Korea and the World Economy, Vol. 14, No. 2 (August 2013) 207-233

Some Evidence on the Asymmetry of Interest Rate Pass-Through in Asian Economies*

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In this paper, we empirically investigate interest rate pass-through (IRPT) from policy rates to bank lending rates in eight Asian countries by employing nonlinear autoregressive distributed lag (NARDL) model developed by Shin, Yu, and Greenwood (2009), which allows us to capture both short-term and long-term asymmetries in transmission process. We find incomplete pass-through in Hong Kong, Indonesia, Thailand and the Philippines to varying degrees and in Japan in a limited case, which may come from a mixture of several factors such as fixed menu costs, high switching costs, imperfect competition and asymmetric information. We find over pass-through in Korea, which suggests that Korean banking sector is highly competitive. Regarding long-run asymmetry, we are able to find positive long-run asymmetric pass-through for Hong Kong and Korea and negative one for Indonesia and Thailand. Banks in Korea and Thailand also exhibit asymmetries in the speed of adjustment. We are not able to find any meaningful interest rate pass-through in Malaysia and Singapore.

JEL Classification: C1, C5, G2

Keywords: interest rate pass-through (IRPT), transmission mechanism, nonlinear autoregressive distributed lag(NADRL) model, asymmetric cointegrating relationships, asymmetric dynamic multipliers

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* Received November 14, 2012. Revised July 17, 2013. Accepted August 7, 2013. This paper is sponsored by Dong-A research fund in 2013.

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1. INTRODUCTION

One of the most important channels of monetary policy in an economy is the interest rate channel. After the monetary authority determines policy rates, the policy rates directly influence short-term money market rates. The short-term money market rates, in turn, affect medium to long-term market rates and bank retail rates, such as deposit or lending interest rates. Bank retail rates have a direct effect on the supply of and demand for funds in an economy, which eventually influences the growth and inflation of the economy. If the interest rate pass-through (IRPT) from policy-controlled rates to retail deposit or lending rates is incomplete or sluggish, then the use of monetary policy as a major tool for modifying aggregate demand in the economy becomes questionable.

Although many theories have been advanced to explain the IRPT from policy rates to bank retail rates, there have always been some questions as to whether data are consistent with the theories. Previous empirical research in this area often failed to confirm a cointegrating relationship between relevant interest rates. While some researchers have found IRPT from policy rates to bank retail rates not only to be incomplete and sluggish, but also to be asymmetric, their conclusions, however, have been controversial with regards to the size, speed of adjustment and asymmetric nature of the transmission mechanism (Cottarelli and Kourelis, 1994; Mojon, 2000; Angeloni and Ehrmann, 2003; De Bondt, 2002, 2005; Kwapil and Scharler, 2006).

In this paper, we investigate IRPT from policy rates to bank lending rates by employing the nonlinear autoregressive distributed lag (NARDL) model for Asian sample countries. NARDL model, developed by Shin, Yu, and Greenwood (2009), allows us to capture both short-run and long-run asymmetries in the transmission mechanism by modeling the long-run relationship and the pattern of dynamic adjustment simultaneously in a coherent manner.

While previous research has extensively focused on advanced markets such as U.S. or European markets, empirical research on Asian markets is scarce. Asian countries, in general, have bank-based financial systems, where retail rates play more important role than they do in a market-based system like the U.S. We analyze the IRPT behavior in eight Asian countries, such as Hong Kong, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, and Thailand, which would shed new light regarding interest rate pass-through mechanisms.

This paper is organized as follows: section 2 provides theoretical explanations for the price rigidity of interest rate pass-through and literature survey. Section 3 describes the methodology and data employed in this study. Section 4 presents empirical findings and section 5 concludes.

2. INTEREST RATE PASS-THROUGH: LITERATURE SURVEY

The mechanism of IRPT can be described in three sequential stages. In the first stage, the monetary policy changes exercised by the central bank directly influences short-term market interest rates by maneuvering money market conditions. Next, the short-term rates have an effect on long-term market interest rates and retail bank interest rates to different degrees. Finally, banks' decisions on the yields of their assets and liabilities affect the investment and financing behavior of deposit holders and borrowers, thus real economic activities.

Researchers have been using two different approaches to explain the IRPT mechanisms: cost of funds approach and monetary policy approach. The cost of funds approach is based on the price-setting decision of banks as indicated by the following equation:

$$y_t = \alpha + \beta x_t, \tag{1}$$

where y_t is the lending rate charged by a bank, α is a constant mark-up, and x_t is the marginal cost approximated by a given market interest rate. The β coefficient stands for the demand elasticity of bank loans with respect to the corresponding bank interest rate. If demand for loans is not fully elastic, the β coefficient in equation (1) is expected to be less than 1. Also, imperfect substitution between bank lending (deposit) and other long-term external financing such as equity and bonds of the same maturity (money market instruments) can cause the value of β coefficient to be less than 1. The underlying idea of the cost of funds approach is that market interest rates are the most appropriate marginal cost, because they accurately reflect the marginal funding costs borne by banks.[1)]

Under the monetary policy approach, researchers have sought to explain the IRPT mechanism by examining the direct relationship between policy rates and retail rates. Assuming that the yield curve of an economy is stable, they search for a co-integrating relationship between policy rates and retail rates. Since the transmission mechanism of monetary policy affects banks' cost of funds, the monetary policy approach is closely related to the cost of funds approach. In this paper, we adopt the monetary policy approach.

Previous researches indicate that the pass-through from policy or market rates to retail rates is sluggish and incomplete (see Cottarelli and Kourelis, 1994; Mojon, 2000; De Bondt, 2002, 2005; Kwapil and Schaler, 2006). Some studies show that the transmission from monetary policy rates to retail rates become quicker and more complete in the recent past, whereas others reach the opposite conclusion.

The price rigidity may come from a mixture of several factors, such as fixed menu costs, high switching costs, imperfect competition, and asymmetric information. Changes in market structure also serve as a factor for the interest rate transmission mechanism. Under the menu costs hypothesis, Dutta, Bergen, Levy, and Venable (1999) show that firms are reluctant to re-quote the prices of their products if the changes in the prices are considered to be very small or temporary in nature. Under the switching

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[1)] In this case, the retail bank rates and the market rates must be of comparable maturity to avoid problems of maturity mismatches.

cost hypothesis, Hefferman (1977) shows that uninformed customers are less likely to switch their financial products and institutions in search of the best price or yield when they face high switching costs.

The imperfect competition hypothesis states that administered interest rates are likely to be adjusted more slowly in an uncompetitive market. Examining the deposit rate setting behavior of U.S. commercial banks, Hannan and Berger (1991) show that firms in more concentrated markets exhibit greater price rigidity. The asymmetric information hypothesis asserts that banks, when they need to raise their loan rates in response to the rise of market interest rates, encounter both adverse selection and moral hazard problems and consequently are reluctant to raise their loan rates significantly over a short period of time (Stiglitz and Weiss, 1981). As a result, banks are more likely to ration the amount of credit extended when there is upward pressure on loan rates, making bank loan rates to be more rigid upwards.[2)]

Some studies relate IRPT heterogeneity to structural differences in each country's financial system. If several large banks dominate a country's banking industry as a result of financial restructuring, it can decrease the pass-through of policy rates to bank lending rates. On the other hand, bank consolidation can increase the effectiveness of IRPT by speeding up the information process and consequently incurring faster transmission of interest rate changes across different financial sectors of a given economy.

