Market Structure, Bargaining, and Covered Interest Rate Parity

Byoung-Ki Kim*

The views expressed herein are those of the author and do not necessarily reflect the official views of the Bank of Korea. When reporting or citing it, the author’s name should always be stated explicitly.


Institute for Monetary and Economic Research
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The validity of the covered interest rate parity is analyzed under an environment in which foreign banks exercise market power in the government bond and the cross-currency swap markets and bargain with domestic banks over the surplus. To do so, this paper presents a simple model that incorporates the market structure of government bond and cross-currency swap markets, and bargaining between domestic and foreign banks. The bargaining solution represents an equilibrium relationship between the government bond and cross-currency swap rates. Foreign banks' profit/surplus maximization, given the bargaining solution, generates equilibrium foreign inflows, government bond and cross-currency swap rates in the model. This paper proves that the covered interest rate parity does not hold in monopolistic or oligopolistic environments. Furthermore, this paper illustrates some comparative statics results, which may be interesting to policymakers, including the responses of equilibrium foreign inflows, government bond and cross-currency swap rates with respect to adjustments of the policy rate. This paper also traces out how these comparative statics change in magnitude as the markets are populated by more and more foreign banks so that the markets become more and more competitive. This paper shows that the equilibrium government bond and cross-currency swap rates approach the condition imposed by covered interest rate parity as the markets get more competitive, and indeed in the limit, i.e. in perfect competition, the covered interest rate parity holds under some conditions.

**Key Words:** monopoly, oligopoly, market structure, market power, cross-currency swap market, bargaining, covered interest rate parity

**JEL Classification:** F31, F32, G12, G15.
1 Introduction

A cross-currency swap contract is a transaction in which two involved parties agree to exchange a given amount of one currency for another, usually at the current spot rates for a given maturity of time.\(^1\) Within and/or at the end of the maturity, interest rate payments are exchanged as well. For example, in a Korean won/US dollar cross-currency swap transaction, the cross-currency swap receiver — who accepts US dollars for Korean won — pays floating US dollar LIBOR (London Interbank Offered Rates) and receives fixed Korean won cross-currency swap rate. Foreign banks or their branches can perform arbitrage transactions by buying domestic government bonds after borrowing US dollars from the international financial market and then going through a Korean won/US dollar cross-currency swap transaction. Figure 1 depicts a Korean won/US dollar cross-currency swap contract: the solid line represents the flow of principal while the dashed line represents the flow of interest. In this figure, USD, KRW, KTB (or TB), FX, and CRS denotes US dollar, Korean won, Korean government bond, foreign exchange, and cross-currency swap, respectively.\(^2\)

One way to derive equilibrium cross-currency swap rate is by applying the covered interest rate parity. The covered interest rate parity is a direct outcome of no-arbitrage condition, therefore, it states that the cross-currency swap rate must be equal to domestic government bond rate since the foreign banks engaged in the arbitrary transaction should end up with no surplus.\(^3\) The covered interest rate parity, however, does not tell much about foreign inflows or the interaction between government bond and cross-currency swap rates. Empirical tests on whether the covered interest rate parity holds are at best controversial. Skinner (2008) finds that the covered interest rate parity holds for triple A rated economies but not for longer maturities for emerging economies, including Brazil, Chile, Russia and South Korea. Recently, Baba and Packer (2008) report that,


\(^2\) In principle, this paper covers any bilateral cross-currency swap, which may or may not involve US dollars. For convenience, however, US dollar is designated as foreign currency.

\(^3\) Figure 1 illustrates that foreign banks receive government bond rate and LIBOR while paying cross-currency swap rate and LIBOR. Therefore, in net terms, foreign banks receive government bond rate and pays cross-currency swap rate. Section 2 contains a more detailed explanation.
affected by international financial market turbulence, sharp and persistent deviations from covered interest rate parity even between the US dollar and the euro are observed.\footnote{Of course this phenomenon is not new. Taylor (1989) reports that profitable arbitrage opportunities existed during the periods of turbulence in the past after examining Eurosterling and Eurodollar deposit rates, and US dollar/UK pound spot and forward exchange rates of various maturities. Frenkel and Levich (1977) suggest, for the study of covered interest arbitrage, to classify periods by the extent of turbulence rather than by legal and institutional arrangements of the exchange regime.} There is a large volume of literature that empirically identifies the sources causing deviations from the covered interest rate parity. These sources include political or credit risk, transactions costs, taxes, market segmentation, and information and communication technology.

In contrast, to our knowledge, there is a small literature that deals with the validity of the covered interest rate parity in theoretical perspectives. Prachony (1970) offers a revised specification of the covered interest rate parity after examining it in an environment in which there is a spread between borrowing and lending interest rates and borrowing rate rises with the amount of arbitrage funds supplied to the market. Frenkel (1973) investigates US and UK treasury markets

Figure 1: A Cross-Currency Swap Contract
to see the validity of the covered interest rate parity; he takes into account the elasticities of domestic supply of funds with respect to domestic interest rate and foreign demand for funds with respect to foreign interest rate, pointing out that if this ‘elasticity approach’ is to be taken seriously then arbitragers must have a relatively high monopoly-monopsony power.\textsuperscript{5} Blenman (1991) shows that market segmentation in the form of exchange and capital controls causes the covered interest arbitrage profits to exist. Recently, Ozdemir (2008)\textsuperscript{6} provides a theoretical and empirical analysis to explain the effects of market structure on the difference in returns to similar assets in two countries. He shows that deviations from the uncovered interest rate parity is partly attributable to the financial market power.\textsuperscript{7}

The objectives of this paper are mainly threefold. First, this paper presents a simple model that incorporates the market structure of the government bond and cross-currency swap markets, and bargaining between domestic and foreign banks. The bargaining solution yields an equilibrium relationship between government bond and cross-currency swap rates. Given this bargaining solution, foreign banks’ profit/surplus\textsuperscript{8} maximization generates equilibrium foreign inflows, government bond and cross-currency swap rates in this model. Second, this paper analyzes different forms of market structure: monopoly, oligopoly, and perfect competition. For each case, the validity of the covered interest rate parity is examined by the way of comparing the model derived equilibrium government bond and cross-currency swap rates with those that the covered interest rate parity predicts. Third, this paper provides comparative statics, which may be interesting to policy makers, including the responses of equilibrium foreign inflows, government bond and cross-currency swap rates with respect to adjustments of the policy rates, and furthermore, traces out how these comparative statics change in mag-

\textsuperscript{5}In conclusion, he casts doubts on the ‘elasticity approach.’ He seems to think the US and UK markets are unlikely to be too imperfect.

\textsuperscript{6}We find Ozdemir’s paper upon the completion of this paper.

\textsuperscript{7}As will be seen, there are many differences between his model and ours. His paper deals with the uncovered interest rate parity while ours deals with the covered interest rate parity. In his model, market power is generated by the collusion — forming a cartel — of domestic banks while in our model by finite number of foreign banks participants in the cross-currency swap market à la Cournot competition. Our model also takes into account bargaining between domestic and foreign banks, which is absent in his model.

\textsuperscript{8}Profit and surplus are interchangeable in this paper.
nitude as the markets are populated by more and more foreign banks so that the markets become more and more competitive.

From our observations, the number of foreign banks which have enough knowledge to invest in a particular emerging country is limited. If this is true, the foreign banks, exercising their market power, can maximize the surplus by limiting the supply of foreign currency in the emerging country’s swap market.

This paper is organized as follows. A simple model is described in Section 2. This model, based on a partial equilibrium approach à la Cournot competition, incorporates the market structure and bargaining between domestic and foreign banks. In Section 3, the equilibrium cross-currency swap rate is represented as a solution of bargaining between domestic and foreign banks. Foreign banks have a relative disadvantage in funding domestic currency, which forces them to share the surplus with domestic banks in the cross-currency swap market. Surplus sharing is assumed to be determined by Nash bargaining. Monopoly case is analyzed and the validity of the covered interest rate parity is examined in Section 4. With the bargaining solution in hand, monopolistic foreign bank’s surplus maximization is nicely defined and solving this problem generates equilibrium foreign inflows, government bond and cross-currency swap rates. Meanwhile, some comparative statics results — the responses of equilibrium foreign inflows, government bond and cross-currency swap rates with respect to changes of exogenous variables: bargaining power of domestic banks, foreign interest rate (LIBOR), policy rate, spot and forward exchange rates, etc. — are also provided. In Section 5, the simple model is extended into an oligopolistic environment and shows that equilibrium government bond and cross-currency swap rates approach the no-arbitrage condition as the market structure becomes more and more competitive under some regularity conditions. Additional comparative statics results generated by the new exogenous variable, number of foreign banks in cross-currency swap market are provided as well. We conclude with some discussions in Section 6.

2 Model

Before describing the model in more detail, we present some symbols used in this paper. $TB$ and $CRS$ represents government bond interest rate and cross-
currency swap rate, respectively. \( LBR \) indicates LIBOR. \( s_0 \) and \( f \) denotes spot exchange rate, the unit of domestic currency per unit of foreign currency, and forward exchange rate, respectively. \( q \) indicates the amount of funds in US dollar that foreign banks supply in the cross-currency swap market.\(^9\)

Two domestic markets are covered in this paper: government bond market and cross-currency swap market.\(^10\) Foreign banks borrow in international financial market at LIBOR and invest in domestic government bond by financing domestic currency through cross-currency swap contracts with domestic banks.\(^11\) Domestic and foreign banks have relative advantages on raising domestic currency denominated debt and US dollar denominated debt, respectively. Therefore, foreign banks must bargain with domestic banks to materialize any surplus in the domestic markets. The surplus is divided by (generalized) Nash bargaining. Domestic banks cannot borrow from the international financial market.\(^12\) All the

\(^9\)In spite of the risk of misunderstanding, \( q \) is called ‘foreign inflows’ in this paper.
\(^10\)A discussion is provided in Section 6 about including spot and forward exchange markets into the analysis.
\(^11\)Branches of foreign banks can do the same thing — borrowing US dollars from the head office which can tap in the international financial market at LIBOR.
\(^12\)This implies that the outside option for domestic banks is zero profit. See next section for details.
domestic banks are homogenous and all the foreign banks are homogeneous.

