Foreign Exchange Derivatives and Bank Lending in China

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Abstract: With the reform of the RMB exchange rate regime, China's banks expose to more exchange rate risks and use foreign exchange derivatives to manage these risks. This paper develops a theoretical model to examine the relationship between foreign exchange derivatives and the foreign currency lending in China's banking sector. In our model, banks choose lending activities in a way analogous to Cournot competition commonly described in industrial organization. We find there is the positive effect of the derivatives position on the total loan volume under the condition that the von Neumann-Morgenstern utility function of bank using derivatives displays either constant or decreasing absolute risk aversion. In the empirical section, we use Vector Autoregression (VAR) model with China's monthly data over the period from Jan 2007 to Jun 2014. Based on techniques commonly used in the VAR literature, the main results suggest that the foreign exchange derivatives transaction has bi-directional Granger causality with bank's foreign currency loan volume, and derivatives transaction has a significantly and persistently positive effect on bank lending. Furthermore, we find that derivatives transaction accounts for over 40 percent of variations in loan volume in the long run.

JEL classification: D43; G21; G28

Key words: Foreign Exchange Derivatives; Bank Lending; Financial Intermediation; Cournot Duopoly; Exchange Rate Risk; RMB Exchange Rate Regime; VAR Model

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1. Introduction

With the breakdown of the Bretton Woods System in the 1970s, the developed countries' currencies formerly pegging with the US dollar began to float. In floating exchange rate system, exchange rate fluctuations become an important source of risk for banking institutions due to currency mismatches on their balance sheets[①]. Since exchange rate risk could cause huge burdens on banks' profitability and even lead to bank failures in the worst-case scenario[②], banks use various tools, especially foreign exchange derivatives[③], to manage and transfer exchange rate risk. In recent years, foreign exchange derivatives market grew rapidly and became the second largest derivatives market in the world. Bank for International Settlements (2014) reports that the notional amount outstanding of the global foreign exchange derivatives market is equal to US$ 70.94 trillion at the end of 2013, which is about 4.5 times as of the end of 2000. In addition, according to International Swaps and Derivatives Association (2009) Survey, 96% of financial institutes in the world's 500 largest companies use foreign exchange derivatives, followed by interest rate derivatives (94 percent), equity derivatives (80 percent), credit derivatives (76 percent) and commodity derivatives (63 percent).

On July 21, 2005, the People's Bank of China (PBOC) proclaimed that China reformed the exchange rate regime by moving into a managed floating exchange rate regime based on market supply and demand with reference to a basket of currencies. Since then RMB was no longer pegged to the US dollar and the RMB exchange rate regime improved with greater flexibility. A more flexible exchange rate will enable the PBOC to more effectively tailor monetary conditions to local needs[④], allow Chinese authorities to more effectively steer the economy and push China shares responsibility for the stability of the global economy (Eichengreen, 2006). The reform of the RMB exchange rate regime was conducted in a

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① In the literature, a large number of empirical works have been carried out to examine the foreign exchange exposure of banks (see, e.g., Grammatikos et al., 1986; Choi and Elyasiani, 1997; Martin and Mauer, 2003; Hahm, 2004; Wong et al., 2009; to name just a few).

② For example, Franklin National Bank of New York collapsed on October 8, 1974 in the United States, and Bankhaus I.D. Herstatt was closed on June 26, 1974 in West Germany.

③ Foreign exchange derivatives (also known as foreign currency derivatives) are contracts that derive their value for the level of an underlying exchange rate of two or more currencies, which include foreign exchange forwards, currency futures, foreign exchange swaps and options.

④ The theory of optimum currency areas (See Mundell, 1961; McKinnon, 1963; Kenen, 1969) and its empirical counterpart suggest that large countries subject to distinctive business-cycle conditions ("asymmetric shocks") will want a more flexible exchange rate, since they can both afford and will wish to tailor monetary policy to domestic conditions.

self-initiated, controllable, and gradual manner, and took into full consideration the economic agents' ability to cope with the reform. In the process of the reform, the floating band of the RMB exchange rate on the inter-bank spot exchange-rate market was expanded in a gradual manner (see Table 1)[①].

China has a banking-oriented financial system, and its economic development is highly dependent on bank credit supply (see Figure 1) [②]. Furthermore, China has 110 banks featured in The Banker's Top 1000 World Banks ranking for 2014, and accounts for one third of all banking profits (The Banker, 30 June 2014). While the reform of the RMB exchange rate regime suggests that Chinese banks in general have become increasingly exposed to exchange rate risk (Wong et al., 2009). At the same time, the PBOC tends to enhance the ability of the banks to manage exchange rate risk by establishing the domestic foreign exchange derivatives market in the nationwide interbank market. Over the period from 2005 to 2011, the market offered RMB/FX forward (Aug 2005)[③], RMB/FX swap (Apr 2006)[④], RMB/FX cross currency swap (Aug 2007)[⑤] and RMB/FX option (Feb 2011)[⑥] in turn, which provide the effective instruments to hedge exchange rate risk for banks in China. With the continuous growth of demand for exchange rate risk hedging, the annual transaction volume of the market increased dramatically from US$ 64.92 billion in 2006 to US$ 3.47 trillion in 2013[⑦].

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① Gradual widening of the floating band will minimize the danger of excessive volatility that could damage financial stability, exports, and economic growth.

② In our paper, the term bank only refers to commercial banks because the regulator limits the ability of commercial banks and investment banks to engage in each other's activities in China.

③ RMB/FX forward is the binding obligation between trading parties to buy or sell a certain amount of foreign currency against RMB at a contracted rate of exchange on a certain date in the future (at least two business days from the trading date).

④ RMB/FX swap is the actual exchange of RMB and foreign currency on a specific date at a rate agreed in the contract, and a reverse exchange of the same two currencies at a date further in the future at another rate agreed in the contract.

⑤ RMB/FX cross currency swap is the binding obligation between trading parties that allows the two parties to exchange steams of interest payments in RMB and foreign currency for an agreed period of time and to exchange principal amounts of the same two currencies periodically at a pre-agreed exchange rate.

⑥ RMB/FX option is the contract offers one party a right to trade a certain volume of foreign currency against RMB at an agreed exchange rate on a given trading day. The option buyer acquires such right by paying an option premium. The option seller collects the option premium and performs its obligation when the buyer chooses to exercise its right.

⑦ Date source: China Foreign Exchange Trade System (CFETS). CFETS, founded on April 18, 1994, is a sub-institution of The People's Bank of China (PBC). Its core functions include: (1) providing trading, information, benchmark and training facilities to the interbank lending, bond and foreign exchange markets; (2) monitoring market transactions; (3) providing services for the operation and transmission of the central bank's monetary policies, and (4) engaging in other businesses authorized by the PBOC.

Although banks dominate most derivatives markets, there is limited research on the implications of derivatives for bank's intermediation. Our paper differs from the previous research in several aspects. First, we examine the relationship between the use of foreign exchange derivatives and foreign currency lending activity, which is ignored in the previous study. Second, we develop a theoretical model, capturing the main characteristics of the banking sector in China, in which banks as oligopolists choose the foreign currency lending activities in a way analogous to Cournot competition commonly described in industrial organization. Finally, an empirical test is presented with VAR model using China's macro data. In the contrast, the previous work uses the panel data models with bank-level micro data.

The remainder of this paper is organized as follows. Section 2 reviews previous work on the effects of financial derivatives on the supply and terms of bank lending. Section 3 develops the theoretical framework, which links bank's foreign exchange derivative positions to the foreign currency loan volumes and captures the main characteristics of the banking sector in China. Section 4 provides the empirical evidence by using the VAR model with China's data. Section 5 summarizes our findings.