The majority of previous studies use linear (or symmetric) models to address the IRPT mechanism. The traditional linear co-integration and error-correction model (ECM), however, is biased since the model does not take into account the fact that market structure or the asymmetry of market information may make the pass-through process nonlinear.

When some research focuses on the asymmetry in interest pass-through, however, they fail to establish a consensus over the nature of asymmetry. Using the ordered probit model, Dueker and Thornton (1994) and Dueker

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[2)] On the other hand, if bank credit is not rationed and consists of relatively risky loans, interest rates on the loans will be very sensitive to the changes in the market rates.

(2000) find positive asymmetry in the U.S. They show that prime bank rates are more likely to change when policy rates rise rather than when they fall. Gropp, Sørensen, and Lichtenberger (2007) show that the loan rates in the Euro area tend to adjust more rapidly to changes in market rates when market rates move upwards than when they move downwards, even though the asymmetry is not statistically significant. In contrast, Sellon (2002) finds negative asymmetry in the U.S., which he attributes to new financial products and lower refinancing costs.

Concerning the IRPT of Asian economies, Wang and Lee (2009) examine interest rate pass-through in nine Asian countries along with the U.S. for the period of January 1988 to December 2004. Employing the asymmetric threshold cointegration test approach proposed by Enders and Siklos (2001), they find that the complete pass-through exists only in the U.S. deposit rate, and that the lending rates in Hong Kong, Philippines, and Taiwan show downward adjustment rigidity.

The failure to establish a consensus over the nature of asymmetry might be linked to the failure to distinguish between short-run and long-run asymmetries. As De Bondt (2005) points out, market structure and asymmetric information costs can have long-term effects on the interest rate pass-through mechanism, and switching costs play an important role in the short-term adjustment process of bank rates to the changes in market interest rates. Greenwood, Shin, and Treeck (2011) applies the nonlinear autoregressive distributed lag (NARDL) model by Shin *et al*. (2009) with which they can disentangle long-run asymmetry from short-run asymmetry in the IRPT mechanism. Their estimation result shows that long-term market rates in the U.S. have similar types of asymmetric relationship with the short-term rates as long-term bank lending rates do in Germany.

3. ECONOMETRIC METHODOLOGY: THE NON-LINEAR ARDL (NARDL) MODEL

3.1. Nonlinear Autoregressive Distributed Lag Model

The nonlinear autoregressive distributed lag (NARDL) model is an asymmetric extension of the linear ARDL approach to modeling long-run level relationships. Developed by Pesaran, Shin, and Smith (2001) and advanced by Shin, Yu, and Greenwood (2009), NARDL model introduces nonlinearity by means of partial sum decompositions. By modeling the long-run relationship and the pattern of dynamic adjustment simultaneously in a coherent manner, NARDL allows to capture both the short-run and long-run asymmetries in the transmission mechanism. The asymmetric co-integrating relationship is defined as

$$y_t = \beta^+ X_t^+ + \beta^- X_t^- + \mu_t, \tag{2}$$

where y_t is a $k \times 1$ vector of lending rates at time *t*, X_t is a $k \times 1$ vector of policy-controlled or market rate. X_t^+ and X_t^- are partial sum process of positive (+) and negative (–) changes in X_t and defined as follows;

$$X_t^+ = \sum\nolimits_{j=1}^{t} \Delta X_j^+, \ X_t^- = \sum\nolimits_{j=1}^{t} \Delta X_j^-, \tag{3}$$

$$\Delta X_j^+ = \max(\Delta X_t, \ 0), \ \ \Delta X_j^- = \min(\Delta X_t, \ 0). \tag{4}$$

β^+ and β^- in equation (2) are the associated asymmetric long-run parameters, indicating that lending rates respond asymmetrically during the rising and falling periods of market interest rates. Embedding the ARDL(*p*, *q*) extension to equation (2), Shin *et al*. (2009) obtains the following error correction model associated with the asymmetric cointegrating relationship as in equation (5), which is referred to as the nonlinear autoregressive distributed lag (NARDL) model.

$$\Delta y_t = \rho y_{t-1} + \theta^+ X_{t-1}^+ + \theta^- X_{t-1}^- + \sum_{j=1}^{p-1} \varphi_j \Delta y_{t-j} + \sum_{j=0}^{q} (\pi_j^+ \Delta X_{t-j}^+ + \pi_j^- \Delta X_{t-j}^-) + \varepsilon_t. \qquad (5)$$

The proposed nonlinear ARDL (NARDL) model enables to analyze the dynamic characteristics of the model. The long-term coefficients can be calculated using the relationship of $L_X^+ = -\theta^+ / \rho$ and $L_X^- = -\theta^- / \rho$. NARDL model has a number of advantages over the existing class of regime-switching techniques. First, once the regressor, X_t are decomposed into X_t^+ and X_t^-, equation (5) can be estimated by standard OLS. Second, the null hypothesis of no long-run relationship between the levels of y_t, X_t^+, and X_t^- (i.e., $\rho = \theta^+ = \theta^- = 0$) can be tested with the (nonstandard) bounds-testing method of Pesaran, Shin, and Smith (2001), which remains valid irrespective of the time series properties of X_t. Third, long-run and short-run asymmetries can be estimated using standard Wald test. In this paper, we estimate four models with different combinations of short-run, long-run symmetries and asymmetries as represented in the following equations of (6) to (9):

long-run and short-run symmetry model

$$\Delta y_t = \rho y_{t-1} + \theta X_{t-1} + \sum_{j=1}^{p-1} \varphi_j \Delta y_{t-j} + \sum_{j=0}^{q} \pi_j \Delta X_{t-j} + \varepsilon_t. \qquad (6)$$

long-run symmetry, short-run asymmetry model

$$\Delta y_t = \rho y_{t-1} + \theta X_{t-1} + \sum_{j=1}^{p-1} \varphi_j \Delta y_{t-j} + \sum_{j=0}^{q} (\pi_j^+ \Delta X_{t-j}^+ + \pi_j^- \Delta X_{t-j}^-) + \varepsilon_t. \qquad (7)$$

long-run asymmetry, short-run symmetry model

$$\Delta y_t = \rho y_{t-1} + \theta^+ X_{t-1}^+ + \theta_{t-1}^- X_{t-1}^- + \sum_{j=1}^{p-1} \varphi_j \Delta y_{t-j} + \sum_{j=0}^{q} \pi_j \Delta X_{t-j} + \varepsilon_t. \qquad (8)$$

long-run and short-run asymmetry model

$$\Delta y_t = \rho y_{t-1} + \theta^+ X_{t-1}^+ + \theta_{t-1}^- X_{t-1}^- + \sum_{j=1}^{p-1} \varphi_j \Delta y_{t-j} + \sum_{j=0}^{q} (\pi_j^+ \Delta X_{t-j}^+ + \pi_j^- \Delta X_{t-j}^-) + \varepsilon_t. \tag{9}$$

NARDL model can be used to derive the asymmetric cumulative dynamic multiplier effects of a unit change in X_t on y_t. By constructing m_h^+ and m_h^- as $h \to \infty$ as shown in equation (10), NARDL model can track down the path to a new long-run steady-state from an initial equilibrium after a shock to an explanatory variable.

$$m_h^+ = \sum_{j=0}^{h} \frac{\partial y_{t+j}}{\partial X_t^+}, \quad m_h^- = \sum_{j=0}^{h} \frac{\partial y_{t+j}}{\partial X_t^-}, \quad h = 0,\ 1,\ 2,\ \ldots \tag{10}$$

3.2. Data

Monthly data of policy rates and retail bank lending rates for eight Asian countries are obtained from International Financial Statistics (IFS) by IMF. As the policy rates do not vary much, short-term market rates, which closely follow the policy rates, are used as proxies for them. Table 1 shows the descriptive statistics of short-term market rates and lending rates for the sample countries during the sample periods. The specific short-term market rates and lending rates used in this study are presented in the third column of table 1.