There are two periods: period 0 and period 1. In period 0, as depicted in Figure 2, domestic banks make forward contracts with exporters, and cross-currency swap contracts with foreign banks. Foreign banks borrow foreign currency from the international financial market at LIBOR and make cross-currency swap contracts with domestic banks. Foreign banks also buy domestic government bonds using domestic currency raised through cross-currency swap contracts. In period 1, as illustrated in Figure 3, all the forward and cross-currency swap contracts are carried out and settled. Domestic banks execute the forward contracts with exporters and the cross-currency swap contracts with foreign banks. Domestic government bonds mature and foreign banks return their international financial market borrowings with interests. It is important to stress that ‘capital gains’ are not considered in this paper; all bonds are held to full maturity. There is no uncertainty in our model. In Figures 2 and 3, $ denotes that it is US dollar denominated and W with a horizontally penetrating solid line denotes that it is domestic currency denominated while KTB denotes domestic government bond.\textsuperscript{13}

\textsuperscript{13}Actually, W with a horizontally penetrating solid line denotes Korean won. It should be stressed, however, that this designated country can be any country in which US dollar is not circulated as a legal tender.
A critical assumption here is that the government bond rate is a function of foreign inflows; as foreign inflows increase (decrease), government bond rate decreases (increases). In this environment, we study the determination of equilibrium government bond and cross-currency swap rates when foreign banks maximize their profit/surplus by exercising monopolist or oligopolists market power in the cross-currency swap market.

3 Individual Rationality Conditions and Bargaining Solutions

Consider the surpluses, which might or might not be zero depending on the market structure or even some other things outside this model, of domestic banks and foreign banks in period 1 when they make a cross-currency swap contract of $q$ in period 0.

\[
(1 + CRS)s_0 \cdot q - (1 + LBR)f \cdot q \geq 0. \tag{1}
\]

\[
(1 + TB)s_0 \cdot q - (1 + CRS)s_0 \cdot q \geq 0. \tag{2}
\]

Equation (1) represents the surplus of domestic banks in terms of domestic currency while Equation (2) the surplus of foreign banks in domestic currency.

First, note that the covered interest rate parity states that both Equations (1) and (2) should be zero. In other words, at the end of the maturity, domestic banks receive cross-currency swap rate together with the principal in domestic currency and pay US dollar LIBOR together with the US dollar principal. Changing these into the domestic currency terms, we get Equation (1) and the covered interest rate parity states that Equation (1) should hold with equality. The same result

\[14\] Bank of Korea, in its biannually published Monetary Policy Reports, frequently attributes the changes of government bond rates to transactions of foreign banks in the government bond futures and spot markets. See Chapter 1, Section 3 of 2007 or 2008 issues of Bank of Korea’s Monetary Policy Report. Even the US treasury bond rates are not free from the behavior of foreign investors. The former US Federal Reserve Chairman Alan Greenspan said “In particular, heavy purchases of longer-term Treasury securities by foreign central banks have often been cited as a factor boosting bond prices and pulling down longer-term yields” in his testimony before the Committee on Financial Services, US House of Representatives, on Feb 17, 2005.

\[15\] Note that foreign inflows, $q$, are in terms of US dollars.
can be derived in the foreign banks’ point of view. Equation (2) states that the foreign banks receive government bond rate together with the principal while paying the same fixed cross-currency swap rate also with the principal, both in terms of domestic currency at the end of the maturity, which should be zero according to the covered interest rate parity.\(^\text{16}\) Summing up, the covered interest rate parity implies \((1 + TB)s_0 \cdot q = (1 + CRS)s_0 \cdot q = (1 + LBR)f \cdot q\).

Second, given the surpluses of domestic and foreign banks, as in Equations (1) and (2) we can impose individual rationality conditions such that domestic and foreign banks should get non-negative net surpluses from a cross-currency swap contract. In particular, domestic and foreign banks will not be interested in making a cross-currency swap contract if the surplus from the contract is negative.

Third, outside options for domestic and foreign banks are assumed to be zero profits. That is, if cross-currency swap transactions are not in place, domestic and foreign banks get zero surplus. This can be unrealistic in the sense that domestic banks can tap in the international financial market if they are willing to pay additional interest rates while foreign banks can use spot and forward foreign exchange markets to convert their US dollar funds into Korean won funds and vice versa. Outside options will be discussed briefly in Section 6.

Fourth, Equations (1) and (2) together state that the total surplus from a cross-currency swap contract should be non-negative. That is,

\[
(1 + TB)s_0 \cdot q - (1 + LBR)f \cdot q \geq 0. \tag{3}
\]

Fifth, we assume that bargaining power of domestic banks is \(\theta\) while that of foreign banks is \(1 - \theta\). The bargaining power, \(\theta \in [0, 1]\), can be thought as a market convention. Suppose that there are \(m \geq 1\) domestic banks and \(n \geq 1\) foreign banks in the cross-currency swap market. Let \(S\) denote total surplus from all of the cross-currency swap contracts between domestic and foreign banks. \(\theta\) is treated as being fixed regardless of \(n\) or \(m\) so that all the domestic and foreign banks get \(\theta S\) and \((1 - \theta)S\). That is, if there is only one foreign bank it will take

\(^{16}\)Note that foreign banks neutralize the inflow and outflow of fund in terms of foreign currency, US dollar. If the foreign banks buy credit default swap for the Korean government bonds, this should be considered as a cost for the foreign banks so that equation (2) changes to \((1 + TB - CDS)s_0 \cdot q - (1 + CRS)s_0 \cdot q\), where \(CDS\) denotes credit default swap rate. Below we assume \(CDS = 0\). This assumption is innocuous in deriving our results.
all the surpluses \((1 - \theta)S\) and if there are \(n\) foreign banks each of them will get \(\frac{(1-\theta)}{n}S\), \(n = 1, 2, 3, \cdots\) since they are all homogeneous. In the following we set \(m = 1\) since domestic banks are passive in the sense that foreign banks determine the foreign inflows.\(^{17}\)

Now equilibrium cross-currency swap rate can be derived from the generalized Nash bargaining solution of surplus sharing between the domestic and foreign banks as presented in the following lemma. Note that the solution is derived by a backward induction. When cross-currency swap rate \((CRS)\) is calculated, all other variables, including government bond rate \((TB)\) should be treated as being fixed.

**Lemma 1** In equilibrium, cross-currency swap rate, \(CRS\), is determined by the following equation:

\[
1 + CRS = \theta(1 + TB) + (1 - \theta)(1 + LBR) \frac{f}{s_0}.
\]

\(^{(4)}\)

**Proof.** First, we prove the lemma for the case in which there are one foreign bank and one domestic bank. Note that the total surplus from cross-currency swap contract of \(q\) is \((1 + TB)s_0 \cdot q - (1 + LBR)f \cdot q\) and that surplus and total surplus from no contract are zero for both domestic and foreign bank. Therefore, domestic bank with bargaining power \(\theta\) should enjoy the following surplus:

\[
(1 + CRS)s_0 \cdot q - (1 + LBR)f \cdot q = \theta [(1 + TB)s_0 \cdot q - (1 + LBR)f \cdot q].
\]

On the other hand, foreign bank with bargaining power \(1 - \theta\) should enjoy the following surplus:

\[
(1 + TB)s_0 \cdot q - (1 + CRS)s_0 \cdot q = (1 - \theta) [(1 + TB)s_0 \cdot q - (1 + LBR)f \cdot q].
\]

The above two equations yield the exactly same solution as presented in Equation (4).

Next, suppose that there are \(n\) homogeneous foreign banks. Since the share \(1 - \theta\) for foreign banks is fixed and all the foreign banks are homogenous, each

\(^{17}\)Given that the bargaining power is independent of the number of domestic or foreign banks, this assumption is innocuous. Setting the number of domestic banks to any finite number will not change our results since, in this paper, the foreign banks determine the equilibrium foreign inflows.
foreign bank $i$ gets the following:

$$(1 + TB)s_0 \cdot q_i - (1 + CRS)s_0 \cdot q_i = \frac{(1 - \theta)}{n} [(1 + TB)s_0 \cdot q - (1 + LBR)f \cdot q],$$

where $q = \sum_{i=1}^{n} q_i, i = 1, 2, \cdots, n$. Adding up for $i$ yields the previously covered case in which there is one foreign bank. Hence the result follows. ■

Note Lemma 1 states that this bargaining solution, which drives equilibrium cross-currency swap rate, can be used regardless of the number of foreign banks in the cross-currency swap market.

4 Analysis of Monopoly Case

With the bargaining solution in hand, it is time to consider the optimization problem of the foreign banks. For a while, assume that there is only one foreign bank which is interested in the designated cross-currency swap market. As emphasized before, this designated market can be of any nation except the US. The foreign bank is in the status of monopoly in supplying the US dollars into the designated swap market. Therefore, it will exploit this monopoly status by maximizing the surplus given that it should divide the surplus with the domestic bank. Formally, the monopolistic foreign bank’s optimization problem\textsuperscript{18} can be represented as the following:

$$\max_{q} [TB - CRS]q.$$  \hspace{1cm} (5)

The foreign bank maximizes the surplus as in Equation (2). By Lemma 1, $CRS = \theta TB + (1 - \theta) \left[ (1 + LBR) \frac{f}{s_0} - 1 \right]$. Therefore, $TB - CRS = (1 - \theta) \left[ 1 + TB - (1 + LBR) \frac{f}{s_0} \right]$. This indicates that Equation (5) can be re-written as equation (6).

$$\max_{q} (1 - \theta) \left[ 1 + TB - (1 + LBR) \frac{f}{s_0} \right] q.$$ \hspace{1cm} (6)

Before presenting and discussing the first order conditions, we make some assumptions on $TB, LBR, s_0$ and $f$ with regard to $q$. These assumptions follow the standard simple assumptions that can be found in the standard analysis of monopoly and oligopoly market structures.\textsuperscript{19}

\textsuperscript{18}The foreign bank maximizes US dollar denominated surplus.

