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.
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 a 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 im complete 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:

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

\[
= \left( \frac{R^k_{t+1} - R^D_{t+1}}{R_{t+1}} \right) Q_t S_{m,t}^F + R^D_{t+1} N_{m,t}^F
\]

net interest margin (spread)
Banker’s Problem (2)

- 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:

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

- 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:

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

\[\text{discounted present value of banking business}\]

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

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

\[\text{value of banking business} \quad \text{payoff of diverting her asset}\]
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:

$$N_{t+1}^F = \gamma^F \left[ \left( R_t^k - R_{t+1}^D \right) \phi_t^F + R_{t+1}^D \right] N_t^F + \xi^F Q_{t+1} S_t^F$$

- $\gamma^F$: Aggregate return to incumbents
- $\xi^F Q_{t+1} S_t^F$: Start-up transfers to entrants
Non-wasteful government spending (1)

Edgeworth complementarity:

- Household $j$’s objective function:

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

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

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

- 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:

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

- 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 differenctiated 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

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

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

- 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

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

MRS between labor supply and consumption

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

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

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

$$U_t = \frac{L_t - \tilde{H}_t}{\tilde{H}_t}$$
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.

\[ C_t = \left[ (1 - \omega_c) \frac{1}{\eta_c} \left( C_t^d \right)^{\frac{n_c - 1}{\eta_c}} + \omega_c \frac{1}{\eta_c} \left( C_t^m \right)^{\frac{n_c - 1}{\eta_c}} \right]^{\frac{\eta_c}{n_c - 1}}, \]

- \( \omega_c \in [0, 0.5] \) 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.
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.
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), \( \xi_x = 0.780 \) (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).
Experiments: Figures description

- Figures 1 to 5 report IRFs for selected variables including output, inflation and unemployment.

- All shocks are unanticipated and stationary one percent deviation shocks from steady states and responses of inflation, nominal interest rate and net interest margin \((E_t R_{t+1} - R^{D}_{t+1})\) are annualized.

- Red lines in all Figures are IRFs with financial friction, Edgeworth complementarity and productive public capital.

- Blue lines in Figures 1 to 3 are IRFs without financial friction \((E_t R_{t+1} = R^{D}_{t+1})\).

- Green lines in Figure 4 are IRFs without Edgeworth complementarity \((\nu_g = 0)\).

- Black lines in Figure 5 are IRFs in case that productivity of public capital is zero \((\alpha_g = 0)\).
IRFs for a temporary positive neutral technology shock, \(\epsilon_t\), related to the aggregate production function:

\[
y_t = \frac{1}{(\bar{p}_t^d)} \left[ \epsilon_t \left( \frac{k_t}{\tilde{k}_t^d} \right)^\alpha \left( \frac{H_t}{\tilde{w}_t} \right)^{1-\alpha} \left( \frac{k_t}{\tilde{g}_t} \right)^{\alpha_g} - \Theta^d \right]
\]

The neutral technology shock is a "supply" shock since this shock generates a negative comovement of output with inflation.

A positive technology shock contribute to the improvement of unemployment:
This result is consistent with Christiano et al. (2004).

Investment without financial friction (FF) is more amplified than that with FF:
\(\epsilon \uparrow \Rightarrow MPK \uparrow \Rightarrow K \uparrow\)

\[
\Rightarrow \begin{cases} 
S^F \uparrow & \text{in case w/o FF} \\
S^F \uparrow \Rightarrow \text{Leverage} \uparrow \Rightarrow R^k \downarrow \Rightarrow I \downarrow & \text{in case with FF}
\end{cases}
\]
Experiments: Figure 2

- IRFs for a temporary negative monetary shock, $\epsilon_t^R$, related to the monetary policy rule:

$$\ln \left( \frac{R_t^D}{R^D} \right) = \rho_R \ln \left( \frac{R_{t-1}^D}{R^D} \right) + (1 - \rho_R) \left[ \ln \left( \frac{\Pi_t^c}{\Pi_t^c} \right) + \phi_{\Pi} \ln \left( \frac{\Pi_t^c}{\Pi_t^c} \right) + \phi_y \ln \left( \frac{y_t}{y} \right) \right] + \epsilon_t^R$$

- The response of output is more amplified with FF than that of without FF.

