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Selected Topics in International Monetary Economics: Uncovered Interest Rate Parity, and Excess Interbank Liquidity and Monetary Policy in Pakistan

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"Everything that has a beginning has an ending." ~ Anonymous

This PhD dissertation that started in late 2009 finally has come to an end with the approval by the reading committee. In last four years Groningen University provided me ample opportunity to ponder on various interesting and feasible ideas and proposals. My PhD thesis is a reflection of it. The first part of this thesis investigates uncovered interest rate parity using LIBOR interest rates while the second part explores the presence of excess interbank liquidity in the interbank market of Pakistan and its impact on the monetary transmission mechanism. Looking back at the last four years, I find it thought provoking, skill enhancing, and simultaneously full of fun. I am thankful to the Faculty of Economics and Business, Groningen University, for organizing so many thought-provoking seminars and also for the departmental activities. Professor Jakob de Haan's generally supports new ideas which encouraged me to work on the divergent topics instead of expanding any particular idea. He is a great supervisor and helps his PhD students to realize their potential. In simple words, under his supervision I could do what I liked best. It was not possible to finish this thesis on time without his help. I am especially thankful to him.

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Chapter 1

Introduction

In an international context, interbank markets seem to work less efficiently, leading to market imperfections such as liquidity shortages or interest rate differentials. Although these differences could be attributed to exchange rate risk, the main barrier to an integrated international market is the existence of asymmetric information between different countries.

(Freixas and Holthausen, 2005, page 481)

Large (capital) inflows (from developed to the emerging market economies after the global financial crisis of 2008-09) can also make more difficult the pursuit of appropriate macroeconomic policies (in these emerging economies) to maintain solid economic growth without rising inflation. If, in response, authorities (in the emerging market economies) raise policy rates while allowing their currencies to appreciate, this leads to a loss of international competitiveness which could hurt export and growth performance. But if they slow the pace of monetary tightening to deter inflows, or if they resist currency appreciation pressures through intervention, the ability to follow appropriate independent monetary policies is compromised. Such a course of action could result in excessive liquidity and economic overheating, creating vulnerability to boom-bust cycles.

(Ahmed and Zlate, 2013, page 1) [1]

1.1 Background

International monetary economics covers issues related to balance of payments imbalances and exchange rate determination (McCallum, 1996). Although the field of international monetary economics covers a wide range of topics, this thesis looks into some selected topics only, namely uncovered interest rate parity (UIP) and excess liquidity in the interbank market of Pakistan.

The first part of this thesis investigates UIP using London Interbank Market Offered Rates (LIBOR). Uncovered interest rate parity is central to international monetary economics as

[1] Text in parentheses is added for clarity.

it links exchange rates and interest rates of different countries. According to the UIP hypothesis, the difference in the return on identical assets from two different countries should be fully offset by the differential of the spot and the expected future exchange rate at the points in time when the interest-bearing assets are bought and redeemed. Most exchange rate determination theories, such as the monetary exchange rate model, Dornbusch's (1976) overshooting model and Krugman's (1991) target zone model, are based on the assumption that uncovered interest rate parity holds. Also, central banks frequently count on this relationship for anchoring exchange rate expectations in the economy (Flood and Rose, 2001; and Kalyvitis and Skotida, 2010).

Generally, the empirical literature does not support the UIP hypothesis in the short run for industrialized economies (reviews on UIP can be found in Froot and Thaler, 1990; MacDonald and Taylor, 1992; Flood and Taylor, 1996; Isard, 1996; Pasricha, 2006; and Alper *et al.*, 2009). UIP is rejected for the short-term horizon, due to frictions arising when assets differ in risk perception (and Frankel 1983; 1984 and Branson and Henderson, 1985), due to transaction costs (Baldwin, 1990; and Dumas, 1992), and due to the irrational noise traders present in the market (Frankel and Froot, 1989; De Long *et al.*, 1990; Mark and Wu, 1998; and Carlson and Osler, 1999).

The empirical literature discussed above has examined the role of frictions that distort UIP. However, to date no study has addressed the research question of whether UIP holds if these frictions are minimal. London interbank market rates, with minimal economic frictions, provide an opportunity to answer our research question. Using the London Interbank Offered Rate (LIBOR) has advantages for testing economic theories, like the uncovered interest rate parity hypothesis (Section 1.2 offers a more detailed discussion of the benefits of using LIBOR). Therefore, the first part of the thesis uses interest rates from the London interbank market to study uncovered interest rate parity. Using LIBOR currency rates, the first part of this thesis addresses the following research question: does uncovered interest rate parity hold for short-term maturities? In the empirical investigation, we split this research question in two parts. We ask in Chapter 2: does UIP hold over short-run horizons for the LIBOR system of currencies? In Chapter 3 we ask: does UIP hold over short-run horizons for individual currencies in the LIBOR system of currencies?

The second part of this thesis is related to international monetary economics in terms of capital inflows. Pakistan, like other developing and emerging economies, has experienced a surge in capital inflows after the global financial crisis. At the same time, the interbank market of Pakistan has experienced an unprecedented accumulation of excess liquidity. The second part of this thesis investigates the nature of the excess liquidity present in the interbank market and its impact on monetary policy transmission in Pakistan. The investigation on excess liquidity is not confined to the capital inflow channel, but also covers other demand and supply factors, such as deficit financing and liquidity risks.

Pakistan, being a developing economy, provides an interesting though hardly researched case study. The performance of its financial sector was outstanding in the last decade even though the country was facing an insurgency at home, and a war at its western border. The commercial banks, which in 2000 reported only a 0.4 percent return on their assets before taxes, witnessed an average of around 1.8 percent return on their assets between 2000 and 2011.

Pakistan's financial sector was hardly affected by the recent global financial meltdown. The capital to assets ratio of the banks in Pakistan declined only marginally from 10 percent in 2008 to 9.6 percent in 2012 due to an increase in assets, while this ratio decreased substantially for most banks around the world after the global financial crisis. Consequently, some of these affected banks became insolvent.

Also, the stock market in Pakistan has performed better than other stock markets. The stock market capitalization in terms of outstanding stocks doubled to Pakistan Rupee 4.61trillion in March 2012, from Pakistan Rupee 2.12 trillion in June 2009.[2] Between January and July 2013, the leading stock exchange in Pakistan (the Karachi Stock Exchange, KSE) has risen by 40 percent. In the group of stock exchanges tracked by The Economist, only the stock market in Japan performed better than the KSE.[3]

Despite the strong performance of Pakistan's financial sector, fiscal policy in Pakistan is seen as very weak. Fiscal mismanagement coupled with the deteriorating law and order situation and terrorism have undermined fiscal stability. The situation worsened despite sustained foreign capital inflows to finance government spending. A recent IMF (2013) report places Pakistan in the group of most vulnerable countries, with a total financing need of 33.2 percent of GDP in the fiscal year 2012-13. The State Bank of Pakistan (2012, p. 65) in its Annual Report 2011-12 notes that:

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[2] Government of Pakistan (2013, p. 80).
[3] http://www.economist.com/blogs/economist-explains/2013/07/economist-explains-19.

> *"The primary balance (the gap between revenues and non-interest expenditures) has also been negative for the last consecutive eight years. It means that the government is not only borrowing for its debt servicing (non-discretionary spending based on past obligations), but also to finance a portion of its non-interest expenditures. The persistence of these deficits is gradually pushing the country into debt trap."*

Like other developing economies, Pakistan is characterized by low per-capita income and widespread prevalence of poverty. Right from its independence, per capita savings in Pakistan were too low to expand production, building infrastructure, and strengthening human capital. To augment domestic savings and achieve a higher rate of economic growth, Pakistan followed a deficit financing strategy. Besides foreign borrowing, the government in Pakistan heavily borrows from the domestic banking sector to cover its budget deficit.

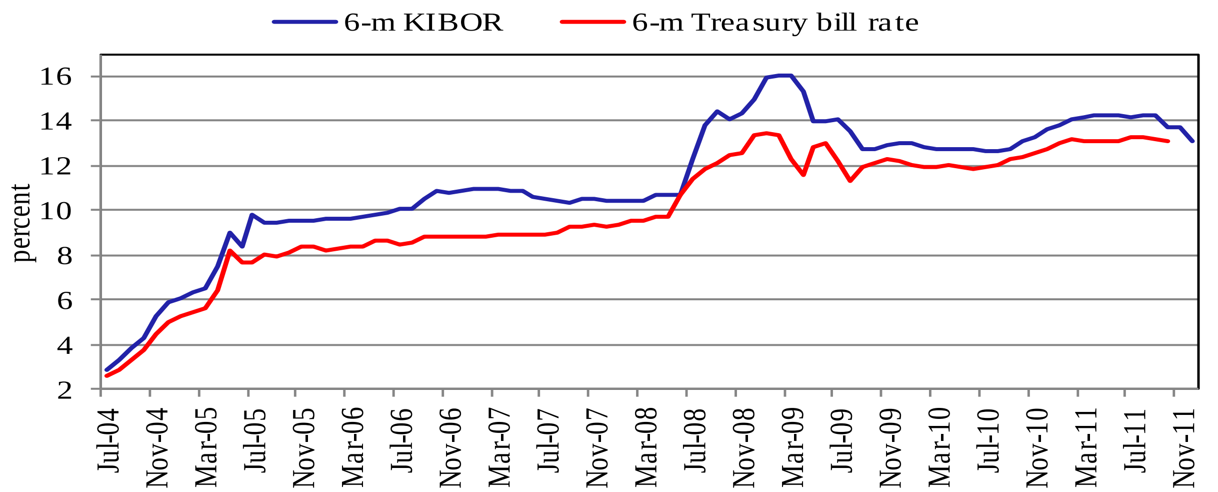
Deficit financing over the years, instead of stimulating domestic savings, has led the country to be heavily indebted. The fiscal deficit in fiscal year 2011-12 was 8.5 percent of GDP, which is the highest over the last forty years. Moreover, interest payments on the domestic and the external debt accounted for 28.5 percent of total government outlays (State Bank of Pakistan, 2012).

Persistent fiscal deficits may also increase the interest rate on government debt. The higher return may attract banks towards risk-free government securities. Mohanty *et al.* (2006) argue that inflationary expectations fuelled by government borrowing may further increase interest rates. In such a high interest rate environment, the banking sector may structurally shift towards holding more risk-free assets, thereby crowding out private sector debt.

Figure 1.1 shows interest rates in Pakistan during the period under consideration in this study. Both the 6-months Treasury bill rate and the 6-months KIBOR (Karachi Interbank Offered Rate) have increased substantially. Treasury bill rates show the cost of deficit financing, while the 6-months KIBOR is a benchmark rate used for interbank and retail lending.

Persistent fiscal deficits may crowd out private sector investments which has a deleterious effect on the economy. The economy's ability to generate higher savings in the long run deteriorates, which also limits its ability to invest in human capital. Moreover, deficit financing often has inflationary effects, and also increases excess interbank liquidity in the interbank market (for details, see Ganley, 2004). Persistent excess interbank liquidity may undermine the effectiveness of monetary policy.[4]

Figure 1.1 Recent Interest Rate Environment in Pakistan



The second part of this thesis (Chapter 4) therefore addresses the following research question: what factors contribute to the excess interbank liquidity accumulation in the interbank market of Pakistan? Chapter 5 assesses the impact of excess liquidity on monetary policy transmission in Pakistan. Specifically, Chapter 5 asks the questions: 1) what is the impact of the main policy tools of the SBP on retail rates and the exchange rate? 2) does excess interbank liquidity affect the monetary transmission mechanism, i.e., the pass-through of the policy tools to the retail rates and the exchange rate? A significant impact of excess liquidity on the monetary policy pass-through will undermine monetary policy.

Sections 1.2 and 1.3 offer the motivation for this thesis. Specifically, Section 1.2 discusses the uncovered interest rate parity and the advantages of using LIBOR for testing UIP, while Section 1.3 discusses the interbank market and monetary policy in Pakistan. Section 1.4 provides an overview of this thesis.

[4] For more detailed discussions, see Nissanke and Aryeetey (1998), Agénor *et al.* (2004), Saxegaard (2006), and Agénor and Aynaoui (2010).

1.2 Uncovered interest rate parity and London interbank market rates

This study uses interest rates from the London interbank market[5], commonly known as London Interbank Offered Rate (LIBOR), to study uncovered interest rate parity (UIP). Using LIBOR has distinct advantages for assessing economic theories like the uncovered interest rate parity hypothesis.

In the London interbank market, capital is perfectly mobile and transaction costs are the same for every currency LIBOR. Both are essential requirements for testing UIP which are not met when domestic interest rates are used. Moreover, the maturity specific interest rates have common underlying characteristics for every currency. For instance, the characteristics of the 3-month Euro rate are identical to those of the 3-month US Dollar rate which is not always the case when domestic interest rates are used. For example, Thomson Reuters reports 22 rates for instruments with a 3-months maturity in the Canadian money market. It is therefore not easy to find the right match for the 3-month Euribor from the Canadian money market if the objective is to test UIP for the Canadian Dollar/Euro exchange rate, say.

LIBOR is based on indicative rates quoted by the participating banks in the London interbank market. For the purpose of compilation of the benchmark, specifically for the money market activities, the British Bankers Association (BBA)[6] asks the banks in the London interbank market to submit offers based upon the lowest perceived rate at which they can obtain funding in the London interbank market for a given maturity or currency.[7] The BBA adopts this procedure to make LIBOR rates statistically representative. A statistically representative benchmark rate requires a liquid market with the capacity to undertake a large number of transactions and the ability to produce the lowest market rates.

The realized market rate, based on actual transactions, often does not have the above features of a benchmark rate. Generally, business cycle movements influence the number of transactions in fixed income securities with shorter or longer maturities. For example, gloomy

[5] The interbank market is the market for trading securities or currencies among banks and other financial institutions.

[6] In September 2012 the 'Wheatley Review' on administration of LIBOR recommended to transfer responsibility of LIBOR to a new administrator. NYSE Euronext Rate Administration Limited will be the new administrator of the LIBOR benchmark from early 2014. For further details see http://www.bbalibor.com/news/bba-to-hand-over-administration-of-libor-to-nyse-euronext-rate-administrati.

[7] For details see BBA LIBOR website, http://www.bbalibor.com/explained/the-basics.

future growth prospects may increase investors' interest in the shorter maturity while better future economic growth prospects may increase interest in the longer term debt instrument. Based on the direction of economic activity, the lack of interest in any specific part of the yield curve may reduce the number of transactions in the related maturities. Therefore, when fewer transactions determine a money market rate which is used as a benchmark, the rate thus produced may not be representative.

The BBA removes outliers from the quoted rates. Moreover, it discards the highest and the lowest quartiles of the distribution to avoid strategic misrepresentation. The remaining rates are then averaged and reported as what is generally known as London Interbank Offered Rates (LIBORs). The use of LIBOR, as a benchmark, is not limited to the UK money market only. Forbes Investopedia estimates that $360 trillion worth of international financial products are benchmarked with LIBOR. Additionally, one trillion Dollars of the world's sub-prime mortgages have rates adjustable to LIBOR.

LIBOR rates are available in ten currencies: Euro, US Dollar, British Pound, Japanese Yen, Swiss Franc, Canadian Dollar, and Australian Dollar, as well as the Danish Kroner, New Zealand Dollar, and Swedish Krona. For our analysis on UIP, this thesis uses the first seven currencies LIBOR rates as they are available for a sufficiently long period.[8]

1.3 Excess interbank liquidity and monetary policy in Pakistan

This thesis uses the term 'interbank market' specifically for the money market where underlying debt securities have maturities of one year or less. In 2013, the interbank market of Pakistan involves 33 commercial banks, 5 Islamic banks, 10 microfinance banks/institutions and 8 development finance institutions. The commercial banks include 17 domestic private banks, 5 public sector banks, 7 foreign banks, and 4 specialized banks focusing on industry or agriculture. Commercial banks hold almost 90 percent of financial assets. Also, microfinance banks/institutions and non-bank financial institutions, like the Employees Old age Benefit Institution (EOBI), insurance companies, and investment banks, actively participate in the interbank market of Pakistan. However, the volume of transactions of these non-bank institutions

[8] The BBA started reporting LIBOR rates for Danish Kroner and New Zealand Dollar from June 16, 2003 and for Swedish Krona from January 23, 2006.

and microfinance banks is very small compared to that of the commercial banks. Islamic banks do not actively participate in the unsecured money market due to its non-sharia compliant nature.

Every bank has to pledge a part of its deposits to the central bank as a cash reserve requirement, and also to the government by investing in government securities in the form of statutory liquidity requirements. Additionally, banks place a portion of their deposits with the central bank, generally known as ‘excess reserves’, as a buffer to liquidity shocks. Banks borrow and lend in the interbank market to manage their liquidity.

Banks hold excess liquidity either involuntarily or voluntarily. When a recession depresses credit demand in an economy, banks tend to hold excess liquidity involuntarily. If the risk of default on extended credit cannot be internalized by increasing the lending rate, banks hold excess liquidity voluntarily. The dynamics of voluntary liquidity accumulation is more complex. Often structural or cyclical factors contribute to voluntary liquidity accumulation in developing economies. Chapter 4 details these structural and cyclical factors leading to the accumulation of excess liquidity.

In Pakistan, both foreign capital inflows and government borrowing from the banking sector increased considerably between 2005 and 2011 (see Table 1.1). Therefore, we briefly review the impact of foreign capital inflows and government borrowing from the banking sector on excess liquidity.

Table 1.1 Overview of Monetary Developments in Pakistan, 2005-2011 (End of the year stock in billion Rupees**)**

	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010	FY2011
Assets							
Government Sector Borrowing (net)	**753**	**834**	**927**	**1509**	**2034**	**2441**	**3021**
Net Budgetary Borrowing (i+ii)	**647**	**708**	**810**	**1365**	**1681**	**2011**	**2602**
(i) From the State Bank of Pakistan	*268*	*404*	*345*	*1034*	*1165*	*1209*	*1201*
(ii) From scheduled banks	*378*	*304*	*465*	*331*	*516*	*803*	*1401*
Credit to Non-Government Sector	**1782**	**2191**	**2576**	**3020**	**3190**	**3389**	**3547**
A. Net domestic assets of the banking system	**2329**	**2718**	**3080**	**4022**	**4641**	**5232**	**5915**
(i) State Bank of Pakistan	195	218	151	773	902	988	1037
(ii) Scheduled banks	2134	2501	2930	3248	3740	4244	4878
B. Foreign assets of the banking system	**637**	**688**	**985**	**668**	**496**	**545**	**780**
(i) State Bank of Pakistan	195	565	788	480	303	379	614
(ii) Scheduled banks	133	123	197	187	193	167	166
Monetary Assets (M2) (A+B)	**2966**	**3407**	**4065**	**4689**	**5137**	**5777**	**6695**
Liabilities							
Currency in Circulation	**666**	**740**	**840**	**982**	**1152**	**1295**	**1501**
Bank Deposits with SBP(Reserves)	**196**	**208**	**305**	**425**	**274**	**290**	**349**
Time and Demand Deposits	**2117**	**2466**	**3011**	**3439**	**3700**	**4130**	**4809**
Foreign Currency Deposits	180	196	207	263	280	345	375
Money Supply(M2)	**2966**	**3407**	**4065**	**4689**	**5137**	**5777**	**6695**

Table 1.1 presents an overview of the assets and liabilities of the banking sector in Pakistan for the 2005-2011 period. Normally, foreign capital inflows lead to the creation of new foreign currency deposits with the banks (see lower panel in Table 1.1). Therefore, both foreign currency liabilities and assets increase in the balance sheet of banks. The new deposits, through the increase in the net foreign assets, increase the money stock (see upper panel in Table 1.1). However, the impact of foreign inflows on excess liquidity is realized only when banks convert their foreign currency assets into local currency. When the central bank purchases foreign currency from banks, banks' local currency deposits with the central bank increase thereby increasing the excess liquidity holdings of the banks.[9] As mentioned earlier, foreign currency deposits have increased steadily after May 24th 2008, when the Pakistan Rupee depreciated sharply against the US Dollar (see Figure 4.1). As regulatory requirements limit the local banks' access to the international market, these local banks often substitute their foreign currency holdings with domestic currency to invest in the local money market.

The central bank of Pakistan (SBP) follows a managed float strategy and replaces these foreign currency inflows with domestic currency both through direct purchases, and through currency swaps when these inflows create upward pressure on the exchange rate. For the banks, the substitution of foreign currency with domestic assets involves exchange rate risk. The SBP's managed float strategy mitigates the exchange rate risk only partly. The banks enter into currency swaps with peer banks or with the central bank to manage exchange rate risk. The SBP's interventions in the foreign exchange market increase interbank liquidity.

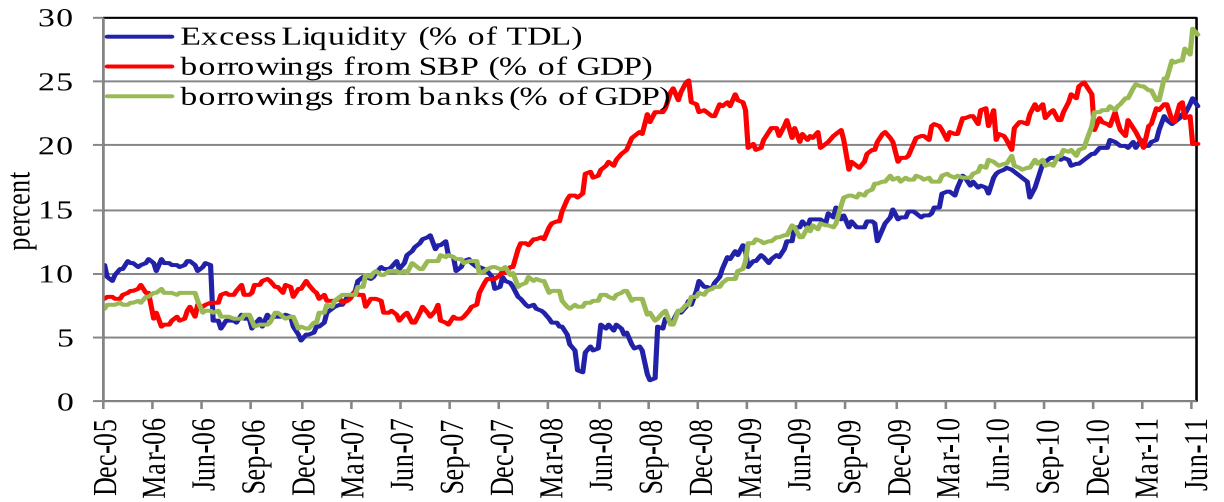
The impact of government borrowing on excess liquidity is subtle. If the government borrows from commercial banks, the banks' excess reserves decrease. As the government makes payments to the individuals and private businesses for the goods and services it receives, the deposits of individuals and private businesses increase thereby replenishing the liquidity holdings of the banks. Therefore, government borrowing from banks should not have any effect on the excess liquidity holding of the banks.

Government borrowing from the central bank leads directly to the creation of new deposits as the borrowed money is transferred to accounts of individuals and businesses. The

[9] On the central bank's intervention in the foreign exchange market, the foreign currency becomes part of the central bank's foreign assets while an equivalent amount of domestic currency provided by the central bank appears as liability. Therefore, the net assets and liabilities composition of the banking sector remains unchanged after the central bank's intervention.

new deposits rapidly increase the money stock through the deposit multiplier effect. Government borrowing from the central bank may thus have a severe inflationary impact on the economy (De Haan and Zelhorst, 1990; Fischer *et al.* 2002; and Catao and Terrones, 2005). As government borrowing from the central bank and the commercial banks increased remarkably during the period under consideration in this study, the interbank market in Pakistan has experienced an unprecedented accumulation of liquidity. Figure 1.2 shows the government borrowing from the SBP and commercial banks, and excess liquidity accumulation in the interbank market of Pakistan.

Figure 1.2 Deficit Financing and Excess Liquidity



Nissanke and Aryeetey (1998) argue that in the presence of excess bank liquidity, it becomes difficult to regulate money supply. Any attempt by the central bank to stimulate aggregate demand by relaxing monetary policy will only increase the prevalent interbank market liquidity. Likewise, if the central bank adopts monetary tightening, any sudden improvement in credit demand may cause rapid increase in credit which may subvert the central bank's tightening initiative.

In a competitive market, banks respond to policy shocks by changing their liquidity holdings; they increase liquidity holdings when monetary policy is expansionary and decrease them when it is tight. Therefore, excess liquidity holdings are temporary. In the second part of this thesis (Chapter 4) it is examined whether excess liquidity in the interbank market of Pakistan is persistent. As mentioned earlier, banks hold excess liquidity either involuntarily (due to lack of credit demand) or voluntarily (due to an increase in the perceived risk of default). Central banks can design monetary policy more effectively if the cause of excess liquidity is known. Therefore, Chapter 4 examines also the long-term and short-term determinants of excess liquidity.

As the findings of Nissanke and Aryeetey (1998) and Agénor and Aynaoui (2010) suggest that excess interbank liquidity in developing economies often limits the ability of the central bank to effectively conduct monetary policy, Chapter 5 examines whether excess interbank liquidity affects the pass-through of the policy tools to the retail rates and the exchange rate. In addition, Chapter 5 analyzes the short- and long-run impact of the main policy tools of the SBP on retail rates and the exchange rate.

1.4 Overview

Chapters 2 and 3 investigate the uncovered interest rate parity using interest rates from the London interbank market. We use daily data on LIBOR from January 1, 2001 to December 31, 2008, to avoid structural breaks associated with the introduction of the Euro in 1999 and the global financial crisis at the end of 2008.[10] Exchange rate differentials are calculated assuming that economic agents have perfect foresight. So the 6-months exchange rate differential series, for example, is calculated by subtracting the current spot rate from the spot rate after six months. Similarly, to generate interest rate differentials we subtract the currency- and maturity-specific LIBOR from the US Dollar LIBOR with similar maturity.

Chapter 2 addresses the question of whether uncovered interest rate parity holds for the system of LIBOR currencies. For this purpose, we use cross-sectional dependence robust block bootstrap (CDRBB) panel unit root tests, proposed by Palm *et al.* (2010), and the error correction based panel cointegration testing procedure, proposed by Westerlund (2007). For cointegrated regressors it is not possible to obtain estimates of long-run relationships using ordinary least square (OLS). Therefore we use panel alternatives, such as the Fully Modified OLS (FM-OLS) estimator or the Dynamic OLS (DOLS) estimators.

Our investigations in Chapter 3 go one step further. This chapter investigates whether UIP holds at the individual currency level. For this purpose, we estimate a system of Seemingly Unrelated Regressions (SUR), proposed by Moon and Perron (2005). This method provides efficient estimates by exploiting correlations among the multiple currencies while allowing for

[10] In addition we employ the period January 1, 2001 to August 30, 2008, i.e. until the fall of Lehman Brothers.

individual currency-specific inferences.

Chapters 4 and 5 investigate the causes of excess interbank liquidity and its effect on the monetary policy transmission mechanism in Pakistan. We use data from December 2005 to July 2011. The time and demand liabilities reported before December 2005 is inconsistent with the currently available information on these variables.

Chapter 4 first examines the persistence of excess liquidity using unit root tests. Intuitively, if excess liquidity is level stationary interbank liquidity accumulation is a short-term phenomenon potentially not undermining monetary policy. On the contrary, if it is difference stationary liquidity accumulation is a long-term phenomenon which may weaken monetary policy (Nissanke and Aryeetey, 1998; Agénor *et al.*, 2004; Saxegaard, 2006; and Agénor and Aynaoui, 2010).

Next, Chapter 4 analyzes the determinants of excess interbank liquidity in Pakistan. For this purpose, we utilize the Bound Testing Approach proposed by Pesaran *et al.* (2001) for identification of a long-run relationship and the Autoregressive Distributed Lag (ARDL) approach for estimation of the long-run relationship between the levels of the variables. The factors contributing to excess interbank liquidity are then separated into voluntary and involuntary liquidity components, to study the behavior of the excess liquidity in the interbank market of Pakistan.

Chapter 5 explores the impact of excess interbank liquidity on the monetary transmission in Pakistan. For this purpose, the short- and long-run pass-through of changes in policy instruments to lending and deposit rates and the exchange rate is estimated with and without excess interbank liquidity in the model. Vector Auto Regression (VAR) is employed for estimation.

Chapter 6 summarizes and concludes the thesis by discussing the findings from our investigations on uncovered interest rate parity and the nature, causes, and impact of excess liquidity on monetary transmission in Pakistan. Based on the findings of the second part of this thesis, Chapter 6 also puts forward a few policy suggestions.

Chapter 2[11]

Testing Uncovered Interest Rate Parity using LIBOR

2.1 Introduction

Uncovered Interest Rate Parity (*henceforth* UIP) is one of the most researched topics in international economics. According to the UIP hypothesis, the difference in the return on identical assets from two different countries should be fully offset by the differential of the spot and the expected future exchange rate at the points in time when the interest-bearing assets are bought and redeemed (Chinn, 2007).

For the short-term horizon, UIP usually is rejected due to frictions like irrational expectations (Frankel and Froot, 1989; Mark and Wu, 1998; and Carlson and Osler, 1999), forecast errors (Lewis, 1989; 1995), and/or non-linearities (Flood and Rose, 1996; Flood and Taylor, 1996; Bansal and Dahlquist, 2000; Sarno *et al*., 2006; and Baillie and Kilic, 2006). Numerous studies examine the importance of these frictions.[12] However, to date no study addresses whether UIP holds if frictions are minimal. This study is an attempt to address this research question. We examine uncovered interest rate parity using London Interbank Offered Rates (LIBOR). LIBOR is a daily reference rate based on the interest paid on unsecured interbank deposits by international banks. As will be explained in more detail in Section 2.2, in the LIBOR market many of the economic frictions which may lead to rejection of UIP are absent.

This chapter contributes to the literature in the following ways. First, to the best of our knowledge, LIBOR has never been directly used for testing UIP. Juselius and MacDonald (2004), Harvey (2005) and Ichiue and Koyama (2007) have used LIBOR, but only as a proxy for Japanese domestic interest rates. LIBOR is widely used as a benchmark for global financial transactions and provides a setup where the impact of several frictions (e.g., frictions arising due to differences in transaction costs and/or imperfect capital mobility) responsible for the failure of UIP are absent.

[11] This chapter is based upon De Haan *et al*. (2012).
[12] Reviews can be found in Froot and Thaler (1990), MacDonald and Taylor (1992), Flood and Taylor (1996), Isard (1996), Pasricha (2006), and Alper *et al*. (2009).

Second, this study tests UIP using fourteen different maturities, ranging from one week to 12-months. Previous studies on UIP (cf. Flood and Rose, 1996; Harvey, 2005; and Krishnakumar and Neto, 2008) mostly used only two or three maturities, such as 3-months, 6-months, or sometimes 12-months, and then generalized their findings. The use of several maturities helps to identify when UIP holds over short horizons.

Third, we employ panel unit root and cointegration techniques. Although the UIP literature has extensively adopted unit root and cointegration techniques, the use of panel cointegration is relatively new to this area. A panel setup has several advantages compared to a bilateral setting based on country specific time series. Section 2.4.1 discusses the advantages of using a panel setup in more detail.

Following most previous studies, we assume perfect foresight with respect to exchange rates. However, our findings deviate from the conclusions reached in most previous UIP studies as reported in Table A2.1 in the Appendix. First, we conclude that UIP holds for almost all maturities between 7 and 12 months. Furthermore, similar to Bekaert *et al*. (2007) we find that the speed of adjustment of the exchange rate due to a shock in interest rates is not related to the maturity of the underlying assets.

The remainder of the chapter is structured as follows. Section 2.2 discusses the salient features of LIBOR. Section 2.3 reviews some previous studies, while Section 2.4 delves into data and methodology issues. Section 2.5 presents our results. Finally, Section 2.6 concludes.

2.2 Salient features of LIBOR

London Inter-Bank Offered Rate (LIBOR) is a widely used benchmark for national and international transactions involving specific currencies. LIBOR, for any specific maturity, has the same definition and characteristics for every quoted currency. In contrast, domestic markets have a large number of debt instruments and thus interest rates, which are often not exactly the same as those in foreign markets.[13] It is hard to find interest rates from two different domestic markets with the same maturity having the same definition and characteristics as required by UIP.

Forbes Investopedia, in 2009, estimated that $360 trillion worth of international financial

[13] For example, Thomson Reuters DataStream reports 22 types of interest rates with a 3-month maturity for the Canadian debt market.

products are benchmarked with LIBOR.[14] The LIBOR rates are used as input for the LIBOR Market Model (LMM) to produce LIBOR forward rates.[15] These LIBOR forward rates are essential for pricing financial derivatives and to determine a hedging strategy for investors who hold them.

In contrast to quantitative finance, LIBOR largely remained an unexplored domain for researchers in international monetary economics. Exceptions are Mariscal and Howells (2002), Harmantzis and Nakahara (2007) and Kwan (2009). Mariscal and Howells (2002) study the interest rate pass-through from the Bank of England's policy rate to the GBP (British Pound)-LIBOR. Harmantzis and Nakahara (2007) provide empirical evidence for a long-term dependence structure in LIBOR using 12 maturities of USD and CHF (Swiss Franc) LIBOR. Kwan (2009) examines the post-financial crisis behavior of the USD (US Dollar)-LIBOR.

The LIBOR market has minimal frictions that may cause deviations from UIP (for details, see Chapter 1).[16] Frictions may arise when assets differ in risk perception (Frankel 1983; 1984; and Branson and Henderson, 1985), due to transaction costs (Baldwin, 1990; and Dumas, 1992), and due to the irrational noise traders present in the market (Frankel and Froot, 1989; De Long *et al*., 1990; Mark and Wu, 1998; and Carlson and Osler, 1999). Specifically in debt markets, the importance of noise traders and the (expected change) in transaction costs determine the market-specific premium. Baldwin (1990) shows that even small transaction costs can induce a relatively broad range of deviations from UIP.

Several studies control for frictions originating from the exchange rate by assuming perfect foresight (cf. Chinn and Meredith, 2004; Carvalho *et al.*, 2004; Bekaert *et al*., 2007; and Tang, 2011). Dealing with other frictions is less straightforward. For example, interest rate differentials calculated for testing UIP are usually based on the assumptions that capital is perfectly mobile and transaction costs are the same among the markets. However, perfect capital mobility and similar transaction costs between markets are unlikely. But currency-specific LIBOR interest rates, generated in the London interbank market, are immune from market-

[14] http://www.investopedia.com/articles/economics/09/london-interbank-offered-rate.asp.

[15] Using a stochastic process, LMM attempts to predict the behavior of the LIBOR interest rates. Initially proposed by Brace *et al*. (1997), Miltersen *et al*. (1997) and Jamshidian (1997), LMM models are continuously updated.

[16] Since LIBOR is based on aggregation of non-binding quotes, as opposed to actual transactions, the possibility of strategic misrepresentation by certain bankers who participate in quoting cannot be ruled out. This might explain why most researchers have not used this important information source. However, Michaud and Upper (2008) note that the BBA tries to reduce the incentives for such behavior (and to remove quotes that are untypical for other reasons) by eliminating the highest and lowest quartiles of the distribution and averaging the remaining quotes.

specific heterogeneity. Additionally, the multi-currency set up of LIBOR is ideal for using panel techniques, so that UIP can be estimated isolating the currency-specific effect.

With the LIBOR setup for the system of currencies it is possible to assess whether UIP holds for bilateral exchange rates and for the system of currencies. While panel cointegration provides inference on both types of relationships, the panel long-run relationship estimation techniques are still under development. For a small number of cross sections, the computed test statistics of a panel long-run relationship estimates often suffer from size distortions, specifically when incorporating individual currency specific effects (see Section 4.2.3 for details). This chapter will therefore focus only on the question of whether UIP holds for the LIBOR system of currencies, ignoring individual currency relationships. The latter will be examined in Chapter 3.

2.3 Literature review

Uncovered interest rate parity is central to international monetary economics as it links exchange rates and interest rates of different countries. Denote r_{it} and r^{*}_{it} as the logarithmic gross return for maturity *i* at any time *t* on a domestic and foreign asset, respectively.[17] Similarly, define s_t and s_{t+i} as the logarithmic spot exchange rate at time *t* and *t+i*, respectively. If f_{t+i} is the forward rate for maturity *i* then Covered Interest Rate Parity (CIP) can be described as:

$$(f_{t+i} - s_t) = \alpha_t + \beta(r_{it} - r_{it}^{*}) \tag{2.1}$$

where α_t is the risk premium required to incorporate the deviation of the expected future spot rate from the forward rate, and β is the slope coefficient.

If investors do not require compensation for uncertainty associated with trading currencies in the future, the expected future spot rate will be same as the forward rate and relationship (2.1) becomes:

$$[E(s_{t+i}) - s_t] = \alpha_t + \beta(r_{it} - r_{it}^{*}) + \varepsilon_{it}\,, \tag{2.2}$$

also known as Uncovered Interest Rate Parity (UIP). $E(s_{t+i})$ is the expected future spot exchange rate at $t+i$, and ε_{it} the error term. If UIP holds, α_t in equation (2.2) is zero, while β is one.

In line with the previous literature we assume that individuals have perfect foresight (cf. Chinn and Meredith, 2004; Carvalho *et al.*, 2004; Bekaert *et al.*, 2007; and Tang, 2011). That

[17] See Table A3.9 in the Appendix to Chapter 3 for the details of the symbols used in Chapters 2 and 3.

means $E(s_{t+i}) = s_{t+i}$, and therefore Equation (2.2) can be modified to:

$$[s_{t+i} - s_t] = \alpha_t + \beta(r_{it} - r_{it}^*) + \varepsilon_{it} . \tag{2.3}$$

For simplicity, the exchange and interest rate differentials are denoted by y_{it} and x_{it}, respectively. Equation (2.3) then simplifies to

$$y_{it} = \alpha_t + \beta x_{it} + \varepsilon_{it} . \tag{2.4}$$

Surveys by Froot and Thaler (1990), MacDonald and Taylor (1992), McCallum (1994), Isard (1996), and Engel (1996) report a negative β at a short-term horizon, in contrast to the theoretical prediction of a positive unit coefficient. For instance, Froot and Thaler (1990) report an average β coefficient of -0.88 for industrialized economies, while McCallum (1994) concludes that β is typically around -3, and Engel (1996) reports that the representative β coefficient falls between -3 and -4.

The empirical rejection of UIP using bilateral exchange rates (Juselius and MacDonald, 2004; Chaboud and Wright, 2005; and Baillie and Kilic, 2006) has instigated researchers to frame this hypothesis in multicurrency testing designs. Often currencies are related with each other, specifically for industrialized economies. For instance, a shock to the US debt market that increases US interest rates *vis-à-vis* Japanese interest rates will activate carry trade which may, in turn, affect the US Dollar-Japanese Yen exchange rate. However, the US specific interest rate shock also affects other markets. Flood and Rose (1996), Bansal and Dahlquist (2000), and Ichiue and Koyama (2007) have employed a pooled setup using multiple currency exchange rates. Other authors (Carvalho *et al.*, 2004; Chinn and Meredith, 2004; and Tang, 2011) have used panel cointegration techniques. The use of panel cointegration is relatively new to this area. A panel setup has several advantages compared to a bilateral or pooled setup, as will be explained in detail in Section 2.4.1.

Interestingly, while testing UIP uses panel cointegration most of studies have assumed that currencies are independent of each other. In this globalized world, financial markets are integrated and currencies are closely related with each other as discussed above, specifically for industrialized economies. Therefore, ignoring the cross currency dependence between currencies may lead to misleading results. This chapter uses panel cointegration techniques to investigate UIP and incorporates the dependence structure between the members of the panel.

Recent studies (as mentioned in Section 2.2) have shown that a number of factors, including the functional form and the core characteristics of the underlying instruments defined by identity, maturity, and inherent risks, may influence the estimation results for UIP. As the focus of this study is on the short-term horizon, generally defined to be a period less than one year, this review is limited to studies using short-term instruments only. Table A2.1 in the Appendix offers a summary of studies focusing on the period of study, maturities, currencies, and the techniques used for analyzing this relationship.[18] In line with the earlier surveys mentioned, Table A2.1 shows that many studies do not support UIP. Although some studies report mixed results, others reject UIP (cf. Mark and Wu, 1998; Juselius and MacDonald, 2004; and Campbell *et al*., 2007).

Most studies use domestic interbank or money market rates to test UIP, except for Juselius and MacDonald (2004), Harvey (2005), and Ichiue and Koyama (2007) who employ LIBOR for one or two maturities. These studies have investigated UIP for the Japanese Yen and note that the information content of the JPY-LIBOR rate is superior to the Japanese short-term interest rate, since the money market in Japan was thin and heavily regulated until the late 1980s.

Finally, almost all studies employ only two or three maturities and then generalize their findings. However, in general the volatility of short-term interest rates is higher than that of long-term rates (Borio and McCauley, 1996). Therefore, the finding that UIP is rejected for 3- or 6-months maturities should not be generalized to all maturities.

2.4 Methodology and data

2.4.1 Methodology

As shown in Table A2.1 (in the Appendix), several authors have used unit root and cointegration techniques. Following Dreger (2010) and Tang (2011), we will use panel cointegration techniques to examine UIP. Using a panel setup has several advantages compared to a bilateral setting based on individual time series. In the first place, it takes into account that financial markets are not isolated as discussed in Section 2.3. Panel techniques may exploit the multi-currency environment to isolate individual currency-specific effects. The within-transformation, used to isolate the currency-specific fixed effect, may lower the correlation between the series,

[18] More details of progress in this area can be found in recent surveys, such as Chinn and Meredith (2004, 2005), Pasricha (2006), and Alper *et al*. (2009).

hence a panel set-up helps in mitigating the multicollinearity problem. Moreover, a panel approach yields efficiency gains and enhances the possibility of estimating the complex dynamics. Finally, the increased sample size using panel design is expected to improve the power of the tests. Time series tests based on small sample often lack power. Pooling information from the members of panel helps in overcoming the small sample size problem.

