ANALYSIS OF FIXED INCOME SECURITIES IN AN EMERGING MARKET

A Ph.D. Dissertation

by

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Department of Management

İhsan Doğramacı Bilkent University

Ankara

May 2016

To my family for their continued support, to Starbucks for its prolificacy-boosting ambience and to Tom Waits for his relaxing music

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Graduate School of Economics and Social Sciences
of
İhsan Doğramacı Bilkent University

by

GÜRSU KELEŞ

In Partial Fulfilment of the Requirements for the Degree of
DOCTOR OF PHILOSOPHY IN MANAGEMENT

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ANKARA

May 2016

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Doctor of Philosophy in Management.

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ABSTRACT

ANALYSIS OF FIXED INCOME SECURITIES IN AN EMERGING MARKET

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May 2016

This thesis intends to analyze the yields of fixed income securities in an emerging market, Turkey. To this end, an international macroeconomic model is set up to capture the stylized facts in the interest rate dynamics of the local currency emerging country bonds while reconciling business cycle facts. The study also empirically analyzes the fundamentals that drive the wedge between the local currency government bond yield curve and the swap curve to better understand the fair pricing in an emerging country fixed income market. The thesis also introduces a novel methodology to extract the liquidity premium and inflation risk premium in Turkish lira denominated government bond yields. For robustness check, the proposed liquidity premium extraction methodology is applied to the US bond market.

Keywords: Bond Pricing, Cross Currency Swaps, Fixed Income Securities, Inflation Linker Securities, Liquidity Premium.

ÖZET

GELİŞMEKTE OLAN BİR PİYASADA SABİT GETİRİLİ KIYMETLERİN ANALİZİ

Keleş, Gürsu

Doktora, İşletme Bölümü

Tez Yöneticisi: Doç. Dr. Levent Akdeniz

Mayıs 2016

Bu tez, gelişmekte olan bir ülke olan Türkiye'de sabit getirili kıymetlerin getirilerini analiz etmeyi amaçlamaktadır. Bu bağlamda, gelişmekte olan ülke yerel para cinsi tahvil faizlerinde gözlenen olguları ve iş çevrimlerini aynı anda modelleyen uluslararası bir makroekonomi modeli kurulmuştur. Çalışma ayrıca gelişmekte olan ülke sabit getiri piyasasındaki makul fiyatlamaya dair bilgimizi geliştirme amacıyla, yerel para cinsi devlet tahvilleri getiri eğrisi ve takas faiz eğrisi arasındaki farkı ortaya çıkartan etmenleri ampirik olarak analiz etmektedir. Ek olarak tez, Türk lirası cinsi devlet tahvil getirilerinde var olan likidite ve enflasyon risk primini elde etmeye yarayan özgün bir ampirik metodoloji tanıtmaktadır. Sağlamlığının testi amacıyla, tanıtılan bu özgün metot ABD tahvil piyasasına da uygulanmaktadır.

Anahtar Kelimeler: Çapraz Kur Takası, Enflasyona Endeksli Kıymetler, Likidite Primi, Sabit Getirili Kıymetler, Tahvil Fiyatlaması.

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1. CHAPTER I

INTRODUCTION

Recently, emerging market economies have been the primary drivers of the global growth. Investing in the emerging economies' local currency debt instruments is a way of getting exposure to the high returns that these economies offer. Investors are looking for ways to access these debt instruments not only for their high returns but also for diversification purposes.

Understanding the underlying fundamentals that drive the return in these markets is essential in identifying the associated risks of investing in these markets. With a special interest in Turkey, this thesis aims to shed light on the factors that affect the yields on the emerging local-currency debt instruments.

International macroeconomic models have been commonly used to address the several features of the world economy since the work of Backus, Kehoe and Kydland (1992, 1995). However, those multi-country models cannot fully explain the interest rate dynamics of the emerging countries. It has been documented that the emerging country bond premium is countercyclical with respect to the output and highly volatile when compared to the developed country bond premium. Neumeyer and Perri (2005), and Uribe and Yue (2006) report the counter-cyclicality of the interest rates for several emerging countries including Argentina, Brazil, Ecuador, Mexico, Peru, Philippines, and South Africa. Both of these studies take interest rates as exogenous and try to measure the contribution of the real interest rate fluctuations to emerging economy output volatility. Reduced form financial frictions (i.e. working capital channel and country premium that depend on macroeconomic fundamentals) act as amplifier for the productivity shocks in these studies.

It is hard for the standard international macroeconomic models to predict these observed facts while reconciling other emerging country business-cycle patterns simultaneously. There are studies which allow the interest rates to be endogenously determined by the emerging country fundamentals (Aguiar & Gopinath, 2008; Arellano, 2008; García-Cicco, Pancrazi, & Uribe, 2010). Arellano (2008) shows that if the cost of default is countercyclical, a small open economy model is able to explain the level and the volatility of the bond premium. Yue (2010) argues that if there is debt negotiation after the default, it is possible to obtain volatile bond premia. Mendoza and Yue (2011) write a general equilibrium model of default and business cycles and show that their model explains several features of the emerging country data. One common property of these aforementioned models is the importance of the default probabilities in deriving first and second moments of the bond premia. Gourinchas, Rey and Govillot (2011) show that US borrows at a lower rate than it lends and that there is a significant premium between the emerging country and US bonds. They call the premium that is collected by the US as the "exorbitant privilege."

Not all studies in the literature resort to financial frictions to match the emerging economy business cycle facts. Aguiar and Gopinath (2007) show that shocks to the trend of the emerging output sufficiently match the stylized facts of the emerging economy business cycles.

Recent literature focuses on micro-founded (firm level) default mechanisms in order to fill the gap between the standard business cycle models and the observed facts for the interest rate dynamics of the emerging economies. Akinci (2013) presents a framework within which stationary productivity shocks are augmented with firm-level financial frictions in the form of financial accelerator a la Bernanke, Gertler, and Gilchrist (1999). Akinci (2013) is able to get countercyclical interest rates and volatile country risk premium. She also reports that the introduction of the financial frictions terminates the importance of non-stationary shocks in deriving the fluctuations in the emerging country business cycle. A more recent paper, by Fernandez and Gulan (2015), shows that it is possible to match the emerging economy interest rate dynamics (and several emerging business cycle dynamics as well) by introducing micro-founded financial frictions to an otherwise standard small open economy model. They model the emerging country interest rates as a function of the default risk of the corporates. They show that a mechanism, which involves a financial accelerator type of amplification through leveraged corporates, accounts well for the interest rate dynamics and some of the main business-cycle patterns in emerging economies. One notable outcome of the model is the estimated persistence of the productivity shock: the model can yield high consumption volatility when the persistence of the productivity shock is close to one. Authors read this as a sign for the existence of frictions that are orthogonal to the financial accelerator mechanism studied in the paper.

These mentioned studies mainly employ representative agents and do not take into account the dynamics that arise due to the interactions among heterogeneous agents. However, as Becker and Mulligan (1997) assert, there are reasons to be susceptible about the representative agent assumption. In their own Becker and Mulligan’s own words; "In many endogenous growth models, preferences are constant across countries, while technologies and therefore rates of return vary. With cross-country differences in rates of return, there must be either large international capital flows or strong barriers to those flows" (Becker & Mulligan, 1997 : 749).

Studies exist in the literature that employ different types of preference heterogeneity both within the same country households and across different country households. For instance, Guvenen (2009) shows that different elasticity of intertemporal substitution among economic agents and limited stock market participation can explain the equity premium puzzle. Borri and Verdelhan (2011) employ trend shocks, default and a time-varying risk aversion in a developed and emerging country set up. They get positive amounts of spread if the endowment processes of developed and emerging countries are assumed to be positively correlated. Gourinchas et al. (2011) also use a model with heterogeneity in risk aversion and find that just the variation in risk aversion or sizes alone is insufficient to generate spreads similar to the data.

There are also studies that employ time preference heterogeneity across emerging and developed country households. Differences in the level of institutional development, reflected in the form of government impatience (as cited in Aguiar, Amador, & Gopinath, 2009; Aguiar & Amador, 2011), or higher risk of expropriation due to the lack of well-established rule of law in emerging countries may force emerging country households to act more impatiently.

The literature presents empirical evidence of the existence of the time preference heterogeneity within the same country and the same age group. Lawrence (1991) estimates high permanent income earners to be more patient than low permanent income earners. Gourinchas and Parker (2002), and Cagetti (2003) report time preference heterogeneity across households with high and low education levels within the same country and the same age group. That said, to the best of our knowledge, there is no empirical evidence of the existence of the time preference heterogeneity across two different country households.

This thesis aims to fill the gap in the literature by explaining observed emerging country interest rate dynamics while reconciling other emerging country business-cycle patterns. For this purpose, it proposes a two-country international macroeconomics model, equipped with time preference heterogeneity. The results of this model, presented in the second chapter, reveal that a standard two-country international macroeconomic model's ability to match the emerging economy interest rate dynamics drastically improves when time preference is assumed to be heterogeneous across emerging and developed country households. More specifically, a lower discount factor for the emerging country households operates through the break-down of the Cole and Obstfeld (1991) type of basic risk sharing mechanism in the goods market, increasing the role of financial markets in hedging against adverse production shocks. Moreover, the existence of the time preference heterogeneity can be viewed as a reflection of deeper (financial) frictions across developed and emerging economies. Hence, the results presented in the second chapter seem to be in concordance with one dimension of the literature which asserts that emerging country interest rate dynamics can be explained by standard models augmented with reduced form financial frictions. Finally, the model's results indicate that almost 75 percent of the volatility of the bond premium is due to the real exchange rate volatility and the remaining 25 percent can be attributed to the consumption risk.

Having analyzed the spread between the yields on emerging country and developed country local bonds in the second chapter, we present an empirical analysis to determine the factors that affect the spread between the USDTRY cross currency swaps and Turkish lira denominated nominal bonds with similar maturities in the third chapter.

Using swap curves instead of the bond curve for pricing issues is a growing trend in international financial markets due to the liquidity in the swap markets. Turkish financial market is not an exception. The market practitioners prefer swap curve over bond yield curve as benchmark for several reasons: i) the fixed swap rate is free of any credit (or sovereign) risk as the TRY fixed rate receiver holds hard currency (USD) as collateral during the life of the swap deal; ii) the liquidity premium in the fixed swap rate is less than the liquidity premium priced in a similar maturity government bond as unwinding an existing swap position is much easier in swaps compared to the illiquid local government bonds. The liquidity in the swap market stems from its popularity among foreign investors, who can gain exposure to the cross-border (Turkey) risk without bearing any credit risk thanks to holding hard currency during the lifetime of the swap. Hence, investigating the fundamentals that drive the swap spread improves our understanding of fair bond pricing. Gaining an intimate knowledge of fair value of a bond is important not only for the market practitioners, but also for academicians and policy makers.

Unfortunately, the literature on the determinants of the cross currency swaps is sparse. To the best of our knowledge, Usmen (1994) is the only paper that proposes a theoretical model to explain the spread of cross currency basis swaps in excess of the local currency government bond yields. Nonetheless, the literature on interest rate swap spreads sheds light on the determinants of cross currency swap spreads as interest rate swaps are a special case of cross currency swaps.

Early literature (Sun, Sundaresan & Wang, 1993; Brown, Harlow & Smith, 1994; Duffie and Singleton, 1997; Minton, 1997; Lang, Litzenberger & Liu, 1998; Eom, Subrahmanyam & Uno, 2000) focuses on the role of counterparty risk in determining the interest swap spreads. These studies have generally employed the spread between AAA and lower rated bonds (i.e. AA, A or B) as a gauge of counterparty risk.

There are also studies which claim that counterparty risk cannot play a major role in explaining the swap spreads (Evans & Bales, 1991; Litzenberger, 1992; Chen & Selender, 1994; Duffie & Huang, 1996, and Cossin & Pirotte, 1997). These studies commonly deny the role of counterparty risk in determining the interest rate swap spread for three reasons; (i) as the notional is not exchanged and interest payments are netted out during in an interest rate swap, the amount that is risked by entering into a swap is not that big and there arises no counterparty risk; (ii) as Smith, Smithson and Wakeman (1988) and Hull (1989) argue, a counterparty will not default as long as the worth of the swap to that counterparty is not negative. That is, for a default event to occur during an interest rate swap, both a counterparty has to default and the net worth of the swap to that counterparty should be negative; (iii)

Sorensen and Bollier (1994) claim that counterparty risk is not unilateral. As both counterparties may default, interest rate swap spread should price the relative counterparty risk, which is the difference between the riskiness of the two counterparties. Therefore, even negative swap spreads can be possible when the riskiness of the swap seller is much higher than that of the buyer.

The literature also reports that the liquidity premium (Duffie & Singleton, 1997; Lekkos & Milas, 2001; In, Brown & Fang, 2003; Fehle 2003; Liu, Longstaff & Mandell, 2006), the swap market's structural differences (Titman, 1992), the slope of the bond yield curve (Minton, 1997; Lang, Litzenberger & Liu, 1998; and Fehle, 2003) are the factors that affect the interest swap spreads. On top of these, in his theoretical model, Usmen (1994) adds the exchange rate volatility as an additional factor determining the cross currency swap spreads.

Stimulated by these studies, the third chapter analyzes the factors that affect the USDTRY cross currency swap spreads. The results reveal that the slope of the local currency bond yield curve and the credit risks of the parties involved in the swap are the main factors that affect the USDTRY cross currency swap spread. More specifically, in the period between October 2009 and May 2013, the swap seller's credit risk, measured by foreign banks' CDS spreads, has a decreasing effect on the swap spread. This is due to the increase in the swap sellers' risk as they are directly, or indirectly, affected by the liquidity and capital shortages in their headquarters operating at the epicenter of the Global Financial Crisis. However, in the period between November 2013 and February 2015, the swap buyer's credit risk gained importance as the risks started to shift towards emerging markets with the Taper Tantrum, which started in May 2013. The surge in the riskiness of local banks increased the swap spread during the second part of the estimations. Finally, steepening in the bond yield curve decreased the cross currency swap spreads.

In the second and third chapters, cross-country and within country analysis were performed for the local currency emerging country bond yields. Now, we further investigate the risk premium pricing across different types of local currency emerging country bonds. With this aim, we analyze the liquidity premium and inflation risk premium embedded in the breakeven inflation rates obtained from the maturity-matched nominal and inflation-linked Turkish lira bonds in the fourth chapter. We use a novel methodology to empirically extract the relative liquidity premium between any two maturity-matched bonds with similar types.

To be able to identify the liquidity premium and inflation risk premium improves market practitioners' ability to compare and contrast relative valuations of the existing fixed income securities. However, it is especially important for the monetary policy makers and fiscal authorities. The ability to accurately measure the liquidity premium and inflation risk premium enables monetary policy makers to track the change in inflation expectations, as well as the effectiveness of their policies. For fiscal authorities, measuring the risk premium means quantifying the extra cost incurred due to the existence of this premium in the issuance of these securities in the primary market.

Using nominal bonds together with inflation CPI-linkers is a very popular way of attaining market based measures of inflation expectations. The literature generally uses affine terms structure models (with no arbitrage assumption) to decompose the breakeven inflation rate into its subcomponents of inflation expectations and inflation risk premium. Affine models with latent factors are simultaneously fitted to both nominal and real government yield curves. The resulting model is estimated with the help of Kalman filter, where high-frequency (i.e. daily) inflation expectations are obtained by the noisy survey data on long-term inflation expectations.

Chen, Liu, and Cheng (2005), Garcia and Werner (2010), Hördahl and Tristani (2010), Christensen, Lopez and Rudebusch (2010) and Joyce, Peter and Steffen (2010) are some of the studies that disentangle breakeven inflation rates in advanced economies, i.e. US, UK and Euro area. D'amico, Kim and Wei (2010) incorporate an additional latent factor to measure the liquidity premium priced in the CPI-linkers.

Some studies used regression-based methodologies to extract the liquidity premium embedded in the yields of the CPI-linkers. These studies regress breakeven inflation rates on various measures of liquidity, i.e. the nominal off-the-run spread, Refcorp spread, relative transaction volume of inflation-indexed bonds and nominal bonds, and proxies for the cost of funding a levered investment in inflation-indexed bonds. Gurkaynak, Sack and Wright (2010), Pflueger and Viceira (2011), and Grishchenko and Huang (2012) are studies of this kind.

To the best of our knowledge, all of the studies in the related literature deem nominal bonds as perfectly liquid. By contrast, the results of the present study indicate that the calculated relative liquidity premium takes values between -26 basis point and 40 basis point for the period between October 2012 and March 2015. This finding asserts that the relative liquidity of the Turkish CPI-linkers can sometimes be higher than that of nominal bonds. Furthermore, the sum of 10 year expected inflation and inflation risk premium takes values between 4.54 percent and 7.38 percent and is 5.38 percent (on average) for the estimation period.

The fifth chapter tests the robustness of the liquidity extraction methodology proposed in the fourth chapter by applying the same methodology to the time period and the maturity-matched (US nominal and TIPS) security pairs used by Fleckenstein, Longstaff and Lustig (2014). The choice of the time period and the securities used in Fleckenstein et al. (2014) is very appropriate for the application of our methodology to the US bond market. Fleckenstein et al. (2014) reports mispricing across maturity-matched US nominal and TIPS during the Global Financial Crisis. However, they cannot attribute this mispricing to the liquidity premium measures across these maturity-matched US Treasury securities. Here, it is critical to check whether the relative liquidity premium calculated for the time period and the maturity-matched US TIPS and nominal bond pairs of Fleckenstein et al. (2014) (i) co-move with well-known liquidity premium measures of the literature and (ii) have a level that is comparable to what is reported in the literature. Pertaining to the first check, the relative liquidity premium calculated across US TIPS and nominal bonds is compared with the Resolution Funding Corporation (Refcorp) spread, a direct measure of the liquidity premium that is first proposed by Longstaff (2004) and used in the literature for the US bond market. Specifically, we calculate the correlation of the Refcorp spread with the average liquidity premium across maturity-matched nominal bonds, across maturity-matched TIPS and across maturity-matched TIPS and nominal bonds respectively. For the April 2005-November 2009 period, these correlations are calculated as 0.83 for the liquidity premium on nominal bonds, 0.83 for the liquidity premium on TIPS, and 0.67 for the liquidity premium between TIPS and nominal bonds. These high levels of correlation may indicate that the calculated premium in the fifth chapter indeed reflects the liquidity premium across these bonds.

