Quantitative Easing in a Small Open Economy: An International Portfolio Balancing Approach

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November 16, 2017
Central Bank Macroeconomic Modelling Workshop

The views expressed are those of the author, not necessarily those of the Bank of Canada.
International Portfolio Balancing

- Portfolio balancing channel of QE: A fall in the stock of long-term gov’t bonds lowers yields below the expected path of short-term rates; i.e., term premium.
  - Tobin (1969): Relative asset supply matters.
- In the case of SOE, a large pool of substitutes exist.
- SOE term premia highly co-move with the global one, albeit not perfectly.
What I do

Main Question:

• How stimulatory can QE be in small open economies?
  • To what extent does domestic term premium deviate from global term premium after a QE shock? Effects through exchange rate?

Method:

• SOE-DSGE model with nominal and real rigidities
  • ST and LT portfolios including domestic and foreign bonds
  • Imperfect substitution between these assets (preferred habitat)

Main finding:

• SOE term premium: a combination of the global term premium and an excess premium that depends on home-foreign asset substitution.
  • CA and US bonds are estimated to be highly substitutable, esp at longer maturities - QE is less effective on rates.
  • High substitution at longer (shorter) maturities implies a larger (smaller) exchange rate response.
Illustration of QE in an SOE

The slope of relative demand curve represents the degree of substitution between assets.
Literature Review


- **Preferred Habitat DSGE models**:

- **Financial Intermediation DSGE models**:

Model Summary

- Small-open economy DSGE model (Monacelli, 2005; Gali and Monacelli, 2005; Justiniano and Preston, 2010) with an exogenous foreign bloc.
  - Nominal rigidities: *price-setters* domestic producers and retail firms.
  - Real rigidities: *habit formation* in consumption.

- Imperfect substitution among assets through portfolio adjustment costs in preferences (Andres et. al, 2004)
  - Introducing long-term bonds: Perpetuities that cost $q_L$ and pay an exponentially decaying coupon $\kappa s$ at period $s + 1$. $R_{L,t} = 1/q_{L,t} + \kappa$

- Both home and foreign assets are internationally traded. However, home assets are negligible part of foreign portfolio.
  - SOE cannot alter world asset prices ($R^*$, $R^*_L$ exogenous).

- Bond supply: Controlled by gov’t through budget constraint.
  - QE shock: Change in the supply of long-term bonds relative to short-term.

- Closing the model: Home goods and asset external demand function.
Households Problem

\[
\max_{t} E_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \left[ \varepsilon^d_t \log[c_{\tau} - \zeta c_{\tau-1}] - \xi n^{1+\vartheta} \frac{1}{1 + \vartheta} - \Theta_t \right]
\]

s.t. \( \Theta_t = \frac{\xi_a}{2} \left( \frac{1 - \gamma_a}{\gamma_a} A_{S,t} - 1 \right)^2 + \frac{\xi_S}{2} \left( \frac{1 - \gamma_S}{\gamma_S} B_{HS,t} - 1 \right)^2 + \frac{\xi_L}{2} \left( \frac{1 - \gamma_L}{\gamma_L} \frac{q_{L,t} B_{HL,t}}{e_t q^*_L B_{FL,t}} - 1 \right)^2 \)

where \( A_{S,t} = B_{HS,t} + e_t B_{FS,t} \) and \( A_{L,t} = q_{L,t} B_{HL,t} + e_t q^*_L B_{FL,t} \).
Households Problem

\[
\max E_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \left[ \varepsilon_t^d \log [c_{\tau} - \zeta c_{\tau-1}] - \xi_n \frac{n_{\tau}^{1+\vartheta}}{1+\vartheta} - \Theta_t \right]
\]

s.t. 
\[
\begin{align*}
& c_t + \frac{B_{HS,t}}{P_t} + \frac{e_t B_{FS,t}}{P_t} (1 + \varepsilon_t^{cr}) + \frac{q_{L,t} B_{HL,t}}{P_t} (1 + \varepsilon_t^{dr}) + \frac{e_t q_{L,t}^* B_{FL,t}}{P_t} (1 + \varepsilon_t^{cr})(1 + \varepsilon_t^{dr}) \\
& \leq \frac{W_t}{P_t} n_t + \frac{R_{t-1} B_{HS,t-1}}{P_t} + \frac{e_t R_{t-1}^* B_{FS,t-1}}{P_t} + \frac{(1 + \kappa q_{L,t}) B_{HL,t-1}}{P_t} \\
& + \frac{e_t \left(1 + \kappa q_{L,t}^*\right) B_{FL,t-1}}{P_t} + \text{profits} - \text{tax},
\end{align*}
\]
Home and Global Term Premium