As a starting point, we check the stationarity of the data used. For this purpose, we employ Palm *et al.*'s (2011) Cross-sectional Dependence Robust Block Bootstrap (CDRBB) technique as it has advantages over first and second generation panel unit root tests. The next section briefly goes into first and second generation panel unit root tests and then details the CDRBB block bootstrapping panel unit root test.

2.4.1.1 Panel unit root tests

The literature describing the panel unit root tests for an autoregressive series, given by Equation (2.5), has evolved considerably over time,

$$\Delta z_{it} = \mu_i + \theta_t + \rho_i z_{it-1} + \upsilon_{it} . \tag{2.5}$$

Equation (2.5) shows the number of cross sections by $i=1,2,\ldots,N$, and the time period by $t=1,2,\ldots,T$, while z_{it} is any series to be tested for unit roots, and μ_i and θ_t are respectively the fixed effects and the unit specific time trends, ρ_i is the unit specific autoregressive parameter and υ_{it} is the error term.

The first generation of panel unit root tests examines the stationarity of a series assuming that the panel is cross sectionally independent.[19] The independent cross section assumption is very restrictive for financial markets in general and for the LIBOR market in particular, as currency specific interest rates influence each other. Baltagi *et al*. (2007) point out that panel unit root tests which do not account for cross-sectional dependence can be subject to considerable size distortions and therefore tend to over-reject the null hypothesis.

To test cross-sectional independence, we use the Breusch and Pagan LM test as recommended by Greene (2000) for panels with long time series. This test exploits contemporaneous correlations using seemingly unrelated regressions (SUR). The resulting test

[19] Notable among the first generation of unit root tests are tests proposed by Harris and Tzaralis (1999), Maddala and Wu (1999) [commonly known as Fischer Test], Breitung (2000), Hadri (2000), Levin *et al*. (2002) [commonly known as LLC], and Im *et al*. (2003) [commonly known as IPS].

statistic has a Chi-square distribution with [*N*(N-1)/2*] degrees of freedom, where *N* indicates the number of cross-sections. The null hypothesis holds that cross sections are independent from each other. As will be discussed in Section 2.5, the test results show that the LIBOR currencies are not independent.

The second generation of panel unit root tests relaxes the assumption of independent cross-sections. To capture the cross sectional dependence between the series, these tests model an unobserved common factor across units.[20] Underlying this technique is the premise that variability among observed variables can be described by a potentially lower number of unobserved variables, called ‘common factors’. These common factors are assumed to account for the variation and co-variation across a range of observed phenomena (for details, see Bai and Ng, 2004; and Moon and Perron, 2004).

The second-generation panel unit root tests require panels with a relatively large number of cross-sections with long time series. In addition, these tests can only deal with common factor structures and contemporaneous dependence. As we use a panel with six cross-sections only, the application of a second-generation test is inappropriate for our study.

The CDRBB test does not entail modeling the temporal and/or cross sectional dependence structures as it uses block bootstrapping. Moreover, inferences from this test are valid under a wide range of possible data generating processes. In a nutshell, the block bootstrap technique is the time series version of a standard bootstrap where the dependence structure of the time series is preserved by dividing data into blocks and then re-sampling the blocks.

The CDRBB test provides ‘pooled (τ_p)’ and ‘group-mean (τ_{gm})’ test statistics, summarized by Equations (2.6) and (2.7), respectively,

$$\tau_p = T \frac{\sum_{i=1}^{N} \sum_{t=2}^{T} y_{i,t-1} \Delta y_{i,t}}{\sum_{i=1}^{N} \sum_{t=2}^{T} y_{i,t-1}^2} \tag{2.6}$$

$$\tau_{gm} = \frac{1}{N} \sum_{i=1}^{N} T \frac{\sum_{t=2}^{T} y_{i,t-1} \Delta y_{i,t}}{\sum_{t=2}^{T} y_{i,t-1}^2} \tag{2.7}$$

[20] Widely used second-generation unit root tests are those proposed by e.g., Bai and Ng (2004), Moon and Perron (2004), Choi (2005), and Pesaran (2007).

where N and T are the number of cross sections and time observations, respectively, and y_{it} refers to exchange rate or interest rate differential series. The 'pooled' statistic presumes that the members of the panel have the same autoregressive coefficient. In other words, the statistics are obtained by pooling information without considering the individual members' characteristics, which is quite restrictive. The 'group mean' test statistic, on the other hand, incorporates the members' specific individual autoregressive coefficients. In essence, the 'pooled' and 'group mean' statistics are defined according to the Levin *et al.* (2002) and Im *et al.* (2003) tests. Both statistics take as the null hypothesis that the series is non-stationary *vis-à-vis* the alternative hypothesis that the series is stationary. Rejection of the null hypothesis when the series is in first differences and non-rejection of the null when the series is in levels indicate that the series concerned has a unit root. Using block bootstrap, the distribution of these test statistics is obtained by resampling the blocks of consecutive observations.

2.4.1.2 Panel cointegration

To detect the long-run relationship between two or more integrated series, the literature generally adopts cointegration estimation techniques. UIP requires a positive long-run relationship between interest and exchange rate differentials. Until recently, the literature has largely adopted residual based panel cointegration tests, like those proposed by McCoskey and Kao (1998), Kao (1999), and Pedroni (1999; 2004). Instead, we adopt the Westerlund (2007) error correction based procedure for testing cointegration. First, this method presupposes that regressors are weakly exogenous. In line with this presumption, the UIP hypothesis assumes that the contemporaneous causality runs from the interest rate to the exchange rate only. Second, this procedure provides robust critical values for the test statistics by applying bootstrapping to account for cross sectional dependence. Besides, the simulation results of Westerlund (2007) show that the test continues to perform well with good power even for only ten cross sectional units. The Westerlund's (2007) panel cointegration test starts from the error correction mechanism (ECM) for i currencies and t time periods,

$$\Delta y_{it} = \delta_i^{'} d_t + \phi_i (y_{i,t-1} - \psi_i^{'} x_{i,t-1}) + \sum_{j=1}^{p_i} \gamma_{1ij} \Delta y_{i,t-j} + \sum_{j=0}^{p_i} \gamma_{2ij} \Delta x_{i,t-j} + u_{it}\,, \tag{2.8}$$

where, $i=1,2,\ldots,N$, and $t=1,2,\ldots,T$, x_{it} and y_{it} are respectively interest and exchange rate differentials, while d_t is the currency-specific deterministic component, δ_i is the associated vector of parameters, ϕ_i is the individual specific speed of adjustment parameter for the error correction term, p_i is the optimal number of leads and lags, and ψ_i is the cointegrating vector. The appropriate number of leads and lags p_i selected by some information criterion transforms u_{it} into white noise.

The null hypothesis of the cointegration test is $\phi_i = 0$, which indicates no cointegration between the variables. The Westerlund (2007) test provides two groups of test statistics, i.e. panel and group mean test statistics, each using Newey-West standard errors and contemporaneously calculated conventional standard errors. The group panel test statistic P_τ and the panel test statistic P_α ,

$$P_\tau = \frac{\hat{\phi}}{SE(\hat{\phi})} \text{ , and } P_\alpha = T\hat{\phi} \tag{2.9}$$

assume that the cross sections have a common error correction parameter $\hat{\phi}$. The alternative hypothesis is that the panel is cointegrated as a whole, and is therefore more relevant for studying the LIBOR system of currencies. The common error correction estimator $\hat{\phi}$ is calculated as $\hat{\phi} = \left(\sum_{i=1}^{N} \sum_{t=2}^{T} \tilde{y}_{it-1}^2 \right)^{-1} \sum_{i=1}^{N} \sum_{t=2}^{T} \frac{1}{\hat{\phi}_i(1)} \tilde{y}_{it-1} \Delta\tilde{y}_{it}$, where $\tilde{y}_{it-1}$ and $\Delta\tilde{y}_{it}$ are projection errors from the regression of Δy_{it} and y_{it-1} on d_i, the lags of Δy_{it}, and the contemporaneous and lagged values of Δx_{it}. The standard error $SE(\hat{\phi})$ uses the Newey-West standard error and is calculated as $SE(\hat{\phi}) = \left((\hat{S}_N^2)^{-1} \sum_{i=1}^{N} \sum_{t=2}^{T} \tilde{y}_{it-1}^2 \right)^{-1/2}$, where $\hat{S}_N^2 = \frac{1}{N} \sum_{i=1}^{N} \hat{\sigma}_i / \hat{\phi}_i(1)$ and $\hat{\sigma}_i$ is the estimated regression standard error and $\hat{\phi}_i(1)$ is the Newey-West standard error.[21] Westerlund (2007)

[21] In order to provide support to our argument in Section 2.5, we discuss the estimates of the Group mean test statistics also. Group mean statistics G_α and G_τ capture the individual specific heterogeneity. These statistics test the alternative hypothesis that at least one member of the panel is cointegrated. Similar to panel statistics, the Group mean statistics are constructed using a conventional variance estimator $G_\tau = N^{-1} \sum_i \frac{\hat{\phi}_i}{SE(\hat{\phi}_i)}$ and a Newey-West

shows that asymptotically these statistics have a limiting normal distribution and that the estimators are consistent. He also shows that the coefficient test statistics P_α and G_α probably have greater power compared to the Newey-West based test statistics P_τ and G_τ, in long panels where *T* is substantially larger than *N*.

2.4.1.3 Estimating the long-run relationship

Presume the following long-run relationship holds between the cointegrated series y_{it} and x_{it}:

$$y_{it} = \alpha_i + \beta_i x_{it} + \varepsilon_{it} \tag{2.10}$$

$$x_{it} = x_{i,t-1} + u_{it}$$

This relationship should not be estimated by ordinary least squares (OLS) as OLS estimates obtained are biased. Phillips and Durlauf (1986) have derived the asymptotic distribution of the OLS estimator and its t-statistics for finite time series. Their evidence shows that the asymptotic distribution of OLS estimator is highly complicated and non-normal, thus invalidating standard inference. Chen *et al*. (1999) have investigated the finite sample properties of OLS as well as the bias corrected OLS estimators and its t-statistics for long panels. They find that both estimators in general fail to solve the simultaneity and endogeneity problems. Therefore, alternatives as Fully Modified OLS (FM-OLS) or Dynamic OLS (DOLS) should be considered for cointegrated panel regressions. Following the suggestion of Kao and Chiang (2001), we use both panel FM-OLS and DOLS for estimation of the long run relationship for the cointegrated series.

The FM-OLS estimator is constructed by correcting the OLS estimator for endogeneity and serial correlation. To remove the nuisance parameters caused by endogeneity and serial correlation, the FM-OLS estimator employs a semi-parametric correction using kernel estimates. For a specification, such as Equations (2.10), where all regressors have a unit root and ε_{it} is white noise, the FM-OLS estimator is given by,

$$\hat{\beta}_{FM} = \left[\sum_{i=1}^{N} \sum_{t=1}^{T} (x_{it} - \bar{x}_i)(x_{it} - \bar{x}_i) \right]^{-1} \left[\sum_{i=1}^{N} \sum_{t=1}^{T} (x_{it} - \bar{x}_i) \hat{y}_{it}^{+} - T\hat{\Delta}_{\varepsilon u}^{+}) \right] \tag{2.11}$$

---

type long-run variance estimator $G_\alpha = N^{-1} \sum_i \frac{T\hat{\phi}_i}{\hat{\phi}_i(1)}$, where $SE(\hat{\phi}_i)$ is the conventional standard error and $\hat{\phi}_i(1)$ is the Newey-West standard error.

where $\bar{x}_i = \frac{1}{T}\sum_{t=1}^{T} x_{it}$, $\hat{y}_{it}^{+} = y_{it} - \hat{\Omega}_{u\varepsilon}\hat{\Omega}_{\varepsilon}^{-1}\Delta x_{it}$ implies endogeneity correction in y_{it} using long-run covariance and auto-covariance estimators $\hat{\Omega}_{u\varepsilon}$ and $\hat{\Omega}_{\varepsilon}^{-1}$ while $\hat{\Delta}_{\varepsilon u}^{+}$ is a serial correlation correction factor estimated using kernel estimates.[22] The estimator thus obtained is asymptotically unbiased with fully efficient mixture normal distribution. Therefore, inferences can be obtained easily (Kao and Chiang, 2001). Originally proposed by Phillips and Hansen (1990) for time series, the FM-OLS estimator has been modified for a panel context by Philips and Moon (1999), Pedroni (2001), and Kao and Chiang (2001).

FM-OLS generates consistent estimates of the parameters in relatively small samples, but also controls for potential endogeneity of the regressors and serial correlation. The FM-OLS and DOLS estimators provide two forms of estimates. First, by restricting the slope parameter across individual members to be common ($\beta_i = \beta$), the estimates obtained are homogenous panel estimates. Second, by allowing the slope parameters to differ across individual cross-sections we obtain so-called heterogeneous panel estimates. As this chapter focuses on the LIBOR system for studying UIP, estimates of the homogenous panel serve our objective well. Heterogeneous panel estimates, on the contrary, are severely affected by the small *N* bias.

Similar to FM-OLS, DOLS estimates the single cointegrating vector ($\beta_i^{'}$) which characterizes the long-run relationship among the variables,

$$y_{it} = \alpha_i + \beta_i^{'} x_{it} + \sum_{j=-p}^{p} \varsigma_{ij}\Delta x_{it} + v_{it} \ . \tag{2.12}$$

The dynamic OLS method removes the nuisance parameters by augmenting lags and leads of the regressors where p represents the number of leads and lags to be incorporated. Some information criterion is used to determine the appropriate number of leads and lags. The DOLS estimators are identically distributed and converge to the same limiting distribution as that of the FM-OLS estimators. McCoskey and Kao (1998) and Kao and Chiang (2001) formulate DOLS for panels using the dynamic OLS method initially proposed by Saikkonen (1992) and Stock and Watson (1993) for time series.[23] The proposed estimators provide asymptotically efficient estimates of the cointegrated system.

[22] We refer to Kao and Chiang (2001) for further details of the FM-OLS estimation methodology.
[23] Mark and Sul (2003) have proposed another version panel DOLS estimator by extending the single equation panel DOLS estimator proposed by Kao and Chiang (2001).

The FM-OLS and DOLS estimators both assume that errors are independent across cross-sections which may not be true when using the LIBOR currency rates for studying UIP. In addition, the number of cross sections (N) in our panel is finite. Monte Carlo simulation results of Kao and Chiang (2001) show that FM-OLS estimates are more biased than those based on DOLS in samples with a small number of cross sections. Moreover, the limiting distributions of both estimators does not support a panel with a finite number of cross sections, as these distribution are based on the sequential limit theory where $T \to \infty$ followed by $N \to \infty$. However, estimation techniques for panel-cointegrated systems are still in an evolutionary phase and widely accepted solutions to these problems have not yet been provided.

2.4.2 Data

We use daily data on LIBOR from January 1, 2001 to December 31, 2008 from the British Bankers Associations' internet archive, which is publicly available.[24] The descriptive statistics of the data used in this study are provided in Tables 2.1 and 2.2. Extending our sample before 2001 would involve structural break issues. The introduction of the Euro, as a single European currency in January 1999, has brought structural changes in the global financial system. In order to make sure that our results are not driven by these changes, we did not include 1999 and 2000. Our sample ends in 2008 in view of the global financial crisis that started with the fall of Lehman Brothers in September 2008.[25] In our view, a financial crisis may distort economic relationships which exist under stable circumstances.

[24] LIBOR rates are, by definition, offered rates. The British Bankers Association (BBA) defines it as, "the rate at which an individual contributor panel bank could borrow funds, were it to do so by asking for and then accepting interbank offers in reasonable market size, just prior to 11:00 AM London time." For details see: http://www.bbalibor.com/rates/historical.

[25] Inclusion of the post Lehman Brother months of 2008 in our sample does not strongly affect our conclusions. The main analysis is based on the longer sample period to use as many observations as possible. We will return to this issue in Section 2.5.

Table 2.1 Descriptive Statistics for Exchange Rate Differentials

Maturity	Genre	Mean	Standard Deviation	Minimum	Maximum	Total No. of Obs.	No. of Panels	No. of Obs. in Panel
1 week	overall	-0.0001	0.0139	-0.1671	0.1008	14539	7	2077
	between		0.0007	-0.0010	0.0009			
	within		0.0139	-0.1676	0.0998			
2 weeks	overall	-0.0002	0.0195	-0.2292	0.1473	14504	7	2072
	between		0.0013	-0.0020	0.0019			
	within		0.0194	-0.2304	0.1452			
1 month	overall	-0.0004	0.0281	-0.3080	0.2251	14427	7	2061
	between		0.0026	-0.0037	0.0037			
	within		0.0280	-0.3102	0.2267			
2 months	overall	-0.0006	0.0406	-0.3435	0.2154	14280	7	2040
	between		0.0051	-0.0071	0.0071			
	within		0.0403	-0.3481	0.2191			
3 months	overall	-0.0006	0.0501	-0.4324	0.2348	14133	7	2019
	between		0.0081	-0.0113	0.0110			
	within		0.0495	-0.4403	0.2413			
4 months	overall	-0.0003	0.0572	-0.4535	0.2447	13986	7	1998
	between		0.0121	-0.0159	0.0161			
	within		0.0561	-0.4663	0.2557			
5 months	overall	0.0002	0.0637	-0.4430	0.2546	13839	7	1977
	between		0.0165	-0.0211	0.0219			
	within		0.0619	-0.4609	0.2703			
6 months	overall	0.0010	0.0680	-0.4372	0.2647	13692	7	1956
	between		0.0217	-0.0272	0.0287			
	within		0.0650	-0.4611	0.2856			
7 months	overall	0.0017	0.0715	-0.4055	0.2624	13545	7	1935
	between		0.0269	-0.0334	0.0355			
	within		0.0670	-0.4356	0.2886			
8 months	overall	0.0023	0.0750	-0.4324	0.2748	13398	7	1914
	between		0.0321	-0.0391	0.0420			
	within		0.0689	-0.4689	0.3067			
9 months	overall	0.0030	0.0787	-0.4055	0.2748	13251	7	1893
	between		0.0373	-0.0448	0.0485			
	within		0.0707	-0.4484	0.3125			
10 months	overall	0.0036	0.0827	-0.3727	0.2792	13104	7	1872
	between		0.0428	-0.0507	0.0551			
	within		0.0726	-0.4223	0.3083			
11 months	overall	0.0042	0.0871	-0.3550	0.2919	12957	7	1851
	between		0.0481	-0.0562	0.0615			
	within		0.0749	-0.4113	0.3147			
12 months	overall	0.0049	0.0926	-0.4324	0.3380	12810	7	1830
	between		0.0533	-0.0615	0.0680			
	within		0.0783	-0.4949	0.3943			

Notes: Genre indicates the type of the statistics calculated. Overall indicates all cross-sections (panels) and their time dimensions are taken together. Between shows the differences within panel members. Within shows the variation within panel members over time.

Table 2.2 Descriptive Statistics for Interest Rate Differentials

Maturity	Genre	Mean	Standard Deviation	Minimum	Maximum	Total No. of Obs.	No. of Panels	No. of Obs. in Panel
1 week	overall	-0.0002	0.0199	-0.0577	0.0535	14574	7	2082
	between		0.0175	-0.0278	0.0238			
	within		0.0116	-0.0301	0.0327			
2 weeks	overall	-0.0001	0.0199	-0.0579	0.0498	14574	7	2082
	between		0.0176	-0.0278	0.0239			
	within		0.0115	-0.0303	0.0320			
1 month	overall	-0.0001	0.0200	-0.0581	0.0484	14574	7	2082
	between		0.0176	-0.0279	0.0239			
	within		0.0115	-0.0303	0.0318			
2 months	overall	-0.0001	0.0199	-0.0572	0.0493	14574	7	2082
	between		0.0176	-0.0280	0.0239			
	within		0.0114	-0.0293	0.0253			
3 months	overall	-0.0001	0.0200	-0.0564	0.0508	14574	7	2082
	between		0.0177	-0.0281	0.0238			
	within		0.0115	-0.0284	0.0268			
4 months	overall	-0.0002	0.0199	-0.0557	0.0521	14574	7	2082
	between		0.0177	-0.0282	0.0238			
	within		0.0114	-0.0277	0.0281			
5 months	overall	-0.0002	0.0199	-0.0552	0.0530	14574	7	2082
	between		0.0177	-0.0284	0.0237			
	within		0.0113	-0.0270	0.0290			
6 months	overall	-0.0003	0.0199	-0.0545	0.0540	14574	7	2082
	between		0.0177	-0.0285	0.0237			
	within		0.0113	-0.0271	0.0300			
7 months	overall	-0.0003	0.0199	-0.0542	0.0549	14574	7	2082
	between		0.0177	-0.0286	0.0237			
	within		0.0112	-0.0272	0.0308			
8 months	overall	-0.0004	0.0198	-0.0535	0.0555	14574	7	2082
	between		0.0177	-0.0287	0.0237			
	within		0.0112	-0.0269	0.0315			
9 months	overall	-0.0004	0.0198	-0.0532	0.0563	14574	7	2082
	between		0.0177	-0.0288	0.0237			
	within		0.0111	-0.0267	0.0322			
10 months	overall	-0.0004	0.0198	-0.0530	0.0566	14574	7	2082
	between		0.0178	-0.0290	0.0237			
	within		0.0110	-0.0267	0.0325			
11 months	overall	-0.0005	0.0198	-0.0528	0.0570	14574	7	2082
	between		0.0178	-0.0291	0.0237			
	within		0.0110	-0.0269	0.0328			
12 months	overall	-0.0005	0.0197	-0.0525	0.0572	14574	7	2082
	between		0.0178	-0.0293	0.0236			
	within		0.0109	-0.0268	0.0331			

Notes: Genre indicates the type of the statistics calculated. Overall indicates all cross-sections (panels) and their time dimensions are taken together. Between shows the differences within panel members. Within shows the variation within panel members over time.

LIBOR rates have been collected for seven currencies (US Dollar, British Pound, euro, Japanese Yen, Swiss Franc, Australian Dollar, and Canadian Dollar) and for fourteen maturities, starting from one week to twelve months. Data on the exchange rate *vis-à-vis* the US Dollar comes from the International Monetary Fund (IMF).[26] Each currency represents a cross-section of the panel while the number of the periods (t = 2082) shows the length of each cross section.

Except for Flood and Rose (1996) and Chaboud and Wright (2005), most studies on UIP have used monthly or quarterly data. Following Flood and Rose (1996), we use daily data assuming that the daily frequency is more helpful in tracking movements in financial variables in this integrated financial world.

A practical problem with the dataset is that it contains only daily values for the five trading days per week. Therefore, the week length has been reduced to five days so that Monday comes immediately after Friday. For missing values, the last quoted value has been used as the current value. In case of a first missing value, we used the first available value to fill the series backward.

As the movement in the exchange rate is calculated by subtracting spot rates s_t from s_{t+i}, the use of overlapping data may cause autocorrelation in the error term as pointed out by Harri and Brorsen (2002). Our unit root and cointegration tests compute critical values using bootstrapping and hence our results will not be affected by this problem.

2.5 Results and analysis

To test cross-sectional independence, we use the Breusch and Pagan LM test. Table A2.2 in the Appendix gives the Chi-square statistics for the null hypothesis of independent cross-sections. The relevant *p*-values suggest that the null hypothesis is rejected at the one percent level of significance for all maturities, indicating that the LIBOR currencies are not independent from each other. Hence, the first generation of panel unit root tests is inapplicable for our study. Also as discussed in Section 2.4.1.1, second-generation tests would be inappropriate for our study as

[26] The exchange rates are IMF reported rates for various currencies in US Dollar. The IMF website explains these rates as follows: “the rates are reported daily to the Fund by the issuing central bank. Rates are normally reported for members whose currencies are used in Fund financial transactions”. Furthermore, the website indicates that the IMF posts Representative and SDR exchange rates every 20 minutes from 11:00 AM to 6:00 PM U.S. EST Monday to Friday except for the holidays. For details see: http://www.imf.org/external/np/fin/data/param_rms_mth.aspx

we use a panel with six cross-sections only. Therefore, this study employs Palm *et al.*'s (2011) Cross-sectional Dependence Robust Block Bootstrap (CDRBB) technique.[27]

Table 2.3 Pooled Statistics from Block Bootstrap Panel Unit Root Tests

	Exchange Rate Differentials			Interest Rate Differentials		
Maturity	**Coefficient**	**5% CV**	***p*-value**	**Coefficient**	**5% CV**	***p*-value**
1 week	-514.964	-18.513	0.000	-2.143	-7.153	0.753
2 weeks	-268.948	-16.189	0.000	-3.746	-13.488	0.804
1 month	-125.332	-13.536	0.000	-2.906	-8.124	0.654
2 months	-58.305	-14.208	0.000	-2.512	-7.211	0.642
3 months	-35.969	-15.774	0.000	-2.588	-6.138	0.563
4 months	-25.998	-16.676	0.001	-1.667	-6.525	0.802
5 months	-19.132	-16.211	0.015	-1.635	-7.241	0.846
6 months	-16.735	-15.850	0.035	-1.529	-8.102	0.888
7 months	-15.334	-16.703	0.083	-1.347	-8.422	0.919
8 months	-14.460	-17.317	0.138	-1.232	-8.866	0.937
9 months	-13.844	-17.686	0.187	-0.724	-9.597	0.972
10 months	-12.711	-17.244	0.249	-0.579	-9.732	0.979
11 months	-12.109	-17.976	0.342	-1.270	-10.269	0.965
12 months	-11.632	-17.541	0.327	-2.997	-11.485	0.931

Notes: Estimated test statistics for Equation (2.5) for the level of exchange rate and interest rate differentials. 5% CV indicates robust critical values calculated at 5% level of significance. *p*-values indicate the corresponding probability values of the calculated test statistics. Block size selected (for both interest rate and exchange rate differentials) is 23 for maturities of 1 week to 4 months and 22 for the rest of the maturities.

Table 2.3 reports pooled statistics of the CDRBB test for the level of the series. The results show that the null hypothesis of non-stationary cannot be rejected for the exchange rate differentials for maturities from 7 to 12 months at the 5 percent level. Often the pooled unit root test rejects the null hypothesis even if some of the units in the panel are not stationary. Therefore, the rejection of the unit root hypothesis for the series for 1 week to 6 months maturities does not imply that all series are stationary (Pesaran, 2012).

Group mean test statistics as suggested by Im *et al.* (2003) reject the unit root null hypothesis if a non-zero fraction of the panel (*N1/N*) follows stationary processes in a panel with a large number of cross sections (*N*); where *N1* is the number of cross-sections that are stationary. The conclusions from the group mean statistics (see Table A2.3 in the Appendix) supplement the result from pooled statistics reported in Table 2.1. The tests for the first differences of these 7 to 12 months maturities reject the null hypothesis (see Table A2.4 in the Appendix), indicating that these series are I(1).

[27] The CDRBB estimation code is obtained from Stephen Smeeke's website: http://www.personeel.unimaas.nl/s.smeekes/

Similarly, for the interest rate differentials, the tests do not (do) reject the null hypothesis for all levels (the first difference) of the interest differentials, indicating the series are I(1).[28] We conclude that both exchange and interest rate differentials with maturities between 7 and 12 months are integrated and therefore the systems of these currencies can be used for cointegration tests.

Our results show the importance of considering a wide array of maturities. Had we considered, say, maturities of 3 and 6 months only, as most previous studies do (see Table A2.1 for details), we would have ended up with the conclusion that both series are not integrated and therefore not-cointegrated. Such an outcome would therefore have led us to reject UIP, as cointegration is a necessary (but not sufficient) condition for UIP to hold.

Table 2.4 Results of the Westerlund Cointegration Test for Homogenous Panel

	P_α			P_τ		
Maturity	**Value**	***z*-value**	**Rob. *p*-value**	**Value**	***z*-value**	**Rob. *p*-value**
7 months	-9.065	-6.801	0.000	-4.166	-2.498	0.030
8 months	-8.141	-6.019	0.010	-3.922	-2.289	0.040
9 months	-10.354	-7.892	0.000	-4.836	-3.072	0.020
10 months	-9.593	-7.248	0.000	-4.726	-2.977	0.0100
11 months	-8.697	-6.489	0.030	-4.521	-2.802	0.0500
12 months	-7.408	-5.399	0.030	-3.987	-2.345	0.0400

Notes: Estimates of ECM coefficient based on Equation (2.7). The alternative hypothesis of these test statistics is that cointegration exists when at least one member of the panel is cointegrated. 5 and 21 are the maximum number of leads and lags considered for estimation. Coefficient gives the estimated values of the group mean statistics and Z-values are their standardized values. Rob. p -values are the robust probability values calculated using the bootstrap technique. The corresponding values show the level of significance.

We apply the Westerlund (2007) cointegration test to the levels of the series. The optimal number of leads and lags (which is different for every maturity) to be included in the error correction equation has been selected on the basis of Akaike's Information Criterion (AIC). Critical values for the test statistics are calculated using bootstrapping. As this chapter focuses on the LIBOR system for studying UIP, Table 2.4 only shows the panel statistics P_α and P_τ. Robust *p*-values for both panel statistics P_α and P_τ indicate that the null hypothesis of no cointegration is rejected at the five percent level of significance for all the maturities with integrated regressors. This evidence shows that the 7 to 12 months maturities of the exchange rate and the interest rate

[28] To check that this result is not driven by persistence in high frequency data, we have applied unit root test to weekly and monthly data, as well. The conclusions are not different from the results as reported in Table 2.3. Chapter 3 discusses these results in detail.

differential series for the LIBOR system are cointegrated.

As a supplement, group-mean statistics are reported in Table A2.5 (in the Appendix) which study the cointegrating behavior at the individual currency level. The robust group-mean statistics G_α also show that the null hypothesis of no cointegration is rejected for maturities of 7 to 11 months, albeit at the ten percent level of significance. In other words, any shock to a currency-specific LIBOR rate *vis-à-vis* another currency-specific rate affects the exchange rates between these currencies in the long run.

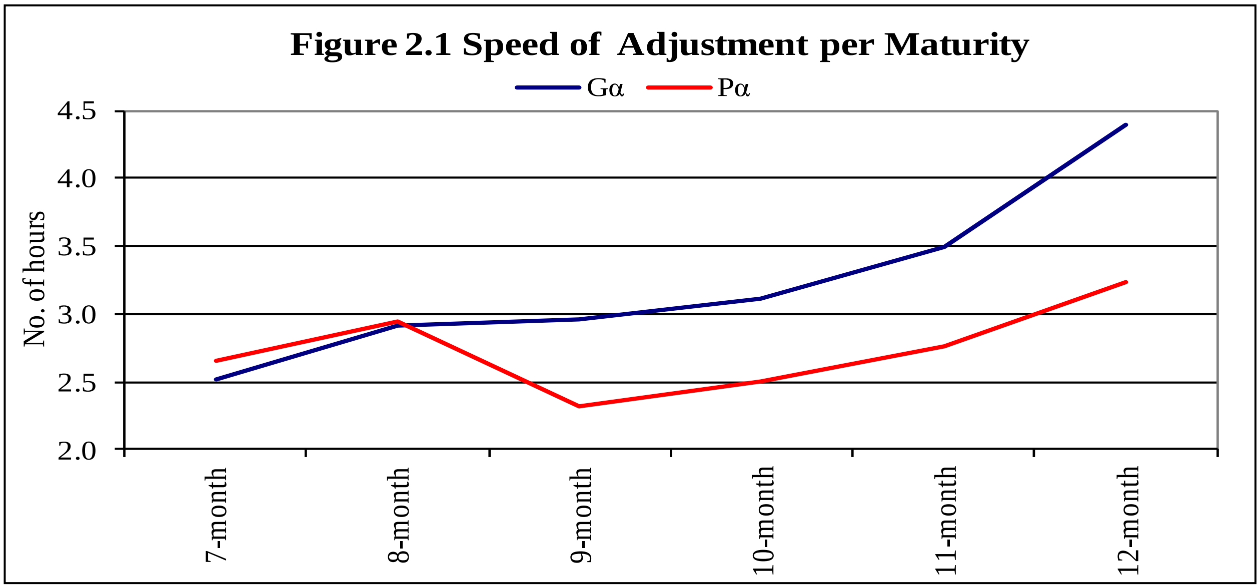
To assess whether our results are driven by the post Lehman Brothers months of 2008, we have re-estimated the cointegration relationship, as reported in Table 2.4, by excluding September – December 2008. Tables A2.6 and A2.7 in the Appendix provide the panel cointegration estimates. The results of both tables suggest that the null hypothesis of no cointegration relationship is rejected more clearly compared to Table 2.4 or Table A2.5.[29] Based on the comparing estimates, we can safely conclude that our results of Table 2.4 (or Table A2.5) are not driven by including September – December 2008.

Next, we have examined the speed of adjustment of the currencies using both panel (P_α) and (G_α) group-mean adjustment coefficients (ϕ_i).[30] Figure 2.1 shows the adjustment speed of the exchange rate for different maturities. The adjustment speed of exchange rate is hardly related to the maturity of the underlying instruments. For the 7 months maturity the adjustment time is around 159 minutes, while for the 12 months maturity it is 194 minutes.[31] The group-mean statistics lead to similar conclusions.

[29] In fact, the group mean statistic estimates of Table A2.7 suggest that for the 10 to 12 months maturities the results become significant when the post Lehman Brother months of 2008 are excluded. However, the same statistics show insignificant speed of adjustment coefficients when the data include September – December 2008 in Table A2.5.

[30] For the G_α slope coefficient, see Table A2.4 in the Appendix.

[31] The maturity-specific adjustment period is calculated using the reciprocal of the ϕ_i coefficient. For example, ϕ_i for 8 months maturity (-8.141) helps us to arrive at the adjustment time (1/ ϕ_i)= -0.123 days, which on further multiplication (with 24 for hours and 60 for minutes) gives 176.9 minutes.



The finding that maturities do not effectively define the adjustment speed of the exchange rates supports the finding of Bekaert *et al*. (2007). Using both short- and long-term debt instruments, Bekaert *et al*. (2007) also conclude that the adjustment period of exchange rates is not related to the maturities of the underlying instruments.

Following the cointegration evidence of Table 2.4, panel FM-OLS and DOLS estimates for the long-run relationship for this cointegrated system are shown in Tables 2.5 and 2.6, respectively. In the FM-OLS estimates, a non-parametric technique (Bartlett kernel) is used to estimate the long-run serial correlation factor. In the DOLS estimates maximum leads of 5 days and maximum lags of 21 days have been used, similar to the cointegration test. We only report the estimates from homogenous panels which assume a common slope coefficient for all the currencies in the system. As mentioned, heterogeneous panel slopes are severely affected by the small *N* bias.

The FM-OLS and DOLS estimates show that interest rates differentials are positively related with exchange rate differentials for all maturities considered (7 to 12 months). This finding is in contrast with the results of most previous studies (for details see Table A2.1 in the Appendix), which generally report negative $\hat{\beta}$ coefficients. In addition, using DOLS the null hypothesis that $\hat{\beta}$ is equal to one cannot be rejected for all maturities at the five percent level of significance except for a maturity of 7 months. This finding suggests that UIP holds if market specific heterogeneity is controlled for.

Table 2.5 Fully Modified OLS for Long-run Equilibrium Relationship

	Homogenous Panel Slopes				
		$H_0 : \hat{\beta} = 0$		$H_0 : \hat{\beta} = 1$	
Maturity	**Coefficient**	***t*-ratio**	***p*-value**	***t*-ratio**	***p*-value**
7 months	0.4456	1.9167	0.0276	-2.3849	0.0085
8 months	0.5716	2.4064	0.0081	-1.8032	0.0357
9 months	0.7069	2.8827	0.0020	-1.1951	0.1160
10 months	0.8768	3.4271	0.0003	-0.4818	0.3150
11 months	1.0450	3.9305	0.0000	0.1692	0.4328
12 months	1.1957	4.1259	0.0000	0.6754	0.2497

Notes: Long-run estimates for homogenous panel based on Equation (2.8). The estimate of long-run variance has used Bartlett kernel in COINT 2.0. Coefficient gives the slope of the interest rate differentials. Additionally, a null hypothesis of $\hat{\beta}$ equals one was also tested to check if UIP holds on one to one basis. The corresponding p–values show the level of significance.

Table 2.6 Dynamic OLS for Long-run Equilibrium Relationship

	Homogenous Panel Slopes				
		$H_0 : \hat{\beta} = 0$		$H_0 : \hat{\beta} = 0$	
Maturity	**Coefficient**	***t*-ratio**	***p*-value**	***t*-ratio**	***p*-value**
7 months	0.4946	2.0988	0.0179	-2.1450	0.0160
8 months	0.6348	2.6358	0.0042	-1.5166	0.0647
9 months	0.8047	3.2364	0.0006	-0.7854	0.2161
10 months	0.9797	3.7763	0.0001	-0.0782	0.4688
11 months	1.1382	4.2208	0.0000	0.5124	0.3042
12 months	1.2950	4.4050	0.0000	1.0036	0.1578

Notes: Long-run estimates for homogenous panel based on Equation (2.10). 5 and 21 are the maximum number of leads and lags specified for estimation. Beta coefficient gives the slope of the interest rate differentials. The *t*-statistics and the relevant *p*-values also provided. The corresponding *p*–values show the level of significance.

Although they are very different, the FM-OLS and DOLS methods provide qualitatively similar estimates for the long-run slope coefficients and their level of significance, which shows the robustness of the estimates. Monte Carlo simulation results of Kao and Chiang (2001) show that FM-OLS estimates are more biased compared to DOLS in samples with a small number of cross sections.

Our study finds support for UIP for maturities above 7 months assuming that the independent cross-section assumption of the FM-OLS and DOLS estimates will not affect our inference severely. Previous studies have ignored two key factors in studying UIP: the non-similarity of domestic interest rates due to differences in transaction costs and capital controls between the markets, and cross currency relationships. Relying on the LIBOR system helps in controlling the non-similarity of interest rates, while the cross currency dependence is taken into account in the cointegration analysis as both unit root and cointegration techniques employed in this study control for the cross currency dependence.

Recently, allegations of LIBOR manipulation by some banks were put forward. However, the statistical support for LIBOR manipulation is not very convincing. Although, the finding of Snider and Youle (2010) substantiate Libor manipulation, Abrantes-Metz *et al.* (2012) report only some evidence of anticompetitive market behavior by the participating banks. Kuo *et al*. (2012) also find some deviations of LIBOR from other borrowing rates like bid rates at the Federal Reserve Term Auction Facility and term borrowing from Fedwire payment data, without emphasizing that this resulted in a misreporting of LIBOR.[32] The results of Monticini and Thornton (2013) suggest that the underreporting of the LIBOR rates by some banks reduced the reported LIBOR rates, specifically for the 1 and 3 months maturities.

As possible LIBOR manipulation may also have affected our results, we experimented with the sample size by extending the data to May 2013. Our panel unit roots test findings (see Table A2.8 in the Appendix) show that the differenced stationary behavior of the interest rate series remains unchanged. In contrast, the level of the exchange rate series becomes stationary for all maturities. This result is different from the results obtained using data for the 2001-2008 for which we found that 6 out of the 14 maturities were difference stationary.

Our experiment using data series ending in December 2010 also shows similar results (see Table A2.9 in the Appendix). The difference stationary behavior of the LIBOR interest rate series remains unchanged. The results suggest that only for three maturities, namely 10 to 12 months, the exchange rates are difference stationary. The changed behavior of exchange rate series and the unchanged behavior of the interest rate series lead us to two important conclusions.

First, the unchanged data generating process as of the interest rate series shows that the alleged LIBOR manipulation does not affect the findings of our study. As discussed above, the literature showing statistical support for LIBOR manipulation is also not conclusive.

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[32] Fedwire Funds Service is a real-time gross settlement system provided by the Federal Reserve banks. The Fedwire is a credit transfer service generally used to make large-value, time-critical payments. It enables participant banks to initiate immediate, final, and irrevocable funds transfer. Participants originate funds transfers by instructing a Federal Reserve Bank to debit funds from its own account and credit funds to the account of another participant. For details, see the website of the Federal Reserve System at:
http://www.federalreserve.gov/paymentsystems/fedfunds_about.htm

Second, findings for the exchange rates series is consistent with commentaries of financial market analysts that some industrialized economies are intervening in foreign exchange markets.[33] The policy of quantitative easing adopted by the Federal Reserve Board not only inundated the US domestic market with liquidity but also caused funds to flow to other industrialized countries as well as to emerging economies. It is not surprising that these economies are taking measures to keep themselves competitive (see for details, Fratzscher *et al.*, 2012; Ahmed and Zlate, 2013; and Chinn, 2013). This result also supports our choice to restrict our sample to 2008 because of the global financial crisis.

2.6 Conclusions

In this chapter we have tested uncovered interest rate parity (UIP) using six currency specific LIBOR rates. Our results show that uncovered interest rate parity holds over short horizon for the industrialized economies for maturities above 7 months and until 12 months. Our finding is a significant contribution to the existing literature on UIP.

The other conclusions of this chapter can be summarized as follows. First, our results support using a broad range of maturities to test UIP, as inferences based on one or two maturities may be misleading. Second, the finding that UIP holds for the LIBOR system of currencies shows that the market-specific heterogeneity may have tainted previous empirical estimates of UIP. Third, our results suggest that the adjustment behavior of exchange rates is independent of the maturities of the underlying instruments. Finally, this chapter shows that LIBOR can be used for meaningful macroeconomic analysis provided the proper techniques are used.

This study has investigated UIP for the LIBOR system of currencies, ignoring the bilateral relationships between the currencies. The next chapter further investigates bilateral UIP, incorporating the cross currency dependence.