Regarding the second check, similar to Musto, Nini and Schwarz (2015), the results indicate that the average liquidity premium across US TIPS and nominal bonds reached up to 75 basis points during 2008-2009 global financial crisis and wandered around 0 other times. On the other hand, the average relative liquidity premium across maturity-matched TIPS and nominal bonds hit its peak around 140 basis points in November 2008. These results are very close to those found by Gurkaynak et al. (2010) but lower than those found by Pflueger and Viceira (2011). However, similar to Pflueger and Viceira (2011), it was found that the relative liquidity premium is time-varying and takes values between 40 and 80 basis points during normal times.

These results also indicate that the empirical methodology that we employed in the fourth chapter indeed can effectively calculate the relative liquidity premium across maturity-matched bond pairs.

All of the chapters serve our understanding of the fundamentals that underlie the emerging country local currency fixed income instruments. The international macroeconomic model, introduced in the second chapter, sheds light on the underlying fundamentals that cause the differences in the emerging economies' interest rate dynamics. The thesis contributes to the literature by proposing an empirical methodology to obtain the liquidity premium between any two maturity-matched fixed income securities with similar types. The empirical examination of local currency fixed income instruments (i.e. cross currency swaps, CPI-linkers and nominal bonds) point out new aspects where emerging economy fixed income instruments differ from those of developed economies. For instance, Turkish inflation-linkers can sometimes be more liquid than nominal bonds with the same maturity and swap spreads being usually negative.

2. CHAPTER II

TIME PREFERENCE AND THE EMERGING COUNTRY BOND PREMIUM

The difference between the interest rate dynamics across the emerging and the developed economies is well documented in the literature (e.g. Neumeyer & Perri, 2005; Uribe & Yue, 2006). The emerging country interest rates are high and more volatile compared to the developed country interest rates. Moreover, they exhibit counter-cyclical behaviour with respect to the output. International macroeconomic models are unable to capture these observed facts while reconciling other emerging country business-cycle patterns simultaneously.

This chapter asserts that a standard two-country international macroeconomic model's ability to match the emerging economy interest rate dynamics drastically improves when time preference is assumed to be heterogeneous across emerging and developed country households. The thesis introduces impatient households for the emerging country to an otherwise standard two-country, two-good endowment economy framework, where each country issues its own domestic currency denominated bonds. A lower discount factor for the emerging country households mainly operates through a break-down of the basic risk sharing mechanism in the goods market and an increased role of financial markets in hedging against adverse production shocks.

Standard international macroeconomic models mainly employ representative agents and do not take into account the dynamics that arise due to the interactions among heterogeneous agents. However, there are numerous studies that employ different types of preference heterogeneity both within the same country households and across different country households in their models. Becker and Mulligan (1997) assert that there are reasons to be susceptible about the representative agent assumption. In their own words; "In many endogenous growth models, preferences are constant across countries, while technologies and therefore rates of return vary. With cross-country differences in rates of return, there must be either large international capital flows or strong barriers to those flows" (Becker & Mulligan, 1997:749).

The literature also presents empirical evidence of the existence of the time preference heterogeneity within the same country and the same age group. Lawrence (1991) estimates high permanent income earners to be more patient than low permanent income earners. Gourinchas and Parker (2002), and Cagetti (2003) report time preference heterogeneity across households with high and low education levels within the same country and the same age group. That said, to the best of our knowledge, there is no empirical evidence of the existence of the time preference heterogeneity across two different country households. However, there are reasons for the emerging country households to act as if they are more impatient although they have a similar type of time preference with their developed country counterparts. Differences in the level of institutional development, reflected in the form of government impatience (as cited in Aguiar et al., 2009; Aguiar & Amador, 2011), or higher risk of expropriation due to the lack of well-established rule of law in emerging countries may force emerging country households to act more impatient. Also, credit-constrained emerging country households generally have reasons to discount future more heavily, compared to their developed country counterparts, whenever the credit constraints are relaxed due to a favorable productivity shock.

In order to understand the importance of time preference heterogeneity in the moments of the emerging interest rates, it is worth mentioning the model's behaviour under homogenous time preference. Under the homogenous time preference case, the model yields a high level of risk sharing across countries. This Cole and Obstfeld type of high risk sharing in the goods market leaves no need for trade in the financial markets. Hence, the model produces a zero bond premium[1] and a very low level of volatility (with respect to the volatility of the output) for the emerging country bonds. Also, the correlation of emerging country bond premium with the output becomes acyclical, which contradicts with the data. Other than the bond dynamics, the model also fails to match some other important emerging country business-cycle facts. For instance, net exports of the emerging country turns out to be procyclical with the output, and the model yields a very low volatility for the real exchange rate (RER).

[1] Bond premium is defined as the yield on the emerging country bond minus the yield on the developed country bond.

The model's failure under homogenous time preferences is mainly due to the high level of risk sharing in the goods market in case of a favorable productivity shock. When the emerging country receives a positive productivity shock, the emerging country households increase their consumption. However, this increase is less than the rise in the level of output as the households smooth their consumption intertemporally. The rest of the output that is not consumed is saved, and net exports become procyclical. Since the increase in the demand for tradable goods does not surpass the rise in the supply of these goods, price of tradable goods decreases, implying a depreciation of the terms of trade (*ToT*). The *ToT* depreciation, in turn, results in high risk sharing in the goods market as the developed country can use emerging tradable inputs at a lower price. As pointed out by Cole and Obstfeld (1991), households can hedge the production risk in the goods market and there remains little gain from engaging in trade in the international financial markets. With the minor role of financial markets, the model yields a zero level for the bond premium. Moreover, the deviations in the bond premium turn out to be low, and the correlation of the bond premium with the output becomes acyclical for the emerging country.

The introduction of the time preference heterogeneity causes drastic changes in the model moments. With time preference heterogeneity, the risk sharing across the two countries breaks down, and households begin to hedge themselves against production risk in the financial markets. Net exports and bond premium become countercyclical in the emerging country. Also, the model begins to match the volatility of the bond premium.

Under the time preference heterogeneity case, consuming today gives more utility to the emerging country households than consuming tomorrow. Hence, when the economy is hit by a favorable shock, the impatient emerging country households increase their current consumption beyond the increase in the level of their output and reduce their net savings. A rise in the level of the output, coupled with a reduction in the net savings, implies countercyclical net exports with the output in the emerging country. Increase in the demand for emerging country households towards tradable and non-tradable domestic goods has also implications for risk sharing across countries. Since the increase in the demand for emerging tradable goods exceeds the increase in the supply, the price of the emerging country tradable goods rises, causing the *ToT* to appreciate. As *ToT* appreciates, the developed country households can no more benefit from the cheaper emerging tradable inputs and the risk sharing across countries in the goods market disappears.

With the disappearance of the hedging opportunities in the goods market and unfavorable movement of the *RER*[2], households prefer the financial market for hedging purposes. Each country household purchases the bonds issued by the other country as possessing other country's bonds constitutes good hedge against the production risk. These bonds pay in units of the other country's consumption goods that become more valuable when the bond holders' consumption is lower. Since the emerging country bonds constitute a good hedge for the developed country households, the demand for emerging country bonds rises following a favorable productivity shock in the emerging country. Hence, the premium between the yields of the bonds of the two countries falls, making the emerging country bond premium

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[2] In the benchmark calibration, non-tradable endowments are taken as complements to the tradables. Hence, the demand for non-tradables rises in harmony with the demand for tradables under a favorable productivity shock that shows itself as an increase in the level of tradable endowment. However, an increase in the demand for non-tradables implies a hike in the price of non-tradable goods, which are fixed in supply. Therefore, a ReR appreciation accompanies the ToT appreciation, making the developed country households even worse off.

countercyclical with its output. The use of financial markets also increases the volatility of the bond premium.

The model's results reveal that, without resorting to exogenous shocks to country interest rates or reduced-form processes or any form of financial friction, it is possible to get volatile and counter-cyclical bond premium in the emerging economies by introducing time preference heterogeneity across the agents of developed and emerging economies. However, the existence of the time preference heterogeneity can also be viewed as a reflection of deeper (financial) frictions across developed and emerging economies. Hence, this study seems to be in favor of the branch of the literature which asserts that emerging country interest rate dynamics can be explained by standard models augmented with reduced form financial frictions. Finally, the model's results indicate that almost 75 percent of the volatility of the bond premium is due to the real exchange rate volatility and the remaining 25 percent can be attributed to the consumption risk.

The structure of this chapter is as follows: Section 2 provides the stylized facts in the data and reviews the related literature; Section 3 displays the model; Section 4 presents the results according to different time preference values across countries; Section 5 makes robustness checks, and Section 6 concludes.

2.1 The Related Literature

Table 1 exhibits the business cycle properties of real variables for a group of developed and emerging countries. The first column of the upper panel of Table 1 shows that the output in the emerging countries is almost twice as volatile as the output in the developed countries. On the other hand, as the second column shows, consumption smoothing is more pronounced in the developed countries.

Table 1: Business Cycle Properties of Real Variables

	$\sigma(Y)$	$\sigma(C)/\sigma(Y)$	$\sigma(NX/Y)/\sigma(Y)$	$\sigma(ReR)/\sigma(Y)$	$\sigma(Premium)/\sigma(Y)$
Emerging Countries					
Mean	4.05	1.15	0.86	3.00	0.83
Median	3.91	1.08	0.81	2.95	
Developed Countries					
Mean	2.25	0.84	0.54	2.64	1.21
Median	2.05	0.84	0.54	3.19	
	$\rho(Y,Y^*)$	$\rho(C,C^*)$	$\rho(NX/Y,Y)$	$\rho(ReR,Y)$	$\rho(Premium,Y)$
Emerging Countries					
Mean	0.01	-0.30	-0.53	0.54	-0.55
Median	0.03	-0.35	-0.57	0.59	
Developed Countries					
Mean	0.45	0.29	-0.42	-0.14	0.20
Median	0.43	0.29	-0.47	-0.13	

Notes: Y is real GDP. C is real consumption. NX/Y is export minus imports over GDP
ReR is the real exchange rate. Premium is the spread btw the returns EM and DM bonds.
All series (except NX and premium) are in logs and have been HP filtered. All statistics are based on yearly data for years between 1970 and 2008 from IMF-IFS. Emerging countires are Argentina, Brazil, Chile, Colombia, India, Indonesia, Israel, Korea, Mexico, Malaysia, Paraguay, Peru, Philippines, Turkey, Uruguay, Venezuella and South Africa. Developed countires are Australia, Canada, England, Finland, France, Germany, Japan, New Zealand, Portugal and the U.S.

The first column of the lower panel of Table 1 also reveals that the developed country output correlates with the US output, whereas the emerging country output does not. As can be seen in the second column, there is no risk sharing across the emerging and developed economies. The fifth column shows that emerging country real exchange rates appreciate in the boom phases of the business cycles. On the other hand, the developed country real exchange rates do not move with the business cycles. The last column exhibits a significant difference in the cyclicality of the bond premium in both country groups. The emerging country bond premium is countercyclical, whereas the developed country bond premium is slightly procyclical.

International macro economy models have been commonly used to address the several features of the world economy since the work of Backus, Kehoe and Kydland (1992, 1995). However, those multi-country models cannot fully explain the interest rate dynamics of the emerging countries. It has been documented that the emerging country bond premium is countercyclical (with respect to the output) and highly volatile (when compared to the developed country bond premium). Neumeyer and Perri (2005) and Uribe and Yue (2006) are two studies that report the countercyclicality of the interest rates in several emerging countries including Argentina, Brazil, Ecuador, Mexico, Peru, Philippines, and South Africa. Both of these studies take interest rates as exogenous and try to measure the contribution of the real interest rate fluctuations to emerging economy output volatility. Reduced form financial frictions (i.e. working capital channel and country premium that depends on macroeconomic fundamentals) act as an amplifier of the productivity shocks in these studies.

In the literature, there are also studies which allow the interest rates to be endogenously determined by the country fundamentals (e.g. Aguiar & Gopinath, 2008; Arellano, 2008; García-Cicco et al. 2010). Arellano (2008) shows that if the cost of default is countercyclical, a small open economy model can explain the level and the volatility of the bond premium. Yue (2010) argues that if there is debt negotiation after the default, it is possible to obtain the volatile bond premia. Mendoza and Yue (2011) develop a general equilibrium model of default and business cycles and show that their model explains several features of the emerging country data. One common property of these aforementioned models is the importance of the default probabilities in deriving the first and second moments of the bond premia. Gourinchas et al. (2011) show that US borrows at a lower rate than it lends and that there is a significant premium between the emerging country and US bonds. They call the premium that is collected by the US as the "exorbitant privilege."

Not all studies in the literature resort to financial frictions to match the emerging economy business cycle facts. Aguiar and Gopinath (2007) show that shocks to the trend of the emerging output is solely sufficient to match the stylized facts of the emerging economy business cycles. However, they also argue that trend shocks should be interpreted as the reflection of deeper frictions. These frictions need not be the financial ones. In a recent study, Arslan, Keles and Kilinc (2012) model the emerging economy business cycles with trend shocks and risk aversion heterogeneity across emerging and developed economies. They are able to break the risk sharing mechanism of the standard international macroeconomics model with the help of the wealth effects caused by the trend shocks. Their model can endogenously produce interest rate dynamics that are in line with the data. The model also yields large portfolio holdings as more risk averse emerging country households tend to hold developed country bonds to smooth out their consumption.

Recent literature focuses on micro-founded (firm level) default mechanisms to fill the gap between the standard business cycle models and the observed facts for the interest rate dynamics of the emerging economies. Akinci (2013) reports that a framework, within which stationary productivity shocks are augmented with firm-level financial frictions in the form of financial accelerator (a la Bernanke et al., 1999), can obtain countercyclical interest rates and volatile country risk premium. She also reports that the introduction of the financial frictions eliminates the importance of non-stationary shocks in deriving the fluctuations in the emerging country business cycle. More recently, Fernandez and Gulan (2015) show that it is possible to match the emerging economy interest rate dynamics, as well as several emerging business cycle dynamics, by introducing micro-founded financial frictions to an otherwise standard small open economy model. They model the emerging country interest rates as a function of the default risk of the corporates. They show that a mechanism, which involves a financial accelerator type of amplification through leveraged corporates, accounts well for the interest rate dynamics and some of the main business-cycle patterns in emerging economies. One notable outcome of the model is the estimated persistence of the productivity shock; the model can yield high consumption volatility when the persistence of the productivity shock is close to one. For the authors, this is a sign of the existence of (Aguiar & Gopinath, 2007) frictions that are orthogonal to the financial accelerator mechanism studied in the paper.

As discussed in the introductory section, the time preference heterogeneity[3] across countries plays an essential role in deriving the results of this paper. A large number of studies use time preference heterogeneity in their models to account for several facts observed in the data, such as wealth inequality, current account imbalances, and sovereign debt accumulation.

Lawrence's study (1991) is an early attempt that makes empirical estimates of the time preference heterogeneity by using first-order equations for the consumption. Using the Panel Study of Income Dynamics data, she estimates the consumption Euler equations. Under perfect capital market assumption, her estimations reveal the existence of the time preference heterogeneity across the US households within the same age group. In particular, she finds a negative correlation between

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[3] The literature also resorts to preference heterogeneity in the elasticity of intertemporal rate of substitution of the agents in the economy. Guvenen (2009) shows that different elasticity of intertemporal substitution among economic agents and limited stock market participation can explain the equity premium. Borri and Verdelhan (2011) employ trend shocks, default and a time-varying risk aversion in a developed and emerging country set up. They get positive amounts of spread if the endowment processes of developed and emerging countries are assumed to be positively correlated. Gourinchas et al. (2011) also use a model with heterogeneity in risk aversion and find that just the variation in risk aversion or sizes alone is insufficient to generate spreads similar to the data.

intertemporal preferences and the permanent income. Those with low permanent income are found to be more impatient and to have higher marginal propensity to consume than those with higher income.

By solving a lifecycle model and using consumption data, Gourinchas and Parker (2002) measure the discount rates of the economic agents within the same age group but with differing levels of education. They find that the more educated the agents are, the less patient they are. Instead of using data on consumption, Cagetti (2003) shows the opposite by using data on asset holdings of the economic agents. Despite their contradicting results, both studies point out the existence of time preference heterogeneity across economic agents with differing education levels.

Buiter (1981) uses a deterministic (two country, one good) overlapping generations model to analyze the international capital movements and welfare implications of financial autarky and financial integration. The two countries in the model are identical in all respects except for the rate of time preferences of their households. Financial integration and international mobility of financial capital should imply equalization of interest rates and marginal products across countries at the steady state. Buiter (1981) shows that, when rates of time preference differ across countries, the country with more impatient (or with a higher pure rate of time preference) households runs a current account deficit in the steady state. However, the model is silent as regards how current account adjusts to the steady state.

Following Buiter's footsteps, Kikuchi and Hamada (2011) investigate the role of time preference in determining the trade and capital flows across countries. They incorporate less-capital-intensive non-tradables into Buiter's model. Incorporation of non-tradables pave the way for more patient country to specialize in the production of non-tradables. Hence, the capital outflows from the country with lower time preference to the country with higher time preference.

