Global vs. Local Liquidity Traps

David Cook * and Michael B. Devereux

This paper examines demand spillovers in a two country open economy model to a demand shock newline (emanating from a single, source country) sufficiently large to push one or both countries into a liquidity trap. The zero lower bound on nominal interest rates keeps the central bank in the source country from fully adjusting monetary policy. We describe a two country New Keynesian model with sufficient home bias so as to exclude symmetric movements in response to demand shocks. We study conditions under which a liquidity trap in one country might spillover to a trading partner. We study, under which conditions, a liquidity trap in one country will lead to a liquidity trap in another country. We also show conditions under which a liquidity trap in another country can spillover into an output expansion in a trading partner.

Keywords: Liquidity trap, Monetary policy, Fiscal policy, International spillovers

JEL Classification: E2, E5, E6

I. Introduction

During 2008 and 2009, emerging markets and developed economies alike experienced a substantial deterioration in economic conditions (see Park and Lee 2009). We might think of the global economic crisis, as a financial tsunami flowing from a negative shock in one country through

* Corresponding Author, Associate Professor, Hong Kong University of Science and Technology, Clearwater Bay, Kowloon, HKSAR, (Tel) +852-2358-7614, (Fax) +852-2358-2084, (E-mail) davcook@ust.hk; Professor, University of British Columbia, 997-1873, East Mall, Vancouver BC V6T 1Z1, Canada, (Tel) +604-822-2542, (Fax) +604-822-5915, (E-mail) devm@mail.ubc.ca, respectively. Devereux thanks SSHRC, the Bank of Canada, and the Royal Bank of Canada for financial support. Cook thanks the Hong Kong Research Grants Council (UST08/09 640908). The opinions in this paper are those of the authors alone and cannot be ascribed to the Bank of Canada.
[**Seoul Journal of Economics** 2011, Vol. 24, No. 4]

the open ocean of liberalized trade and financial markets to spill over to the economies of other countries. Indeed, natural causes of the slump have been identified in the real estate pricing crashes that occurred in the United States, along with some European economies. However, the consequences have not been limited to those countries whose financial systems might be thought to be most directly implicated. This paper will study the analytics of international demand spillovers in a global liquidity crisis.

A key element of the crisis was the limitation it exposed in monetary policy practice. Given the deflationary aspects of the crisis, inflation targeting central banks might have been expected to respond by lowering interest rates. However, the sheer depth of the crisis prevented central banks from responding adequately, as money market rates cannot be reduced below the zero lower bound. This lack of a full monetary policy response can explain some of the size of the economic damage.

In the international environment, though, it is important to consider the monetary policy response of foreign trading partners to a liquidity crisis whose source comes from one country. Naturally, if the global slump is sufficiently severe that foreign trading partners are pushed toward the zero lower bound, then monetary policy will lose effectiveness world wide. However, foreign trading partners that retain monetary policy effectiveness may not only stabilize the impact of foreign shocks on their own economy but also impact the cyclical response of other countries that might find themselves at their own lower bound.

To study the issue of financial spillovers, we will construct a two country sticky price dynamic general equilibrium rational expectations model which can be used to explore, analytically, negative spillovers that might lead to a global financial slump. One key feature of the model will be persistent price stickiness. This allows for the examination of persistent demand shocks. A second feature is the modeling of home bias in preferences over goods. This can be thought of as a measure of the openness of countries to international trade. Home bias is an essential aspect of the model in order to capture the fact that international trade in most countries is a limited fraction of the share of GDP. Perhaps more importantly, the modelling of realistic home bias will be critical in studying the effects of demand shocks. In the absence of home bias, consumers in all countries will have the same market basket; demand shocks in one country would be felt symmetrically across all countries. Under more realistic parameterizations of home bias, trading partners may not move in parallel.

This paper follows a large literature which examines issues related to monetary policy at the zero lower bound including Krugman (1998), Eggertson and Woodford (2003, 2005), Jung *et al.* (2005), and Auerbach and Obstfeld (2005). Eggertsson (2009) and Woodford (2011) study the analytics of the fiscal multiplier in a closed economy. and many other writers explored how monetary and fiscal policy could be usefully employed even when the authorities have no further room to reduce short term nominal interest rates. Fujiwara *et al.* (2010a) examine the optimal monetary problem with commitment in a multi country situation under conditions of no home bias. Fujiwara *et al.* (2010b) examine monetary policy spillover responses to cost-push shocks in a global liquidity trap. Bodenstein *et al.* (2009) examine the effects of foreign shocks at the zero lower bound. Jeanne (2009) examines a 'global liquidity trap' using one-period sticky prices.

II. A Two Country Model of Interacting Monetary and Fiscal Policy

The model of the economy will feature two equally sized countries, designated 'home' and 'foreign.' Firms of each country produces a specific range of differentiated goods for global consumption. Households in each country consume a specific market basket of private goods consisting of goods from both countries. Potentially, households will consume a market basket of goods that is more heavily concentrated on the goods produced in the home country. We measure this 'home bias' with a single parameter, $1<\nu<2$; the steady state share of foreign goods consumed by a home household is $\nu/2$. Though, consumer households may have a home bias in consumption, we assume full risk sharing in financial markets. When $\nu=1$, there is no home bias. For $\nu>1$, the home consumer puts a higher weight on consuming home goods. For $\nu=2$, home bias is complete, and we have effectively two closed economies.

The goods produced in each country are produced with a constant returns to scale function of labor. Due to our focus on demand shocks, we abstract from technology and cost-push shocks. Producers of differentiated goods are monopolistic competitors and set prices to maximize profits. Firms are not free to adjust their prices instantly. Instead, only a fraction of firms are able to adjust their prices at any time, as in the Calvo pricing model. Consumer households act as workers and have a disutility of labor (in addition getting utility from private goods).

In the Appendix, we specify the full model which follows Cook and Devereux (2011).[1] We assume the existence of a shock to the subjective discount factor, ξ_t, which shifts the weight that preferences put on current consumption toward future consumption. We will construct a macroeconomic model from log-linearized versions of the Euler equations of the optimization problem of households and profit maximizing firms. The equations will be linearized around the non-stochastic steady state. We assume that 1) the government operates a set of subsidies financed with lump sum taxes to insure that the steady state economy (which features monopolistic consumption) operates at a level consistent to the perfectly competitive, first best equilibrium; 2) that monetary policy is set so that the flexible price equilibrium would feature zero inflation.

Define the demand shock variable in the home economy, $\varepsilon_t \equiv U_{C\xi}/U_C \ln(\xi_t)$, as the preference shock multiplied by the marginal impact of the shock on marginal utility of consumption relative to marginal utility of consumption evaluated at the steady state. In order to examine the economy at the zero lower bound liquidity trap, we assume that this shock term follows of a Markov process. Assume that at time t there is an unanticipated fall in ε_t to $\bar{\varepsilon}_L < 0$. Assume that ε_t reverts back to 0 with probability $1-\mu$ in each period henceforth, and then remains at 0 thereafter. We assume that the parallel foreign demand shock is zero, ε_t^*. We will assume that the home economy is the source of the global slump.