Since all the sample countries experienced serious financial turmoil during the period between 1995 and 1999, the sample period starts in January 2000 ending in August 2009. Since 2000 the sample countries have seen substantial development in their financial markets with further liberalization and internationalization of capital markets.[3)]

[3)] Most Asian countries abolished interest rate control by 2005. In most of these countries, bank lending rates are now directly linked to either the policy rates or short-term market

Table 1 Descriptive Statistics of Short-run and Lending Interest Rates

Country	Interest Rate		Mean	Median	Max.	Min.	Std.
Hong Kong	Short-run (x_t)	Money Market Rate	2.562	2.190	7.130	0.070	1.965
	Lending (y_t)	Lending Rate	6.382	5.250	9.500	5.000	1.544
Indonesia	Short-run (x_t)	Call Money Rate	9.099	8.895	22.06	3.760	3.610
	Lending (y_t)	Working Capital Loans Rate	15.994	15.695	20.080	12.880	2.192
Japan	Short-run (x_t)	Call Money Rate	0.136	0.020	0.520	0.000	0.192
	Lending (y_t)	Lending Rate	1.845	1.840	2.120	1.600	0.129
Korea	Short-run (x_t)	Money Market Rate	4.027	4.290	5.390	1.770	0.783
	Lending (y_t)	Lending Rate on DMB Loans	6.667	6.420	8.790	5.400	0.945
Malaysia	Short-run (x_t)	Interbank Overnight Money Rate	2.945	2.770	3.520	2.000	0.376
	Lending (y_t)	Average Lending Rate	6.471	6.345	7.810	5.110	0.577
Philippines	Short-run (x_t)	Money Market Rate	7.592	7.130	15.060	4.570	1.808
	Lending (y_t)	Average Lending Rate	9.897	9.730	14.470	7.770	1.316
Singapore	Short-run (x_t)	3Month Interbank Rate	1.822	1.750	3.560	0.630	0.953
	Lending (y_t)	Minimum Lending Rate	5.419	5.330	5.850	5.300	0.188
Thailand	Short-run (x_t)	Money Market Rate	2.432	2.010	4.950	1.000	1.175
	Lending (y_t)	Lending Rate	6.694	6.850	8.000	5.500	0.800

The countries have substantially different economic backgrounds and their central banks have adopted different management policies, which may lead to different adjustment processes of retail interest rates reacting to changes in the policy rates. Indonesia introduced a fully fledged inflation targeting

rates. These rates are negotiable with customers, which allow some differentiation in regards to a customer's size and creditworthiness. Some Asian countries still control the interest rates for certain categories of borrowers and amounts of transactions. In Malaysia and Thailand, for instance, there is a maximum rate for consumer loans.

framework in July 2005. Since then, Bank Indonesia has been using the BI rate as a policy rate responding to future trends in inflation. On the other hand, Bank of Japan, under deflationary environment, moved to zero interest rate policy (ZIRP) in the spring of 1999, which continued until August 2000. Quantitative easing (QE) was introduced in March 2001 and stayed until March 2006, when Bank of Japan changed its policy from QE back to ZIRP with an acceptable, not a target, range of inflation rate.[4)] Bank of Korea adopted inflation targeting after the 1997-1998 financial crisis and started using the rate as an operation target rate.

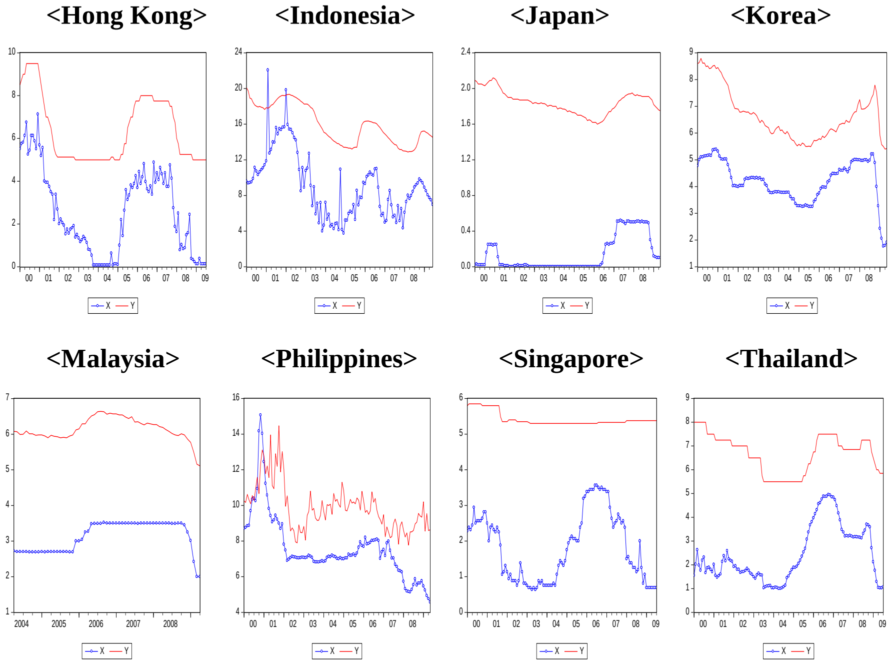
Central banks of Malaysia and Thailand, assessing the risk of inflation, temporarily announced a target for short-term rate. In Malaysia, overnight interest rate has been serving as the country's policy rate since April 2004, while Bank of Thailand has been signaling its policy stance with 4-day repo rate since early 2000. Philippines adopted formal inflation targeting in 2002 and the BSP (Banko Sentralng Pilipinas) uses overnight repo rate to have an effect on short-term, long-term, and retail bank rates. Hong Kong SAR continues to operate under a currency board system and Singapore's monetary policy is centered on foreign exchange rates. These two countries' target is focused on foreign exchange rates rather than short-term rates.

The means of short-term market rates shown in table 1 vary across the countries. Short-term rates are relatively high in Indonesia and Philippines, with means of 9.10 percent and 7.59 percent, respectively. Japan, Singapore, and Thailand demonstrate lower means of 0.14 percent, 1.82 percent and 2.43 percent, respectively. Japan's low interest rate can be attributed to the adoption of ZIRP by Bank of Japan.

Figure 1 presents the trends of short term market rates and lending rates together for the sample countries. For Hong Kong, Indonesia, Korea, Philippines, and Thailand, close relationships are observed between two interest rates, while not for Japan, Malaysia, and Singapore.