Long-term rate at home:

\[
\hat{R}_{L,t} = \left(1 - \frac{\kappa}{R_L}\right) E_t \sum_{s=0}^{\infty} \left(\frac{\kappa}{R_L}\right)^s \left\{ \hat{R}_{t+s} + \frac{1 - \zeta}{a} \hat{T}_{t+s} \right\}
\]

where

\[
\hat{T}_t = \frac{\xi_a}{\gamma_a(1 - \gamma_a)} \left( \hat{a}_{L,t} - \hat{a}_{S,t} \right) + \frac{\xi_L}{(1 - \gamma_a) \gamma_L} \left( \hat{q}_{L,t} + \hat{b}_{HL,t} - \hat{r}_{t} - \hat{q}_{L,t}^{*} - \hat{b}_{FL,t} \right)
\]

\[
- \frac{\xi_S}{\gamma_a \gamma_L} \left( \hat{b}_{HS,t} - \hat{r}_{t} - \hat{b}_{FS,t} \right) + \hat{\varepsilon}_t^{dr}.
\]

A similar relationship can be written for the global term premium and portfolios and then combined with the above equation to get:

\[
\Rightarrow \hat{T}_t = \hat{T}_t^{*} + \frac{\xi_L}{\gamma_1} \left[ \hat{q}_{L,t} + \hat{b}_{HL,t} - \left( \hat{r}_{t} + \hat{q}_{L,t}^{*} + \hat{b}_{FL,t} \right) \right] - \frac{\xi_S}{\gamma_2} \left[ \hat{b}_{HS,t} - \left( \hat{r}_{t} + \hat{b}_{FS,t} \right) \right]
\]

where \( \gamma_1 = (1 - \gamma_a) \gamma_L(1 - \gamma_L) \) and \( \gamma_2 = \gamma_a \gamma_S(1 - \gamma_S) \). Note that \( \hat{T}_t = \hat{T}_t^{*} \) when \( \xi_S = \xi_L = 0 \).
Exchange Rate in the Model

Modified UIP:

\[ E_t \hat{d}_{t+1} = \hat{R}_t - \hat{R}_t^* - \frac{(1 - \zeta)}{a} \xi_S \frac{\xi_S}{\gamma_2} \left[ \hat{b}_{HS,t} - \left( \hat{re}_t + \hat{b}_{FS,t} \right) \right] + \hat{\epsilon}_{cr} \]

Combining with \( \hat{T}_t - \hat{T}_t^* \):

\[ E_t \hat{d}_{t+1} = \hat{R}_t - \hat{R}_t^* + \frac{(1 - \zeta)}{a} \left( \hat{T}_t - \hat{T}_t^* \right) - \frac{(1 - \zeta)}{a} \xi_L \frac{\xi_L}{\gamma_1} \left[ \hat{q}_{L,t} + \hat{b}_{HL,t} - \left( \hat{re}_t + \hat{q}_L^*, \hat{b}_{FL,t} \right) \right] + \hat{\epsilon}_{cr} \]

- UIP deviations - costs of adjusting home and foreign asset ratio.
  - Under ZLB, QE depreciates the currency only if \( \xi_S > 0 \).
- FX rate depends on short-term rate and term premium differentials, as well as relative long-term bond holdings.
- Summary of QE effects on the domestic term premium and the exchange rate
  - Higher \( \xi_S \): Higher term premium and higher depreciation
  - Higher \( \xi_L \): Higher term premium but lower depreciation
**Policy and BoP**

- Consolidated budget constraint:
  \[
  \frac{R_{t-1}}{\pi_t} b_{S,t-1} + \frac{R_{L,t} q_{L,t}}{\pi_t} b_{L,t-1} = tax_t + b_{S,t} + q_{L,t} b_{L,t}
  \]

- Government controls the supply of LT bonds: \(q_{L,t} b_{L,t} = \Gamma \varepsilon_t^b b_{S,t}\)
  \(\varepsilon_t^b\) follows an AR(1) process.

