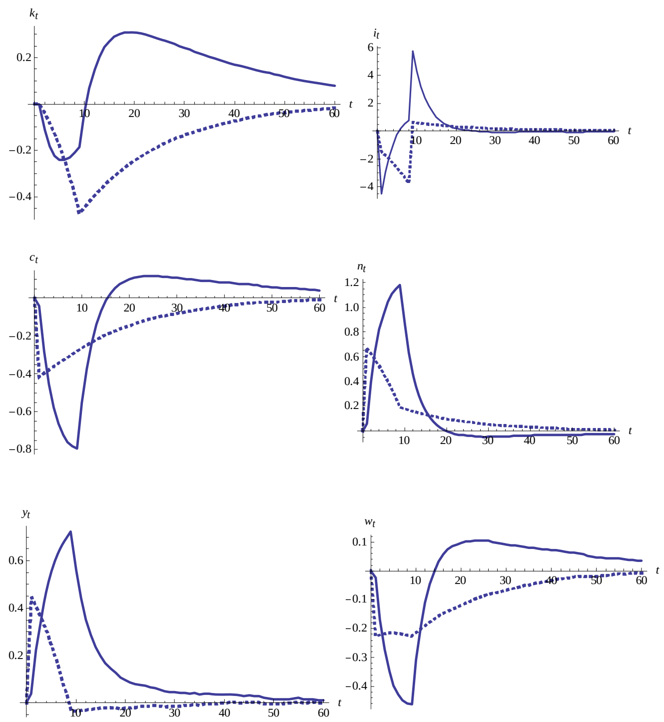

Figure 1: Dynamic paths for an 8 periods increase in government purchases. The solid lines are the learning paths while the dashed lines are the RE paths.

- RE dynamics well-known: consumption smoothing by reduction in i_t and boom after g_t returns to lower value.

- Learning: sharp fall in i_t and smaller change in c_t. Hump-shaped response in c_t and also in y_t, n_t. A spike in i_t and build-up of k_t, when g_t returns.

- Comparison of multipliers: in RBC models these are known to be too small. Empirically, Hall (2009) suggests range $0.7-1$ and Ramey (2011) $0.8-1.5$.

- Cumulative multipliers are computed as a discounted sum

$$ym_t = \frac{y_t - \bar{y}}{\bar{g}' - \bar{g}} \text{ and } ycm_t = \frac{\sum_{i=1}^{t} \beta^{i-1}(y_i - \bar{y})}{(\bar{g}' - \bar{g}) \sum_{i=1}^{T_g - 1} \beta^{i-1}}, \text{ for } t = 1, 2, 3, \ldots$$

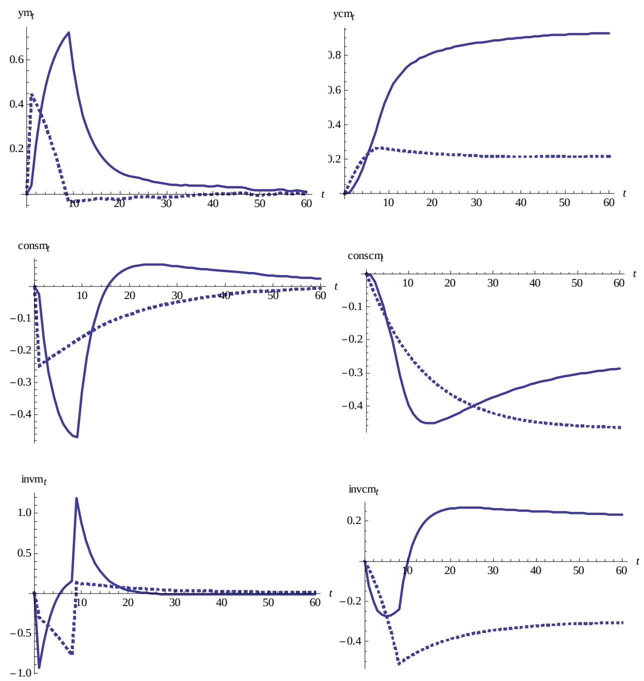

Figure 2: Multipliers as a distributed lag response (left hand side) and cumulative multipliers (right hand side). The solid and dashed lines are the learning and RE paths, respectively.