\textsuperscript{19}For example, Jean Tirole (1988).
Assumption 1  
1. Government bond rate, $TB$, is a linear function of foreign inflows $q$, while spot and forward exchange rates $s_0$ and $f$, LIBOR $LBR$, and bargaining power $\theta$ are independent of $q$.

$$TB(q) = TB_N - k \cdot s_0 \cdot q,$$

where $k > 0$ and $TB(q) = 0$ if $q \geq \frac{TB_N}{k \cdot s_0}$.

2. The maximum amount of foreign inflows, $\bar{q}$, is restricted to $\frac{TB_N}{k \cdot s_0}$.

3. Further, the following inequality holds:

$$(1 + TB_N) - (1 + LBR) \frac{f}{s_0} > 0.$$ 

Note that $TB_N$ can be regarded as the ‘neutral’ government bond rate when there are no foreign inflows ($q = 0$). Further we assume that $TB_N$ is directly controlled by the policy rate. $^20$ $k$ measures the intensity of the effect of foreign bank’s demand on the domestic government bond rate, in domestic currency. Assumption 1 reflects that the designated country is a small open economy and that the foreign bank, although being a monopolist in the domestic market, faces the perfectly competitive environment in the international financial market. Note that the bargaining power $\theta$ is also independent of how much US dollars the foreign bank provide in the cross-currency swap market, $q$. One may think it too restrictive that the spot and forward exchange rates, $s_0$ and $f$, are independent of $q$. A discussion regarding this problem appears in Section 6.

The second assumption of the maximum amount of foreign inflows being restricted to $\bar{q} = \frac{TB_N}{k \cdot s_0}$ reflects that the foreign investments in domestic government bond cannot be too large so that the government bond rate approaches zero in practice. Without this assumption, optimal foreign inflows can be infinite. If optimal foreign inflows are $\bar{q}$ then government bond rate is zero and cross-currency swap rate is negative. $^21$ Given this, increasing additional foreign inflows will not further lower the government bond rate, and in turn will not change the cross-currency swap rate according to Lemma 1. Hence, the foreign bank increases foreign inflows indefinitely.

$^20$ That is, if the central bank hikes the policy rate by, say, 25 basis points then $TB_N$ increases by the exact amount.

$^21$ See Proposition 1 and numerical examples presented below.
Further, if the $TB$ function is given as in Assumption 1, foreign inflows are strictly positive only if $(1 + TB_N) - (1 + LBR)\frac{f}{s_0} > 0$. This inequality is also assumed to hold to restrict our attention to interesting cases only.\(^\text{22}\)

In addition, note that the $TB$ function is kinked at $q = \frac{TB_N}{k \cdot s_0}$. Unfortunately, there is no reason that the solution — that is, derived $q^*$ — should be less than $\frac{TB_N}{k \cdot s_0}$.\(^\text{23}\) A definition below clarifies these cases.

**Definition 1** The constraint, $\frac{TB_N}{k \cdot s_0}$, is said to be binding (not binding) if

$$\frac{1}{2k \cdot s_0} \left[ 1 + TB_N - (1 + LBR)\frac{f}{s_0} \right] > \frac{TB_N}{k \cdot s_0}.$$ 

The constraint, $\frac{TB_N}{k \cdot s_0}$, is said to be just binding if

$$\frac{1}{2k \cdot s_0} \left[ 1 + TB_N - (1 + LBR)\frac{f}{s_0} \right] = \frac{TB_N}{k \cdot s_0}.$$ 

Under Assumption 1, we can derive the unique optimal solution $q^*$ which maximizes the monopolistic foreign bank’s surplus. Further, this solution also gives equilibrium government bond rate and equilibrium cross-currency swap rate as presented in the proposition below.

**Proposition 1** Suppose that monopolistic foreign bank in the cross-currency swap market shares surplus with the domestic bank as stated in Lemma 1, and that the monopolistic foreign bank’s optimization problem can be represented by Equation (6). Suppose further that Assumption 1 is satisfied. If the constraint is not binding, equilibrium foreign inflows $q^*$, government bond rate $TB^*$, and cross-currency swap rate $CRS^*$ are:

$$q^* = \frac{1}{2k \cdot s_0} \left[ 1 + TB_N - (1 + LBR)\frac{f}{s_0} \right] \quad (7)$$

$$1 + TB^* = \frac{1}{2} (1 + TB_N) + \frac{1}{2} (1 + LBR)\frac{f}{s_0} \quad (8)$$

$$1 + CRS^* = \frac{\theta}{2} (1 + TB_N) + \left( 1 - \frac{\theta}{2} \right) (1 + LBR)\frac{f}{s_0}. \quad (9)$$

\(^{22}\) The original existence of the surplus when $q = 0$ can be caused by any reason that is generated outside the model. Our ‘partial’ model will show that if there were a deviation from the covered interest rate parity, it would not disappear in the monopolistic market structure.

\(^{23}\) This is in sharp contrast with the result of textbook Cournot competition models with linear inverse demand in which interior solution is generally achieved.
If the constraint is binding, equilibrium foreign inflows $q^*$, government bond rate $TB^*$, and cross-currency swap rate $CRS^*$ are:

\[
q^* = \frac{TB_N}{k \cdot s_0} \quad (10)
\]

\[
1 + TB^* = 1 \quad (11)
\]

\[
1 + CRS^* = \theta + (1 - \theta)(1 + LBR) \frac{f}{s_0}. \quad (12)
\]

If the constraint is just binding, all the Equations (7) - (12) hold.

Proof. Suppose the constraint is not binding. Then, under Assumption 1, Equation (6) is equivalent to the following:

\[
\max_q (1 - \theta) \left[ 1 + TB_N - k \cdot s_0 \cdot q - (1 + LBR) \frac{f}{s_0} \right] q.
\]

First order condition of the above equation with respect to $q$ yields

\[
1 + TB_N - (1 + LBR) \frac{f}{s_0} - 2k \cdot s_0 \cdot q^* = 0.
\]

Rearranging the above equation with respect to $q^*$ gives the solution in Equation (7).

Given $q^*$, $TB^* = TB_N - k \cdot s_0 \cdot q^*$ from Assumption 1 yields Equation (8) In particular, if $q^*$ is given as in Equation (7),

\[
TB^* = TB_N - k \cdot s_0 \cdot q^*
\]

\[
= TB_N - k \cdot s_0 \cdot \frac{1}{2k \cdot s_0} \left[ 1 + TB_N - (1 + LBR) \frac{f}{s_0} \right]
\]

\[
= \frac{1}{2} (1 + TB_N) + \frac{1}{2} (1 + LBR) \frac{f}{s_0} - 1.
\]

By Equation (4) in Lemma 1, $CRS^*$ can be directly derived from $TB^*$ as follows.

\[
1 + CRS^* = \theta (1 + TB^*) + (1 - \theta) \left[ (1 + LBR) \frac{f}{s_0} \right]
\]

\[
= \theta \left[ \frac{1}{2} (1 + TB_N) + \frac{1}{2} (1 + LBR) \frac{f}{s_0} \right] + (1 - \theta) \left[ (1 + LBR) \frac{f}{s_0} \right]
\]

\[
= \theta \frac{1}{2} (1 + TB_N) + \left( 1 - \frac{\theta}{2} \right) (1 + LBR) \frac{f}{s_0}.
\]

13
If the constraint is binding, \( q^* = \frac{TB_N}{k \cdot s_0} \) by definition. Then \( TB^* = TB_N - k \cdot s_0 \cdot q^* \) from Assumption 1 and \( 1 + CRS^* = \theta(1 + TB^*) + (1 - \theta) \left[(1 + LBR)\frac{L}{s_0}\right] \) from Equation (4) in Lemma 1 drives the results.

If the constraint is just binding, \( q^* = \frac{1}{2k \cdot s_0} \left[1 + TB_N - (1 + LBR)\frac{L}{s_0}\right] = \frac{TB_N}{k \cdot s_0} \) by definition, which yields \( 1 - TB_N - (1 + LBR)\frac{L}{s_0} = 0 \). The latter equation proves the equivalence of Equations (8) and (11), and Equations (9) and (12).

Note that the equilibrium forward purchase of the domestic bank from domestic exporters, \((1 + LBR)q^*\), is \( \frac{1 + LBR}{2k \cdot s_0} \left[1 + TB_N - (1 + LBR)\frac{L}{s_0}\right] \) if the constraint is not binding, whereas it turns out to be \( (1 + LBR)\frac{TB_N}{k \cdot s_0} \) with binding constraint.

Further, according to Proposition 1, the monopolistic foreign bank enjoys, in the US dollar terms, \( \frac{1}{2}(1 - \theta) \left[(1 + TB_N - (1 + LBR)\frac{L}{s_0})\right] \) per each unit of \( q^* \) if the constraint is not binding while the monopolist extracts \( (1 - \theta) \left[1 - (1 + LBR)\frac{L}{s_0}\right] \) per each unit of \( q^* \) if the constraint is binding. In line with these, the foreign bank’s maximized surplus, \([TB^* - CRS^*]q^*\), is \( \frac{1 - \theta}{2k \cdot s_0} \left[1 + TB_N - (1 + LBR)\frac{L}{s_0}\right] \) if the constraint is not binding, and \( \frac{(1 - \theta)TB_N}{k \cdot s_0} \left[1 + TB_N - (1 + LBR)\frac{L}{s_0}\right] \) if binding.

The fact that the monopolistic foreign bank is enjoying surplus implies that the covered interest rate parity does not hold in this environment, which is summarized in the following lemma.

**Lemma 2** Suppose that there is a monopolistic foreign bank in the cross-currency swap market. Suppose, further, that all the conditions in Proposition 1 are satisfied. Then the covered interest rate parity does not hold.