2. Review of the Literature

According to the classic Modigliani and Miller (1958) paradigm, risk management is irrelevant to the commercial banks as shareholders can do it on their own more efficiently, for example, by holding well-diversified portfolios. However, we obviously do not live in a Modigliani-Miller world and firms need to manage their risks actively. The motivations for managing risk exposure include managerial risk aversion (Stulz, 1984), the convexity of taxes, financial distress (Smith and Stulz, 1985), underinvestment problem (Froot et al., 1993), costly lower-tail outcomes (Stulz, 1996), and information asymmetry between the insiders and outsiders of the firm (DeMarzo and Duffie, 1995). In addition, frictions in the market such as moral hazard and adverse selection problems lead banks to acquire private information about their borrowers that makes loans illiquid and hard to trade. Meanwhile, the existence of private information also makes bank failure costly.

Diamond (1984) develops a theory of financial intermediation based on minimizing the cost of monitoring information which is useful for resolving incentive problems between borrowers and lenders, and finds that diversification within a financial intermediary services to reduce the monitoring information costs even in a risk neutral economy. His model also implies that use of derivatives leads to improvement in the intermediation efficiency that, in turn, provide incentives for banks to increase their lending activities. In managing loan portfolios, banks should make the decisions about how much to lend, the terms on which loans will be made, and how the risk of those loans will be managed, and these decisions are made with regard to the extent of economic and regulatory capital capacity to absorb additional risk (Froot and Stein 1998). Risk-reducing mechanisms such as derivatives can result in lower allocated capital for a given scale of business or can allow a business to expand its activities for a given amount of capital.

In the past decade, some progress has been made in the empirical literature on the relationship between financial derivatives and bank lending, as banks have become active participants in the derivative products markets. The related literature has two strands: one is on the effect of interest-rate derivatives on bank lending; the other is the impact of credit derivatives on bank credit.

2.1 Effect of Interest-rate Derivatives on Bank Lending

Brewer et al. (2000) examine relationship between interest-rate derivatives usage and bank loans for the period 30 June 1985 through the end of 1992 with the sample of all FDIC-insured American commercial banks having total assets greater than US$300 million. They find that banks using interest-rate derivatives experience greater growth in their commercial and industrial (C&I) loan portfolios than banks that do not use these financial instruments. Purnanandam (2007) analyzes impact of monetary policy shocks on lending volume of interest-rate derivative users and non-users based on a sample of the U.S. commercial banks from 1997-2003. The results show that the derivative non-user bank's lending volume declines significantly with the contraction in the money supply, and on the other hand derivative users remain immune to the monetary policy shocks.

Zhao and Moser (2009) also find the positive relationship between interest-rate derivative usage by U.S. banks and growth in their commercial and industrial loan portfolios, with a sample consisting of all FDIC-insured commercial banks having total assets greater than $300 million and having a portfolio of C&I loans between 1996 and 2004 covering a full business cycle. Meanwhile they find this positive association holds for different types of interest-rate derivatives such as interest-rate options, forwards, and futures. Deng et al. (2010) examine the association between the positions in derivatives and lending patterns in U.S. bank holding companies (BHCs) during 1996-2008. They find that larger financial hedging with derivatives is associated with greater overall lending and a greater C&I loan ratio for a given level of total loans, and derivatives hedging also allows banks to make more loans to borrowers with greater credit risk. Furthermore, an interesting finding is that during the financial crisis of 2007-2009 greater hedging positions did not allow BHCs to increase their total loans, to raise their fraction of C&I loan, or to lend more to borrowers with greater credit.

2.2 Impact of Credit Derivatives on Bank Credit

Using an annual dataset spanning ten years (1995-2004) and covering 900 of the world's largest banks, Goderis et al. (2007) find that banks having the issuance of at least one collateralized loan obligation (CLN) experience a permanent increase in their target loan levels of around 50% and the impact on actual loan levels is spread over several years. Hirtle (2009) finds evidence that greater use of credit derivatives is associated with greater supply of bank credit for large term loans—newly negotiated loan extensions to large corporate borrowers, with the sample of US banks having average real assets of $10 billion from 1997 to 2006. Moreover, it is further interesting to note that the impact of credit derivatives protection for these borrowers is primarily on the terms of lending – longer loan maturity and lower spreads – rather than on loan volume. Using a sample of U.S. commercial banks from 2001 to 2008, Salah and Fedhila (2014) find that a greater recourse to securitization is associated with an increase of bank lending capacities and makes banks (especially less liquid ones) less sensitive to a monetary tightening.

Based on a sample of European banks from 1999 to 2005, Altunbas et al. (2009) find that the use of securitization appears to shelter banks' loan supply from the effects of monetary policy, and securitization activity strengthens the capacity of banks to supply new loans but this capacity depends upon business cycle conditions and banks' risk positions. Carbó-Valverde et al. (2012) study whether the involvedness of Spanish commercial and savings banks into asset backed securities (ABS) influences credit supply before and during the 2007-8 financial crisis. The result implies that ABS activity in banks lowers their lending standards in normal times, and banks with more ABS activity reduce their lending more in crisis times.

3. Theoretical Model

In this section, we set up a theoretical model, capturing the main characteristics of the banking sector in China, to analyze the effect of foreign exchange derivatives on bank's foreign currency lending. We model banks as oligopolists, in the sense that each bank chooses the foreign currency lending activity in a way analogous to Cournot competition commonly described in industrial organization (Freixas and Rochet, 2008, ch.3).

3.1 Assumptions

To focus our analysis on the linkage between foreign exchange derivatives usage and bank's foreign currency lending, we make a number of simplifying assumptions.

First, we condition our analysis on a one-period model of two banks, the local bank (called bank A) and the foreign bank (called bank B), each of which supplies homogenous foreign currency loans to the credit market in China at the end of the period under exchange rate uncertainty. In addition, we suppose that bank A also supplies the RMB (the local currency) loan, but bank B not.[①] Let L_{AF} and L_B be the foreign currency loan volume supplied by bank A and B respectively, which are both denominated in the foreign currency. Meanwhile, suppose the RMB loan volume provided by bank A, L_{AR}, is exogenously determined, thereby not a choice variable of bank A for simplicity.[②].

Second, we assume that bank A and B compete as Cournot quantity-setters in the foreign currency loan market in China and the inverse market demand of loans at the end of the period is specified by a downward-sloping function[③], $r_{LF}\left(L_{AF}+L_B\right)$, which is the gross interest rate banks charge on the foreign currency loans. In addition, to keep things simple, we assume that

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① Though since 2002 the foreign banks in China were permitted to provide the RMB loan, comparing with the local banks, the share of the RMB loan supplied by the foreign banks is very small due to their limited RMB funding sources.

② In practice, the large local banks in China, such as the "Big Four"banks of ICBC, BOC, CBC, and ABC, are stated-owned so that the RMB lending decisions are usually related to the political and other non-economic reasons rather than for-profit goals (Allen et al. 2012).

③ The assumption of a downward sloping demand curve for loans is supported by broad empirical evidence (e.g., Den Haan et al., 2007).

the banks views themselves as the price-takers in the markets of the RMB lending, the RMB deposit and the foreign currency deposit, that is, the banks take the RMB lending rate r_{LR}, the RMB deposit rate r_{DR}, and the foreign currency deposit rate r_{LF} as exogenous variables and fixed parameters.①

Third, banks fund themselves with two different types of sources: deposit and equity capital. Let K_A, denominated in RMB, and K_B, denominated in the foreign currency, be the equity capital for bank A and B respectively, and consider to be constant for the simple analysis. Besides the cost of liability funding, for bank A there are the operational cost of the RMB loan $C_A(L_{AR})$ and the foreign currency loan $C_A(L_{AF})$, both of which are denominated in RMB. In addition, the operation cost of the foreign currency loan is denoted as $C_B(L_B)$, which is quoted in the foreign currency. All the operation costs are strictly increasing and convex.