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[33] For example, see for discussion on the exchange rate intervention, http://www.project-syndicate.org/commentary/the-logic-of-today-s-brewing-currency-wars-by-mohamed-a--el-erian

2.7 Appendix

Table A2.1 Literature Review

Author (s)	Period	Est. Type	Currency/Country Horizon	Interest Rate Variable	Methodology	Conclusion
De Haan *et al*. (1992)	1979 M10-1989 M6; Monthly	Time series	Dutch/German Exchange Rate	3-months Euro deposit rates and Amsterdam interbank rate	Unit Roots and Cointegration	Rejected
Baillie and Kilic (2006)	1978- 1998/2002; Monthly	Ind. Time Series	9 currencies	BIS; end month asked rates	Dynamic smooth transition regression	Mixed
Bansal and Dahlquist (2000)	1976 M1 to 1998 M5	Pooled	28 (Emerging and Developed	Spot Exchange Rate, Forward Rate, Interest Rate	Pooled OLS	Mixed
Bekaert *et al.* (2007)	1972-1991; Monthly	Ind. Time Series	3 currencies, US, UK and Germany	Jorion and Mishkin (1991) dataset	VAR Analysis	Mixed
Bruggemann and Lütkepohl (2005)	1985 M1-2004 M12; Monthly	Ind. Time Series	Euro Vs USD	3-m Money Market Rates and 10-years Bonds	VECM	Supports UIP
Carvalho *et al.* (2004)	1990-2001; Monthly	Panel	4 currencies (Argentina, Brazil, Chile and Mexico)	Domestic Interest rates and official exchange rates	fixed and random effects	Mixed
Chaboud and Wright (2005)	1988-2002; high freq. data (5-min interval)	Time Series	JPY, Euro(DM), CHF, GBP against USD	Reuter Quotes at 5 min for ER and Overnight rate	OLS	Mixed*
Chinn and Meredith (2004)	1980-2000; Quarterly	Panel	G-7 countries	3-, 6- and 12- m exchange rate movement;	GMM	Mixed**
Flood and Rose (1996)	1981- 1994; daily	Pooled	Australia; Canada; France; Germany; Japan; Switzerland; and UK all against US	1- and 3-months Interest rate differential ; 1- and 3-months exchange rate movements	SUR technique	UIP holds
Campbell *et al.* (2007)	1970 M1- 2005 M12; Monthly	Individual Time Series	18 currencies against USD	Short term domestic treasury bills or money market rates	Standard and Rolling regression	Rejected
Candelon and Gil-Alana (2006)	1980 M1 - 2001 M12; Monthly	Ind. Time Series	6 Emerging economies	Short-term interest rates	Fractional Integration Technique	Mixed
Harvey (2005)	1989-1998; Quarterly	Ind. Time Series	USD- DM and USD- JPY	I-month LIBOR on USD, DM and JPY	Simple regression	Rejected
Ichiue and Koyama (2007)	1980-2007; Monthly	Pooled	JPY, GBP, CHF and DM against USD	IFS and LIBOR	Regime Switching	Mixed
Tang (2011)	1978Q1-2008Q4	Panel	Asean-5	IFS	Panel Unit root and cointegration	Mixed
Juselius and MacDonald (2004)	1975 M7- 1998 M1	Time series	USD-JPY	Long Bond rates and LIBOR	VAR Analysis	Rejected
Mark and Wu (1998)	1976 M1 to 1994 M1; Quarterly	Ind. Time Series	USD, GBP, DM, JPY	-	VECM	Rejected
Krishnakumar and Neto (2008)	1986 M1 - 2007 M2; Monthly	Time series	USD - CHF	3-month for short term and 1-year for long term interest rates	Threshold vector ECM	Supports UIP

Notes: * UIP accepted over very short windows of data that span the time of the discrete interest payment. However, adding even a few hours to the span window destroyed the positive UIP results.; ** Rejected in the short run, more support in the long run

Table A2.2 Test for Cross-Sectional Independence

Maturity	***Chi*-Square**	***p*-values**
1 week	6,692.4*	0.000
2 weeks	7,733.4*	0.000
1 month	8,735.0*	0.000
2 months	10,475.9*	0.000
3 months	10,918.0*	0.000
4 months	10,873.6*	0.000
5 months	11,029.5*	0.000
6 months	10,998.1*	0.000
7 months	11,130.2*	0.000
8 months	10,084.9*	0.000
9 months	9,958.0*	0.000
10 months	9,595.4*	0.000
11 months	9,497.2*	0.000
12 months	9,653.7*	0.000

Notes: Breusch and Pagan LM statistics has the null hypothesis that the Cross sections are independent. The test statistics have a *Chi*-square distribution with *N(N-1)/2* degrees of freedom. * indicates 1-percent level of significance.

Table A2.3 Group Mean Statistics from Block Bootstrap Panel Unit Root Tests
(at Level**)**

Maturity	**Exchange Rate Differentials**			**Interest Rate Differentials**		
	Coefficient	**5% CV**	***p*-value**	**Coefficient**	**5% CV**	***p*-value**
1 week	-498.929	-21.563	0.000	-2.229	-8.212	0.819
2 weeks	-258.809	-18.622	0.000	-4.084	-14.634	0.830
1 month	-120.584	-15.416	0.000	-3.027	-9.216	0.740
2 months	-56.536	-16.139	0.000	-2.546	-7.857	0.717
3 months	-34.642	-17.823	0.000	-2.588	-7.056	0.674
4 months	25.329	-19.299	0.003	-1.692	-7.415	0.858
5 months	-18.604	-18.710	0.053	-1.657	-8.443	0.897
6 months	-16.486	-18.470	0.104	-1.556	-9.237	0.932
7 months	-14.989	-18.917	0.195	-1.392	-9.667	0.949
8 months	-13.960	-19.657	0.305	-1.245	-10.274	0.964
9 months	-13.261	-19.883	0.384	-0.666	-11.283	0.986
10 months	-12.184	-19.742	0.458	-0.535	-11.406	0.990
11 months	-11.556	-20.726	0.572	-1.152	-11.988	0.986
12 months	-11.056	-20.536	0.544	-2.801	-13.392	0.972

Notes: Estimated test statistics for Equation (2.6) with exchange rate and interest rate differentials. 5% CV indicates robust critical values at the 5-percent level of significance. *p*-values are the corresponding probability values of the calculated test statistics.

Table A2.4 Group Mean Statistics Block Bootstrap Panel Unit Root Tests
(First Difference)

	Exchange Rate Differentials			Interest Rate Differentials		
Maturity	**Coefficient**	**5% CV**	***p*-value**	**Coefficient**	**5% CV**	***p*-value**
1 week				-1,940.604	-18.369	0.000
2 weeks				-1,915.166	-14.263	0.000
1 month				-1,769.901	-10.416	0.000
2 months				-1,743.905	-8.977	0.000
3 months				-1,757.255	-8.411	0.000
4 months				-1,812.592	-8.172	0.000
5 months	-1,703.683	-16.316	0.000	-1,845.944	-8.258	0.000
6 months	-1,696.805	-15.831	0.000	-1,891.622	-8.400	0.000
7 months	-1,703.485	-15.189	0.000	-1,921.791	-8.457	0.000
8 months	-1,679.473	-16.408	0.000	-1,941.652	-8.572	0.000
9 months	-1,669.145	-16.707	0.000	-1,979.724	-8.722	0.000
10 months	-1,497.150	-5.285	0.000	-1,988.774	-8.893	0.000
11 months	-1,481.831	-6.251	0.000	-1,999.809	-9.181	0.000
12 months	-2,057.435	-12.471	0.000	-2,003.817	-9.395	0.000

Notes: Estimated test statistics for Equation (2.6) with the first difference of exchange rate and interest rate differentials. 5% CV indicates robust critical values at the 5-percent level of significance. *p*-values are the corresponding probability values of the calculated test statistics.

Table A2.5 Results of Westerlund Cointegration Test for Heterogeneous Panel

	G_α			G_τ		
Maturity	**Value**	***z*-value**	**Rob. *p*-value**	**Value**	***z*-value**	**Rob. *p*-value**
7 months	-9.515	-3.077	0.020	-1.737	-1.790	0.070
8 months	-8.250	-2.395	0.050	-1.583	-1.429	0.110
9 months	-8.098	-2.314	0.000	-1.643	-1.570	0.040
10 months	-7.714	-2.107	0.060	-1.646	-1.577	0.100
11 months	-6.863	-1.648	0.070	-1.548	-1.347	0.120
12 months	-5.467	-0.897	0.220	-1.287	-0.731	0.270

Notes: Estimates of ECM coefficient based on Equation (2.7). The null hypothesis is that the ECM coefficient is zero. Group mean test statistics shown in this table has alternative hypothesis that at least one of the members of the panel is cointegrated. The maximum number of leads and lags considered for estimation are 5 and 21, respectively. Values give the estimated values of the coefficients and *z*-values are their standardized values. Rob. *p*-values are the robust probability values calculated using the bootstrap technique.

Table A2.6 Results of the Westerlund Cointegration Test for Homogenous Panel
(Data Ending on September 9, 2008**)**

	P_α			P_τ		
Maturity	**Value**	***z*-value**	**Rob. *p*-value**	**Value**	***z*-value**	**Rob. *p*-value**
7 months	-20.558	-9.009	0.000	-7.321	-3.797	0.000
8 months	-19.618	-8.490	0.000	-7.402	-3.879	0.000
9 months	-16.424	-6.728	0.000	-6.458	-2.929	0.000
10 months	-13.977	-5.378	0.000	-5.810	-2.277	0.050
11 months	-12.387	-4.500	0.000	-5.383	-1.848	0.030
12 months	-11.456	-3.987	0.000	-5.194	-1.658	0.080

Notes: Estimates of ECM coefficient based on Equation (2.7). The alternative hypothesis of these test statistics is that cointegration exists when at least one member of the panel is cointegrated. 5 and 21are the maximum number of leads and lags considered for estimation. Coefficient gives the estimated values of the group mean statistics and Z-values are their standardized values. Rob. p -values are the robust probability values calculated using the bootstrap technique. The corresponding values show the level of significance.

Table A2.7 Results of Westerlund Cointegration Test for Heterogeneous Panel
(Data Ending on September 9, 2008**)**

	G_α			G_τ		
Maturity	**Value**	***z*-value**	**Rob. *p*-value**	**Value**	***z*-value**	**Rob. *p*-value**
7 months	-20.039	-5.803	0.000	-2.954	-3.207	0.000
8 months	-19.374	-5.504	0.000	-3.009	-3.358	0.000
9 months	-16.351	-4.144	0.010	-2.651	-2.381	0.010
10 months	-13.523	-2.871	0.030	-2.305	-1.438	0.110
11 months	-12.359	-2.347	0.000	-2.199	-1.150	0.080
12 months	-11.524	-1.972	0.030	-2.142	-0.993	0.150

Notes: Estimates of ECM coefficient based on Equation (2.7). The null hypothesis is that the ECM coefficient is zero. Group mean test statistics shown in this table has alternative hypothesis that at least one of the members of the panel is cointegrated. The maximum number of leads and lags considered for estimation are 5 and 21, respectively. Values give the estimated values of the coefficients and *z*-values are their standardized values. Rob. *p*-values are the robust probability values calculated using the bootstrap technique.

Table A2.8 Group Mean Statistics Block Bootstrap Panel Unit Root Tests
[2001- (May) 2013**]**

	Exchange Rate Differentials			Interest Rate Differentials		
Maturity	**Coefficient**	**5% CV**	***p*-value**	**Coefficient**	**5% CV**	***p*-value**
1 week	-687.224	-22.950	0.000	-9.034	-17.973	0.575
2 weeks	-351.671	-19.304	0.000	-5.600	-14.067	0.719
1 month	-158.609	-14.263	0.000	-3.581	-8.619	0.651
2 months	-79.281	-14.507	0.000	-2.994	-7.533	0.660
3 months	-54.407	-15.903	0.000	-2.750	-7.053	0.658
4 months	-38.981	-15.927	0.000	-2.698	-7.550	0.728
5 months	-30.582	-15.259	0.000	-2.718	-8.192	0.785
6 months	-26.376	-15.577	0.000	-2.812	-9.229	0.838
7 months	-22.124	-15.030	0.001	-2.814	-9.542	0.863
8 months	-20.535	-16.487	0.006	-2.878	-10.117	0.886
9 months	-18.566	-16.424	0.018	-3.010	-10.909	0.905
10 months	-17.624	-17.278	0.041	-3.090	-11.330	0.913
11 months	-17.007	-16.816	0.046	-3.199	-11.822	0.921
12 months	-16.382	-16.145	0.045	-3.336	-12.436	0.929

Notes: Estimated test statistics for Equation (2.6) with exchange rate and interest rate differentials. 5% CV indicates robust critical values at the 5-percent level of significance. *p*-values are the corresponding probability values of the calculated test statistics.

Table A2.9 Group Mean Statistics Block Bootstrap Panel Unit Root Tests
(2001-2010**)**

	Exchange Rate Differentials			Interest Rate Differentials		
Maturity	**Coefficient**	**5% CV**	***p*-value**	**Coefficient**	**5% CV**	***p*-value**
1 week	-554.402	-22.787	0.000	-7.677	-18.086	0.698
2 weeks	-284.946	-19.165	0.000	-4.827	-14.332	0.796
1 month	-126.722	-14.091	0.000	-3.081	-8.847	0.739
2 months	-63.601	-14.559	0.000	-2.543	-7.782	0.753
3 months	-43.580	-16.271	0.000	-2.293	-7.305	0.752
4 months	-31.685	-16.059	0.000	-2.238	-7.768	0.808
5 months	-25.215	-15.484	0.000	-2.252	-8.423	0.850
6 months	-21.898	-15.389	0.002	-2.321	-9.384	0.895
7 months	-18.271	-14.812	0.008	-2.318	-9.781	0.912
8 months	-18.259	-16.467	0.023	-2.368	-10.458	0.931
9 months	-16.774	-16.285	0.040	-2.481	-11.234	0.944
10 months	-16.044	-16.898	0.075	-2.546	-11.682	0.951
11 months	-15.471	-17.283	0.104	-2.638	-12.245	0.955
12 months	-15.076	-16.328	0.084	-2.754	-12.769	0.961

Notes: Estimated test statistics for Equation (2.6) with exchange rate and interest rate differentials. 5% CV indicates robust critical values at the 5-percent level of significance. *p*-values are the corresponding probability values of the calculated test statistics.

Chapter 3[34]

Does Uncovered Interest Rate Parity Hold After All?

3.1 Introduction

Uncovered interest rate parity (*henceforth* UIP) suggests that any arbitrage opportunity between interest-earning assets of different economies but with similar characteristics will disappear due to exchange rate movements. A positive shock to the domestic interest rate *vis-à-vis* the foreign interest rate will lead to the depreciation of the home currency and *vice versa*. UIP plays a critical role in most exchange rate determination theories, such as the traditional monetary exchange rate model[35], Dornbusch's (1976) overshooting model and Krugman's (1991) target zone model. Often a policy shock from a central bank induces an appreciation or depreciation of the exchange rate of that country. Central banks frequently count on this relationship for anchoring exchange rate expectations in the economy (Kalyvitis and Skotida, 2010).

As pointed out in Chapter 2, support for UIP is ambiguous. Given the crucial role played by UIP in exchange rate theories and exchange rate stabilization policies, this hypothesis warrants more detailed investigation. Evidence supporting UIP will not only increase confidence in the existing exchange rate models, but may also enhance the quality of monetary policy decision-making. This research is an effort in this direction. We estimate uncovered interest rate parity using currency specific London Interbank Offered Rates (LIBORs).

This chapter extends the existing UIP literature by zooming in on important issues affecting this relationship. First, we use a multi-currency setup to exploit cross currency correlation. Some previous studies (such as, Flood and Rose, 1996; and Mark and Wu, 1998) have exploited cross currency correlations using Seemingly Unrelated Regressions (SUR). However, most studies investigate UIP mostly on a bilateral basis. In our view, such studies ignore the impact of other economies on the bilateral UIP relationship. This is equally true for studies using a panel setup that ignores cross sectional dependence. In a globalized world, any shock to the US debt market will not only affect the Japanese debt market but also the Euro debt market. Therefore, an interest rate shock in the US will not only affect the US Dollar and the

[34] This chapter is based upon De Haan *et al*. (2013).
[35] For details, see Neely and Sarno (2002).

Japanese Yen exchange rate or the US Dollar and the Euro exchange rate, but also the Euro-Yen exchange rate. Studies on UIP have mostly ignored this cross currency correlation.

In Chapter 2 we incorporated the cross currency relationship up to the unit root and the cointegration tests. In that chapter, the inferences on the equilibrium long-run relationships are based on the assumption that the currencies behave independently from each other. In this chapter we incorporate the dependence structure between the currencies for drawing inferences on the bilateral UIP relationship between the currencies.

Second, we use data for industrial economies as the literature suggests that for these countries the problem of a forward premium puzzle is more prominent (see Bansal, 1997; Bansal and Dahlquist, 2000; and Alper *et al*., 2009). The forward premium puzzle is closely related to the failure of uncovered interest parity, as the forward premium usually points in the wrong direction for the ex post movement in the spot exchange rate. For developing and emerging market economies, the empirical evidence provides more support for UIP (see, for example, Bansal and Dahlquist, 2000; Flood and Rose, 2002; Frankel and Poonawala, 2006; and Ferreira and Leon-Ledesma, 2007).

Third, instead of using domestic interest rates we use London Interbank Offered Rate (LIBOR) rates. LIBOR is an indicative interbank rate for specific currencies based on the non-binding quotes in the London interbank market.[36] LIBOR rates are widely used as benchmarks in global financial transactions. Factor analysis shows that the LIBOR rates are driven by only one factor, i.e. domestic interest rates, suggesting that our results are not driven by the use of LIBOR only.[37] Using LIBOR has several advantages. For instance, the currency specific LIBOR rates have similar transaction costs for the assets denominated in various currencies. Moreover, capital is perfectly mobile between the assets of various currencies within the London interbank market. Absence of these features when domestic interest rates are used may have tainted the earlier estimation results on UIP. Juselius and MacDonald (2004), Harvey (2005) and Ichiue and Koyama (2007) have also used LIBOR as a proxy for Japanese domestic interest rates, arguing that the thin and heavily regulated Japanese money market in the eighties and nineties did not reflect Japan's economic fundamentals very well.

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[36] For details see Michaud and Upper (2008).
[37] Factor analysis is widely used technique for summarizing a usually large number of variables with a small number of factors. We will return to this issue in Section 3.4.

Finally, following a suggestion of Moon and Perron (2005), we take as our null hypothesis that UIP holds (the slope coefficient of the interest rate differential in UIP relationship is unity). Typically, a classical testing methodology has a strong bias towards the null hypothesis. The null hypothesis that a certain theory does not hold is not rejected unless there is strong evidence against it. The classical methodology often rejects an economic theory even if the evidence is not very strong.

Our estimates using weekly data for the period January 2001 to December 2008 support UIP over the short-term (6 to 12 months) horizon for currencies from advanced countries. Moreover, our currency specific estimates show that the UIP null hypothesis can generally not be rejected at the 5 percent level of significance. However, for the Japanese Yen and the Swiss Franc, the slope coefficients are negative. This finding is consistent with the argument put forward by Bansal and Dahlquist (2000) and Ballie and Kilic (2006) that deviations from UIP appear only when the US interest rate exceeds the foreign interest rate (state dependence). Once we incorporate the negative interest rate differential, UIP cannot be rejected for the Japanese Yen and the Swiss Franc. Our results show that cross currency effects play an important role in determining the exchange rate between currencies. Finally, we also find some support for Dornbusch’s (1976) overshooting hypothesis for exchange rates, specifically for the Japanese Yen and the Swiss Franc against the US Dollar. Since both currency interest rates are lower than the US interest rate, our finding suggests that state dependence can also be instrumental in explaining exchange rate overshooting.

The rest of the chapter is structured in the following way. Section 3.2 reviews the literature. Section 3.3 delves into methodology issues and data, while Section 3.4 presents our results. Finally, Section 3.5 offers our conclusions.

3.2 Literature review

According to the Covered Interest Rate Parity (CIP) hypothesis, the ratio of the forward to the spot exchange rate will be equal to the ratio of the returns on two similar assets, measured in the local currencies under risk free arbitrage. Expressing the forward and spot rates in logarithms, CIP can be written as:

$$(f_{t+i} - s_t) = (r_{it} - r_{it}^{*}), \tag{3.1}$$

where f_{t+i} is the forward rate for maturity *i*, s_t is the spot exchange rate, r_{it} and r_{it}^* are the nominal return at any time *t* for maturity *i* on a domestic and foreign asset, respectively.[38] However, if forward rates deviate from the expected future spot rate, a risk premium is required such that

$$[E(s_{t+i}) - s_t] = \alpha_t + (r_{it} - r_{it}^*), \tag{3.2}$$

where α_t is the risk premium and $E(s_{t+i})$ is the expected future exchange rate at time *t+i*. Under UIP, the risk premium is zero and the coefficient of the interest differential (slope coefficient) is one. Since the future spot exchange rates cannot be observed directly, UIP is generally tested jointly with a particular assumption about the way expectations are formed in the foreign exchange market (Chinn, 2007).

Following previous studies, we use the following model:

$$[RE(s_{t+i}) - s_t] = \alpha_t + \beta(r_{it} - r_{it}^*) + \varepsilon_{it}. \tag{3.3}$$

where $RE(s_{t+i})$ is the expected exchange rate in *i* period future, β is the slope coefficient and ε_{it} is the error term. Following previous studies, such as Chinn and Meredith (2004), Carvalho *et al*. (2004), Bekaert *et al*. (2007), and Tang (2011), we assume that agents have perfect foresight so that exchange rate movements can be estimated using

$$[s_{t+i} - s_t] = \alpha_t + \beta(r_{it} - r_{it}^*) + \varepsilon_{it}. \tag{3.4}$$

Most studies on UIP report a negative β over the short horizon (see Froot and Thaler, 1990; MacDonald and Taylor, 1992; McCallum, 1994; Isard, 1996; Engel, 1996; and Chin and Meredith, 2004). A notable exception is Flood and Rose (1996), who report a slope coefficient close to one during the period with exchange rate alignments within the European Exchange Rate Mechanism (ERM). Other studies, like Huisman *et al*. (1998), Bruggemann and Lütkepohl (2005), and KrishnaKumar and Neto (2008) provide indirect support for UIP. More precisely, Huisman *et al*. (1998) show that large forward premiums in the foreign exchange market provide an unbiased estimate of the future change in the spot exchange rate while small forward premium fail in doing so. Bruggemann and Lütkepohl (2005) and KrishnaKumar and Neto (2008) test UIP jointly with the expectation hypothesis of the term structure using US-Euro and US-Swiss interest rate differentials, respectively. Assuming that exchange rates are generated by a stationary process, they provide evidence in support of UIP.

[38] See Table A3.9 in the Appendix to Chapter 3 for the details of the symbols used in Chapters 2 and 3.

Bansal (1997) notes that the failure of UIP is more prominent for industrial economies than for developing economies. In addition, Bansal and Dahlquist (2000) and Ballie and Kilic (2006) point to state dependence in the UIP relationship, i.e. the exchange rate denominated in the US Dollars responds differently to positive and negative interest rate differentials. More specifically, deviations from UIP appear only when the US interest rate exceeds the foreign interest rate. When the foreign interest rate exceeds the US interest rate, the expected depreciation and the increase in the interest rate differentials are positively related.

Several studies have tested UIP bilaterally, thereby implicitly imposing restrictions on third country effects. This restriction may have fostered non-linearities in the UIP relationship, a subject investigated by a different string of literature.[39] Studies using panel techniques and ignoring cross currency effect (such as, Carvalho *et al*., 2004; Chinn and Meredith, 2004; and Tang, 2011) suffer from similar problems.

Chinn and Meredith (2004) note that UIP models by construction have cross-equation correlation of the error terms which may affect estimates and the inferences. Therefore, techniques incorporating cross-currency correlations, such as seemingly unrelated regressions (SUR), are appropriate. Two studies, Flood and Rose (1996) and Mark and Wu (1998), employ SUR to control for cross currency correlations. However, these studies arrive at very different conclusions. While Flood and Rose (1996) report slope coefficient (β) close to unity during the period with exchange rate alignment within the ERM, Mark and Wu (1998) do not find strong support for UIP.[40] Mark and Wu (1998) employ SUR to control for feedback effects, in vector error correction procedure, using individual time series. In contrast, Flood and Rose (1996) uses SUR to control for the contemporaneous correlation between the bilateral exchange rates while combining the data across countries.

Often financial and economic time series show non stationary behavior. Therefore, it is essential to determine the data generating processes of the regressors using unit root tests. When regressors are cointegrated, Moon and Perron (2005) show in a dynamic panel context that the

[39] Studies discussing non-linearities in UIP include Baldwin (1990), Dumas (1992), Carlson and Osler (1999), Sercu and Wu (2000), Lyons (2001), and Kilian and Taylor (2003).

[40] The two studies differ substantially in methodology, time period, and the number of currencies investigated. Flood and Rose (1996) have used, in a pooled setup, daily data for the period 1981to 1994 for investigating UIP for the currencies of Australia; Canada; France; Germany; Japan; Switzerland; and the UK all against the US. Mark and Wu (1998), on the other hand, have used SUR for estimating bilateral UIP relationships using quarterly data for the currencies of the US, the UK, Germany, and Japan for the 1976 to 1994 period.

limiting distributions of OLS estimators are non-normal. These authors propose augmenting the regressors with their leads and lags to capture the long-run relationship. In addition, they advocate the use of the long-run covariance matrix instead of the contemporaneous covariance matrix, which enhances the efficiency gain of the long-run estimators. Our study therefore uses SUR with integrated regressors as proposed by Moon and Perron (2005).

3.3 Methodology and data

3.3.1 Methodology

Previous studies using a panel setup, generally adopted panel unit root tests (see Maddala and Wu, 1999; Harris and Tzaralis, 1999; Breitung, 2000; Hadri, 2000; Levin *et al*., 2002; and Im *et al*., 2003). However, these unit root tests are limited in scope in the presence of cross correlation effects between the members of the panel (for further discussion, see Section 2.4.1.1 in Chapter 2). Therefore, we apply the Cross-sectional Dependence Robust Block Bootstrap (CDRBB) panel unit roots test proposed by Palm *et al.* (2011).

The CDRBB unit root test does not require modeling the temporal or cross-sectional correlation (dependence) structure between the currency specific interest rates.[41] Moreover, it uses the block bootstrap technique, a time series version of a standard bootstrap where the dependence structure of the time series is preserved by dividing data into blocks and then re-sampling the blocks. Inferences from the CDRBB test are valid under a wide range of possible data generating processes, which makes it an appropriate tool for dealing with the fixed number of correlated cross-sections and large time series asymptotics. However, the block length selected can have a substantial impact on the performance of any designed block bootstrap test.

The CDRBB test provides both ‘pooled’ (τ_p) and ‘group-mean’ (τ_{gm}) test statistics, but we only discuss the outcomes for the ‘group mean’ statistics here (the pooled statistics are shown in Table A3.2 in the Appendix). The ‘group mean’ statistic for variable y_{it} does not impose restrictions on individual parameters, which is more relevant for the analysis at hand. The null hypothesis states that the variable is non-stationary while the alternative hypothesis, following Im *et al.* (2003), states that a non-zero fraction of the panel (*N1/N*) follows a stationary processes

[41] Both the CDRBB test and the Westerlund (2007) panel cointegration tests (to be discussed later in this section) have been discussed earlier in Chapter 2.

in a panel with a large number of cross sections (*N*); where *N1* is the number of cross-sections that are stationary. Rejection of the null hypothesis for the first difference of a variable and non-rejection for the level of the same variable indicates that the variable concerned has a unit root.

$$\tau_{gm} = \frac{1}{N}\sum_{i=1}^{N} T \frac{\sum_{t=2}^{T} y_{it-1}\Delta y_{it}}{\sum_{t=2}^{T} y_{it-1}^{2}}, \tag{3.5}$$

The symbols have the same meaning as of Equations (2.6) and (2.7) in Chapter 2. The pooled statistics (τ_p),

$$\tau_p = T \frac{\sum_{i=1}^{N}\sum_{t=2}^{T} y_{it-1}\Delta y_{it}}{\sum_{i=1}^{N}\sum_{t=2}^{T} y_{it-1}^{2}}, \tag{3.6}$$

on the other hand, presume that the members of the panel have the same autoregressive coefficient. In other words, the statistics are obtained by pooling information without considering the individual members' characteristics, which is quite restrictive.

Next, we apply Westerlund's (2007) ECM based panel cointegration test. This test takes cross-correlation effects between the currencies into account. Westerlund (2007) suggests a panel cointegration test based on the following error correction mechanism (ECM)

$$\Delta y_{it} = \delta_i' d_t + \phi_i (y_{it-1} - \psi_i' x_{it-1}) + \sum_{j=1}^{p_i} \gamma_{1ij}\Delta y_{it-j} + \sum_{j=0}^{p_i} \gamma_{2ij}\Delta x_{it-j} + u_{it}, \tag{3.7}$$

where, $i=1,2,...,N$, and $t=1,2,...,T$, x_{it} and y_{it} are respectively interest and exchange rate differentials, while d_t is the currency specific deterministic component, δ_i is the associated vector of parameters, ϕ_i is the individual specific speed of adjustment parameter for the error correction term, p_i is the optimal number of leads and lags, and ψ_i is the cointegrating vector. The appropriate number of leads and lags p_i as selected by some information criteria transforms the error term u_{it} into white noise.

The null hypothesis of the cointegration test is $\phi_i = 0$, which indicates no cointegration relation between the variables, while the alternative hypothesis is that at least one cross-section is cointegrated. Four alternative tests exist depending on the homogeneity assumption of ϕ_i. Two of the tests are termed as group mean tests (G_α and G_τ) since they do not require ϕ_i to be equal for all the cross-section. The other two are known as panel tests (P_α and P_τ) as they assume that ϕ_i is equal for all the cross-section of the panel. Whereas G_α (P_α) is calculated by aggregating the individual (common) slope coefficients with the help of conventional standard errors, G_τ (P_τ) is calculated by aggregating the individual (common) slope coefficients using the long-run standard errors of Newey and West (1994).

Simulation results of Westerlund (2007) show that G_α (P_α) has higher power than G_τ (P_τ) in samples where *T* is substantially larger than *N*. Asymptotically, these statistics have a limiting normal distribution, and they are consistent. Moreover, Westerlund's (2007) procedure provides robust critical values for the test statistics by applying block bootstrapping which accounts for the cross sectional dependence.

For drawing inference about the long-run relationships, we use Moon and Perron's (2005) efficient estimation method of a system of Seemingly Unrelated Regressions (SUR) with integrated regressors. For a system containing multiple equations with integrated regressors, such as,

$$y_{it} = \alpha_i + \beta_i' x_{it} + \varepsilon_{it} \quad (3.8)$$

$$x_{it} = x_{it-1} + u_{it} \quad ,$$

Moon and Perron's (2005) procedure provides efficient estimates by exploiting the correlations among the multiple currencies, while allowing for individual currency specific inferences. Conventional system estimation methods with integrated regressors, such as GLS, have a non-standard limiting distribution that is skewed and does not converge to the true parameters. This makes inference difficult. Moon and Perron (2005) propose a method for obtaining efficient estimators with a mixed normal limiting distribution. By adding the leads and lags of the first differences of the regressors, they suggest applying GLS on this augmented dynamic regression model using information on the long-run covariance matrix. Equation (3.9) shows the dynamic GLS estimator using the multivariate format of SUR

$$\hat{b}_{DGLS} = \left(\sum_{t=k+1}^{T-k} z_t \hat{\Omega}_{uu.v}^{-1} z_t' \right)^{-1} \left(\sum_{t=t+k}^{T-k} z_t \hat{\Omega}_{uu.v}^{-1} y_t \right) = b + \left(\sum_{t=k+1}^{T-k} z_t \hat{\Omega}_{uu.v}^{-1} z_t' \right)^{-1} \left(\sum_{t=t+k}^{T-k} z_t \hat{\Omega}_{uu.v}^{-1} \xi_t^* \right). \quad (3.9)$$

Here, *b* is matrix of coefficients of regressors, and the leads and lags of the first difference of the regressors is $z_t = (\tilde{x}_t^{'}, \Delta x_{t-k}^{'} \otimes I_N, ..., \Delta x_{t+k}^{'} \otimes I_N)^{'}$, where $\tilde{x}_t^{'} = diag(\tilde{x}_{1t}, ..., \tilde{x}_{Nt})$, and $\tilde{x}_{it} = (1, x_{it}^{'})$, and $x_{it} = (x_{1t}^{'}, ..., x_{Nt}^{'})^{'}$, $\hat{\Omega}_{uu.v}$ indicates a part of the partitioned variance covariance matrix, while ξ_t^* is an error term with the non-estimable part of regressors beyond lag *k*. The null hypothesis is that the individual slope coefficient (*b*) is unity, or in other words that UIP holds on a currency specific basis.

Similar to the DGLS estimator, Moon and Perron (2005) suggest a number of other estimators, such as system dynamic OLS (DOLS) or fully modified OLS (FM-OLS), using their proposed method based on SUR. As a robustness check we will also provide system DOLS estimates given by:

$$\hat{b}_{DOLS} = \left(\sum_{t=k+1}^{T-k} z_t z_t^{'} \right)^{-1} \left(\sum_{t=t+k}^{T-k} z_t y_t \right) = b + \left(\sum_{t=k+1}^{T-k} z_t z_t^{'} \right)^{-1} \left(\sum_{t=t+k}^{T-k} z_t \xi_t^* \right) \quad (3.10)$$

Both estimators $\hat{b}_{DOLS}$ and $\hat{b}_{DGLS}$ use the long-run correlation information of the system $\hat{\Omega}$.

The Monte Carlo simulation results of Moon and Perron (2005) show that system DGLS has the lowest size distortion compared to other proposed estimators. Moreover, the efficiency gain of the system DGLS estimator is greater than that of other estimators. Furthermore, the system DGLS estimator suffers least from distortions due to small samples. Based on its superior performance, we utilize the system DGLS estimator.

This approach based on the SUR methodology allows for testing the UIP hypothesis directly. Another advantage of the Moon and Perron test design is that it does not require testing cointegration separately. If the model error is non-stationary, the test statistics diverge to infinity thereby rejecting the null hypothesis that UIP holds. Cheung and Lai (1993) suggest that the test for cointegration based on coefficients of the cointegrating vector is more powerful than simple cointegration tests, often used for testing the UIP hypothesis.

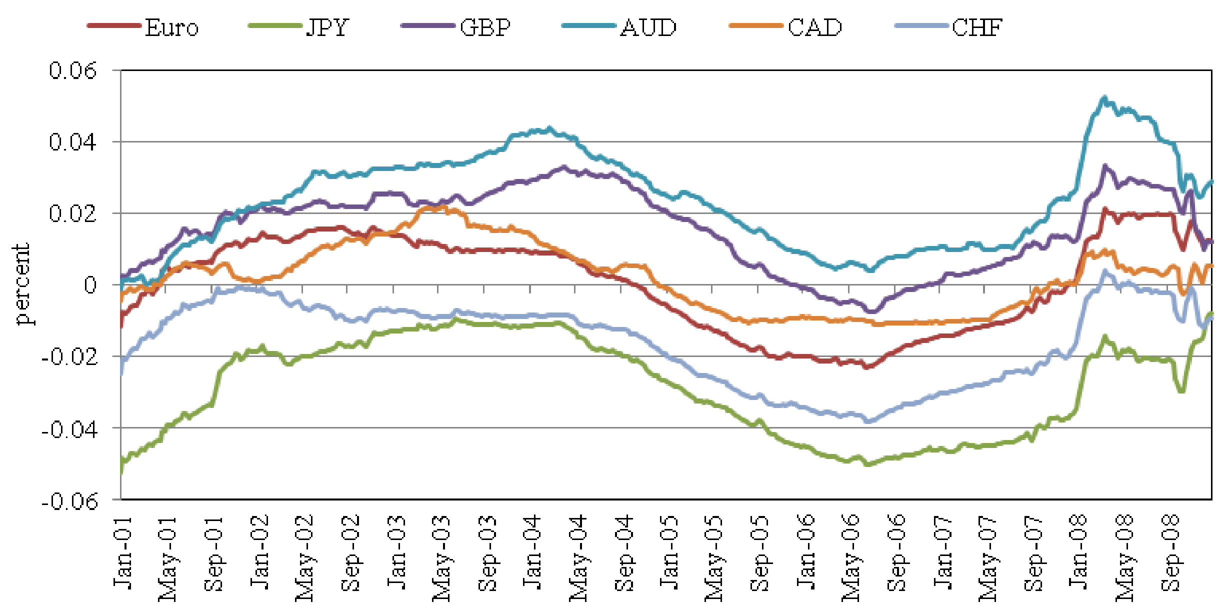
3.3.2 Data

Our sample period is January 2001 - December 2008. For the following currencies[42]: the Euro, the Japanese Yen (JPY), the British Pound (GBP), the Australian Dollar (AUD), the Canadian

[42] As the British Bankers Association (BBA) started reporting LIBOR for Danish Kroner and New Zealand Dollar from June 16, 2003 and for Swedish Krona from January 23, 2006 only, these currencies are not included in our analysis.

Dollar (CAD), and the Swiss Franc (CHF), we have acquired daily data on the exchange rates against the US Dollar (USD) from the International Monetary Fund (IMF).[43] For the interest rates we use daily LIBOR rates for the above currencies, with maturities from one week to 12 months. The LIBOR data come from the British Bankers Association (BBA) website.[44] Exchange rate differentials are calculated assuming that economic agents have perfect foresight. So the 6 months exchange rate differential series, for example, is calculated by subtracting the current spot rate from the spot rate after six months.[45] Similarly, to generate interest rate differentials we subtract the currency and maturity specific LIBOR from the US Dollar LIBOR with similar maturity. In view of the outcomes of unit root tests (to be discussed below), we use maturities ranging from 6 to 12 months.

Figure 3.1: Movement in 6-months Interest Rate Differentials



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[43] http://www.imf.org/external/np/fin/data/param_rms_mth.aspx

[44] http://www.bbalibor.com/rates/historical

[45] This procedure leads to an overlapping data problem as indicated by the Harri and Brorsen (2002). However, as the long-run covariance matrices are estimated using the Andrews (1991) procedure with data-based bandwidth and quadratic spectral kernel, our analysis does not suffer from this problem. Andrews (1991) developed an optimal data-based bandwidth selection procedure for given kernels based on an asymptotic truncated mean squared error (MSE) criterion. Monte Carlo evidence presented by Andrews (1991) shows that this procedure can improve size properties of test statistics. For details, see Cheun and Lai (1997).

From daily data we calculate weekly and monthly data.[46] Figure 3.1 shows the 6 months interest rate differentials for all currencies. Other maturities show more or less similar patterns. Figure 3.1 shows that the 6 months interest rate differential series are highly positively correlated (see Panel A of Table A3.1 in the Appendix for the correlation between the first differences of these series). Importantly, both Japan and Switzerland have negative interest rate differentials with respect to US since the US Dollar LIBOR rates are higher than these currency specific rates in the whole sample.

3.4 Results

Table 3.1 Block Bootstrap Panel Unit Root Test Results

	Exchange Rate Differentials			Interest Rate Differentials		
Maturity	**Statistics**	**5% CV**	***p*-value**	**Statistics**	**5% CV**	***p*-value**
1 week	-314.757	-19.173	0.000	-3.944	-17.715	0.875
2 weeks	-166.162	-23.638	0.000	-2.886	-13.987	0.854
1 month	-69.851	-20.694	0.000	-2.116	-9.980	0.790
2 months	-32.029	-14.419	0.000	-2.188	-8.204	0.689
3 months	-19.117	-12.178	0.002	-2.287	-7.962	0.649
4 months	-12.612	-12.346	0.045	-2.206	-7.235	0.648
5 months	-8.113	-11.926	0.234	-2.161	-6.874	0.657
6 months	-6.934	-11.447	0.337	-2.154	-6.789	0.662
7 months	-6.547	-12.116	0.422	-2.130	-6.815	0.682
8 months	-5.718	-12.148	0.570	-2.093	-6.913	0.706
9 months	-5.940	-12.411	0.601	-2.078	-7.033	0.727
10 months	-5.746	-13.237	0.674	-2.073	-7.148	0.742
11 months	-5.598	-13.242	0.633	-2.103	-7.328	0.752
12 months	-5.891	-13.060	0.587	-2.122	-7.512	0.769

Notes: Estimated test statistics for Equation (3.5) for exchange rate and interest rate differentials. 5% CV indicates robust critical values calculated at the 5 percent level of significance. *p*-values indicate the corresponding probability values of the calculated test statistics.

Table 3.1 reports the group mean CDRBB panel unit root tests.[47] In the main text, we will only present the group mean test statistics (G_α and G_τ). The pooled test statistics P_α and P_τ outcomes are shown in Table A3.2 in the Appendix. For both the interest and the exchange rate

[46] Our daily dataset contains more than fourteen thousand observations in any specific maturity. Using Moon and Perron' (2005) procedure of SUR expands the data metrics considerably, as the procedure treats every currency as a single equation in a system. As the estimation of the variance-covariance matrix involves kronecker product, the use of (2082x6x6) observations in kronecker product leads to the breakdown of the estimation procedure using the daily data. Therefore, we use the weekly averages using five working days in a week.
[47] The CDRBB estimation code is obtained from Stephen Smeeke's website: http://www.personeel.unimaas.nl/s.smeekes/

differentials, the null hypothesis of a unit root cannot be rejected for maturities of 5 months and higher at the 5 percent level of significance. This result suggests that the levels of these series are non-stationary. The pooled test statistics yield similar results (see Table A3.2 in the Appendix). In the rest of the chapter, we will focus on maturities of 6 months and higher.