[4)] Morgan (2010) reviews the effectiveness of unconventional monetary policies and their relevance for emerging markets. Morgan (2010) argues that unconventional policies may be useful either when interbank rates fall to zero, or when a credit crunch or rise in risk premium impairs the normal transmission mechanism of monetary policy.

Figure 1 Trends of Short-term Rates and Lending Rates



4. EMPIRICAL RESULTS AND INTERPRETATION

We estimate four models of equation (6), (7), (8) and (9) for each country, which allows us to combine various forms of short and long-run asymmetries. Table 2-table 9 report the estimation results of four different models for Hong Kong, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore and Thailand, respectively.

In all cases, general-to-specific lag selection is performed starting from a maximum lag length of 12 using a sequential 10% rule. Tables should be read in conjunction with figures of figure A1-figure A8 presented at the appendix, where dynamic cumulative multipliers are calculated by equation (10). In the figures, when the change in short-term interest rates occurs by one percentage point, its effects on bank lending rates over the following

Table 2 Hong Kong

L_r/S_rSymmetric		L_rSym/S_rAsym		L_rAsym/S_rSAm		L_r/S_rAsymmetric	
L_X	0.564 (0.000)	L_X	0.566 (0.000)	L_X^+ L_X^-	0.610 (0.000) 0.576 (0.000)	L_X^+ L_X^-	0.680 (0.000) 0.646 (0.000)
Adj. R^2	0.621	Adj. R^2	0.575	Adj. R^2	0.647	Adj. R^2	0.551
DW	2.071	DW	1.777	DW	2.005	DW	1.642
SIC	–0.894	SIC	–0.892	SIC	–0.897	SIC	–0.871
F_{PSS}	6.723**	F_{PSS}	8.210***	F_{PSS}	7.651***	F_{PSS}	10.902***
W_{LR}		W_{LR}		W_{LR}	8.506***	W_{LR}	6.782***
W_{SR}		W_{SR}	8.649***	W_{SR}		W_{SR}	5.898***

Notes: L_X^+ and L_X^- represent long-run coefficients where $L_X^+ = -\hat{\theta}^+ / \hat{\rho}$ and $L_X^- = -\hat{\theta}^- / \hat{\rho}$. F_{PSS} is F statistics for the null of $\rho = \theta^+ = \theta^- = 0$ by Pesaran, Shin and Smith (2001). Critical value for the F statistics is 4.14, 4.85 and 6.36 for the significance level of 10%, 5% and 1%. W_{LR} and W_{SR} is Wald test statistics for the symmetry of long-run and short-run respectively. ***, **, * represent statistically significant statistics at the level of 1%, 5% and 10% respectively.

Table 3 Indonesia

L_r/S_rSymmetric		L_rSym/S_rAsym		L_rAsym/S_rSAm		L_r/S_rAsymmetric	
L_X	0.549 (0.000)	L_X	0.563 (0.000)	L_X^+ L_X^-	0.316 (0.000) 0.361 (0.000)	L_X^+ L_X^-	0.277 (0.001) 0.330 (0.000)
Adj. R^2	0.548	Adj. R^2	0.548	Adj. R^2	0.634	Adj. R^2	0.580
DW	1.762	DW	2.175	DW	2.002	DW	1.838
SIC	–0.634	SIC	–0.589	SIC	–0.692	SIC	–0.674
F_{PSS}	5.115*	F_{PSS}	8.651***	F_{PSS}	6.741***	F_{PSS}	6.689***
W_{LR}		W_{LR}		W_{LR}	9.774***	W_{LR}	17.206***
W_{SR}		W_{SR}	36.991***	W_{SR}		W_{SR}	9.059***

Notes: L_X^+ and L_X^- represent long-run coefficients where $L_X^+ = -\hat{\theta}^+ / \hat{\rho}$ and $L_X^- = -\hat{\theta}^- / \hat{\rho}$. F_{PSS} is F statistics for the null of $\rho = \theta^+ = \theta^- = 0$ by Pesaran, Shin and Smith (2001). Critical value for the F statistics is 4.14, 4.85 and 6.36 for the significance level of 10%, 5% and 1%. W_{LR} and W_{SR} is Wald test statistics for the symmetry of long-run and short-run respectively. ***, **, * represent statistically significant statistics at the level of 1%, 5% and 10% respectively.

Table 4 Japan

L_r/S_rSymmetric		L_rSym/S_rAsym		L_rAsym/S_rSAm		L_r/S_rAsymmetric	
L_X	0.785 (0.085)	L_X	0.598 (0.019)	L_X^+	3.057 (0.532)	L_X^+	1.405 (0.117)
				L_X^-	0.205 (0.936)	L_X^-	1.139 (0.149)
Adj. R^2	0.597	Adj. R^2	0.549	Adj. R^2	0.609	Adj. R^2	0.595
DW	2.401	DW	1.932	DW	2.179	DW	2.168
SIC	–6.128	SIC	–5.894	SIC	–5.970	SIC	–5.935
F_{PSS}	2.811	F_{PSS}	5.647*	F_{PSS}	6.830***	F_{PSS}	4.508*
W_{LR}		W_{LR}		W_{LR}	0.191	W_{LR}	0.008
W_{SR}		W_{SR}	0.381	W_{SR}		W_{SR}	0.006

Notes: L_X^+ and L_X^- represent long-run coefficients where $L_X^+ = -\hat{\theta}^+ / \hat{\rho}$ and $L_X^- = -\hat{\theta}^- / \hat{\rho}$. F_{PSS} is F statistics for the null of $\rho = \theta^+ = \theta^- = 0$ by Pesaran, Shin and Smith (2001). Critical value for the F statistics is 4.14, 4.85 and 6.36 for the significance level of 10%, 5% and 1%. W_{LR} and W_{SR} is Wald test statistics for the symmetry of long-run and short-run respectively. ***, **, * represent statistically significant statistics at the level of 1%, 5% and 10% respectively.

Table 5 Korea

L_r/S_rSymmetric		L_rSym/S_rAsym		L_rAsym/S_rSAm		L_r/S_rAsymmetric	
L_X	0.998 (0.000)	L_X	1.192 (0.000)	L_X^+	1.971 (0.004)	L_X^+	2.872 (0.026)
				L_X^-	1.089 (0.001)	L_X^-	1.194 (0.005)
Adj. R^2	0.592	Adj. R^2	0.622	Adj. R^2	0.617	Adj. R^2	0.650
DW	1.919	DW	1.984	DW	1.975	DW	2.162
SIC	–1.556	SIC	–1.570	SIC	–1.566	SIC	–1.582
F_{PSS}	3.039	F_{PSS}	8.018***	F_{PSS}	8.110***	F_{PSS}	12.894***
W_{LR}		W_{LR}		W_{LR}	3.090***	W_{LR}	2.909*
W_{SR}		W_{SR}	6.707***	W_{SR}		W_{SR}	17.162***

Notes: L_X^+ and L_X^- represent long-run coefficients where $L_X^+ = -\hat{\theta}^+ / \hat{\rho}$ and $L_X^- = -\hat{\theta}^- / \hat{\rho}$. F_{PSS} is F statistics for the null of $\rho = \theta^+ = \theta^- = 0$ by Pesaran, Shin and Smith (2001). Critical value for the F statistics is 4.14, 4.85 and 6.36 for the significance level of 10%, 5% and 1%. W_{LR} and W_{SR} is Wald test statistics for the symmetry of long-run and short-run respectively. ***, **, * represent statistically significant statistics at the level of 1%, 5% and 10% respectively.