Devereux and Shi (1991) construct a two-country and one-sector model where credit markets are competitive, physical capital is mobile across countries, and the rates of time preference are endogenous. According to this model, more-patient countries should be creditors in the steady state. However, asset accumulation behaviour may exhibit overshooting on the path towards the steady state.

Ogaki and Atkeson (1997) use household level panel data of India to estimate a model in which they enable both the rate of time preference and intertemporal elasticity of substitution to change across households with different wealth levels. They conclude that the intertemporal elasticity of substitution differs as the poor is more risk averse. However, the rate of time preference is constant across rich and poor households.

Krusell and Smith (1998) introduce low levels of time preference heterogeneity to an otherwise standard stochastic growth model with infinitely lived consumers. The consumers in the model face uncertainty in aggregate productivity and receive idiosyncratic income shocks. Under a setting with incomplete markets, and idiosyncratic and uninsurable risk, the preference heterogeneity leads to drastic changes in wealth inequality across households. Impatient households consume more and save less as the magnitude of the transitory income shocks in the model are not large enough to have them increase their precautionary savings. Hendricks (2007) reports that, with a realistic amount of income shock, the wealth inequality of Krusell and Smith (1998) becomes less sensitive to the time preference heterogeneity. Nonetheless, Hendricks acknowledges that time preference heterogeneity also improves his model's ability to match the degree of wealth inequality among US households with similar lifetime earnings.

Mankiw (2000) proposes a new fiscal policy model, in which he classifies households into two: savers and spenders. Savers are high wealth households that smooth not only their own consumption but also that of their future offsprings. Spenders, on the other hand, are low (or even zero) wealth households with short time horizons. Spenders are not capable of smoothing their consumption over time.

Eaton and Kletzer (2000) model the credit relationship between the borrower and the lender under time preference heterogeneity. In their model, the risk aversions also differ, and the third-party enforcement of loan contracts is absent. In particular, the lender is risk-neutral, whereas the borrower is risk averse. Moreover, the borrower has a higher rate of time preference than the lender. The borrower has an endogenous income and borrows in order to smooth his or her consumption. However, having a higher rate of time preference motivates the borrower to borrow for reasons other than smoothing. Hence, even in the absence of income variation, the borrower borrows at the early periods to finance growth and pays at later periods.

Using a theoretical model with no uncertainty, Lengwiler (2005) shows how a small deviation from the time preference homogeneity assumption triggers a drastic change in the equilibrium real interest rates. With heterogeneous time preferences, interest rates at shorter horizon increase due to the consumption timing effect, whereas interest rates at longer horizon decrease due to the averaging effect, producing an inverse term structure of real interest rates. With a numerical example, he further shows that the most impatient agent brings consumption forward and accumulates debt at the very beginning, whereas the most patient one has a monotonically increasing consumption path and accumulates wealth.

Aguiar et al. (2009) employ an impatient government in a small open economy model to investigate the interplay of investment and sovereign debt. In their model, the government may fail to commit its pre-announced fiscal policy and default on its existing debt. Similar to Thomas and Worrall’s (1994), their model implies that, if the government discounts future at the market rate, it eventually piles up assets to insure its domestic risk-averse constituency against adverse effects of lack of commitment. If the government is impatient and brings the consumption forward, it fails to accumulate assets that will assure complete risk-sharing against the probability of lack of commitment. The impatience of the government leads to an increase in the stock of debt, causing a decrease in the net asset position, and this stock of debt adversely affects both first and second moments of the sustainable level of investment in the long-run. They reason that the positive probability of losing office justifies the impatience of the government.

Aguiar and Amador (2011) introduce the government impatience and lack of commitment to an otherwise standard open economy neoclassical growth model. Impatience of the government makes it longer for the economy to arrive at a steady state and alters the level of the steady state debt.

2.2 The Model

This section presents a two-country, two-bond and two-sector endowment economy model, which is basically borrowed from Arslan et al. (2012).

In the model, there are two countries; developed and emerging. The developed country is indexed as *D* and the emerging country is indexed as *E*. Every period, both countries receive tradable and non-tradable endowment shocks. Only the tradable endowments are traded across the developed and emerging country. By using its tradable endowment and imported tradable goods, each country produces its intermediate good. Finally, the two countries use these intermediate goods and their non-tradable endowment to produce their unique final goods.

The proposed model departs from Backus et al. (1995) and Stockman and Tesar (1995) with two properties. First, the model assumes that the agents in the emerging economy are more impatient than the agents in the developed economy. Second, each country issues its own currency denominated bond instead of an international bond.

2.2.1 Endowment Shocks

The timing of the model is as follows:

Every period, the two countries get transitory tradable and non-tradable endowment shocks that are denoted as $E_{i,T,t}$ and $E_{i,N,t}$ respectively.

$$E_{i,T,t} = e^{z_{iE,T,t}} \text{ and } E_{i,N,t} = e^{z_{iE,N,t}},\ i\text{=}D,E \tag{1}$$

These transitory shocks have an AR(1) process that is given as;

$$z_{i,j,t} = \rho_z z_{i,j,t-1} + \varepsilon_{i,j,t} \tag{2}$$

, where we denote tradable endowment as j=T and non-tradable endowment as j=N. The AR coefficient (ρ_z) is less than unity and the error term is distributed as follows $\varepsilon_{i,j,t} \sim N(0, \sigma_z^2)$.

Having received the endowment shocks, countries engage in the trade of the tradable endowments:

$$E_{i,T,t} = X_{iD,T,t} + X_{iE,T,t} \quad i = D, E \tag{3}$$

For i=D, the developed country uses $X_{DD,T,t}$ part of its tradable endowment in its own intermediate good production and export the $X_{DE,T,t}$ part to the emerging country. The net trade balance for the developed country can be given as $(P_{D,T,t}X_{DE,T,t} - X_{ED,T,t})$. Same notation applies to the emerging country.

2.2.2 Intermediate and Final Goods Production

Intermediate good producers operate in a perfectly competitive market. The production function is given as:

$$Y_{i,T,t} = [\vartheta_i^{\frac{1}{\kappa_i}} X_{Ei,T,t}^{1-\frac{1}{\kappa_i}} + (1-\vartheta_i)^{\frac{1}{\kappa_i}} X_{Di,T,t}^{1-\frac{1}{\kappa_i}}]^{\frac{\kappa_i}{\kappa_i - 1}} \quad i = D, E \tag{4}$$

In this production technology, the elasticity of intertemporal substitution (κ_i) between the tradable endowments of the two countries is constant. We denote the share of each country's tradable input in its intermediate good production by ϑ_i. We take the price of the emerging country tradable endowment $(P_{E,T} = 1)$ as numeraire and denote other endowment prices ($P_{D,T}, P_{D,N}$ and $P_{E,N}$) relative to $P_{E,T}$. Hence, the intermediate good price can be written as follows:

$$P_{i,Tradable,t} = [\vartheta_i + (1-\vartheta_i)\, P_{D,T,t}^{1-\kappa_i}]^{\frac{1}{1-\kappa_i}} \quad i = D, E \tag{5}$$

Final good producers also operate in a perfectly competitive market. They combine intermediate goods with the non-tradable endowment to produce the final good. The production function is given as:

$$Y_{i,t} = [\theta_i^{\frac{1}{\eta_i}} Y_{i,T,t}^{1-\frac{1}{\eta_i}} + (1-\theta_i)^{\frac{1}{\eta_i}} E_{i,N,t}^{1-\frac{1}{\eta_i}}]^{\frac{\eta_i}{\eta_i - 1}} \quad i = D, E \tag{6}$$

In this production technology, the elasticity of intertemporal substitution between the intermediate goods and non-tradable endowments is represented as η_i. The share of tradable goods in the production of the final good is denoted with θ_i. In accordance with the intermediate goods price, the final good price can be written as follows:

$$P_{i,t} = [\theta_i \, P_{i,Tradable,t}^{1-\eta_i} + (1-\theta_i) \, P_{i,N,t}^{1-\eta_i}]^{\frac{1}{1-\eta_i}} \quad i = D, E \tag{7}$$

Each country households can only consume the final goods produced in their home countries.

Having provided the prices for the endowments and the produced goods, we define the terms of trade and the real exchange rate from the perspective of the emerging market. Therefore, we define the terms of trade (*ToT*) as the ratio of emerging country export prices to its import prices. Accordingly, we define the real exchange rate (*ReR*) as the ratio of emerging country final good prices to developed country final good prices:

$$ToT_t = \frac{1}{P_{D,T,t}} \quad and \quad ReR_t = \frac{P_{E,t}}{P_{D,t}} \tag{8}$$

2.2.3 Financial Markets

In the model's set up, each country issues local currency denominated, non-contingent bonds. That is to say, bonds are non-defaultable, have zero net supply and pay in units of their own final good.

We formulate the income that emerging country households earn from their endowments as $E_{E,T,t} + P_{E,N,t}E_{E,N,t}$. The emerging country households face the following budget constraint:

$$P_{E,t}c_{E,t} + Q_{E,t}B_{E,t+1} + Q_{D,t}B_{D,t+1} \ = P_{E,t}Y_{E,t} + (X_{ED,T,t} - P_{D,T,t}X_{DE,T,t}) + P_{E,t}B_{E,t} + P_{D,t}B_{D,t} \tag{9}$$

In this equation, the term $\left(X_{ED,T,t} - P_{D,T,t}X_{DE,T,t}\right)$ refers to the net trade balance of the emerging country households. $Q_{E,t}$ and $Q_{D,t}$ are the nominal bond prices for the emerging and developed countries. At time *t-1*, the emerging country issues bonds at an amount of $B_{E,t}$ and at a price of $Q_{E,t-1}$. At time *t*, this bond pays $B_{E,t}$ units of emerging country final good, which has a price of $P_{E,t}$.

In a similar fashion, the budget constraint of the developed country households is as follows:

$$P_{D,t}c_{D,t} + Q_{D,t}B^*_{D,t+1} + Q_{E,t}B^*_{E,t+1} \ = P_{D,t}Y_{D,t} + (P_{D,T,t}X_{DE,T,t} - X_{ED,T,t}) + P_{D,t}B^*_{D,t} + P_{E,t}B^*_{E,t} \tag{10}$$

In this equation, the term $\left(P_{D,T,t}X_{DE,T,t} - X_{ED,T,t}\right)$ refers to the net trade balance of the developed country households. Countries cannot short their own bonds and net supply of each bond should be non-negative which implies the following; $B_{E,t} \ \leq 0$ and $B^*_{D,t} \ \leq 0$.

2.2.4 Households' Dynamic Optimization Problem

The emerging and developed country households have constant relative risk aversion type of utility function:

$$U_{i,t} = \frac{c_{i,t}^{1-\gamma_i}}{1-\gamma_i}$$

Households get utility from the consumption of their final goods and the risk aversion parameter for country *i* households is denoted by γ_i. Having observed their endowments shocks and the previous period holdings of the two bonds, the emerging country households solve the following dynamic optimization problem:

$$V_{E,t} = Max_{B_{D,t+1},B_{E,t+1}} \{u(c_{E,t}) + \beta E_t(V_{E,t+1}(E_{E,T,t+1}, E_{E,N,t+1}, E_{D,T,t+1}, E_{D,N,t+1}, B_{D,t+1}, B_{E,t+1}))\} \tag{11}$$

In a similar fashion, the developed country households solve the following dynamic optimization problem:

$$V_{D,t} = Max_{B^*_{D,t+1},B^*_{E,t+1}} \{u(c_{D,t}) + \beta E_t(V_{D,t+1}(E_{D,T,t+1}, E_{D,N,t+1}, E_{E,T,t+1}, E_{E,N,t+1}, B^*_{D,t+1}, B^*_{D,t+1}, B^*_{E,t+1}))\} \tag{12}$$

2.2.5 Calibration

The calibration is mainly based on the standard values used in Corsetti, Dedola and Leduc (2008) and Garcia-Cicco et al. (2010). The parameter showing the home tradable share in the intermediate goods production, ϑ, is taken as *0.72*. This means a home bias in the production of the intermediate goods. The elasticity of intertemporal substitution between home and foreign tradable endowments, κ, is *2.* This means that two tradable endowments are regarded as substitutes in the production of the intermediate goods. The parameter showing the intermediate goods share in the final goods production, γ, is *0.55*. The elasticity of intertemporal substitution between home-produced intermediate goods and non-tradable endowments, η, is *2/5*. This means that the home-produced intermediate goods and non-tradable endowments are regarded as complements in the production of the final goods. Both country households are risk averse with a parameter of *σ=2.* In the calibration, each period refers to one year and *AR(1)* coefficient for endowments shocks is taken from Garcia-Cicco et al. (2010) as *0.83*. We approximate the AR process with a two-state Markov Chain process a la Tauchen (1986). Parameters are summarized in Table 2.

Table 2: Calibration

Definition	Parameter	Value
Home input share in intermediate tradables production	v	0.72
Elasticity of intertemporal substitution bw home and foreign tradable inputs	κ	2
Intermediate tradable goods share in final goods production	γ	0.55
Elasticity of intertemporal substitution bw intermediate tradable and non-tradable	η	2/5
Discount factor for Developed Country	β^*	1/1.02
Discount factor for Emerging Country	β	1/1.06
Risk aversion parameter for households	σ	2
AR(1) coefficient for stationary shocks	ρ_z	0.83

For the standard case, discount factor for households, β, is 1/1.04, implying a risk-free interest rate of 4 percent for both countries. Heterogeneous time preferences case employs lower values for the discount factor of emerging country households compared to that of developed country households. Benchmark case takes the yearly discount factor as 1/1.02 for the developed country and as 1/1.06 for the emerging country.

2.3 Results

In this section, the results of the standard model with homogenous time preference is compared to the results of that with heterogeneous time preference.

2.3.1 The Homogenous Time Preference Case

The first column of Table 3 summarizes the data, and the subsequent column presents the basic business cycle properties of the standard version of the model with the homogenous time preference. Under the homogenous time preference case, there is a high level of risk sharing across countries, and there is no spread between the emerging and developed country bonds. Also, the model produces almost no volatility for the bond premium. Moreover, net exports are procyclical in the emerging country.

Table 3: Model Moments with Various Time Preferences

		Model			
	Data	$\beta = 0.96, \beta^* = 0.96$	$\beta = 0.955, \beta^* = 0.965$	$\beta = 0.95, \beta^* = 0.97$	$\beta = 0.94, \beta^* = 0.98$
Emerging Return %		3.98	4.57	5.14	6.10
Developed Return %		3.98	3.83	3.72	3.86
Bond Premium		0.00	0.74	1.42	2.24
NX/Y		0.05	0.58	1.46	3.94
$\sigma(Y)$	4.05	0.93	1.07	1.32	1.89
$\sigma(C)/\sigma(Y)$	1.15	1.00	1.00	1.00	1.00
$\sigma(NX/Y)/\sigma(Y)$	0.86	0.39	0.50	0.70	0.92
$\sigma(ToT)/\sigma(Y)$		0.53	0.47	0.43	0.39
$\sigma(ReR)/\sigma(Y)$	3.00	0.50	1.45	2.19	2.65
$\sigma(Premium)/\sigma(Y)$	0.83	0.11	0.67	1.01	1.11
$\rho(Y, Y^*)$	0.01	0.93	0.28	-0.29	-0.67
$\rho(C, C^*)$	-0.30	0.93	0.28	-0.29	-0.67
$\rho(NX/Y, Y)$	-0.53	0.91	0.25	-0.29	-0.66
$\rho(ToT, Y)$		-0.98	-0.70	-0.22	0.32
$\rho(ReR, Y)$	0.54	0.63	0.64	0.77	0.88
$\rho(Premium, Y)$	-0.55	-0.05	-0.35	-0.51	-0.62

The mechanism of the standard business cycle model is as follows: when the emerging country receives a favorable productivity shock, the emerging country households increase their consumption. However, this increase is less than the rise in the level of output as the households smooth their consumption intertemporally. The excess supply is saved, and therefore net exports becomes positively correlated with the output. This is shown by the correlation coefficient of 0.91 in the second column of Table 3. This is at odds with the data as net exports are countercyclical, with a correlation coefficient of -0.53, for the emerging countries.

Moreover, under a favorable productivity shock, the standard model yields a high level of production sharing across countries, with correlation coefficient of 0.93. This is again inconsistent with the data, which points out an acyclic pattern. The consumption smoothing mechanism has a role in such a high level of production sharing. In the event that the tradable endowment of the emerging country increases, the demand for that good cannot exceed the rise in its supply as the emerging country households increase their consumption at a rate which is less than the increase in the output level. The rest of the output that is not consumed is saved. As a result, the net exports positively correlate with the output (with a correlation coefficient of 0.91).

The excess supply of the emerging country tradable good has other implications. The excess supply suppresses the price of the tradable good. This causes *ToT* to depreciate and negatively correlate (-0.98) with the output. Basically, a *ToT* depreciation implies that both the emerging and the developed country can use the emerging country tradable goods at a lower price when a favorable productivity shock hits the emerging country economy. Therefore, both countries use more of the emerging tradable input and their outputs rise in tandem. This produces a positive correlation between the outputs of the two countries. The resulting positive correlation implies a strong production risk sharing in the goods markets.

This is the mechanism pointed out by Cole and Obstfeld (1991). As both country households hedge production risk in the goods market, there is not much gain from engaging in trade in the international financial markets. With the minor role of financial markets, there is almost no deviation in the bond premium. Moreover, the bond premium becomes acyclic with the output with a correlation coefficient of -0.05.