- Observations under learning much more consistent with empirics.

- A larger output multiplier under learning than under RE.
  - This follows from the hump-shape in consumption path.

- Consumption multiplier under learning turns positive under distributed lag measure or is less negative than under RE.

- Big difference in investment multiplier under learning vs. RE.

Fiscal Stimulus in Recessions

- Event like the Great Recession in the US: $\tilde{u}_t = -2\sigma_u$ in periods $t = 1, 2, 3, 4$, followed by $\tilde{u}_t = -\sigma_u$ in $t = 5, 6$. From period $t \geq 7$ onwards $\tilde{u}_t$ drawn from its usual distribution with $\sigma_u = 0.007$.

- Policy response like the American Recovery and Reinvestment Act (ARRA): at $t = 5$ it is announced that $\bar{g}' = 0.21$ for periods $t = 7, ..., 16$ and return original level from $t = 17$ onwards. 20.000 replications.

- Figure 3 gives the time paths under learning with and without policy change.

- Figure 4 compares the output multiplier under learning and RE.

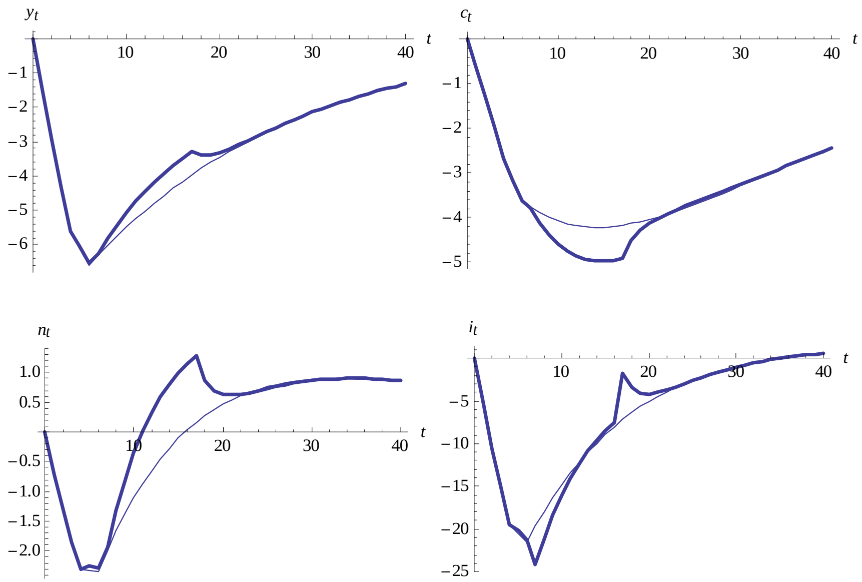

Figure 3: Dynamic paths showing the impact on major variables of a fiscal stimulus announced in the midst of the Great Recession. The solid black line gives paths with the policy change and the lighter shaded line without the policy change.