A. Demand Shocks Natural Interest Rates

Define $\sigma \equiv -(U_{CC}\bar{C})/U_C$ as the inverse of the elasticity of intertemporal substitution in consumption at the steady state, $\phi \equiv -(V''\bar{H})/V'$ as the elasticity of the marginal disutility of hours worked. We will assume that households have (realistically) less than unit elasticity of intertemporal substitution $\sigma > 1$. In a linearized model, it is possible to show that the value of the flexible price equilibrium interest rate in both the home and foreign economy, $\tilde{r}_t$ and $\tilde{r}_t^*$, are functions of the demand shock in the home country (assuming that the foreign demand shock is zero). Define $\Delta = \phi(\sigma\upsilon(2-\upsilon) + (1-\upsilon)^2) + \sigma > 0$.

[1] Note that the focus of Cook and Devereux (2011) was fiscal policy. This paper abstracts from government spending. The model also uses some insights from Beetsma and Jensen (2005).

$$\tilde{r}_t = \bar{r} + \left(\frac{\phi}{\phi + \sigma} + \frac{\phi(\upsilon - 1)}{\Delta} \right) \frac{(1-\mu)}{2} \varepsilon_t \tag{1}$$

which we can write as:

$$\tilde{r}_t = \bar{r} + \upsilon \frac{\phi^2(\sigma - 1)(2-\upsilon) + \sigma\phi + \phi^2}{\Delta(\phi + \sigma)} \frac{(1-\mu)}{2} \varepsilon_t \tag{2}$$

In similar manner, we can write the foreign natural nominal interest rate as:

$$\tilde{r}_t^* = \bar{r} + (2-\upsilon) \frac{\phi^2(\sigma - 1)\upsilon + \sigma\phi + \phi^2}{\Delta(\phi + \sigma)} \frac{(1-\mu)}{2} \varepsilon_t \tag{3}$$

Defining $\bar{r} \equiv (1/\beta) - 1$ is the steady state net interest rate with $0 < \beta < 1$ denoting the subjective discount factor.

These equations imply that regardless of home bias, a negative home preference shock will reduce the natural interest rate in both economies. An important point about this set of equations is that when there is no home bias, the natural interest rate is the same in both countries. The intuition is that complete risk sharing will equalize the marginal utility of consumption relative to the price of the market basket (evaluated in a common currency) in the two countries. When there is no home bias, the price of the market basket is equalized. According to the Euler equation, equalized marginal consumption utility will then imply equalized interest rates.

In order to push the natural interest rate in the home economy to zero, the shock must satisfy the condition:

$$\varepsilon_t \leq \underline{\varepsilon}_L^{L:OCAL} = -\left[\upsilon \frac{\phi^2(\sigma - 1)(2-\upsilon) + \sigma\phi + \phi^2}{\Delta(\phi + \sigma)} \frac{(1-\mu)}{2} \right]^{-1} \bar{r} \tag{4}$$

However, the condition that the shock pushes the natural rate below zero in *both* economies is

$$\varepsilon_t \leq \underline{\varepsilon}_L^{GLOBAL} = -\left[(2-\upsilon) \frac{\phi^2(\sigma - 1)\upsilon + \sigma\phi + \phi^2}{\Delta(\phi + \sigma)} \frac{(1-\mu)}{2} \right]^{-1} \bar{r} \tag{5}$$

Notice also that as υ approaches 2, $\underline{\varepsilon}_L^{GLOBAL}$, becomes infinitely large. When the economies engage in trade only to a small degree, only a very large demand shock in one country can lead to significant spillovers to another country.

The ratio of the two threshold values of shocks is:

$$\frac{\underline{\varepsilon}_L^{GLOBAL}}{\underline{\varepsilon}_L^{L:OCAL}} = \frac{\upsilon}{(2-\upsilon)} \frac{\phi(\sigma-1)(2-\upsilon)+\sigma+\phi}{\phi(\sigma-1)\upsilon+\sigma+\phi} > 1$$

To put this in a quantitative perspective, we could parameterize $\phi=1$, $\sigma=2$, and $\upsilon=1.5$ so the home household consumes 3 times as many home goods as foreign goods, then the size of the shock needed to push both countries natural interest rates below zero would be 8/3 times as large as the size of the shock needed to push the source country's natural interest rate below zero.

B. New Keynesian International Model

This paper follows Engel (2010) in modelling a New Keynesian international economy with home bias. Define N_t and N_t^* as home and foreign labor; and, π_t and π_t^* as home and foreign inflation. Define a variable $\hat{x}_t$ as the percentage gap between the outcome of X_t and the outcome, that would prevail in a flexible price equilibrium, so that $\hat{x}_t \equiv \ln(X_t/\tilde{X}_t)$ We can arrange log linearized versions of the first order conditions to construct an open economy version of the New Keynesian model.

The home economy has an IS curve representing the Euler equation, which can be written in terms of the output gap (equal to the employment gap), inflation, and interest rates. This is

$$\begin{aligned} &E_t(\hat{n}_{t+1}-\hat{n}_t)(D+\upsilon-1)+E_t(\hat{n}^*_{t+1}-\hat{n}^*_t)(D-(\upsilon-1)) \\ &=\frac{2D}{\sigma}E_t\left(r_t-\tilde{r}_t-\pi_{Ht+1}-(1-\frac{\upsilon}{2})\frac{\sigma((\hat{n}_{t+1}-\hat{n}^*_{t+1})-(\hat{n}_t-\hat{n}^*_t))}{D}\right) \end{aligned} \tag{6}$$

For the foreign economy the analogous equation is:

$$\begin{aligned} &E_t(\hat{n}^*_{t+1}-\hat{n}^*_t)(D+\upsilon-1)+E_t(\hat{n}_{t+1}-\hat{n}_t)(D-(\upsilon-1)) \\ &=\frac{2D}{\sigma}E_t\left(r^*_t-\tilde{r}^*_t-\pi^*_{Ft+1}+(1-\frac{\upsilon}{2})\frac{\sigma((\hat{n}_{t+1}-\hat{n}^*_{t+1})-(\hat{n}_t-\hat{n}^*_t))}{D}\right) \end{aligned} \tag{7}$$

where r_t and r_t^* represents the interest rate set by the central bank, π_H is inflation in the price of home produced goods and π_F is inflation in the price of foreign produced goods. Here we define $D \equiv \sigma\upsilon(2-\upsilon)+(1-\upsilon)^2>0$. Note that if $\upsilon=1$, then $D\equiv\sigma$. Further, it is easy to show that for all υ we see that if $\sigma>1$ then $D-1=(\sigma-1)\upsilon(2-\upsilon)>0$ so $D>1$ and also $\sigma>D=\sigma+(1-\sigma)(1-\nu)^2$.