The outcomes of the Westerlund (2007) ECM based panel cointegration test (group mean statistics) are shown in Table 3.2. For the purpose of estimation, we have used a maximum of 5 leads and 21 lags; optimal leads and lags have been selected using Akaike's Information Criterion (AIC). The results suggest that the null hypothesis of no cointegration is rejected for maturities ranging between 6 and 9 months, at the 5 percent level of significance. At least one member of the panel is cointegrated for these maturities. For the other maturities, the evidence for no cointegration is rather weak as the rejection probabilities (*p*-values) are close to 10 percent. Cointegration results based on panel statistic (see Table A3.3 in the Appendix) lead to the same conclusion that the panel as whole is cointegrated, for 6 to 12 months maturities at the 10 percent level of significance.

Table 3.2 Results for the Westerlund Cointegration Test (Group Mean Test)

	G_α			G_τ		
Maturity	**Coefficient**	***z*-value**	**Rob. *p*-value**	**Coefficient**	***z*-value**	**Rob. *p*-value**
6 months	-12.208	-4.527	0.000	-2.256	-3.012	0.002
7 months	-9.812	-3.237	0.000	-1.926	-2.237	0.020
8 months	-8.359	-2.454	0.020	-1.743	-1.805	0.054
9 months	-7.654	-2.074	0.036	-1.751	-1.824	0.064
10 months	-6.634	-1.525	0.056	-1.623	-1.522	0.062
11 months	-5.467	-0.896	0.124	-1.431	-1.071	0.144
12 months	-5.326	-0.821	0.122	-1.443	-1.099	0.124

Notes: Estimates of ECM coefficient based on Equation (3.7). The null hypothesis is that the series are not cointegrated. The alternative hypothesis is that cointegration exists when at least one member of the panel is cointegrated. 5 and 21 are the maximum number of leads and lags considered for estimation. Coefficient gives the estimated values of the group mean statistics and *z*-values are their standardized values. Rob. *p*-values are the robust probability values calculated using the bootstrap technique. The corresponding values show the level of significance.

As pointed out in Section 3.3, the methodology we have adopted for making inference does not require testing cointegration separately. Therefore, our cointegration results as reported in Table 3.2 (and Table A3 in the Appendix) should be considered as a robustness check of the system SUR estimates to which we turn now.

We have applied SUR using interest rate and exchange rate differentials for each maturity separately using a maximum of 12 leads or lags. Table 3.3 shows the estimation results using system DGLS (Equation (3.9)), which includes the individual slope coefficient for each currency *vis-à-vis* the US Dollar.[48] The Wald test examines the joint significance of the unity slope coefficient for this system of currencies. The null hypothesis of this test is that the joint slope coefficient is unity. In other words, it tests whether UIP holds for the system of currencies taken together. The reported *p*-values for the Wald test statistics show that the null hypothesis cannot be rejected for maturities ranging between 10 and 12 months. Hence, UIP holds for these maturities when all six currencies are taken together.[49]

Table 3.3 Estimation Results Using System DGLS

Currency	6 months	7 months	8 months	9 months	10 months	11 months	12 months
Euro	3.0261	2.3765	3.8135	5.1693**	2.9493	2.9231	3.2848
	1.7716	*1.5452*	*1.8149*	*2.2376*	*2.3597*	*2.8520*	*3.6336*
JPY	-1.2921**	-1.1077**	-1.296**	-1.5944*	-1.0286**	-1.6118**	-1.3214
	1.2585	*1.2611*	*1.1870*	*1.0759*	*1.0482*	*1.0551*	*1.5769*
GBP	2.1321	0.4204	0.4771	-0.1292	-0.4108	0.1099	3.1353
	1.6566	*1.3567*	*1.5417*	*1.9650*	*2.3640*	*2.0442*	*2.1757*
AUD	0.5314	-0.4379	0.6683	-0.1183	1.3554	1.9217	1.0261
	1.7308	*1.6050*	*1.9285*	*2.3469*	*3.1521*	*2.2673*	*2.5794*
CAD	-0.1784	1.1095	0.0519	-1.1833	-0.4472	0.0817	-1.4897
	1.6382	*1.9127*	*1.7832*	*1.7276*	*1.6198*	*1.9262*	*2.8642*
CHF	-5.6004*	-3.3885*	-1.8798**	-1.6504**	-1.3616**	-1.1008	-1.5929
	2.4140	*1.7692*	*1.5111*	*1.5988*	*1.3264*	*1.7211*	*1.7633*
Wald Stats	17.3979	16.0100	12.6966	19.2999	9.3929	7.5384	7.8070
Wald P	0.0079	0.0137	0.0481	0.0037	0.1527	0.2739	0.2526

Notes: This table shows system DGLS ($\hat{b}_{DGLS}$) estimates using Equation (3.9). For estimation, average weekly data with maximum leads and lags of 12 weeks is used. The optimal lag lengths (which are different for each maturity) are selected using Bayesian Information Criteria (BIC). The null hypothesis is that individual currency slope coefficients are one. The alternative hypothesis is that the coefficient is not unity or changes in the two series are not proportional. Figures in italics show standard errors. The null hypothesis for the Wald test is that the joint $\hat{b}_{DGLS}$ coefficient is unity. Wald P shows the *p*-values of the Wald test statistics. The symbols indicates *, < 5% and ** < 10% level of significance, respectively.

Table 3.3 also shows the individual currency specific results. The slope coefficients of the currencies show the currency specific behavior and as expected these differ across the currencies. The null hypothesis of unit slope coefficients cannot be rejected for almost all maturities at the 5 percent level of significance, except for the Japanese Yen in 9 months maturity and the Swiss Franc in 6 and 7 months maturities. The slope coefficients of the

[48] The estimation codes have been kindly provided by Benoit Perron.

[49] As Table A3.4 in the Appendix shows, estimates based on monthly data lead to similar conclusions. The null hypothesis of the Wald tests that aggregate unity slope coefficients, for this system of currencies, cannot be rejected for all maturities. The bilateral currency estimates also give similar results.

Japanese Yen and the Swiss Franc are persistently negative. However, as pointed out in Section 3.3.2, both currencies have negative interest rate differentials *vis-à-vis* the US. Bansal (1997), Bansal and Dahlquist (2000), and Ballie and Kilic (2006) provide evidence that the exchange rate *vis-à-vis* the US Dollar responds differently to positive and negative interest rates differentials. Specifically, Bansal and Dahlquist (2000) argue that a forward premium puzzle (as discussed in Section 3.1) is present only when the US interest rate exceeds the foreign interest rate.

Interestingly, for the negative interest rate differential series, any increase in the domestic (Japanese or Swiss) interest rates *vis-à-vis* the US interest rate means a decrease in the differential. Some studies have used the US Dollar as the domestic currency, instead of the foreign currency, to avoid the negative interest rate differential. In a bilateral environment, flipping of the exchange rate may work, but it is less likely to work in our multi-currency setup. Panel B of Table A3.1 shows the correlations between the (first differences of the) interest rate differential series when the Japanese Yen and Swiss Franc are taken as the numéraire against the US Dollar. Flipping currencies solves the problem of the negative interest rate differential since the US Dollar becomes the home currency. However, the uniform positive correlation structure between the interest rate differential of the various currencies gets destroyed. Our estimations with this modified Japanese Yen and Swiss Franc interest rate setup give a similar picture of the slope coefficients (see Table A3.5 in the Appendix).

The alternative hypothesis in the Moon and Perron (2005) tests design is that the series under investigation are not cointegrated. Whenever the null hypothesis is rejected in our setup it implies overshooting/undershooting of exchange rates, consistent with Dornbusch's (1976) exchange rate overshooting hypothesis. Dornbusch (1976) showed that a monetary expansion in an economy induces an immediate depreciation of its currency in excess of its long-run equilibrium value.

According to Frenkel and Rodriquez (1982), the exchange rate overshoots when capital is highly mobile whereas it undershoots when capital is highly immobile. In the London interbank market, banks can place their funds in any desired currency without facing capital controls. We find some evidence of persistent overshooting in line with the view of Frenkel and Rodriquez (1982). For both the Japanese Yen and the Swiss Franc the null hypothesis of a unit slope coefficient is rejected at the 10 per cent level of significance. This indicates that a positive unit shock to these interest rates (or a negative unit shock to their interest rate differentials), assuming that the US interest rate remains constant, leads to a more than proportional increase in their exchange rate differentials. However, we find little evidence of overshooting for the other currencies. This suggests that overshooting is a state dependent phenomenon as well. In other words, when currencies have low interest rates compared to the US, overshooting of the exchange rate becomes a possibility. However, more research is needed to draw strong conclusions. Since investigations in this direction are beyond the scope of this chapter, we leave it for future research.

As a robustness check, Table A3.6 gives the results for the system DOLS estimator. This estimator is the most efficient next to the DGLS estimator and suffers less from size distortion than fully modified estimators. It turns out that the system DOLS estimates are very similar to those reported in Table 3.3.

Finally, a caveat that has to be made is that both efficient system estimators, DGLS and DOLS, show high variances for the individual slope coefficients. In contrast, fully modified estimators, such as FM-GLS, show relatively small estimated variances (results are shown in Table A3.7). However, simulation results of Moon and Perron (2005) show that these FM-GLS estimates are less efficient in exploiting the cross currency correlation than the system DGLS or DOLS estimators. Moreover, the simulation results of Moon and Perron (2005) show that these fully modified estimators suffer more from size distortion than DGLS or DOLS estimators.

To check whether our results are driven by the use of LIBOR alone, we subject all fourteen maturities of currency specific weekly LIBOR rates to factor analysis. The notes to Table A3.8 in the Appendix provide further details of the procedure. The eigenvalue as shown in Table A3.8 shows the variance accounted for by the factors while ‘proportion’ indicates the relative weight of each factor in the total variance when all maturities of a currency specific interest rate are taken together. We use the ‘Kaiser Criterion’ for selecting the number of factors, i.e. we only retain factors with ‘eigenvalue’ greater than one. Factor loadings indicate variation explained by the selected factor in any specific maturity.

The estimates reported in Table A3.8 suggest that the LIBOR rates are driven by only one factor. Moreover, almost all variation in the LIBOR rates is explained by Factor 1. The last column in Table A3.8 shows the correlations between Factor 1 and 1 month interest rates from domestic markets. The table suggests that the correlations between Factor 1 and the domestic interest rates are very high, which indicates that the domestic interest rates are the driving force behind the LIBOR interest rates.

3.5 Conclusions

We test uncovered interest rate parity (UIP) over short-term horizons using the major international currencies. Our findings in this chapter add to the literature on UIP which has rejected this relationship, both at the individual currency level and also for the group of currencies when taken together (for details, see Table A2.1 in the Appendix of Chapter 2). We find that UIP generally holds above 6 months maturities for individual and the group of currencies. Our findings in this chapter support the results in Chapter 2, which shows that UIP holds for the LIBOR system of currencies for 7 to 12 months maturities.

Compared to previous research, we are using both a different technique and different interest rates. In principle, both differences might explain why our results on UIP are different from the findings of earlier studies. However, factor analysis shows that LIBOR rates are defined by only one factor, i.e. domestic interest rates, suggesting that our results are not driven by the use of LIBOR. We are therefore inclined to conclude that the technique we have adopted is the main reason why our results are different from previous studies. In our research design we take cross currency effects into account, which play an important role in the determination of the exchange rate, by using the SUR methodology.

We also find that state dependence in the interest rate differential series (i.e., the US interest rate exceeds the foreign interest rate) significantly affects the estimate of the slope coefficients. Once the negativity of the interest rate differential is accounted for, UIP is validated. Finally, we find some support for exchange rate overshooting notably for currencies with a negative interest differential *vis-à-vis* the US Dollar suggesting that this phenomenon may also be related to state dependence.

3.6 Appendix

Table A3.1 Correlation between Interest Rate Differentials (First Differences**)**

Currency	Euro	JPY	GBP	AUD	CAD	CHF
Panel A: Full Sample differential *vis-à-vis* US interest rate						
Euro	1.00	0.81	0.72	0.64	0.51	0.82
JPY	0.81	1.00	0.58	0.64	0.54	0.76
GBP	0.72	0.58	1.00	0.62	0.35	0.66
AUD	0.64	0.64	0.62	1.00	0.55	0.63
CAD	0.51	0.54	0.35	0.55	1.00	0.49
CHF	0.82	0.76	0.66	0.63	0.49	1.00
Panel B: Full Sample Japanese and Swiss interest rates differential *vis-à-vis* US interest rate						
Euro	1.00	-0.81	0.72	0.65	0.51	-0.83
JPY	-0.81	1.00	-0.59	-0.64	-0.54	0.76
GBP	0.72	-0.59	1.00	0.62	0.36	-0.66
AUD	0.65	-0.64	0.62	1.00	0.55	-0.64
CAD	0.51	-0.54	0.36	0.55	1.00	-0.49
CHF	-0.83	0.76	-0.66	-0.64	-0.49	1.00

Notes: This table shows the correlation structure between first differences of currency specific 6 months interest rate differentials. In Panel A, 6 months interest rate differential series are calculated by subtracting the US Dollar interest rate from other currency interest rate. In Panel B, a similar procedure is applied for all currency specific interest rates except for the Japanese Yen and the Swiss Franc. For these two, the domestic interest rates are subtracted from the US Dollar interest rate.

Table A3.2 Block Bootstrap Panel Unit Root (Pooled) Tests

	Exchange Rate Differentials			**Interest Rate Differentials**		
Maturity	**Statistics**	**5% CV**	***p*-value**	**Statistics**	**5% CV**	***p*-value**
1 week	-314.231	-17.362	0.000	-3.545	-15.553	0.862
2 weeks	-165.287	-21.692	0.000	-2.654	-12.288	0.835
1 month	-69.344	-19.167	0.000	-1.950	-8.846	0.770
2 months	-31.896	-13.112	0.000	-2.083	-7.443	0.658
3 months	-19.186	-10.816	0.001	-2.210	-7.350	0.615
4 months	-12.551	-11.117	0.026	-2.140	-6.730	0.607
5 months	-7.838	-10.736	0.181	-2.101	-6.442	0.610
6 months	-6.425	-10.262	0.297	-2.102	-6.370	0.616
7 months	-6.027	-10.785	0.378	-2.082	-6.431	0.630
8 months	-5.253	-10.991	0.516	-2.047	-6.503	0.652
9 months	-5.873	-11.059	0.455	-2.034	-6.578	0.668
10 months	-5.617	-12.135	0.557	-2.030	-6.667	0.681
11 months	-5.570	-11.717	0.514	-2.061	-6.822	0.692
12 months	-5.986	-11.848	0.457	-2.080	-6.958	0.705

Notes: Estimated test statistics for Equation (3.6) with exchange rate and interest rate differentials. 5% CV indicates robust critical values at the 5-percent level of significance. *p*-values are the corresponding probability values of the calculated test statistics.

Table A3.3 Results of Westerlund Cointegration Panel Test

	P_α			P_τ		
Maturity	**Coefficient**	**Z-value**	**Rob. *p*-value**	**Coefficient**	**Z-value**	**Rob. *p*-value**
6 months	-11.084	-8.509	0.000	-5.176	-3.363	0.004
7 months	-8.378	-6.220	0.002	-4.193	-2.521	0.014
8 months	-7.708	-5.653	0.004	-4.116	-2.455	0.036
9 months	-7.207	-5.229	0.006	-4.184	-2.514	0.028
10 months	-6.801	-4.885	0.008	-4.115	-2.454	0.016
11 months	-5.474	-3.763	0.024	-3.532	-1.955	0.064
12 months	-5.182	-3.516	0.016	-3.409	-1.849	0.062

Notes: Estimates of ECM coefficient based on Equation (3.7). The null hypothesis is that the ECM coefficient is zero. Group mean test statistics shown in this table have as the alternative hypothesis that at least one of the members of the panel is cointegrated. The maximum number of leads and lags considered for estimation are 5 and 21, respectively. Values give the estimated values of the coefficients and Z-values are their standardized values. Rob. *p*-values are the robust probability values calculated using the bootstrap technique.

Table A3.4 Estimation Results for System DGLS (Monthly Data**)**

	6 months	**7 months**	**8 months**	**9 months**	**10 months**	**11 months**	**12 months**
Euro	-0.2891	0.1103	2.8782	0.8791	-0.7631	17.0376*	21.8353*
	2.3187	*3.0917*	*2.8813*	*2.9739*	*6.5479*	*4.3569*	*4.8998*
JPY	-3.4596*	-0.2399	1.1653	1.8085	-2.8062**	-1.4989	0.8416
	2.0816	*2.2002*	*1.6906*	*1.6871*	*2.1245*	*2.0517*	*2.5742*
GBP	-0.2934	-0.1913	1.9738	-1.1612	-6.5941*	-3.1139**	1.5832
	1.6146	*1.8934*	*1.568*	*1.7073*	*3.1399*	*2.3495*	*2.7434*
AUD	-0.7196	-0.1402	0.9967	2.8111	0.8597	2.5259	1.5688
	1.8027	*1.4448*	*1.5513*	*1.4736*	*1.9878*	*1.7369*	*2.3275*
CAD	1.5326	-0.0836	-4.0469*	-1.9124**	5.3586**	0.7959	-2.4556
	1.8467	*2.066*	*2.0445*	*1.5508*	*2.3028*	*1.7798*	*2.3412*
CHF	-3.3382	-4.6011	-8.2813*	-5.3422*	-6.0788*	0.6033	6.1701*
	3.8133	*4.3311*	*2.8784*	*2.2252*	*2.485*	*1.6825*	*2.0713*
Wald Stats	11.4885	4.1313	10.0425	7.8104	12.738	10.1588	6.5247
Wald p	0.0744	0.6589	0.1229	0.2523	0.0474	0.1181	0.3670

Notes: This table shows estimates of the system DGLS ($\hat{b}_{DGLS}$) coefficient using Equation (3.9). For estimation, average monthly data with maximum leads and lags of 4 months is used. The optimal lag lengths are selected using the Bayesian Information Criterion (BIC). The null hypothesis is that the individual slope coefficient is unity. The alternative hypothesis is that the slope coefficient is not unity or changes in the two series are not proportional. The figures in italics show the standard errors. The null hypothesis for the Wald test is that the joint slope $\hat{b}_{DGLS}$ coefficient is unity. Wald p shows the *p*-values of the Wald test statistics. The symbols indicates *, < 5% and ** < 10% level of significance, respectively.

Table A3.5 Estimation Results for System DGLS
(Using JPY and CHF as numéraire for USD exchange rate**)**

	6 months	**7 months**	**8 months**	**9 months**	**10 months**	**11 months**	**12 months**
Euro	0.9749	0.3808	0.4918	0.0173	0.0238	0.753	0.753
	0.8341	*0.8741*	*0.9993*	*1.1273*	*0.9304*	*1.029*	*1.029*
JPY	-1.5757*	-1.2098*	-0.9576*	-1.4304*	-1.1407**	-0.998	-0.998
	0.9678	*1.0271*	*0.8305*	*0.8968*	*1.2036*	*1.2124*	*1.2124*
GBP	0.3856	-0.3261	-0.4591	-0.9489	-0.4989	-0.1572	-0.1572
	1.3557	*1.3439*	*2.1738*	*1.5597*	*1.5894*	*1.6807*	*1.6807*
AUD	-0.2886	-1.2131**	-1.5927*	-1.8158*	-1.2951	-0.9884	-0.9884
	1.2945	*1.1461*	*1.1851*	*1.4628*	*1.4331*	*1.3878*	*1.3878*
CAD	0.7904	1.8192	1.2226	1.0142	0.8282	0.8261	0.8261
	1.3898	*1.6533*	*1.6581*	*1.6717*	*1.6908*	*1.7922*	*1.7922*
CHF	-1.0412**	-0.8017	-1.417**	-1.418**	-1.1458**	-0.5586	-0.5586
	1.0586	*1.3073*	*1.2466*	*1.3557*	*1.2965*	*1.3637*	*1.3637*
Wald Stats	37.5276	31.008	50.9728	44.1297	31.9431	13.6584	13.6584
Wald p	0.0000	0.0000	0.0000	0.0000	0.0000	0.0337	0.0337

Notes: This table shows estimates of the system DGLS ($\hat{b}_{DGLS}$) coefficient using Equation (3.9). These estimates are obtained using JPY and CHF as numéraire for their USD exchange rates. The optimal lag lengths are selected using the Bayesian Information Criterion (BIC). The null hypothesis is that the individual slope coefficient is unity. The alternative hypothesis is that the slope coefficient is not unity or changes in the two series are not proportional. The figures in italics show the standard errors. The null hypothesis for the Wald test is that the joint slope $\hat{b}_{DGLS}$ coefficient is unity. Wald p shows the *p*-values of the Wald test statistics. The symbols indicates *, < 5% and ** < 10% level of significance, respectively.

Table A3.6 Estimation Results for System DOLS

	6 months	7 months	8 months	9 months	10 months	11 months	12 months
Euro	-0.278	2.4236	3.5999	4.7121	6.152**	8.3515*	9.7004**
	2.0146	*2.1105*	*2.7217*	*2.8512*	*2.7927*	*3.7077*	*4.5603*
JPY	-0.7075	-1.048**	-1.1609	-1.1378	-0.7956	-0.6515	-1.0312
	1.2539	*1.1603*	*1.3721*	*1.3674*	*1.4037*	*1.7217*	*1.9135*
GBP	-0.6000	-0.1023	-0.6930	-0.4170	-0.6122	0.8814	3.7240
	1.7103	*1.5082*	*1.9771*	*2.0987*	*1.8826*	*2.4351*	*2.7847*
AUD	-0.9933	-0.9490	-0.5355	-0.5590	-0.6936	-0.7358	0.9697
	1.2610	*1.6110*	*2.2190*	*2.0494*	*1.8770*	*2.2867*	*2.6355*
CAD	0.0444	-0.3957	-0.9880	-2.2319**	-2.2188**	-3.0872**	-3.9464**
	1.4682	*1.7028*	*2.0284*	*1.8667*	*1.7915*	*2.1988*	*2.7878*
CHF	-1.4158	-4.0798*	-3.2265*	-2.1787	-1.8461	-1.2688	-0.1325
	2.6703	*2.2338*	*2.5293*	*2.4684*	*2.0253*	*2.3883*	*2.5069*
Wald Stats	12.2551	13.6237	11.5634	14.5290	13.6779	9.6855	7.6626
Wald p	0.0565	0.0341	0.0724	0.0243	0.0334	0.1385	0.2639

Notes: This table shows estimates of system DGLS ($\hat{b}_{DOLS}$) coefficient using Equation (10). For estimation, average weekly data with maximum leads and lags of 12 weeks is used. The optimal lag lengths are selected using Bayesian Information Criteria (BIC). The null hypothesis is individual slope coefficient is unity. The alternative hypothesis is the slope coefficient is not unity or changes in the two series are not proportional. The figures in italics show the standard errors. The null hypothesis for the Wald test is the joint slope $\hat{b}_{DOLS}$ coefficient is unity. Wald p shows the *p*-values of the Wald test statistics. The symbols indicates *, < 5% and ** < 10% level of significance, respectively.

Table A3.7 Estimation Results for Fully Modified GLS

	6 months	7 months	8 months	9 months	10 months	11 months	12 months
Euro	-0.1343*	-0.1009*	-0.2798*	-0.2166**	0.9372	0.9682	2.0269
	0.3910	*0.4133*	*0.5771*	*0.6671*	*0.6569*	*0.7542*	*0.8333*
JPY	-2.5297*	-1.9882*	-2.6277*	-2.9759*	-3.1833*	-3.018*	-3.3997*
	0.7423	*0.6328*	*0.7704*	*0.7519*	*0.7710*	*0.9044*	*1.0604*
GBP	-2.7716*	-2.9399*	-3.4442*	-2.9375*	-1.594*	-1.1135*	-0.6979
	0.8325	*0.8597*	*0.9831*	*0.9786*	*1.0246*	*1.0299*	*1.1889*
AUD	-1.6014*	-1.957*	-2.1516*	-2.059*	-1.1999*	-1.4672*	-0.2616
	0.5065	*0.5582*	*0.7257*	*0.7719*	*0.7692*	*0.8853*	*0.9032*
CAD	0.6367	1.2165	0.5112	0.6486	-0.8737*	-0.0695	-0.3639
	0.7251	*0.8215*	*0.8769*	*0.9564*	*0.9486*	*1.0073*	*1.1083*
CHF	-0.0669*	0.0167**	-0.0223	0.1068	-1.5258*	-1.9338*	-2.948*
	0.5270	*0.5661*	*0.6754*	*0.8305*	*0.8261*	*0.9489*	*0.8932*

Notes: This table shows estimates of system FM-GLS coefficients. For estimation, average weekly data with maximum leads and lags of 12 weeks is used. The optimal lag length is selected using the Bayesian Information Criterion (BIC). The null hypothesis is that the individual slope coefficient is unity. The alternative hypothesis is that the slope coefficient is not unity or changes in the two series are not proportional. Figures in italics show the standard errors. The symbols indicates *, < 5% and ** < 10% level of significance, respectively.

Table A3.8 Details of Factor Analysis Using LIBOR

	Factor 1		Factor Loadings							Correl. with domestic 1 month rates
	Eigenvalue	**Proportion**	**6m**	**7m**	**8m**	**9m**	**10m**	**11m**	**12m**	
Euro	13.76645	0.9839	0.9986	0.9976	0.9963	0.9946	0.993	0.9911	0.9891	0.9745
USD	13.84885	0.9894	0.9989	0.9984	0.9975	0.9962	0.9948	0.9931	0.9911	0.9248
JPY	13.8258	0.9902	0.9988	0.9986	0.9981	0.9974	0.9965	0.9952	0.9937	0.9856
GBP	13.56402	0.9702	0.9975	0.9963	0.9941	0.9909	0.9871	0.9825	0.9771	0.8917
AUD	13.7935	0.9856	0.9988	0.9979	0.9966	0.9948	0.9931	0.9912	0.9889	0.8825
CAD	13.7242	0.9805	0.9986	0.9975	0.9955	0.9925	0.9893	0.9853	0.9801	0.9803
CHF	13.80587	0.9866	0.9988	0.9981	0.9971	0.9956	0.9942	0.9925	0.9905	0.9769

Notes: Euro, USD, JPY, GBP, AUD, CAD, and CHF indicate currency specific LIBOR rates for the Euro, the US Dollar, the Japanese Yen, the British Pound, the Australian Dollar, the Canadian Dollar, and the Swiss Franc respectively. We have used the followings 1-month domestic interest rates. For the Euro, 1 month Euribor (offered rate), for the Yen 1 month Tokyo Interbank (offered rate), for the GBP 1 month UK Treasury Bill Tender (middle rate), for the AUD 1 month Australian Dollar Deposit (middle rate), for the CAD 1 month Canada Prime Corp. Paper (middle rate), for the CHF 1 month Swiss Interbank (ZRC: SNB) (bid rate). For Factor Analysis we have used weekly currency specific LIBOR interest rates with 14 maturities, starting from 1 week to 12 months. Eigenvalue indicates the variance accounted for by the factors while 'proportion' indicates the relative weight of each factor in the total variance when all maturities of a currency specific interest rate are taken together. Based on the 'Kaiser Criterion', which suggests retaining those factors with 'eigenvalue' greater than 1, we have selected only one factor ('Factor1'). There were other factors, for each currency; however, their Eigenvalues were less than 1 and hence not reported here. In addition, 'Proportion' shows that almost all variation is explained by the first factor for each currency. Factor Loadings indicates the variation explained by Factor 1. The numbers clearly shows that Factor 1 explains almost all variation. Finally, the last column indicates the correlation between the currency specific factor and the 1 month interest rate in the domestic market related to the specific currency. These correlations are very high, which indicates that the domestic interest rates are the driving force behind the LIBOR market interest rates.

Table A3.9 List of Symbols Used in Chapters 2 and 3

r_{it}	Logarithmic gross return of domestic assets for maturity *i* at any time *t*
r^*_{it}	Logarithmic gross return of foreign assets for maturity *i* at any time *t*
f_{t+i}	Forward rate for maturity *i* at time *t*
α_t	Risk premium
β_i	Cross-section specific slope coefficient for UIP
$E(s_{t+i})$	Expected future spot exchange rate at time *t+i*
s_{t+i}	Realized exchange rate at *t+i*
ε_{it}	Error term
x_{it}	Interest rate differential series
y_{it}	Exchange rate differential series
z_{it}	Any series to be tested for unit roots
μ_i	Fixed effect
θ_t	Unit specific time trend
ρ_i	Unit specific autoregressive parameter
υ_{it}	Error term in unit root models.
N	Number of cross sections
T	Number of observations in time dimension
Δ	Change of a variable
τ_p	Pooled test statistics of CDRBB unit root test
τ_{gm}	Group mean test statistics of CDRBB unit root test
d_t	Currency-specific deterministic component
δ_i	Associated vector of parameters of currency-specific deterministic component
p_i	Optimal number of leads and lags
ϕ_i	Individual specific speed of adjustment parameter for the error correction term
ψ_i	Cointegrating vector.
P_α	Panel statistics using conventional standard error
P_τ	Panel statistics using Newey-West standard error
G_α	Group mean statistics using conventional standard error
G_τ	Group mean statistics using Newey-West standard error
$\hat{\sigma}_i$	Estimated regression standard
$\hat{\phi}_i(1)$	Newey-West standard error
$\hat{\beta}_{FM}$	Panel FM-OLS estimator for slope coefficient
$\bar{x}_i$	Mean of x_{it} for time period T
$\hat{\Omega}_{u\varepsilon}$	Endogeneity correction factor in long-run auto-covariance estimators
$\hat{\Omega}_{\varepsilon}^{-1}$	Endogeneity correction factor in long-run variance estimators

$\hat{\Delta}^{+}_{\varepsilon u}$	Serial correlation correction factor estimated based on kernel estimates
$\otimes$	Kronecker product
$\hat{b}_{GLS}$	GLS based Panel SURE estimator for slope coefficients
$\hat{b}_{DOLS}$	DOLS based Panel SURE estimator for slope coefficients
ξ^{*}_{t}	Error term with non-estimable part of regressors beyond k in Panel SURE estimation
$\hat{\Omega}_{uu.v}$	Part of the partitioned variance covariance matrix

Chapter 4

An Empirical Analysis of Excess Interbank Liquidity: A Case Study of Pakistan

4.1 Introduction

Excess interbank liquidity is defined as the pool of reserves held by the commercial bank with the central bank, over and above the regulatory liquidity requirements (Mishkin, 2012). The findings of Nissanke and Aryeetey (1998) and Agénor and Aynaoui (2010) suggest that excess interbank liquidity in developing economies often limits the ability of the central bank to effectively conduct monetary policy.

Several studies (including Agénor *et al*., 2004 and Saxegaard, 2006) investigate excess interbank liquidity by distinguishing between supply and demand components. The demand component reflects low demand for credit in the economy, while the supply component constitutes the part of excess liquidity that banks hold for precautionary reasons. Banks may be holding liquidity for precautionary reasons if the risk of default is likely to increase and this perceived default risk cannot be internalized by raising the risk premium on lending (Agénor *et al*., 2004). In addition, structural or cyclical factors may lead to precautionary liquidity accumulation. As will be discussed in more detail in Section 4.2.1, structural determinants include the presence of a large informal sector, inaccessibility of remote areas of the country, and a weak or inefficient payment system. Cyclical factors, such as fluctuations in foreign capital inflows, a change in inflationary expectations or government borrowing, may also cause banks to hold liquidity for precautionary reasons (Agénor and Aynaoui, 2010).

Central banks can design monetary policy more effectively if the cause of excess liquidity is known. For example, if excess liquidity is largely due to low credit demand expansionary monetary policy may not be very effective. Any attempt by the central bank to stimulate aggregate demand by relaxing monetary policy will only add to excess liquidity. Likewise, if the central bank would tighten its policies in the presence of excess liquidity, a sudden improvement in credit demand may cause a rapid increase in credit thereby undermining the central bank's policies.

This chapter examines the interbank market of Pakistan as a case study. In response to the recent global financial crisis, the State Bank of Pakistan (*henceforth* SBP) eased its policies. As will be explained in more detail in Section 4.2.2, the regulatory liquidity requirements have been relaxed frequently since June 2008, while the pool of securities that are eligible as reserves has been widened. These measures led to an unprecedented liquidity accumulation in the interbank market of Pakistan. The presence of excess interbank liquidity may weaken the monetary transmission mechanism as acknowledged in the State Bank of Pakistan (2011). We investigate the nature and causes of excess liquidity in the interbank market of Pakistan.

Moreover, in Chapter 5 we build on the findings of this chapter and explore the impact of excess interbank liquidity on the monetary transmission mechanism in Pakistan. For this purpose, the short- and long-run pass-through of changes in policy instruments to lending and deposit rates and the exchange rate is estimated with and without excess interbank liquidity in the models. Our findings on the interbank liquidity and its impact on the policy tools' pass-through may aid in designing a more effective monetary policy in Pakistan and may be helpful for other developing economies facing similar problems.

This study is innovative for two reasons. First, we investigate the persistence of excess liquidity.[50] To the best of our knowledge, persistence of excess interbank liquidity has not been evaluated before using high frequency data. Second, the study defines interbank liquidity by augmenting it with government securities that are eligible to meet liquidity requirements. Mohanty *et al.* (2006) argue that banks' deposits at the central bank may be misleading as indicator of liquidity if the banks hold substantial amounts of government securities that can be sold easily to the central bank.

Our findings suggest persistence of interbank excess liquidity. Our results also indicate that the financing of the government's budget deficit by the central bank is one of the causes of this persistence in interbank liquidity. Moreover, we identify a structural shift in the interbank market in June 2008. Before June 2008, low credit demand was driving excess liquidity holdings by banks. After June 2008, banks' precautionary investments in risk free securities drive their liquidity holdings.

The remainder of the chapter is structured as follows. The next section discusses the implications of excess liquidity for monetary policy and outlines monetary policy in Pakistan.

[50] Fuhrer (2009) defines 'persistence' as a tendency of an economic variable not to change, in the absence of economic forces that could have move it elsewhere.

Section 4.3 discusses previous studies, while Section 4.4 describes our methodology. Section 4.5 describes the data used and Section 4.6 offers our main results. Finally, Section 4.7 concludes.

4.2 Excess liquidity and monetary policy in Pakistan

Following Mohanty *et al*. (2006), we include government securities that are eligible in meeting regulatory liquidity requirements in calculating excess liquidity.[51] Thus we define excess liquidity as the ratio of reserves deposited with the central bank by the banks, cash in their vaults and eligible government securities, in excess of the statutory limit to the total time and demand liabilities of the banks.[52] We include eligible securities as the banking sector in Pakistan holds a considerable amount of highly liquid short-term government securities, which banks can substitute for cash using the SBP's discount window at their own discretion (Mohanty *et al*., 2006).

4.2.1 Excess liquidity and monetary policy

The SBP actively uses all policy tools at its disposal to manage liquidity. These policy tools are direct tools, such as cash reserve requirements and statutory liquidity requirements, and indirect tools, such as the discount rate and open market operations.[53]

If the SBP raises reserve or liquidity requirements, excess interbank liquidity decreases immediately, which in turn causes the interbank lending rate to increase. Subsequently, the lending and the deposit rates respond. If the central bank raises the discount rate, risk-averse banks are likely to increase their liquidity holdings to mitigate liquidity risk. Likewise, open market operations of the central bank will affect interbank liquidity.

Banks hold excess liquidity either due to low demand for credit (involuntary excess liquidity) or for precautionary reasons (voluntary excess liquidity). If firms' demand for credit declines due to weak economic activity, banks accumulate excess liquidity. Alternatively, banks may hold liquidity as a precaution if the risk of default on extended credit is expected to rise.

[51] Agénor *et al*. (2004), Ruffer and Stracca (2006), Saxegaard (2006), and Gigineishvili (2011) use similar measures for excess liquidity but do not include short-term government securities.
[52] The eligible assets include short-term market treasury bills, Pakistan Investment Bonds (PIBs) up to a certain maximum, and some government enterprise bonds.
[53] The SBP also frequently uses 'moral suasion', i.e., the commercial banks' executives are briefed on objectives of a specific policy move and the central bank's expectation of the market response.

Moreover, structural and/or cyclical factors may promote precautionary liquidity holdings by banks. Often structural impediments like a less developed financial sector or a large informal sector force banks to hold extra liquidity. For example, banks tend to have greater demand for liquidity due to the unreliability of the payment system. Also, the cost of processing information, evaluating projects, and monitoring borrowers is relatively high in these economies, which generally leads to accumulation of liquidity (Agénor and Aynaoui, 2010). Similarly, the presence of a large informal sector promotes cash transactions instead of transactions through bank instruments like checks or bills in order to avoid taxes. The banks are then forced to hold large liquid reserves to meet frequent large demands for cash.

Cyclical factors refer to fluctuations in inflationary expectations, foreign capital inflows, and government borrowing (Agénor and Aynaoui, 2010). Elaborately, a higher volatility in prices increases uncertainty about the value of the collateral pledged by the borrower. The banks may react to inflation risk by charging a higher premium to the borrower or by increased rationing of credit. Agénor and Aynaoui (2010) argue that both an increase in the risk premium and credit rationing may result in the involuntary accumulation of excess liquidity.

Furthermore, in the past two decades, foreign capital inflows have contributed significantly to the accumulation of excess liquidity in developing economies (Ganley, 2004; and Agénor and Aynaoui, 2010). Irrespective of the presence of a pegged or a managed float (or a crawling peg) regime, capital inflows add to excess interbank liquidity. Under a pegged exchange rate regime, foreign capital inflows cause upward pressure on the nominal exchange rate which may lead to central bank foreign exchange interventions. If the central bank sterilizes these interventions by selling securities to the banks, excess liquidity holdings of the banks increases. The situation is not very different under a managed float regime, except that here the central bank always intervenes to maintain the exchange rate within the targeted range.

Finally, government borrowing from the central bank may act as a catalyst of excess interbank liquidity accumulation. In developing economies, often the government borrows directly from the central bank. This borrowed money enters in the monetary system very quickly in the form of deposits at banks and hence becomes part of the money supply (see Table 1.1 in Chapter 1 for an overview of Pakistan's recent monetary developments).[54] For this reason, the

[54] When government borrows from the central bank, the central bank's assets in the form of government securities increase. In exchange for those securities, the central bank increases the government's deposit at the central bank.

government borrowing from the central bank is generally known as monetization of the deficit.[55] The increase in deposits leads to excess liquidity holding of the banks. Ganley (2004) notes that the monetization of the deficit is one of the main sources of excess liquidity in some developing countries.

Persistent fiscal deficits may also increase the interest rate on the government debt. The higher return may attract the banks towards risk free government securities. Mohanty *et al*. (2006) argue that inflationary expectations fuelled by government borrowing may further increase interest rates. In such a high interest rate environment, the banking sector may structurally shift towards holding more risk-free assets, thereby crowding out private sector debt.

4.2.2 Recent developments in monetary policy in Pakistan

As discussed in Chapter 1, two important features characterize the period under consideration in this study (2005-2011). First, the foreign currency deposits steadily increased over this period, specifically after May 24th 2008, when the exchange rate depreciated sharply (see the lower panel in Figure 4.1). The Pakistan Rupee depreciated against the US Dollar by almost 7 percent in May 2008 due to speculative attacks. Resident foreign currency deposits are deposits denominated in foreign currency held by individuals or firms with local banks, independent of the nationality or residential status of the holder. As regulatory requirements limit the local banks' access to the international market, banks often substitute the foreign currency for domestic currency to invest in the local money market.

The SBP has a managed float strategy to mitigate exchange rate volatility and to alleviate perceived exchange rate risk. To stabilize the exchange rate, the SBP replaces the foreign exchange inflows with domestic currency, either through direct purchases, or through currency swaps.[56] The interventions in the exchange rate market thus increase interbank liquidity. The banks prefer placing this liquidity in the form of short-term risk-free securities as financial

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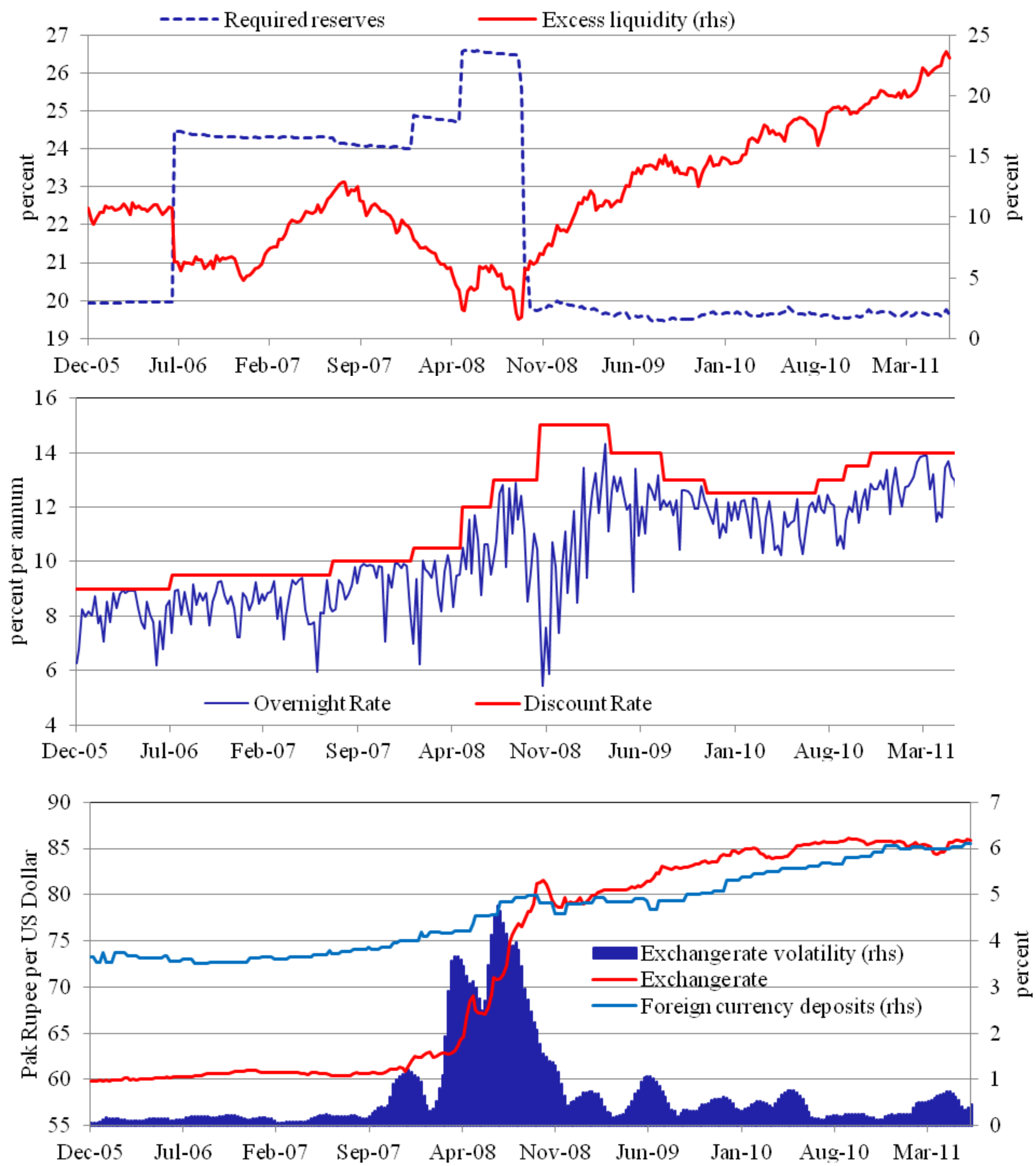
When the government pays for goods and the services, the private sector's deposits at the banks increase at the expense of the government's deposit at the central bank. Consequently, the central bank's liabilities to the banks increase. The increased deposit base increases the money supply. Table 1.1 in Chapter 1 gives an overview of this mechanism.