- Tax policy: \(tax_t = \Xi_y \left( \frac{b_{S,t-1} + q_{L,t-1} b_{L,t-1}}{b_S + q_L b_{L}} \right)^{\tau b} \varepsilon_t^\tau\)

- Conventional Monetary Policy: Taylor Rule

- Balance of Payments:
  \[
  \left( rer_t b_{FS,t} - \frac{rer_t R_{t-1}^* b_{FS,t-1}}{\pi_t^*} \right) + \left( rer_t q_{L,t}^* b_{FL,t} - \frac{rer_t R_{L,t}^* q_{L,t}^* b_{FL,t-1}}{\pi_t^*} \right) \\
  - \left( \frac{b_{FS,t}^*}{rer_t} - \frac{R_{t-1} b_{FS,t-1}}{rer_t \pi_t} \right) - \left( \frac{q_{L,t} b_{FL,t}^*}{rer_t} - \frac{R_{L,t} q_{L,t} b_{FL,t-1}}{rer_t \pi_t} \right) = \rho_{h,t} c_{f,t}^* - rer_t c_{f,t} 
  \]
  \(1\)
Closing the model

1. External demand for home goods:

\[ c^*_{f,t} = \left( \frac{P^*_{f,t}}{P^*_t} \right)^{\lambda^*_c} c^*_t \]

2. External demand for home short-term bonds:

\[ \frac{b^*_{FS,t}}{rer_t} = \left( \frac{R_t \varepsilon_t^{cr}}{R^*_t E_t d_{t+1}} \right)^{-\eta^*_S} b^*_S,t \]

3. External demand for home long-term bonds:

\[ \frac{q_{L,t} b^*_{FL,t}}{rer_t} = \left( \frac{R^e_{L,t} \varepsilon_t^{cr}}{R^*_t E_t d_{t+1}} \right)^{-\eta^*_L} q^*_L b^*_L, t \]

4. Foreign bloc: VAR(2) of \( \hat{y}^* \), \( \hat{\pi}^* \), \( \hat{R}^* \), \( \hat{R}_L^* \), \( \hat{b}_S^* \), \( \hat{q}_L^* b_L^* \)
## Parameters

**Table: Calibrated parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount factor, $\beta$</td>
<td>0.985</td>
<td>matching the st.-st. interest rate (1.1 %, quarterly)</td>
</tr>
<tr>
<td>Home share (short), $\gamma_S$</td>
<td>0.93</td>
<td>st-st ratio of home bonds in short-term portfolio</td>
</tr>
<tr>
<td>Home share (long), $\gamma_L$</td>
<td>0.92</td>
<td>st-st ratio of home bonds in long-term portfolio</td>
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<td>Short share, $\gamma_a$</td>
<td>0.42</td>
<td>st-st ratio of short-term bonds in overall portfolio</td>
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<tr>
<td>Coupon, $\kappa$</td>
<td>0.98</td>
<td>calibrated matching the average duration of bonds (5 years)</td>
</tr>
<tr>
<td>Home biasness, $\gamma_c$</td>
<td>0.70</td>
<td>matching the st-st ratio of imports-to-GDP (30 %)</td>
</tr>
</tbody>
</table>
Parameters

Table: Estimated parameters - portfolio

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Density</th>
<th>Prior</th>
<th>Posterior</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST-LT portfolios, adj. cost 100ξ_a</td>
<td>G</td>
<td>0.60</td>
<td>0.30</td>
</tr>
<tr>
<td>H-F Short-term bonds, adj. cost 100ξ_S</td>
<td>G</td>
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<td>0.10</td>
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<td>H-F Long-term bonds, adj. cost 100ξ_L</td>
<td>G</td>
<td>0.10</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Prior mean for ξ_a: Model matches US QE effects in a closed economy setup. Prior means for ξ_S and ξ_L: SOE QE is at least as effective as in closed economy.


Observables (US, VAR): GDP, GDP deflator, FFR, 5yr yield, long- and short-term government bond supply.
QE Shock
Trade-off: term premium and the exchange rate

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QE in SOE-DSGE
BoC
Sensitivity on H-F bond substitution in short-term maturities

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QE in SOE-DSGE
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Domestic debt market: Closed vs. Open

Term premium
Long-term rate
GDP
Inflation
Policy rate
QE shock (Long-term outstanding)
Short-term Canadian bond outstanding
CAD depreciation
RER
Real exports
Home LT bond holdings by Canadian residents
Home ST bond holdings by Canadian residents
US LT bond holdings by Canadian residents
US ST bond holdings by Canadian residents
Concluding Remarks

- In a SOE model with preferred habitat, QE is effective only when domestic and foreign assets are not perfect substitutes.

- The substitution between home and foreign assets is estimated to be high, implying a smaller QE effect in a SOE than in a large economy.
  - However, lower substitution at shorter maturities could imply significant exchange rate response.