The supply side of the economy is represented by the New Keynesian Phillips curve for the home economy:

$$\pi_{Ht} = k\left(\phi\hat{n}_t + \frac{\sigma}{2D}[\hat{n}_t(1+D)+\hat{n}_t^*(D-1)]\right) + \beta E_t \pi_{Ht+1} \tag{8}$$

and the foreign economy:

$$\pi_{Ft}^* = k\left(\phi\hat{n}_t^* + \frac{\sigma}{2D}[\hat{n}_t^*(1+D)+\hat{n}_t(D-1)]\right) + \beta E_t \pi_{Ft+1}^* \tag{9}$$

where $k=\{(1-\beta\kappa)(1-\kappa)\}/\kappa$, and $1-\kappa$ is the fraction of firms that receive an opportunity to change their prices in every period.

The system (6)-(9) may be solved for the four variables $\hat{n}_t$, $\hat{n}_t^*$, $\hat{\pi}_{Ht}$, and $\hat{\pi}_{Ft}^*$, given an assumption about monetary policy r_t and r_t^* in each country. Given strictly positive realizations of the natural interest rate, the central bank can achieve both zero inflation and zero output gaps by setting the interest rate, r_t equal to the natural rate implementing the flexible price equilibrium. We focus however on cases where either $\tilde{r}_t$, $\tilde{r}_t^*$, or both are below zero, so the policy interest rate cannot achieve the natural real interest rates and simultaneously achieve zero inflation.

It is convenient to rewrite the model in terms of the global economy. For any variable x, define $x^W=(x+x^*)/2$ as the world average, and $x^R=(x-x^*)/2$ as the world relative in the variable. Since then $x=x^W+x^R$ we first add both sides of (8) and (9)

$$\begin{gathered} D\{\pi_{Ht}+\pi_{Ft}^*\}=Dk\phi\{n_t+n_t^*\}+\sigma(D)\,[\hat{n}_t^*+\hat{n}_t] \;\; +\beta D E_t\{\pi_{Ht+1}+\pi_{Ft+1}^*\} \\ \{\pi_t^W\}=k(\phi+\sigma)\,\{n_t^W\}+\beta E_t\,\{\pi_{t+1}^W\} \end{gathered} \tag{10}$$

Then, add and subtract both sides of (6) and (7)

$$2D\{\hat{n}_{t+1}+\hat{n}_{t+1}^*\}+2D\{\hat{n}_t+\hat{n}_t^*\}$$

$$= \frac{2D}{\sigma} E_t[\{r_t + r_t^*\} - \{\tilde{r}_t + \tilde{r}_t^*\} - \{\pi_{Ht+1} + \pi_{Ft+1}^*\}] \tag{11}$$

$$\{\hat{n}_{t+1}^W - \hat{n}_t^W\} = \frac{1}{\sigma} E_t[\{r_t^W\} - \{\tilde{r}_t^W\} - \pi_{t+1}^W]$$

One result implied here is that, conditional on world economic policy, r_t^W, the dynamics of world output and inflation are not affected by the degree of home bias. Indeed, the dynamics of the world economy are equivalent to the canonical New Keynesian closed economy macro model. The world nominal interest rate is given by:

$$\tilde{r}_t^W = \bar{r} + \left(\frac{\phi}{\phi + \sigma}\right) \frac{(1-\mu)}{2} \varepsilon_t \tag{12}$$

So the world natural interest rate is also is also invariant to the degree of home bias.

We can also derive the equations for the *relative* allocation of world output gaps and inflation by subtracting both sides of (9) from (8). For the world relative New Keynesian Phillips curve, we have:

$$\begin{aligned} &\{\pi_{Ht} - \pi_{Ft}^*\} = k\phi\{n_t - n_t^*\} + \frac{\sigma}{D}[\{n_t - n_t^*\}] + \beta E_t\{\pi_{Ht+1} - \pi_{Ft+1}^*\} \\ &\{\pi_t^R\} = k\left(\phi + \frac{\sigma}{D}\right)\{n_t^R\} + \beta E_t\{\pi_{t+1}^R\} \end{aligned} \tag{13}$$

From the definition of the IS curves, (7) and (6), we have:

$$\begin{aligned} &E_t(\hat{n}_{t+1} - \hat{n}_t)(D + \upsilon - 1) + E_t(\hat{n}_{t+1}^* - \hat{n}_t^*)(D - (\upsilon - 1)) \\ &= \frac{2D}{\sigma} E_t\left(r_t - \tilde{r}_t - \pi_{Ht+1} - (1 - \frac{\upsilon}{2})\frac{\sigma((\hat{n}_{t+1} - \hat{n}_{t+1}^*) - (\hat{n}_t - \hat{n}_t^*))}{D}\right), \end{aligned} \tag{14}$$

and:

$$\begin{aligned} &E_t(\hat{n}_{t+1}^* - \hat{n}_t^*)(D + \upsilon - 1) + E_t(\hat{n}_{t+1} - \hat{n}_t)(D - (\upsilon - 1)) \\ &= \frac{2D}{\sigma} E_t\left(r_t^* - \tilde{r}_t^* - \pi_{Ft+1}^* + (1 - \frac{\upsilon}{2})\frac{\sigma((\hat{n}_{t+1} - \hat{n}_{t+1}^*) - (\hat{n}_t - \hat{n}_t^*))}{D}\right), \end{aligned} \tag{15}$$

so that, the world relative IS curve is:

$$
\begin{aligned}
&(\upsilon-1)E_t(\hat{n}^R_{t+1}-\hat{n}^R_t) \\
&=\frac{D}{\sigma}E_t[r^R_t-\tilde{r}^R_t-\{\pi^R_{t+1}\}]-(2-\nu)E_t(\hat{n}^R_{t+1}-\hat{n}^R_t) \\
&E_t(\hat{n}^R_{t+1}-\hat{n}^R_t)=\frac{D}{\sigma}E_t[r^R_t-\tilde{r}^R_t-\{\pi^R_{t+1}\}]
\end{aligned}
\tag{16}
$$

Note, the difference equations here *are* affected by the degree of home bias, but this operates through the ratio D/σ. However, we can also see that differences in the natural interest rate are:

$$\tilde{r}^R_t=\frac{\phi(\upsilon-1)}{D\phi+\sigma}\frac{(1-\mu)}{2}\varepsilon_t \tag{17}$$