[55] This monetization may have inflationary consequences (De Haan and Zelhorst, 1990; Fischer *et al*. 2002; and Catao and Terrones, 2005).

[56] The substitution of foreign currency by domestic asset involves exchange rate risk. The SBP's managed float strategy does not eliminate exchange rate risk completely. To reduce exchange rate risk, banks use currency swaps with the central bank and also with peer banks.

markets in Pakistan lack financial depth.

Figure 4.1 Excess Liquidity, Interest Rates and Exchange Rate



On May 24th 2008, the SBP further tightened its policies using both direct and indirect tools. As a result, the effective reserve requirements reached 26.5 percent of time and demand liabilities of the banks, the highest the banking sector of Pakistan has witnessed over the last decade.[57] The SBP relaxed this requirement at the start of the global financial crisis. In October 2008, the requirements were brought down twice with 100 bps. However, the SBP continued its tight monetary policy stance using the discount rate (see Table 4.1 for details).

Table 4.1 Chronology of Changes in Policy Instruments

Date	**Cash reserve requirements**				**Liquidity requirements**		**Discount rate**
	Demand liabilities		**Time liabilities**		**Demand liabilities**	**Time liabilities**	
	Weakly average	Daily minimum	Weakly average	Daily minimum			
31-Dec-05	5.0	4.0	5.0	4.0	15.0	15.0	9.0
22-Jul-06	7.0	4.0	3.0	1.0	18.0	18.0	
29-Jul-06							9.5
19-Jan-07	7.0	6.0	3.0	2.0			
1-Aug-07							10.0
4-Aug-07	7.0	6.0	0.0	0.0	18.0	18.0	
2-Feb-08	8.0	7.0					10.5
24-May-08	9.0	8.0			19.0	19.0	12.0
30-Jul-08							13.0
11-Oct-08	8.0	7.0					
18-Oct-08	6.0	5.0					
1-Nov-08	5.0	4.0					
13-Nov-08							15.0
21-Apr-09							14.0
15-Aug-09							13.0
25-Nov-09							12.5
2-Aug-10							13.0
30-Sep-10							13.5
30-Nov-10							14.0

Second, monetary policy was tightened as the discount rate mostly moved upward (see the panel in the middle of Figure 4.1). Table 4.1 details the various policy steps of the SBP. First, on 22nd July 2006 all savings deposits were classified as demand liabilities. Other notable changes include the re-classification of special notice deposits and time deposits of less than 6

[57] The figures in Table 4.1 indicate separate reserve requirements on time and demand liabilities and these are different from effective reserve requirements. The effective reserve requirements for any given week is the weighted average of the cash and liquidity reserve requirements based on their respective time and demand liabilities.

months from time liabilities to demand liabilities. The re-classification was extended to time deposits with maturities up to 12 months on 4th August 2007. In tandem, reserve requirements were increased on demand liabilities but were relaxed on time liabilities (see Table 4.1). These measures increased the effective reserve requirements to more than four percent of time and demand liabilities, i.e. PKR 12.7 billion (see the upper panel in Figure 4.1). As will be explained in more detail below, the SBP aimed to push the sticky deposit rate upward. The SBP also wanted to reduce the maturity mismatch between the assets and the liabilities of the banking sector and therefore time liabilities are exempted from cash reserve requirements since August 4th 2007.[58]

On October 18th 2008, the SBP increased the eligibility of long-term government bonds from 5 to 10 percent of the statutory liquidity requirements. The move increased the borrowing ability of banks from the SBP's discount window by roughly PKR135 billion thereby increasing excess liquidity holdings of the banks substantially. As the literature shows that persistent excess liquidity weakens monetary policy, it is important to investigate whether these policy moves by the SBP have led to persistent excess liquidity in the interbank market of Pakistan. Moreover, identification of the causes of liquidity accumulation may contribute to understanding the dynamics of banks' behavior and the effectiveness of monetary policy in Pakistan.

4.3 Related studies

The economic literature on interbank liquidity is mostly theoretical, striving to model the banks' behavior and/or the central bank's policy response when the interbank market suffers from adverse liquidity shocks, be it aggregate or idiosyncratic shocks. Bhattacharya and Gale (1987), Freixas and Holthausen (2005), Allen *et al*. (2009), and Heider *et al*. (2010) examine the banks' behavior in case of aggregate shocks, while Bolton *et al*. (2009), Diamond and Rajan (2009), Freixas *et al*. (2011), and Acharya *et al*. (2012) focus on scenarios in which banks suffer from idiosyncratic shocks. However, only a few studies examine interbank liquidity in normal times. Wyplosz (2005) examines the accumulation of excess liquidity in the Eurozone before the crisis, arguing that this buildup was due to deficient borrowing resulting from weak growth prospects.

[58] The State Bank of Pakistan (2006) identifies the following objectives of these changes in the reserve requirements: (i) draining excess liquidity from the inter-bank market, in order to put upward pressure on the money market rates; and (ii) encouraging banks to mobilize long-term deposits.

Agénor *et al*. (2004) analyze the buildup of excess liquidity in the interbank market of Thailand during the East Asian crisis. Their results also suggest that the increased excess liquidity by banks reflected weak credit demand in the wake of the crisis. Likewise, based on a survey among central banks of developing and emerging economies, Mohanty *et al*. (2006) argue that the buildup of excess liquidity in the last decade was due to weak credit demand from the business sector.

Surprisingly, there is little work formalizing the channels through which excess liquidity impacts the monetary transmission mechanism. Saxegaard (2006) examines excess liquidity in sub-Saharan Africa and its consequences for the effectiveness of monetary policy. He quantifies the impact of excess liquidity using impulse responses from threshold VAR models. The study suggests a weakening of the monetary policy transmission mechanism in the presence of excess liquidity.

More recently, Agénor and Aynaoui (2010) provide a theoretical framework for modeling excess liquidity in a general equilibrium setup. They argue that excess liquidity may hamper the ability of monetary policy makers to lower inflation. Their model shows that excess liquidity induces easing of collateral requirements on borrowers, which in turn may translate into a lower risk premium and lower lending rates, thus resulting in asymmetric bank pricing behavior. To the best of our knowledge, excess liquidity in the interbank market of Pakistan has not been studied before.

4.4 Methodology

We first use unit root tests to examine the data generating processes of the variables used in the analysis. If excess liquidity is stationary in levels, we see interbank liquidity accumulation as a short-term phenomenon not hampering monetary policy. If excess liquidity has a difference stationary data generating process, we see liquidity accumulation as a long-term phenomenon which may have serious repercussions for the effectiveness of monetary policy as discussed in Section 4.1. Next, we investigate the long- term determinants of excess interbank liquidity, distinguishing between voluntary and involuntary liquidity holdings.

4.4.1 Persistence of interbank liquidity

In generalized form, an augmented unit root test can be described by

$$\Delta y_t = \mu_0 + \mu_1 \tau + \rho y_{t-1} + \sum_{p=1}^{k-1} \gamma \Delta y_{t-i} + \varepsilon_t \tag{4.1}$$

where y_t is the series to be tested, τ is a deterministic trend, μ_0 and μ_1 are parameters, while ρ and γ are the coefficients of the unit root and the lagged difference of the series respectively, and ε_t is the error term (for details, see Hamilton, 1994; and Enders, 2004).[59] Empirical studies frequently use the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests. However, the performance of these tests deteriorates significantly in the presence of structural changes (Perron, 1989). As policy variables, such as the discount rate and required reserves, are subject to policy shocks (see Figure 4.1), we will use unit root tests that allow for structural breaks.

The literature proposes a number of unit root tests incorporating structural breaks (e.g., Perron 1989, 1990; Perron and Vogelsang 1991, 1992; Zivot and Andrews, 1992; and Ng and Perron, 2001).[60] Shresta and Chowdhury (2005) argue that the power of the Perron and Vogelsang (1992) test is superior in the presence of a structural break. Enders (2004) argues that the Perron-Vogelsang test is more appropriate in case of an uncertain break date. Table 4.1 and Figure 4.1 suggest a number of policy shifts during the period under consideration in this study. If an economic series experiences more than one structural shift, Ben-David *et al*. (2003) argue that the power of the unit root test with one structural break reduces significantly. Figure 4.1 shows that some variables may have more than one shift.

We employ the unit root test with two breaks as suggested by Clemente *et al*. (1998), which is an extension of the Perron and Vogelsang (1992) test with one structural break.[61] This class of unit root tests distinguishes two types of outliers: an additive outlier and an innovative outlier. The additive outlier test suits best to series exhibiting a sudden change in the mean, while the innovative outlier test assumes that the change takes place gradually. As the power of these

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[59] For the list of the symbols used in Chapters 4 and 5, see Table A5.5 in the Appendix to Chapter 5.
[60] For empirical studies of unit root tests with structural breaks, we refer to Banerjee *et al*. (1992), Christiano (1992), De Haan and Zelhorst (1994), Perron (2005), Glyn *et al*. (2007), and Carrion-Silvestre *et al*. (2009).
[61] If the test of Clemente *et al*. (1998) suggests both structural shifts are significant we keep this result. However, if this test finds only one significant structural shift we employ the Perron and Vogelsang (1992) test.

tests improves considerably if the break points are known *a priori*, often the tests employ grid search to locate the break points. For simplicity, assume that the breaks occur at an unknown date, $1 < T_{b1} < T_{b2} < T$ with T being the sample size. The additive outlier test follows a two-step procedure. First, the deterministic part of the series is filtered using

$$y_t = \mu + \delta_1 DU_{1t} + \delta_2 DU_{2t} + \tilde{y}_t, \tag{4.2}$$

where break dummies $DU_{mt} = 1$ for $t > T_{bm}$, and 0 otherwise, for *m = 1, 2,* and the remaining noise $\tilde{y}_t$ is examined for a unit root

$$\Delta\tilde{y}_t = \sum_{i=1}^{k} \theta_{1i} D(T_{b1})_{t-i} + \sum_{i=1}^{k} \theta_{2i} D(T_{b2})_{t-i} + \rho\tilde{y}_{t-1} + \sum_{i=1}^{k} \gamma_i \Delta\tilde{y}_{t-i} + e_t, \tag{4.3}$$

The change in the break dummy $D(T_{bm})_{t-i} = 1$ if $t = T_{bm} + 1$ and zero otherwise, for *m = 1, 2*, while *k* is the truncated lag parameter determined by a set of sequential F-tests.

The innovative outlier model assumes that an economic shock to a variable affects its subsequent observations. The estimation strategy is based on

$$y_t = \mu_0 + \delta_1 DU_{1t} + \delta_2 DU_{2t} + \theta_1 D(T_{b1})_t + \theta_2 D(T_{b2})_t + \rho y_{t-1} + \sum_{i=1}^{k} \gamma_i \Delta y_{t-i} + e_t \quad , \tag{4.4}$$

$$y_t = \mu + \phi(L)(e_t + \delta_1 DU_{1t} + \delta_2 DU_{2t}), \tag{4.5}$$

where, L is the lag operator ($Ly_t = y_{t-1}$). Both models test the null hypothesis of a unit root, that is $\rho = 1$. The limiting distribution of these test statistics does not follow the Dickey–Fuller distribution and Perron and Vogelsang (1992) and Clemente *et al*. (1998) provided the critical values respectively for one and two structural breaks. The null hypothesis is rejected if $\rho < 1$, and series is stationary. The test proposed by Clemente *et al*. (1998) is identical to the Perron and Vogelsang (1992) test when *m=1*, i.e. there is only one break.

4.4.2 Long-term determinants of excess liquidity

To identify the long-term determinants of excess liquidity in Pakistan, we utilize the methodology proposed by Agénor *et al*. (2004), augmented by Saxegaard (2006). Equation (4.6) presents excess liquidity with its voluntary and involuntary determinants

$$\alpha_1(L)EL_t = \alpha_2(L)X_t^1 + \alpha_3(L)X_t^2 + v_t \tag{4.6}$$

where, $\alpha_j(L)$ are lag polynomials, EL_t is the ratio of excess reserves to total deposits, X_t^1 and X_t^2 are vectors of variables that explain voluntary and involuntary excess liquidity holdings, respectively, and v_t is an error term. Any structural break can be included as a trend component in the model.

The vector X_t^1 includes variables, such as required reserves, discount rate, output gap, volatility in the overnight rate, volatility in the government borrowing from the SBP, and foreign currency deposits. Any change in the policy tools (required reserves and the discount rate) has a direct impact on excess liquidity in the interbank market. Following Saxegaard (2006), the output gap is included to capture demand for cash.[62] The volatility of the overnight rate is an indicator of interbank liquidity risk. The more volatile the overnight rate is, the more banks will be cautious in managing their liquidity holdings. Volatility in government borrowing from the SBP also increases volatility of the current deposits with the banks and hence banks may become more vigilant in managing their precautionary liquidity holdings. Foreign currency deposits are included to capture exchange rate risk. As discussed in Section 4.2.2, the banks in Pakistan substitute foreign currency assets for domestic government securities. Typically, such substitution involves exchange rate risk. The managed float strategy practiced by the SBP reduces the volatility in the exchange rate and hence partially mitigates the exchange rate risk. However, foreign currency deposits are denominated in foreign exchange and any sudden speculative withdrawal of foreign currency deposit may expose banks to exchange rate risk.

Agénor *et al*. (2004) propose to derive the determinants of involuntary excess liquidity X_t^2, as a residual from Equation (4.6), when this equation includes only voluntary liquidity accumulation factors, X_t^1. This approach, however, inherently minimizes involuntary excess liquidity X_t^2. To overcome this drawback, Saxegaard (2006) proposes augmenting the approach of Agénor *et al*. (2004) with variables that are important in the buildup of involuntary excess liquidity. Since involuntary accumulations are driven by a deficient private sector credit demand, Saxegaard (2006) proposes to include a large number of macroeconomic factors as

[62] The output gap could be considered as part of the involuntary liquidity accumulation as it captures the fluctuation in credit demand. However, following Saxegaard (2006), we include it as a determinant of voluntary liquidity accumulation. Saxegaard (2006, p. 21) argues: “We also include the output gap Y (in voluntary liquidity) to proxy for demand for cash. In particular, in a cyclical downturn one would expect the demand for cash to fall and commercial banks to decrease their holdings of excess reserves”. We will discuss this issue further in Section 4.6.2.

explanatory variables for X_t^2. Following Saxegaard (2006), we include credit to the private sector, credit to the government (by the SBP, commercial banks, and the non-banking sector), the index of industrial production (IIP) indicating the level of economic activity, and the exchange rate as explanatory variables in X_t^2.

Private sector credit is negatively related to excess liquidity. Any increase in private sector credit decreases excess liquidity holdings of the banks. The impact of government borrowings from the SBP, the commercial banks, and the non-banks on excess liquidity may differ. Government borrowing from the central bank leads to the creation of new deposits. When the government borrows from the central bank, the central bank increases the government's deposit with the central bank. When the government makes payments for the goods and services it has acquired, the increase of the deposit rapidly increases the monetary base. Table 1.1 in Chapter 1 shows the impact of government borrowing on the assets and liabilities of the banking sector. Ganley (2004) suggests that borrowing from the central bank is the main source of excess interbank liquidity in many countries. We therefore expect that government borrowing from the SBP will have a positive effect on excess liquidity.

Borrowing from non-banks involves a transfer of funds from the banks to the non-bank institutions and hence it should affect excess interbank liquidity negatively.

When the government borrows from commercial banks, reserves of the banks with the central bank are transferred to the government account. When the government makes payments for the goods and services it acquires, the borrowed amount gets transferred quickly from the government account to the accounts of individuals or private businesses thus replenishing the liquidity holdings of the banks. Therefore, government borrowing from the banks is not expected to have any impact on excess liquidity as the assets and liabilities of the banking sector remain unchanged (see Table 1.1 in Chapter 1).

An increase in the level of economic activity, as captured by the Index of Industrial Production, is likely to increase the money demand in the economy which in turn increases the liquidity holdings of banks. We expect a positive relation between increased industrial production and excess liquidity. Similarly, when the Pakistan Rupee depreciates the foreign currency liabilities of the banks will increase. Therefore, banks are likely to exchange their excess liquidity with foreign currency assets. Hence, we expect exchange rate movements to have a negative effect on excess liquidity.

Separation of the voluntary and involuntary components of liquidity in the framework of Equation (4.6) requires identification of the intercept and the lagged dependent variable. This can be explained as follows. Rewriting Equation (4.6) gives:

$$EL_t = [a^s + (1 - a^s)]\hat{c} + (\alpha_1^s + \alpha_1^d)EL_{t-p} + (L)X_t^1 + \alpha_3(L)X_t^2 + v_t \qquad (4.7)$$

where $\hat{c}$ is the intercept and p is the number of lags of the dependent variable. In Equation (4.7), the intercept has a voluntary component a^s and an involuntary component $(1-a^s)$ which are indistinguishable. The voluntary α_1^s and involuntary α_1^d parts of the lagged dependent variable are also indistinguishable. As we are interested in the long-run relationship and the long-run coefficients estimation uses the lagged dependent variable EL_{t-p}, identifying separate values for α_1^s and α_1^d is not necessary. However, identification of the intercept is required. Ideally, we would like to have information on the banks' precautionary reserves on a weekly basis. As this information is not available, we use the minimum average cash reserves held by the banks above statutory requirements, in any given week, as a proxy for the precautionary liquidity holdings intercept a^s. We assume that the minimum amount of cash reserves held by the banks is the 'mean' of precautionary liquidity holding.

As will be discussed in Section 4.6, some explanatory variables are difference stationary. Therefore, we will use the Bound Testing Approach proposed by Pesaran *et al*. (2001) for identification and the Autoregressive Distributed Lag (ARDL) approach for estimation of the long-run relationship between the levels of the variables.

Compared to other procedures for detecting long-run relationships, such as Johansen's rank test, the Bound Testing procedure has two distinct advantages. First, it does not require testing the data generating processes of the underlying series and remains applicable even if regressors are a mixture of I(0) and I(1) variables. Second, it allows a large number of explanatory variables, as in Equation (4.6), which involves in our application thirteen regressors and their lags. The Bound Testing procedure employs a generalized Dickey–Fuller type regression and tests the significance of the lagged level of the variables in a conditionally unrestricted error correction model (ECM)

$$\Delta EL_t = \mu_0 + \mu_1\tau + \pi_{EL}EL_{t-1} + \pi_x^{'}x_{t-1}^j + \sum_{k=0}^{n}\gamma_k^{'}\Delta x_{t-1}^j + \sum_{k=1}^{n}\delta_k^{'}\Delta EL_{t-1} + u_t\,, \qquad (4.8)$$

where x_t^j indicates j^{th} regressor, μ_0 and μ_1 are trend parameters, $\gamma_k^{'}$ and $\delta_k^{'}$ are short-run regressor parameters, u_t is the error term, and π_{EL}, and π_x are long-run parameters, the joint significance of which is tested using an F-test. The asymptotic distribution of the F-statistic is non-standard. Pesaran *et al*. (2001) provide two sets of asymptotic critical values for the upper and lower bounds for the F-statistic. The upper bound assumes that all regressors are I(1), while the lower bound assumes that they are all I(0). The F-test has the null hypothesis that there exists no long-run relationship between the variables, i.e. $\pi_{EL} = \pi_x = 0$. If the F-statistic falls outside the upper bound, the null hypothesis of no long-run relationship is rejected indicating that the regressors are forcing a long-run relationship on the dependent variable.[63] However, if the F-statistic falls within the bounds information on the order of integration of the underlying variables is essential to draw conclusions.

The long-run relationship is estimated from the ARDL equation,

$$EL_t = \mu + \sum_{j=1}^{m} \sum_{k=0}^{n} \psi_k^j x_{t-k}^j + \sum_{k=1}^{n} \alpha_k EL_{t-k} + \varsigma_t \quad . \tag{4.9}$$

Here x_t is the set of regressors, $\psi^j{}_k$ are coefficients for any j^{th} regressor at lag *k*, α_k reflects the stickiness of the dependent variable at lag '*k*'. Starting with a maximum number of lags, a general to specific approach is used to adopt a parsimonious model with white noise residuals. We employ a battery of diagnostic tests to check the robustness of the specified model.[64]

The ARDL procedure presumes that only one long-run relationship exists running from regressors to the dependent variable. When the explanatory variables drive the dependent variable in the presence of only one cointegrating vector, the explanatory variables are weakly exogenous to the system (Kirchgässner and Wolters, 2007, p. 207).[65] However, if the dependent

[63] The Bound test assumes that only one cointegrating relationship exists when a weakly exogenous dependent variable forces a long-run relationship on the dependent variable. This method of detecting a long-run relationship remains valid even in the presence of more than one long-run relationship.

[64] For example, we test for serial correlation with the Breusch-Godfrey test and/or Portmanteau (Q) test. The Breusch-Godfrey test is useful in testing low order autocorrelation, whereas the Portmanteau (Q) tests works better for higher order autocorrelation (Lütkepohl and Kratzig, 2004, p. 129). Both tests take no serial correlation as the null hypothesis. Normality of the residuals is tested using the Shapiro-Wilk test with normally distributed residuals as the null hypothesis. For checking the stability of the specified model, CUSUM and CUSUMSQ tests, proposed by Brown *et al*. (1975) are used. The CUSUM test uses cumulative sums of recursive residuals based on the first *n* observations, which are updated recursively and plotted against the break points. If the plot of the CUSUM statistics stays within the 5 percent significance level, the coefficient estimates are said to be stable. CUSUMSQ applies a similar procedure based on the squared recursive residuals.

[65] Kirchgässner and Wolters (2007, p. 225) define weak exogeneity as: "A variable is weakly exogenous with respect to the cointegration parameters if and only if no cointegrating relation is included in the equation of this variable."

variable also forces a long-run relationship on one or more of the regressors, the assumptions that there exists only one cointegrating vector and that the regressors are weakly exogenous are violated. In that case, the coefficient estimates obtained from the ARDL model are not efficient.[66] However, they remain asymptotically consistent and can be used for making inferences (Harris, 1995).

We use the Bound Test for establishing the weak exogeneity of regressors. Each regressor is used as a dependent variable to test for the existence of a long-run relationship with excess liquidity. If the F-statistic does not reject the null hypothesis of no long-run relationship between the variables, the regressor can be considered weakly exogenous for the relationship specified in Equation (4.9).

The long-run relationship is obtained from the ARDL estimates of Equation (4.9). For this purpose, the lagged dependent variable is calculated as

$$\hat{\beta}_i = \frac{\sum_{k=0}^{n} \hat{\psi}^{j}{}_{k}}{1 - \sum_{k=1}^{n} \hat{\alpha}_k} \; . \qquad (4.10)$$

Using information on 'excess cash reserves' holdings (a^s) and the long-run estimates using Equation (4.10), the 'voluntary' (EL^s) and the 'involuntary' (EL^d) component of excess liquidity can be calculated, as shown by Equation (4.11).

$$\hat{EL}_t^s = a^s \hat{c} + \hat{\alpha}_2(L) X_t^1 \qquad (4.11)$$

$$\hat{EL}_t^d = (1 - a^s)\hat{c} + \hat{\alpha}_3(L) X_t^2 + v_t \, ,$$

where v_t is the error term incorporating banking risks other than liquidity risk.

4.5 Data

We use weekly data from the last week of December 2005 up to and including the first week of July 2011. The SBP reports net time and demand liabilities in a new format since the last week of December 2005, excluding Islamic banks and foreign currency liabilities from net time and demand liabilities. Previously, Islamic banks and foreign currency liabilities were not clearly

[66] Harris (1995, p. 62) notes that: "Assuming that there is only one cointegrating vector, when in fact there are more, leads to inefficiency in the sense that we can only obtain a linear combination of these vectors when estimating a single equation model."

identified. Hence, excess liquidity calculated using recent information is not consistent with excess liquidity based on figures before December 2005. Unfortunately, net time and demand liabilities do not include foreign currency deposits held by banks. Foreign currency asset and liability holdings of the banks are accounted separately and are subjected to different prudential requirements. However, compared to the total demand and time liabilities the magnitude of foreign currency deposits is small.

We employ weekly data as it helps in maintaining sufficient degrees of freedom which is important as our specification involves a large number of explanatory variables and their lags. Using weekly data has a serious drawback too. Some explanatory variables are reported on a monthly basis. Fortunately, the specification used in this study involves only two variables with a monthly frequency, namely the index of industrial production, and government borrowing from non-banks. We disaggregate them into weekly data using forward moving averages over six weeks as the series obtained using this procedure yields lowest mean errors.[67] Table A4.1 in the Appendix provides further details of the variables used in this study.

For estimating the output gap, we employ the Hodrick-Prescott (HP) filter to the index of industrial production since GDP is only available on a yearly basis.[68] The output gap is measured as the gap between the HP trend and the actual level of output at any given time. Further details are provided in Office for Budget Responsibility (2011). The volatilities of the overnight rate and of government borrowing from the SBP are calculated as ratios of standard deviation to the average over a moving 13 weeks period. The effective reserve requirements for any given week is the weighted average of the cash and liquidity reserve requirements based on their respective time and demand liabilities.

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[67] Forward moving average is based on, $n_t = \frac{1}{6}\sum_{i=1}^{6} n_{t+i}$, where n_t indicates any specific week at time *t*.

[68] We have used λ=270,400. However, following Ravn and Uhlig (2002)'s recommendation to use λ= 45,697,600 gave similar de-trended series. See Figure A4.1 in the Appendix for the comparison of the two series obtained using the above values of λ.

4.6 Results

4.6.1 Unit root tests

The results for the Augmented Dickey-Fuller (ADF) and Phillips and Perron (PP) unit root tests are reported in Table A4.2 (in the Appendix). Except for the output gap and the volatility of the government borrowing from the SBP, all variables appear difference stationary at the five percent level of significance. Figure 4.1 shows sharp shifts in the policy variables. Therefore, the difference stationary variables are subjected to the unit root test proposed by Clemente *et al*. (1998), which allows for two structural breaks. This test also helps in identifying whether there are one or two structural breaks. If the test of Clemente *et al*. (1998) suggests two significant structural shifts we retain the test results, but if this test suggests only one significant structural shift we employ the Perron and Vogelsang (1992) test with one structural break.

The results for the unit root test with structural breaks are reported in Table 4.2. Except for excess liquidity and macroeconomic variables that are normalized by GDP (such as private credit, foreign currency deposits, government borrowing from banks and non-banks) all variables are level stationary with significant breaks. The identified break dates are in the vicinity of the various policy moves of the SBP as described in Table 4.1. For example, the unit root test for the discount rate shows that the series has a structural break on May 10 2008, while the SBP increased the discount rate by 150 bps on May 23rd 2008.

Table 4.2 Results for Unit Root Tests with Structural Breaks

	Additive Outlier Test			Innovative Outlier Test		
	Test stats.	**# breaks**	**Break dates**	**Test stats.**	**# breaks**	**Break dates**
Excess liquidity	-2.841	2	28-03-09, 08-05-10	-2.585	2	19-01-08, 4-10-08
Required reserves	-4.187	2	17-05-08, 25-10-08	-9.530*	2	10-05-08, 04-10-08
Discount rate	-1.842	2	12-07-08, 01-08-09	-5.447*	1	10-05-08
Private credit	-3.068	2	24-11-07, 13-06-09	-3.504	2	19-09-07, 14-03-09
Foreign currency deposits	-1.909	2	03-05-08, 02-01-10	-3.329	2	12-01-08, 12-12-09
Exchange rate	-2.222	2	19-07-08, 08-08-09	-6.292*	2	05-04-08, 14-06-08
Government borrowing from:						
Commercial banks	-1.428	2	24-03-07, 22-08-09	-0.539	-	
SBP	-3.076	2	12-01-08, 14-06-08	-4.579*	1	11-10-07
Non-banks	-0.796	2	05-05-07, 06-03-10	0.217	1	12-12-09
			**5% Critical Values*			
2-breaks	*-5.49*			*-5.49*		
1-break	*-3.56*			*-4.27*		
			***10% Critical Values*			
2-breaks	*-5.24*			*-5.24*		
1-break	*-3.22*			*-3.86*		

Notes: Only difference stationary variables in ADF or PP test are subjected to unit root tests with structural breaks. # breaks shows the significant number of breaks at the five percent significance level, suggested by the unit root tests. The 2 breaks statistics refer to the test proposed by Clemente *et al*. (1998), while the 1 break test statistics refer to the test proposed by Perron and Vogelsang (1992). The null hypothesis assumes that series has a unit root. Break dates are identified by the unit root tests. Break dates should be read as week ending on day-month-year.

As the difference stationary behavior of excess liquidity is directly related to the effectiveness of monetary policy, it is investigated thoroughly. In a competitive market, banks are expected to respond to policy shocks by changing their liquidity holdings; they increase liquidity holdings when monetary policy is lax and decrease them when it is tight. The estimates reported in Table 4.2 show that the null hypothesis of unit root excess liquidity cannot be rejected at the 5 percent level of significance. It is possible that excess liquidity has more than two structural shifts though. The power of the test proposed by Clemente *et al*. (1998) in the presence of more than two structural shifts is low, leading to non-rejection of the unit root null hypothesis even if this series is stationary. To be certain about the integrated behavior of excess liquidity, we utilized rigorous tests as proposed by Carrion-i-Silvestre *et al*. (2009). These authors suggest a variety of unit root tests, including a DF type of test with structural breaks as proposed by Harris *et al.* (2009) that can accommodate up to 5 structural breaks. The null hypothesis of a unit root cannot be rejected confirming the integrated behavior of excess liquidity. For example, the calculated test statistic for the test proposed by Harris *et al*. (2009) is -4.32, which is below the 5 percent critical value (-4.56).

The unit root characterization of the data generating process of excess liquidity confirms the persistence of excess liquidity in the interbank market of Pakistan which may undermine monetary policy. The persistence of interbank liquidity may have resulted from policy surprises (as shown by Figure 4.1) during the period under consideration. Rubina and Shahzad (2011) suggest that monetary policy of the SBP is often inconsistent and non-transparent so that markets only slowly learn the true intentions of the monetary authorities. Westelius (2005) argues that such a learning process creates persistence.

4.6.2 Analysis of long-run relationship

As discussed in Section 4.2, we use the Bound Test Approach for testing the existence of a long-run relationship as the specification involves variables that are I(0) and I(1). We included shift dummies but they turned out to be insignificant. A maximum of five lags is imposed for all estimation purposes to obtain reasonable degrees of freedom as the model has a large number of regressors.

Table 4.3 shows the F-statistics for the joint significance of the error correction term of the Bound test.[69] The F-statistic (3.45) for excess liquidity is greater than the five percent critical value indicating that the regressors are forcing a long-run relationship on excess liquidity. To determine whether the regressors are weakly exogenous, separate Bound tests have been conducted, using each regressor in Equation (4.6) as a dependent variable. The significant F-statistics for required reserves, the exchange rate, and the volatility in government borrowing from the SBP suggest that these regressors are not weakly exogenous.

[69] Pesaran *et al.* (2001) provide critical values only up to ten variables whereas our model includes 12 explanatory variables. The table with critical values provided by Pesaran *et al.* (2001) shows that the critical values generally decrease with the increased number of regressors. Hence, our inference is probably not affected.

Table 4.3 Estimation of Long-run Relationship for Interbank Liquidity

	F-Statistics	Long-run relationship	
		Coefficient	***p*-values**
Excess liquidity	3.45**		
Required reserves	4.39***	-1.357	0.000
Output gap	2.15	-0.366	0.000
Discount rate	2.36	0.863	0.021
Exchange rate	3.14*	-0.885	0.000
Volatility of overnight rate	2.61	0.055	0.426
Private credit	2.07	-0.799	0.000
Index of Industrial Production	2.04	0.392	0.000
Foreign currency deposits	1.48	5.796	0.003
Volatility in government borrowing from SBP	3.34**	-0.119	0.073
Government borrowing from:			
SBP	2.88	0.657	0.002
Commercial banks	2.53	1.147	0.000
Non-banks	1.28	-0.374	0.005
Intercept		16.269	0.133
Critical values for I(1) Boundary¹	*F-Statistics*		
1%	3.86		
5%	3.24		
10%	2.94		

Notes: The second column shows the results of the bound test, as well as, the weak exogeneity test for the regressors. Pesaran *et al.* (2001) only provide critical values for 10 variables; the data period includes 289 observations. ***, ** and * indicate significance at the 1, 5 and 10% level. The last two columns show the estimates of the long-run relationship between excess liquidity and the regressors and the relevant *p*-values. The long-run variance is estimated using Newey-West (1987). Dynamic estimates are obtained using Equation (4.9) and the long-run coefficients are calculated using Equation (4.10).

The single equation estimation strategy yields asymptotically consistent, though inefficient, estimates in the absence of weakly exogenous regressors. Hence the estimates can be used for inference. We use the Autoregressive Distributed Lag (ARDL) procedure to estimate the long-run relationship. The estimated parsimonious ARDL model is shown in the upper panel of Table A4.3 (in the Appendix). The specified model is subjected to a battery of diagnostic tests. The results from these tests, reported in the lower panel of Table A4.3, do not suggest that the specification is wrong.[70]

[70] Serial correlation is tested using the Breusch-Godfrey test with 12 lags and the Portmanteau (Q) test with 40 lags. Both tests indicate that residuals are white noise. Normality of the residuals is tested using the Shapiro-Wilk test. The null hypothesis of normally distributed residuals is rejected at the five percent level of significance. To further analyze this issue, a non-parametric Kernel density estimation procedure is employed. Kernel density estimators, similar to histograms, approximate the density *f(x)* from observations on *x*. The data are divided into non-

Table A4.3 shows that some of the regressors explain the variation in excess liquidity with their long lags. These variables, such as government borrowing from the central bank and non-bank institutions, are responsible for structural persistence in the interbank excess liquidity, which, in turn, may undermine the effectiveness of monetary policy. Fuhrer (2009) argues that the persistence in an economic variable is structural if the factors explaining this variable also have persistence.

The long-run coefficients together with their *p*-values are shown in the last two columns of Table 4.3. These long-run coefficients are calculated using Equation (4.10) and the ARDL estimates reported in Table A4.3. Except for the volatility of the overnight rate and the volatility of government borrowing from the SBP, all long-run coefficients are significant at the 5 percent level. Volatility of government borrowing from the SBP is significant at the 10 percent level. The insignificance of the volatility of the overnight rate is not surprising. Since 17th August 2009, the SBP has introduced an interest rate corridor to reduce the volatility in the overnight money market repo rate.[71] This policy move has reduced the variation in the overnight rate.

The signs of the long-run coefficients are in line with our expectations. The negative coefficient of required reserves indicates that increasing required reserves directly drain liquidity from the interbank market. The positive coefficient of the discount rate shows that the banks respond to a positive discount rate change by increasing their excess liquidity holdings. However, the SBP frequently resorts to open market operations to mop up liquidity from the interbank market. The banks willingly substitute their cash liquidity for short-term government securities as the latter yield a lucrative risk-free return besides enhancing their ability to borrow from the SBP discount window, and thus reducing their liquidity risk.

The coefficient of the exchange rate is negative suggesting that a depreciation of the Pakistan Rupee leads banks to decrease their liquidity holdings. Moreover, the coefficient of foreign currency deposits is positive and large in magnitude, which suggests that an increase in foreign currency deposits leads to an increase in excess liquidity holdings of banks. The large

overlapping intervals, and counts are made of the number of data points within each interval. Figure A4.2 (in the Appendix) shows that the deviation of Kernel density estimate from the normal density estimate is minor and can be ignored without significant implication for inference. The stability of the specified model is tested using the CUSUM and CUSUMSQ tests, proposed by Brown *et al*. (1975). The graph shown in Figure A4.3 (in the Appendix) indicates that the stable specification null hypothesis cannot be rejected.

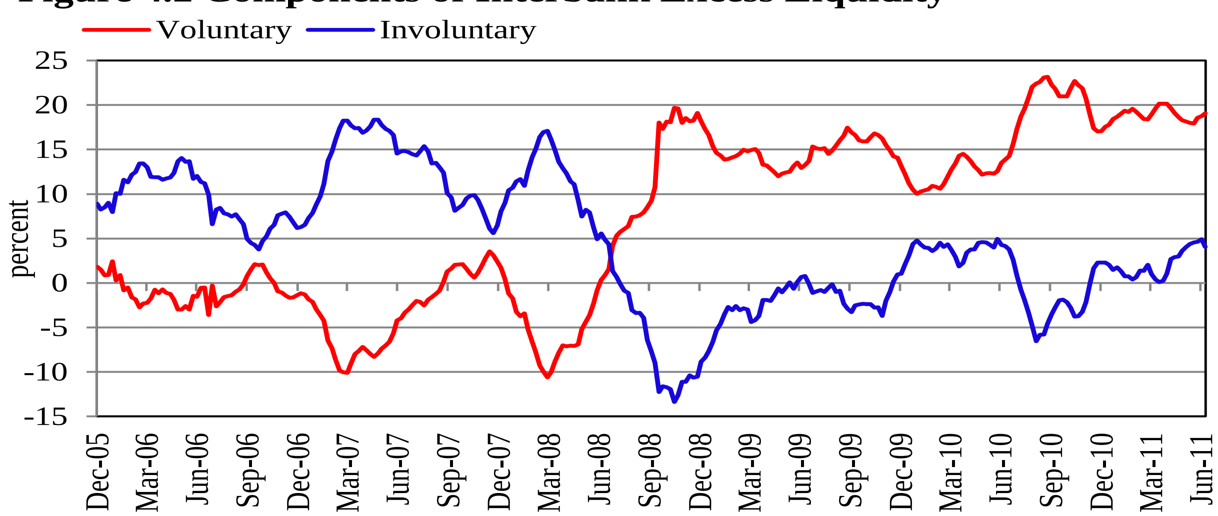
[71] Vide DMMD Circular No.1 of 2009, State Bank of Pakistan.

magnitude reflects the exchange rate of the Pakistan Rupee against the US Dollar.[72] Finally, a one percent increase in the foreign currency deposits causes a 5.8 percent increase in excess liquidity in the interbank market.

The estimates reported in Table 4.3 also show that government budget deficit financing by commercial banks and the SBP has positive long-run effects on excess liquidity. The positive coefficient of the SBP credit to the government supports Ganley's (2004) argument that the monetization of the government's budget deficit is a main cause of excess liquidity in some countries. The negative coefficient of credit of non-bank institutions shows that this source of financing has a negative long-run effect on excess liquidity, but its magnitude is small.[73]

Next, we decompose excess liquidity into its voluntary and involuntary components, as indicated in Equation (4.11), using the long-run coefficients of Table 4.3. The outcome is shown in Figure 4.2. This figure indicates that the interbank market of Pakistan has experienced a structural shift since June 2008. Before June 2008, banks' holdings of excess liquidity were largely 'involuntary' representing lack of credit demand in the economy. Wyplosz (2005) argues that a policy of monetary tightening may not be effective if excess liquidity accumulation is demand driven. Any improvement in credit demand may cause a rapid increase in credit. Not surprisingly, the SBP consistently missed the inflation projections between 2005 and 2008.[74]

Figure 4.2 Components of Interbank Excess Liquidity



[72] Over the period of this study, the average of the Pakistan Rupee - US Dollar exchange rate was 72.97.

[73] When government borrows from non-banks, excess liquidity with banks decreases as the deposits from banks get transferred to the non-bank institutions.

[74] Inflation projections are inflation figures underlying the government budget plans. For a discussion on the deviation of actual from 'projected' inflation, see Omer and Saqib (2009).

After June 2008, excess liquidity holdings by banks have become voluntary. The persistent foreign currency inflows and government deficit financing by the banking sector increased excess interbank liquidity. As Pakistan's financial markets lack depth, banks preferred parking their liquidity in short-term government securities. Also, the SBP's liquidity management after the fall of Lehman Brothers contributed to the banking sector's shift towards precautionary behavior. On 18th October 2008, the SBP expanded the eligibility of long-term government bonds from five to ten percent. This move was meant to provide liquidity support to the interbank market and caused an increase in the borrowing ability of banks from the SBP discount window by roughly PKR135 billion, hence increasing 4 percent excess liquidity holdings of the banks in terms of their total time and demand liabilities.