- Ignoring foreigners’ access to domestic debt market could mistakenly make the policy look more effective.
Without ZLB commitment

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QE in SOE-DSGE
BoC
Alternative ways to introduce imperfect substitution

1 Financial intermediaries that collect one-period deposits from households at rate $R^A$, financed by investments in short- and long-term government debt in a similar fashion as in Harrison (2011).

$$\max E_t \left[ R_t B_{HS,t} (i) + e_t R_{t-1}^* B_{FS,t-1} (i) + (1 + \kappa q_{L,t}) B_{HL,t-1} (i) + e_t \left( 1 + \kappa q_{L,t}^* \right) B_{FL,t-1} (i) \right]$$

$$- \left( R_t^A A_t + \left( \gamma_a \frac{a_{S,t} (i)}{a_{L,t} (i)} - 1 \right)^2 + \left( \gamma_S \frac{b_{HS,t} (i)}{rer_t b_{FS,t} (i)} - 1 \right)^2 + \left( \gamma_a \frac{q_{L,t} b_{HL,t} (i)}{rer_t q_{L,t}^* b_{FL,t} (i)} - 1 \right)^2 \right)$$

2 In a similar fashion as in Alpanda and Kabaca (2015), portfolios enter in a CES specification:

$$\max E_0 \sum_{t=0}^{\infty} \beta^t v_t \left[ \log [c_t (i) - \zeta c_{t-1}] + \xi_a \log a_t (i) - \xi_n \frac{n_t (i)^{1+\vartheta}}{1+\vartheta} \Theta_t \right]$$

$$a_t (i) = \left[ \gamma_a^\frac{1}{\lambda_a} \left[ a_{S,t} (i) \right]^\frac{\lambda_a - 1}{\lambda_a} + (1 - \gamma_a)^\frac{1}{\lambda_a} \left[ a_{L,t} (i) \right]^\frac{\lambda_a - 1}{\lambda_a} \right]^\frac{\lambda_a}{\lambda_a - 1}$$

3 Portfolio adjustment costs in household’s budget constraint
Log-linearizing external asset demand

since \( a^*_S, t = b^*_HS \) and \( a^*_L, t = q^*_L, t b^*_HL \):

\[
E_t \hat{d}_{t+1} = \hat{R}_t - \hat{R}^*_t - \left( \frac{1 - \beta \frac{R}{\pi}}{\beta \frac{R}{\pi}} \right) \frac{1}{\lambda^*_S} \left[ \hat{b}^*_{FS, t} - (\hat{rer}_t + \hat{b}^*_{HS, t}) \right]
\]

\[
E_t \hat{d}_{t+1} = \hat{R}^e_{L, t} - \hat{R}^e^*_L - \left( \frac{1 - \beta \frac{R}{\pi}}{\beta \frac{R}{\pi}} \right) \frac{1}{\lambda^*_L} \left[ \hat{q}_{L, t} + \hat{b}^*_{FL, t} - (\hat{rer}_t + \hat{q}^*_L, t + \hat{b}^*_{HL, t}) \right]
\]

back
## Estimated Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Prior</th>
<th>Posterior</th>
<th>Density</th>
<th>Mean</th>
<th>Std</th>
<th>Mean</th>
<th>Std</th>
<th>5 %</th>
<th>90 %</th>
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<tr>
<td>ST-LT portfolios, adj. cost</td>
<td>100ξ&lt;sub&gt;a&lt;/sub&gt;</td>
<td>G</td>
<td>0.60</td>
<td>0.30</td>
<td>0.2584</td>
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<td>Habit</td>
<td>ζ</td>
<td>B</td>
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<td>0.10</td>
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<td>Calvo domestic prices</td>
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<td>Taylor rule, smoothing</td>
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<td>Pers. productivity</td>
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<td>ρ&lt;sub&gt;r&lt;/sub&gt;</td>
<td>B</td>
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<td>Std. productivity</td>
<td>σ&lt;sub&gt;z&lt;/sub&gt;</td>
<td>IG</td>
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<td>0.9861</td>
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<td>Std. cos-push imports</td>
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<td>2.00</td>
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QE in SOE-DSGE  
BoC
Short-term US Bond Holdings by Canadians

Chart 1: Canadian holdings of U.S. Treasury Bills
US$ billions, annual data

Source: US Treasury
Last observation: June 2011

Chart 1: Canadian holdings of U.S. Treasury bills and dollars
US$ billions, annual data

Source: US Treasury and Bank calculations
Last observation: June 2011

BoC
Foreign Currency Deposits in Canada

Chart 1: Foreign currency deposits of Canadian residents
CAD$ billions, monthly data

Source: Bank of Canada via Hover Analytics
Last observation: December 2013
Bayesian IRFs

Term premium

Long-term rate

GDP

Inflation

Policy rate

RER

Real imports

Real exports

Long-term Canadian bond outstanding

Short-term Canadian bond outstanding

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