The model also has poor performance in matching the dynamics of the real exchange rate. The real exchange rate has a correlation of 0.63 with the output and a standard deviation that is half of the output. The correlation of the real exchange rate with the output is compatible with the data. However, the volatility of the real exchange rate relative to that of the output is far below what is observed in the data. This low volatility can be attributed to the opposite movements of *RER* and *ToT* under a productivity shock. With a favorable productivity shock, an increase in the supply of the tradable inputs causes final goods producers to increase their demand for non-tradable input, which is fixed in supply. This increase in the demand increases the price of non-tradable goods, whereas the price of tradable inputs decreases due to the excess supply. Although *ToT* depreciates, the rise in the price of non-tradable goods compensates for the reduction in *ToT*. Hence, the opposite movement of the tradable and non-tradable prices constrains the volatility of *RER*.

2.3.2 The Heterogenous Time Preference Case

The following columns of Table 3 present the business cycle properties of the model for progressively increasing time preference heterogeneity across the two country households. With sufficiently high heterogeneity, the emerging country households act impatiently and discount future heavily. Hence, consuming today gives higher utility to the emerging country households than consuming tomorrow. Therefore, whenever they get a favorable productivity shock, they increase their current consumption beyond the increase in the level of the output. This little change in the emerging country households' attitude makes a big difference in the model's moments. To start with, the emerging country households borrow to be able to fund their excessive consumption. This makes net exports countercyclical with the output. More importantly, the *ToT* appreciates under a favorable productivity shock. This appreciation causes the risk sharing in the goods market to break down. As a result, both country households start to use the financial markets to hedge themselves against the production risk. Increased importance of the financial assets has also important implications for the moments of the bond premium.

The third column shows the case where a slight heterogeneity is introduced across the emerging and developed country households. The most striking difference between the second and the third column is the drastic decrease in the correlation between the two countries' production levels. When the emerging country households get a favorable productivity shock, they increase their net saving by less than the amount they did under the homogenous time preference case. Therefore, the *ToT* depreciates but at a smaller amount. This is seen in the reduction of the correlation of the *ToT* with the output from -0.90 to -0.70. Although the *ToT* depreciates less, the developed country can still benefit from the cheaper emerging country tradable goods in case of a favorable productivity shock. Therefore, the main mechanism that causes high production risk sharing starts to break down. Put differently, the lower level of depreciation of the *ToT* results in an impairment in the risk sharing across countries; a fall in the correlation between the two countries' consumption from 0.93 to 0.28.

As the gap between the two country households' time preferences widens, the mechanism, which produces procyclical net exports and high risk sharing, breaks. A 100 basis points difference between the two country households' time preferences begins to reverse the dynamics of the net savings. However, a difference of 100 basis points does not suffice to totally break down the mechanism under the homogenous time preference case.

Under a 200 basis points difference, as presented in the fourth column, *ToT* still depreciates as the increased current consumption does not suffice to produce a demand that is in excess of the increased output. However, the emerging country households begin to pay a net premium of 142 basis points for the bonds they issue. The emerging country households pay this premium partly for being more impatient and partly for transferring their consumption volatility to the developed economy. Only after a difference of 400 basis points, *ToT* starts to appreciate, and the main mechanism totally operates in the opposite direction.

With 400 basis points gap between the time preferences, the emerging country households reduce their net savings and increase their current consumption beyond the increase in their output level. Parallel to the reduction in net savings, net exports become countercyclical with output; a correlation of -0.66. The demand of the emerging country households for the emerging country tradable goods exceeds the supply; causing the *ToT* to appreciate. As the *ToT* appreciates, the developed country households can no more benefit from the rise in the emerging country output. They are rather worse off with rising input prices. Hence correlation of outputs across countries becomes negative; -0.67.

As the emerging tradable input prices increase with a favorable shock to the emerging economy, opportunities of hedging the production risk in the goods market totally disappear. Moreover, unfavorable tradable input prices necessitate alternative means of hedging for both country households. Therefore, each country household begins to purchase other country's bonds that are traded in the financial markets. Since these bonds pay in units of the other country's consumption goods and pay more when the bond holders' consumption is lower, they provide a good hedge against the production risk. As the degree of emerging country households' impatience and the consumption volatility transferred to the developed economy increase, the bond premium between the yields of bonds issued by the emerging and the developed economy widens to 224 basis points.

The time preference heterogeneity also causes the bond premium to present a countercyclical pattern with the output. As the developed country households become worse off with the increase in the emerging tradable goods prices, they demand the emerging bonds more following a favorable productivity shock. This increase in the demand for the emerging country bonds rise prices of these bonds, making the emerging country bond premium countercyclical with the output (with a correlation coefficient of -0.62).

Finally, rising demand of the emerging country households for the emerging tradable goods has implications for the *RER*. As the tradables and the non-tradables are complements in the production of the final consumption goods, the emerging country households also increase their demand for the non-taradables whenever they receive a favorable productivity shock. However, the non-tradables are fixed in supply, hence their prices increase under a positive productivity shock. The increase in the non-tradable goods prices, coupled with *ToT* appreciation, causes *RER* to appreciate. The correlation between the *RER* and the output becomes 0.88. Synchronized appreciation of the *ToT* and *RER* is the main driver of the high volatility in the real exchange rates under the heterogeneous time preference case. However, if the financial markets were not available for consumption smoothing purposes, it would not be possible to have such high level of real exchange rate volatility. The model yields real exchange rates and the emerging country bond premium that are 2.65 and 1.11 times more volatile than the output respectively.

2.4 Robustness Analysis

The case with 400 basis points difference across time preferences constitutes the benchmark case for the robustness analysis.

2.4.1 The Persistence of the Productivity Shocks

The robustness analysis of benchmark results was conducted for different levels of persistence for the productivity shock (Table 4). As discussed above, the main mechanism that breaks down the strong risk sharing under a positive productivity shock starts with a reduction in the net savings of the emerging country households. As presented in Table 4, this mechanism relies on the persistence of the shock. In the benchmark case, as shown in the first column, the AR(1) coefficient of the productivity shocks, ρ_z, is taken as 0.83. This is the standard value that is used in the literature. The next column shows the results for an AR(1) coefficient of 0.63. With 0.63 persistence, the emerging country households still prefer to consume today in excess of the increase in the level of the output. However, a lower level of persistence implies a lower amount to be discounted from the future as the shock dies out more quickly. As a result, the reduction in the net savings decreases in absolute terms; correlation between the net exports and the output decreases from -0.67 to -0.43.

Table 4: Model Moments: Robustness Analysis wr to Persistence Levels

		Model		
		$\beta = 0.94,\quad \beta^* = 0.98$		
	Data	$\rho_z = 0.83$	$\rho_z = 0.63$	$\rho_z = 0.00$
Emerging Return %		6.10	5.16	4.15
Developed Return %		3.86	3.99	4.15
Bond Premium		2.24	1.17	0.00
NX/Y		3.94	1.71	0.00
$\sigma(Y)$	4.05	1.89	1.77	1.03
$\sigma(C)/\sigma(Y)$	1.15	1.00	1.00	1.00
$\sigma(NX/Y)/\sigma(Y)$	0.86	0.92	0.80	0.57
$\sigma(ToT)/\sigma(Y)$		0.39	0.42	0.66
$\sigma(ReR)/\sigma(Y)$	3.00	2.65	2.35	0.39
$\sigma(Premium)/\sigma(Y)$	0.83	1.11	0.89	0.00
$\rho(Y, Y^*)$	0.01	-0.67	-0.43	0.97
$\rho(C, C^*)$	-0.30	-0.67	-0.43	0.97
$\rho(NX/Y, Y)$	-0.53	-0.66	-0.43	0.97
$\rho(ToT, Y)$		0.32	-0.03	-0.98
$\rho(ReR, Y)$	0.54	0.88	0.81	-0.32
$\rho(Premium, Y)$	-0.55	-0.62	-0.63	0.40

The main results of the benchmark case of heterogeneous time preferences totally disappear when the shocks are i.i.d., as shown in Table 4. Since there is nothing in the next periods to discount, the emerging country households do not decrease their net saving when the economy is hit by a positive shock. The correlation of the net exports with the output becomes positive: 0.97. As the economic theory predicts, the net savings increases as a response to a transitory increase in income. Despite the 400 basis points of time preference gap, the model yields almost the same results with the homogenous time preferences case (Table 3).

2.4.2 The Elasticity Assumption

Table 5 displays the impact of the elasticity assumptions on the results of the model. In the benchmark case, tradable and non-tradable intermediate goods are assumed to be complements (with an elasticity coefficient of η=2/5), and home and foreign tradable inputs are taken as substitutes (with an elasticity coefficient of $\kappa = 2$). The second column of Table 5 presents the robustness check, where the elasticity for tradable inputs is kept intact and the elasticity between tradables and non-tradables is increased (η=100) to treat them as substitutes rather than complements. In this setting, the model's main results as to the level and the correlation of the bond premium do not change as the break-down of the risk sharing mechanism does not depend on the elasticity assumptions.

Table 5: Model Moments: Robustness Analysis wr to Elasticities

		Model		
		$\beta = 0.94,\quad \beta^* = 0.98$		
	Data	$\eta = 2/5$, $\kappa = 2$	$\eta = 100$, $\kappa = 2$	$\eta = 100$, $\kappa = 100$
Emerging Return %		6.10	5.85	5.71
Developed Return %		3.86	3.73	3.59
Bond Premium		2.24	2.12	2.12
NX/Y		3.94	5.52	5.52
$\sigma(Y)$	4.05	1.89	3.96	4.45
$\sigma(C)/\sigma(Y)$	1.15	1.00	1.00	1.00
$\sigma(NX/Y)/\sigma(Y)$	0.86	0.92	0.99	1.04
$\sigma(ToT)/\sigma(Y)$		0.39	0.43	0.01
$\sigma(ReR)/\sigma(Y)$	3.00	2.65	0.45	0.03
$\sigma(Premium)/\sigma(Y)$	0.83	1.11	0.40	0.28
$\rho(Y, Y^*)$	0.01	-0.67	-0.95	-0.96
$\rho(C, C^*)$	-0.30	-0.67	-0.95	-0.96
$\rho(NX/Y, Y)$	-0.53	-0.66	-0.91	-0.97
$\rho(ToT, Y)$		0.32	0.89	0.90
$\rho(ReR, Y)$	0.54	0.88	0.89	0.98
$\rho(Premium, Y)$	-0.55	-0.62	-0.80	-0.78

However, the most dramatic change takes place in the volatility of the bond premium. The bond premium volatility decreases parallel to the reduction in the exchange rate volatility. The relative volatility of the real exchange rate with respect to the output volatility falls from 2.65 to 0.45. Under a positive tradable shock, the demand for non-tradables does not increase as it does in the benchmark case. Firms can now substitute the non-tradables, which is limited in supply, with tradables in the final goods production. Hence, the upward pressure on the non-tradable good prices, and on the *RER* as well, diminishes. The contribution of non-tradable goods' prices to *RER* volatility disappears, and the volatility of *RER* is due to the volatility of *ToT*. The reduction in the volatility of real exchange rates decreases the frequency of hedging against the production risk in the financial markets. The volatility of the bond premium decreases from 1.11 to 0.40.

The third column presents the robustness check, where the elasticity between home and foreign tradable inputs is increased (η,κ=100) to treat them as perfect substitutes while keeping the tradables and non-tradables as perfect substitutes. Consequently, the part of RER volatility coming from the volatility of *ToT* also goes away. Hence, the relative volatility of *ToT* and *RER* with respect to that of the output decrease to 0.01 and 0.03, respectively. The volatility of the bond premium continues to fall parallel to the decrease in the real exchange rate volatility. The volatility of the bond premium decreases from 0.40 to 0.28. The robustness check implies that existence of non-tradables, which are complements to tradables, is crucial for the second moments of the terms of trade, the real exchange rate and the bond premium.

2.4.3 The Risk Aversion Assumption

Table 6 investigates how the model results react to a change in the risk aversion assumption. The third column of Table 6 presents the case where the developed country households are assumed almost risk neutral. With risk neutral developed country households, the part of the bond premium demanded as risk premium disappears. The level of the bond premium decreases (from 2.24 percent to 1.36 percent) by 88 basis points despite the 400 basis points of heterogeneity across the time preferences. Moreover, the second moment of the bond premium (relative to that of the output) decreases from 1.11 to 0.75 although the second moment of the *RER* remains almost the same. That reduction can be viewed as the elimination of the volatility due to the pricing of consumption risk.

Table 6: Model Moments: Robustness Analysis wrt Risk Aversion and Elasticities

		Model		
		$\beta = 0.94, \quad \beta^* = 0.98$		
		$\eta = 2/5, \kappa = 2$	$\eta = 2/5, \kappa = 2$	$\eta = 100, \kappa = 100$
	Data	$\sigma = 2,\ \sigma^* = 2$	$\sigma = 2,\ \sigma^* = 0.01$	$\sigma = 2,\ \sigma^* = 0.01$
Emerging Return %		6.10	3.28	2.39
Developed Return %		3.86	1.92	2.23
Bond Premium		2.24	1.36	0.16
NX/Y		3.94	3.74	-0.12
$\sigma(Y)$	4.05	1.89	1.77	3.04
$\sigma(C)/\sigma(Y)$	1.15	1.00	1.00	1.00
$\sigma(NX/Y)/\sigma(Y)$	0.86	0.92	1.01	1.01
$\sigma(ToT)/\sigma(Y)$		0.39	0.46	0.01
$\sigma(ReR)/\sigma(Y)$	3.00	2.65	2.88	0.03
$\sigma(Premium)/\sigma(Y)$	0.83	1.11	0.75	0.04
$\rho(Y, Y^*)$	0.01	-0.67	-0.66	-0.94
$\rho(C, C^*)$	-0.30	-0.67	-0.66	-0.94
$\rho(NX/Y, Y)$	-0.53	-0.66	-0.64	-0.94
$\rho(ToT, Y)$		0.32	0.37	0.85
$\rho(ReR, Y)$	0.54	0.88	0.86	0.95
$\rho(Premium, Y)$	-0.55	-0.62	-0.55	-0.15

It is noteworthy a bond premium still exists even though the developed country households are almost risk neutral. The remaining (1.36 percent) premium can be explained by the efficiency argument. In fact, developed country firms have an efficient production scheme, where they use $1 - \vartheta_D$ portion of their tradable endowment in the production of their intermediate tradable goods and export the rest. When emerging households demand more than is exported, this creates an inefficiency in the production scheme of the developed country firms. This 136 basis points spread reflects the premium demanded by the developed country households due the loss of efficiency in the goods trade. If the developed country firms do not discriminate between the domestic and foreign inputs, then this premium would boil down to zero. The fourth column checks this argument by assuming foreign and domestic inputs as perfect substitutes (with κ=100). U Here, the bond premium almost boils down to zero. The second moment of the bond premium decreases almost to zero as the real exchange rate volatility touches zero. These calculations indicate that almost 25 percent of the bond premium volatility (0.28 of 1.11) is due to the consumption risk. The remaining 75 percent (0.83 of 1.11) can be attributed to the real exchange rate volatility.

2.5 Conclusion

In this chapter, we introduce time preference heterogeneity to an otherwise standard two-country and two-good endowment economy model, where each country issues a domestic currency denominated bond. Having more impatient emerging country households drastically improves the model's ability to match the emerging economy interest rate dynamics. Impatience of the emerging country households mainly breaks down the Cole and Obstfeld type of risk sharing in the goods market by causing the terms of trade to appreciate at times of a favorable productivity shock. However, the existence of the time preference heterogeneity can be viewed as the reflection of deeper (financial) frictions across the developed and emerging economies. Hence, the findings of this chapter seem to confirm the branch of the literature which asserts that emerging country interest rate dynamics can be explained by standard international macroeconomic models augmented with financial frictions. Finally, the results of the model also indicate that the real exchange rate volatility drives much of the volatility in the emerging country bond premium.

3. CHAPTER III

USD-TRY CROSS CURRENCY ASSET SWAP SPREADS

This chapter investigates the determinants of the USD-TRY cross currency swap spread, which is defined as the difference between the fixed rate paid in the swap transaction and the yield on a treasury bond that has the same maturity with the cross currency swap.

A cross currency swap (XCCY) is an agreement between the two parties to exchange interest payments and principals denominated in two different currencies. According to the figures published by Bank for International Settlements, the daily global volume of currency swaps increased from 1 billion US dollars (USD) a day in 1998 to 54 billion USD in April 2013. On the other hand, the total outstanding swap stock increased by ten folds to 26.4 trillion USD in the same period[4].

[4] These figures are available on the "Triennial Central Bank Survey: Foreign exchange turnover in April 2013" published on September, 2013 and "Statistical Release: OTC derivatives statistics at end-June 2013" published on November, 2013.

Investigating the factors that affect the cross currency swap spreads improves our understanding of the fair bond pricing. To have a profound knowledge of fair value of a bond is important not only for the market practitioners, but also for academicians and policy makers. Market practitioners may long the undervalued bonds and short the overvalued ones once they have a better gauge for measuring the fair prices. Policy makers, on the other hand, will have more accurate information derived from the bond market once fair pricing is achieved through the swap market.

A cross currency swap deal can be also deemed as an exchange of a fixed coupon bond that is denominated in one currency with a floating rate bond that is denominated in another currency. A cross currency swap enables its holder to gain exposure to a country's risk without physically holding its bonds. There is a growing trend in international financial markets towards using the swap curve instead of the bond curve for pricing issues due to the liquidity in the swap markets. Swap markets are much more liquid than government bond markets both for emerging and developed countries. The liquidity in the bond market may dry up during times of turmoil, whereas the swap market sustains a certain level of liquidity due to differences in its structure[5].