Define $\sigma^D\equiv\sigma/D$. We can write the four equations of dynamics as:

$$\{\pi^W_t\}=k\,(\phi+\sigma)\,\{\hat{n}^W_t\}+\beta E_t\,\{\pi^W_{t+1}\} \tag{18}$$

$$\{\hat{n}^W_{t+1}-\hat{n}^W_t\}=\frac{1}{\sigma}E_t[\{r^W_t\}-\{\tilde{r}^W_t\}-\pi^W_{t+1}] \tag{19}$$

$$\{\pi^R_t\}=k\,(\phi+\sigma^D)\,\{\hat{n}^R_t\}+\beta E_t\,\{\pi^R_{t+1}\} \tag{20}$$

$$E_t(\hat{n}^R_{t+1}-\hat{n}^R_t)=\frac{1}{\sigma^D}E_t[r^R_t-\tilde{r}^R_t-\{\pi^R_{t+1}\}] \tag{21}$$

Note that the dynamics of world averages and differences are separable. Also, they are exactly parallel to one another except that the parameter of intertemporal substitution governing the latter two equations is σ^D rather than σ. Note that since $\sigma>D$, then $\sigma^D>1$. Also note that the following decompositions apply:

$$
\begin{gathered}
D=\sigma+(1-\sigma)(1-\nu)^2<\sigma \\
D-\sigma=(1-\sigma)(1-\nu)^2 \\
\sigma-D=(\sigma-1)(1-\nu)^2 \\
\sigma_D-1=(\sigma-1)\frac{(1-\nu)^2}{D}
\end{gathered}
$$

In addition, we have that:

$$\frac{(1-\nu)^2}{D}=\frac{(1-\nu)^2}{\sigma\upsilon(2-\upsilon)+(1-\upsilon)^2}<1\rightarrow\sigma_D<\sigma$$

Given perfect freedom to set r_t and r_t^*, each central bank can close the interest rate gap in each country, stabilize prices and eliminate the output gap. However, we examine the response of the economy when $\varepsilon_t<\underline{\varepsilon}_L^{LOCAL}$ so that, at the least, the home central bank cannot close the gap. Instead, the home central bank will set $r_t=0$. We examine the effects of demand shocks under different assumptions about the foreign central bank.

III. World Liquidity Traps

First, assume that $\varepsilon_t<\underline{\varepsilon}_L^{GLOBAL}$, so that neither country can match their natural interest rate. Assume that both countries are forced to the zero lower bound, so $r_t=r_t^*=r_t^W=r_t^R=0$. The once and for all shock has a probability $1-\mu$ reverting back to 0 in each future period. As there are no state variables, upon reversion, all the variables will revert to steady state. Thus, for any variable x_t, $E_t[x_{t+1}]=\mu x_t$. Define $\Psi=\sigma(1-\beta\mu)(1-\mu)-\mu k(\sigma+\phi)>\Psi^D=\sigma_D(1-\beta\mu)(1-\mu)-\mu k(\sigma_D+\phi)$. For determinacy of the equilibrium, it is required that $\Psi^D>0$. We restrict ourselves to examine the symmetric equilibrium.

Solving the dynamic Equations (18)-(21).

$$\Psi\hat{n}_t^W=(1-\beta\mu)\{\tilde{r}_t^W\} \tag{22}$$

$$\Psi^D\hat{n}_t^R=(1-\beta\mu)\{\tilde{r}_t^R\}. \tag{23}$$

From the Equation, (12), we see that the negative demand shock to the home economy has a negative impact on the world average natural interest rate. First, a negative realization in the world natural interest rate, $\tilde{r}_t^W$, due to a demand shock has a negative marginal impact on world output. Interestingly, this negative realization is invariant to home bias. However, we can also see by inserting (17) into (23) that a negative realization of ε_t will lead to a negative realization of $\hat{n}_t^R$, indicating that the home shock will have a stronger impact on the home economy in the case of home bias.

$$\hat{n}_t^R = \frac{(1-\beta\mu)}{\Psi^D}\frac{\phi(\upsilon-1)}{D\phi+\sigma}\frac{(1-\mu)}{2}\varepsilon_t \tag{24}$$

Since the world average output declines and the decline is relatively stronger in the home economy, it is easy to see that home output declines.

But what about foreign output? In the case of no home bias, we know that foreign output would respond identically to the home economy. So both economies would share the same natural interest rate and $\hat{n}_t^R=0$ when $\nu=1$. At the least, in the case with home bias, output will decline by less in the foreign economy. However, in the home bias case we can also see examples in which, the global liquidity trap will be expansionary for the foreign economy. Inserting (1) into (22) we get,

$$\hat{n}_t^W = \frac{(1-\beta\mu)}{\Psi}\cdot\left(\bar{r}+\left(\frac{\phi}{\phi+\sigma}\right)\frac{(1-\mu)}{2}\varepsilon_t\right) \tag{25}$$

We know $n_t^*=n_t^W-n_t^R$. Subtracting (24) from (25)

$$\begin{aligned}\hat{n}_t^* &= (1-\beta\mu)\left[\frac{\{\tilde{r}_t^W\}}{\Psi}-\frac{\{\tilde{r}_t^R\}}{\Psi^D}\right]\\ &= \frac{(1-\beta\mu)\bar{r}}{\Psi}+(1-\beta\mu)\frac{(1-\mu)}{2}\left(\left(\frac{\phi}{\Psi(\phi+\sigma)}\right)-\frac{(\upsilon-1)\phi}{\Psi_D\Delta}\right)\varepsilon_t\end{aligned} \tag{26}$$

Now consider if the shock were exactly sufficient to drive the foreign economy into a liquidity trap. This would occur when $\varepsilon_t=\underline{\varepsilon}_L^{GLOBAL}$.

Insert (5) into (26), and conduct the following derivation:

$$\begin{aligned}\hat{n}_t^* &= (1-\beta\mu)\bar{r}\left\{\frac{1}{\Psi}+\left[\left(\frac{(\upsilon-1)(\phi^2+\sigma\phi)}{\Psi_D}-\frac{\Delta\phi}{\Psi}\right)\frac{1}{(2-\upsilon)\phi^2(\sigma-1)\upsilon+\sigma\phi+\phi^2}\right]\right\}\\ &= (1-\beta\mu)\bar{r}\left[\frac{(2-\upsilon)\phi(\sigma-1)\upsilon+\sigma+\phi-\Delta}{\Psi\{(2-\upsilon)\phi(\sigma-1)\upsilon+\sigma+\phi\}}+\frac{(\upsilon-1)(\phi^2+\sigma\phi)}{\Psi_D}\right]\end{aligned}$$

Then, since:

$$(2-\upsilon)\phi(\sigma-1)\upsilon+\sigma+\phi-\Delta$$

$$=(2-\upsilon)\phi(\sigma-1)\upsilon+\sigma+\phi-\phi(\sigma\upsilon(2-\upsilon)+(1-\upsilon)^2)-\sigma$$
$$=-(2-\upsilon)\upsilon\phi+\phi(1-(1-\upsilon)^2)=0,$$

we have:

$$\hat{n}_t^* = (1-\beta\mu)\bar{r}\left[\frac{(\upsilon-1)(\phi^2+\sigma\phi)}{\Psi_D}\right] > 0$$

So if $\nu > 1$, so that there is home bias, a negative demand shock from the home economy that *marginally* pushes the foreign economy into a liquidity trap will have a positive impact on foreign output. The foreign economy faces a decline in demand from home consumers, but also a cut in interest rates. As long as the decline in demand is not too large, foreign output will expand in the global slump.