**Proof.** Recall that the covered interest rate parity implies \( 1 + TB^* = 1 + CRS^* = (1 + LBR)\frac{L}{s_0} \). Suppose the constraint is not binding. Then from Proposition 1,

\[
1 + TB^* = \frac{1}{2} \left[1 + TB_N - (1 + LBR)\frac{L}{s_0}\right] + (1 + LBR)\frac{L}{s_0} > (1 + LBR)\frac{L}{s_0}.
\]

The last inequality follows from Assumption 1. Therefore the covered interest rate parity, which states that \( 1 + TB^* = (1 + LBR)\frac{L}{s_0} \) does not hold.

In case the constraint is binding, again from Proposition 1,

\[
1 + TB^* = 1 > (1 + LBR)\frac{L}{s_0}
\]
The last inequality follows from the fact that the constraint is binding only if \[ 1 - \left( 1 + LBR \right) \frac{f_s}{s_0} > 0. \] Otherwise, the foreign bank is running a deficit at \( q^* = \frac{TB_N}{k \cdot s_0} \), which implies that the foreign bank can do better by setting \( q^* = 0 \) so that the constraint cannot be binding. Therefore, the result follows.

If the constraint is just binding, \( 1 - TB_N - (1 + LBR) \frac{f_s}{s_0} = 0 \) by definition. Then, proof for the cases, either binding or not, can be used to show the result.

In case the constraint is not binding, \( TB^* - CRS^* = \frac{1}{2} (1 - \theta) \left[ 1 + TB_N - (1 + LBR) \frac{f_s}{s_0} \right] \). This is strictly positive according to Assumption 1 unless \( \theta = 1 \). Even if \( \theta = 1 \), it means \( 1 + TB^* = 1 + CRS^* \neq (1 + LBR)f s_0 \). This is a case in which the domestic bank gets all the positive surplus. The covered interest rate parity demands that the surplus should be zero. In general case with \( \theta \in (0, 1) \), both the domestic bank and the foreign bank enjoy positive surpluses. The monopolistic foreign bank, exercising its market power, maximizes the surplus by limiting the supply of foreign currency in the swap market.

### Table 1: Numerical Examples

<table>
<thead>
<tr>
<th>( f )</th>
<th>( q^* )</th>
<th>( TB^* )</th>
<th>( CRS^* )</th>
<th>Unit Surplus( \dagger )</th>
<th>Surplus( \ddagger )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.90</td>
<td>50.00</td>
<td>0.0000</td>
<td>-0.0365</td>
<td>0.0365</td>
<td>1.8250</td>
</tr>
<tr>
<td>0.95</td>
<td>35.75</td>
<td>0.0142</td>
<td>-0.0036</td>
<td>0.0179</td>
<td>0.6390</td>
</tr>
<tr>
<td>1.00</td>
<td>10.00</td>
<td>0.0400</td>
<td>0.0350</td>
<td>0.0050</td>
<td>0.0500</td>
</tr>
<tr>
<td>1.05</td>
<td>0.00</td>
<td>0.0500</td>
<td>0.0658</td>
<td>-0.0158</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

Note: Exogenous variables are set as follows. \( TB_N = 0.05 \), \( LBR = 0.03 \), \( s_0 = 1.0 \), \( k = 0.001 \), and \( \theta = 0.5 \).

\( \dagger \) Calculated by \( TB^* - CRS^* \).

\( \ddagger \) Calculated by Unit Surplus \( \times q^* \).

For a reference, numerical examples are provided in Table 1. Note, in Table 1, ‘Unit Surplus’ indicates the foreign bank’s surplus per each unit of \( q^* \), and ‘Surplus’ shows the foreign bank’s total surplus generated by supplying \( q^* \) to the cross-currency swap market. The first row shows the case in which the constraint is binding. Notice that equilibrium government bond rate is zero while the cross-currency swap rate is negative. The second row is interesting in the sense that equilibrium government bond rate is positive while the cross-currency swap rate
is still negative. The third row may represent the most common situation. The equilibrium government bond rate is a little bit low compared to neutral government bond rate $TB_N$ because of positive foreign inflows, and cross-currency swap rate is positive and lower than government bond rate so that the foreign bank enjoys surplus. The fourth row demonstrates the case in which individual rationality conditions are violated, and therefore, surplus per unit of foreign inflows is negative.

Since Proposition 1 presents the equilibrium foreign inflows ($q^*$), government bond and cross-currency swap rates ($TB^*$ and $CRS^*$) in terms of exogenous variables such as neutral government bond rate ($TB_N$), LIBOR ($LBR$), spot and forward exchange rates ($s_o$ and $f$), and bargaining power ($\theta$), etc., comparative statics can be derived. The results for the case in which the constraint $\frac{TB_N}{k \cdot s_0}$ is not binding are provided in the following lemma.

**Lemma 3** Suppose that the constraint is not binding and that the changes in exogenous variables are small enough in the sense that the constraint is still not binding after the changes of exogenous variables. Then the equilibrium foreign inflows $q^*$, government bond rate $TB^*$, and cross-currency swap rate $CRS^*$ respond to the changes of exogenous variables as follows.

1. If the domestic bank’s bargaining power, $\theta$ increases, then foreign inflows and government bond rate are not affected but cross-currency swap rate increases.

2. If LIBOR, $LBR$ goes up, then foreign inflows decrease while government bond and cross-currency swap rates increase such that (i) the government bond rate increases less than LIBOR provided $2s_0 > f$, (ii) the cross-currency swap rate increases more than the government bond rate provided $\theta \neq 1$.

3. If the intensity of the effect of foreign bank’s demand on the domestic government bond rate, $k$, increases, then foreign inflows decrease while government bond and cross-currency swap rates are not affected.

Indeed, in South Korea, one year cross-currency (Korean won/US dollar) swap rate closed negative many times on daily basis during October 2008 - January 2009 influenced by international financial market turmoil.
4. If the policy rate, $TB_N$, is raised, then foreign inflows increase, and government bond and cross-currency swap rates increase such that (i) the government bond rate increases less than the policy rate, (ii) the government bond rate increases more than the cross-currency swap rate provided $\theta \neq 1$.

5. If spot foreign exchange rate, $s_0$ increases, then foreign inflows increase provided that $1 + TB_N < 2(1 + LBR)\frac{L}{s_0}$, government bond and cross-currency rates decrease such that the cross-currency swap rate decreases more than then government bond rate provided $\theta \neq 1$.

6. If forward foreign exchange rate, $f$ increases, then foreign inflows decrease, government bond and cross-currency rates increase such that the cross-currency swap rate increases more than then government bond rate provided $\theta \neq 1$.

Proof. For the first part, note $\frac{\partial q^*}{\partial \theta} = \frac{\partial TB^*}{\partial \theta} = 0$, and $\frac{\partial CRS^*}{\partial \theta} = \frac{1}{2}\left[1 + TB_N - (1 + LBR)\frac{L}{s_0}\right] > 0$ by Assumption 1.

For the second part, $\frac{\partial q^*}{\partial LBR} = -\frac{1}{2k}\frac{1}{s_0} f < 0$, $\frac{\partial TB^*}{\partial LBR} = \frac{L}{2s_0} > 0$, $\frac{\partial CRS^*}{\partial LBR} = \frac{f}{2s_0}(2 - \theta) > 0$. Note $\frac{\partial TB^*}{\partial LBR} = \frac{L}{2s_0} < 1$ provided $2s_0 > f$, and $\frac{\partial TB^*}{\partial LBR} < \frac{\partial CRS^*}{\partial LBR}$ if $\theta \neq 1$.

For the third part, $\frac{\partial q^*}{\partial k} = -\frac{1}{2k}\frac{1}{s_0} \left[1 + TB_N - (1 + LBR)\frac{L}{s_0}\right] < 0$, and $\frac{\partial TB^*}{\partial k} = \frac{1}{2}\frac{1}{s_0} > 0$.

For the fourth part, $\frac{\partial TB^*}{\partial s_0} = \frac{1}{2k} > 0$, $\frac{\partial TB^*}{\partial s_0} = \frac{1}{2} > 0$, and $\frac{\partial CRS^*}{\partial s_0} = \frac{\theta}{2} > 0$. Note $1 > \frac{\partial TB^*}{\partial s_0} > \frac{\partial CRS^*}{\partial s_0} > 0$ if $\theta \in (0, 1)$, $1 > \frac{\partial TB^*}{\partial s_0} = \frac{\partial CRS^*}{\partial s_0} > 0$ if $\theta = 1$, and $1 > \frac{\partial TB^*}{\partial s_0} > \frac{\partial CRS^*}{\partial s_0} = 0$ if $\theta = 0$.

For the fifth part, $\frac{\partial q^*}{\partial s_0} = -\frac{1}{2k}\frac{1}{s_0} \left[1 + TB_N - 2(1 + LBR)\frac{L}{s_0}\right] > 0$ provided $1 + TB_N < 2(1 + LBR)\frac{L}{s_0}$. Note $\frac{\partial TB^*}{\partial s_0} = -\frac{1}{2}(1 + LBR)\frac{L}{s_0} < 0$, and $\frac{\partial CRS^*}{\partial s_0} = \left(1 - \frac{\theta}{2}\right)(1 + LBR)\frac{L}{s_0}$.

For the sixth part, $\frac{\partial q^*}{\partial f} = -\frac{1}{2k}\frac{1}{s_0} \left((1 + LBR)\frac{L}{s_0}, \frac{\partial TB^*}{\partial f} = \frac{1}{2}(1 + LBR)\frac{L}{s_0}$, and $\frac{\partial CRS^*}{\partial f} = \left(1 - \frac{\theta}{2}\right)(1 + LBR)\frac{L}{s_0}$.]