Fourth, loans are usually risky, so we suppose that λ_A denotes the share of loan portfolio of bank A, which is non-performing at the end of the period in the sense that borrowers default both on payment of interest and on repayment of principal, with $\lambda_A \in (0,1)$ as usual. Similarly, λ_B is the non-performing loan share for bank B, with $\lambda_B \in (0,1)$. For simplicity, we treat θ_A and θ_B as exogenous and not change in our model.

Fifth, suppose the prevailing spot exchange rate at the end of the period $\widetilde{S}$, expressed in units of RMB per unit of the foreign currency, is a stochastic variable and cannot be perfectly predicted ex ante②, with $\widetilde{S} > 0$. Since the foreign currency loans quoted in the foreign currency, bank A inevitably faces exchange rate risk exposure of $\widetilde{S}[(1-\lambda_A)L_{AF}r_{LF}(L_{AF}+L_B)-(\lambda_A+r_{DF})L_{AF}]$. To hedge against its foreign exchange risk exposure,

① In July 2013, the PBC removed the floor for the RMB lending rates of financial institutions (with the exception of mortgage loans). However, the banks peg the RMB lending rate strictly to the official benchmark rate. Meanwhile, China's most binding interest rate control currently is a ceiling on RMB deposit rate, and the deposit rate is usually equal to the highest policy rate set by the regulator. In addition, as the country with the largest foreign reserve, China has the ample foreign currency fund so that the foreign currency deposit rate is stable.

② Meese and Rogoff (1983 a,b, 1988) suggest that economic models are very difficult to predict exchange rate fluctuations and the random walk model maybe do better (the Meese and Rogoff puzzle).

bank A can trade infinitely divisible currency forwards position[①] X in China's foreign exchange derivatives market at the beginning of the period without any cost[②], each of which calls for delivery of F units of RMB per unit of the foreign currency at the end of the period. To focus on the bank's hedging motive, we assume that the forwards market is unbiased so that the forward exchange rate is set equal to the expected value of the end-of-period spot exchange rate, $F = E(\tilde{S})$ [③].

Sixth, the random profit of bank A the end of the period $\tilde{\pi}_A$, quoted in RMB, is given by

$$\begin{aligned}\tilde{\pi}_A =& (1-\lambda_A)\left[L_{AR}r_{DR} + \tilde{S}L_{AF}r_{LF}(L_{AF}+L_B)\right] - \lambda_A\left(L_{AR}+\tilde{S}L_{AF}\right) - (L_{AR}-K_A)r_{DR} - \tilde{S}L_{AF}r_{DF} - C_A(L_{AR}) \\ & - C_A(L_{AF}) + \left(F - \tilde{S}\right)X\end{aligned} \tag{1}$$

where a tilde "~" denotes a stochastic variable. For bank A, its ex-ante decision problem is to choose foreign currency loan volume L_B and currency forwards position X, so as to maximize the expected utility of its end-of-period profit $E[U(\tilde{\pi}_A)]$, where $U(\tilde{\pi}_A)$ is the von Neumann-Morgenstern (VNM) utility function with $U(0)=0$, $U'(\tilde{\pi}_A)>0$, and $U''(\tilde{\pi}_A)<0$. On the other hand, the profit of bank B at the end of the period, π_B, quoted in the foreign currency, is given by

$$\pi_B = (1-\lambda_B)L_B r_{LF}(L_{AF}+L_B) - \lambda_B L_B - (L_B - K_B)r_{DF} - C_B(L_B) \tag{2}$$

which is deterministic. Thus, bank B simply maximizes its end-of-period profit so that exchange rate risk plays no role in its decision making.

Last, suppose that the foreign currency loans supplied by bank A and B are strategic substitutes defined by Bulow et al. (1985)[④], so that we obtain

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① The payoff of currency futures is similar to the forward. In addition, swap can be replicated by using forwards. Thus, without any loss of generality, we restrict the firm to use currency forwards only in our model.

② Suppose there are no commission fees, margin requirements, and capital outlays. In addition, transactions in the derivatives market are costless.

③ In the literature on the currency hedging, it is usual to make the assumption that the forward or futures markets are unbiased (see Wong, 2003; Broll et al, 2009)

④ Bulow et al. (1985) state that strategic substitutes and complements are analogously defined by whether a more "aggressive" strategy by firm A (e.g., lower price in price competition, greater quantity in quantity competition, increased advertising, etc) lowers or raises firm B's marginal profits.

$$\frac{\partial^2 \tilde{\pi}_A}{\partial L_{AF} \partial L_B} = (1 - \lambda_A)\tilde{S}\left[r'_{LF}(L_{AF} + L_B) + L_{AF} r''_{LF}(L_{AF} + L_B)\right] < 0 \tag{3}$$

$$\frac{\partial^2 \pi_B}{\partial L_B \partial L_{AF}} = (1 - \lambda_B)\left[r'_{LF}(L_{AF} + L_B) + L_B r''_L(L_{AF} + L_B)\right] < 0 \tag{4}$$

Given the assumption of strategic substitutes, the reaction functions of bank A and B would be downward sloping.

The set-up is a two-stage game under the exchange rate uncertainty, wherein there are the hedging stage and the lending stage in turn. In the first stage, bank A chooses its forwards position X at the predetermined forward exchange rate F at the beginning of the period. In the second stage, given the common knowledge about the forwards position of bank A, two banks engage in Cournot competition in the foreign currency credit market and choose their foreign currency loan volumes simultaneously prior to the resolution of the exchange rate uncertainty. Selten's (1975) subgame-perfect Nash equilibrium (SPNE) with a triple, $\left[X^*, L^*_{AF}(X), L^*_B(X)\right]$, applies to our two-stage game. In SPNE, no bank can make better off by unilaterally deviating, and meanwhile $L^*_{AF}(X)$ and $L^*_B(X)$ constitute the Cournot-Nash equilibrium foreign currency loans for any possible forwards position X.

3.2 The Subgame-Perfect Nash Equilibrium

In this subsection, we demonstrate how to solve the problem of SPNE by using backward induction. In the first step, we derive the Cournot-Nash equilibrium in the lending stage in each subgame defined by every possible forwards position of bank A. In the second step, we go back to the hedging stage to solve the optimal forwards position.

3.2.1 The Lending Stage

Consider the lending stage under a subgame defined by a given forwards position of bank A. Before the exchange rate uncertainty is resolved, bank A, taking the loan volume of bank B as given, chooses the volume of foreign currency loans L_{AF} to maximize the expected utility of its end-of-period profit denominated in RMB:

$$\begin{aligned} \underset{L_{AF}}{Max} E\left[U(\tilde{\pi}_A)\right] = \underset{L_{AF}}{Max} E\Big\{U\Big[(1 - \lambda_A)\big(L_{AR} r_{DR} + \tilde{S} L_{AF} r_{LF}(L_{AF} + L_B)\big) - \lambda_A\big(L_{AR} + \tilde{S} L_{AF}\big) \\ - (L_{AR} - K_A) r_{DR} - \tilde{S} L_{AF} r_{DF} - C_A(L_{AR}) - C_A(L_{AF}) + (F - \tilde{S})X\Big]\Big\} \end{aligned} \tag{5}$$

Meanwhile, bank B, taking the foreign currency loan volume of bank A as given, chooses loan volume L_B to maximize its end-of-period profit quoted in the foreign currency:

$$\underset{L_B}{Max}\pi_B = \underset{L_B}{Max}\left[(1-\lambda_B)L_B r_{LF}(L_{AF}+L_B) - \lambda_B L_B - (L_B - K_B)r_{DF} - C_B(L_B)\right] \tag{6}$$

Assuming an interior optimum for each bank, this means that a Cournot-Nash equilibrium in the lending stage under this subgame is a pair (L_{AF}, L_B) that satisfy the two first-order conditions:

$$E\left\{U'(\tilde{\pi}_A)\left\{(1-\lambda_A)(r_{LF}+L_{AF}r'_{LF})\tilde{S} - (\lambda_A + r_{DF})\tilde{S} - C'_A(L_{AF})\right\}\right\} = 0 \tag{7}$$

$$(1-\lambda_B)(r_{LF}+L_B r'_{LF}) - \lambda_B - r_{DF} - C'_B(L_B) = 0 \tag{8}$$