As discussed in Section 4.4.2, our involuntary liquidity estimates includes the output gap following Saxegaard (2006). We re-estimated the model with the output gap as a determinant of the involuntary liquidity accumulation, dropping the index of industrial production (IIP). Figure A4.4 in the Appendix shows that the overall conclusion of this chapter remains unchanged.

4.7 Conclusions

We investigate excess liquidity in the interbank market of Pakistan using the bound test and the Autoregressive Distributed Lag approach on weekly data for December 2005 to July 2011. Our findings suggest persistence of interbank excess liquidity. Our results also indicate that the financing of the government's budget deficit by the central bank and non-banks contribute to persistence in interbank liquidity. This persistence may weaken the monetary transmission mechanism.

Moreover, we identify a structural shift in the interbank market in June 2008. Before June 2008, low credit demand was driving excess liquidity holdings by banks. After June 2008, precautionary investments in risk free securities drive the liquidity holdings by banks. Perhaps, the change in the political regime in 2008 is related to this structural change. On June 11 2008, the government formed after the general election in February 2008, presented its first budget. Importantly, we did not include any break dummy in our model, as they were not significant although the unit root tests suggested structural breaks in the number of variables.

Mohanty (2006) argues that such a structural shift in the banking sector's behavior towards holding government securities may have repercussions on the economy, such as persistently higher interest rates, a higher sovereign risk premium, and crowding out of private sector investments. Mishra *et al*. (2011) argue that the objective of deficit financing may become so important that it turns into a source of macroeconomic instability instead of stabilization. The independence of the central bank and its ability to conduct monetary policy effectively are then compromised.

Given our findings, we suggest reducing the government budget deficit and to limit borrowing, especially from the central bank, in order to reduce liquidity inflows in the interbank market. We consider the recent legislative move aimed at limiting the government's borrowing as a step in the right direction. On March 2012, the State Bank of Pakistan Act (1956) has been amended restricting the government from borrowing from the SBP for more than one quarter (Clause 9C, p.13). However, further steps seem to be necessary, such as capping the government's debt. Also, further liberalization of the foreign exchange market aimed at increasing the access of domestic banks to international financial markets could be helpful in enhancing banks' foreign exchange management. A better ability of banks to manage their foreign exchange inflows may help the SBP to move from a managed float to a free floating exchange rate regime. All this could help in reducing the liquidity glut in the interbank market of Pakistan which is essential for increasing the efficacy of monetary policy.

4.8 Appendix

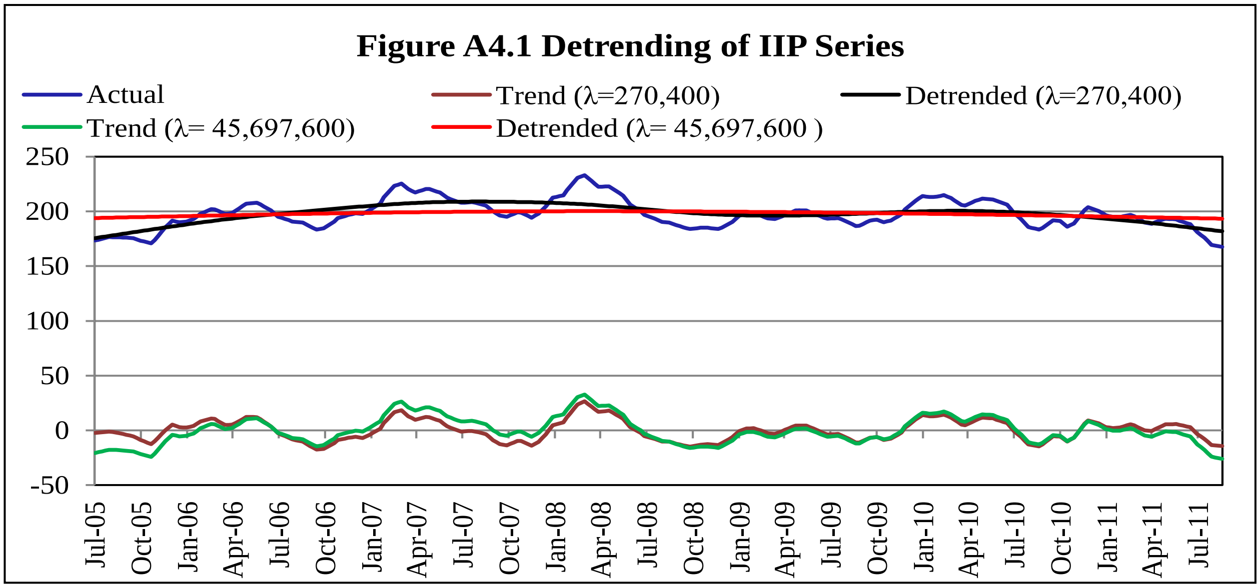


Figure A4.1 Detrending of IIP Series
Actual
Trend (λ=270,400)
Detrended (λ=270,400)
Trend (λ= 45,697,600)
Detrended (λ= 45,697,600)
250
200
150
100
50
0
-50
Jul-05
Oct-05
Jan-06
Apr-06
Jul-06
Oct-06
Jan-07
Apr-07
Jul-07
Oct-07
Jan-08
Apr-08
Jul-08
Oct-08
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Oct-10
Jan-11
Apr-11
Jul-11

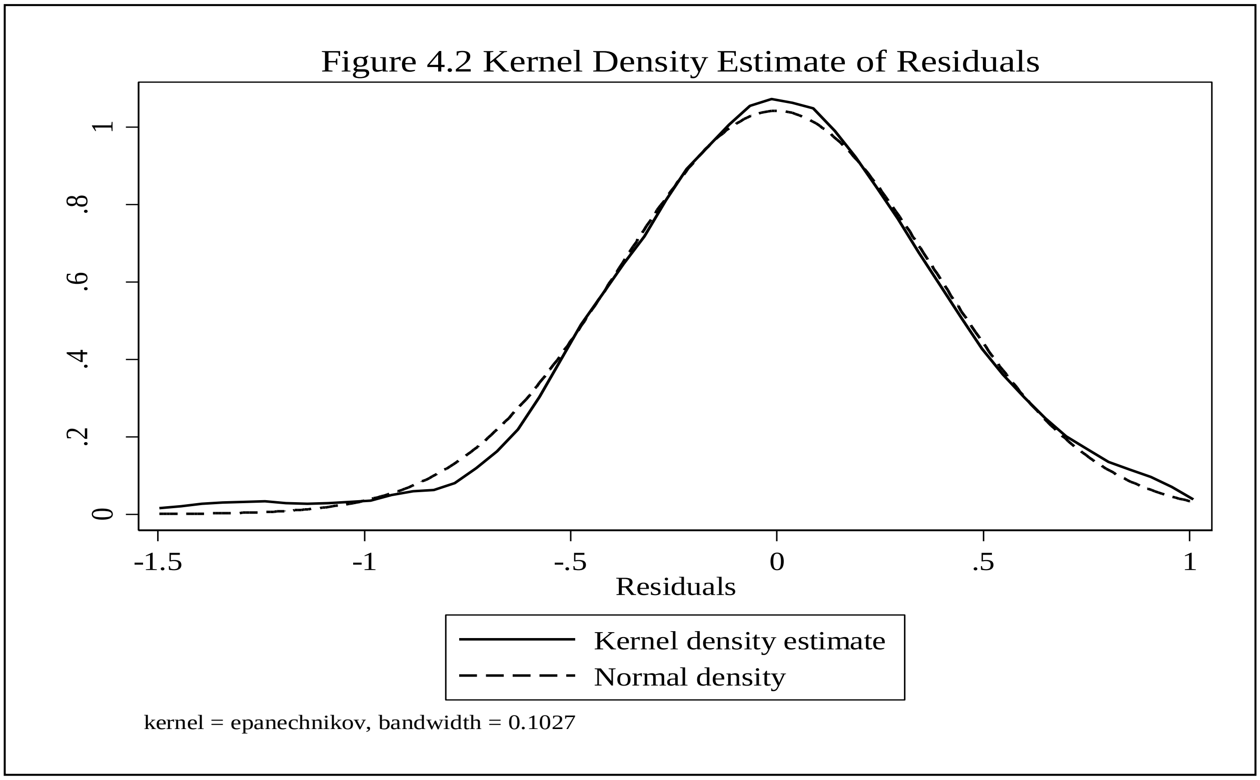
Figure 4.2 Kernel Density Estimate of Residuals
0
.2
.4
.6
.8
1
-1.5
-1
-.5
0
.5
1
Residuals
Kernel density estimate
Normal density
kernel = epanechnikov, bandwidth = 0.1027

Figure A4.3 Stability Test

CUSUM Test Statistics with 95 % Confidence Interval

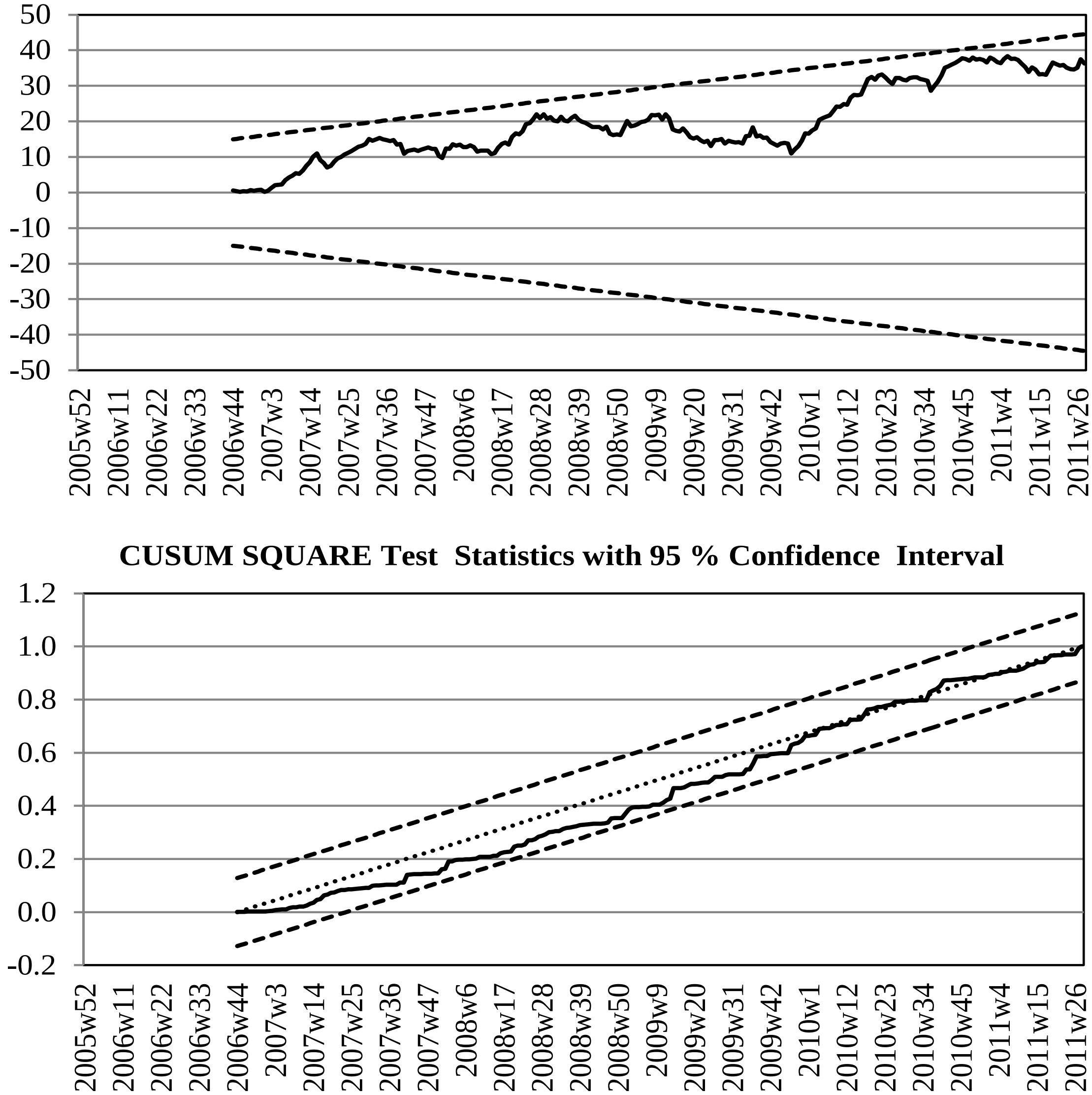

Figure A4.4 Components of Interbank Excess Liquidity (Involuntary Output Gap)

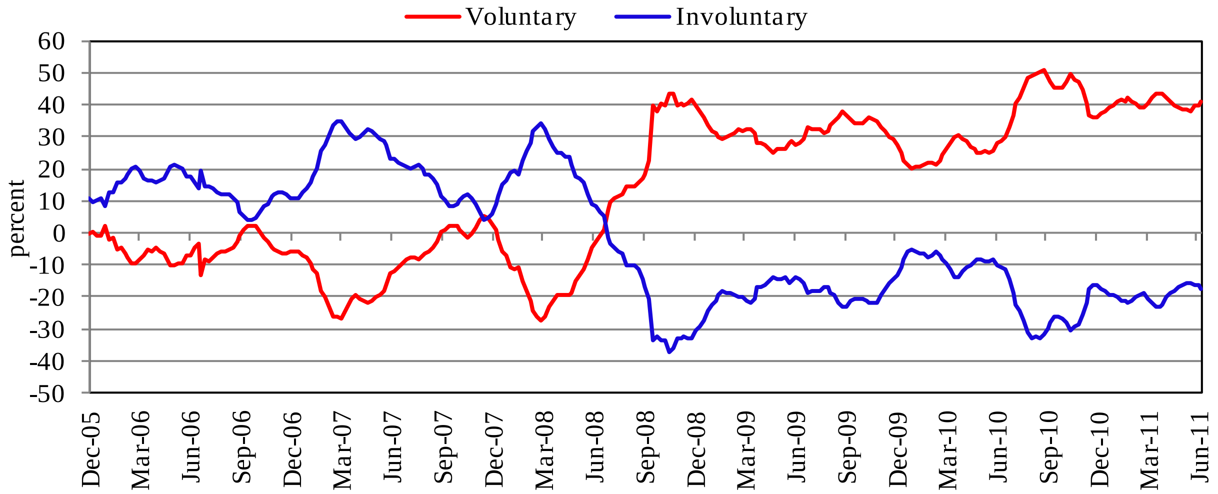

Table A4.1 Description of Variables

Name	Description
Excess liquidity	Reserves excess of statutory requirements (quantity of reserves deposited with the central banks + cash in their vaults + eligible securities) to the total time and demand liabilities.
Required reserves	Required reserves is the combined effect of cash reserve requirement and statutory liquidity requirements over the period as shown in Table 4.1.
Output Gap	Output gap calculated using the index of industrial production and the HP Filter, using λ=270,400 as smoothening parameter. The output gap is measured as the gap between the trend and the actual level of output.
Discount Rate	SBP 3-day reverse repo rate
Exchange Rate	Average weekly exchange rate of Pakistan Rupee per US Dollar
Volatility in overnight rate	Volatility of interbank overnight rate measured as ratio of 13 week moving average standard deviation and mean.
Private Credit	Private sector credit (as percentage of GDP) extended by banks
Govt. borrowing- SBP	Government borrowing (as percentage of GDP) from the central bank
Govt. borrowing-banks	Government borrowing (as percentage of GDP) from the commercial banks
Government borrowing from Non-Banks	Government borrowing (as percentage of GDP) from the non-banking sector
Index of Industrial Production	Monthly index of industrial production is disaggregated using 6-week forward moving average.
Foreign currency deposits	Residents' foreign currency deposits (as percentage of GDP) deposited with the banks in Pakistan Rupee.
Volatility in Govt. borrowing from SBP	Volatility of government borrowing from the central bank measured as ratio of 13 week moving average standard deviation and mean.
MTBs	6-months Treasury Bills rate used as a proxy for the Discount Rate

Table A4.2 Unit Root Test Results

	Dickey-Fuller Test		Philips-Perron Test	
	drift only	**drift with trend**	**drift only**	**drift with trend**
Excess liquidity	0.003	-1.924	0.174	-1.708
Required reserves	-1.635	-2.835	-1.58	-2.412
Output gap	-5.833*	-5.822*	-2.968*	-2.962
Volatility in overnight rate	-2.236	-2.46	-2.391	-2.481
Volatility in SBP financing	-3.272*	-3.309	-3.185*	-3.718*
Credit to private sector	-1.729	-1.909	-1.718	-1.522
Foreign currency deposits	0.279	-3.153	0.526	-2.901
Government borrowing from:				
Banks	1.622	-0.729	2.428	-0.042
SBP	-1.586	-1.665	-1.12	-1.304
Non-banks	2.867	0.944	1.578	-0.924
Exchange rate	-0.846	-1.855	-0.442	-1.145
95% Critical Values	*-2.879*	*-3.429*	*-2.878*	*-3.428*

Notes: The null hypothesis of ADF and PP tests assumes that the series has unit root. * indicates that the null hypothesis is rejected at the 5% level of significance.

Table A4.3 Estimates of Short-run Determinants of Excess Interbank Liquidity

	Level	lag (1)	lag (2)	lag (3)	lag (4)	lag (4)
Excess liquidity	-	0.814***				
		(0.000)				
Required reserves	-0.927***	0.674				
	(0.000)	(0.000)				
Output gap	-0.019	-0.0003	-0.049*			
	(0.627)	(0.995)	(0.064)			
Discount rate	0.271*	-0.130	0.184	-0.164		
	(0.060)	(0.480)	(0.315)	(0.222)		
Exchange rate	-0.278***	0.113				
	(0.001)	(0.162)				
Volatility in overnight rate	0.033	0.009	0.050	-0.08***		
	(0.168)	(0.797)	(0.139)	(0.001)		
Credit to private sector	-0.451***	0.161	0.141*			
	(0.000)	(0.108)	(0.072)			
Government borrowing from:						
SBP	0.235***	-0.066	-0.062	0.008	-0.080	0.087*
	(0.000)	(0.354)	(0.301)	(0.896)	(0.208)	(0.089)
Banks	0.407***	-0.193**				
	(0.000)	(0.030)				
Non-banks	0.037	0.063	-0.081*	-0.038	0.052	-0.103***
	(0.367)	(0.182)	(0.053)	(0.353)	(0.238)	(0.005)
Index of industrial production	-0.003	0.077*				
	(0.934)	(0.066)				
Foreign currency deposits	1.080***					
	(0.003)					
Volatility in SBP financing	-0.022*					
	(0.073)					
Intercept	3.030					
	(0.133)					
Diagnostic Tests	*Statistics*	*p-values*				
Adj. R-square	0.994					
F-Statistics	1182.59	(0.000)				
Normality	2.261	(0.012)				
Ramsey Reset Test	0.390	(0.760)				

Notes: ***, **, and * indicates significance at 1, 5, and 10 percent level of significance. *p*-values are reported in parenthesis. Normality test is based on Shapiro and Wilk (1965). The null hypothesis assumes that the variable is normally distributed. Ramsey Reset Tests is related to specification error. Non-rejection of the null hypothesis indicates that the model specification does not suffer from omitted variables.

Chapter 5

The Impact of Interbank Liquidity on Monetary Transmission Mechanism: A Case Study of Pakistan

5.1 Introduction

Usually, it is assumed that a change in central bank interest rates is transmitted through interbank liquidity to lending and deposit rates, thereby influencing spending decisions of firms and households (Mohanty and Turner, 2008). The role of interbank liquidity in monetary transmission has mostly been examined theoretically.[75] The empirical literature has mainly assessed the transmission mechanism following Bernanke and Gertler's (1995) 'black box' approach ignoring the role of interbank liquidity. The role played by interbank liquidity is still not well understood, even though there is some evidence that notably the presence of excess liquidity may limit the ability of central banks in developing economies to conduct monetary policy effectively.[76]

The experience of Pakistan provides a good illustration of the issue at hand as the interbank market of Pakistan has witnessed an unprecedented growth in excess liquidity in the recent period. Since 2006, repeated attempts by the State Bank of Pakistan (*henceforth* SBP) to increase deposit rates using monetary policy tools proved largely ineffective. In its Monetary Policy Statement of July 2011 (State Bank of Pakistan, 2011), the SBP acknowledges weaknesses in the monetary policy transmission mechanism.[77] Several studies point to excess interbank liquidity as an important cause for ailing monetary transmission. For instance, Agénor and Aynaoui (2010) argue that excess liquidity leads to stickiness of the deposit rate during monetary contractions in middle-income economies, undermining the effectiveness of

[75] See, for example, Ganley (2004), Ulrich *et al.* (2004), Allen *et al.* (2009), Agénor and Aynaoui (2010), Freixas *et al.* (2011), and Acharya *et al.* (2012).

[76] See, for example, Nissanke and Aryeetey (1998), Agénor et al. (2004), Saxegaard (2006), and Agénor and Aynaoui (2010).

[77] State Bank of Pakistan (2011, pp. 11), states that;

"... unlike the lending rates, the (Weighted Average) Deposit Rate (WADR) has not changed much during fiscal year 2011. It increased from 6.8 % in June 2010 to 7.2 percent in June 2011. This represents a weakness in the monetary transmission mechanism as is evident from a stagnant and high currency to deposit ratio of 29% on 30th June 2011."

deflationary monetary policy.

We investigate the impact of interbank liquidity on monetary transmission mechanism in Pakistan, as our findings in Chapter 4 point to a long-term presence of excess liquidity in the interbank market of Pakistan. This chapter assesses the interest rate pass-through using monthly data from July 2004 to December 2011. The pass-through of the discount rate and required reserves is used to describe how changes in the central bank's policy tools have a short-run and a long-run impact on the retail lending and deposit rates. We also investigate the policy instruments' pass-through to the exchange rate. We address the following research questions: What is the impact of the main policy tools of the SBP on retail lending and deposit rates, and the exchange rate? Does excess interbank liquidity affect the monetary transmission mechanism, i.e., the pass-through of the policy tools to the retail rates and the exchange rate?

Our study is unique in a number of ways. To the best of our knowledge, the role of interbank liquidity has never been assessed directly in research on monetary transmission in developing economies. Previous studies on non-industrial countries, such as Egert and MacDonald (2009) and Gigineishvili (2011), evaluate the impact of interbank liquidity only indirectly (see Section 5.2 for more details).

Moreover, we examine not only the transmission of changes in the discount rate, but also of changes in the reserve requirements. Previous empirical studies have ignored the pass-through of the required reserves, as they are not changed very frequently. However, from July 22 2006 onwards, the SBP has imposed reserve requirements on banks for time and demand liabilities separately, so that there is sufficient variability in required reserves for a meaningful economic analysis.

Finally, in addition to the transmission of policy tools to retail interest rates, we also examine their transmission to the exchange rate. As central banks in several emerging economies aim to stabilize exchange rates, a better understanding of monetary transmission mechanisms requires an analysis of the response of the exchange rate to a monetary policy shock (Disyatat and Vongsinsirikul, 2003; and Aleem, 2010). In a small open economy, the exchange rate channel may often affect the economy through the bond market and the banking system (Adolfson, 2001).[78]

[78] Bhattacharya *et al.* (2011), Smets and Wouters (2002); Zorzi *et al.* (2007) and Ito and Sato (2008) analyze the inter-linkages between the interest and exchange rate channels.

Our results suggest that the pass-through of the discount rate to the lending rate is complete but it is incomplete for required reserves. However, only shocks to required reserves have an effect on the deposit rate and the exchange rate in the long run. Finally, our findings suggest a structural shift in June 2008 in the interbank money market in Pakistan.

The chapter is structured as follows. Section 5.2 reviews the relevant literature, while Section 5.3 discusses monetary policy in Pakistan. Section 5.4 outlines the methodology and Section 5.5 describes the data employed. Section 5.6 analyzes the results obtained and Section 5.7 concludes.

5.2 Literature review

The literature suggests that the transmission of monetary policy changes to lending and deposit rates may be impaired due to several structural rigidities. Previous studies investigating this issue have referred to market concentration and lack of competition (Hannan and Berger, 1991; and Neumark and Sharp, 1992), menu costs (Cottarelli and Kourelis, 1994; and Mester and Saunders, 1995), asymmetric information (Stiglitz and Weiss, 1981), high volatility and uncertainty (Borio and Fitz, 1995) and excess market liquidity (Sørensen and Warner, 2006; Lucchetta, 2007; Egert and MacDonald, 2009; and Gigineishvili, 2011).

So far, empirical studies have paid limited attention to the effect of excess interbank liquidity on monetary policy transmission in developing countries (Agénor and Aynaoui, 2010), even though several theoretical studies referred to earlier suggest that excess liquidity impairs monetary transmission mechanism in these economies. Previous empirical assessments of the impact of excess liquidity on monetary transmission include Ruffer and Stracca (2006); Sørensen and Warner (2006); Lucchetta (2007); Egert and MacDonald (2009); Gigineishvili (2011) and Rocha (2012). Only the studies of Egert and MacDonald (2009) and Gigineishvili (2011) relate to non-industrial economies. Egert and MacDonald (2009) show that the reaction of banks to the monetary policy changes in Central and East European countries depends on certain characteristics, including their liquidity position. Gigineishvili (2011) estimates the interest rate pass-through in some 70 developing countries. The estimated pass-through coefficient is then explained by a host of macroeconomic variables, including liquidity holdings of banks. His findings suggest that excess bank liquidity impedes interest rate pass-through.

In contrast to these studies, we assess the impact of excess liquidity by comparing the pass-through coefficient of the policy tools in a nested setting, by excluding and including excess liquidity in our models for pass-through. By doing so, this study makes a direct assessment of the effect of interbank liquidity on monetary policy transmission.

The remainder of this section reviews studies on the pass-through of the policy rate to retail interest rates and the exchange rate, for developing economies only. For detailed surveys of monetary transmission in industrial countries we refer to Boivin *et al.* (2010), Bhattacharya *et al.* (2011), Mishra *et al.* (2011) and Mohanty (2012).

The survey of Mohanty and Turner (2008) among central banks of developing and emerging economies reveals that most central banks consider interest rates as the most important channel for the transmission of a policy shock. However, recent empirical studies on the interest rate pass-through yield diverse results. For example, using data for Turkey from April 2001 to June 2007, Ozdemir (2009) reports complete pass-through to the lending rate and the deposit rate in the long run. In a complete pass-through the changes in the policy tool are transmitted completely to the retail rates. Similarly, Durán-Víquez and Esquivel-Monge (2008) report complete pass-through of the policy interest rate in the long run, using data for the 1996-2007 period for Costa Rica. In addition, Poddar *et al.* (2006) find that in Jordan the central bank's target rate affects the banks' retail rates. Ganev *et al.* (2002) and Dabla-Norris and Floerkemeier (2006) report complete pass-through only to the lending rates in some Eastern European countries (Bulgaria, Estonia, Latvia, Lithuania, Romania, and Slovakia) and Armenia, respectively. Al-Mashat and Billmeier (2007) find that both lending and deposit rates move in the direction of policy changes in Egypt but only the change in the deposit rate is statistically significant.

Similar to the findings for other developing economies, Table 5.1 summarizes related research on Pakistan. Except for Mohsin (2011), this literature suggests that the discount rate pass-through in the long run is almost complete for the lending rate, but sticky and often incomplete for the deposit rate. In their empirical investigations, the State Bank of Pakistan (2005) and Hanif and Khan (2012) used the Auto Regressive Distributed Lag Approach, while Qayyum *et al.* (2006), and Khawaja and Khan (2008) apply the transfer function approach. The transfer function approach is frequently used to characterize the input-output relationships for a system that can be described by linear time-invariant differential equations. Using the panel cointegration methodology Mohsin (2011) reports a long-run relationship only between the discount rate and the lending rate.

Table 5.1 Literature on Interest Rate Pass-through to Retail Rates in Pakistan

Study	Period	Instrument	Method	Pass-through estimates			
				Short run		Long run	
				Lending rate	Deposit Rate	Lending rate	Deposit Rate
State Bank of Pakistan (2005)	1999:07-2006:06	TB cut-off rate	ARDL	0.198	0.044	0.987	0.444
Qayyum *et al.* (2006)	1991:03 - 2004:12	TB rate	TFA	Nil	0.180	0.410[2]	0.223[1]
Khawaja and Khan (2008)	1991:06 - 2008:06	TB rate	TFA	Nil	Nil	0.430[3]	0.160[4]
Mohsin (2011)	2001:11 - 2011:03	DR	PC	0.100	0.160	0.200	Nil
Hanif and Khan (2012)	2001:07 - 2011:08	1-wk KIBOR	ARDL	0.300	0.130	0.910	0.640

Notes: TB: Treasury Bill, DR: Discount Rate, KIBOR: Karachi Interbank Offered Rate, ARDL: Auto Regressive Distributed Lags, TFA: Transfer Function Approach, PC: Panel Cointegration. Nil indicates no pass-through detected.
[1] Pass-through to the saving deposit rate (deposit with less than 6-month maturity), while long-run pass-through takes around 3 years to complete. [2] No short-run pass-through and long-run pass-through requires one and half to two years to complete. [3] Long-run pass-through requires one to one and half years. [4] Long-run pass-through requires one year.

The exchange rate is one of the policy variables through which monetary policy is transmitted to the larger economy by its impact on domestic inflation, the external sector, capital flows, and financial stability. The relationship between policy rates and the exchange rate can be described by the uncovered interest rate parity (UIP) hypothesis according to which the differential between domestic and foreign economies interest rates is determined by the differential between the future expected and the current exchange rate, and the time varying risk premium. The risk premium is the compensation required by the investors not only for an expected depreciation, but also for holding domestic assets.

For developing economies and emerging market economies, the literature in general provides support for UIP (see for example, Bansal and Dahlquist, 2000; Flood and Rose, 2001; Frankel and Poonawala, 2006; and Ferreira and Leon-Ledesma, 2007).[79] However, empirical literature on interest rate pass-through to the exchange rate in developing economies is scarce.

[79] Chapters 2 and 3 investigated the uncovered interest rate parity but only for developed economies. Smets and Wouters (2002), Zorzi *et al.* (2007), Ito and Sato (2008), Boivin *et al.* (2010), and Bhattacharya *et al.* (2011) provide evidence about the linkages between the interest and the exchange rate channels for industrial economies.

This is also true for Pakistan. To the best of our knowledge, only Agha *et al.* (2005) study the impact of monetary policy changes on the real effective exchange rate in Pakistan. Using Vector Auto Regressions (VAR) they report that a 0.8 percentage point rise in the 6-month Treasury bill rate leads to a marginal appreciation of 0.2 percent of the real exchange rate during the first two months.

5.3 Excess liquidity and monetary policy in Pakistan

Saxegaard (2006) and Agénor *et al.* (2004) define excess liquidity as the ratio of the quantity of reserves deposited with the central bank by banks (and cash in their vaults) in excess of the statutory liquidity requirements, to the total time and demand liabilities of the banks. Mohanty *et al.* (2006) argue that if banks hold substantial amounts of government securities, bank reserves with the central bank only capture a part of the total holdings of liquid asset and are therefore less reliable as a measure of liquidity holdings. We therefore augment excess liquidity, as defined by Saxegaard (2006) and Agénor *et al.* (2004), with high-powered securities owned by banks that are eligible for statutory liquidity requirements. These securities include mostly short-term Treasury bills and long-term government bonds (known as Pakistan Investment Bonds or PIBs) up to a maximum determined by the SBP. Thus similar to Chapter 4, the definition of excess liquidity used in this chapter is the ratio of the quantity of bank reserves deposited with the central bank, cash held by banks, and securities that are eligible as reserves in excess of the statutory liquidity requirements, to the total time and demand deposits of banks.

The SBP has a monetary targeting strategy with the objective of maintaining price stability and promoting economic growth.[80] Its main policy tool is the discount rate. Theoretically, any change in the discount rate alters the marginal cost of maintaining excess reserves, which is transmitted to retail rates through changes in the marginal cost of interbank lending. In addition, the SBP frequently uses direct policy tools, such as cash reserve requirements and statutory liquidity requirements. Cash reserve requirements consist of non-remunerated deposits that bank have to keep at the central bank to back up their deposit holdings. Statutory liquidity requirements refer to liquidity that banks are required to maintain in the form of government securities or securities of government-owned enterprises. Changes in both types

[80] For details see Omer and Saqib (2008).

of required reserves influence banks' excess reserves, thereby changing the interbank market rates. The lending and the deposit rates, in turn, are influenced by changes in the interbank market rates.

Between 2004 and 2011 the SBP tightened its policy frequently (see the upper panel in Figure 5.1 showing movements in the policy tools, and Table 4.1 (in Chapter 4) which gives the details of the policy changes) as the central bank was struggling to curtail inflation, which frequently was in the double-digit range.[81] Real lending and deposit rates were mostly negative due to high inflation during this period (see the middle panel in Figure 5.1). The banks' nominal lending rates generally responded to the central bank's tightening measures, but deposit rates were stickier, as the State Bank of Pakistan (2011) suggests.

Until June 2008, the SBP had little success in increasing deposit rates. As a consequence, the SBP asked the banks to pay a minimum return of five percent on all Pak Rupee savings products from 1 June 2008 onwards.[82] A floor for deposit rates implies that the nominal interest rate cannot fall below this level, reducing both the flexibility of monetary policy to address deflationary pressures and the transmission of policy shocks through interest rates.

Financial developments and the relevant policy measures adopted by the SBP have amassed excess liquidity in the interbank market of Pakistan during our study period. For example, due to the global financial crisis the cash reserve requirements were relaxed. In October 2008, these requirements were brought down twice by 100 bps within a span of a week (see Table 4.1, in Chapter 4). In tandem, the SBP increased the eligibility of long-term government bonds for the statutory liquidity requirements from 5 to 10 percent. The move increased the borrowing ability of the banks from the SBP's discount window roughly by PKR135 billion.[83] Also, unprecedented foreign exchange inflows in the form of the remittances allowed the banks to park funds in short-term government securities. Accordingly, the banking sector witnessed a steep growth in liquidity, specifically since June 2008.

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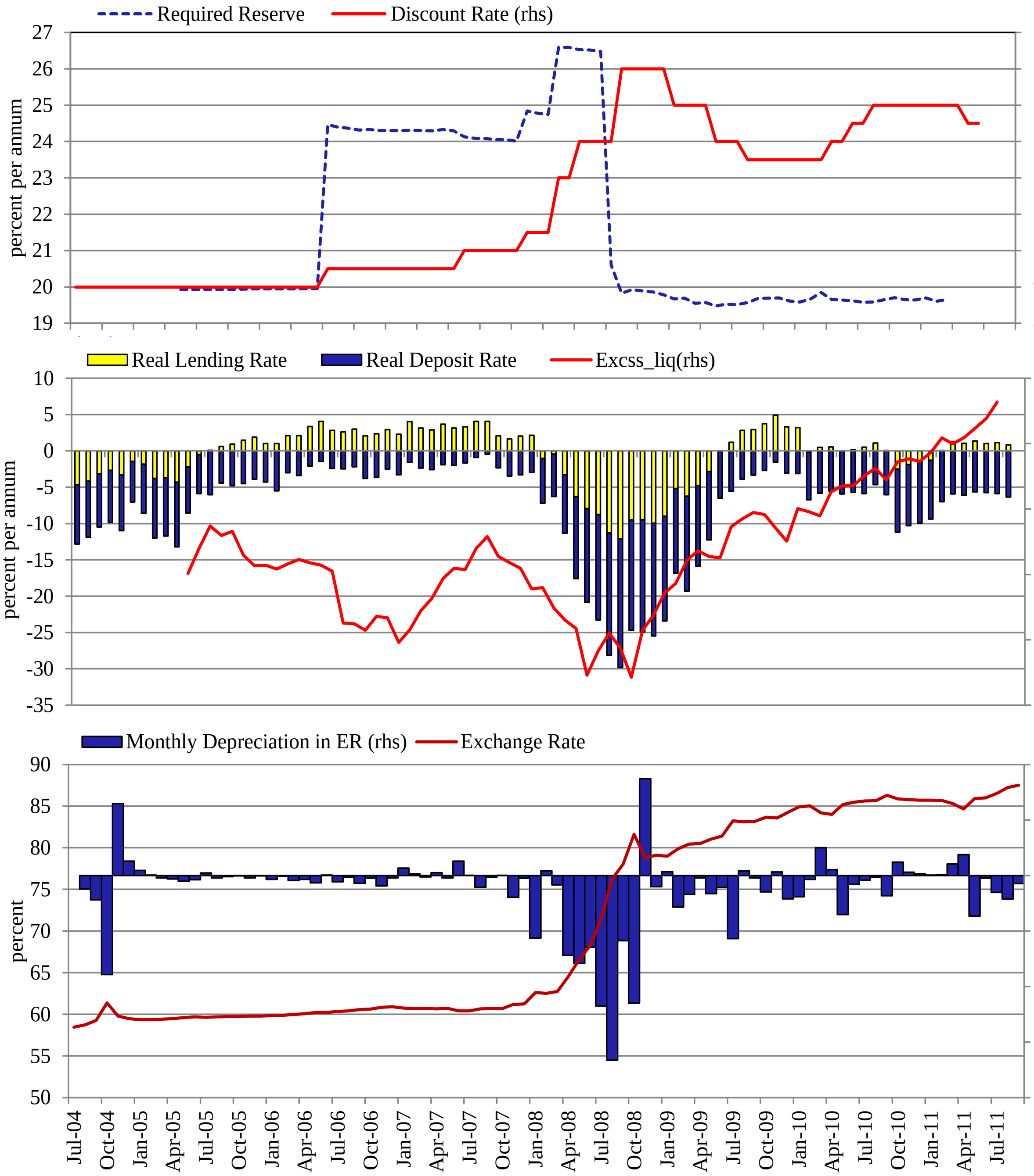
[81] For more details, see Omer and Saqib (2008), and Government of Pakistan (2007- 2009).

[82] The regulatory deposit rate was raised to 6 percent on May 01, 2012 (see BPRD Circular No. 01of 2012, SBP). The regulatory deposit rate is linked with the SBP discount rate from September 27, 2013. As a result, since then the minimum deposit rate has increased to 6.5 percent (see BPRD Circular No. 07of 2013, SBP).

[83] Amounts to US$ 1.66 billion.

FIgure 5.1 Interbank Liquidity, Policy Instruments and Retail Rates



Top panel: shows required reserves and the discount rate.

Middle panel: shows excess liquidity, the real lending and the real deposit rates.

Bottom panel: shows the exchange rate and its monthly depreciation. Monthly depreciation is calculated using the monthly growth of the exchange rate.

5.4 Model and methodology

Similar to Chapter 4, we first use unit root tests to examine the data generating processes of the variables used in the analysis. In a generalized form, an augmented unit root process can be described by

$$\Delta y_t = \mu_0 + \mu_1 \tau + \rho y_{t-1} + \sum_{p=1}^{k-1} \gamma \Delta y_{t-i} + \varepsilon_t \tag{5.1}$$

where y_t is the series to be tested, τ is the deterministic trend, μ_0 and μ_1 are parameters, while ρ and γ_i are the coefficients of the unit root and the lagged difference of the series, respectively, and ε_t is the error term (for details, see Enders, 2004 Chapter 4; and Hamilton, 1994 Chapter 15).[84] Conventionally, the unit root tests test the null hypothesis that the series has a unit root, i.e. $\rho = 1$. As the findings of Chapter 4 suggest a structural shift in the banks' behavior, this chapter also utilizes unit root tests with structural shifts when conventional unit root tests fails to reject the null hypothesis.

The tests suggested by Clemente *et al*. (1998) allow for unit root testing with two breaks. This test is an extension of the Perron and Vogelsang (1992) test with one structural break.[85] As discussed in Chapter 4, this class of unit root tests distinguishes two types of outliers: an additive outlier and an innovative outlier. The additive outlier test suits best to series exhibiting a sudden change in the mean, while the innovative outlier test assumes that the change takes place gradually. As the power of these tests improves considerably if the break points are known *a priori*, often the tests employ grid search to locate the break dates. For simplicity, assume that the breaks occur at an unknown date, $1 < T_{b1} < T_{b2} < T$, with T being the sample size. The additive outlier test follows a two-step procedure. First, the deterministic part of the series is filtered using

$$y_t = \mu + \delta_1 DU_{1t} + \delta_2 DU_{2t} + \tilde{y}_t, \tag{5.2}$$

[84] For the list of the symbols used in Chapters 4 and 5, see Table A5.5 in the Appendix to Chapter 5.
[85] If the test of Clemente *et al*. (1998) suggests that both structural shifts are significant we keep this result. However, if this test finds only one significant structural shift we employ the Perron and Vogelsang (1992) test.

where the break dummies $DU_{mt} = 1$ for $t > T_{bm}$, and 0 otherwise, for *m = 1, 2*, and the remaining part noise $\tilde{y}_t$ is examined for a unit root

$$\Delta\tilde{y}_t = \sum_{i=1}^{m1}\theta_{1i}D(T_{b1})_{t-i} + \sum_{i=1}^{m2}\theta_{2i}D(T_{b2})_{t-i} + \rho\tilde{y}_{t-1} + \sum_{i=1}^{k-1}\gamma_i\Delta\tilde{y}_{t-i} + e_t\,, \qquad (5.3)$$

The change in the break dummy $D(T_{bm})_{t-i} = 1$ if $t = T_{bm} + 1$ and zero otherwise; $m1$ and $m2$ are the maximum lags of the breaks; $\Delta\tilde{y}_t$ are included to control for serial correlation and heteroskedasticity in the errors, while k-1 is the truncated lag parameter. Often specification of lag length in a unit root tests involves practical issues. If k-1 is too small then the remaining serial correlation in the errors will bias the test. If k is too large then the power of the test will suffer. Here the lag length k is determined by a set of sequential F-tests.[86]

The innovative outlier model assumes that an economic shock to a variable affects the subsequent observations. Starting from its initial position the shocks propagate to the subsequent observations through the memory of the system. The estimation strategy of innovative outlier tests is based on;

$$y_t = \mu_1 + \delta_1 DU_{1t} + \delta_2 DU_{2t} + \theta_1 D(T_{b1})_t + \theta_2 D(T_{b2})_t + \alpha y_{t-1} + \sum_{i=1}^{k-1}c_i\Delta y_{t-i} + e_t\,, \qquad (5.4)$$

$$y_t = a + \phi(L)(e_t + \delta_1 DU_{1t} + \delta_2 DU_{2t})\,. \qquad (5.5)$$

In Equations (5.2) and (5.4), δ_i measures the immediate impact of the changes in the mean. The innovative outlier test can identify the long-run impact of changes in trends by the design of its alternative hypothesis. Here, L is the lag operator defined as $Ly_t \equiv y_{t-1}$, while $\phi(L)$ defines the moving average representation of a stationary and invertible noise function e_t. The immediate impact of a change in the mean is equal to δ_m, m=1,2, and the long-run impact is $\delta_m\phi(1)$ in Equation (5.5), where $\phi(1)$ is equal to the sum of all coefficients of the lag polynomial $\phi(L)$. Both models test the null hypothesis of a unit root, that is $\rho = 1$. The limiting distribution of these test statistics does not follow the Dickey–Fuller distribution; Perron and Vogelsang

[86] This procedure works as follows: First, for a given value of T_{bm}, a maximum value of k (k_{max}) the auto regressions (AR) are estimated with (k_{max}), and (k_{max} - 1) lags. If the F-test suggests that the coefficient of $k^{th}_{\max}$ lag is significant, the value of k is chosen. If not, the model is estimated with (k_{max} - 1) versus (k_{max} – 2) lags. The procedure is repeated by lowering k until a rejection of the null hypothesis that additional lags are insignificant occurs or the lower bound $k = 0$ is attained.