The first part of Lemma 3 reflects that the foreign bank actually maximizes the surplus without considering its bargaining power. The first order condition does not show bargaining power-related terms. Hence the equilibrium foreign inflows and, in turn, the government bond rate are not responding to the changes.
of bargaining power. However, the equilibrium cross-currency swap rate is dependent on bargaining power. If domestic bank’s bargaining power grows then the foreign bank should pay a higher cross-currency swap rate so that the latter’s share of total surplus shrinks. Lemma 3 also tells, in the second part, that a rise of LIBOR reduces foreign inflows and in turn raises the government bond and cross-currency swap rates. In normal circumstances in which $2s_0 > f$ and $\theta \neq 1$, the effect of foreign interest rate hike on the government bond rate is damped down while the effect on the cross-currency swap rate might not be damped down that much. If the intensity of the effect of foreign bank’s demand on the domestic government bond rate, $k$, increases, the third part of Lemma 3 indicates, foreign inflows decrease by the exact amounts to neutralize the decrease on the government bond and cross-currency swap rates so that the original rates are restored. Further, Lemma 3 demonstrates in the fourth part that, with the monopolistic cross-currency swap market, the interest rate-oriented monetary policy, that is adjusting the policy rate, is still effective while the effectiveness reduces to half a level. It would be worthwhile to see changes of the effectiveness as the number of foreign banks in the market increases.\textsuperscript{25} In addition, In the fifth and sixth part, Lemma 3 illustrates that, in normal circumstances,\textsuperscript{26} if spot exchange rate increases — i.e. the foreign currency gets more valuable with respect to domestic currency — foreign inflows increase since surplus per foreign inflows, $TB^* - CRS^*$, increases.\textsuperscript{27} Similarly, if forward foreign exchange rate increases then foreign inflows decrease due to the reduction of surplus per foreign inflows, $TB^* - CRS^*$.

The following lemma presents the comparative statics for the case in which the constraint is binding. Note that the foreign inflows are not affected since the constraint is assumed to be binding after the changes of exogenous variables.

**Lemma 4** Suppose that the constraint is binding and that the changes in exogenous variables are small enough in the sense that the constraint is still binding after the changes of exogenous variables. Then government bond rate $TB^*$, and cross-currency swap rate $CRS^*$ respond to the changes of exogenous variables as

\textsuperscript{25}The result is presented in Section 5.

\textsuperscript{26}$1 + TB_N < 2(1 + LBR)\frac{s_0}{f}$ should be satisfied in normal circumstances. Note that if $f = s_0$ and $LBR > 0$ then $TB_N > 1 = 100\%$ is necessary for the condition to be violated.

\textsuperscript{27}Note that the cross-currency swap rate decreases more than the government bond rate.
1. If the domestic bank’s bargaining power, \( \theta \) increases, then government bond rate is not affected but cross-currency swap rate increases.

2. If LIBOR, \( LBR \) goes up, then government bond rate is not affected while cross-currency swap rate increases.

3. If the intensity of the effect of foreign bank’s demand on the domestic government bond rate, \( k \), increases, then government bond and cross-currency swap rates are not affected.

4. If the policy rate, \( TB_N \), increases, then government bond and cross-currency swap rates are not affected.

5. If spot foreign exchange rate, \( s_0 \) increases, then government bond rate is not affected, and cross-currency rate decreases provided \( \theta \neq 1 \).

6. If forward foreign exchange rate, \( f \) increases, then government bond rate is not affected, and cross-currency rate increases provided \( \theta \neq 1 \).

**Proof.** For the first part, \( \frac{\partial TB^*}{\partial \theta} = 0 \), and \( \frac{\partial CRS^*}{\partial \theta} = 1 - (1 + LBR) \frac{L}{s_0} > 0 \). The last inequality follows from individual rationality conditions.

For the second part, \( \frac{\partial TB^*}{\partial LBR} = 0, \frac{\partial CRS^*}{\partial LBR} = \frac{L}{s_0} (1 - \theta) > 0 \).

For the third part, \( \frac{\partial TB^*}{\partial k} = \frac{\partial CRS^*}{\partial k} = 0 \).

For the fourth part, \( \frac{\partial TB^*}{\partial TB_N} = \frac{\partial CRS^*}{\partial TB_N} = 0 \).

For the fifth part, \( \frac{\partial TB^*}{\partial s_0} = 0 \), and \( \frac{\partial CRS^*}{\partial s_0} = -(1 - \theta)(1 + LBR) \frac{L}{s_0} < 0 \) provided \( \theta \neq 1 \).

For the sixth part, \( \frac{\partial TB^*}{\partial f} = 0 \), and \( \frac{\partial CRS^*}{\partial f} = (1 - \theta)(1 + LBR) \frac{L}{s_0} > 0 \) provided \( \theta \neq 1 \).

In case the constraint is binding, according to partial derivatives, equilibrium foreign inflows should decrease if, for example, there is a rise in the intensity \( k \), or in spot foreign exchange rate \( s_0 \). The equilibrium foreign inflows should be fixed at \( \frac{TB_N}{k s_0} \) because of the binding constraint. This indicates that the assumption in the Lemma 4 that the constraint is still binding after the changes of exogenous variables plays important role. This binding case, however, is not interesting as
much as the not binding case. As mentioned earlier in the explanation of Assumption 1, this binding case, to our knowledge, is very hard to observe in practice. As such, the comparative statics for just binding case or binding from/to not binding case are omitted. Intuitively, it is a problem of applying the appropriate parts of Lemmas 3 and 4.

5 Extension to Oligopoly Cases

In this section, we extend our model into an oligopolistic environment. Now suppose there exist homogeneous \( n \) foreign banks in the domestic cross-currency swap market and let \( q_i, i = \{1, 2, \ldots, n\} \) denote the amount of foreign inflows foreign bank \( i \) provides in the cross-currency swap market.

If we define \( q \equiv \sum_{i=1}^{n} q_i \), Assumption 1 can be used without any change while Definition 1 needs a slight change as follows.

**Definition 2** Suppose that there are \( n \in \{1, 2, 3, \ldots\} \) foreign banks in the cross-currency swap market. The constraint, \( \frac{TB_N}{k \cdot s_0} \), is said to be binding (not binding) if

\[
\frac{n}{(n + 1)k \cdot s_0} \left[ 1 + TB_N - (1 + LBR) \frac{f}{s_0} \right] > \frac{TB_N}{k \cdot s_0}. 
\]

The constraint, \( \frac{TB_N}{k \cdot s_0} \), is said to be just binding if

\[
\frac{n}{(n + 1)k \cdot s_0} \left[ 1 + TB_N - (1 + LBR) \frac{f}{s_0} \right] = \frac{TB_N}{k \cdot s_0}. 
\]

Note Definition 2 contains Definition 1 as a special case in which \( n = 1 \). Hence from now on Definition 2 takes over the place of Definition 1.

Now, foreign bank \( i \)'s optimization problem can be stated as follows.

\[
\max_{q_i} \frac{1}{n} \left[ 1 + TB_N - k \cdot s_0 \cdot \sum_{i=1}^{n} q_i - (1 + LBR) \frac{f}{s_0} \right] q_i 
\]

A standard Cournot competition yields the following proposition.

**Proposition 2** Suppose that there exist \( n \in \{1, 2, 3, \ldots\} \) homogeneous foreign banks in the cross-currency swap market sharing surplus with the domestic bank
as stated in Lemma 1, and that optimization problem of specific foreign bank
$i$ can be represented in accordance with Equation (13). Suppose further that
Assumption 1 is satisfied.

If the constraint is not binding, equilibrium foreign inflows for each foreign
bank $q_i^*$ and total foreign inflows $q^*$, government bond rate $TB^*$, and cross-
currency swap rate $CRS^*$ are:

\[ q_i^* = \frac{1}{(n + 1)k \cdot s_0} \left[ 1 + TB_N - (1 + LBR) \frac{f}{s_0} \right], \quad (14) \]
\[ q^* = \frac{n}{(n + 1)k \cdot s_0} \left[ 1 + TB_N - (1 + LBR) \frac{f}{s_0} \right], \quad (15) \]
\[ 1 + TB^* = \frac{1}{n + 1} (1 + TB_N) + \frac{n}{n + 1} (1 + LBR) \frac{f}{s_0}, \quad (16) \]
\[ 1 + CRS^* = \frac{\theta}{n + 1} (1 + TB_N) + \left( 1 - \frac{\theta}{n + 1} \right) (1 + LBR) \frac{f}{s_0}. \quad (17) \]

If the constraint is just binding, all the Equations (14)-(12) hold.

**Proof.** Suppose the constraint is not binding. We will derive $q_i^*$ first. Each
foreign bank solves Equation (13). The first order condition is represented as
follows.

\[ 1 + TB_N - k \cdot s_0 (q_1 + \cdots + q_{i-1} + q_{i+1} + q_n) - (1 + LBR) \frac{f}{s_0} - 2k \cdot s_0 \cdot q_i^* = 0. \]

By rearranging, this yields the following solution for $q_i^*$:

\[ q_i^* = \frac{1}{2k \cdot s_0} \left[ 1 + TB_N - (1 + LBR) \frac{f}{s_0} \right] - \frac{1}{2} \sum_{j \neq i} q_j. \quad (22) \]

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By symmetry, we have

\[
\sum_{j \neq i} q_j = \frac{n - 1}{2k \cdot s_0} \left[ 1 + TB_N - (1 + LBR) \frac{f}{s_0} \right] - \frac{1}{2} \left[ \sum_{j \neq 1} q_j + \sum_{j \neq 2} q_j + \cdots + \sum_{j \neq i-1} q_j + \sum_{j \neq i+1} \cdots \sum_{j \neq n} q_j \right] = \frac{n - 1}{2k \cdot s_0} \left[ 1 + TB_N - (1 + LBR) \frac{f}{s_0} \right] - \frac{1}{2} \left[ (n - 1)q_i + (n - 2) \sum_{j \neq i} q_j \right].
\]

Therefore, solving the above equation for \( \sum_{j \neq i} q_j \) yields

\[
\sum_{j \neq i} q_j = \frac{n - 1}{n \cdot k \cdot s_0} \left[ 1 + TB_N - (1 + LBR) \frac{f}{s_0} \right] - \frac{n - 1}{n} q_i.
\]

Plugging this into Equation (22), we have

\[
q_i^* = \frac{1}{2k \cdot s_0} \left[ 1 + TB_N - (1 + LBR) \frac{f}{s_0} \right] - \frac{1}{2} \frac{n - 1}{n \cdot k \cdot s_0} \left[ 1 + TB_N - (1 + LBR) \frac{f}{s_0} \right] - \frac{n - 1}{2n} q_i^* = \frac{1}{2n \cdot k \cdot s_0} \left[ 1 + TB_N - (1 + LBR) \frac{f}{s_0} \right] - \frac{n - 1}{2n} q_i^*.
\]

Solving the above equation for \( q_i^* \) drives the result.