We could also consider whether there are situations where a global liquidity trap results in expansion for the foreign economy, regardless of the size. Consider the Equation (26). As long as the coefficient on ε_t, given by $\Gamma \equiv \left((\frac{\phi}{\Psi(\phi+\sigma)}) - \frac{(\upsilon-1)\phi}{\Psi_D\Delta} \right)$ is negative, it does not matter how large the shock is, a negative demand shock in the home country will lead to an increase in foreign output. Conversely, if $\Gamma > 0$, then it will always be the case that a sufficiently large demand shock can lead to a contraction in the foreign economy.

This is a complicated function of a number of parameters, but a parameter of particular interest to us is the degree of home bias. We again set $\phi = \sigma = 2$, we assume $\beta = .99$ and price setting averaging a price change every 4 periods. We set $\mu = .5$ so the slump lasts an average of two quarters. We allow υ to vary over the range $1 < \nu < 2$. Figure 1 reports the outcome of Γ at different levels of home bias. Unsurprisingly, when the level of ν is near 1 and the economies have almost no home bias in trade, we observe that $\Gamma > 0$. In this range, a sufficiently large negative demand shock in the home economy must have a negative outcome for foreign output. However, as we move away from the no home bias case, there can be mildly positive spillovers. Again, this captures the intuition that the decline in demand in the home economy does not fall very hard on the home economy, yet at the same time the interest rate will fall sharply.

Figure 1 shows the response of Γ to a home demand shock. A negative outcome for Γ implies that regardless of the size of the negative demand shock it will lead to expansion in the foreign economy.

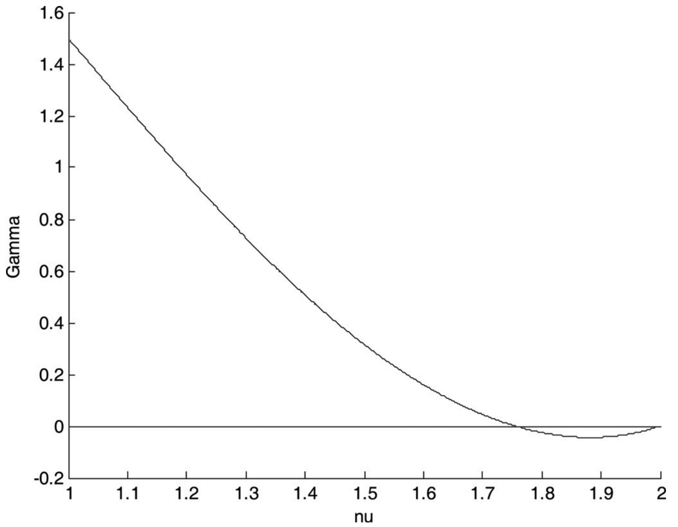

FIGURE 1

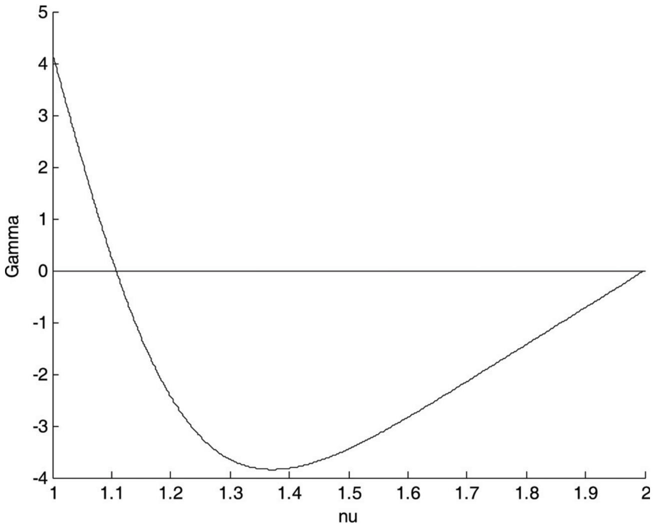

FIGURE 2

Interestingly, we see that a positive spillover is more likely to occur when the shock is persistent. We calibrate the model at $\mu = .6$. Figure 2 reports Γ under different parameterizations of ν. When the shocks are expected to be more persistent, home demand responds more sharply but also we see that the persistent interest rate decline can lead to an output expansion in the foreign economy.

IV. Local Liquidity Traps

We also consider the case where $\underline{\varepsilon}_L^{GLOBAL} > \varepsilon_t > \underline{\varepsilon}_L^{LOCAL}$. This can only be a relevant case when there is home bias. In this case, r_t^* might be non-zero, since the foreign country has a natural real interest rate above zero. Consider if the foreign central bank continues to eliminate the natural real interest rate, so that $r_t^* = \tilde{r}_t^*$. Then we have:

$$\{r_t^W\} - \{\tilde{r}_r^W\} = \{r_t^R\} - \{\tilde{r}_r^R\} = -\frac{\tilde{r}_t}{2}$$

Using this, we can then show that:

$$\Psi \hat{n}_t^W = (1 - \beta\mu) E_t \left[\frac{\tilde{r}_t}{2} \right] \tag{27}$$

$$\Psi^D \hat{n}_t^R = (1 - \beta\mu) E_t \left[\frac{\tilde{r}_t}{2} \right] \tag{28}$$

Premultiply both conditions by Ψ^D, to get:

$$\Psi^D \Psi \cdot \hat{n}_t^W = \Psi^D (1 - \beta\mu) E_t \left[\frac{\tilde{r}_t}{2} \right]$$

$$\Psi^D \Psi \cdot \hat{n}_t^R = \Psi \cdot (1 - \beta\mu) E_t \left[\frac{\tilde{r}_t}{2} \right]$$

Using these results, we have:

$$\hat{n}_t = \hat{n}_t^W + \hat{n}_t^R = (1 - \beta\mu) \frac{\Psi^D + \Psi}{\Psi^D \Psi} E_t \left[\frac{\tilde{r}_t}{2} \right]$$

$$\hat{n}_t^* = \hat{n}_t^W - \hat{n}_t^R = (1 - \beta\mu) \frac{\Psi^D - \Psi}{\Psi^D \Psi} E_t \left[\frac{\tilde{r}_t}{2} \right]$$

Thus, in a local liquidity trap, the home country output always falls.