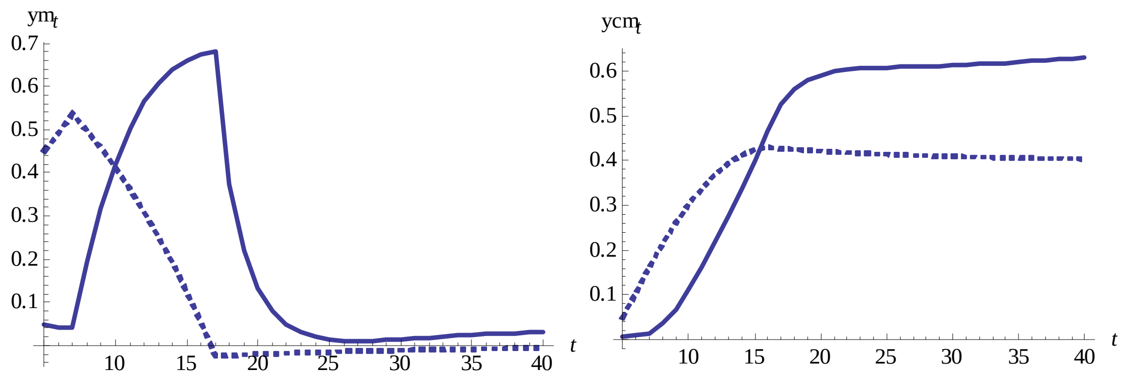

Figure 4: Output multiplier (distributed lag in left and cumulative in right hand panel) for the policy in Figure 3. The solid lines are the learning paths while the dashed lines are the RE paths.

Fiscal Consolidation

- So-called "non-Keynesian" effects of fiscal policy after Giavazzi and Pagano (1990).

- Studies in 1990s on effects of consolidation on consumption. Recently, Alesina et al (2002) look at effects on investment.

- Fiscal consolidations are modeled as a surprise permanent reduction in government purchases. At $t = 1$, a policy announcement of permanent reduction $\bar{g} = 0.22$ to $\bar{g}' = 0.20$. 100.000 simulations.
  - Long-run effects are well-known: higher c_t and lower i_t.

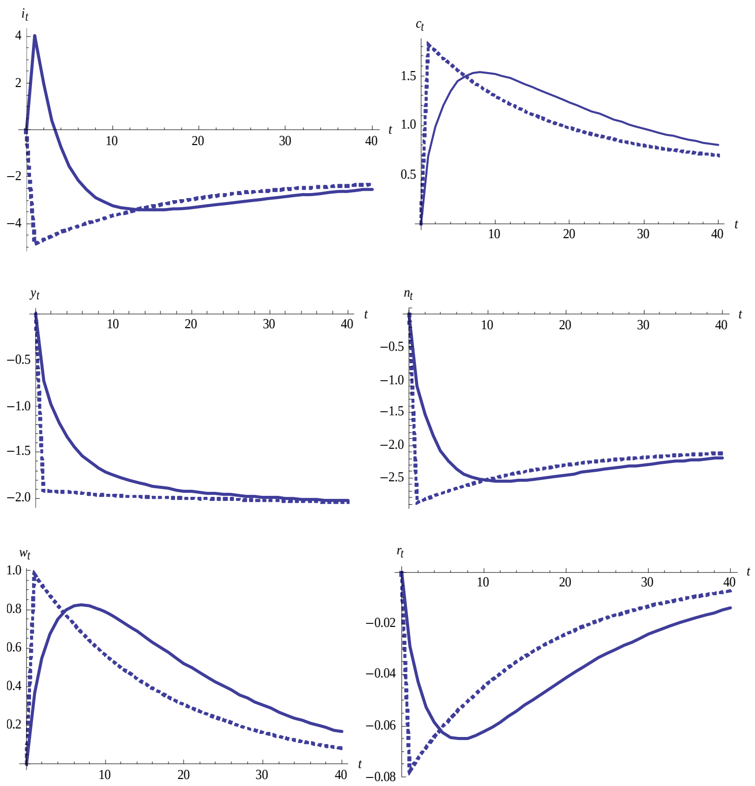

Figure 5: Dynamic paths for a surprise permanent reduction in g.

- c_t rise under learning and RE, then declines.

- There is a big difference in response of i_t under learning vs. RE.
  - i_t initially rises under learning. This is consistent with empirical studies.
  - This comes from expectations effects.

- Note that there is decline in output and employment under both learning and RE.

Conclusion

- Learning makes a big difference to dynamics vs. RE.

- Households incorporate known policy changes in expectations but must forecast market variables.

- In the RBC model one starts to get results that are in the right ball park relative to empirics.
  - Under RE the basic RBC model does not perform well.

- Current research: multipliers in NK models under learning.