To get \( q^* \) for the not-binding case, simply add up \( q_i^* \) for \( i = 1, 2, \ldots, n \).

\[
q^* = \sum_{i=1}^n q_i = n \cdot q_i = \frac{n}{(n + 1)k \cdot s_0} \left[ 1 + TB_N - (1 + LBR) \frac{f}{s_0} \right].
\]

Once \( q^* \) is known, Assumption 1 determines the equilibrium government bond rate. In particular,

\[
TB^* = TB_N - k \cdot s_0 \cdot q^*
\]

\[
= TB_N - k \cdot s_0 \cdot \frac{n}{(n + 1)k \cdot s_0} \left[ 1 + TB_N - (1 + LBR) \frac{f}{s_0} \right] = \frac{1}{n + 1} (1 + TB_N) + \frac{n}{n + 1} (1 + LBR) \frac{f}{s_0} - 1.
\]
This $TB^*$, in turn, can be used to derive $CRS^*$.

\[
1 + CRS^* = \theta(1 + TB^*) + (1 - \theta) \left[ (1 + LBR) \frac{f}{s_0} \right] \\
= \theta \left[ \frac{1}{n+1}(1 + TB_N) + \frac{n}{n+1}(1 + LBR) \frac{f}{s_0} \right] \\
+ (1 - \theta) \left[ (1 + LBR) \frac{f}{s_0} \right] \\
= \frac{\theta}{n+1}(1 + TB_N) + (1 - \frac{\theta}{n+1})(1 + LBR) \frac{f}{s_0}.
\]

Note that the first equation comes from Equation (4) from Lemma 1.

Now, suppose that the constraint is binding. Note $q^* = \frac{TB_N}{k-s_0}$ by definition. This implies, by symmetry, $q_i^* = \frac{TB_N}{k-s_0}$. Then, $TB^* = TB_N - k \cdot s_0 \cdot q^* = 0$ by Assumption 1, and

\[
1 + CRS^* = \theta(1 + TB^*) + (1 - \theta) \left[ (1 + LBR) \frac{f}{s_0} \right] = \theta + (1 - \theta)(1 + LBR) \frac{f}{s_0} \text{ by Equation (4)}.
\]

If the constraint is just binding, $q^* = \frac{n}{(n+1)k-s_0} \left[ 1 + TB_N - (1 + LBR) \frac{f}{s_0} \right] = \frac{TB_N}{k-s_0}$ by definition. By symmetry, Equations (14) and (18) are equivalent. This also implies $\frac{1}{n}TB_N = 1 - (1 + LBR) \frac{f}{s_0}$. The latter equation proves the equivalence of Equations (16) and (20), Equations (17) and (21).

Note that the equilibrium forward purchases of the domestic bank from domestic exporters, $(1 + LBR)q^*$, is $\frac{n(1+LBR)}{(n+1)k-s_0} \left[ 1 + TB_N - (1 + LBR) \frac{f}{s_0} \right]$ if the constraint is not binding, whereas it turns out to be $(1 + LBR) \frac{TB_N}{k-s_0}$ if the constraint is binding.

An interesting feature to consider is the impacts of recent international financial turmoil. If foreign banks have some difficulties in funding the US dollars in the international financial market quantitatively, this would limit their foreign inflows. If foreign banks cannot borrow the optimal foreign inflows $q^*$, then the foreign inflows may be lower than the optimal $q^*$, driving up the government bond and cross-currency swap rates such that the former increases more than the latter. Hence, in turn, the surplus per each unit of foreign inflows gets larger.

28Foreign banks may even be forced clear their current investment positions in the designated country. They may sell off their domestic currency denominated assets and withdraw their investment before the maturity. These are not covered in our model since there are only two periods and the government bonds are held to full maturity.

29This is due to Lemma 1.
This also gives a rationale why central banks of emerging economies actually lowered their policy rates as facing a sudden reversal of foreign inflows influenced by recent international financial turmoil. If foreign banks’ capacity of supplying foreign currency to the domestic market is constrained then raising the policy rate does not induce more foreign inflows. Therefore, it would be better to focus on domestic economy in monetary policy decisions. In these regards, Proposition 2 is consistent with the observations of impacts of recent international financial market turmoil.

If there exist \( n \) foreign banks in the cross-currency swap market with non-binding constraint, Proposition 2 tells that each oligopolistic foreign bank enjoys, in US dollar terms, 
\[
\frac{1}{n} \left[ 1 + TB_N - (1 + LBR) \frac{f}{s_0} \right] \]
per each unit of \( q^*_i \). The first term, \( \frac{1}{n} \), indicates the bargaining share and the second term, \( \frac{1}{n+1} \), reflects the oligopoly with \( n \) foreign banks. The third term \( 1 + TB_N - (1 + LBR) \frac{f}{s_0} > 0 \) is the surplus when there is no foreign inflows. All in all, each foreign bank’s surplus per unit of foreign inflows decreases as the number of foreign banks in the cross-currency swap market increases. If the constraint is binding, the surplus should be 
\[
\frac{1}{n} \left[ 1 - (1 + LBR) \frac{f}{s_0} \right] \]
per unit of \( q^*_i \) for each foreign bank. The first term \( \frac{1}{n} \) denotes the bargaining share and the second term in [ ] reflects that equilibrium government bond rate is zero. Note that the second term is strictly positive; otherwise, foreign banks are running a deficit at \( q^* = \frac{TBS}{k_{s_0}} \), leading to a contradiction that the constraint cannot be binding since foreign banks can do better by setting \( q^* = 0 \) instead of \( q^* = \frac{TBS}{k_{s_0}} \). As seen in the monopoly case, this positive surplus indicates that the covered interest rate parity does not hold in the oligopolistic market structure, either. In the oligopolistic environment, foreign banks’ market power diminishes but still is positive, which prevents the covered interest rate parity from holding.

**Lemma 5** Suppose that there are \( n \in \{1, 2, 3, \cdots \} \) foreign banks in the cross-currency swap market. Suppose, further, that all the conditions in Proposition 2 are satisfied. Then the covered interest rate parity does not hold.

**Proof.** Suppose that the constraint is not binding. From Proposition 2,
\[
1 + TB^* = \frac{1}{n+1} \left[ 1 + TB_N - (1 + LBR) \frac{f}{s_0} \right] + (1 + LBR) \frac{f}{s_0} > (1 + LBR) \frac{f}{s_0}.
\]

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The last inequality follows from Assumption 1. Therefore the covered interest rate parity, which states that \(1 + TB^* = (1 + LBR)\frac{f}{s_0}\) does not hold.

In case the constraint is binding, again from Proposition 1,
\[1 + TB^* = 1 > (1 + LBR)\frac{f}{s_0}\]
The last inequality follows from the fact that the constraint is binding only if \(1 - (1 + LBR)\frac{f}{s_0}\) > 0. Otherwise, foreign banks are running a deficit at \(q^* = \frac{TB_N}{s_0}\) implying that the foreign banks can do better by setting \(q^* = 0\) so that the constraint cannot be binding. Therefore, the result follows.

If the constraint is just binding, \(\frac{1}{n}TB_N = 1 - (1 + LBR)\frac{f}{s_0}\) by definition. Then, proof for the cases, either binding or not, can be used to show the result.

A glance at Proposition 2 shows that comparative statics results reported in Lemma 3 still hold with some small changes. It would be worthwhile, however, to compare the magnitude of responses with the monopoly case. Only the not-binding case is analyzed since the binding case gives exactly the same equilibrium foreign inflows, government bond and cross-currency swap rates, and hence, the same comparative statics as reported in Lemma 4.

**Lemma 6** Suppose that there are \(n \in \{1, 2, 3, \cdots\}\) foreign banks in the cross-currency swap market. Suppose that the constraint is not binding and that the changes in exogenous variables are small enough in the sense that the constraint is still not binding after the changes of exogenous variables. Then, the equilibrium foreign inflows for each foreign bank \(q_i^*\), total foreign inflows \(q^*\), government bond rate \(TB^*\), and cross-currency swap rate \(CRS^*\) respond to the changes of exogenous variables as follows.

1. If the domestic bank’s bargaining power, \(\theta\) increases, foreign inflows (each and total) and government bond rate are not affected but cross-currency swap rate increases.

2. If LIBOR, LBR goes up, foreign inflows (each and total) decrease while government bond and cross-currency swap rates increase such that (i) the government bond rate increases less than LIBOR provided \((n + 1)s_0 > nf\),
(ii) the cross-currency swap rate increases more than the government bond rate provided \( \theta \neq 1 \).

3. If the intensity of the effect of foreign bank’s demand on the domestic government bond rate, \( k \), increases, foreign inflows (each and total) decrease while government bond and cross-currency swap rates are not affected.

4. If policy rate, \( TB_N \), is raised, foreign inflows (each and total) increase, and government bond and cross-currency swap rates increase such that (i) the government bond rate increases less than the policy rate, (ii) the government bond rate increases more than the cross-currency swap rate provided \( \theta \neq 1 \).

5. If spot foreign exchange rate, \( s_0 \), increases, then foreign inflows increase provided that \( 1 + TB_N < 2(1 + LBR) \frac{f}{s_0} \), government bond and cross-currency rates increase such that the cross-currency swap rate decreases more than then government bond rate provided \( \theta \neq 1 \).