We can also say that since $\Psi^D < \Psi$, a local liquidity trap is always expansionary for the foreign economy.

It is also interesting to consider the impact of the freedom that the foreign economy has on foreign and domestic output. Say that the foreign central bank sets r_t^* while $r_t = 0$ due to the domestic economy being in a liquidity trap. Then $\{r_t^W\} = r_t^*/2 = -\{r_t^R\}$

$$\Psi_D \Psi \hat{n}_t^W = (1-\beta\mu)\Psi_D E_t\left[-\left\{\frac{r_t^*}{2}\right\} + \{\tilde{r}_t^W\}\right] \tag{29}$$

$$\Psi_D \Psi \hat{n}_t^R = (1-\beta\mu)\Psi E_t\left[\frac{r_t^*}{2} + \tilde{r}_t^R\right] \tag{30}$$

Solving for GDP

$$\hat{n}_t = \hat{n}_t^W + \hat{n}_t^R = (1-\beta\mu)\frac{\Psi - \Psi^D}{\Psi^D\Psi} E_t\left[\frac{r_t^*}{2}\right] + \ldots$$

$$\hat{n}_t^* = \hat{n}_t^W - \hat{n}_t^R = (1-\beta\mu)\frac{-\Psi^D - \Psi}{\Psi^D\Psi} E_t[\tilde{r}_t] + \ldots$$

So, taking the home and natural foreign interest rates as given, if the foreign economy takes advantage of the home liquidity trap to cut interest rates, it will have a positive effect on foreign output, but have a negative effect on home output. Note, however, that the impact on world and foreign output will be positive.

V. Conclusion

This paper has first given a calibration of how large a demand shock needs to be to lead to a global slump (or zero lower bound), under reasonable home bias. We have shown that the scale of the global slump is invariant to home bias. In either a global or local slump, the home country (the source of the negative demand shock) always has a negative output response. But we give examples (one analytic, one numerical) of cases where the non-source foreign economy's output will increase. The analytic case pertains to the situation where the home demand shock is only marginally large enough to send the foreign economy to the zero lower bound. The numerical case holds for reasonable paramaterizations. Then a home demand shock of any size will lead to a global slump that (mildly) increases foreign output.

The general message of the paper is that the international transmission of shocks when the world economy is in either a global or local liquidity trap can imply surprising and non-intuitive results. As a result, the implications for international policy (both monetary and fiscal policy) have to be assessed with caution.

(Received 1 October 2010; Revised 19 January 2011; Accepted 20 January 2011)

Appendix

A. The Model

The model follows Engel (2010), who looked at an optimal policy environment with home bias in consumer preferences.

a) Households

Define utility of a infinitely lived representative household from the home economy:

$$U_0 = E_0 \sum_{t=0}^{\infty} (\beta)^t (U(C_t, \xi_t) - V(N_t)) \tag{A1}$$

where U, and V, represent the utility of the composite home consumption bundle C_t, and the disutility of labour supply N_t. U is continuous and concave in C while V is continuous and convex in N. The variable ξ_t represents a preference, or 'demand' shock, where we assume that $U_{12} > 0$.

Composite consumption is defined as

$$C_t = \Phi C_{Ht}^{\upsilon/2} C_{Ft}^{1-\upsilon/2}, \quad \upsilon \geq 1$$

where $\Phi = (\upsilon/2)^{\upsilon/2} (1-(\upsilon/2))^{\upsilon/2}$, C_{Ht} is the consumption of the home country composite good by the home household, and C_{Ft} is home consumption of the foreign good. Limiting $\upsilon \geqslant 1$ insures home bias in preferences except when $\upsilon = 1$ in which both countries will equally value goods from both sources.

The composite good, C_H, is a unit range of home differentiated goods and C_F is a unit range of foreign differentiated goods.

$$C_H = \left[\int_0^1 C_H(i)^{1-\frac{1}{\theta}} di \right]^{\frac{1}{1-\frac{1}{\theta}}}, \quad C_F = \left[\int_0^1 C_F(i)^{1-\frac{1}{\theta}} di \right]^{\frac{1}{1-\frac{1}{\theta}}}, \quad \theta > 1.$$

where the elasticity of substitution between goods is θ. The home price indices for these goods are:

$$P_H = \left[\int_0^1 P_H(i)^{1-\theta} di \right]^{\frac{1}{1-\theta}}, \quad P_F = \left[\int_0^1 P_F(i)^{1-\theta} di \right]^{\frac{1}{1-\theta}},$$

while $P = P_H^{\upsilon/2} P_F^{1-\upsilon/2}$ is the (CPI) price index. The first order conditions for individual firms can be written as isoelastic functions of relative prices with elasticity θ. Nominal wages, W_t are set in competitive markets. The optimal labor-consumption trade-off is:

$$U_C(C_t, \ \xi_t) W_t = P_t V'(N_t). \tag{A2}$$

The household in the foreign economy faces an analogous problem where S_t is the nominal exchange rate (home price of foreign currency). Foreign households preferences and choices can be defined in parallel. The only difference is that the foreign household has weight $\upsilon/2$ on home goods and $(1-\upsilon/2)$ on the foreign composite good. The foreign *CPI* is $P_t^* = P_F^{*\upsilon/2} P_H^{*1-\upsilon/2}$. We assume producer currency pricing so the law of one prices holds for all goods at all times, so, for example, $P_F = SP_F^*$.

We assume a complete set of state contingent international assets markets allowing for complete risk sharing. This implies that nominal marginal utility is equated across countries. This implies the following equation:

$$U_C(C_t, \xi_t) = U_C(C_t^*, \xi_t^*) \frac{S_t P_t^*}{P_t} = U_C(C_t^*, \xi_t^*) T_t^{\upsilon-1}, \tag{A3}$$

defining $T = SP_F^*/P_H$ is the home country terms of trade. Implicit in this condition is the assumption that the law of one price holds in individual goods and home and foreign composite consumption goods (*i.e.*, so that $P_F = SP_F^*$, *etc.*). There is also a risk free interest rate in each country currency paying an interest rate of R_t in all states of the world. Thus we can define an Euler equation:

$$\frac{U_C(C_t, \xi_t)}{P_t} = E_t \beta \frac{U_C(C_{t+1}, \xi_{t+1})}{P_{t+1}} R_{t+1}. \tag{A4}$$

b) Firms

Differentiated goods firms transform labor into goods on a one-to-one basis with production function, $Y_t(i) = N_t(i)$ where $Y_t(i)$ is output of firm i. The home firm profits, $\Pi_t(i) = P_{Ht}(i) Y_t(i) - W_t H_t(i)(1-s)$, are maximized where s is a steady state wage subsidy offered to each home firm by the home government, financed with lump-sum taxation. Each home firm resets its price along the lines of Calvo where a given firm has an idiosyncratic probability of re-adjusting its price, $1-\kappa$.