To ensure the existence and uniqueness of the Cournot-Nash equilibrium, we need to impose the Hahn (1962) stability condition, $AB - CD > 0$, where

$$\begin{aligned} A = \frac{\partial^2 E[U(\tilde{\pi}_A)]}{\partial L_{AF}^2} &= E\left\{U''(\tilde{\pi}_A)\left[(1-\lambda_A)(r_{LF}+L_{AF}r'_{LF})\tilde{S} - (\lambda_A + r_{DF})\tilde{S} - C'_A(L_{AF})\right]^2\right\} \\ &+ E\left\{U'(\tilde{\pi}_A)\left[(1-\theta_A)(2r'_{LF}+L_{AF}r''_{LF})\tilde{S} - C''_A(L_{AF})\right]\right\} < 0 \end{aligned} \tag{9}$$

$$B = \frac{\partial^2 \pi_B}{\partial L_B^2} = (1-\lambda_B)(2r'_{LF}+L_B r''_{LF}) - C''_B(L_B) < 0 \tag{10}$$

$$\begin{aligned} C = \frac{\partial^2 E[U(\tilde{\pi}_A)]}{\partial L_{AF}\partial L_B} &= E\left[U'(\tilde{\pi}_A)(1-\lambda_A)(r_{LF}+L_B r'_{LF})\tilde{S}\right] \\ &+ E\left\{U''(\tilde{\pi}_A)(1-\lambda_A)L_{AF}r'_{LF}\tilde{S}\left\{\left[(1-\lambda_A)(r_{LF}+L_{AF}r'_{LF}) - \lambda_A - r_{DF}\right]\tilde{S} - C'_A(L_{AF})\right\}\right\} \end{aligned} \tag{11}$$

$$D = \frac{\partial^2 \pi_B}{\partial L_{AF}\partial L_B} = (1-\lambda_B)(r'_{LF}+L_B r''_{LF}) < 0 \tag{12}$$

Given the stability condition, we can write $[L_{AF}(X), L_B(X)]$ that solves Equation (7) and (8) simultaneously as the unique Cournot-Nash equilibrium in the subgame defined by a given forwards position of bank A.

3.2.2 The Hedging Stage

In the hedging stage, by anticipating the Cournot-Nash equilibrium in the lending stage, bank A chooses forwards position X to maximize the expected utility of its end-of-period profit:

$$\begin{aligned} \underset{X}{Max}\,E\Big\{U\Big\{&(1-\lambda_A)L_{AR}r_{DR} + (1-\lambda_A)\tilde{S}L_{AF}(X)r_{LF}(L_{AF}(X)+L_B(X)) - \lambda_A\left[L_{AR}+\tilde{S}L_{AF}(X)\right] \\ &- (L_{AR}-K_A)r_{DR} - \tilde{S}r_{DF}L_{AF}(X) - C_A(L_{AR}) - C_A(L_{AF}(X)) + (F-\tilde{S})X\Big\}\Big\} \end{aligned} \tag{13}$$

The first-order condition for Equation (13) is given by

$$E\left\{U'\left(\tilde{\pi}_A^*\right)\left\{(1-\lambda_A)\tilde{S}L'_{AF}\left(X^*\right)r_{LF}\left(L_{AF}\left(X^*\right)+L_B\left(X^*\right)\right)+(1-\lambda_A)\tilde{S}L_{AF}\left(X^*\right)\left[L'_{AF}\left(X^*\right)+L'_B\left(X^*\right)\right]\right.\right.$$
$$\left.\left.\times r'_{LF}\left(L_{AF}\left(X^*\right)+L_B\left(X^*\right)\right)-\lambda_A\tilde{S}L'_{AF}\left(X^*\right)-\tilde{S}r_{DF}L'_{AF}\left(X^*\right)-L'_{AF}\left(X^*\right)C'_A\left[L_{AF}\left(X^*\right)\right]+\left(F-\tilde{S}\right)\right\}\right\}=0 \quad (14)$$

where an asterisk (*) indicates an optimum level.

3.3 Economic Implications

In this subsection, we will make use of the unique SPNE to derive the important economic implications.

Proposition: In the Cournot-Nash equilibrium, if the VNM utility function of bank A displays either constant or decreasing absolute risk aversion[①], there is the positive effect of forwards position used by bank A on the total foreign currency loan volume in the credit market.

Proof: By differentiating Equations (7) and (8) with respect to the forwards position *X* and using Cramer's rule, we can obtain

$$\frac{dL_{AF}(X)}{dX}=-\frac{BZ}{AB-CD} \quad (15)$$

$$\frac{dL_B(X)}{dX}=\frac{DZ}{AB-CD} \quad (16)$$

where *A*, *B*, C, and *D* are defined in Equation (9), (10), (11) and (12) respectively, and *Z* is given by

$$Z=\frac{\partial^2 E\left[U\left(\tilde{\pi}_{AB}\right)\right]}{\partial L_{AF}\partial X}=E\left\{U''\left(\tilde{\pi}_A\right)\left(F-\tilde{S}\right)\left\{\tilde{S}\left[(1-\lambda_A)\left(r_{LF}+L_{AF}r'_{LF}\right)-\lambda_A-r_{DF}\right]-C'_A\left(L_{AF}\right)\right\}\right\} \quad (17)$$

Then, differentiating the total loan volume $L_{AF}+L_B$ with respect to the forwards position *X* and using Equation (15) and (16) yields

$$\frac{d\left[L_{AF}(X)+L_B(X)\right]}{dX}=\frac{dL_{AF}(X)}{dX}+\frac{dL_B(X)}{dX}=\frac{\left[C''_B\left(L_B\right)-\left(1-\lambda_B\right)r'_{LF}\right]Z}{AB-CD} \quad (18)$$

According to the assumptions of model, we can obtain $C''_B\left(L_B\right)-\left(1-\lambda_B\right)r'_{LF}>0$. Then, the stability condition ensures $AB-CD>0$. Meanwhile, in the appendix we approve that *Z* is positive when the VNM utility function of bank A satisfies either constant or decreasing absolute risk aversion. Therefore, we can obtain

① Constant or decreasing absolute risk aversion is generally a sensible restriction to impose.

$$\frac{d[L_{AF}(X)+L_B(X)]}{dX} > 0 \tag{19}$$

This completes our proof for the proposition.

The result of our theoretical model suggests that foreign exchange derivatives contracts allow China's banks to lessen their systematic exposures to changes in the RMB exchange rates with the gradual reform of the exchange rate regime, thereby strengthening their ability to provide more financial intermediation services.

4. Empirical Evidence

Section 3 only suggests the possible outcomes theoretically regarding the positive effect of foreign exchange derivatives on bank lending, and this type of problem is inherently empirical. Hence, this section uses Vector Autoregression (VAR) model in order to analyze how foreign exchange derivatives promote the foreign currency lending in China. There are three reasons why China was chosen for the empirical study. First, China has the world's second largest economy and belongs to the emerging market. Second, foreign exchange derivatives have been in use there for almost a decade, thus providing sufficient time series data. Last but not least, compared with the developed countries and other major emerging economies, China's financial system has been dominated by a large banking sector.

4.1 Vector Autoregression Models Methodology

Compared to large-scale macroeconomic models, VAR model is a useful tool to capture the linear interdependencies among multiple time series because it does not require as much knowledge about the forces influencing a variable as do structural models with simultaneous equations. The only prior knowledge required is a list of variables which can be hypothesized to affect each other intertemporally. The basic method involves regressing each variable on every variable, including itself, lagged up to a given length. Impulse response functions (IRF) and variance decompositions are easily computed from VAR estimates.