6. If forward foreign exchange rate, \( f \), increases, then foreign inflows decrease, government bond and cross-currency rates increase such that the cross-currency swap rate increases more than then government bond rate provided \( \theta \neq 1 \).

**Proof.** For the first part, note \( \frac{\partial q^*}{\partial q} = \frac{\partial q^*}{\partial q} = \frac{\partial TB^*}{\partial q} = 0 \), and \( \frac{\partial CRS^*}{\partial q} = \frac{1}{n+1} \left[ 1 + TB_N - (1 + LBR) \frac{f}{s_0} \right] > 0 \) by Assumption 1.

For the second part, \( \frac{\partial q^*}{\partial LBR} = -\frac{n}{(n+1)s_0} < 0 \), \( \frac{\partial q^*}{\partial CRS^*} = -\frac{n}{(n+1)s_0} < 0 \), \( \frac{\partial TB^*}{\partial LBR} = \frac{nf}{(n+1)s_0} > 0 \), \( \frac{\partial CRS^*}{\partial LBR} = \left[ 1 - \frac{\theta}{n+1} \frac{f}{s_0} \right] > 0 \). Note \( \frac{\partial TB^*}{\partial LBR} = \frac{nf}{(n+1)s_0} < 1 \) provided \((n+1)s_0 > nf \), and \( \frac{\partial CRS^*}{\partial LBR} < 0 \) if \( \theta \neq 1 \).

For the third part, \( \frac{\partial q^*}{\partial TB} = -\frac{f}{(n+1)s_0} \left[ 1 + TB_N - (1 + LBR) \frac{f}{s_0} \right] < 0 \), and \( \frac{\partial TB^*}{\partial TB} = \frac{\partial CRS^*}{\partial TB} = 0 \).

For the fourth part, \( \frac{\partial q^*}{\partial TB} = -\frac{n}{(n+1)s_0} > 0 \), \( \frac{\partial q^*}{\partial CRS^*} = \frac{n}{(n+1)s_0} > 0 \), \( \frac{\partial TB^*}{\partial TB} = \frac{1}{n+1} > 0 \), and \( \frac{\partial CRS^*}{\partial TB} = \frac{\theta}{n+1} > 0 \). Note \( \frac{\partial TB^*}{\partial CRS^*} > 0 \) if \( \theta \neq 1 \).

For the fifth part, provided that \( 1 + TB_N < 2(1 + LBR) \frac{f}{s_0} \), \( \frac{\partial q^*}{\partial q} = -\frac{n}{(n+1)s_0} > 0 \), \( \frac{\partial q^*}{\partial CRS^*} = -\frac{n}{(n+1)s_0} > 0 \), \( \frac{\partial TB^*}{\partial q} = -\frac{n}{(n+1)s_0} (1 + LBR) \frac{f}{s_0} < 0 \), and \( \frac{\partial CRS^*}{\partial q} = -\left( 1 - \frac{\theta}{n+1} \right) (1 + LBR) \frac{f}{s_0} < 0 \).
For the sixth part, \( \frac{\partial q^*}{\partial j} = -\frac{1}{(n+1)k} s_0 (1 + LBR) \frac{f}{s_0} < 0 \). Note \( \frac{\partial TB^*}{\partial j} = \frac{n}{n+1} (1 + LBR) \frac{1}{s_0} \), and \( \frac{\partial CRS^*}{\partial j} = \left(1 - \frac{\theta}{n+1}\right) (1 + LBR) \frac{1}{s_0} \).

The second part of Lemma 6 is noteworthy: as the number of foreign banks in the cross-currency swap market increases, the government bond rate is more susceptible to the changes of LIBOR. It is possible for the government bond rate to over-react to the changes of LIBOR in the sense that \( \frac{\partial TB^*}{\partial LBR} = \frac{n f}{(n+1)s_0} > 1 \). This over-reaction happens provided that \( (n+1)s_0 < nf \). Furthermore, the difference between changes of cross-currency swap rate and government bond rate in response to the change of LIBOR gets smaller as the number of foreign banks in the cross-currency swap market increases, although the former is always bigger than the latter provided \( \theta \neq 1 \). The fourth part tells about the effectiveness of the monetary policy. In particular, as the number of foreign banks in the cross-currency swap market increases, the magnitude of impact of adjusting the policy rate on the government bond rate diminishes. Eventually, if the cross-currency swap market is populated by infinite number of foreign banks, that is, in perfect competition, adjusting the policy rate does not have any impact on the government bond rate.

Note that there is another exogenous variable, the number of foreign banks. The comparative statics are presented in the following lemma.

**Lemma 7** Suppose that there are \( n \in \{1,2,3,\cdots\} \) foreign banks in the cross-currency swap market. Suppose that the constraint is not binding. Then, as the number of foreign banks in the cross-currency swap market, \( n \), increases, the equilibrium foreign inflow, \( q^* \), increases while equilibrium government bond and cross-currency swap rates, \( TB^* \) and \( CRS^* \), decrease. Further, foreign banks’ unit surplus per each unit of foreign inflows, calculated by \( (TB^* - CRS^*) \), and foreign banks’ surplus, calculated by \( (TB^* - CRS^*)q^* \), decrease with the increase of \( n \).

**Proof.** Although \( n \) changes discretely, partial derivatives are used in this proof rather than the mathematical induction. Take partial derivatives of Equa-
tions (15), (16) and (17) with respect to \( n \).

\[
\frac{\partial q^*}{\partial n} = \frac{1}{(n+1)^2 k \cdot s_0} \left[ 1 + TB_N - (1 + LBR) \frac{f}{s_0} \right] > 0,
\]

\[
\frac{\partial TB^*}{\partial n} = -\frac{1}{(n+1)^2} \left[ 1 + TB_N - (1 + LBR) \frac{f}{s_0} \right] < 0,
\]

\[
\frac{\partial CRS^*}{\partial n} = -\frac{\theta}{(n+1)^2} \left[ 1 + TB_N - (1 + LBR) \frac{f}{s_0} \right] < 0.
\]

The last inequalities in the above equations are due to Assumption 1.

Note \( TB^* - CRS^* = \frac{1 - \theta}{n+1} \left[ 1 + TB_N - (1 + LBR) \frac{f}{s_0} \right] \) and \( (TB^* - CRS^*) q^* = \frac{n(1-\theta)}{(n+1)^2 k \cdot s_0} \left[ 1 + TB_N - (1 + LBR) \frac{f}{s_0} \right]^2 \). These lead to the following:

\[
\frac{\partial (TB^* - CRS^*)}{\partial n} = -\frac{1 - \theta}{(n+1)^2} \left[ 1 + TB_N - (1 + LBR) \frac{f}{s_0} \right] < 0,
\]

\[
\frac{\partial (TB^* - CRS^*) q^*}{\partial n} = -\frac{(n+1)(n-1)}{(n+1)^4} \frac{1 - \theta}{k \cdot s_0} \left[ 1 + TB_N - (1 + LBR) \frac{f}{s_0} \right]^2.
\]

The right hand side of the last equation is negative except when \( n = 1 \), in which case it’s zero. It is easy, however, to see that \( (TB^* - CRS^*) q^* |_{n=1} - (TB^* - CRS^*) q^* |_{n=2} = \frac{1 - \theta}{366 \cdot s_0} \left[ 1 + TB_N - (1 + LBR) \frac{f}{s_0} \right] > 0 \). Therefore the results follow.

Note Lemma 7 implies that each foreign bank’s surplus also declines as the number of foreign banks in the cross-currency swap market, \( n \), increases. The surplus in Lemma 7 denotes the surplus of all the foreign banks. If the surplus of all the foreign banks decreases, so does each foreign bank’s surplus.\(^{30}\) One more thing to note is that as \( n \) increases, \( 1 + TB^* \) and \( 1 + CRS^* \) both approach \( (1 + LBR) \frac{f}{s_0} \). Equation (20) indicates that \( 1 + TB^* \) is a weighted average of \( 1 + TB_N \) and \( (1 + LBR) \frac{f}{s_0} \). The weight of the latter approaches 1 as \( n \) increases.

Similarly, Equation (21) demonstrates the same pattern for \( 1 + CRS^* \). This implies that the deviations from the covered interest rate parity diminish as the number of foreign banks increases.\(^{31}\)

Figure 4 illustrates the results of a simulation on the number of foreign banks in the cross-currency swap market.\(^ {32}\) The figure depicts the traces of equilibrium

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\(^{30}\) Even with the same \( n \), this is true. \( n \) actually increases.

\(^{31}\) Recall that the covered interest rate parity states that \( 1 + TB^* = 1 + CRS^* = (1 + LBR) \frac{f}{s_0} \).

\(^{32}\) Exogenous variables are set as follows. \( TB_N = 0.05, LBR = 0.03, s_0 = 1.0, f = 1.0, k = 0.001, \theta = 0.5 \).
foreign inflows $q^*$, government bond rate $TB^*$, and cross-currency swap rate $CRS^*$ as the number of foreign banks $n$ changes from 1 to 30. Note that the government bond rate decrease more than the cross-currency swap rate when the number of foreign banks increases if the bargaining power of the domestic bank is not one — $\frac{\partial TB^*}{\partial n} < \frac{\partial CRS^*}{\partial n} < 0$ if $\theta \neq 1$. This implies that foreign banks’ surplus per each unit of foreign inflows, $TB^* - CRS^*$, decreases as $n$ increases. The foreign banks’ surplus, calculated by $(TB^* - CRS^*)q^*$, also declines as the markets become more competitive.

What will happen when the cross-currency swap market is populated by infinite number of foreign banks? The following lemma shows that in the limit ($n \to \infty$) the covered interest rate parity holds if the constraint is not binding.