Table 6 Malaysia

L_r/S_rSymmetric		L_rSym/S_rAsym		L_rAsym/S_rSAm		L_r/S_rAsymmetric	
L_X	–0.246 (0.548)	L_X	–0.307 (0.279)	L_X^+	–0.070 (0.895)	L_X^+	–0.695 (0.527)
				L_X^-	–0.109 (0.950)	L_X^-	–2.297 (0.601)
Adj. R^2	0.437	Adj. R^2	0.550	Adj. R^2	0.416	Adj. R^2	0.556
DW	2.252	DW	2.357	DW	2.313	DW	2.416
SIC	–2.810	SIC	–2.739	SIC	–2.781	SIC	–2.683
F_{PSS}	6.477**	F_{PSS}	10.150***	F_{PSS}	3.670	F_{PSS}	7.318***
W_{LR}		W_{LR}		W_{LR}	0.000	W_{LR}	0.227
W_{SR}		W_{SR}	0.455	W_{SR}		W_{SR}	1.193

Notes: L_X^+ and L_X^- represent long-run coefficients where $L_X^+ = -\hat{\theta}^+ / \hat{\rho}$ and $L_X^- = -\hat{\theta}^- / \hat{\rho}$. F_{PSS} is F statistics for the null of $\rho = \theta^+ = \theta^- = 0$ by Pesaran, Shin and Smith (2001). Critical value for the F statistics is 4.14, 4.85 and 6.36 for the significance level of 10%, 5% and 1%. W_{LR} and W_{SR} is Wald test statistics for the symmetry of long-run and short-run respectively. ***, **, * represent statistically significant statistics at the level of 1%, 5% and 10% respectively.

Table 7 Philippines

L_r/S_rSymmetric		L_rSym/S_rAsym		L_rAsym/S_rSAm		L_r/S_rAsymmetric	
L_X	0.625 (0.000)	L_X	0.605 (0.004)	L_X^+	0.539 (0.058)	L_X^+	0.553 (0.064)
				L_X^-	0.588 (0.000)	L_X^-	0.587 (0.004)
Adj. R^2	0.382	Adj. R^2	0.465	Adj. R^2	0.376	Adj. R^2	0.502
DW	2.021	DW	2.027	DW	2.020	DW	2.217
SIC	2.304	SIC	2.205	SIC	2.348	SIC	2.374
F_{PSS}	9.680***	F_{PSS}	5.513*	F_{PSS}	6.431***	F_{PSS}	7.079***
W_{LR}		W_{LR}		W_{LR}	0.115	W_{LR}	0.082
W_{SR}		W_{SR}	0.173	W_{SR}		W_{SR}	0.696

Notes: L_X^+ and L_X^- represent long-run coefficients where $L_X^+ = -\hat{\theta}^+ / \hat{\rho}$ and $L_X^- = -\hat{\theta}^- / \hat{\rho}$. F_{PSS} is F statistics for the null of $\rho = \theta^+ = \theta^- = 0$ by Pesaran, Shin and Smith (2001). Critical value for the F statistics is 4.14, 4.85 and 6.36 for the significance level of 10%, 5% and 1%. W_{LR} and W_{SR} is Wald test statistics for the symmetry of long-run and short-run respectively. ***, **, * represent statistically significant statistics at the level of 1%, 5% and 10% respectively.

Table 8 Singapore

L_r/S_rSymmetric		L_rSym/S_rAsym		L_rAsym/S_rSAm		L_r/S_rAsymmetric	
L_X	0.017 (0.755)	L_X	0.012 (0.846)	L_X^+	0.017 (0.761)	L_X^+	0.025 (0.773)
				L_X^-	0.018 (0.760)	L_X^-	–0.029 (0.779)
Adj. R^2	0.186	Adj. R^2	0.126	Adj. R^2	0.178	Adj. R^2	0.129
DW	1.958	DW	1.409	DW	1.958	DW	1.451
SIC	–3.872	SIC	–3.834	SIC	–3.829	SIC	–3.804
F_{PSS}	4.532	F_{PSS}	3.950	F_{PSS}	2.911	F_{PSS}	3.903
W_{LR}		W_{LR}		W_{LR}	0.001	W_{LR}	0.570
W_{SR}		W_{SR}	8.952***	W_{SR}		W_{SR}	9.929***

Notes: L_X^+ and L_X^- represent long-run coefficients where $L_X^+ = -\hat{\theta}^+ / \hat{\rho}$ and $L_X^- = -\hat{\theta}^- / \hat{\rho}$. F_{PSS} is F statistics for the null of $\rho = \theta^+ = \theta^- = 0$ by Pesaran, Shin and Smith (2001). Critical value for the F statistics is 4.14, 4.85 and 6.36 for the significance level of 10%, 5% and 1%. W_{LR} and W_{SR} is Wald test statistics for the symmetry of long-run and short-run respectively. ***, **, * represent statistically significant statistics at the level of 1%, 5% and 10% respectively.

Table 9 Thailand

L_r/S_rSymmetric		L_rSym/S_rAsym		L_rAsym/S_rSAm		L_r/S_rAsymmetric	
L_X	0.822 (0.009)	L_X	0.689 (0.004)	L_X^+	0.774 (0.000)	L_X^+	0.756 (0.000)
				L_X^-	1.032 (0.000)	L_X^-	1.031 (0.000)
Adj. R^2	0.201	Adj. R^2	0.278	Adj. R^2	0.259	Adj. R^2	0.207
DW	2.092	DW	2.118	DW	2.093	DW	1.971
SIC	–0.980	SIC	–0.971	SIC	–0.960	SIC	–0.946
F_{PSS}	5.070*	F_{PSS}	5.310*	F_{PSS}	5.312**	F_{PSS}	4.280*
W_{LR}		W_{LR}		W_{LR}	7.345**	W_{LR}	14.243***
W_{SR}		W_{SR}	1.110	W_{SR}		W_{SR}	7.392***

Notes: L_X^+ and L_X^- represent long-run coefficients where $L_X^+ = -\hat{\theta}^+ / \hat{\rho}$ and $L_X^- = -\hat{\theta}^- / \hat{\rho}$. F_{PSS} is F statistics for the null of $\rho = \theta^+ = \theta^- = 0$ by Pesaran, Shin and Smith (2001). Critical value for the F statistics is 4.14, 4.85 and 6.36 for the significance level of 10%, 5% and 1%. W_{LR} and W_{SR} is Wald test statistics for the symmetry of long-run and short-run respectively. ***, **, * represent statistically significant statistics at the level of 1%, 5% and 10% respectively.

months are simulated.

Our estimation result reveals quite heterogeneous pass-through across different sample economies in terms of size, nature of asymmetry and speed of adjustment. For four countries such as Hong Kong, Indonesia, Thailand and Philippines, all the PSS-*F*-tests reject the null of no cointegration between short-term market rates and bank lending rates regardless of model specifications. Adjusted R^2, in general, increases as various forms of asymmetric dynamics are incorporated in the model. The goodness of fit is relatively high for Hong Kong and Indonesia, where adjusted R^2 varies around 0.548 to 0.647, that of Philippines around 0.376 to 0.502, and Thailand around 0.201 to 0.278.