The situation is not different in Turkey. The use of swaps in Turkey started in mid-2000's and has gained pace since then. The popularity of the swaps was a response to the banking system's need to hedge the interest rate risk due to the maturity

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[5] While there is a supplier monopoly in the government bond market, a large number of suppliers are involved in supplying swap deals. This structural difference makes swaps highly liquid. Also ease of unwinding an existing position in the swaps market adds to the liquidity of the swaps. Also the collateral being a hard currency in a XCCY deal increases the popularity of swaps especially among foreign investors.

mismatch of the assets and liabilities in the bank balance sheets[6]. Net outstanding swap stock, the amount that foreign investors supply to the Turkish banks, takes values between 3 and 35 billion USD for the period between 2006 and 2015. As of February 2015, the level of net outstanding swap stock is 19.5 billion USD. The liquidity in the swap market stems from its popularity among foreign investors, who can gain exposure to the cross-border (Turkey) risk without bearing any credit risk thanks to holding hard currency during the lifetime of the swaps.

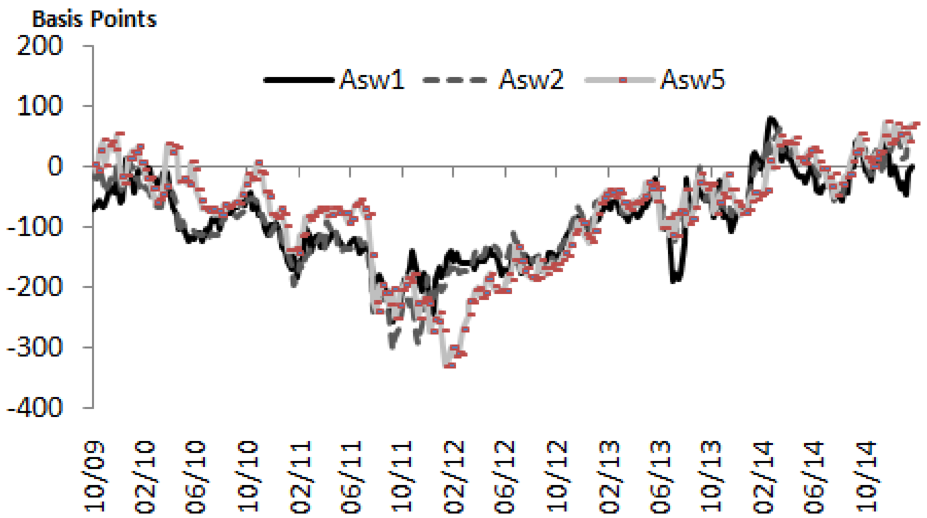

Figure 1. Cross Currency Swap Spreads

The lack of a deep and liquid interest rate swap market referenced to a reliable and hedgable benchmark interbank rate prevents banks from converting their fixed-income assets into floating ones. Hence, extending the duration of the liabilities via cross currency swaps has become the second best option for the banks until

[6] The weighted average duration of the Turkish lira deposits in the banking system is still less than 3 months, whereas duration of loans is measured in years. Hence, a typical Turkish bank is in need of hedging the interest rate risk arising from the maturity mismatch.

recently[7]. Therefore, XCCY swaps have become the most widely used form of swaps in Turkey. Being liquid, the fixed rates on these swaps constitute a benchmark for relative pricing for the Turkish Treasury bonds. For Turkey, the cross currency swap spread has had values ranging from 80 bp to -300 bp during the period between 2010 and 2015, as shown in Figure (1).

In the remainder of this chapter, Section 2 briefly reviews the related literature; Section 3 explains the mechanics of a cross currency swap; Section 4 presents the empirical model and outlines the data set; Section 5 gives the findings of the empirical model, and the final section concludes.

3.1 Literature Review

The theoretical and empirical literature on swap spreads, on interest rate swap in particular, is voluminous. Usmen (1994) is the only paper that proposes a theoretical model to explain the spread of cross currency basis swaps in excess of government yields. As cross currency swaps are mainly used in emerging markets, it is hard to find academic studies on this swap type. However, as interest rate swaps are a special case of cross currency swaps, one can expect the determinants of interest rate swap spreads to be also effective in explaining cross currency swap spreads. Therefore, from now on, the literature review focuses on the interest rate swap spread.

[7] Cross currency swaps are also prevalent in China, Indonesia, Russia and Romania. Infact, banks would prefer to use interest rate swaps to cross currency swaps in hedging their interest rate risk, because the former does not necessitate any exchange of notional. Recently, Turkish banks started to use a special form of interest rate swap where 3-month USDTRY implied forward rates are used at the floating leg.

The early literature located counterparty risk at the epicenter of the determinants of the interest rate swap spread. In other words, the main reason for swap yields to deviate from government bond yields was believed to be the counterparty risk, which was then taken to be existent in swap pricing but absent in government bond pricing[8]. Sun et al. (1993), Brown et al. (1994), Duffie and Singleton (1997), Minton (1997), Lang et al. (1998), Eom et al. (2000), Lekkos and Milas (2001), Fehle (2003), Kobor et al. (2005), and Feldhütter and Lando (2008) are examples of the studies that focused on the role of counterparty risk in explaining interest rate swap spreads. The studies in the related literature have generally employed the spread between AAA and lower rated bonds (i.e. AA, A or B) as a gauge of counterparty risk.

On the other hand, in the literature there are also studies which claim that counterparty risk cannot play a major role in explaining the interest rate swap spreads. Evans and Bales (1991), Litzenberger (1992), Chen and Selender (1994), Duffie and Huang (1996) and Cossin and Pirotte (1997) are examples of such studies. They in general cite three reasons to deny the role of counterparty risk in determining the interest rate swap spread; (i) the notional amount is not exchanged and interest payments are netted out during an interest rate swap, and the amount that is risked by entering into a swap is not that big, resulting in no counterparty risk, (ii) Smith et al. (1988) and Hull (1989) argue that a counterparty will not default as long as the net worth of the swap to that counterparty is not negative. Thus, for a default event to occur during an interest rate swap, both a counterparty

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[8] The government bonds denominated in local currencies are deemed to be risk-free as the government can always pay its arrears by printing money. However, there are occasions, in which sovereigns opted to default on their domestic currency liabilities, in the finance history. This can be so as long as the debt has a very short-term maturity and/or the domestic debt mainly consists of floating rate notes.

has to default and the net worth of the swap to that counterparty should be negative, (iii) Sorensen and Bollier (1994) claim that counterparty risk is not unilateral. As both counterparties may default, interest rate swap spread should price the relative counterparty risk, which is the difference between the riskiness of the two counterparties. Assuming this holds, even negative swap spreads can be possible when the riskiness of the swap seller is much higher than that of the buyer.

Other than counterparty risk, some factors that inhibit the pricing of the counterparty risk are also believed to impact the interest rate swap spreads. Smith et al. (1988) argue that term premium affects the interest rate swap yields by influencing the counterparty risk embedded in the swap prices. On the other hand, Sorensen and Bollier (1994) evaluate the counterparty risk by modeling the renewal cost of the swap in case of a default. Exploiting the resemblance between options and swaps, Sorensen and Bollier (1994) use methodologies employed in option analysis. Accordingly, the current value of an option incorporates option renewal costs of all possible states. Hence, the shape and the volatility of the bond yield curve affect interest rate swap spreads as they influence the price of the option that incorporates the renewal cost of the swap[9]. For example, as an escalation in the interest rate volatility or a steepening yield curve increases the probability of higher future interest rates, a fixed payer in the swap agreement becoming more valuable. This, in turn, increases the probability of default of the swap seller (fixed rate receiver), so fixed rate payer wants to pay a lower rate, which will result in a reduced interest rate swap spread. However, empirical studies in the literature do not

[9] Level of interest rates, term premium, the slope of the yield curve and volatility of the interest rates are the factors that are mentioned in the literature to have an effect on the pricing of the counterparty risk.

arrive at a clear conclusion about the relation of interest rate volatility (or the slope of the bond yield curve) with the interest rate swap spread. For example, Minton (1997) and In et al. (2003) report a positive relation between the interest rate volatility and interest rate swap spreads, whereas Lekkos and Milas (2001) find a negative relation between the two.

Usmen (1994) adds exchange rate movements to his theoretical model of the currency swap spreads. When cross currency swaps are considered, it is plausible to add the volatility of the exchange rate to empirical models as well.

Another factor that is believed to affect the interest rate swap spread in the literature is the liquidity premium. LIBOR rates are higher than comparable risk-free government bond yields as they are uncollateralized and prone to drying out of the funding liquidity. Use of LIBOR rates, instead of risk-free government yields, at the floating leg of the swap increases the fixed rate that has to be paid by the swap buyer as well[10]. Then, the positive interest rate swap spread can be attributed to the liquidity premium priced in the TED spread, the difference between the LIBOR rate and U.S. government bill being with same maturities. Duffie and Singleton (1997), He (2000), Lekkos and Milas (2001), In et al. (2003), Fehle (2003), Liu et al. (2006) are examples of the studies that find the liquidity premium responsible for the movements in the interest rate swap spread.

One final factor to affect the interest rate swap spreads is the structure of the swap market. According to that hypothesis, the market structure has an effect on the

[10] Fehle (2003) provides a good representation of this fact.

spread through its impact on the demand and supply in the market. Smith et al. (1988), Wall (1989) and Titman (1992) report the inefficiencies (i.e. asymmetric information, the cost of financial distress and financing strategies like fixed vs. floating payments) in the loanable funds market. The structure of swap market enables its participants to overcome these inefficiencies and gain economic profit. Therefore, the swap yields can be thought as a function of market inefficiencies.

One of the main factors that has an essential impact on the supply of swap is the slope of the bond yield curve. The swap seller can be thought as an investor who invests in a long-term fixed coupon bond and finance himself or herself with rolling short term floating rates. Therefore, the swap seller is expected to be rewarded by a positive return for taking risk when the yield curve is upward sloping. This is a term premium like compensation for the swap seller who runs the interest rate risk. As Minton (1997), Lang et al. (1998), and Fehle (2003) point out, the interest rate risk born by the swap seller should be negatively reflected in the fixed rate that is paid by the buyer. However, we have term premium also in the bond yield curve. Therefore, to be able to affect the spread between the two market yields, term premium changes in the swap market and the bond market should differ from each other. The literature states that it is the difference in both demand and supply market structures that causes such deviations in the term premium reflected in them. As notional amount is not exchanged, especially in interest rate swaps, and unwinding an existing position is much easier in the swaps market, they are more liquid than bond markets. Hence, a common factor that impacts either market has different effects on the term premium in each market.

3.2 Mechanics of the Cross Currency Swap

Cross currency swap is a mix of currency swap and an interest rate swap. In a typical plain vanilla currency (FX) swap, the two parties swap the notional on the settlement date and then exchange the principal and accrued interest in one currency to another at the maturity. The currency swap exposes both parties to the other currency during the life time of the swap. On the other hand, in an interest rate swap, the two parties regularly exchange fixed vs floating interest rates without swapping any notional. In a cross currency swap, the two parties exchange notional in two different currencies both on the settlement date and at the maturity of the deal. Besides, both parties regularly exchange the interest rates on either currencies every quarter during the lifetime of the swap contract[11]. The mechanism of a cross currency swap is shown in Figure (2)[12].

In a typical swap contract in Turkey, Bank B in Figure (2) represents the Turkish banks, which are in need of interest risk hedging or long term TRY funding. In net, Turkish banks exchange their USD holdings for TRY funding. Bank A can be regarded as a foreign bank or an affiliate of a foreign bank that holds TRY funds in its balance sheet. Indeed, at the first step just before the swap contract, at $t=0$, that foreign bank (shown as Bank A) converts her USD holdings to TRY at the spot exchange rate, denoted as S. And then Bank A enters into a swap contract in order to gain exposure to TRY return. In the market's jargon, Bank A is named as swap seller (TRY receiver or floating payer). Bank B, on the other hand, is called as swap

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[11] An interest swap, where both parties exchange floating vs. fixed interest rates in the same currency, is a special form of the cross currency swap that also involves the exchange of notional in different currencies.
[12] The cross currency swap involves the exchange of a floating interest rate on one currency for a fixed rate in the other currency. On the other hand, a cross currency basis swap involves the exchange of a floating vs. floating rates in either currencies.

buyer (TRY payer or fixed payer). The minimum maturity for the cross currency swap is one year, and the most active maturity is five years in the Turkish case.

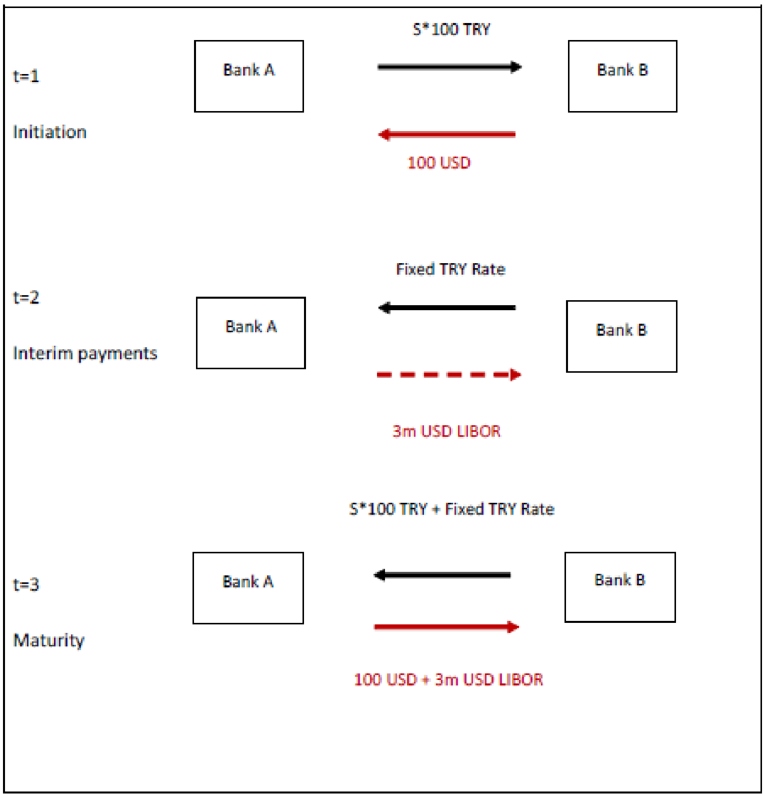

Figure 2. Mechanics of a Cross Currency Swap

The main motivation of the TRY payer in the cross currency swap is to guarantee long-term TRY funding at a fixed rate, while the TRY receiver gains the TRY interest rate on excess of USD LIBOR. Cross currency swaps enable Turkish banks to convert their USD funding to TRY funding without running an open fx position in their balance sheets. By this mean, Turkish banks can reduce the maturity mismatch of the asset and liability sides of their balance sheets.

Turkish banks may also be in the TRY receiver position in order to raise USD funding or to be able to hedge an existing position in another agreement. However, in net terms, Turkish banks mainly use these swaps to access long-term TRY funding.

The swap agreement, itself, does not expose the two counterparties to any exchange rate risk. Both counterparties swap their cash holdings at a fixed rate, *S*, at both initiation and maturity. However, if the TRY receiver is a foreigner, she takes foreign exchange risk as she converts her USD holdings to TRY at the spot market at $t=0$ and swap position does not eliminate or hedge that risk.

3.3 Empirical Model and Data

3.3.1 The Model

Variables that are found to be effective in the pricing of the interest rate swaps serve the design of the empirical model.. Furthermore, the additional factors that arise due to the difference in the nature of the cross currency swap contracts are incorporated.

As the cross currency swaps involve the exchange of notional, the counterparty risk may be expected to be more decisive in XCCYs than it is in interest rate swaps. Besides, in this model, estimation period spans crises and turmoil periods, where credit risk of buyers and sellers are more pronounced. Hence, it uses the credit risks of the both swap parties as explanatory variables.

Empirical studies in the literature cannot effectively measure netted counterparty risk in a swap deal as they employ macro level data. In other words, one needs micro level data to identify the involved counterparties and associated risks in a swap deal. The structure of the cross currency swap market in Turkey helps overcome this complication in the literature[13]. An analysis of the Central Bank of Turkey's exclusive data set on swap deals reveals that, in net terms, only a small number of foreign banks constitute the swap seller side. On the other hand, swap buyers, in net, are the local banks that are in need of TRY liquidity. Therefore, we can use credit risks of the swap seller and buyer separately in our empirical analysis.

Moreover, we include the slope of the bond yield curve in our empirical model. This slope is expected to affect the cross currency swap spread in two ways. First, flattening or steepening of bond yield curve is not always directly reflected on the swap yields due to the structural differences across two markets. Second, the changes in the slope of the yield curve influence the pricing of the counterparty risk. Hence, it would be convenient to use the slopes of both US Treasury and Turkish Treasury bond yield curves separately in order to capture each one's effect on the swap spread. However, being a small open economy and changes in the Turkish bond yields are usually driven by the changes in the US bond yields. To prevent a possible multi-collinearity in the estimations, only the slope of Turkish bond yield curve was used in estimations.