- We expect the response of investment is to be shown as the following result:

$\epsilon_t^R \downarrow \Rightarrow$ Leverage $\downarrow \Rightarrow$ Net interest margin$\downarrow \Rightarrow I^\uparrow$

However, investment initially decreases to the monetary easing policy in both cases due to the highly interest rate-elastic response of consumption.
Experiments: Figure 3

- IRFs for a temporary negative capital quality shock, $\varepsilon_t^k$, related to the aggregate production function and realized nominal capital return:

\[
R_t^k = \frac{\varepsilon_t^k}{Q_t} \left[ (1 - \delta) Q_{t+1} + (1 - \tau_{t+1}^k) \left( \frac{P_{t+1}^d \alpha_{\varepsilon_t^k}^{\frac{Y_{t+1}+\Theta_t^d}{K_{t+1}}} - P_{t+1}^i a(u_{t+1})}{Q_t} \right) \right].
\]

- The capital quality shock indicates the deterioration of banker’s asset.

- The capital quality shock is a “demand” shock since this shock generates a comovement of output with inflation.

- Initial response: $\varepsilon_t^k \downarrow \rightarrow N^F \downarrow \rightarrow$ Leverage $\uparrow$

  $Q \downarrow$ (due to $QK = N^F + D$ and real rigidities of $K$) $\Rightarrow R_t^k \uparrow$

- Responses followed: Higher Leverage $\Rightarrow S^F \downarrow \Rightarrow K \downarrow$ Leverage gradually decreases $QK \uparrow \Rightarrow R_t^k$ gradually decreases.

- This result is consistent with Gertler and Karadi (2011).
Experiments: Figure 4

- IRFs for a temporary positive government consumption shock, $\epsilon_t^{g,c}$, related to the fiscal policy rule:
  \[
  \ln \left( \frac{g_t^c}{g_c^c} \right) = \rho_{g^c} \ln \left( \frac{g_t^{c-1}}{g_c^c} \right) - (1 - \rho_{g^c}) \phi_{g^c} \ln \left( \frac{a_t}{a} \right) + \epsilon_t^{g,c}
  \]

- Private consumption crowds "out" even if the Edgeworth complemetarity (EC) is implemented. This is the contrary result reported by Iwata (2013).

- Extra experiment: We investigate the sensitivity of the EC parameter $\nu_g$. We find higher absolute value of the EC parameter leads to the initial positive response of consumption (crowd "in"). We also find the Taylor coefficient for output $\phi_y$ also matters: A lower Taylor coefficient for output helps a positive response of private consumption. The magnitude of the complementarity parameter and the parameter configuration matter.
Experiments: Figure 5

* IRFs for a temporary positive government investment shock, \( \epsilon_t^{g^i} \), related to the fiscal policy rule:

\[
\ln \left( \frac{g_t}{g^i} \right) = \rho_{g^i} \ln \left( \frac{g_t^{i-1}}{g^i} \right) - (1 - \rho_{g^i}) \phi_{g^i} \ln \left( \frac{a_t}{a} \right) + \epsilon_t^{g^i}
\]

* Government investment has positive externalities to improve private firms’ productivity through productive public capital (PPC). Thus, aggregate demand curve shifts to right and aggregate supply curve (NKPC) also shifts to right. The result depicts the shift of aggregate demand dominates that of NKPC, since this shock generates a comovement of output with inflation, which indicates a “demand” shock.

* The shift of NKPC through PPC depresses inflation, which leads to a moderate monetary tightening policy i.e. nominal (and real) interest rate relatively lowers than that of the case without PPC.

* As a result, the lower real interest rate boosts private investment, the decrease of private consumption’s crowd out and moderates the exchange rate appreciation.
Conclusion

We built a large-scale DSGE model incorporating the four features; Our model introduces...

- financial friction between bankers and depositors,
- involuntary unemployment,
- non-wasteful government spending (Edgeworth complementarity and productive public capital),
- into a small open economy including home bias and nominal price rigidities to produce the incomplete exchange rate pass-through.
Conclusion (cont’d)

- We provided several experiments to illustrate how the model behaves. Our numerical experiments show...
  - A positive neutral technology shock improves unemployment rate.
  - The response of output is amplified with financial friction to a negative monetary policy shock.
  - A negative capital quality shock amplifies the decrease of output through the financial accelerator mechanism.
  - Private consumption’s crowd “out” is shown by a positive government consumption shock in our parameter settings.
  - A positive government investment shock amplifies output and private investment.
- Our future work is to estimate the model parameters based on actual data to measure quantitative effects of financial friction, Edgeworth complementarity and productive public capital.