Our VAR model specification, following Sims' (1980) method on VAR, can be written in matrix form as

$$y_t = k + A(L)y_{t-1} + Bx_t + \mu_t \tag{20}$$

where y_t is the vector of endogenous variables, k the vector of constants, x_t the vector of exogenous variables, and μ_t the vector of serially uncorrelated disturbances with a zero mean and a time invariant covariance matrix. In addition, *A* and *B* are coefficient matrices, *L* is the lag-operator.

In our VAR model specification, the vector of endogenous variables y_t consists of two variables: the foreign currency loan volume in China (FCL_t) and the transaction volume of China's foreign exchange derivatives market (FXD_t):

$$y_t = \left(FCL_t, FXD_t\right) \tag{21}$$

Meanwhile, throughout our paper, the exogenous vector x_t is assumed to contain change in nominal RMB effective exchange rate index (ΔRMB_t) and China's import volume ($Import_t$):

$$y_t = \left(\Delta RMB_t, Import_t\right) \tag{22}$$

which are included to control for fluctuations in the value of RMB, and the demands for the foreign currency lending[①]. Given that the foreign exchange derivatives and bank lending are unlikely to have the significant impact on the RMB exchange rate and China's import level, these variables (i.e. ΔRMB_t and $Import_t$) are treated as exogenous. So we allow for a contemporaneous impact of the exogenous on the endogenous variables, but not for a feedback.

The VAR model is estimated in levels, using monthly data over the period from Jan 2007 to Jun 2014. Meanwhile, in order to reduce heteroscedasticity, all variables except change in RMB exchange rate are transformed into natural logarithms. Data for the foreign currency loan volume and the import volume are obtained from China Economic & Industry Data Database (CEIC). Data for the transaction volume of foreign exchange derivatives market is obtained from CFETS. The nominal RMB effective exchange rate index is taken from Bank for International Settlements database. Time series of the variables describe in Figure 2.

4.2 Empirical Results

4.2.1 Unit Root Test

① For example, foreign investment enterprises and domestic enterprises assembling imported components have strong needs for foreign-currency-denominated funds in China.

Most economic variables that exhibit strong trends are not stationary with the unit roots, which will cause the spurious results with classical significance tests incorrectly identifying significant relationships between the variables. Therefore, as a first step in the analysis we test the series for unit roots using Augmented Dickey–Fuller (ADF, 1981) test. Null hypothesis of the test is that the variable has a unit root. The test results are shown in Table 2, which suggest that each variable has not a unit root and is stationary.

4.2.2 Causality Tests

To examine the lead-lag relationships between the foreign currency loans and the foreign exchange derivatives transaction, we perform pairwise Granger causality tests (Granger, 1969). The key step is to determine the maximum lag (order) of the VAR model. We use standard information criteria to determine the lag length of the VAR, and based on the Hannan-Quinn criterion (HQ) and the Schwarz information criterion (SIC) the lag order turns out to be two[①]. Table 4 presents the results for the Granger-causality tests, which shows that the foreign exchange derivative market transaction has bi-directional Granger causality with the foreign currency loan volume at 5% confidence level. This result is consistent with the notion that derivatives market has influence on bank credit supply, and while bank lending activity can also affect its decision to use derivatives for risk management.

4.2.3 Impulse Response Analysis

No root lies outside the unit circle (see Table 4 and Figure 3), which imply that VAR satisfies the stability condition. In order to evaluate the dynamical interactions between the foreign exchange derivatives market transaction and the foreign currency loan volume, we use the analysis with generalized impulse response function (GIRF, Pesarana and Shin, 1998) based on the VAR model. Figure 4 displays the effect (the impulse response) of a one-standard deviation foreign exchange derivatives transaction change—defined as an exogenous, unexpected, temporary rise in the foreign exchange derivatives market transaction at *t=0*—on the foreign currency loan with a 95 percent confidence band. Figure 5 displays the impact of a one-standard deviation foreign currency loan shock—defined as an exogenous, unexpected,

[①] We disregard the Akaike information criterion (AIC) as it asymptotically overestimates the order with some probability, whereas HQ estimates the order consistently and SIC is even strongly consistent under fairly general conditions (see, for example, Lütkepohl, 2005).

temporary rise in the foreign currency loan—on the foreign exchange derivatives transaction with a 95 percent confidence band.

Figure 4 suggests that the foreign exchange derivatives transaction has a significantly and persistently positive effect on the foreign currency loan volume, which is in line with prediction by the theoretical model built in section 3. In the detail, an unexpected and temporary rise in the foreign exchange derivatives transaction is followed by the bank lending expansion, with the effect peaking at 5 to 7 months and remaining positive for over 36 months after the shock. This result is consistent with the notion that derivatives markets allow banks to increase lending activities at a greater rate than they would have otherwise.

Likewise, Figure 5 indicates that foreign currency loan volume has a significantly and persistently positive impact on the derivatives market transaction. An unexpected and temporary rise in the loan volumes tends to be followed by increase in foreign exchange derivatives transaction, with the effect peaking at first month after the shock and then almost decreasing gradually. This result can be explained by the risk management functions of foreign exchange derivatives. Larger foreign currency loan usually undertakes more exchange rate risk exposures, and as the consequence banks are more likely to hedge these risks by derivative contracts.

4.2.4 Variance Decomposition

The variance decomposition indicates the amount of information each variable contributes to the other variables in VAR model. It determines how much of the forecast error variance of each of the variables can be explained by exogenous shocks to the other variables. We use the variance decomposition method to gauge the relative importance of foreign exchange derivatives transaction for variations in bank's foreign currency loan volume. The results of the variance decomposition are presented in Figure 6.

As Figure 6 suggest, concerning the response of the foreign currency loan volumes to its own shock, the explanation of the forecast error variance is about 95% in the first month, while the influence of the foreign exchange derivatives transaction shock is 5%. Furthermore, the result shows that influence of derivatives transaction increase gradually during 15 months after the shock. In the long run derivatives transaction accounts for more than 40 percent of the variations in the foreign currency loan volumes, while less than 60 percent of the fluctuations in loan volumes can be attributed to itself. Hence, consistent with the impulse response analysis, foreign exchange derivative market plays the significant role in the foreign currency credit supply in China's bank sector.

5. Conclusion

Our paper examines the effect of foreign exchange derivatives on bank's foreign currency lending in China theoretically and empirically. We builds a theoretical model capturing the main characteristics of the China's banking sector, in which banks choose the foreign currency lending volumes in a way analogous to Cournot competition commonly described in industrial organization. We find the positive effect of foreign exchange derivatives position on the total foreign currency loan volume in the credit market under the condition that the von Neumann-Morgenstern utility function of derivatives-use bank displays either constant or decreasing absolute risk aversion.

In the empirical section, we use Vector Autoregression (VAR) model with China's monthly data over the period from Jan 2007 to Jun 2014. The Granger-causality tests show that the foreign exchange derivatives transaction has bi-directional Granger causality with the foreign currency loan volume at 5% confidence level. The generalized impulse response function indicates that the derivatives market has a significantly and persistently positive effect on bank lending denominated in foreign currency. Meanwhile, the variance decomposition displays that the derivatives market transaction account for over 40 percent of variations in the foreign currency loan volume in the long run.

Our findings confirm the general efficiency enhancing implications of new risk management techniques in a world with frictions suggested in the theoretical literature, and complement empirical findings of positive impacts on loan supplies from China's data. Our findings suggest that China's banks hedge their marketable risk (i.e., exchange rate risk), in order to further their intermediation activity (their main area of expertise) and to absorb a greater level of credit risk. Our results also imply that government restrictive policies for banks' derivatives activity will have the negative consequences for bank credit supply.

Although financial derivative securities are powerful instruments for transferring and hedging risk, they also allow agents to quickly and cheaply take speculative risk (Gorton and

Rosen, 1995). The impact of China's banks involvement in derivatives market on the financial system stability as a whole remains the main question that raises the anxiety of both regulators and market participants. There will be always a room for further researches on the trade-off between expected benefits and potential externalities of the existence of such financial innovations-based market, in particular in the aftermath of every repeated financial crisis.