**Lemma 8** Suppose that there are $n \in \{1, 2, 3, \cdots\}$ foreign banks in the cross-currency swap market. Suppose that all the conditions in Proposition 2 are satisfied. Suppose, further, that the constraint is not binding. If the number of foreign banks in the cross-currency swap market, $n$, approaches infinity, then the covered interest rate parity holds.
Proof. From Proposition 2, the followings hold.

\[
\lim_{n \to \infty} (1 + TB^*) = (1 + LBR) \frac{f}{s_0}, \quad \text{and} \\
\lim_{n \to \infty} (1 + CRS^*) = (1 + LBR) \frac{f}{s_0}.
\]

That is, if \( n \) approaches infinity, \( 1 + TB^* = 1 + CRS^* = (1 + LBR) \frac{f}{s_0} \). And this is exactly the covered interest rate parity. \( \blacksquare \)

If the constraint is binding, however, this result cannot be achieved. Note \( \lim_{n \to \infty} (1 + TB^*) = 1 \) while \( \lim_{n \to \infty} (1 + CRS^*) = \theta + (1 - \theta)(1 + LBR) \frac{f}{s_0} \). Therefore, the covered interest rate parity holds only in an environment in which the cross-currency market is perfectly competitive with not-binding constraint.

6 Conclusion

This paper has presented a simple model that incorporates the market structure of the government bond and cross-currency swap markets, and the bargaining between domestic and foreign banks. In particular, foreign banks exercise market power in the government bond and the cross-currency swap markets and they bargain with domestic banks over the surplus. This simple model has been used to analyze the validity of the covered interest rate parity under various market structures: monopoly, oligopoly, and perfect competition. This paper has proved that the covered interest rate parity does not hold in either monopolistic or oligopolistic environment because foreign banks, exercising their market power, maximize their surplus by limiting the supply of foreign currency in emerging countries’ swap market. This paper has also shown that as the cross-currency swap market is populated by more and more foreign banks so that the market becomes more and more competitive, the equilibrium government bond and cross-currency swap rates approach the condition imposed by covered interest rate parity, and indeed in the limit the covered interest rate parity holds if the constraint is not binding. Furthermore, some comparative statics results, which may be interesting to policy makers, have also been provided: if the central bank raises the policy rate then foreign inflows rise, while government bond and cross-currency swap rates increases only with diminishing effectiveness of the monetary policy. That
is, as the government bond and cross-currency swap markets become more competitive, the magnitude of impact of adjusting the policy rate on the government bond rate decreases. In the limit when the market gets perfectly competitive, monetary policy does not have any impact on the government bond rate.

Inevitably, our model have some shortcomings. First, our simple two-period model is based on a partial equilibrium approach, meaning there may exist cases for which our model cannot explain. For example, the fact that the cross-currency swap market is populated by only one monopolistic foreign bank does not necessarily mean that there should be positive surplus in cross-currency swap contracts. There may exist no surplus because of some other facts outside the model — behaviors of exporters and/or importers can possibly dry out the surplus.

Second, our model presumes that spot and forward exchange rates are independent of foreign inflows. One may suggest it would be more appropriate to assume \( s_0'(q) < 0 \) and \( f'(q) > 0 \). However, as pointed out by Cavallo (2006), carry trades are intensively used because these usually do not hold. Furthermore, as can be seen in the real data, spot and forward exchange rates interact with each other in such a way that they show co-movements. We opt out of analyzing these spot and forward markets in which exporters and importers may play important roles; our model is anyway based on a partial equilibrium approach in which we do not fully take into account the behaviors of exporters and importers. Our model also spans over the analysis of the oligopoly cases, which implies that the model should be simple.\(^33\) Our assessment is that even if spot and forward exchange rates are affected by \( q \), our results would not change much. The intuition is that, even if we consider the impacts of \( q \) on spot and forward exchange rates, as \( q \) increases the spot and forward exchange rates move in such a way that the foreign banks’ surplus per unit of \( q \) decreases.\(^34\) Therefore, the basic mechanism

\(^33\)As pointed out by Gary-Bobo (1989), “Cournot’s model is a nice theoretical construction whose mathematical properties are awkward · · ·.” The existence of Cournot equilibrium cannot be guaranteed without very restrictive assumptions. Admitting this is very valuable, this paper, however, does not pursue finding the most loose conditions.

\(^34\)For an illustration, let \( s_0(q) = s_0^N - h_1 \cdot q \) and \( f(q) = f^N + h_2 \cdot q \), where \( h_1, h_2 > 0 \) and \( s_0^N \) and \( f^N \) denote spot and forward exchange rates when \( q = 0 \). Consider the monopoly case. Under Assumption 1, the foreign bank’s problem is as follows.

\[
\max_q (1 - \theta) \left[ 1 + TB^N - k \cdot (s_0^N - h_1 \cdot q) \cdot q - (1 + LBR) \frac{f^N + h_2 \cdot q}{s_0^N - h_1 \cdot q} \right] q.
\]
does not change if we add the impacts of $q$ on the spot and forward exchange rates into consideration.

Third, bargaining in our model does not involve outside options, which is truly restrictive. If domestic banks can borrow in the international financial market with some additional cost — at LIBOR + $\alpha$, then the results in this paper may change drastically. The bargaining solution may be dependent on $\alpha$ but not on LIBOR since the surplus from trade is $\alpha$ with this kind of outside option. Therefore, the covered interest rate parity may not hold even in perfect competition. Bargaining with outside options, however, is left for future research.

We argue that, despite of all these shortcomings, this paper presents a tangible model good enough to analyze not only the validity of the covered interest rate parity in the imperfectly competitive environments but also the impacts of changes of exogenous variables (bargaining power, LIBOR, policy rate, spot and forward exchange rates, etc.) on the equilibrium foreign inflows, government bond and cross-currency swap rates. We have shown that very simple and standard tools of Cournot equilibrium analysis could serve to explain the prolonged

This problem yields the following first order condition:

$1 + TB_N - 2k \cdot s^N_0 \cdot q + 3k \cdot h_1 \cdot q^2 - (1 + LBR) \frac{h_2(s^N_0 - h_1 \cdot q) + h_1(f^N + h_2 \cdot q)}{(s^N_0 - h_1 \cdot q)^2} q$

$- (1 + LBR)f^N + h_2 \cdot q \left( s^N_0 - h_1 \cdot q \right) = 0.$

This is a quartic equation. Instead of solving for $q^*$, let’s assume that $h_1 = 0$ so that $s'_0(q) = 0$ and $s_0 = s^N_0$ for all $q$. In other words, assume that the impact of increase in foreign inflows are all materialized by the changes in forward exchange rate. This serves as a good approximation for our purpose. Then the first order condition, from the foreign bank’s problem with $h_1 = 0$, simplifies to the following:

$\left[ 1 + TB_N + (1 + LBR) \frac{h_2}{s_0} + (1 + LBR) \frac{f^N}{s_0} \right] - \left[ 2k \cdot s_0 - (1 + LBR) \frac{h_2}{s_0} \right] q = 0.$

Therefore,

$q^* = \frac{1 + TB_N + (1 + LBR) \frac{h_2}{s_0} + (1 + LBR) \frac{f^N}{s_0}}{2k \cdot s_0 - (1 + LBR) \frac{h_2}{s_0}}.$

Notice that this $q^*$ is greater than the previous $q^*$ with $s'_0(q) = f'(q) = 0$. Allowing the forward rate to change reduces the market power of the monopolist so that the surplus per unit of $q$ decreases faster as $q$ rises. In addition, $2k \cdot s_0 - (1 + LBR) \frac{h_2}{s_0} \frac{h_2}{s_0}$ must be greater than zero for $q^*$ to be positive, which implies that $h_2 < \frac{2k \cdot s^2_0}{1 + LBR}$. That is, the forward rate have to be not too sensitive for the solution to exist.
departure from the covered interest rate parity. Our model delivers a simple and clear message: the covered interest rate parity must be thought together with the market structure and bargaining between the market participants.

References


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이 논문은 기존 연구에서 시도되지 않았던 시장구조(Market Structure) 및 내쉬협상(Nash Bargaining)에 기반한 이익배분 모형을 구축하여 통화스왑(CRS) 및 국채 금리, 나아가 재정거래 차익의 결정요인을 이론적으로 분석하였다.

일반적인 무위험평형조건과 달리 동 모형에서는 정책금리 인상, 해외금리 상승, 국내은행의 협상력(Bargaining Power) 증대 등에 대한 외자유입, 국외금리, CRS금리의 반응을 수리적으로 분석하는 것이 가능하다. 아울러 통화스왑시장에서 무위험금리평형 이탈이 장기간에 걸쳐 나타나는 이유를 이론적으로 제시할 수 있다.

본 논문의 주요결과를 살펴보면 다음과 같다. 우선 재정거래 유인이 존재하더라도 외국은행들은 시장지배력(Market Power)을 이용하여 양의 수익을 달성할 수 있도록 제한된 규모의 외자들을 도입하는 것으로 분석되었다. 또한, 정책금리 등 외생변수(exogenous variable)가 변동할 경우 균형 외자유입액, 국고채금리 및 CRS금리는 다음과 같이 반응하는 것으로 나타났다.

(i) 국내은행의 협상력이 증대되면 CRS금리가 상승
(ii) 해외금리가 상승하면 외자유입액은 감소하고 국고채금리는 해외금리 변동폭보다 작게, CRS금리보다 작게 상승
(iii) 정책금리가 상승하면 외자유입액은 증대되고 국고채금리는 정책금리 상승폭보다 작게, CRS금리보다 크게 상승
(iv) 현물환율이 상승하면 외자유입액이 증대되고 선물환율이 상승하면 외자유입액이 감소
(v) CRS시장에 참여하고 있는 외국은행의 숫자가 증가할 경우 균형 외자유입액은 증대되며 국고채금리와 CRS금리는 하락

특히 본 논문에서는 시장이 보다 경쟁적일수록 국고채금리와 CRS금리가 무위험금리평형조건에 접근하며, 정책금리 조정이 국고채금리에 미치는 영향의 크기가 점차 감소하면서 통화정책의 파급효과도 줄어드는 것으로 분석되었다.

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