The point estimates of long-run coefficients are, in general, less than one except for Thailand when policy interest rates decrease, which suggests the incomplete pass-through of interest rates. The magnitude of long-run coefficient is largest for Thailand varying across 0.689-1.032, followed by Hong Kong and Philippines with 0.539-0.680, and then by Indonesia with 0.277-0.549.

When we particularly look at the estimation results where long run or both short run and long run asymmetries are imposed in order to investigate the nature of long run asymmetric pass-through, we find positive pass-through for Hong Kong and negative pass-through for Indonesia and Thailand. However, for Philippines, Wald test does not support any asymmetric interest rate pass-through in both short term and long term.

In Hong Kong, when long run or both the long run and short run asymmetries are imposed, Wald tests reject the equality of long run coefficients and the long-run coefficients are larger when the policy rates increase than decrease, which implies the positive asymmetric pass-through. On the other hand, in Indonesia and Thailand, Wald tests reject the equality of long run coefficients and the long-run coefficients are larger when the policy rates decrease than increase, displaying negative asymmetries. It suggests that banks in Hong Kong transfer the changes in policy rates to lending rates more when the policy rates increase than decrease, while banks in Indonesia and Thailand transfer policy rates to lending rates more when the policy rates decrease than increase.

Even though the pass-through of interest rates shows asymmetry, the speed of adjustment may not tell the same story. In order to evaluate the response of lending rates over time, we look at the traces of dynamic cumulative multipliers in the figures. In Hong Kong as shown in figure 1 in appendix, bank lending rates initially overreact to the changes in short-term interest rates with long-run coefficients reaching around 0.8-1 within the first 8 months, before they reach a long-run equilibrium level in around 29 months. Even though we could find the long-run asymmetric pass-through here, the speed of adjustment of lending rates doesn't seem to be the case, since cumulative multipliers display the same dynamics regardless of the direction of changes in short-term interest rates.

Lending rates respond steadily to the changes in short-term rates up to 8 months for Indonesia and 22-36 months for Thailand without any initial overreaction before they reach a long-run equilibrium level. The speed of adjustment of lending rates is symmetric for Indonesia while it is asymmetric for Thailand. In Thailand, the changes in short-term rates are more rapidly transferred to lending rates when they increase than decrease. For Philippines, lending rates initially overreact to the changes in short-term rates before they reach a long-run equilibrium level of 0.625 in 19 months. As the pass-through doesn't show any asymmetric behavior, the speed of adjustment doesn't seem to be asymmetric either.

For Japan and Korea, we find cointegrating relationships between short term and lending rates in three cases where short run, long run, or both the short run and long run asymmetries are incorporated in the model. It demonstrates the importance of proper model specification. When short-term market rates and lending rates exhibit non-linear asymmetric relationship, the models which strictly assume symmetry would produce empirical results biased toward no cointegration. Even though PSS-*F*-test indicates long-run cointegrating relationship for the three cases in Japan, the pass-through transmission mechanism seems to be weak. Only when short run asymmetry with long run symmetry is incorporated, the long-run coefficient is statistically significant and less than one.

The estimation for Korean banking system suggests the existence of highly efficient interest rate pass-through channels. In the models where the cointegrating relationships are found, the long-run coefficients are larger than one ranging over 1.089-2.872 and statistically significant, which implies that the interest pass-through is more-than-one-to-one. This over pass-through may suggest that the Korean banking sector is highly competitive.

Where long run or both the long run and short run asymmetries are imposed, Wald test rejects the symmetry of long-run coefficient, and the long-run coefficients are larger when interest rates increase than when they decrease. It suggests the positive pass-through, implying that banks transfer policy interest rates to lending rates more when the policy rates increase than when they decrease.

Along with asymmetric long-run pass-through, the speed of adjustment of lending rates appears to be asymmetric too. However, the speed of adjustment is faster when the policy interests decrease than when they increase. Banks adjust their lending rates over 41-61 months when the policy rates decrease, while they adjust their lending rates over more than 80 months when the policy rates increase.

The transmission mechanisms of Malaysia and Singapore are not well identified, which is already suggested by figure 1. In Malaysia, even for the three models where the PSS-*F*-tests suggest the cointegrating relationship, the long-run coefficients are negative. This counterintuitive test results raise doubt about the existence of monetary policy transmission mechanism in the country at all. For Singapore, we are not able to find any meaningful cointegrating relationship for all the model specifications either.

Summing up, we are able to find incomplete pass-through in Hong Kong, Indonesia, Thailand and the Philippines to varying degrees and in Japan in a limited case. Imperfect competition, menu costs, switching costs and long-run relationship between banks and customers may be the theoretical explanations for the incomplete pass-through. Globalization can be pointed out as another structural factor for price rigidity. Although the general shift towards more flexible exchange rates suggests greater independence of national monetary policies and hence domestic short-term interest rates in Asian economies, increased capital mobility tends to favor an international convergence of long-term interest rates, resulting in incomplete pass-through from short-term to long-term interest rates domestically.

Another reason for weak pass-through, at least during certain periods, has to do with the health of financial system, which may apply to Japanese case. When banking system is in poor health, it is highly likely that the economy simultaneously face difficulties. In such situation, banks behave in a highly risk-averse manner. Rising information costs prevent banks from acting counter-cyclically (by lending to those who can take advantage of opportunities created by the failure of others) and may increase the Stiglitz-Weiss type credit rationing, which reduces the sensitivity of lending rates to the changes in funding costs.

We are not able to find any meaningful interest rate pass-through in Malaysia and Singapore. For Malaysia, we find negative sign of long-run coefficients, which is counterintuitive. Malaysia adopted market short-term rates as the operating target in April 2004, and the rates remained fixed for extensive periods of time. It could be the reason why we are not able to find any meaningful monetary transmission mechanism in the country. In Singapore which operates under exchange-rate-centered monetary policy regime, the operating target is exchange rate rather than short-term interest rate. The central bank does not control short-term market rate, which could be the reason for no meaningful monetary transmission mechanism found in the country.

Korea is of special interest since it shows over pass-through. It suggests that Korean banking sector is highly competitive. Korean banking sector went through a wide range of financial restructuring since the 1997 Asian financial crisis. Even though the banking market has become highly concentrated since then, the market is still regarded to be contestable since banks compete on financial products and are challenged by non-bank financial institutions.

Regarding long-run asymmetry, we are able to find positive long-run asymmetric pass-through for Hong Kong and Korea, and negative one for Indonesia and Thailand. When there is positive asymmetry where lending rates are tilted toward slow downward adjustment, monetary tightening has more pronounced effect on bank retail rates, which works to the disadvantage of loan customers, bank-dependent firms as a group. In that case, caution is needed when policy makers attempt to tame an overheated economy. On the other hand, policy makers should be more aggressive in cutting the policy rates in recessionary environment.

Asymmetric pass-through does not necessarily imply the asymmetry in the speed of adjustment. Only the banks in Korea and Thailand exhibit asymmetric speed of adjustment. It takes longer for lending rates to adjust in Korea when short term rates increase than when they decrease, while it is the opposite in Thailand. If monetary easing takes longer time before it becomes effective, policymakers should be careful of medium-term overshooting of intended outcome.

