Introducing Financial Friction, Unemployment and Non-wasteful Government Spending into a Small Open Economy Model
The Role of Fiscal Policy

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Motivation

- It becomes more common for central banks and other policy institutions to develop a large-scale DSGE model and apply those to the policy analyses.
- In particular, they have paid attentions to analysis of a propagation mechanism of the collapse of the banking system followed by massive involuntary unemployment from one country to other countries using the DSGE models, since the financial crisis 2008 so-called "the Great Recession" triggered by the Lehman Brothers failure.
- In addition, the role of fiscal policy has been put on the review, because major developed countries have encountered the zero lower bound of nominal interest rate which has taken the mobility out of monetary policy and let it be silent.
Motivation

This paper struggles with following questions:

- How important are financial and labor market frictions for business cycle dynamics?
- What are the qualitative effects of financial shocks on investment and output?
- How is unemployment affected by a sudden and temporary increase in aggregate demand including government spending?
Motivation

To address these questions, we extend the stylized DSGE model by incorporating the following four features:

- First, we embed an agency problem between bankers and depositors occurring financial friction in banking sector, where banks must occasionally be subject to endogenously determined balance sheet constraints, following Gertler and Kardi (2011).

- Second, we incorporate involuntary unemployment following the manner proposed by Gali et al. (2012).

- Third, to classify the roles of government spending in term of both demand and supply sides, we adopt non-wasteful government spending along the line of Iwata (2013).

- Fourth, we also allow for incomplete exchange rate pass-through by introducing home bias and nominal rigidities of importers following Adolfson et al. (2007).
Motivation

- The stylized DSGE model includes following features (e.g. Christiano et al. 2005, Smets and Wouters 2003, 2007): habit formation, sticky price, sticky wage, investment adjustment cost, Taylor rule, etc.

- The idea is to embed bank balance sheets, unemployment, non-wasteful government spending and exchange rate imcomplete pass-through to the stylized DSGE model.

- As a result, our model consists of 121 structural equations (121 endogenous variables) and 22 structural shocks (22 exogenous variables).

- We focus on the explanation for the extension parts from the stylized DSGE model and illustrate how the model behaves to key structural shocks.
Banker’s Problem (1)

- Banker’s balance sheet: Bankers borrow funds as deposits from households and purchase claims of intermediate goods firms.

\[ Q_t S_{m,t}^F = N_{m,t}^F + D_{m,t} \]

- Net worth transition equation:

\[ N_{m,t+1}^F = \frac{R_{t+1}^k Q_t S_{m,t}^F}{\text{gross return from investment}} - \frac{R_{t+1}^D D_{m,t}}{\text{debt repayment}} \]

\[ = \left( R_{t+1}^k - R_{t+1}^D \right) \frac{Q_t S_{m,t}^F + R_{t+1}^D N_{m,t}^F}{\text{net interest margin (spread)}} \]
Bankers invest in the claims $S_t^F$ at price $Q_t$ issued by intermediate goods firms. Then, intermediate goods firms purchase capital goods $K_{t+1}$ at price $Q_t$ from capital goods producing firms:

$$Q_t K_{t+1} = Q_t S_t^F$$

(Realized) gross nominal capital return can be derived by:

$$R_{t+1}^k = \frac{\epsilon_{t+1}^k}{Q_t} \left[ (1 - \delta) Q_{t+1} + (1 - \tau_{t+1}^k) \left( \frac{P_{t+1}^d \frac{Y_{t+1} + \Theta_d^d}{\epsilon_{t+1}^k K_{t+1}} - P_{t+1}^i a(u_{t+1})}{Q_t} \right) \right]$$

Banker’s capital return $R_{t+1}^k$ faces an uncertainty. $\epsilon_{t+1}^k$ is the capital quality shock which is realized after banker’s investment.
Banker’s Problem (3)

- Bankers are risk-neutral and the survival rate is assumed to be \( \gamma^F \in (0, 1) \).
- Banker’s objective function:

\[
V_{m,t}^F = \mathbb{E}_t \sum_{i=0}^{\infty} \beta^{i+1} \Lambda_{t,t+i+1} (1 - \gamma^F) \left( \gamma^F \right)^i N_{m,t+i+1}^F
\]

discounted present value of banking business

- Moral hazard/costly enforcement problem:
  - Bankers have technology to divert fraction \( \lambda \) of assets.
  - Incentive constraint for a banker to remain in business becomes:

\[
V_{m,t}^F \geq \lambda Q_t S_{m,t}^F
\]

value of banking business \quad payoff of diverting her asset
Banker's Problem (4)