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Table 1

Adjustments of RMB Exchange Rate Band on Inter-Bank Spot Exchange-Rate Market

Date	Scope of Exchange Rate	Daily Floating Band
Jan 1994	RMB against US Dollar	Set as 0.3%
Jul 2005	RMB against non-US Dollar currencies	Set as 1.5%
Sep 2005	RMB against non-US Dollar currencies	Enlarged from 1.5% to 3%.
May 2007	RMB against US Dollar	Enlarged from 0.3% to 0.5%.
Apr 2012	RMB against US Dollar	Enlarged from 0.5% to 1%.
Mar 2014	RMB against US Dollar	Enlarged from 1% to 2%.
Jul 2014	RMB against Malaysia Ringgit and Russian Ruble	Enlarged from 3% to 5%

Source: *The People's Bank of China.*

Table 2: Results of ADF Test

Variable Name	Constant	Trend	P	t-Statistic	Prob.	Conclusion
$LnFCL_t$	Yes	Yes	3	-4.617796	0.0018	Stationary
$LnFXD_t$	Yes	Yes	0	-5.198465	0.0002	
ΔRMB_t	No	No	0	-5.954710	0.0000	
$Ln\,Im\,port_t$	Yes	Yes	0	-4.639385	0.0017	

Note: *Lag Length (P) is automatic based on* Schwarz *information criterion (SIC).*

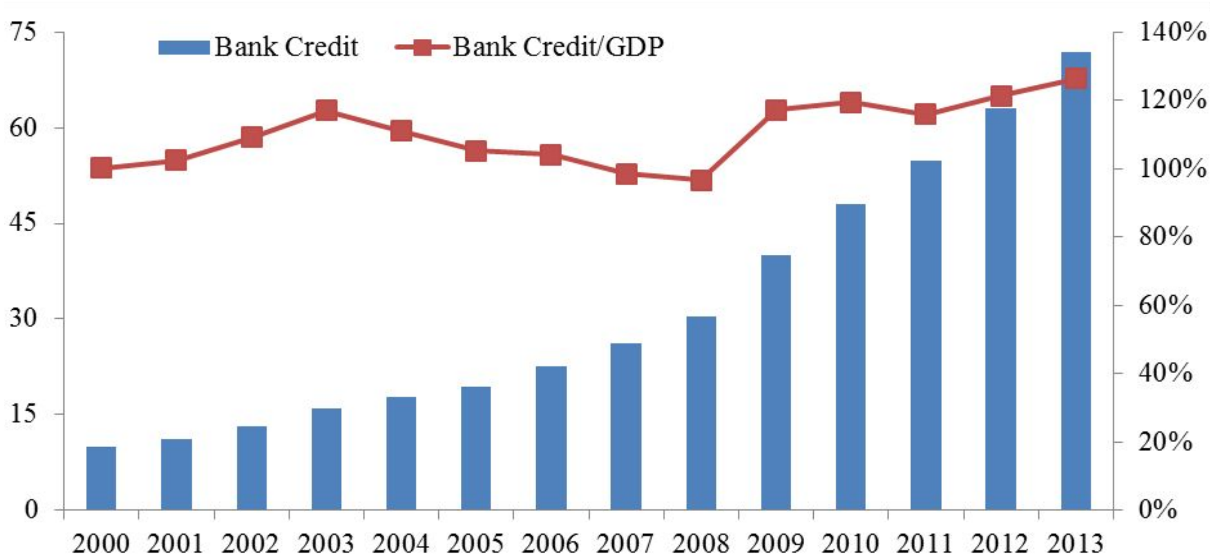
Table 3: Results of Pair-Wise Granger Causality Test

Pair	Null Hypothesis	t-Statistic	Prob.
$LnFCL_t$ & $LnFXD_t$	$LnFCL_t$ does not cause $LnFXD_t$	3.45717	0.0361
	$LnFXD_t$ does not cause $LnFCL_t$	5.28002	0.0069

Table 4: Roots of Characteristic Polynomial

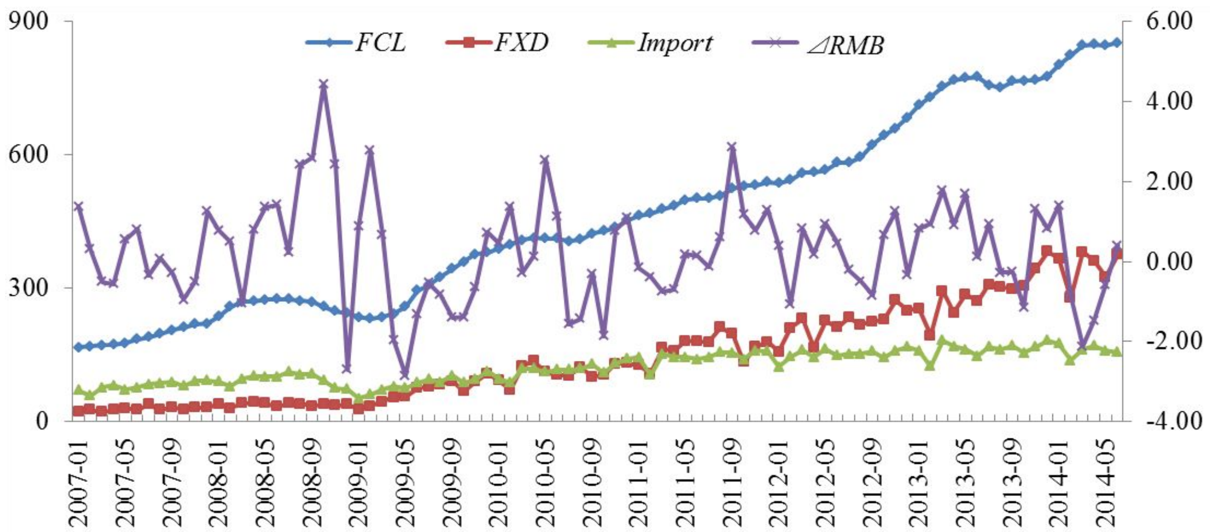
Root	Modulus
0.929451	0.929451
0.574632 - 0.176357i	0.601085
0.574632 + 0.176357i	0.601085
-0.315751	0.315751

Figure 1: Bank Credit Volumes and Bank credit/GDP in China: 2000-2013



Note: *The left axis measures bank credit volume (in trillions of RMB), and the right axis measures the ratio of bank credit volume to GDP.*
Data source: *Statistical Yearbooks of China.*

Figure 2: Time Series of Variables (Not Transformed into Natural Logarithms)



Note: *The left axis measures foreign currency loan volume, foreign exchange derivatives transaction volume and import volume (in billions of USD), and the right axis measures the changes in the nominal RMB effective exchange rate index.*
Data source: *CEIC, CFETS, Bank for International Settlements.*