Furthermore, we can classify movements of the slope of TRY bond yield curve into two: changes due to the variations in the slope of the US bond yield curve and

[13] As a remedy to this complication, the literature on interest rate swap spreads generally uses the difference between the borrowing rates of an AA and a triple-A rated bank (AA spread) as a proxy for the counterparty risk between the two parties. This assumption implies the spread between the risks of two counterparties to be equal to AA spread. This simplification may lead to misleading results especially when the spread between the two parties' risks is substantially different than the AA spread. This simplification may be the reason why the literature reports counterparty risk coefficient that is insignificant or with unexpected signs.

idiosyncratic changes specific to Turkey[14]. In the former, a bull-steepening[15] US bond yield curve would be expected to decrease the cross currency swap spread. A decrease in the short-end of the US bond yield curve means a reduction in the costs of the swap seller who is the floating payer. As the long-end of the US bond yield curve, and hence long-end of TRY yield curve, remain unchanged under a bull-steepening, the swap spread would be expected to decline. A bear-steepening[16] US bond yield curve would also be expected to decrease the cross currency swap spread but this time through an increase in the long-term TRY bond yields. A steepening of either kind will lead to a surge in the likelihood of default of the swap seller and a decrease in the cross currency swap spread. In the latter, idiosyncratic changes in the slope of the TRY yield curve are not expected to affect the risk or profit of the swap seller who pays the floating USD LIBOR rate. However, the increase in the term premium due to the idiosyncratic factors may not be fully reflected in the fixed swap rates as swap market eliminates some of the imperfections that exist in the bond market. Hence, idiosyncratic shocks that increase the slope of the TRY bond curve will result in a decrease in the swap spread.

The empirical model here also includes the foreign exchange rate volatility, which affects the pricing of the counterparty risk in the swap deal. A surge in foreign exchange rate volatility is expected to increase the swap spread. This channel

[14] Idiosyncratic changes refer to Turkey specific monetary policy shocks and risk premium changes. TRY related idiosyncratic have almost no effect on US bond yields.
[15] Bull-steepening implies a reduction in the short-end of the yield curve while the long-end remains intact.
[16] Bear-steepening implies an increase in the long-end of the yield curve while the short-end remains intact.

operates through an increase in the probability of default of the local banks, which are net swap buyers, due to heightened foreign exchange rate volatility[17].

Lastly, the turnover rates of TRY denominated bonds are used to account for the liquidity premium between swap and bond markets. As a surge in turnover rates will imply a lower liquidity premium priced in bond yields, a positive sign for the coefficient in front of the turnover rates is likely. It should be noted that this conclusion relies on the assumption that swap markets are highly liquid.

Based on these explanations, the regression equation estimated with OLS is produced for the cross currency swap spread with maturity *i*;

$$\Delta asw_{i,t} = \beta_{i,0} + \beta_{i,1}\left(\Delta risk_{i,t}^{swapseller}\right) + \beta_{i,2}\left(\Delta risk_{i,t}^{swapbuyer}\right) + \beta_{i,3}(\Delta excvol_t) + \beta_{i,4}\left(\Delta slope_{i,t}\right) + \varepsilon_{i,t} \tag{1}$$

Here, *asw* represents the spread of a cross currency swap over a government bond with the same maturity, *i* year. The variables $risk^{swapseller}$ and $risk^{swapbuyer}$ refer to the counterparty risk of the swap seller and the swap buyer, respectively. Finally, *excvol* and *slope* refer to the exchange rate volatility of the spot USDTRY rates and the slope of the TRY bond yield curve. This thesis estimates the model in first differences.

[17] The level of the open foreign exchange rate position that Turkish banks may run cannot exceed 20 percent of their capitals. This is stated by the law. However, Turkish banks are exposed to credit risk as the corporates, to which banks extend loans in USD, usually go unhedged as they are not subject to such restriction. Higher exchange rate volatility translates into higher credit risk and higher credit risk translates into higher probability of default for the Turkish banks.

3.3.2 Data

This subsection introduces the data set used in the empirical analysis, which covers the period between October 2009 and February 2015. Weekly data is used in the empirical analysis. Maturities of 1, 2, and 5 years were chosen for examination due to their data availability and volume. Except for the outstanding amount of total swap transactions, all of the data is available on Bloomberg[18]. Table 7 presents the results of descriptive statistics used in the empirical analysis.

Table 7: Descriptive Statistics

Variables	Mean	Median	Min	Max	Std.Dev
Asw1	−87.66	−85.75	−257.00	81.50	68.06
Asw2	−85.03	−80.00	−303.00	64.00	75.31
Asw5	−76.85	−62.25	−330.50	74.50	89.89
Sellers' Exp Risk Prem (1y)	33.37	14.67	−14.02	168.01	38.54
Sellers' Exp Risk Prem (2y)	124.21	114.77	53.67	295.96	52.18
Sellers' Exp Risk Prem (5y)	95.56	94.04	29.23	236.64	44.47
Buyers' Risk Prem (5y)	166.67	174.40	39.10	274.70	48.43
Exchange Rate Volatility	2.22	0.74	0.00	23.80	3.63
Slope of TRY Bond Curve (1y)	−84.01	−96.50	−274.00	167.00	89.87
Slope of TRY Bond Curve (2y)	−60.73	−58.00	−291.50	179.00	103.05
Slope of TRY Bond Curve (5y)	−36.15	−41.50	−285.50	177.50	105.85

The average USD credit default swap (CDS) rates of three main (net) swap sellers (Citibank, HSBC and JP Morgan) is used to represent the credit risk of the swap seller (Figure 3).

[18] The data on total stock of swaps and parties involved is exclusively obtained from Central Bank of Turkey. However, we do not use this data in our estimations.

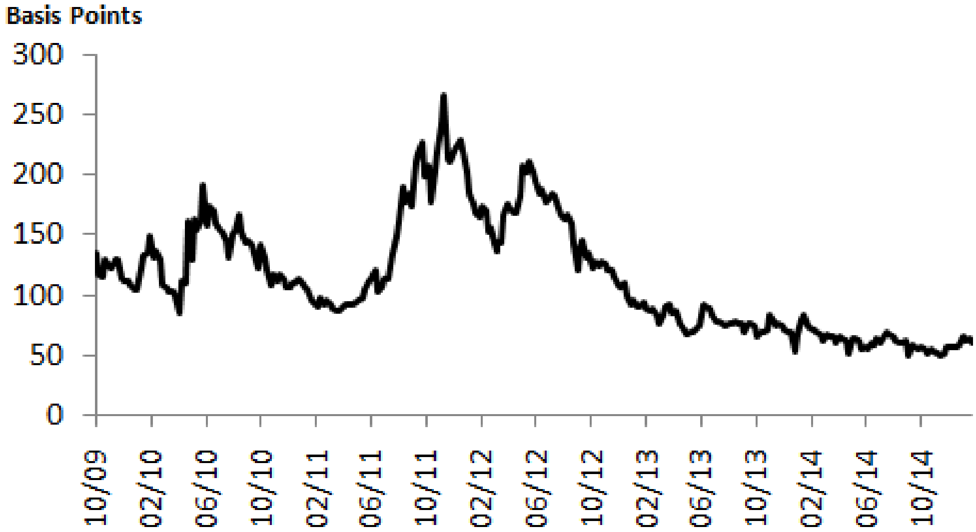

Figure 3. Credit Risk of the Swap Seller (USD risk, 5y)

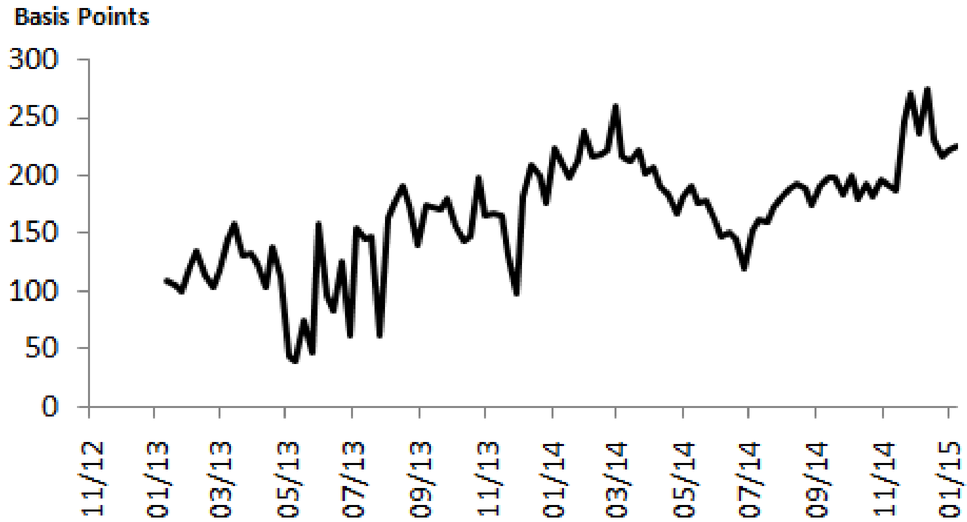

Figure 4. Credit Risk of the Swap Buyer (TRY risk, 5y)

Similarly, the average TRY risk of Turkish banks is used to represent the counterparty risk of the swap buyer. The model also uses the spread between the yields of TRY denominated Turkish banks' bonds[19] and the government bonds with same maturity in the secondary market as the TRY risk of the swap buyer (Figure 4). Due to data unavailability, this spread can only be calculated after February 2013.

For each of the three set of regressions, the difference between the bond yield at corresponding maturity with the swap deal and 3 month bond yield as the slope of the bond yield curve is used (Figure 5).

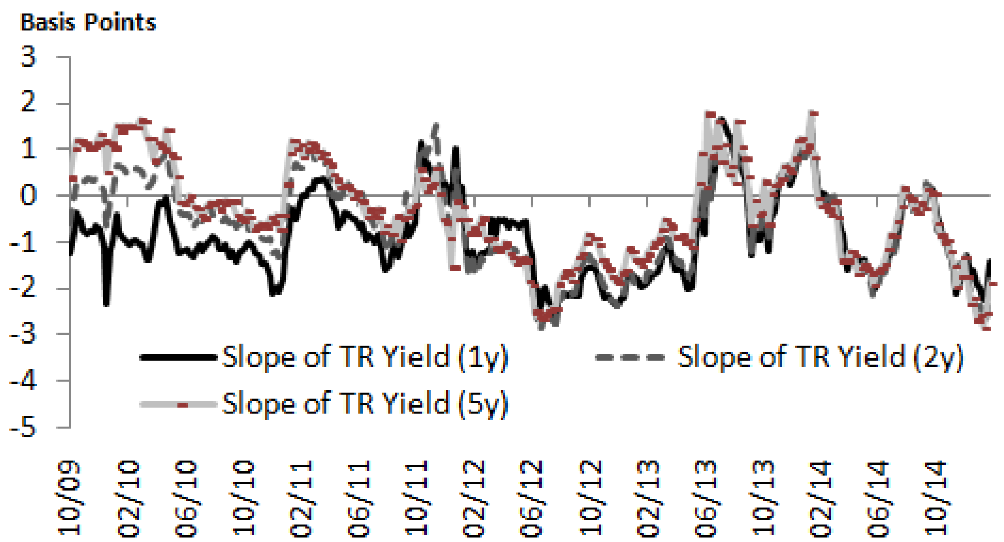

Figure 5. Slope of the TRY Bond Yield Curve

The nominal exchange rate volatility measure is the historical volatility calculated as the square of weekly changes in the nominal USDTRY spot rates (Figure 6).

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[19] Using Nelson-Siegel methodology, we calculate a generic yield curve for the Turkish banks' bonds available in the secondary market. Number of bank bonds traded on Borsa Istanbul changes from four to eight through the estimation period.

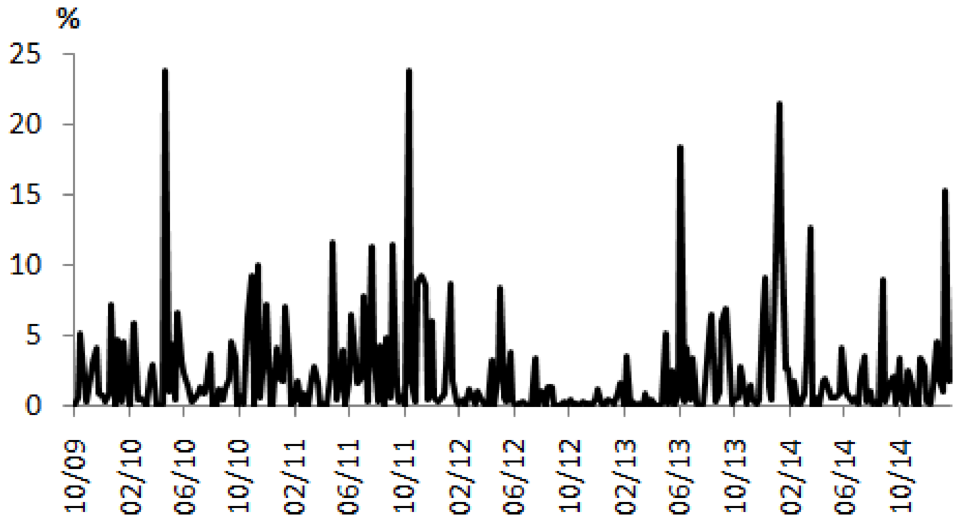

Figure 6. Exchange Rate Volatility (weekly, realized)

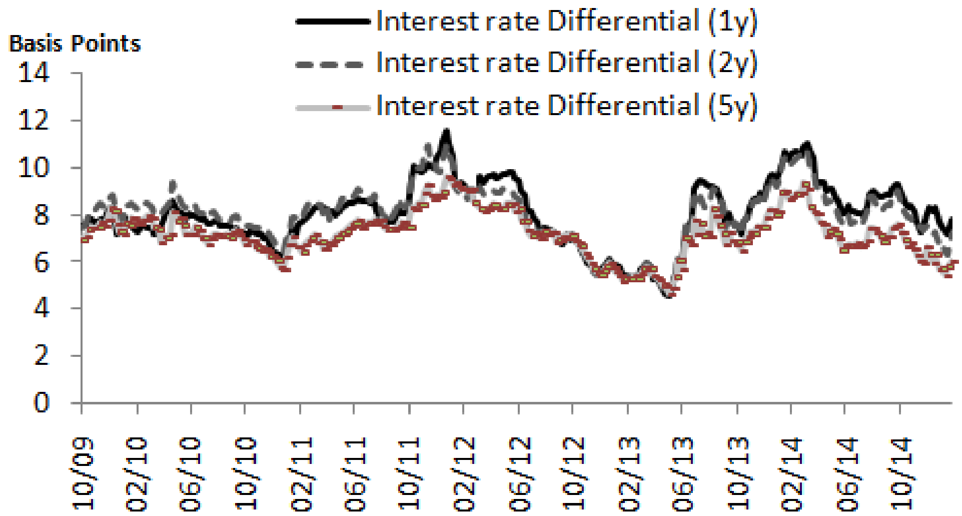

Figure 7. Expected Percentage Exchange Rate Change from UIP

Finally, for a given maturity, an expected USDTRY rate is needed to calculate the counterparty risk of the swap seller in terms of TRY. A standard uncovered interest parity equation is followed by the use of the ratio of two countries' n year interest rates to represent the expected foreign exchange rate at the n^{th} year (Figure 7). Table 8 exhibits the results of the unit root tests.

Table 8: Unit Root Test Results

			Period: Oct.2009 - Feb.2015		
Variables (level)	t-stat	p-value	Variables (difference)	t-stat	p-value
Asw1	−2.433	0.134		−17.165	0.000
Asw2	−1.802	0.379		−16.862	0.000
Asw5	−1.705	0.427		−17.373	0.000
Sellers' Exp Risk Prem (1y)	−2.835	0.055		−19.200	0.000
Sellers' Exp Risk Prem (2y)	−1.577	0.493		−20.300	0.000
Sellers' Exp Risk Prem (5y)	−1.523	0.521		−20.743	0.000
Buyers' Risk Prem (5y)	−2.502	0.118		−10.300	0.000
Exchange Rate Volatility	−15.20	0.000		−15.810	0.000
Slope of TRY Bond Curve (1y)	−3.382	0.012		−17.487	0.000
Slope of TRY Bond Curve (2y)	−2.976	0.039		−18.017	0.000
Slope of TRY Bond Curve (5y)	−2.200	0.207		−19.864	0.000

3.4 Results

Equation (1) is estimated to obtain heteroscedasticity and autocorrelation consistent (HAC) standard errors of the coefficients from OLS in first differences. A structural break is found after the Taper Tantrum, which started in May 2013 and caused market liquidity to dry up in emerging economies. Hence, the regressions were used for two different periods; the first period is between October 2009 and May 2013, and the second period is between November 2013 and February 2015. The results of the estimations for three different maturities and two different periods are shown in Table 9.

The R^2 values shown in Table 9 are satisfactory for an estimation in first differences. This shows us that the variables in the empirical model are successful in explaining the variations in the cross currency swap spreads.

As shown in Table 9, prior to May 2013 the swap seller's risk had a decreasing effect on the swap spread. A 100 basis points hike in the swap seller's risk decreases the 1, 2 and 5 year swap spreads by 15, 23 and 18 basis points, respectively. This fact can be attributed to the rise in the level and importance of the swap sellers' CDS spreads in the aftermath of Global Financial Crisis of 2008. In the aftermath of the crisis, some swap sellers are directly, and some indirectly, affected by the liquidity and capital shortages in their headquarters operating at the epicenter of the crisis. When the risks started to shift towards emerging markets with the Taper Tantrum, the swap seller's risk loses its significance in determining swap spreads in the period after November 2013. On the other hand, the surge in the risk of the swap buyer has an increasing effect on the 2 and 5 year swap spreads by 17[20] and 31 basis points, respectively in the second period of the estimations. Due to lack of the counterparty risk measure that we use for the Turkish banks prior to March 2013, we cannot include swap buyer's risk into the estimations in the first period.

[20] At 10 percent significance level.