(1992) and Clemente *et al*. (1998) provide the critical values for one and two structural breaks, respectively. The null hypothesis is rejected if $\rho < 1$; in that case the series is level stationary. The Clemente *et al*. (1998) tests collapse to the Perron and Vogelsang (1992) tests when the restriction m=1, is imposed, i.e. there is only one break.

To estimate the policy tools' pass-through, we follow the procedure of De Bondt (2002) and Chong *et al*. (2006). We employ the vector auto regressions (VAR) methodology for estimating the relationships between the policy tools and the impact variables (lending rate, deposit rate, and exchange rate). We employ levels of all variables in the VAR except for the variables which are difference stationary, as indicated by the unit root tests. For the difference-stationary series, we use first differences. The VAR methodology presumes that all regressors are endogenous, where variables are explained by their lags. A VAR for N variables of order p is written as

$$Z_t = \mu + \Psi(L) Z_{t-p} + \xi_t , \tag{5.6}$$

where $Z_t = (z_{1t}, z_{2t}, ..., z_{Nt})'$ represents a vector of ($Nx1$) variables with their p lags, $\Psi\ (L)$ is a lag polynomial of order p, while ξ_t is ($Nx1$) unobservable zero mean white noise vector process. The optimal lag length k is selected using the HQ criterion (as suggested by Lütkepohl and Kratzig, 2004).

The coefficients of the first lag of the policy tools of the VAR estimates shows the immediate impact of changes in the policy tool, generally termed as the short-run pass-through of policy tools. The long-run pass-through coefficient $\hat{\beta}$ for the first variable is found by aggregating and normalizing the short-run coefficients. To illustrate this for a bivariate VAR system with two lags, such as:

$$\begin{pmatrix} Z_{1t} \\ Z_{2t} \end{pmatrix} = \begin{pmatrix} \mu_1 \\ \mu_2 \end{pmatrix} + \begin{pmatrix} \Psi_{11}^1 \Psi_{12}^1 \\ \Psi_{21}^1 \Psi_{22}^1 \end{pmatrix} \begin{pmatrix} Z_{1t-1} \\ Z_{2t-1} \end{pmatrix} + \begin{pmatrix} \Psi_{11}^2 \Psi_{12}^2 \\ \Psi_{21}^2 \Psi_{22}^2 \end{pmatrix} \begin{pmatrix} Z_{1t-2} \\ Z_{2t-2} \end{pmatrix} + \begin{pmatrix} \xi_{1t} \\ \xi_{2t} \end{pmatrix}$$

we compute

$$\hat{\beta}_1 = \frac{\sum_{p=1}^{2} \Psi_{12}^p(L)}{1 - \sum_{p=1}^{2} \Psi_{11}^p(L)} \quad , \tag{5.7}$$

where $\Psi_{11}(L)$ are coefficients of the lag dependent variable and $\Psi_{12}(L)$ are coefficients of the explanatory variable of interest.

5.5 Data

The monetary policy instruments in Pakistan change infrequently (for details, see Table 4.1 in Chapter 4). Therefore, following Agha *et al.* (2005), Qayyum *et al.* (2006), and Khawaja and Khan (2008), we use the 6-month Treasury bill rate as a proxy for the discount rate.[87] Reserve requirements often suffer from a similar non-variability problem. Finding a proxy for the reserve requirements is not easy which may explain why previous studies have not considered the pass-through of this instrument. Since 22nd July 2006 the SBP imposed separate reserve requirements for time and demand liabilities (also shown in Table 4.1 in Chapter 4).[88] We will therefore use the effective reserve requirements as weighted average of the cash reserve requirements and the statutory liquidity requirements. This creates sufficient variability in reserve requirements to be used for estimation purposes.

We use monthly data from July 2004 to December 2011.[89] Table 5.2 provides the descriptive statistics of the variables employed. The lending and the deposit rates used are weighted averages of rates offered by banks on new loans and deposits using amounts as weights, in any given month.[90] These rates are consistently available since July 2004. Prior to July 2004, the lending rate reported referred to new lending, while the deposit rate reported referred to outstanding deposits. Monthly data on excess liquidity is based on information for the last weekend of the month.

Table 5.2 Descriptive Statistics

Variables	No. of Observation	Mean	Standard Deviation	Minimum	Maximum
Lending rate	88	11.50	2.74	4.63	15.54
Deposit rate	88	5.83	2.06	1.20	9.53
Discount rate	90	11.32	2.13	9.00	15.00
6-month market Treasury bill rate	88	9.99	2.74	2.58	13.44

[87] The correlation between the discount rate and the 6-month Treasury bill rate in our sample is 0.966.
[88] The SBP defines special notice deposits and time deposits with maturity of 12 months or less as demand liabilities. Time deposits with maturities above 12 months are categorized as time liabilities.
[89] The sample size reduces to June 2005 - June 2011 when the investigation involves excess liquidity. We also estimated all models reported for this shorter sample period but this gave fairly similar results.
[90] Weighted averages are calculated by weighting interest rates by the corresponding amounts of loans/deposits across all banks. The formula used by the SBP is: $\text{Weighted Average Rate} = \sum(\text{rate} \times \text{amount}) \div \sum(\text{amount})$.

Excess liquidity	74	11.75	4.94	2.13	23.19
Required reserve	74	21.58	2.47	19.48	26.59
Exchange rate	87	70.79	11.60	58.45	87.50

Currently, the SBP reports net time and demand liabilities excluding the foreign currency and Islamic banks' deposits. The foreign currency and Islamic banks' deposits are reported separately, with different statutory requirements. Before December 2005, reported data included both foreign exchange and Islamic banks' deposits and hence are not comparable to the current data. We have successfully extended the time series for deposits six month backward using reported information of the SBP so that our sample starts in June 2005. We use the growth rate of the exchange rate, as the pass-through estimation requires that variables used have the same unit of measurement. All data have been kindly provided by the SBP.

5.6 Results

Table 5.3 provides the results of the conventional unit root tests, as well as unit root tests allowing for structural breaks. The results suggest that except for excess liquidity all variables included in the investigation are level stationary. For instance, the null hypothesis of unit root is rejected at 10 percent significance level for the lending rate (Phillips-Perron test) and for the deposit rate (innovative outlier test). Moreover, the test results for the deposit rate suggest that this variable has two significant structural shifts. Similarly, the results for the required reserves also suggest two structural shifts in this variable. The identified break dates are in the vicinity of the policy moves of the SBP as described in Table 4.1 in Chapter 4. For example, the results for required reserves show that the series had a structural break in May 2005 and August 2008. Table 4.1 in Chapter 4 shows that the SBP increased the cash reserve requirements on demand liability by 200 bps in July 2006, and by 100 bps in May 2008.

Only excess liquidity follows a difference stationary or I(1) process as a unit root null hypothesis cannot be rejected at the 5 percent significance level both for the conventional unit root tests and for the unit root tests incorporating structural breaks. We therefore employ first differences of the excess liquidity in the VAR system.

Table 5.3 Unit Root Test Results

	Without Structural Break				With Structural Break					
	Dickey-Fuller test		**Philips-Perron test**		**Additive outlier test**			**Innovative Outlier test**		
	No trend	**Trend**	**No trend**	**Trend**	**Stats**	**# Breaks**	**Dates**	**Stats**	**# Breaks**	**Dates**
Lending rate	-1.439	-1.268	-2.742**	-2.159						
Deposit rate	-1.973	-1.935	-2.122	-2.098	-4.683	2	11-05, 02-08	-3.915**	2	12-05, 01-08
Discount rate	-0.931	-1.800	-3.005*	-2.978						
Required reserves	-1.486	-2.98	-1.666	-1.876	-5.718*	2	08-06, 11-08	-14.722*	2	05-06, 08-08
Excess liquidity	0.771	-1.447	-0.17	-1.088	-0.655	2	03-08, 03-09	-3.061	2	12-07, 08-08
Exchange rate	-2.143	-2.109	-7.205	-7.173*						
**5% C. V*										
No Break	-2.911	-3.476	-2.9	-3.463						
1-break					-3.560			-4.270		
2-breaks					-5.490			-5.490		
***10% C.V.*										
No Break	-2.590	-3.166	-2.585	-3.158						
1-break					-3.22			-3.86		
2-breaks					-5.24			-5.24		

Notes: The additive outlier test assumes a sudden break while the innovative outlier test assumes a break in trend. The null hypothesis of ADF or PP test is that the series has a unit root, while for Clemente et at. (1998) test is that the series has unit root with structural breaks. For details see Clemente et at. (1998). Dates indicates break dates and should be read as month and year (*mm-yy*).

The break dates identified by the unit root tests are different for each variable indicating that different policy moves by the central bank may have had different impacts on these variables. Following the findings of Chapter 4, we incorporate only one shift, the break in June 2008. Several important developments suggest that a structural shift has occurred in the financial system of Pakistan in June 2008. On 1 June 2008, the SBP imposed a minimum regulatory deposit rate of five percent, to be paid to the depositors, on all savings products as discussed in Section 5.3. Moreover, excess liquidity of banks witnessed an unprecedented growth since June 2008 (see the panel in the middle in Figure 5.1). Finally, the SBP changed its use of policy tools.

After May 2008, reserve requirements were relaxed but the central bank continued to raise the discount rate (see Table 4.1 in Chapter 4). Earlier, the SBP used both the required reserves and the discount rate for monetary tightening. In view of the structural shift in June 2008 and following Glynn *et al.* (2007), we include both shift and pulse dummies (change in the shift dummy) in our VAR models.

Tables A5.1, A5.2, and A5.3 in the Appendix to this chapter present the detailed estimates of the VAR models showing the short-run (upper panel) and long-run (the lower panel) impact of the changes in policy rates on the lending rate, the deposit rate, and the exchange rate, respectively. Various diagnostic tests are applied to each model, the results of which are provided in Table A5.4, also in the Appendix.[91] Although the assumption that the residuals are normally distributed is often rejected, we analyze deviations from normality using a non-parametric Kernel density estimation procedure. Kernel density estimators, similar to histograms, approximate the density $f(x)$ from observations on x. The data are divided into non-overlapping intervals, and counts are made of the number of data points within each interval. The kernel density estimates presented in Figures A5.1 to A5.12 show the density estimates of residuals and a normally distributed data with similar features. These graphs suggest that the residuals deviation from normality is generally marginal and can be ignored without significant implication for inference.

Table 5.4 provides the long-run pass-through estimates. The upper panel shows the estimates for the discount rate while the lower panel shows the estimates for required reserves. Before discussing the long-run pass-through results in more details, we want to point out that the dummies for the structural breaks are significant in most of the cases supporting the findings of Chapter 4 that a structural shift in the interbank market of Pakistan occurred in June 2008. Therefore, previous studies on monetary transmission in Pakistan may have produced misleading inferences by ignoring this shift if the data span covers 2008.

[91] Details of the applied diagnostic tests can be found at the bottom of Table A5.5.

Table 5.4 Long-run Interest Rate and Exchange Rate Pass-through Estimates

Dependent variable	**Lending rate**		**Deposit rate**		**Exchange rate**	
Include excess liquidity	No	Yes	No	Yes	No	Yes
	Policy tool: discount rate					
Model No.	(1)	(2)	(3)	(4)	(5)	(6)
Discount rate	0.928*	0.489	0.586	-0.325	-0.0784	0.196
	[0.002]	[0.196]	[0.200]	[0.613]	[0.746]	[0.713]
D(Excess liquidity)		-0.448*		-0.342		0.195
		[0.018]		[0.174]		[0.567]
Intercept	2.224*	6.156*	0.198	8.294**	0.406	-2.061
	[0.037]	[0.001]	[0.933]	[0.074]	[0.845]	[0.663]
Break Dummy	0.156	1.861*	0.186	3.532**	0.072	-0.862
	[0.750]	[0.008]	[0.877]	[0.076]	[0.948]	[0.677]
D(Break)	4.360*	2.246*	5.095**	0.690	-0.959	-0.160
	[0.000]	[0.018]	[0.054]	[0.823]	[0.675]	[0.957]
	Policy tool: required reserves					
Model No.	(7)	(8)	(9)	(10)	(11)	(12)
Required reserves	0.232*	0.210*	0.322*	0.301*	-0.362*	-0.361*
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
D(Excess liquidity)		-0.244*		-0.112		0.133
		[0.010]		[0.327]		[0.262]
Intercept	5.367*	5.839*	-2.095	1.600	7.887*	7.890*
	[0.004]	[0.003]	[0.154]	0.270	[0.001]	[0.000]
Break Dummy	3.965*	4.072*	3.126*	3.127*	-1.118*	-1.226*
	[0.000]	[0.000]	[0.000]	[0.000]	[0.001]	[0.000]
D(Break)	0.912	-0.059	1.058	-1.449	0.348	0.884
	[0.448]	[0.961]	[0.429]	[0.283]	[0.780]	[0.503]

Notes: *, **, indicates significance at respectively the 5 and 10 percent levels. The coefficients are the long-run pass-through estimates of shocks to the regressors (policy variable and excess liquidity) on the impact variables (lending rate, deposit rate, and exchange rate) as calculated by Equation 5.7.

5.6.1 Pass-through to the lending rate

The coefficient of the discount rate in model (1) of Table 5.4 is significant at the five percent level and suggests that 0.93 percentage-points of a unit shock to the discount rate is passed on to the lending rate in the long run. Thus, the long-run pass-through to the lending rate is almost complete. However, when excess liquidity is introduced in the model, the pass-through becomes insignificant (model (2)). In other words, a change in discount rate has no significant effect on the lending rate when one controls for excess liquidity.

The coefficient of excess liquidity in model (2) is negative and significant at the 5 percent level indicating that any unit positive change to the (difference of) excess liquidity leads to a decrease in the lending rate by 0.45 percentage point in the long-run. This result suggests that an increase in excess liquidity has a deterring effect on the lending rate in the long-run. Our findings of lending rate pass-through with model (1) are in line with the literature on monetary transmission in Pakistan (see Table 5.1) suggesting high pass-through to the lending rate in the long-run (State Bank of Pakistan, 2005; Khawaja and Khan, 2008; and Hanif and Khan, 2012). Also our finding that inclusion of excess liquidity has a decreasing effect on the pass-through to lending rates is in line with some previous research for other countries (Ruffer and Stracca, 2006; Sørensen and Warner, 2006; Lucchetta, 2007; and Gigineishvili, 2011).[92]

Models (7) and (8) in Table 5.4 show the estimates for the long-run pass-through from required reserves to the lending rate. The coefficients indicate that the long-run pass-through to the lending rate is only 0.23- percentage point and significant at the 5- percent level. Inclusion of excess reserves has negligible effect on lending rate and reduces the long-run pass-through to 0.21 percentage point. The results suggest that the long-run pass-through of required reserves to the lending rate is low and incomplete.

5.6.2 Pass-through to the deposit rate

Models (3) and (4) in Table 5.4 show that the pass-through of the discount rate to the deposit rate is insignificant independent of the presence of excess liquidity in the model. Our findings of no pass-through of the discount rate to the deposit rate stands in contrast to the findings of the State Bank of Pakistan (2005) and Khawaja and Khan (2008) who report low pass-through of the discount rate to the deposit rate. The introduction of the regulatory deposit rate in June 2008 may have destroyed the weak pass-through to the deposit rate, reported by earlier studies. Significant break dummies weakly supports our argument that the transmission mechanism to the deposit rate has changed.[93]

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[92] The lower panel of Table A5.1 (model (1) and (3) in grey) shows the results for the model in which the causality runs in the opposite direction. The results suggest that the lending rate has no effect on the discount rate independent of the inclusion of excess liquidity in the model.

[93] The lower panel of Table A5.2 (models (3) and (4) in grey) shows the results for the models in which the causality runs in the opposite direction. The results suggest that the deposit rate has significant long-run effect at the 5 percent level on the discount rate only when excess liquidity is controlled for (model (4)). A 100 bps increase in the deposit rate leads to 46 bps increase in the discount rate. The reverse causation from the deposit rate to the discount rate indicates the ineffectiveness of this policy tool. Perhaps, the regulatory deposit rate imposed by the SBP may have

Models (9) and (10) in Table 5.4 show the long-run pass-through of required reserves to the deposit rate. Typically, this long-run pass-through is low, independent of whether excess liquidity is included or not. Almost 0.32 percentage point of a unit shock to required reserves is passed through to the deposit rate in the long run. If excess liquidity is controlled for, this pass-through reduces marginally to 0.30 percentage points. Still, compared to the discount rate, reserve requirements appear to be a more effective policy tool for influencing the deposit rate.

5.6.3 Pass-through to the exchange rate

Models (5) and (6) in Table 5.4 show the long-run pass-through estimates of the discount rate to the exchange rate. The coefficients of the discount rate are insignificant independent of the inclusion of excess liquidity in the model. This suggests that the discount rate does not influence the (growth of the) exchange rate in the long run.[94]

Models (11) and (12) in Table 5.4 display the pass-through of required reserves to the (growth in) exchange rate. The coefficient is significant at the five percent, independent of the inclusion of excess liquidity in the model. A one percent increase in required reserves leads to a 0.38 percentage point appreciation in Pakistan Rupee against the US Dollar. However, when excess liquidity is controlled for, the appreciation of the Pakistan Rupee slightly reduces to 0.36 percentage points.

5.7 Conclusions

We have investigated the effect of excess liquidity on the pass-through from the discount rate and required reserves to retail interest rates and the exchange rate in Pakistan. For this purpose, data from July 2004 to December 2011 has been used. Our findings suggest that excess liquidity significantly affects the pass-through of the discount rate to the lending rate. Moreover, the pass-through to the lending rate is complete for the discount rate but incomplete for required reserves.

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strengthened this reverse causation from the deposit rate to the discount rate, while weakening the desired transmission mechanism from the discount rate to the deposit rate. Moreover, this result also suggests that excess liquidity has a distortionary effect on the interest rate pass-through to the deposit rate.

[94] The estimates for the models in which the causality runs in the opposite direction (shown in the lower panel of Table A5.3, model (5) in grey) suggest that exchange rate movements significantly influence the discount rate. A one percent depreciation of the exchange rate leads to a 0.73 percentage point decrease of the discount rate. As discussed in Section 5.2, this relationship is not in line with the UIP hypothesis. We suspect that this result is related to the borrowing cost on external debt and may be period specific.

However, only changes in required reserves affect the deposit rate and the exchange rate in the long run, even though pass-through is incomplete. Additionally, our results suggest the presence of a structural shift in the interbank money market in Pakistan in June 2008. Studies ignoring this shift may produce misleading conclusions.

Our finding is important as the global increase in liquidity has resulted in foreign capital inflows to the developing and emerging economies thereby flooding their interbank markets with excess liquidity (for a detailed discussion, see Chinn, 2013). Also Ahmed and Zlate (2013), while discussing the impact of foreign capital inflows to emerging economies, point out that the monetary policies of the emerging economies are likely to suffer from this increase in excess interbank liquidity. Therefore, our study provides first-hand information on the impact of excess liquidity on the monetary policy transmission mechanism in developing economies. The conclusion of our study is likely to help policy makers in developing economies, in general, and Pakistan, in particular.

Finally, some caveats are in order. First, we have considered only positive changes to the policy tools assuming that the negative changes will have similar effect on our symmetric models. The literature on monetary policy pass-through suggests that pass-through is often different for positive and negative changes in the policy tools. As our data primarily refer to a period with monetary tightening, we leave this issue of asymmetric pass-through for future research. Second, the interbank market involves other players, like Islamic banks, microfinance banks, and non-bank financial institutions in addition to commercial banks. However, in view of their low shares in the interbank market, their excess liquidity position is unlikely to affect our conclusions.

5.8 Appendix

Table A5.1 Estimates of Policy Impact on Lending Rate

Model #	(1)	(1)	(2)	(2)	(7)	(7)	(8)	(8)
Dependent Variable	**Lending rate**	**Discount rate**	**Lending rate**	**Discount rate**	**Lending rate**	**Required reserves**	**Lending rate**	**Required reserves**
Policy Tool	Discount rate	Discount rate	Discount rate	Discount rate	Required reserves	Lending rate	Required reserves	Lending rate
Liquidity Included	No	No	Yes	Yes	No	No	Yes	Yes
Lag Selection criteria	HQ	HQ	HQ	AIC	HQ	HQ	SBC	SBC
No of Lags	(5,5)	(5,5)	(5,5,5)	(5,5,5)	(1,1)	(1,1)	(1,1,1)	(1,1,1)
Lending rate (-1)	0.725*	0.122	0.725*	0.183*	0.720*	0.007	0.714*	-0.044
	[0.000]	[0.189]	[0.000]	[0.080]	[0.000]	[0.962]	[0.000]	[0.784]
Lending rate (-2)	-0.073	0.043	-0.191	0.057				
	[0.572]	[0.712]	[0.175]	[0.655]				
Lending rate (-3)	0.233**	-0.127	0.369*	-0.136				
	[0.064]	[0.263]	[0.005]	[0.261]				
Lending rate (-4)	0.0964	0.313*	-0.158	0.2100*				
	[0.458]	[0.008]	[0.238]	[0.085]				
Lending rate (-5)	-0.294*	-0.435*	-0.0477	-0.437*				
	[0.002]	[0.000]	[0.613]	[0.000]				
Discount rate (-1)	0.343*	0.878*	0.370*	0.907*				
	[0.002]	[0.000]	[0.001]	[0.000]				
Discount rate (-2)	-0.098	-0.432*	-0.236	-0.414*				
	[0.490]	[0.001]	[0.113]	[0.002]				
Discount rate (-3)	-0.004	0.224**	0.128	0.065				
	[0.980]	[0.088]	[0.409]	[0.645]				
Discount rate (-4)	0.0832	0.0783	0.0482	0.404*				
	[0.553]	[0.536]	[0.739]	[0.002]				
Discount rate (-5)	-0.034	0.1704**	-0.163	0.048				
	[0.744]	[0.072]	[0.149]	[0.641]				
Required reserves (-1)					0.065*	0.867*	0.060*	0.872*
					[0.000]	[0.000]	[0.000]	[0.000]
D(Excess liquidity (-1))			-0.064	-0.014			-0.070*	0.088
			[0.011]	[0.547]			[0.010]	[0.299]
D(Excess liquidity (-2))			-0.008	0.031				
			[0.735]	[0.171]				
D(Excess liquidity (-3))			0.0138	-0.0060				
			[0.589]	[0.783]				
D(Excess liquidity (-4))			-0.0224	-0.0310				
			[0.368]	[0.177]				
D(Excess liquidity (-5))			-0.054*	-0.008				
			[0.027]	[0.711]				
Intercept	0.696*	1.621*	1.855*	1.212*	1.503*	3.127*	1.669*	3.559*
	[0.037]	[0.000]	[0.001]	[0.020]	[0.004]	[0.047]	[0.003]	[0.040]
Break	0.0488	0.626*	0.677*	0.417*	1.110*	-0.692	1.164*	-0.569
	[0.750]	[0.000]	[0.018]	[0.031]	[0.000]	[0.258]	[0.000]	[0.379]
D(Break)	1.364*	0.473**	0.561	0.489**	0.255	1.026*	2.146	1.222
	[0.000]	[0.087]	[0.008]	[0.060]	[0.448]	[0.047]	[0.961]	[0.251]
Long run Pass-Through Coefficients								
Discount rate	0.928*		0.489					
	[0.002]		[0.196]					
Required reserves					0.232*		0.210*	
					[0.000]		[0.000]	
Lending rate		-1.042		11.322		0.0524		-0.344
		[0.282]		[0.190]		[0.962]		[0.784]
D(Excess liquidity)			-0.448	2.577			-0.244	0.686
			[0.018]	[0.593]			[0.010]	[0.299]

Notes: Gray columns indicate the auxiliary regression showing the reverse direction of presumed relationship. No. of lags read as (dependent variables, policy/impact variable, excess liquidity). * and ** respectively indicates significance at 5 and 10 percent level. HQ and AIC indicates Hannan-Quinn and Akaike Information Criteria respectively. Long-run pass-through estimates are based on Equation 5.7.

Table A5.2 Estimates of Policy Impact on Deposit Rate

Model #	(3)	(3)	(4)	(4)	(9)	(9)	(10)	(10)
Dependent Variable	**Deposit rate**	**Discount rate**	**Deposit rate**	**Deposit rate**	**Deposit rate**	**Required reserves**	**Deposit rate**	**Required reserves**
Policy Tool	Discount rate	Discount rate	Discount rate	Discount rate	Required reserves	Required reserves	Required reserves	Required reserves
Liquidity Included	No	No	Yes	Yes	No	No	Yes	Yes
Lag Selection criteria	HQ	HQ	HQ	HQ	HQ	HQ	SBC	SBC
No of Lags	(4,4)	(4,4)	(1,1,1)	(1,1,1)	(1,1)	(1,1)	(1,1,1)	(1,1,1)
Deposit rate (-1)	0.633*	0.119	0.841*	0.150*	0.691*	0.034	0.806*	-0.284*
	[0.000]	[0.137]	[0.000]	[0.006]	[0.000]	[0.823]	[0.000]	[0.030]
Deposit rate (-2)	0.298*	0.220*						
	[0.021]	[0.021]						
Deposit rate (-3)	-0.036	-0.114						
	[0.784]	[0.249]						
Deposit rate (-4)	-0.050	-0.188*						
	[0.672]	[0.031]						
Discount rate (-1)	0.267**	0.866*	-0.052	0.676*				
	[0.069]	[0.000]	[0.613]	[0.000]				
Discount rate (-2)	-0.456*	-0.459*						
	[0.015]	[0.001]						
Discount rate (-3)	0.603*	0.300*						
	[0.001]	[0.033]						
Discount rate (-4)	-0.323*	0.097						
	[0.012]	[0.311]						
Required reserves (-1)					0.099*	0.861*	0.052*	0.927*
					[0.000]	[0.000]	[0.015]	[0.000]
D(Excess liquidity (-1))			-0.054	-0.044			-0.019	0.087
			[0.174]	[0.112]			[0.640]	[0.331]
Intercept	0.0307*	1.570*	1.320	2.137*	-0.648	3.152*	-0.158	3.148*
	[0.933]	[0.000]	[0.074]	[0.000]	[0.154]	[0.003]	[0.760]	[0.006]
Break Dummy	0.0289	0.647*	0.562	0.814*	0.967*	-0.769	0.533*	0.331
	[0.877]	[0.000]	[0.076]	[0.000]	[0.000]	[0.136]	[0.004]	[0.418]
D(Break)	0.790**	0.360*	0.110	0.086	-0.327	1.083	0.070	0.569
	[0.054]	[0.000]	[0.823]	[0.799]	[0.429]	[0.261]	[0.875]	[0.564]
Long run Pass-Through Coefficients								
Discount rate	0.586		-0.325					
	[0.200]		[0.613]					
Required reserves					0.322*		0.301*	
					[0.000]		[0.000]	
Deposit rate		0.196		0.464*		0.246		0.072
		[0.501]		[0.006]		[0.823]		[0.950]
D(Excess liquidity)			-.342	-0.135			-0.112	0.654
			[0.174]	[0.112]			[0.327]	[0.304]

Notes: Gray columns indicate the auxiliary regression showing the reverse direction of presumed relationship. No. of lags read as (dependent variables, policy/impact variable, excess liquidity). * and ** respectively indicates significance at 5 and 10 percent level. HQ and AIC indicates Hannan-Quinn and Akaike Information Criteria respectively. Long-run pass-through estimates are based on Equation 5.7.

Table A5.3 Estimates of Policy Impact on Exchange Rate Growth

Model #	(5)	(5)	(6)	(6)	(11)	(11)	(12)	(12)
Dep. Var.	**Exchange rate**	**Discount rate**	**Exchange rate**	**Discount rate**	**Exchange rate**	**Required reserves**	**Exchange rate**	**Required reserves**
Policy Tool	Discount rate	Discount rate	Discount rate	Discount rate	Required reserves	Required reserves	Required reserves	Required reserves
Liquidity Included	No	No	Yes	yes	No	No	Yes	Yes
Lag Selection	HQ	HQ	HQ	HQ	HQ	HQ	HQ	HQ
No. of Lags	(4,4)	(4,4)	(2,2,2)	(2,2,2)	(1,1)	(1,1)	(1,1,1)	(1,1,1)
Exchange rate (-1)	0.281*	0.029	0.201**	0.065*	0.079	-0.066	0.081	-0.066
	[0.008]	[0.296]	[0.079]	[0.013]	[0.485]	[0.450]	[0.473]	[0.456]
Exchange rate (-2)	0.338*	-0.055*	0.319*	-0.070*				
	[0.001]	[0.039]	[0.007]	[0.010]				
Exchange rate (-3)	-0.043	-0.012						
	[0.683]	[0.679]						
Exchange rate (-4)	-0.100	-0.074*						
	[0.327]	[0.005]						
Discount rate (-1)	-0.479	0.972*	-0.796**	1.070*				
	[0.238]	[0.000]	[0.096]	[0.000]				
Discount rate (-2)	-0.069	-0.501*	0.890*	-0.275*				
	[0.899]	[0.000]	[0.037]	[0.005]				
Discount rate (-3)	0.8964**	0.328*						
	[0.098]	[0.019]						
Discount rate (-4)	-0.389	0.047						
	[0.268]	[0.608]						
Required reserves (-1)					-0.334*	0.847*	-0.332*	0.847*
					[0.000]	[0.000]	[0.000]	[0.000]
D(Excess liquidity(-1))			0.123	-0.025			0.122	0.083
			[0.307]	[0.367]			[0.262]	[0.328]
D(Excess liquidity (-1))			-0.029	-0.002				
			[0.794]	[0.933]				
Intercept	0.213	1.422*	-0.988	1.836*	7.263*	3.637*	7.249	3.653*
	[0.845]	[0.000]	[0.663]	[0.001]	[0.000]	[0.003]	[0.000]	[0.003]
Break	0.038	0.485*	-0.413	0.737*	-1.030*	-0.743*	-1.126	-0.813*
	[0.948]	[0.001]	[0.677]	[0.001]	[0.001]	[0.002]	[0.001]	[0.002]
D(Break)	-0.503	0.565**	-0.077	0.312	0.320	0.969	0.812	1.307
	[0.675]	[0.068]	[0.957]	[0.336]	[0.780]	[0.278]	[0.503]	[0.167]
Long run Pass-Through Coefficients								
Discount rate	-0.078		0.196					
	[0.746]		[0.713]					
Required reserves					-0.363*		-0.362	
					[0.002]		[0.000]	
Exchange rate		-0.725*		-0.024		-0.434		-0.431
		[0.003]		[0.874]		[0.450]		[0.456]
D(Excess liquidity)			0.195	-0.132			0.133	0.541
			[0.567]	[0.471]			[0.262]	[0.328]

Notes: Gray columns indicate the auxiliary regression showing the reverse direction of presumed relationship. No. of lags read as (dependent variables, policy/impact variable, excess liquidity). * and ** respectively indicates significance at 5 and 10 percent level. HQ and AIC indicates Hannan-Quinn and Akaike Information Criteria respectively. Long-run pass-through estimates are based on Equation 5.7.

Table A5.4 Diagnostic Checks of the Estimated Relationship

Model #	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Dependent Variable	**Lending rate**		**Deposit rate**		**Exchange rate**		**Lending rate**		**Deposit rate**		**Exchange rate**	
D(Excess Liquidity) included	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Policy Instrument	Discount rate						Required reserves					
Serial Correlation	1.912	10.871	1.042	5.296	6.346	11.728	0.401	6.628	0.326	7.061	0.813	13.137
	[0.752]	[0.285]	[0.904]	[0.808]	[0.175]	[0.230]	[0.983]	[0.676]	[0.989]	[0.631]	[0.937]	[0.156]
Normality	1.644	0.339	18.198	16.060	200.357	135.919	40.221	76.551	28.066	24.231	48.892	32.721
	[0.440]	[0.844]	[0.001]	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
EV Stability Condition	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The serial correlation is tested using the LM test. For checking stability of VAR models, Eigen value stability conditions requires these calculated Eigen values to be should be strictly less than one (Lütkepohl, 2005). The normality of residuals is tested using the Jargue-Bera test. Table presents only the normality test for the main model where policy tool (and excess liquidity) affects the impact variables (lending rate, deposit rate, and exchange rate). Both test statistics are Chi-square test statistics.

Table A5.5 List of Symbols Used in Chapters 4 and 5

y_t	Series to be tested for unit roots
Δ	Changes in a variable
τ	Deterministic trend
μ_0	Intercept parameter
μ_1	Trend parameter
ρ	Coefficient of the unit root
γ	Coefficient of the lagged differenced dependent variable
p	Optimal number of lag length
ε_{it}	Error term
δ_m	Coefficient of the m^{th} break dummy
θ_m	Coefficient of the m^{th} pulse (change in break) dummy
T_{bm}	Break dates (m indicate the number of break)
υ_{it}	Error term in unit root models with structural breaks.
k	Truncated lag parameter determined in unit root test with breaks
T	Number of observations in time dimension
L	Lag operator
$\alpha_j(L)$	Lag polynomials
EL_t	Ratio of excess reserves to total deposits
X_t^1	Vectors of variables for voluntary excess liquidity holdings
X_t^2	Vectors of variables for involuntary excess liquidity holdings
v_t	Error term
$\hat{c}$	Intercept term for the model for excess liquidity.
a^s	Voluntary component of intercept
α^d	Involuntary component of lag dependent variable
α^s	Voluntary component of lag dependent variable
x_t^j	j^{th} regressor in the model
π_{EL}	Long-run dependent variable parameters in bound test
π_x	Long-run regressors parameters in bound test
$\gamma_k^{'}$	Short run regressor parameters in bound test
$\delta_k^{'}$	Short run parameters for dependent lag variable in bound test
$\psi^j{}_k$	Coefficients for any j^{th} regressor at lag k
α_k	Stickiness in the dependent variable at lag 'k'
$\hat{\beta}_i$	Long run pass-through coefficient
EL^s	Voluntary excess liquidity holdings
EL^d	Involuntary excess liquidity holdings
Z_t	Vector of (*nx1*) regressors with their k lags
ξ_t	Vector (*nx1*) unobservable zero mean white noise vector process

Figures

Figures for the kernel density estimates show the density estimates of residuals and a normally distributed data with similar features. Kernel density estimators, similar to histograms, approximate the density *f(x)* from observations on *x*. The data are divided into non-overlapping intervals, and counts are made of the number of data points within each interval.