Figure 3: Inverse Roots of AR Characteristic Polynomial

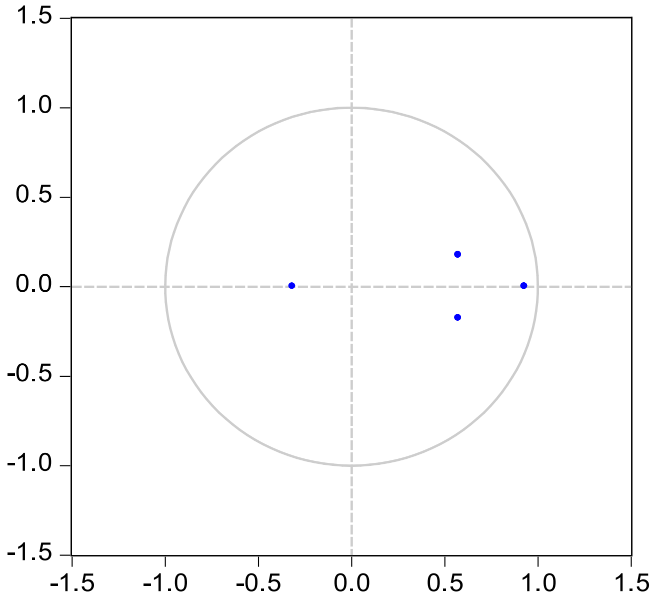
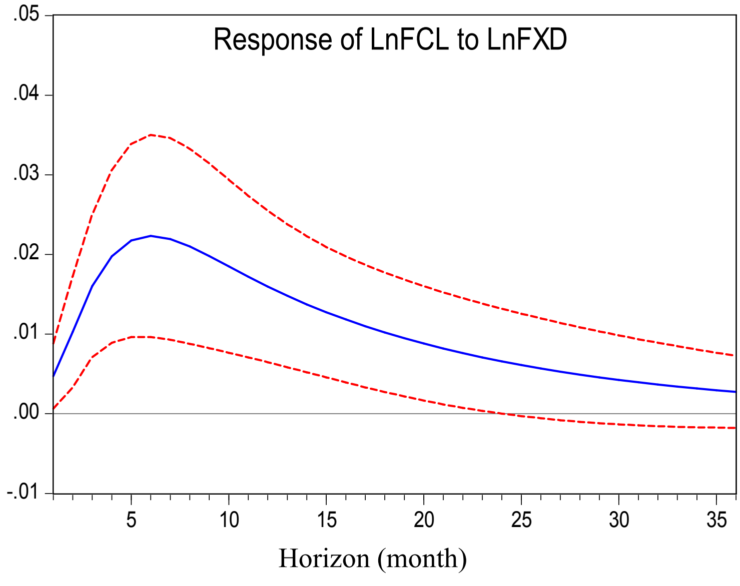
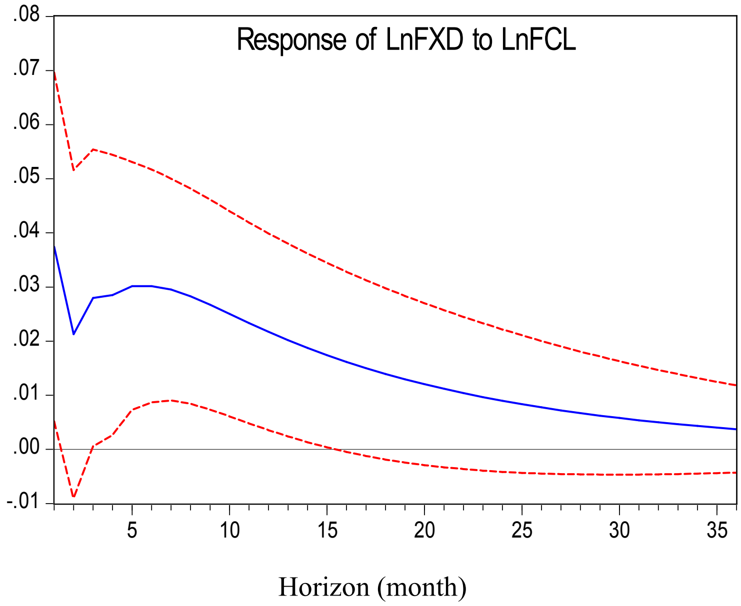


Figure 4: Response of $LnFCL_t$ **to** $LnFXD_t$



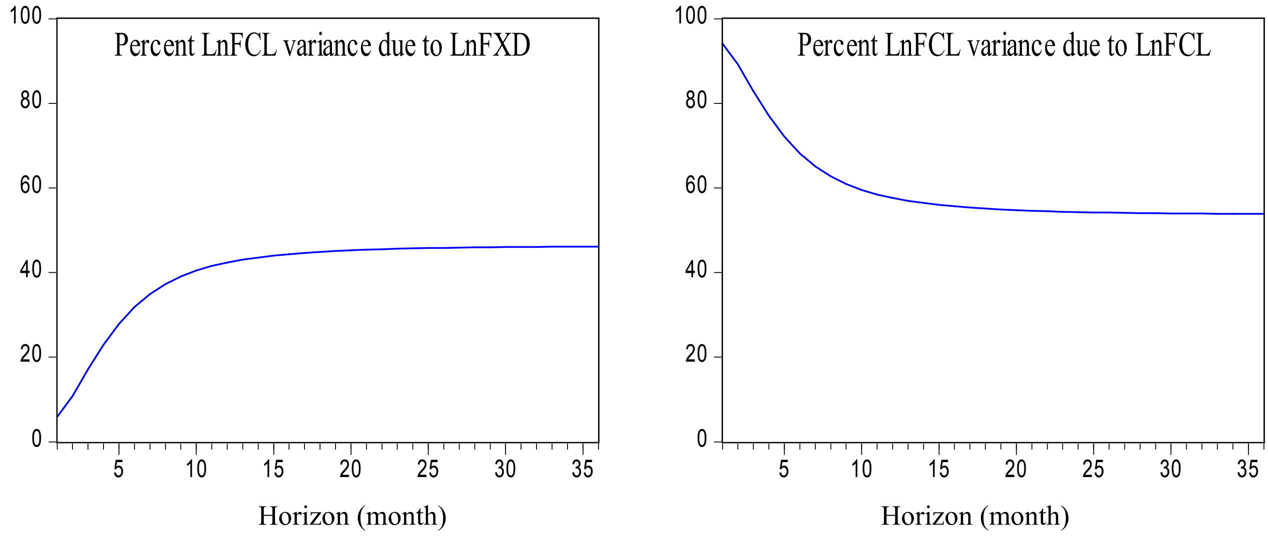
Note: *The dotted lines show the 95 percent confidence band, derived by bootstrapping.*

Figure 5: Response of $LnFXD_t$ to $LnFCL_t$



Note: *The dotted lines show the 95 percent confidence band, derived by bootstrapping.*

Figure 6: Results of the Variance Decomposition



Appendix

This appendix demonstrates that Equation (17) is positive, $Z > 0$, if the VNM utility function of bank A displays either constant or decreasing absolute risk aversion.

Because the currency forwards market is unbiased (i.e. $F = E(\tilde{S})$), Equation (17) can be rewritten as:

$$\begin{aligned} Z = & -\frac{E\left\{U''(\tilde{\pi}_A)\left\{\tilde{S}[(1-\lambda_A)(r_{LF}+L_{AF}r'_{LF})-\lambda_A-r_{DF}]-C'_A(L_{AF})\right\}^2\right\}}{(1-\lambda_A)(r_{LF}+L_{AF}r'_{LF})-\lambda_A-r_{DF}} \\ & +\frac{E(\tilde{S})[(1-\lambda_A)(r_{LF}+L_{AF}r'_{LF})-\lambda_A-r_{DF}]-C'_A(L_{AF})}{(1-\lambda_A)(r_{LF}+L_{AF}r'_{LF})-\lambda_A-r_{DF}}E\left\{U''(\tilde{\pi}_A)\left\{\tilde{S}[(1-\lambda_A)(r_{LF}+L_{AF}r'_{LF})-\lambda_A-r_{DF}]-C'_A(L_{AF})\right\}\right\} \end{aligned} \tag{A1}$$

Since $U''(\tilde{\pi}_A) < 0$ and $(1-\lambda_A)(r_{LF}+L_{AF}r'_{LF})-\lambda_A-r_{DF} > 0$ [①], the first term on the right-hand side of Equation (A1) is positive.