Table 9: Estimation Results

		Period I Oct. 2009 - May 2013	Period II Nov. 2013 - Feb. 2015
ΔASW Model (1 year)			
ΔSeller's Expected Credit Risk	Coeff.	**-0.148**	-0.073
	p-value	0.100	0.910
ΔBuyer's Credit Risk	Coeff.	-	-0.102
	p-value	-	0.334
ΔExchange Rate Volatility	Coeff.	**-0.461**	**1.212**
	p-value	0.038	0.087
ΔSlope of TRY Yield	Coeff.	-0.114	-0.028
	p-value	0.155	0.770
R^2		**0.152**	**0.124**
ΔASW Model (2 year)			
ΔSeller's Expected Credit Risk	Coeff.	**-0.229**	-0.013
	p-value	0.006	0.972
ΔBuyer's Credit Risk	Coeff.	-	**0.169**
	p-value	-	0.064
ΔExchange Rate Volatility	Coeff.	-0.219	**1.342**
	p-value	0.331	0.016
ΔSlope of TRY Yield	Coeff.	**-0.127**	**-0.094**
	p-value	0.038	0.023
R^2		**0.202**	**0.174**
ΔASW Model (5 year)			
ΔSeller's Expected Credit Risk	Coeff.	**-0.183**	0.125
	p-value	0.046	0.656
ΔBuyer's Credit Risk	Coeff.	-	**0.312**
	p-value	-	0.001
ΔExchange Rate Volatility	Coeff.	0.035	**1.079**
	p-value	0.916	0.009
ΔSlope of TRY Yield	Coeff.	**-0.213**	-0.025
	p-value	0.002	0.760
R^2		**0.185**	**0.226**

In accordance with our prior expectations, the sign of the coefficient in front of the slope of the Turkish bond yield curve is found to be negative. In other words, a steepening in the bond yield curve decreases the cross currency swap spreads. However, only the coefficient for the estimation at two year maturity is statistically significant for both periods. For the five-year maturity, only the coefficient for the first period turns out to be statistically significant.

Realized exchange rate volatility of USDTRY spot rates has an alternating effect across the two periods of the estimations. Prior to May 2013, an increase in the realized volatility had a decreasing effect on the swap spread for the one-year maturity and had no significant effect on the swap spreads at other maturities. However, after November 2013 the picture changed drastically; realized volatility increases had a positive and highly significant effect on swap spreads at all maturities. A one percent increase at the realized volatility is shown to increase the 1, 2 and 5 year swap spreads by 121, 134 and 108 basis points, respectively. Coefficient of realized volatility became positive after November 2013. From this, we can deduce that the surge in USDTRY implied volatility increased the credit risk of Turkish banks relatively more than it increased that of foreign banks after November 2013. This fact can be attributed to the high level of foreign debt in Turkish banks' balance sheets.

Finally, we can also evaluate the determinants of the swap spread with respect to the maturities of the swap contracts. For the period before May 2013, the spread on short term (1 and 2 years) swap deals were mainly affected by the credit risk of the foreign banks and implied volatility of USDTRY. For the same period, the spread on long term (5 year) swap deals were mainly affected by the credit risk of the foreign banks and the slope of TRY denominated bond yield curve. After November 2013, the spread on short term swap deals were mainly affected by the implied volatility of USDTRY. And for the period after November 2013, in addition to implied volatility of USDTRY, the credit risk of Turkish banks was found to be effective in determining the spread on long term swap deals.

3.5 Conclusion

The theoretical and empirical literature mainly focuses on the determinants of the spread on interest rate swaps. This chapter aims to fill the gap in the literature on the determinants of cross currency swap spreads with a special focus on Turkey. It proposes an empirical model, based on the variables used in the literature, to identify the determinants of the USDTRY swap spreads.

Before the Taper Tantrum, it was widely the credit risk of the swap sellers (foreign banks) that derived the swap spread, yet after November 2013 the credit risk of the Turkish banks became more pronounced in determining the spread. This can be attributed to the increased significance of the foreign exchange rate volatility in the second period of estimations. The credit risk of the Turkish banks deteriorates due to the heightened foreign exchange rate volatility after May 2013 turbulence. It is also noteworthy that a steepening in the TRY bond curve decreases the swap spread in both periods.

CHAPTER IV

MEASURING CHANGES IN LONG-TERM INFLATION EXPECTATIONS IN TURKEY

This chapter, using 10-year nominal and inflation index-linked government (CPI-linker) bonds, introduces a market-based gauge of measuring changes in long-run inflation expectations for Turkey. The methodology introduced to identify the relative liquidity premium embedded in treasury bonds is novel and simple. Measuring the level of and change in inflation expectations is a central issue for most of the agents in the economy, but it is especially important for monetary policy makers. A central bank's power to affect aggregate demand, thus inflation, relies on its power to change real interest rates prevalent in the economy[21]. However, central

[21] Economic theory asserts that agents in the economy make consumption (or investment) decisions by comparing the prevalent real rate in the economy to their discount factor (or internal rate of return of the investment).

banks cannot set the real rates. They can only set the nominal rates. In response to the nominal policy rate changes, it is the change in inflation expectations that decides for the real rates at the end of the day. Hence, a timely and accurate measure that can identify the changes in inflation expectations, especially in the long run, would be a must-have weapon in every central bank's arsenal[22].

There are basically two ways of having such a measure: (i) directly surveying the market participants what their inflation expectation is, or (ii) inferring policy related information from market prices. The latter way has several superiorities to the former: (i) it is timely, that is, it has a higher frequency compared to surveys done twice a month or once a month, (ii) market players risk their money while trading in the market, but survey respondents are neither punished nor rewarded for their answers, (iii) market based measures represent the whole market, whereas survey respondents only form a small sample it.

Using nominal bonds together with inflation CPI-linkers under a no-arbitrage assumption is a very popular way of arriving at market based measures of inflation expectations. In this study, what is observed as the real rate of a CPI-linker is comprised of future expected real rate, a real rate premium, and a liquidity premium. On top of these, a nominal rate on a nominal government bond contains future expected inflation rate, an inflation risk premium, and a liquidity premium that is not necessarily equal to that of the CPI-linker. Despite the complication caused by these premiums, many attempts were made to decompose the real and nominal yields in order to obtain an accurate measure of inflation expectations.

[22] These measures not only help in assessing the effectiveness of the monetary policy changes but also the credibility of the central bank.

In the present study's market-based methodology of measuring changes in long-run inflation expectations, the sum of average 10-year expected inflation and inflation risk premium is 5.38 percent for the period between October 2012 and March 2015. Furthermore, inflation expectations and the level of inflation risk premium fluctuates around this average by hitting to 4.54 percent at its minimum and 7.38 percent maximum.

The organization of this chapter is as follows: Section 2 briefly reviews the recent literature on market-based measure of inflation expectations; Section 3 introduces the mechanics of linkers and demonstrates the similarities and disparities between nominal bonds and linkers; Section 4 introduces the methodology and the data set used; Section 5 presents our results, and the final section concludes.

4.1 Literature Review

This section briefly reviews the recent literature related to the use of inflation-indexed bonds[23] and nominal bonds together to extract inflation expectations and associated risk premia.

The literature mostly uses affine term structure models (with no arbitrage assumption) to decompose the breakeven inflation rate into its subcomponents of inflation expectations and inflation risk premium. Affine models with latent factors are simultaneously fitted to both nominal and real government yield curves. The

[23] There are two good review papers on issues related to inflation-indexed bonds. The first belongs to Campbell & Viceira (2009), who present the mechanics of the inflation-indexed bond markets in the U.S. and in the U.K. The second one belongs to Bekaert and Wang (2010), who reviews the literature on inflation-indexed bonds.

resulting model is estimated with the help of Kalman filter, where high-frequency (i.e. daily) inflation expectations are obtained from the noisy survey data on long-term inflation expectations. Chen et al. (2005) use a two-factor affine model with weekly data, whereas Hördahl and Tristani (2010) use an affine macro-finance model with monthly data on yields, inflation, output gap, survey based inflation expectations and short-term interest rates together with nominal and real yields to decompose the breakeven inflation rate in the US. Adrian and Wu (2009) use an eight-factor term structure and Christensen et al. (2010) use a three-factor affine model, which does not employ any data on inflation expectations and inflation, for the US. Joyce et al. (2010) also use a three-factor model with a monthly data to obtain inflation expectations and inflation risk premium for UK. Again with a similar survey methodology, Garcia and Werner (2010) apply a term structure model on Euro denominated nominal and real yields to get inflation expectations and inflation risk premium for Euro area.

These aforementioned models are silent on the relative liquidity premium that exists between the nominal bonds and linkers. However, neglecting this relative liquidity premium may have misleading implications for the calculated inflation expectations and inflation risk premium. D'amico et al. (2010) incorporate a fourth factor, which deals with the liquidity premium, to an otherwise three-factor affine model. However, in their model nominal bonds are assumed to be perfectly liquid and the liquidity premium is only demanded by the holders of the linkers. Being aware of this liquidity premium, Grishchenko and Huang (2012) provide a liquidity correction for the inflation risk premium. Their study is model-free and takes the indexation lag into consideration in the calculation of inflation compensation of linkers. Their liquidity premium estimation is based on Hu, Pan, and Wang (2013).

They measure the market liquidity of linkers by using the difference between the generic real yield curve and the benchmark real yields observed in the linkers market. The proposed measure both incorporates the price of liquidity risk and the amount of that risk.

There are also regression-based methodologies to extract the liquidity premium embedded in the yields of the CPI-linkers. A regression-based measure of liquidity premium is provided by Gurkaynak et al. (2010), where they regress breakeven inflation rates on measures of liquidity. As simple OLS regressions are not capable of identifying the level of liquidity effect on breakeven rates, they normalize this effect to zero in April 2005[24] in order to observe the relative changes since that time. Implementing the Kalman filter to eliminate the noise in the survey based inflation expectations, authors manage to decompose high frequency inflation expectations and the inflation risk premium from the breakeven inflation rates. Using the same liquidity premium cleaning methodology with that of Gurkaynak et al. (2010), Pflueger and Viceira (2011) regress breakeven inflation rate on various indicators of liquidity[25] to extract the relative liquidity premium between nominal bonds and linkers both in US and UK.

To our knowledge, there is only one study on deriving the breakeven inflation rate from Turkish lira denominated nominal bonds and linkers. Duran, Gulsen and Gurkaynak (2011) fit daily nominal and real yield curves by using Nelson-Siegel methodology for the period of October 2009-July 2011. They also empirically check

[24] Authors choose April 2005 as benchmark since the TIPS liquidity premium at that date is estimated to be the lowest during the sample period.
[25] These indicators include the nominal off-the-run spread, relative transaction volume of inflation-indexed bonds and nominal bonds, and proxies for the cost of funding a levered investment in inflation-indexed bonds.

for a possible liquidity premium embedded in the breakeven rates but do not find any sign of liquidity premium in linkers.

4.2 Bond Notation and Definitions

This section covers the notations and definitions that are used in the rest of the paper. To make them better understood, first the basic differences between a nominal and CPI-linker bond are explained.

A nominal bond is a financial instrument that guarantees a fixed nominal rate of return to investors who hold the bond till its maturity. On the other hand, a CPI-linker is a bond that guarantees a fixed real rate of return that pays to its investor[26]. CPI-linkers can be claimed to provide their investors with protection against the adverse realizations in the headline inflation in the future. The nominal coupon and principal payments of the CPI-linkers are indexed to a reference index according to the following formulation:

$$Index\ Ratio_t = \frac{Price\ Index_{\ t}}{Price\ Index_{\ 0}} \tag{1}$$

This index ratio, calculated by the reference price index, is used to adjust the nominal amounts of the real coupon payments and the principal payment at any time *t*. The reference index[27] for the d^{th} day of n^{th} month, which is daily announced on the Undersecretariat of Turkish Treasury's web-site, is calculated as follows:

[26] The real coupon rate, which is fixed through the life of the bond, is announced prior to auctions.
[27] More information on the linkers issued by the Turkish Treasury and details of the mechanics can be found in the document titled as "Consumer Prıce Index (CPI) Indexed Government Bonds" on Turkish Treasury's web-site (http://treasury.gov.tr/en-US/Pages/Investors-Guides).

$$Reference\ Index_t = CPI_{n-3}\frac{d-1}{D}(CPI_{n-2} - CPI_{n-3}) \tag{2}$$

, where CPI_{n-2} and CPI_{n-3} denote the consumer price indices of month *n-2* and *n-3* respectively. Here, *d* denotes the number of days that passed in month *n* and *D* is the total number of days in month *n*. The value of the index for a given day of the month is calculated by interpolation of CPI_{n-2} and CPI_{n-3}.

In market practice, the price quotations for the linkers are given by the clean price. The clean price calculation for linkers is not different from the calculation for nominal bonds. In the pricing of the CPI-linkers, the real coupon rates and the real returns are used instead of nominal coupons and discount rates. The equation that establishes the relation between the price and the real return on holding the bond till its maturity can be given as follows:

$$P_t = \sum_{i=1}^{m}[\frac{c^{real}.100}{(1+r)^i} + \frac{100}{(1+r)^m}] \tag{3}$$

, where P_t , c^{real}, *r* and *m* are the clean price of the linker, the (real) coupon rate, the real rate of return on holding the bond till its maturity and remaining number of coupons, respectively. At any given time t, the accrued interest (AI_t) for the linker is given as follows:

$$AI_t = c^{real}.100\frac{Number\ of\ days\ accrued\ in\ the\ coupon\ period\ till\ time\ t}{Total\ number\ of\ days\ in\ the\ coupon\ period} \tag{4}$$

Regarding the notations, the continuously compounded zero yield on a nominal bond and on a CPI-linker (both with τ years to maturity) are denoted by y_t^τ and by r_t^τ respectively, What follows is the presentation of the building blocks of each zero-yield, starting with r_t^τ:

$$r_t^\tau \ = rr_t^\tau + rr_t^{prem,\tau} + liq_t^{Linker} \tag{5}$$

As of time t, the continuously compounded real yield r_t^τ consists of an average real rate rr_t^τ, an average real rate premium $rr_t^{prem,\tau}$ and an average liquidity premium liq_t^{Linker} for holding the CPI-inker throughout the τ years. The definitions of the components that form the yield on a CPI-linker is given as follows:

The real rate (rr_t^τ): the average annual real return demanded for holding the CPI-linker over the (τ-t) years till maturity.

The real rate premium ($rr_t^{prem,\tau}$): The premium demanded by the investor for the probability of having future realized real rate in the economy different from if it were gotten from holding the bond till maturity. It can also be deemed as the compensation for the uncertainty associated with the variability in the real interest rates.

The liquidity premium demanded for holding the CPI-linker (liq_t^{Linker}): the premium demanded by the investor for holding the CPI-linker, which can be bought or sold costly relative to a liquid asset that offers an equivalent future cash flow in any possible state of the world

Here, the assumption is that market players price nominal bonds and linkers are so consistent that the real rate (rr_t^{τ}) and the real rate premium ($rr_t^{prem,\tau}$) priced in linkers are also exactly priced in the nominal bonds. With this in mind, the nominal zero-yield (y_t^{τ}) is written as follows:

$$y_t^{\tau} \; = \left(rr_t^{\tau} + rr_t^{prem,\tau}\right) + \pi_t^{\tau,e} + \pi_t^{prem,\tau} + liq_t^{Nom} \qquad (6)$$

As of time *t*, in addition to the real rate (rr_t^{τ}) and the real rate premium ($rr_t^{prem,\tau}$), the continuously compounded nominal yield (y_t^{τ}) consists of an expected average inflation rate ($\pi_t^{\tau,e}$), an average inflation risk premium ($\pi_t^{prem,\tau}$) and an average liquidity premium (liq_t^{Nom}) for holding the nominal bond throughout the τ years. The definitions for the real rate (rr_t^{τ}) and the real rate premium ($rr_t^{prem,\tau}$) also apply to the nominal bond. The definitions of the other components forming the yield on a nominal bond is given as follows:

The expected inflation rate ($\pi_t^{\tau,e}$): the average of the expected year-on-year changes in the price index over the (τ -*t*) years till maturity.

The inflation risk premium ($\pi_t^{prem,\tau}$): The premium demanded by the investor for the probability of having future realized inflation different from the expected. This premium arises from the covariance between the real stochastic discount factor and the expected inflation in the fundamental asset pricing equation provided by Cochrane (2009). Hence, its sign can be positive or negative depending on how the inflation risk covaries with the marginal utility of consumption.

The liquidity premium demanded for holding the nominal bond (liq_t^{Nom}): the premium demanded by the investor for holding the nominal bond, which can be bought or sold costly relative to a liquid asset that offers an equivalent future cash flow in any possible state of the world.

Below is the definition of breakeven inflation rate (b_t^τ) as the difference between the time *t* nominal and real yields for the maturity τ:

$$b_t^\tau = y_t^\tau - r_t^\tau \tag{7}$$

Inserting equation (5) and (6) into (7) yields the following:

$$b_t^\tau = E_t^\tau[\pi] + \pi_t^{prem,\tau} + (liq_t^{Nom} - liq_t^{Linker}) \tag{8}$$

Equation (8) tells us that the breakeven inflation rate at any given point in time and for any maturity includes an inflation risk premium and a relative liquidity premium[28] besides the expected inflation for that maturity. Thus, the task is to extract the associated relative liquidity premium and the inflation risk premium from the breakeven rates to attain the expected inflation.

4.3 Methodology and Data

This section details the methodology and the data used to identify the changes in the inflation expectations priced in Turkish lira (TRY) denominated nominal bonds with

[28] This relative liquidity premium need not to be necessarily positive or negative.

10 year maturity. In a nutshell, empirical methods are used to extract relative liquidity premium and other premia embedded in the breakeven inflation rates given by equation (8).

4.3.1 Methodology

In order to get the 10 year breakeven inflation rates, we fit daily yield curves for the nominal bonds and linkers separately. For 794 days between July 2010 and March 2015, we separately fit smoothed cubic spline to the nominal and real continuously compounded yields obtained from the clean prices of traditional bonds and linkers respectively[29].