Firm i adjusts its price to maximizes the present value of profits while facing a demand curve with elasticity θ. This leads to the common optimal price setting condition as follows:

$$\tilde{P}_{Ht} = \frac{\theta}{\theta - 1}(1 - s) \frac{E_t \sum_{j=0} m_{t+j} \kappa^j W_{t+j} Y_{t+j}}{E_t \sum_{j=0} m_{t+j} \kappa^j Y_{t+j}}. \tag{A5}$$

where the stochastic discount factor $m_{t+j} = \frac{P_t}{U_C(C_t, \varepsilon_t)} \frac{U_C(C_{t+j}, \xi_{t+j})}{P_{t+j}}$. In the aggregate, the price index for the home good then follows the process given by:

$$P_{Ht}^{1-\theta} = [(1 - \kappa)\tilde{P}_{Ht}^{1-\theta} + \kappa P_{Ht-1}^{1-\theta}] \tag{A6}$$

The behavior of foreign firms and the foreign good price index may be described analogously.

c) Market Clearing

Market clearing in the home good is defined as

$$Y_{Ht} = \frac{\upsilon}{2} \frac{P_{Ht}}{P_t} C_t + (1 - \frac{\upsilon}{2}) \frac{P_{Ht}}{S_t P_t^*} C_t^*. \tag{A7}$$

where $Y_{Ht} = V_t^{-1}\int_0^1 Y_{Ht}(i)di$ is aggregate home country output, defining $V_t = \int_0^1 \left(\frac{P_{Ht}(i)}{P_{Ht}}\right)^{-\theta} di$. It follows that home country employment (employment for the representative individual home household) is given by $N_t = \int_0^1 N(i)\, di = Y_{Ht}V_t$.

The aggregate market clearing condition for the foreign good as

$$Y_{Ft} = \frac{\upsilon}{2}\frac{P_{Ft}^*}{P_t^*}C_t^* + (1-\frac{\upsilon}{2})\frac{S_tP_{Ft}^*}{P_t}C_t \tag{A8}$$

and foreign employment as: $N_t^* = \int_0^1 N_t^*(i)di = Y_{Ft}V_t^*$, where $V_t^* = \int_0^1 \left(\frac{P_{Ft}^*(i)}{P_{Ft}^*}\right)^{-\theta} di.$

d) Flexible Price Equilibrium

Focus on the flexible price equilibrium $\kappa=0$ in each country, $\kappa=0$, so $P_{Ht}(i)=P_{Ht}$, $P_{Ft}(i)=P_{Ft}$, and $V_t=V_t^*=1$. Given optimal subsidies, $P_{Ht}= W_t$ and $P_{Ft}^*=W_t^*$. Then we may describe a flexible price efficient equilibrium by the equations:

$$U_C(\tilde{C}_t^*,\ \xi_t)=\tilde{T}_t^{1-\upsilon/2}\,V'(\tilde{N}_t), \qquad U_C^*(\tilde{C}_t^*,\ \xi_t^*)=\tilde{T}_t^{1-\upsilon/2}\,V'(\tilde{H}_t^*) \tag{A9}$$

$$U_C(\tilde{C}_t^*,\ \xi_t)=U_C^*(\tilde{C}_t^*,\ \xi_t^*)\,T_t^{\upsilon-1}, \tag{A10}$$

$$\tilde{N}_t = \frac{\upsilon}{2}\tilde{T}_t^{1-\upsilon/2}\tilde{C}_t + (1-\frac{\upsilon}{2})\tilde{T}_t^{\upsilon/2}\tilde{C}_t^* \tag{A11}$$

$$\tilde{N}_t^* = \frac{\upsilon}{2}\tilde{T}_t^{-(1-\upsilon/2)}\tilde{C}_t^* + (1-\frac{\upsilon}{2})\tilde{T}_t^{-\upsilon/2}\tilde{C}_t \tag{A12}$$

This implicitly describes the efficient world equilibrium for consumption, output (or employment), and the terms of trade.

Although monetary policy is entirely neutral in this setting, we can also define the nominal interest rate that is associated with an optimal global flexible price equilibrium. We assume that an optimal policy is to set inflation to zero. There is no generality lost in making this assumption, since as we see below, an optimal unconstrained monetary policy in an environment of sticky prices will also set domestic inflation rates to zero. Hence, the nominal interest rates that supports the optimal global flexible price equilibrium for the home and foreign countries are given by:[2]

$$\tilde{R}_{t+1} = \frac{1}{\beta}\frac{U_C(C_t, \xi_t)}{P_t E_t \dfrac{U_C(C_{t+1}, \xi_{t+1})}{P_{t+1}}}, \quad \tilde{R}^*_{t+1} = \frac{1}{\beta}\frac{U^*_C(C^*_t, \xi^*_t)}{P^*_t E_t \dfrac{U^*_C(C^*_{t+1}, \xi^*_{t+1})}{P^*_{t+1}}} \tag{A13}$$

In an economy with sticky prices as described below, if monetary authorities can set interest rates as in (A13) without violating the zero lower bound constraint, then a globally efficient allocation can be supported. Thus, these conditions give us the key information as to when each country's optimal monetary policy will be constrained by the zero bound on nominal interest rates.

Take a linear approximation around the globally efficient steady state. For variable X, define $\tilde{x}=\ln(\tilde{X}/\bar{X})$ to be the log difference of the global efficient value from the steady state, except for and $\tilde{\pi}_{Ht+1}$ and $\tilde{r}_t$, which refer respectively to the *level* of the inflation rate and nominal interest rate. At steady state, $T=1$. Then we may express the linear approximation of (A9)-(A13) as:

$$\sigma\tilde{c}_t - \varepsilon_t + \phi\tilde{n}_t + (1-\frac{\upsilon}{2})\tilde{\tau}_t = 0 \tag{A14}$$

$$\sigma\tilde{c}^*_t - \varepsilon^*_t + \phi\tilde{n}^*_t + (1-\frac{\upsilon}{2})\tilde{\tau}_t = 0 \tag{A15}$$

$$\tilde{n}_t = cy(\frac{\upsilon}{2}\tilde{c}_t + (1-\frac{\upsilon}{2})\tilde{c}^*_t) + cy\cdot 2\frac{\upsilon}{2}(1-\frac{\upsilon}{2})\tilde{\tau}_t \tag{A16}$$

$$\tilde{n}^*_t = cy(\frac{\upsilon}{2}\tilde{c}^*_t + (1-\frac{\upsilon}{2})\tilde{c}_t) - cy\cdot 2\frac{\upsilon}{2}(1-\frac{\upsilon}{2})\tilde{\tau}_t \tag{A17}$$

$$\sigma\tilde{c}_t - \varepsilon_t = \sigma\tilde{c}^*_t - \varepsilon^*_t + (\upsilon-1)\tilde{\tau}_t, \tag{A18}$$

where $\sigma\equiv-(U_{CC}\bar{C})/U_C$ is the inverse of the elasticity of intertemporal substitution in consumption and $\phi\equiv-(V''\bar{N})/V'$ is the elasticity of the marginal disutility of hours worked. Finally, $\varepsilon_t=U_{C\xi}/U_C\ln(\xi_t)$ is the measure

[2] These represent equilibrium values for nominal interest rates, when inflation rates are equal to zero. In order to implement this outcome, the monetary authorities must follow a rule in which the price levels in each country are determinate. Thus, the zero lower bound constraint must be satisfied even in a flexible price economy. We do not pursue the implications of the zero lower bound in this setting, because in a purely flexible price economy it would be easy for the monetary authority to satisfy the zero lower bound at any value of the real interest rate simply by letting the inflation rate adjust costlessly.

of a positive demand shock in the home country, with an equivalent definition for the foreign country.