Then, we show that the second term is not negative. Using the covariance operator[②], we can rewrite Equation (7) as

$$\frac{E(\tilde{S})[(1-\lambda_A)(r_{LF}+L_{AF}r'_{LF})-\lambda_A-r_{DF}]-C'_A(L_{AF})}{(1-\lambda_A)(r_{LF}+L_{AF}r'_{LF})-\lambda_A-r_{DF}} = -\frac{Cov[U'(\tilde{\pi}_A),\tilde{S}]}{E[U'(\tilde{\pi}_A)]} \tag{A2}$$

Let $\rho(\tilde{\pi}_A) = -U''(\tilde{\pi}_A)/U'(\tilde{\pi}_A)$ be the Arrow-Pratt measure of absolute risk aversion for bank A （Arrow,1970; Pratt,1964）, also known as the coefficient of absolute risk aversion, and let $\hat{\pi}_A$ be $\tilde{\pi}_A$ evaluated at $\hat{S} = C'_A(L_{AF})/[(1-\lambda_A)(r_{LF}+L_{AF}r'_{LF})-\lambda_A-r_{DF}]$. Using Equation (7), we can obtain

$$\begin{aligned} & E\left\{U''(\tilde{\pi}_A)\left\{\tilde{S}[(1-\lambda_A)(r_{LF}+L_{AF}r'_{LF})-\lambda_A-r_{DF}]-C'_A(L_{AF})\right\}\right\} \\ & = E\left\{U'(\tilde{\pi}_A)[\rho(\hat{\pi}_A)-\rho(\tilde{\pi}_A)]\left\{\tilde{S}[(1-\lambda_A)(r_{LF}+L_{AF}r'_{LF})-\lambda_A-r_{DF}]-C'_A(L_{AF})\right\}\right\} \end{aligned} \tag{A3}$$

Thus, the second term on the right-hand side of Equation (A1) can write as

$$\begin{aligned} & \frac{E(\tilde{S})[(1-\lambda_A)(r_{LF}+L_{AF}r'_{LF})-\lambda_A-r_{DF}]-C'_A(L_{AF})}{(1-\lambda_A)(r_{LF}+L_{AF}r'_{LF})-\lambda_A-r_{DF}}E\left\{U''(\tilde{\pi}_A)\left\{\tilde{S}[(1-\lambda_A)(r_{LF}+L_{AF}r'_{LF})-\lambda_A-r_{DF}]-C'_A(L_{AF})\right\}\right\} \\ & = -\frac{Cov[U'(\tilde{\pi}_A),\tilde{S}]}{E[U'(\tilde{\pi}_A)]}E\left\{U'(\tilde{\pi}_A)[\rho(\hat{\pi}_A)-\rho(\tilde{\pi}_A)]\left\{\tilde{S}[(1-\lambda_A)(r_{LF}+L_{AF}r'_{LF})-\lambda_A-r_{DF}]-C'_A(L_{AF})\right\}\right\} \end{aligned} \tag{A4}$$

---

① Since $U'(\tilde{\pi}_A) > 0$ and $C'_A(L_{AF}) > 0$, if $(1-\lambda_A)(r_{LF}+L_{AF}r'_{LF})-\lambda_A-r_{DF} < 0$, we will arrive at $E\left\{U'(\tilde{\pi}_A)\left\{(1-\lambda_A)(r_{LF}+L_{AF}r'_{LF})\tilde{S}-(\lambda_A+r_{DF})\tilde{S}-C'_A(L_{AF})\right\}\right\}<0$, which is contradictory to Equation (7). Meanwhile, Equation (8) also shows $(1-\lambda_B)(r_{LF}+L_Br'_{LF})-\lambda_B-r_{DF} = C'_B(L_B) > 0$. Therefore it is sensible to conclude $(1-\lambda_A)(r_{LF}+L_{AF}r'_{LF})-\lambda_A-r_{DF} > 0$.

② For any two random variables, *X* and *Y*, we have $Cov(X,Y) = E(XY) - E(X)E(Y)$.

Consider two scenarios to assess the symbols of Equation (A4).

Scenario 1: The VNM utility function of bank A displays constant absolute risk aversion (CARA).

In Scenario 1, $\rho(\tilde{\pi}_A)$ equals a constant for all $\tilde{\pi}_A$ (i.e. $\rho(\tilde{\pi}_A) = \rho(\hat{\pi}_A)$) so that Equation (A4) is equal to zero. It follows the second term on the right-hand side of Equation (A1) vanishes and thus $Z > 0$.

Scenario 2: The VNM utility function of bank A displays decreasing absolute risk aversion (i.e. $\frac{d\rho(\tilde{\pi}_A)}{d\tilde{\pi}_A} < 0$).

In Scenario 2, since $\frac{\partial \tilde{\pi}_A}{\partial \tilde{S}} = [(1-\lambda_A)r_{LF} - \lambda_A - r_{DF}]L_{AF} - X$, we discuss the following three sub-scenario to assess the symbols of Equation (A4).

Sub-scenario 2.1: $\frac{\partial \tilde{\pi}_A}{\partial \tilde{S}} > 0$ (i.e. $[(1-\lambda_A)r_{LF} - \lambda_A - r_{DF}]L_{AF} > X$). Since $U''(\tilde{\pi}_A) < 0$, we have $Cov[U'(\tilde{\pi}_A), \tilde{S}] < 0$.

If $\tilde{S} > \hat{S}$, we can obtain $\tilde{S}[(1-\lambda_A)(r_{LF} + L_{AF}r'_{LF}) - \lambda_A - r_{DF}] - C'_A(L_{AF}) > 0$ and $\rho(\tilde{\pi}_A) < \rho(\hat{\pi}_A)$. Therefore, Equation (A4) is positive.

If $\tilde{S} < \hat{S}$, we can obtain $\tilde{S}[(1-\lambda_A)(r_{LF} + L_{AF}r'_{LF}) - \lambda_A - r_{DF}] - C'_A(L_{AF}) < 0$ and $\rho(\tilde{\pi}_A) > \rho(\hat{\pi}_A)$. Therefore, Equation (A4) is positive too.

If $\tilde{S} = \hat{S}$, we can obtain $\rho(\tilde{\pi}_A) = \rho(\hat{\pi}_A)$. Therefore, Equation (A4) is zero.

Sub-scenario 2.2: $\frac{\partial \tilde{\pi}_A}{\partial \tilde{S}} < 0$ (i.e. $[(1-\lambda_A)r_{LF} - \lambda_A - r_{DF}]L_{AF} < X$). Since $U''(\tilde{\pi}_A) < 0$, we have $Cov[U'(\tilde{\pi}_A), \tilde{S}] > 0$.

If $\tilde{S} > \hat{S}$, we can obtain $\tilde{S}[(1-\lambda_A)(r_{LF} + L_{AF}r'_{LF}) - \lambda_A - r_{DF}] - C'_A(L_{AF}) > 0$ and $\rho(\tilde{\pi}_A) > \rho(\hat{\pi}_A)$. Therefore, Equation (A4) is positive.

If $\widetilde{S} < \hat{S}$, we can obtain $\widetilde{S}[(1-\lambda_A)(r_{LF} + L_{AF} r'_{LF}) - \lambda_A - r_{DF}] - C'_A(L_{AF}) < 0$ and $\rho(\widetilde{\pi}_A) < \rho(\hat{\pi}_A)$. Therefore, Equation (A4) is positive too.

If $\widetilde{S} = \hat{S}$, we can obtain $\rho(\widetilde{\pi}_A) = \rho(\hat{\pi}_A)$. Therefore, Equation (A4) is zero.

Sub-scenario 2.3: $\frac{\partial \widetilde{\pi}_A}{\partial \widetilde{S}} = 0$ (i.e. $[(1-\lambda_A) r_{LF} - \lambda_A - r_{DF}] L_{AF} = X$). We can obtain $Cov[U'(\widetilde{\pi}_A), \widetilde{S}] = 0$, and furthermore Equation (A4) is equal to zero.

Based on the analysis of Scenario 1 and 2, we can ensure that Equation (17) is positive, *Z* > 0, if the VNM utility function of bank A displays either constant or decreasing absolute risk aversion.