- Imposing this constraint, Gertler and Kiyotaki (2010) and Gertler and Karadi (2011) show the NPV of banking business to be

\[ V_{m,t}^F = \nu_t Q_t S_{m,t}^F + \eta_t N_{m,t}^F \]

- marginal value of assets
- marginal value of net worth

- Also, they show the bank leverage ratio to be constrained by

\[ \frac{Q_t S_{m,t}^F}{N_{m,t}^F} \leq \frac{\eta_t}{\lambda - \nu_t} \equiv \phi_{t}^F \]

- leverage ratio
- upper bound of leverage ratio
Gertler and Kiyotaki (2010) and Gertler and Karadi (2011) show that $\nu_t$, $\eta_t$, and $\phi_t^F$ to be equal across bankers which makes the aggregation very simple.

Aggregate net worth transition:

$$N_{t+1}^F = \gamma^F \left[ \left( R_{t+1}^k - R_{t+1}^D \right) \phi_t^F + R_{t+1}^D \right] N_t^F + \underbrace{\xi^F Q_{t+1} S_t^F}_{\text{Aggregate return to incumbents}} + \underbrace{\xi^F Q_{t+1} S_t^F}_{\text{Start-up transfers to entrants}}$$
Non-wasteful government spending (1)

Edgeworth complementarity:

- Household $j$'s objective function:

$$E_t \sum_{i=0}^{\infty} \beta^i \left( \zeta^c_{t+i} \ln \left( \tilde{C}_{j,t+i} - h\tilde{C}_{t+i-1} \right) - \zeta^h_{t+i} \chi^h_{t+i} A_H \frac{\tilde{H}_{j,t+i}^{1+\sigma_h}}{1 + \sigma_h} \right),$$

where $\tilde{C}_{j,t} = C_{j,t} + \nu_g G_{t}^c$.

- Following Iwata (2013), $\tilde{C}_{j,t}$ consists of private consumption $C_{j,t}$ and government consumption $G_{t}^c$.

- If the parameter $\nu_g$ is negative (positive), then an increase of government consumption lead to an increase (a decrease) of the marginal utility of private consumption, which is the so-called Edgeworth complementarity (substitutability).
Non-wasteful government spending (2)
Productive public capital:

- The intermediate-good firm $j$ produces a differentiated good $Y_{j,t}$ ($j \in [0, 1]$), using the following production function:

$$Y_{j,t} = \epsilon_t \left( \epsilon_t^k \tilde{K}_{j,t} \right)^\alpha \left( z_t H_{j,t} \right)^{1-\alpha} \left( K_{t}^g \right)^{\alpha_g} - z_t^+ \Theta^d. $$

- Following Iwata (2013), the public capital $K_{t}^g$ accumulated by the government is assumed to improve the private firm's productivity.

- $\alpha_g$ stands for productivities of public capital.
Unemployment (1): Preference specification:

- Preference specification:
  - The household $j$ owns a differenciated skill $j \in [0, 1]$.
  - Following Gali et al. (2012), each household has members who have different labor disutilities, and the labor disutility of a member $h$ distribute uniformly as $h \in [0, 1]$ (Thus, we consider the household of a huge size as $[0, 1] \times [0, 1]$).
  - Each members who belong to the same household share the same level consumption.

Then, the utility of a member $h$ (who has a disutility $h$) in a household $j$ at period $t$ can be written by

$$
\zeta^c_t \ln \left( \tilde{C}_{j,t} - \theta \tilde{C}_{t-1} \right) - \zeta^h_t \chi^h_t A_H h^{\sigma_h}
$$
Unemployment (2): Household $j$’s preference:

- Household $j$’s preference: Aggregating the member’s utility regarding $h$, we can derive household $j$’s utility at period $t$ as follows:

$$
\zeta_t^c \ln \left( \tilde{C}_{j,t} - \theta \tilde{C}_{t-1} \right) - \zeta_t^h x_t^h A_H \int_0^{\tilde{H}_{j,t}} h^{\sigma_h} dh
$$

$$
= \zeta_t^c \ln \left( \tilde{C}_{j,t} - \theta \tilde{C}_{t-1} \right) - \zeta_t^h x_t^h A_H \frac{\tilde{H}_{j,t}^{1+\sigma_h}}{1+\sigma_h}
$$

- Following Erceg et al. (2000), employment agency bundles skilled labor $j$, produces a homogenous labor and sells it to the intermediate goods firms.