5. CONCLUSION

The interest rate pass-through (IRPT) from policy controlled rates to retail deposit or lending rate is one of the most important channels of monetary policy in an economy. If the IRPT is incomplete or sluggish so that changes in the policy rates are not fully reflected in the retail rates, then the use of monetary policy as a major tool for modifying aggregate demand in the economy becomes questionable.

While some researchers have found IRPT from policy rates to bank retail rates not only to be incomplete and sluggish, but also to be asymmetric, their conclusions, however, have been controversial with regard to the size, speed of adjustment and asymmetric nature of the transmission mechanism. The IRPT exhibits positive (negative) asymmetry if retail rates are more likely to change when policy rates rise (fall) rather than when they fall (rise). When there is positive asymmetry where lending rates are tilted toward slow downward adjustment, monetary tightening has more pronounced effect on bank retail rates, which works to the disadvantage of loan customers, bank-dependent firms as a group. In this case, caution is needed when policy makers attempt to tame an overheated economy. On the other hand, policy makers should be more aggressive in cutting the policy rates in recessionary environment.

In this paper, we empirically investigate the interest rate pass-through (IRPT) from policy rates to bank lending rates in eight Asian countries over the sample periods of January 2000 to August 2009. We employ the nonlinear autoregressive distributed lag (NARDL) model developed by Shin, Yu and Greenwood (2009). By modeling the long-run relationship and the pattern of dynamic adjustment simultaneously in a coherent manner, NARDL model allows us to capture both short-term and long-term asymmetries in transmission mechanism.

We find incomplete pass-through in Hong Kong, Indonesia, Thailand and the Philippines to varying degrees and in Japan in a limited case, which may arise from a mixture of several factors, such as fixed menu costs, high switching costs, imperfect competition and asymmetric information. We find over pass-through for Korea, which could suggest that Korean banking sector is highly competitive. Regarding long-run asymmetry, we are able to find positive long-run asymmetric pass-through for Hong Kong and Korea and negative one for Indonesia and Thailand. Regarding the speed of adjustment, only banks in Korea and Thailand exhibit the asymmetric speed of adjustment. We are not able to find any meaningful interest rate pass-through in Malaysia and Singapore.

APPENDIX

Figure A1 Hong Kong

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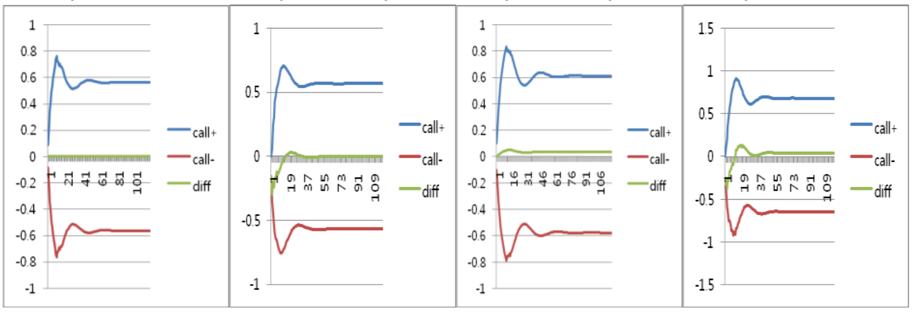