For any variable x, define $x^W=(x+x^*)/2$ as the world average, and $x^R=(x-x^*)/2$ as the world relative in the variable. Since then $x=x^W+x^R$, we can write home and foreign consumption responses to demand shocks as:

$$\tilde{c}_t = \frac{1}{\sigma}(1-\frac{\phi c_y}{\phi+\sigma})\varepsilon_t^W + \frac{1}{\sigma}(1-\frac{\phi c_y(1-\upsilon)^2}{\Delta})\varepsilon_t^R$$

$$\tilde{c}_t^* = \frac{1}{\sigma}(1-\frac{\phi c_y}{\phi+\sigma})\varepsilon_t^W - \frac{1}{\sigma}(1-\frac{\phi c_y(1-\upsilon)^2}{\Delta})\varepsilon_t^R$$

A demand shock raises the efficient flexible price world consumption level, but the impact on individual country consumption depends on the source of the demand shock. A world demand shock will raise the flexible price level of home and foreign consumption equally, but a relative home country demand shock will raise the flexible price home consumption, while reducing the flexible price level of foreign consumption.

The impact of demand shocks on flexible price output levels are likewise written as:

$$\tilde{n}_t = \frac{c_y}{\phi+\sigma}\varepsilon_t^W + \frac{c_y(\upsilon-1)}{\Delta}\varepsilon_t^R$$

$$\tilde{n}_t^* = \frac{c_y}{\phi+\sigma}\varepsilon_t^W - \frac{c_y(\upsilon-1)}{\Delta}\varepsilon_t^R$$

A world demand shock raises equilibrium output in both countries. When there is home bias in preferences, so that $\upsilon>1$, a relative home demand shock tends to raise home output and reduce foreign output.

Demand shocks also affect the flexible price efficient response of the terms of trade. We can show that:

$$\frac{\tilde{\tau}_t}{2} = -\frac{\phi c_y(\upsilon-1)}{\Delta}\varepsilon_t^R$$

A home relative demand shock will cause a terms of trade improvement, raising the relative price of the home good.

If monetary authorities can adjust nominal interest rates freely to respond to demand shocks, then the flexible price efficient global equilibrium can be sustained. Therefore, the critical issue as regards the limits of monetary policy is the impact of the demand shock on the flexible price efficient (or 'Wicksellian') nominal interest rate. Denote $\tilde{r}_t$ as the (level of the) net nominal interest rate, and $\bar{r}$ its steady state value. The a log linear approximation of (A13) leads to the expressions for the flexible price equilibrium nominal interest rate in the home country as:

$$\tilde{r}_t = \bar{r} + \sigma E_t(\tilde{c}_{t+1} - \tilde{c}_t) - E_t(\varepsilon_{t+1} - \varepsilon_t) + E_t \tilde{\pi}_{Ht+1} + (1 - \frac{v}{2}) E_t(\tilde{\tau}_{t+1} - \tilde{\tau}_t) \quad \text{(A19)}$$

References

Auerbach, Alan, and Obstfeld, Maurice. "The Role for Open Market Operations in a Liquidity Trap." *American Economic Review* 95 (No. 1 2005): 110-37.

Beetsma, Roel, and Jensen, Henrik. "Monetary and Fiscal Policy Interactions in a Micro-Founded Model of a Monetary Union." *Journal of International Economics* 67 (No. 2 2005): 320-52.

Bodenstein, Martin, Erceg, Christopher J., and Guerrieri, Luca. The Effect of Foreign Shocks when Interest Rates Are at Zero. IFdp 983, Board of Governors of the Federal Reserve System, 2009.

Cook, David, and Devereux, Michael B. "Optimal Fiscal Policy in a World Liquidity Trap." *European Economic Review* 55 (No. 4 2011): 443-62.

Eggertson, Gauti, and Woodford, Michael. "The Zero Interest Bound and Optimal Monetary Policy." Brookings Papers on Economic Activity 34 (No. 1 2003): 139-235.

________. Optimal Monetary and Fiscal Policy in a Liquidity Trap. ISOM Annual, 2005.

Eggertsson, Gauti. What Fiscal Policy is Effective at Zero Interest Rates? FRBNY, 2009.

Engel, Charles. Currency Misalignments and Optimal Monetary Policy: A Reinvestigation. mimeo, 2010.

Fujiwara, Ippei, Sudo, Nao, and Teranishi, Yuki. "The Zero Lower Bound and Monetary Policy in a Global Economy: A Simple Analytical Investigation." *International Journal of Central Banking* 6 (No. 1 2010a): 103-32.

Fujiwara, Ippei, Nakajima, Tomoyuki, Sudo, Nao, and Teranishi, Yuki. Global Liquidity Trap. IMES Discussion Paper Series 10-E-11, Institute for Monetary and Economic Studies, Bank of Japan, 2010b.

Jeanne, Olivier. The Global Liquidity Trap. mimeo, 2009.

Krugman, Paul. "It's Baaack: Japan's Slump and the Return of the Liquidity Trap." *Brookings Papers on Economic Activity* 29 (No. 2 1998): 137-87.

Jung, Taehun, Terinishi, Yuki, and Watanabe, Tsutomo. "The Zero Bound on Nominal Interest Rates and Optimal Monetary Policy." *Journal of Money Credit and Banking* 37 (No. 5 2005): 813-35.

Park, Jae-Ha, and Lee, Sangche. "Global Financial Crisis: Background, Prospects, and Its Impacts on Korea." *Seoul Journal of Economics* 22 (No. 1 2009): 77-94.

Roel, Beetsma, and Jensen, Henrik. "Monetary and Fiscal Policy Interactions in a Micro-Founded Model of a Monetary Union." *Journal of International Economics* 67 (No. 2 2005): 320-52.

Woodford, M. "Simple Analytics of the Government Expenditure Multiplier." *American Economic Journal: Macroeconomics* 3 (No. 1 2011): 1-35.