- The household $j$ who has the differenciated skilled labor $j$ optimizes her nominal wage (thus, her labor supply) under Calvo-type nominal wage rigidities.

- As a result, we can derive the real wage, thus aggregate employment $\tilde{H}_t$. 
Unemployment (3): Desired labor supply and unemployment rate

- Given the real wage $w_{j,t}$, the member $h$ is willing to work, if

$$\left(1 - \tau_t^h\right)w_{j,t} \geq \frac{\zeta_t^h x_t^h h^{\sigma_h}}{\varphi_{j,t}^c p_t^c (1 + \tau_t^c)}$$

MRS between labor supply and consumption

- From the consumption sharing assumption and the same real wage across households, the desirable aggregate labor supply $L_t \left(\equiv \int_0^1 L_{j,t} d_j\right)$ can be derived as:

$$\left(1 - \tau_t^h\right)w_t = \frac{\zeta_t^h}{\zeta_t^c} z_{x,t} L_t^{\sigma_h}.$$

- Let $\tilde{H}_t \left(\equiv \int_0^1 \tilde{H}_{j,t} d_j\right)$ denote the aggregate employment. Then, unemployment rate $U_t$ is defined as the following equation.

$$U_t \equiv \frac{L_t - \tilde{H}_t}{\tilde{H}_t}.$$
Small open economy (1): Home bias

- Following Adolfson et al. (2007), retailers produce a homogenous domestic final consumption goods by combining domestic final goods and imported goods.

\[ C_t = \left[ (1 - \omega_c) \frac{1}{\eta_c} \left( C^d_t \right)^{\frac{\eta_c-1}{\eta_c}} + \omega_c \frac{1}{\eta_c} \left( C^m_t \right)^{\frac{\eta_c-1}{\eta_c}} \right]^{\frac{\eta_c}{\eta_c-1}} , \]

- \( \omega_c \in [0, 0.5] \) is the home bias parameter. The home bias, i.e. \( \omega_c < 0.5 \), indicates domestic goods needed more to produce the bundled homogenous consumption goods.
- Investment goods retailers produce a bundled homogenous investment goods in the same fashion as consumption goods.
Small open economy (2): Nominal rigidities

- We assume importers and exporters have market powers (they can produce differenciated intermediate goods by “brand naming technologies”) and set their prices in the buyer’s currency (“pricing to market”).
- In addition, importers and exporters set their prices under Calvo-type nominal rigidities.
- Then, the combination of the home bias and nominal rigidities of importers lead to the exchange rate incomplete pass-through. Thus, a change of the exchange rate does not immediately pass on the domestic prices.
Experiments: IRFs to five disturbances

To illustrate how the model behaves, we consider the impulse response functions (hereafter, IRFs) of the model economy to five disturbances:

- A positive neutral technology shock,
- A negative monetary policy shock (monetary easing policy shock),
- A negative capital quality shock,
- A positive government consumption shock,
- A positive government investment shock.
Experiments: Parameters settings

The calibrated parameter values are borrowed mainly from Christiano et al. (2011), Gertler and Karadi (2011), Gali et al. (2012) and Iwata (2013). Key parameters value are set as follows:

- Fraction of capital that can be diverted: $\lambda = 0.383$.
- Inverse Frisch elasticity: $\sigma_h = 3.990$.
- Edgeworth complementarity: $\nu_g = -0.415$.
- Productivity of productive public capital: $\alpha_g = 0.046$.
- Home bias parameters: $\omega_c = 0.350$ (consumption goods), $\omega_i = 0.330$ (investment goods) and $\omega_x = 0.350$ (export goods).
- Nominal rigidities: $\xi_d = 0.656$ (intermediate goods), $\xi_e = 0.780$ (export goods), $\xi_{m,c} = 0.827$ (imported consumption goods), $\xi_{m,i} = 0.931$ (imported investment goods), $\xi_{m,x} = 0.340$ (imported goods for export production), and $\xi_w = 0.470$ (nominal wage).