Figure A2 Indonesia

<Sym LR&SR> <Asym SR & Sym LR> <Asym LR & Sym SR> <Asym LR&SR>

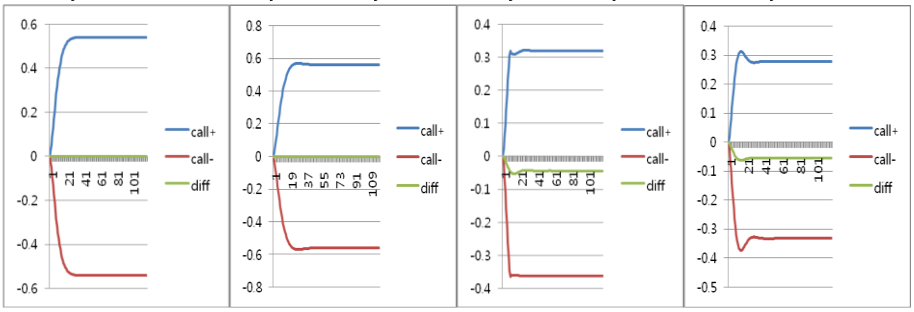


Figure A3 Japan

<Sym LR&SR> <Asym SR & Sym LR> <Asym LR & Sym SR> <Asym LR&SR>

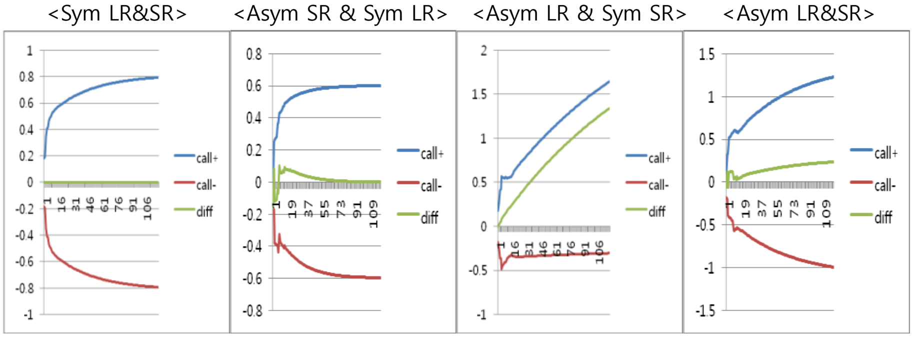


Figure A4 Korea

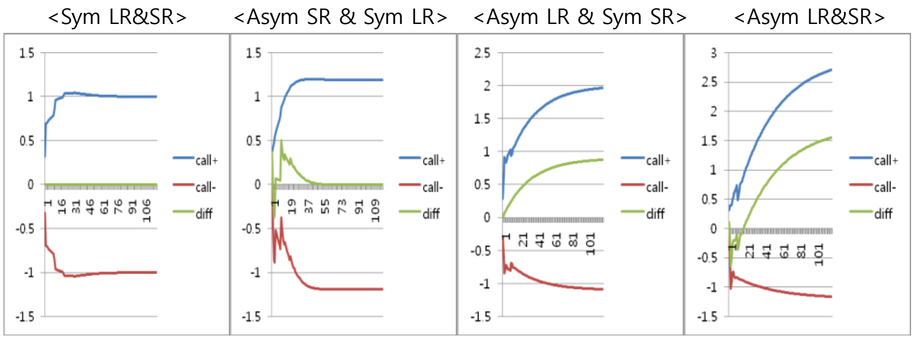


Figure A5 Malaysia

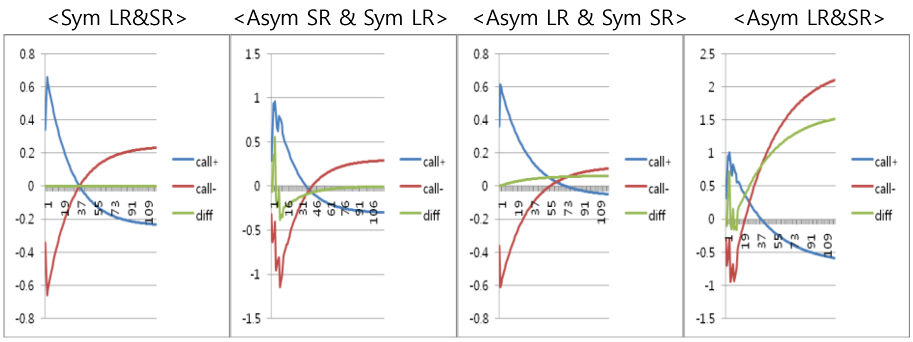


Figure A6 Philippines

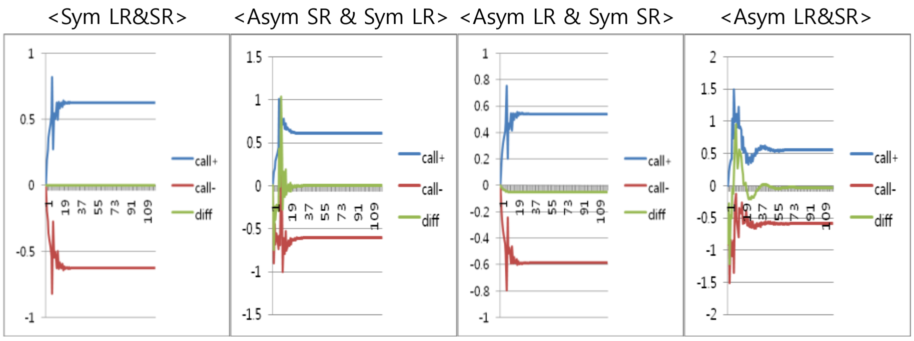


Figure A7 Singapore

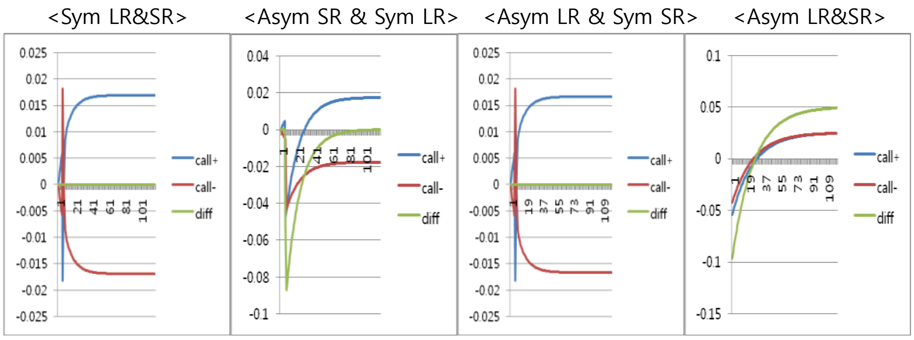
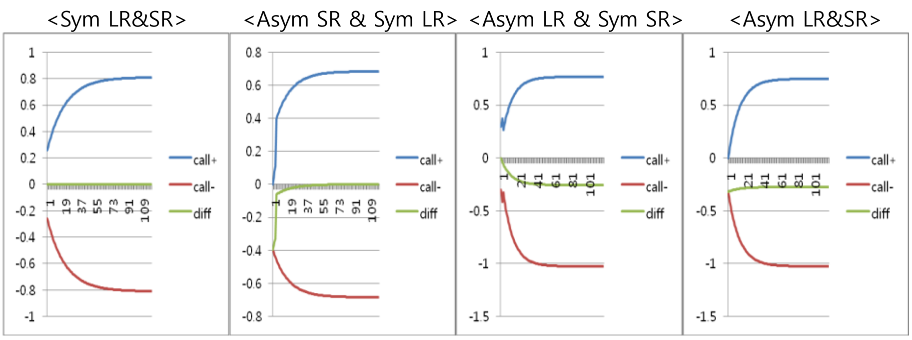


Figure A8 Thailand



REFERENCES

Angeloni, Ignazio and Michael Ehrmann, “Monetary Policy Transmission in the Euro Area: Early Evidence,” *Economic Policy*, 37, 2003, pp. 470-492.

Cottarelli, Carlo and Angeliki Kourelis, “Financial Structure, Bank Lending Rates, and the Transmission Mechanism of Monetary Policy,” IMF Working Paper, No. 94/39, March 1994.

De Bondt, “Retail Bank Interest Rate Pass-Through: New Evidence at the Euro Area Level,” European Central Bank Working Paper Series, No. 136, April 2002.

__________, "Interest Rate Pass-through: Empirical Results for the Euro Area," *German Economic Review*, 6(1), 2005, pp. 37-78.

Dueker, Michale J., "Are Prime Rate Changes Asymmetric?," *Review of Federal Reserve Bank of St. Louis*, September 2000, pp. 33-40.

Dueker, Michale J. and Daniel L. Thornton, "Asymmetry in the Prime Rate and Firms' Preference for Internal Finance," Working Papers 1994-017, Federal Reserve Bank of St. Louis, 1994.

Dutta, S., M. Bergen, D. Levy, and R. Venable, "Menu Costs, Posted Prices, and Multiproduct Retailers," *Journal of Money, Credit, and Banking*, 31, 1999, pp. 683-703.

Enders, W. and P. Siklos, "Cointegration and Threshold Adjustment," *Journal of Business and Economics Statistics*, 19, 2001, pp. 166-176.

Greenwood-Nimmo, Matthew, Youngcheol Shin, and Till Van Treeck, "New Evidence of Asymmetric Interest Rate Pass-Through in the United States and Germany," manuscript, December 2011.

Gropp, R., C. Kok Sørensen, and J. Lichtenberger, "The Dynamics of Bank Spreads and Financial Structure," ECB Working Paper, No. 714, 2007.

Hannan, Timothy H. and Allen N. Berger, "The Rigidity of Prices: Evidence from the Banking Industry," *American Economic Review*, 81, 1991, pp. 938-945.

Hefferman, S. A., "Modeling British Interest Rate Adjustment: An Error Correction Approach," *Economica*, 64, 1997, pp. 211-231.

Kwapil, C. and J. Scharler, "Interest Rate Pass-Through, Monetary Policy Rules and Macroeconomic Stability," Working Papers, 118, OeNB, 2006.

Mojon, Benoit, "Financial Structure and the Interest Rate Channel of ECB Monetary Policy," Working Paper Series, 40, European Central Bank, 2000.

Morgan, Peter J., "The Role and Effectiveness of Unconventional Monetary Policy," *Journal of the Korean Economy*, 11(1), April 2010, pp. 55-102.

Pesaran, H. M., Y. Shin, and R. J. Smith, "Bounds Testing Approaches to the Analysis of Level Relationships," *Journal of Applied Econometrics*, 16, 2001, pp. 289-236.

Sellon, G. H., "The Changing U.S. Financial System: Some Implications for Monetary Transmission," *Federal Reserve Bank of Kansas City Economic Review*, 2002, pp. 5-35.

Shin, Y., Byungchul Yu, and Matthew Greenwood-Nimmo, "Modeling Asymmetric Cointegration and Dynamic Multipliers in a Nonlinear ARDL Framework," Working Paper, February 2009.

Stiglitz, Joseph E. and Andrew Murray Weiss, "Credit Rationing in Markets with Imperfect Information," *American Economic Review*, 71(3), June 1981, pp. 393-410.

Wang, Kuan-Min and Yuan-Ming Lee, "Market Volatility and Retail Interest Rate Pass-Through," *Economic Modeling*, 26, 2009, pp. 1270-1282.