Figure A5.1:Model 1 (Kernel Density Estimate)

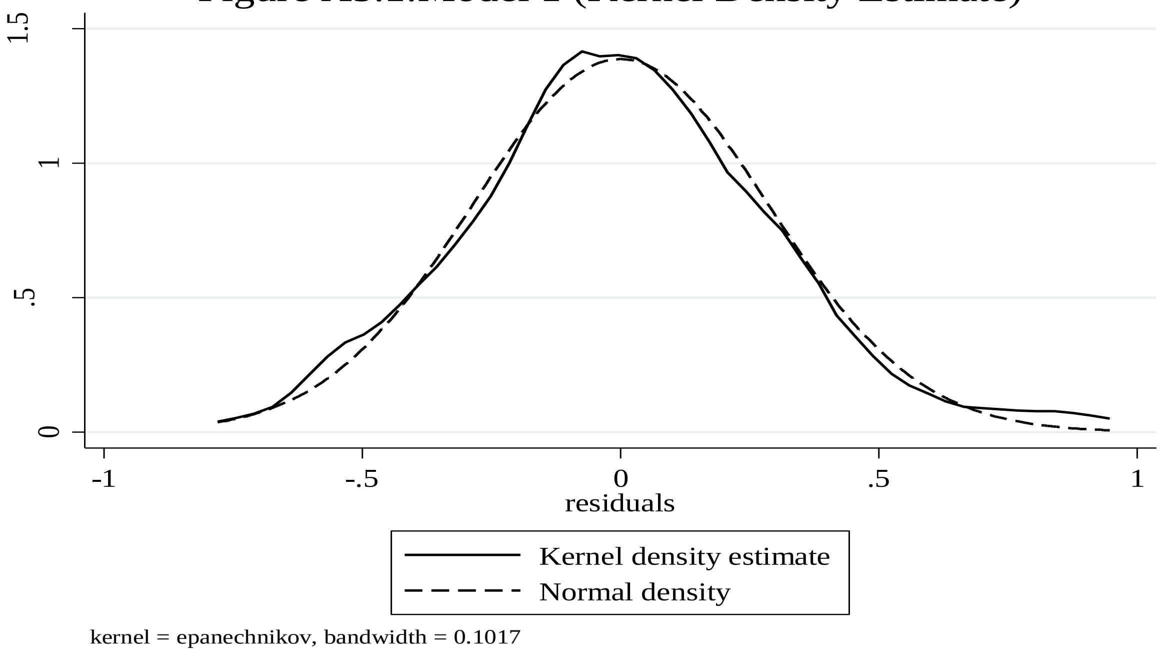
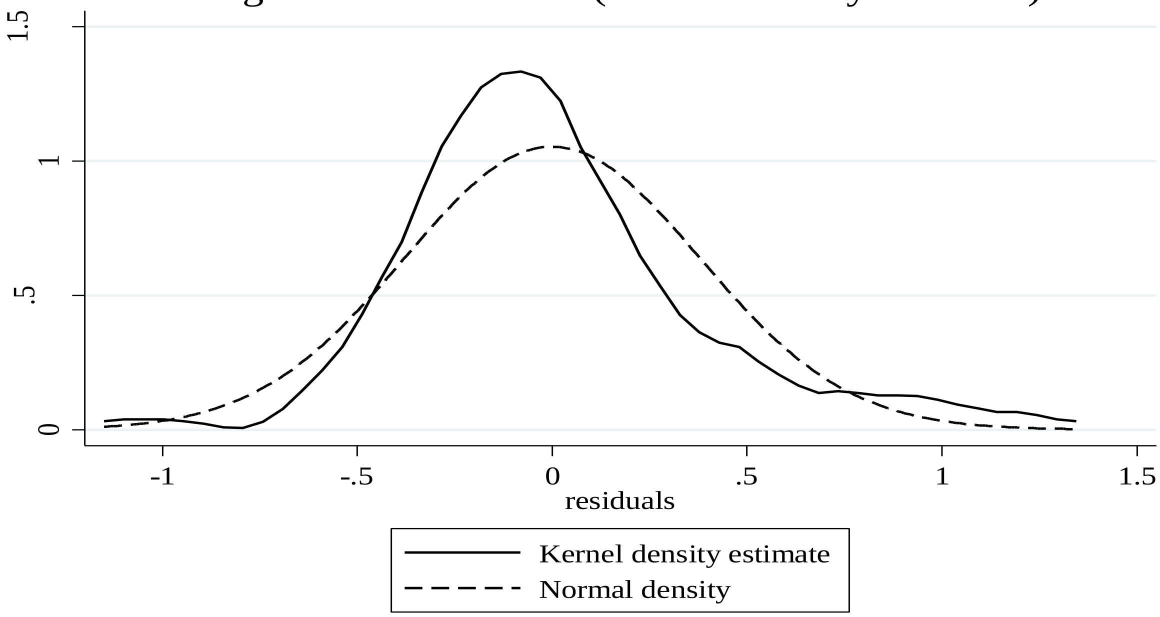
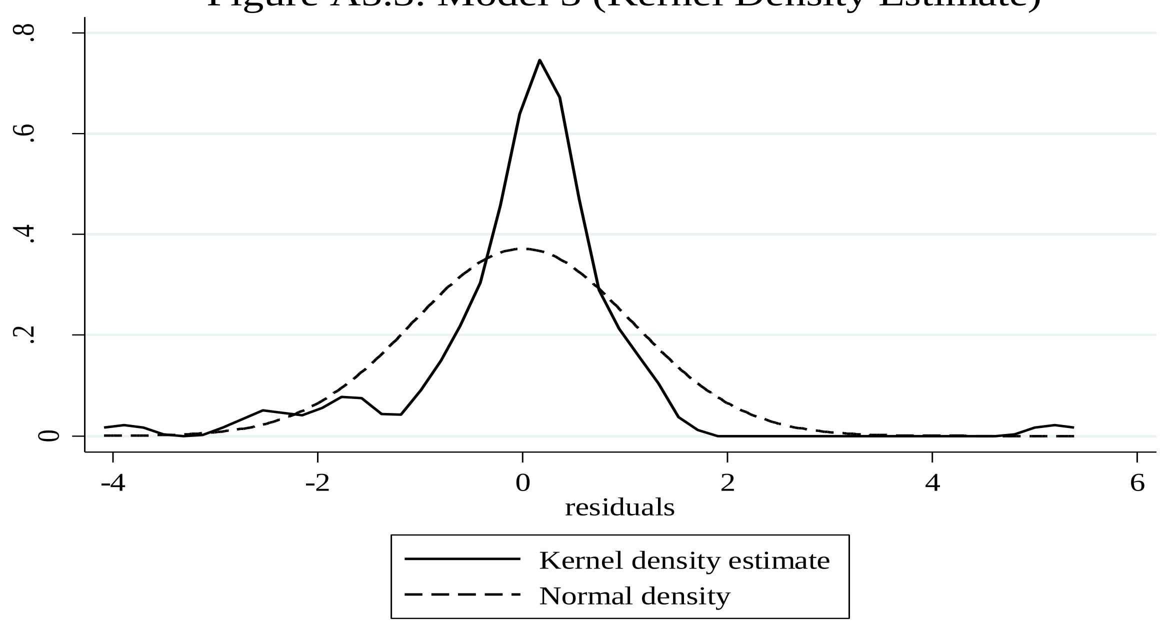


Figure A5.2: Model 2 (Kernel Density Estimate)



kernel = epanechnikov, bandwidth = 0.1029

Figure A5.3: Model 3 (Kernel Density Estimate)



kernel = epanechnikov, bandwidth = 0.1916

Figure 5.4: Model 4 (Kernel Density Estimate)

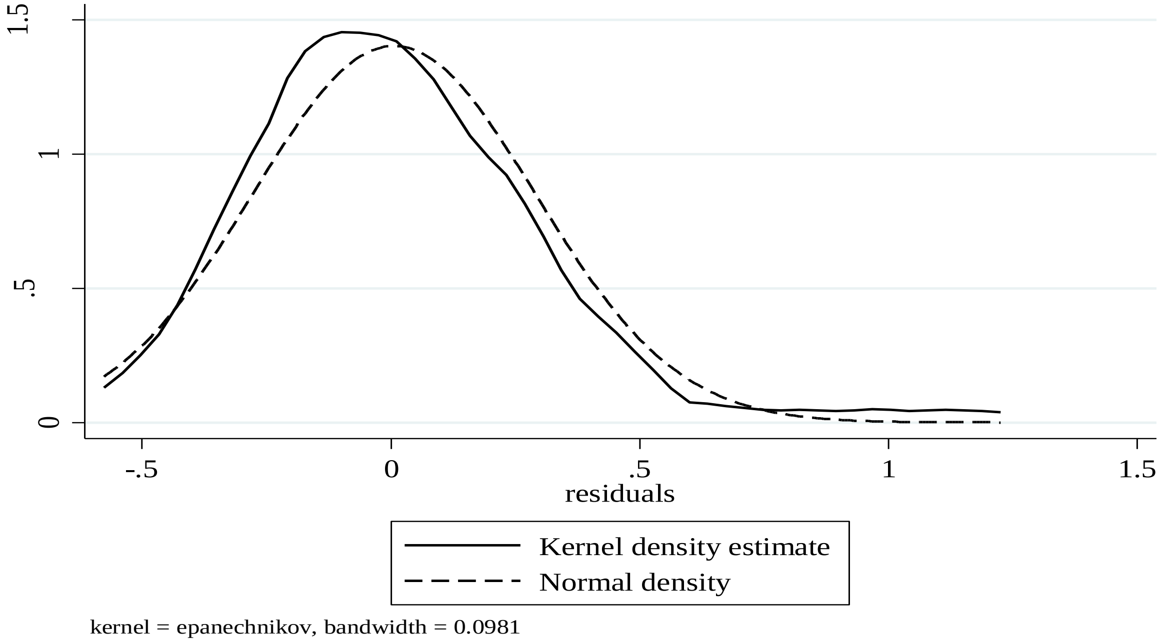


Figure A5.5: Model 5 (Kernel Density Estimate)

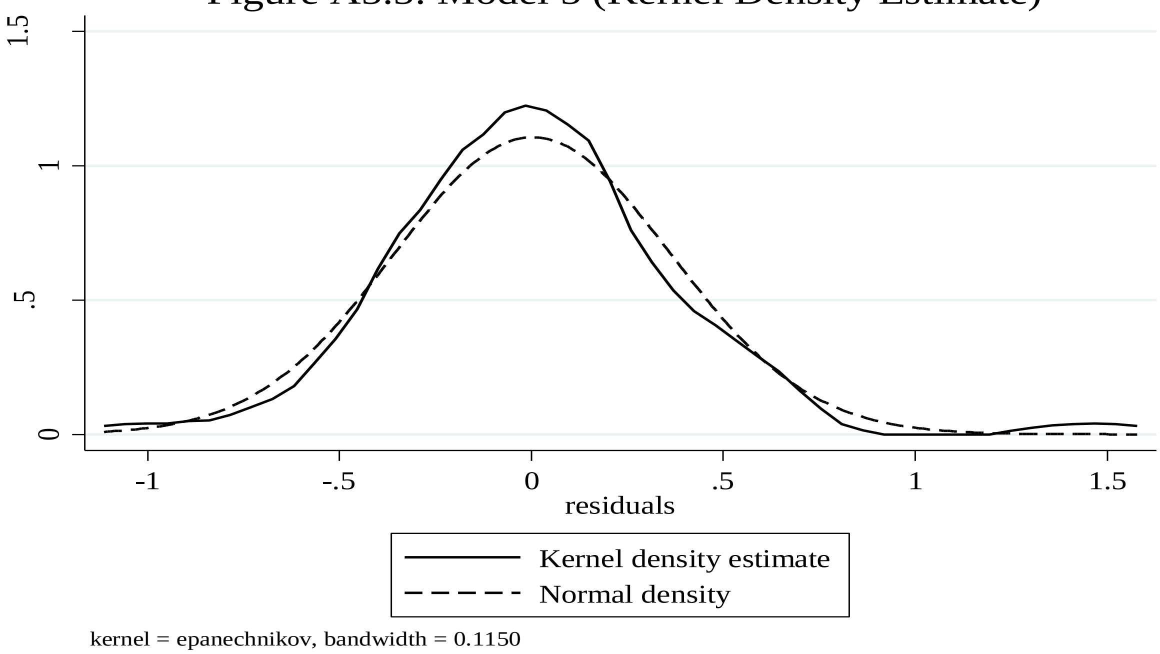


Figure A5.6: Model 6 (Kernel Density Estimate)

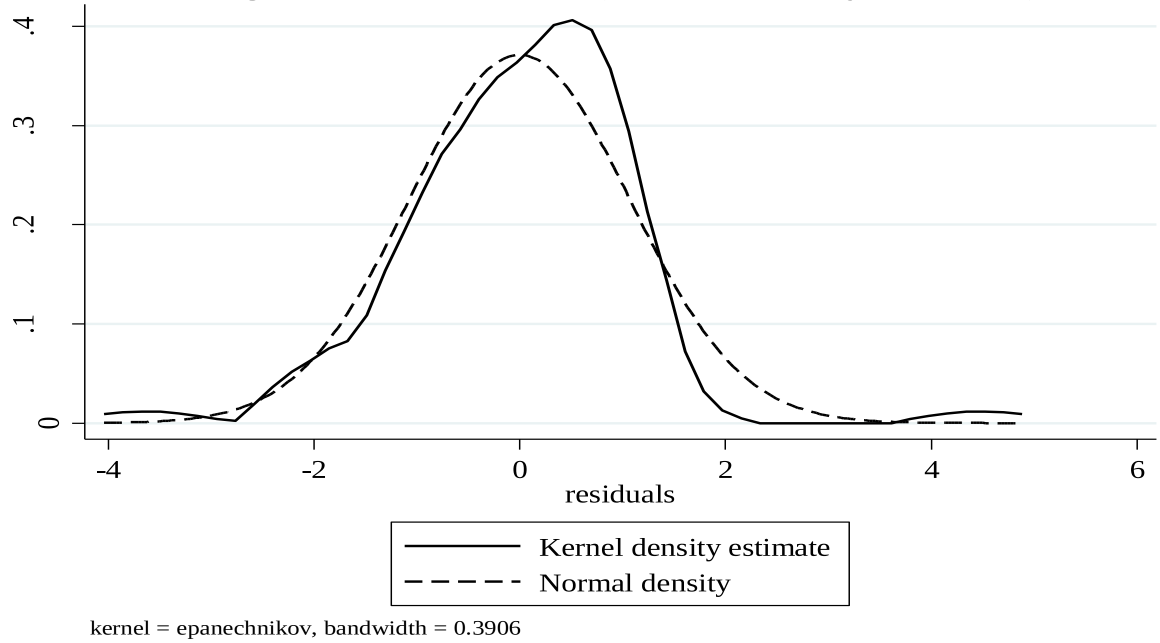


Figure A5.7: Model 7 (Kernel Density Estimate)

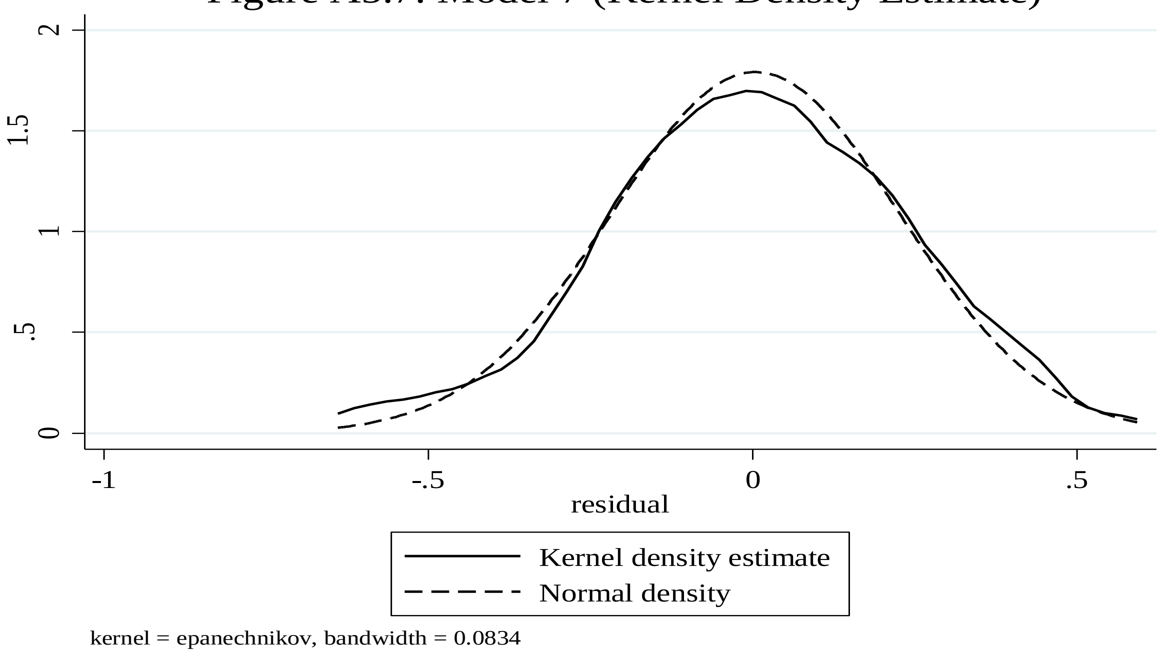
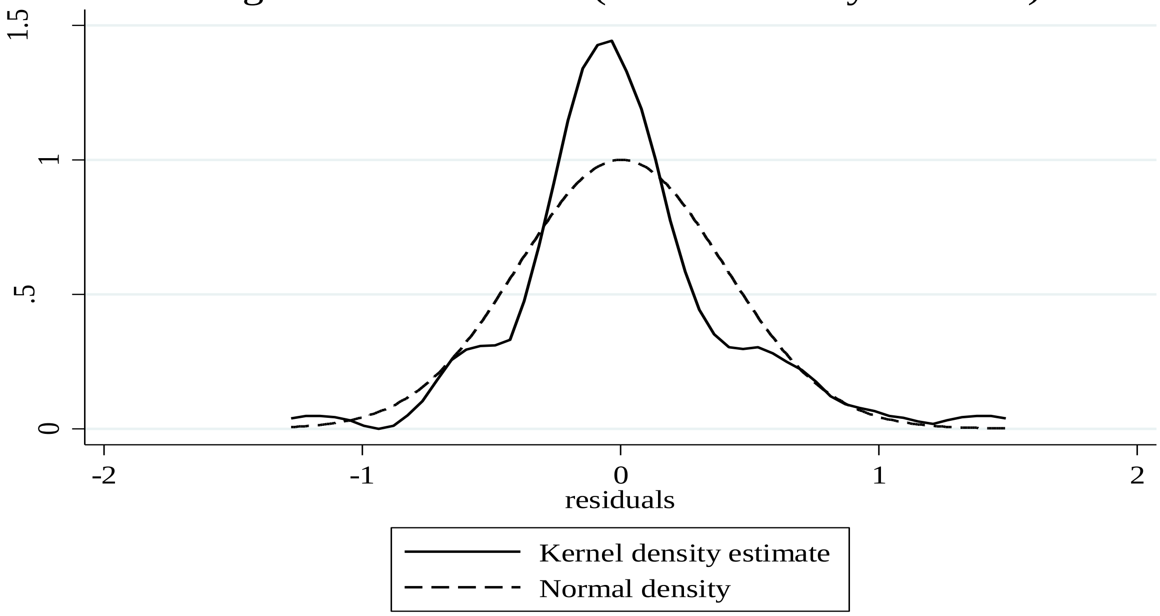
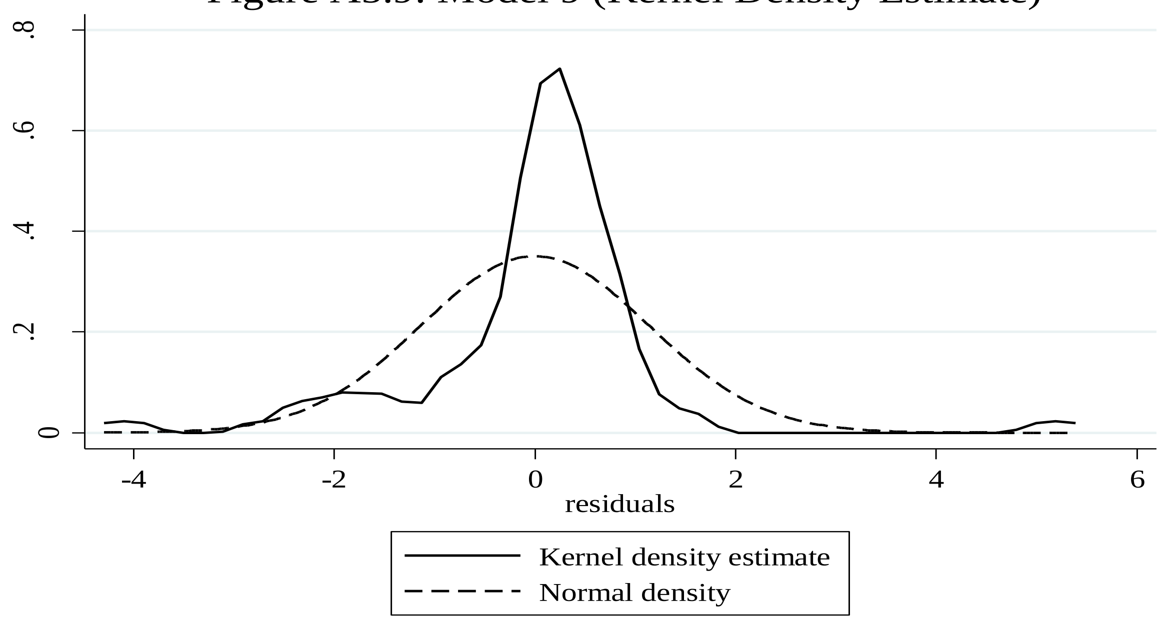


Figure A5.8: Model 8 (Kernel Density Estimate)



kernel = epanechnikov, bandwidth = 0.0957

Figure A5.9: Model 9 (Kernel Density Estimate)



kernel = epanechnikov, bandwidth = 0.2012

Figure A5.10: Model 10 (Kernel Density Estimate)

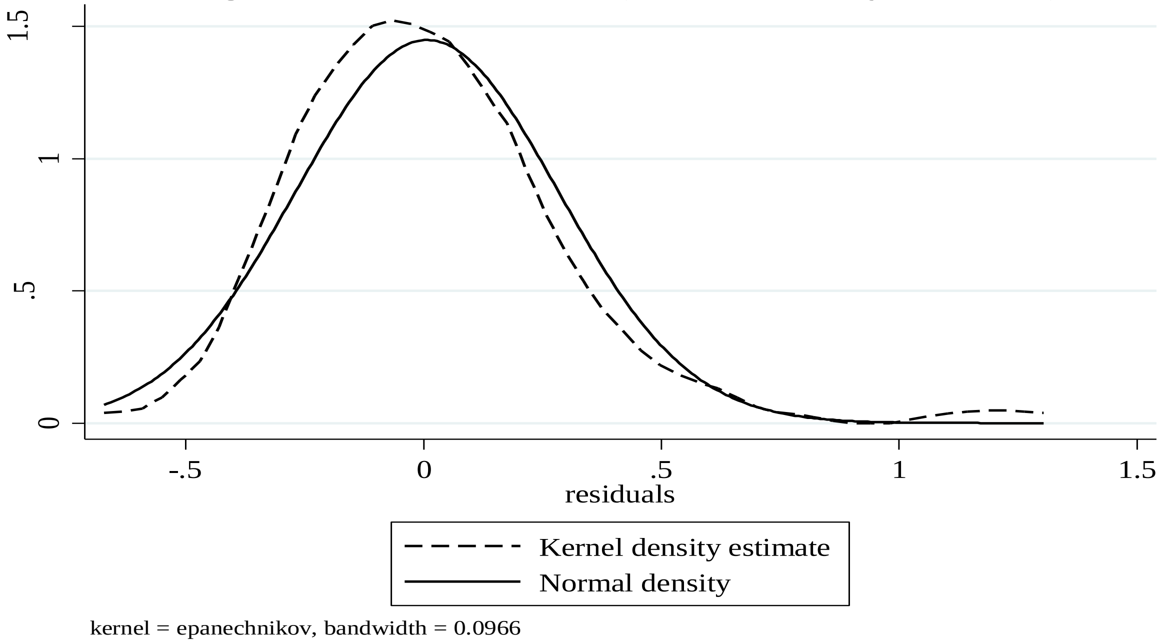


Figure A5.11: Model 11 (Kernel Density Estimate)

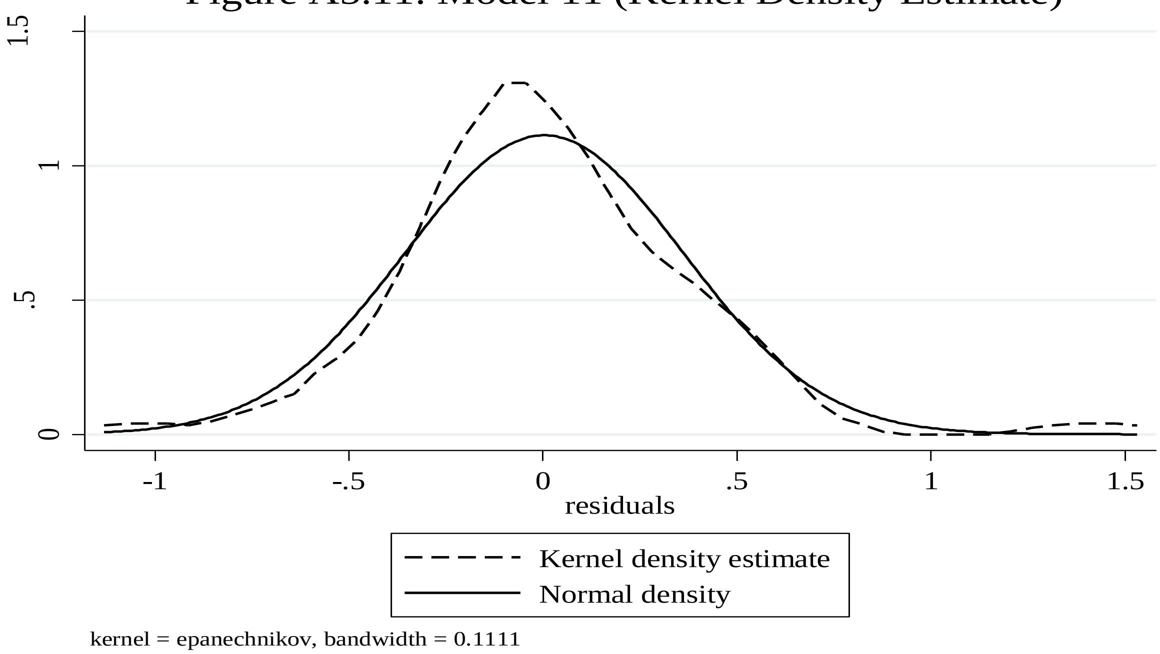
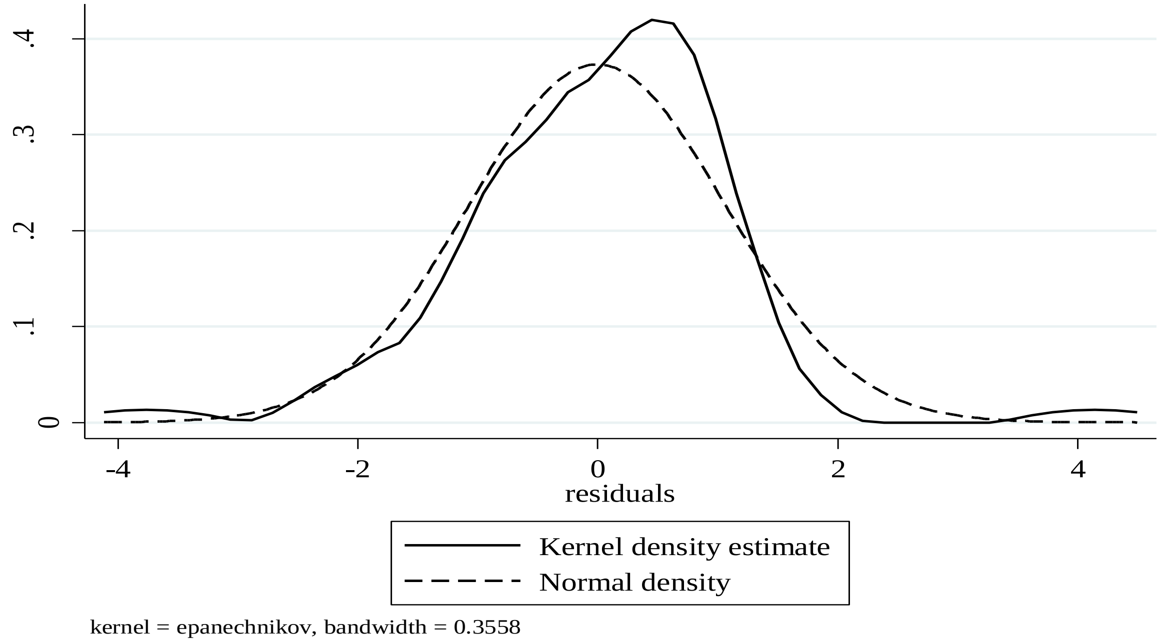


Figure A5.12: Model 12 (Kernel Density Estimate)



Chapter 6

Summary and Conclusions

6.1 Uncovered interest rate parity

Using LIBOR currency rates, the first part of this thesis addresses the following research question: does uncovered interest rate parity hold for short-term maturities? In the empirical investigation, we split this research question in two parts. We ask in Chapter 2: does UIP hold over short-run horizons for the LIBOR system of currencies? In Chapter 3 we ask: does UIP hold over short-run horizons for individual currencies in the LIBOR system of currencies? We argued that the LIBOR rates have minimal economic frictions and are more suitable for testing economic theories, such as UIP.

To address the research question of Chapter 2, we used block bootstrap panel unit root tests and panel cointegration tests. To estimate long-run relationships, we employed panel FM-OLS and DOLS estimators. The findings of Chapter 2 suggest that UIP holds for the LIBOR system of currencies for maturities 7 to 12 months. Moreover, similar to the findings of Bekaert *et al.* (2007) this chapter concludes that the speed of adjustment of the exchange rate in response to a shock to the LIBOR rates is independent of the maturity of underlying instruments.

To address the research question of Chapter 3 we used the SUR based dynamic GLS estimator proposed by Moon and Perron (2005). This method provides efficient individual currency specific estimates by exploiting the correlations between the currencies (in our case, Euro, US Dollar, Japanese Yen, British Pound, Australian Dollar, Canadian Dollar, and Swiss Franc). The key findings of Chapter 3 suggest that UIP holds over the short horizon for LIBOR currencies; both for individual currencies, and for the system of currencies. Specifically for the individual currencies, the results suggest that UIP hold for all currencies in 6 to 12 months maturities, except for the Japanese Yen and the Swiss Franc. For the Japanese Yen and the Swiss Franc, we find negative slope coefficients.

As discussed in Chapter 3, our results showing negative slope coefficients for Japanese Yen and Swiss Franc are related to the underlying negative interest rate differentials for these currencies. Therefore, our results find support for the view put forward by Bansal and Dahlquist

(2000), and Ballie and Kalic (2006) that deviations from UIP are state dependent, i.e., these deviations appear only when the US interest rate exceeds the foreign interest rate. Once we incorporate the negative interest rate differential, our results suggest that the UIP cannot be rejected for the Japanese Yen and the Swiss Franc.

Similar to Chapter 2, the results of Chapter 3 also suggest that UIP holds for the LIBOR system of currencies for 10 to 12 months maturities when all six currencies vis-à-vis the US Dollar are taken together. Our findings in Chapters 2 and 3 that UIP holds over the short-term horizon is an important addition to the existing literature which mostly rejected this hypothesis. In addition, the findings of Chapter 3 support Dornbusch's (1976) overshooting hypothesis for exchange rates, specifically for the Japanese Yen and the Swiss Franc. Dornbusch (1976) showed that a monetary expansion in an economy induces an immediate depreciation of its currency in excess of its long-run equilibrium value. Our results suggest that 'state dependence' could also be instrumental in explaining exchange rate overshooting. However, this insight needs further analysis and we left it for future research.

Chapters 2 and 3 helped us to arrive at more general conclusions. For instance, our results suggest that both market specific heterogeneity and cross currency correlations play an important role in empirical tests of the uncovered interest rate parity hypothesis. Both non-similarity in transaction costs and immobility of capital between markets promotes market heterogeneity. Also, we find that it is important to consider a wide array of maturities. Had we only considered maturities of 3 and 6 months, say, as most previous studies did, we would have ended up with the conclusion that UIP does not hold for the short-term horizon. Finally, this thesis shows that LIBOR can be used for meaningful international monetary economic analysis subject to the choice of the proper technique. In quantitative finance, LIBOR has been used as input for pricing financial derivatives and determining hedging strategies for investors who hold them. In contrast, LIBOR is hardly used by researchers in macroeconomics.

Recently, allegations of LIBOR manipulation by some banks were put forward. However, the statistical support for LIBOR manipulation is not very convincing. Although the findings of Snider and Youle (2010) substantiate LIBOR manipulation, Abrantes-Metz *et al.* (2012) report only some evidence of anticompetitive market behavior by the participating banks. Kuo *et al*. (2012) also find some deviations of LIBOR from other borrowing rates like bid rates at Federal Reserve Term Auction Facility and term borrowing from Fedwire payment data, without emphasizing that this resulted in a misreporting of LIBOR. The results of Monticini and Thornton (2013) suggest that the underreporting of the LIBOR rates by some banks reduced the reported LIBOR rates, specifically for the 1 and 3 months maturities.

As possible LIBOR manipulation may also have affected our results, we experimented with the sample size by extending the data beyond 2008 (for details, see Chapter 2 Section 2.5). The results of panel unit root tests on the extended sample suggest that the difference stationary behavior of the interest rate differential series remain unchanged when sample is extended to 2010 or (May) 2013. In contrast, the data generating process of the exchange rate differentials series changes with the sample size. If the sample is extended to 2010, only three maturities show the difference stationary behavior compared to six maturities reported for the 2001-2008 sample. If the sample is extended to May 2013, none of the exchange rate differentials series show difference stationary behavior.

The changed behavior of exchange rate series and the unchanged behavior of the interest rate series lead us to two important conclusions. First, the unchanged data generating process as of the interest rate series shows that the alleged LIBOR manipulation does not affect the findings of our study. As discussed above, the literature showing statistical support for LIBOR manipulation is also not conclusive.

Second, findings for the exchange rates series is consistent with the view that the industrialized economies are intervening in foreign exchange markets. The policy of quantitative easing adopted by the Federal Reserve Board not only inundated the US domestic market with liquidity but also caused funds to flow to other industrialized countries as well as to emerging economies. It is not surprising that these economies are taking measures to keep themselves competitive. This result also supports the choice to restrict our sample to 2008 because of the global financial crisis.

6.2 Interbank Liquidity and Monetary Policy in Pakistan

The second part of this thesis (Chapters 4 and 5) investigated the causes of excess liquidity in the interbank market of Pakistan, and its impact on the monetary policy transmission in Pakistan. Chapter 4 addresses the following research question: what factors contribute to the excess interbank liquidity accumulation in the interbank market of Pakistan? Chapter 5 assesses the impact of excess liquidity on monetary policy transmission in Pakistan. Specifically, Chapter 5 asks the questions: 1) what is the impact of the main policy tools of the SBP on retail rates and the exchange rate? and 2) does excess interbank liquidity affect the monetary transmission mechanism, i.e., the pass-through of the policy tools to the retail rates and the exchange rate?

In Chapter 4 we have used the bound testing procedure for detecting the long-run relationship between excess liquidity and its determinants. For the estimation of short-run and long-run relationships we used the Auto Regressive Distributed Lags (ARDL) approach. Our empirical investigation identifies a number of variables contributing to excess interbank liquidity, such as deficit financing, foreign currency deposits, discount rate, volatility in the overnight rate, and industrial production. Also, our results point to the deficit financing by the central bank and non-banks for explaining persistence in interbank liquidity. The determinants of excess liquidity were then separated into voluntary and involuntary liquidity components. The key finding suggests that the interbank market in Pakistan has experienced a structural shift in June 2008. Before June 2008, low credit demand was driving (involuntary) excess liquidity holdings by banks. After June 2008, banks' precautionary investments in risk free securities drive their (voluntary) liquidity holdings.

This permanent shift of the banking sector towards holding government securities is not healthy. As discussed in Chapter 4, if the banking sector experiences a structural shift towards holding more risk free assets, the economy may get adversely affected. Mohanty *et al.* (2006) argue that inflationary expectations fuelled by government borrowing may further increase interest rates. A large stock of government securities in the banking sector pushes up the risk premium on sovereign debt, which could also lead to a sharp increase in the interest rate charged to private sector borrowers. A high interest rate environment generally leads to the crowding out of private sector investments. Thus in the long run, the economy's ability to generate higher savings as well as to borrow from external sources at lower cost deteriorate, which also limits its ability to invest in human capital. Moreover, the stock of government securities increases the borrowing ability of banks from central bank and thus causes an increase in excess liquidity in the interbank market. Persistent excess interbank liquidity may undermine the effectiveness of monetary policy.[95]

[95] For more detailed discussions, see Nissanke and Aryeetey (1998), Agénor *et al.* (2004), Saxegaard (2006), and Agénor and Aynaoui (2010).

Therefore, as a follow up, Chapter 5 investigates the impact of excess liquidity on monetary transmission in Pakistan using the Vector Auto Regressions (VAR) methodology. The main findings of Chapter 5 suggest that excess liquidity significantly affect the pass-through of the policy tools to the lending rate. Excess liquidity has no long-run effect on the pass-through of the policy tools to deposit rate and (growth of) exchange rate. Moreover, the pass-through of the discount rate to the lending rate is complete but it is incomplete for required reserves. Furthermore, only changes to required reserves have an effect on the deposit rate and the exchange rate in the long run.

Our research contributes to the literature on excess liquidity and monetary policy pass-through in a number of ways. To the best of our knowledge, the nature of excess liquidity in the interbank market of Pakistan has never been assessed earlier. Neither has the empirical literature on developing economies made any direct assessment of the impact of interbank liquidity on the monetary policy transmission mechanism. Previous studies on non-industrial countries, such as Egert and MacDonald (2009) and Gigineishvili (2011), evaluate the impact of interbank liquidity indirectly (for details, see Chapter 5).

Moreover, we have examined not only the transmission of changes in the discount rate, but also the transmission of changes in reserve requirements. Previous empirical studies have largely ignored the pass-through of required reserves as a monetary policy tool, as they are not changed very frequently. Currently, reserve requirements on banks in Pakistan are based on time and demand liabilities separately, which produced sufficient variability in this policy tool to be used for a meaningful economic analysis.

Furthermore, in addition to the transmission of shocks from policy tools to retail interest rates, we also have examined the transmission of these shocks to the exchange rate. The impact of the changes in the policy tools on the exchange rate was completely ignored in previous studies on Pakistan. The SBP, like other central banks, does not pay attention to the exchange rate specifically. However, central banks' interest in the exchange rate developments is well documented by McKinnon (1995), Clarida and Gertler (1997), and Clarida (2001) The use of monetary policy tools in tandem with the speculative pressure on the Pakistan Rupee-US Dollar exchange rate often creates the impression that the SBP uses a *de facto* fixed exchange rate policy. This thesis shows that only required reserves has an impact on the exchange rate which is likely to bring clarity in understanding the exchange rate channel of monetary policy pass-through in Pakistan.

It is important to point to some caveats. First, the interbank market involves other players like microfinance banks, and non-bank financial institutions in addition to commercial banks. However, in view of their low shares in the interbank market, their excess liquidity positions are unlikely to affect our conclusions. Moreover, Chapter 5 has considered only positive changes to the policy tools assuming that the negative changes will have similar effect on our symmetric models. The literature on monetary policy pass-through suggests that pass-through is often different for positive and negative changes in the policy tools. As our data primarily refer to a period with monetary tightening, we leave this issue of asymmetric pass-through of policy tools for future research.

Given our findings in the second part of this thesis, we suggest reducing the government budget deficit and to limit borrowing, especially from the central bank, in order to reduce liquidity inflow in the interbank market. We consider the recent legislative move aimed at limiting the government's borrowing as a step in the right direction. However, further steps are necessary, such as capping the government's debt.

Finally, further liberalization of the foreign exchange market aimed at increasing the access of domestic banks to international financial markets could be helpful in enhancing banks' foreign exchange management. A better ability of banks to manage their foreign exchange inflows may help the SBP to move from a managed float to a free floating exchange rate regime. All this could help in reducing the liquidity glut in the interbank market of Pakistan which is essential for increasing the efficacy of monetary policy.

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Samenvatting

Dit proefschrift behandelt twee geselecteerde onderwerpen uit het gebied van de internationale monetaire economie, namelijk ongedekte rente pariteit (UIP) en overtollige liquiditeit in de interbancaire geldmarkt van Pakistan.

Het eerste deel van dit proefschrift onderzoekt UIP op basis van de op de interbancaire markt in Londen aangeboden rentes (LIBOR). Volgens de UIP hypothese wordt het verschil in het rendement op identieke activa uit twee verschillende landen volledig gecompenseerd door het verschil in de verwachte wisselkoers op de tijdstippen waarop de rentedragende activa worden gekocht en verkocht.

In het algemeen wordt UIP niet bevestigd voor geïndustrialiseerde economieën voor de korte termijn horizon als gevolg van fricties, zoals uiteenlopende risicopercepties, transactiekosten, en de aanwezigheid van zogenoemde ‘noise traders’. Tot op heden is echter geen enkele studie ingegaan op de onderzoeksvraag of UIP opgaat als deze fricties minimaal zijn. De Londen interbancaire marktrentes, met een minimum aan economische fricties, bieden de gelegenheid om deze onderzoeksvraag te beantwoorden. Gebruikmakend van London Interbank Offered Rates richt het eerste deel van dit proefschrift zich op de volgende onderzoeksvraag: gaat UIP op voor leningen met een korte looptijd? In het empirisch onderzoek splitsen we deze onderzoeksvraag in twee delen. Wij vragen in hoofdstuk 2 of UIP geldt op de korte termijn voor het systeem van LIBOR valuta's. In hoofdstuk 3 vragen we: gaat UIP op de korte termijn op voor individuele LIBOR valuta's?

De bevindingen van hoofdstuk 2 suggereren dat UIP geldt voor het systeem van LIBOR valuta’s voor leningen met een looptijd van 7 tot 12 maanden. Bovendien blijkt in dit hoofdstuk dat de snelheid van de aanpassing van de wisselkoers in reactie op een schok los staat van de looptijd van de onderliggende instrumenten. Uit de resultaten van hoofdstuk 3 blijkt dat UIP ook geldt voor individuele LIBOR valuta's voor leningen van met een looptijd van 10 tot 12 maanden, wanneer alle zes valuta's ten opzichte van de US Dollar gelijktijdig worden geanalyseerd. De bevindingen in hoofdstukken 2 en 3, namelijk dat UIP opgaat voor leningen met een korte looptijd, is een belangrijke aanvulling op de bestaande literatuur die meestal deze hypothese verwerpt. Daarnaast ondersteunen de resultaten van hoofdstuk 3 de opvatting van Bansal en Dahlquist (2000) en Ballie en Kalic (2006) dat afwijkingen van UIP zich voordoen wanneer de Amerikaanse rente hoger is dan de buitenlandse rente. Zodra rekening wordt gehouden met dergelijke renteverschillen, suggereren onze resultaten dat UIP niet voor de Japanse yen en de Zwitserse frank kan worden afgewezen.

Het tweede deel van dit proefschrift is gerelateerd aan internationale monetaire economie in termen van instroom van kapitaal. Net als andere ontwikkelingslanden en opkomende

economieën, kreeg Pakistan te maken met een stijging van de instroom van kapitaal na de wereldwijde financiële crisis. Tegelijkertijd kenmerkte de interbancaire markt van Pakistan zich door een ongekende opeenstapeling van overtollige liquiditeit. Het tweede deel van dit proefschrift onderzoekt de aard van de overtollige liquiditeit in de interbancaire markt en de impact ervan op de transmissie van het monetaire beleid in Pakistan. Het onderzoek op overtollige liquiditeit is niet beperkt tot de instroom van kanaal, maar heeft ook betrekking op andere vraag- en aanbodfactoren, zoals de financiering van het begrotingstekort van de overheid en liquiditeitsrisico's.

Hoofdstuk 4 richt zich op de volgende onderzoeksvraag: welke factoren dragen bij aan de accumulatie van overtollige liquiditeit in de interbancaire markt van Pakistan? Hoofdstuk 5 evalueert de impact van overtollige liquiditeit op de transmissie van het monetaire beleid in Pakistan. Specifiek, behandelt dit hoofdstuk de volgende vragen: 1) wat is de impact van de belangrijkste beleidsinstrumenten van de centrale bank van Pakistan op de retail tarieven en de wisselkoers? 2) heeft overtollige interbancaire liquiditeit invloed op de monetaire transmissiemechanisme, dat wil zeggen, de doorwerking van de beleidsinstrumenten op de retail-interest en de wisselkoers?

Ons empirisch onderzoek identificeert een aantal variabelen die bijdragen aan overtollig interbancaire liquiditeit, zoals de financiering van overheidstekorten, vreemde valuta deposito's, de disconteringsvoet, de volatiliteit van de daggeldrente, en de industriële productie. Onze resultaten wijzen op de financiering van het overheidstekort door de centrale bank en niet-banken als verklaring van de persistentie in de interbancaire liquiditeit. De determinanten van overliquiditeit zijn vervolgens gescheiden in vrijwillige en onvrijwillige liquiditeitscomponenten. De belangrijkste bevinding is dat de interbancaire markt in Pakistan een structurele verschuiving in juni 2008 heeft ervaren. Vóór juni 2008 was sprake van een geringe kredietvraag waardoor (onvrijwillige) liquiditeitsoverschotten bij banken ontstonden. Na juni 2008 leidden investeringen van banken in risicovrije effecten (staatsobligaties) ertoe dat ze vrijwillig liquiditeiten aanhouden. Deze permanente verschuiving van de bancaire sector in de richting van die staatsobligaties is niet gezond. Een grote voorraad van staatsobligaties in de bancaire sector duwt de risicopremie op de overheidsschuld op, die ook kan leiden tot een sterke stijging van de rente voor particuliere kredietnemers, hetgeen kan leiden tot verdringing van investeringen door de particuliere sector. Bovendien kan aanhoudende overtollige interbancaire liquiditeit de effectiviteit van het monetaire beleid ondermijnen.

De bevindingen van hoofdstuk 5 suggereren inderdaad dat het interbancaire liquiditeitsoverschot een significante invloed heeft op de doorwerking van de beleidsinstrumenten op de beleningsrente. Daarentegen heeft het liquiditeitsoverschot geen lange termijn effect op de doorwerking van de beleidsinstrumenten op (de groei van) de wisselkoers. De doorwerking van de disconteringsvoet op de beleningsrente is compleet, maar het is onvolledig voor de vereiste reserves. Bovendien, hebben wijzigingen in verplichte reserves alleen op de lange termijn een effect op de depositorente en de wisselkoers.