Once the 10 year breakeven rate is obtained for b_t^{10}, the focus becomes the other side of the equation (8). First, the relative liquidity premium on the right hand side of the equation is dealt with equation (8). This premium is attained in a novel way that has not been used in the literature so far. The measure in this study incorporates both the amount and the price of liquidity at the same time. First, the price of liquidity should be the same for any kind of government bond denominated in the same currency with similar maturities. Based on this logic, the study takes the difference between the yields of two nominal government bonds with maturities close to 10 years to represent the relative liquidity premium between these bonds. Other than the liquidity premium, which is specific to each bond[30], these two

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[29] We let the smoothing parameter be 0.5 in order to have a balance between fidelity to the data and smoothness of the curve. We could not use parametric methodologies (i.e. Nelson-Siegel or Svensson) due to the parameter instability caused by small number of observations in linkers.
[30] In Turkey, the on-the-run and off-the-run securities do not necessarily differ in terms of market liquidity. Sometimes, current on-the-run bonds may be less liquid than previous on-the-run bond till the new bond's outstanding stock reaches at considerable levels.

nominal bonds should possess the same amount of risks and inflation expectations as given in equation (6)[31]. Then this yield difference is regressed, which is considered as the relative liquidity premium, on relative liquidity measures of these two bonds in the following regression equation:

$$liqprem_t = \alpha_0 + \alpha_1(BA_t^{Nom1} - BA_t^{Nom2}) + \alpha_2(TO_t^{Nom1} - TO_t^{Nom2}) + \eta_t \tag{9}$$

, where BA_t^{Nom1} and BA_t^{Nom2} represent the spread of bid-ask yields corresponding to the first and the second 10-year nominal bonds. TO_t^{Nom1} and TO_t^{Nom2} denote the turnover ratios of the two bonds[32]. We interpret the coefficients, obtained from equation (9), as the market price of liquidity risks of different forms (i.e. transaction costs, breadth etc.). Therefore, the coefficient α_0 is the constant liquidity premium demanded on any security, α_1 corresponds to the price of liquidity demanded from the security for transaction costs and finally, α_2 denotes the price of liquidity demanded from the security for lacking breadth[33].

We use the coefficients ($\widehat{\alpha_0}, \widehat{\alpha_1}$ and $\widehat{\alpha_2}$) obtained from the above regression equation, together with the values of $BA_t^{Nom}, BA_t^{Linker}, TO_t^{Nom}$ and TO_t^{Linker} corresponding to the 10-year nominal bond and the linker respectively, to get the relative liquidity premium between the nominal bonds and linkers at a given time.

[31] Here, we assume that the less than 6 months difference between the maturities of the two bonds can be neglected when we consider the average risks and inflation expectations over the 10 year.
[32] The details of the calculations on the bid-ask spreads and turnover ratios, and other variables as well, are provided in the data subsection at the end of this section.
[33] Sarr and Lybek (2002) provides a good discussion on the several dimensions of the market liquidity.

We subtract the relative liquidity premium, which obtained at the previous step, so that the expected inflation and associated inflation risk premium at the 10year maturity remains. Below is the resulting liquidity adjusted breakeven rate (lab_t^{10y}) as;

$$lab_t^{10y} = b_t^{10y} + (liq_t^{Nom} - liq_t^{Linker}) \tag{10}$$

At this point, variation is eliminated due to the inflation risk premium. When survey based long-term expected inflation rates are not available, it may not be possible to back out inflation risk premium from breakeven inflation rates. As a remedy to this problem, we regress lab_t^{10y} on a risk premium measure that moves parallel to variations in the inflation risk premium. Assuming that purchasing power parity holds in the long-run, the anticipated volatility in the expected inflation (inflation uncertainty) should be reflected in the expected volatility in the foreign exchange rates[34].

Hence, the study employs the deviation of the long-term, at-the-money currency call option implied volatility from its unconditional mean as a proxy for the deviations in the inflation risk premium. The implied volatility that is derived from at-the-money currency call options is denoted as $impl_t$. More specifically, the following regression equation serves the elimination of the variation in liquidity adjusted breakeven rates due to the variation in the inflation risk premium:

[34] An investor who expects a x percent inflation differential between two currencies would also expect the nominal exchange rates to change by x percent in the long-run. Hence, the uncertainties expected in the level of long-run nominal exchange rates should be due to the uncertainties anticipated in the level of long-run inflation expectations due to the purchasing power parity.

$$lab_t^{10y} = \beta_0 + \beta_1(impl_t^{5y} - \overline{impl}) + \varepsilon_t \tag{11}$$

Here, it becomes possible to get rid of the variation in liquidity adjusted breakeven rate due to the variation in the inflation risk premium by the help of the product of $\widehat{\beta_1}$ and $(impl_t^{5y} - \overline{impl})$. Therefore, the estimated coefficient $\widehat{\beta_0}$ is read as the sum of expected inflation $E_t^{10y}[\pi]$ and the inflation risk premium $\pi_t^{prem,10y}$ for the 10 year maturity[35]. Finally, we interpret the remaining part, which is the residual ε_t, as the deviation of the long-run inflation expectations from its constant mean ($\widehat{\beta_0}$) as of time *t*. Hence, $\Delta\varepsilon_t$ gives us the change in the 10-year inflation expectations as of time *t-1* to *t*.

The regression equation given by equation (11) can be used in event studies to analyze the impact of a monetary policy shock or the change in credibility after a certain event. At any given day, once the breakeven inflation rate is adjusted with respect to the relative liquidity, $\widehat{\beta_0}$ and the product of $\widehat{\beta_1}$ and $(impl_t^{5y} - \overline{impl})$ can be subtracted from the liquidity adjusted breakeven rate to get the net change in the long-run inflation expectations. A positive reading in $\Delta\varepsilon_t$ will imply a deterioration in long-run inflation expectations and central bank's credibility as well.

[35] Unfortunately, our methodology cannot decompose the constant term, $\widehat{\beta_0}$, into its sub-components. Nonetheless, we get a number that is solely related to the first and the second moments of inflation expectations.

4.3.2 Data

Our data set includes compounded yields[36] of each nominal and inflation-indexed bond traded on a given day for the period between July 2010 and March 2015[37]. In the selected time period, we can fit a real yield curve to linkers for the 794 trading days. Those days are excluded because there is not enough number of observations in linkers to be able to fit a yield curve. Besides compounded yields, we also collect daily bid and ask yield quotations, total daily trading volume and the outstanding nominal stock of each bond traded during our sample period.

All of the TRY denominated 10-year government bonds that we use have a par value of 100 and pay coupons semi-annually. Day count convention for these bonds is actual/365. More specifically, linkers in Turkey are indexed to Consumer Price Index published by the TurkStat on a monthly basis. The first CPI-linker was issued on February 9, 2007 with a 5-year maturity that ends at February 12, 2012. From April 14, 2010, the Undersecretariat of Turkish Treasury started to issue linkers at 10 year maturity and began to conduct auctions for these securities every month of the calendar year. Total stock of the outstanding linkers is roughly 9.5 billion TRY, which constitutes 22.2 percent of the total outstanding TRY denominated debt as of May 2015.

The 5-year implied foreign exchange rate volatility is obtained from the 25 delta at-the-money USDTRY currency call options. Bloomberg terminal reports these

[36] At the end of each trading day, Borsa Istanbul publishes (on its website) trade weighted compounded yields of each security traded on that day. The published yields are semi-annually compounded.

[37] We select this time period according to the first issuance dates of the 10-year nominal and inflation-linked bonds. The first TRY denominated 10 year nominal bond was issued on Jan 27, 2010 and first TRY denominated 10 year CPI-linker was issued on April 14, 2010.

implied volatility rates, derived from the Black-Scholes formula, for several maturities on a daily basis. In addition to implied volatilities, we obtain the bid and ask yields for all the bonds in our sample period from Bloomberg. The rest of the data that we use is accessible on the website of Borsa Istanbul. Table 10 presents the descriptive statistics of the data set.

Table 10 : Descriptive Statistics

Variables	Mean	Min	Max	Std.Dev
10 year Nominal Yield	7.981	5.995	10.840	1.168
10 year Real Yield	1.949	0.832	3.754	0.782
10 Y Nominal Bid-Ask Spread	0.053	0.020	0.150	0.023
10 Y Linker Bid-Ask Spread	0.077	−0.012	0.594	0.080
10 Y Nominal Turnover Ratio	1.363	0.005	9.846	1.616
10 Y Real Turnover Ratio	0.498	0.001	22.73	2.153
Implied Exchane Rate Volatility	8.346	4.470	18.14	2.835

4.3.3 Results

We start presenting the calculated breakeven inflation rates from the fitted nominal and real yield curves. Although the estimations in the study only relate to 10-year maturity our, breakeven inflation rates for 1, 2 and 5 year maturities are reported as well. A visual exhibition of the obtained breakeven inflation rates is presented in Figure 8[38].

[38] Seasonality effects in the real yields, obtained from linkers, sometimes constitute serious problems that have to be dealt with while fitting yield curves. However, we do not have such problems due to the following reasons: (i) the issuance dates of the linkers are not concentrated in certain months. Instead, they are evenly distributed in a calendar year. Hence, we have seasonality effects distributed evenly onto the whole real yield curve. (ii) Seasonality is a severe problem especially for maturities less than one year. We use breakeven rates for 10 year, where seasonality constitutes no problem.

At this point in the study, it is necessary to turn attention to the relative liquidity premium calculation process. In 278 days out of 794 days, we can find two nominal government bonds that are traded on the same day and with maturities close to 10 year. Hence, we run the regression given by equation (9) for these 278 days[39]. Multiplying the estimated coefficients ($\widehat{\alpha_0}, \widehat{\alpha_1}$ and $\widehat{\alpha_2}$) with the bid-ask spread and turnover differences corresponding to 10 year nominal bond and the linker produces the relative liquidity premium between the two bonds. The obtained relative liquidity premium is presented in Figure 9. During our estimation period, the calculated relative liquidity premium takes values between -26 basis point and 40 basis point.

Table 11: Estimation Results (Liquidity Regression given by Eqn 9)

		Period I Oct. 2012 - May 2014	Period II June 2014 - Mar. 2015
Dependent Var: Liquidity Premium			
Constant	Coeff.	**0.03**	**0.12**
	p-value	0.000	0.000
Bid-Ask Spread Difference	Coeff.	0.46	0.80
	p-value	0.082	0.095
Turnover Difference	Coeff.	**-0.012**	**-0.008**
	p-value	0.028	0.039
R^2		**0.18**	**0.18**

A positive reading in the 10 year relative liquidity premium ($liq_t^{Nom} - liq_t^{Linker}$) can be read as the 10 year linker being more liquid relative to the 10 year nominal

[39] Due to the structural break, we run regression for two separate periods. We provide the regression results in Table 11.

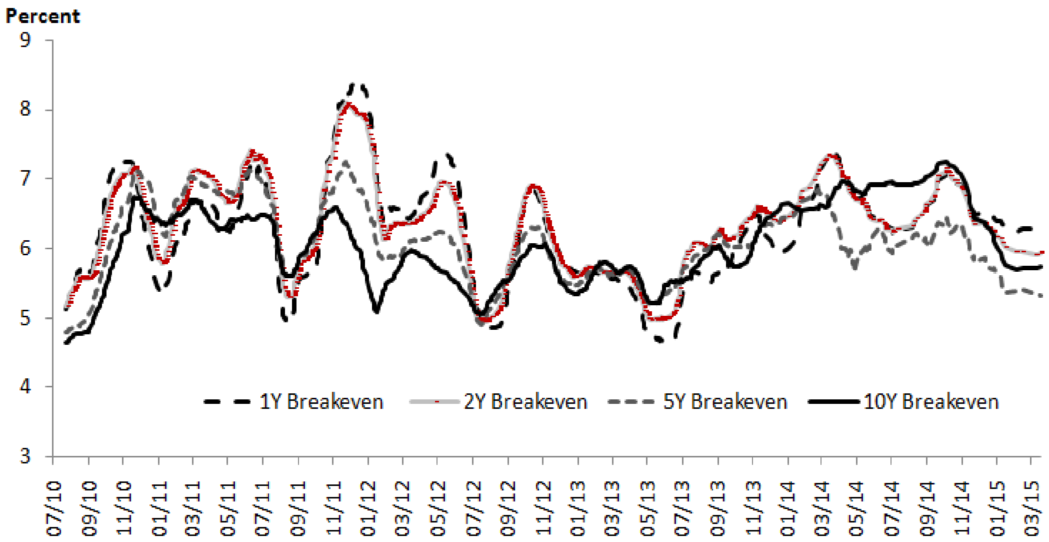

Figure 8. Breakeven Inflation Rates (2W MA)

bond. Whenever the 10 year linker becomes more (less) liquid relative to the 10 year nominal bond, the liquidity adjusted 10 year breakeven inflation rates, given by equation (10), becomes smaller (larger) than the original breakeven inflation rates (b_t^{10y})[40].

The final step involves refining the liquidity adjusted breakeven inflation rate from the variation in the inflation risk premium. This is done by the help of regression equation given by equation (11). The results of the regression of lab_t^{10y} on $impl_t^{5y}$ are presented in Table 12.

[40] This phenomenon occurs especially in turbulent times. During turbulent times, heightened risk translates into a depreciation in local currency and a surge in inflation expectations, which eventually cause a run away from nominals and rush into linkers.

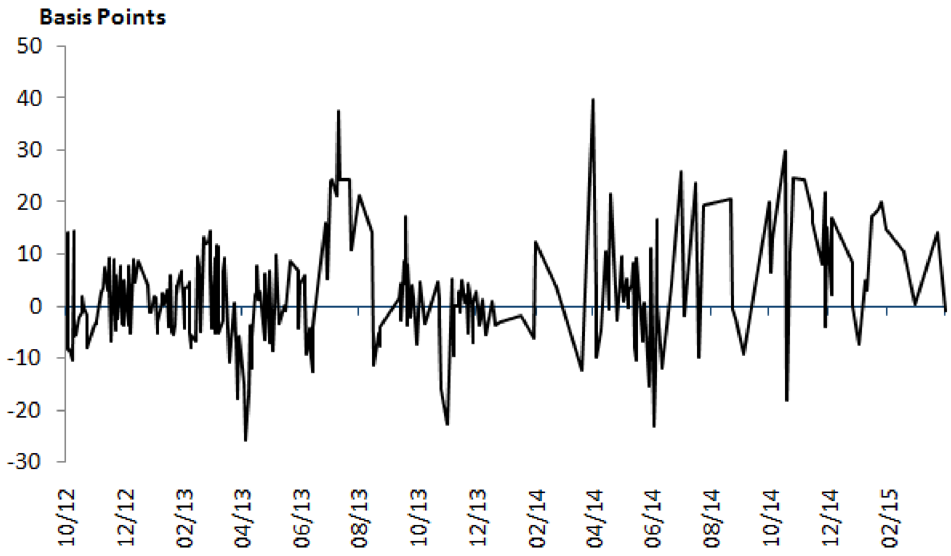

Figure 9. Relative Liquidity (2W MA)

Table12 : Estimation Results (Inflation Risk Regression given by Eqn 11)

		Oct. 2012 - May 2015
Dependent Var: Liquidity Adj. Breakeven Rate		
Constant	Coeff.	**5.38**
	p-value	0.000
Implied Vol.	Coeff.	**0.07**
	p-value	0.000
R^2		**0.14**

The results reveal that the sum of average 10-year expected inflation and inflation risk premium ($\widehat{\beta_0}$) is 5.38 percent for the period between October 2012 and March 2015. With the variations due to the cumulative changes in long-run expected inflation ($\widehat{\beta_0} + \varepsilon_t$) leads to long-run inflation expectations (plus the level of inflation risk premium) wanders between 4.54 percent and 7.38 percent for the period between October 2012 and March 2015. Figure 10 provides a visual illustration of the cumulative changes in the long-run expected inflation ($\widehat{\beta_0} + \varepsilon_t$) and daily changes in the long-run expected inflation ($\Delta\varepsilon_t$).

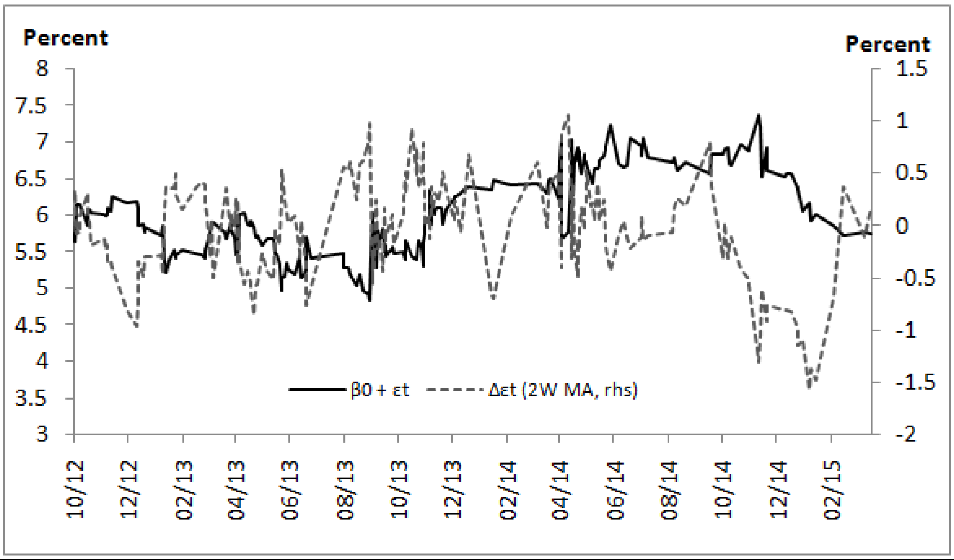

Figure 10. Change in Long-Run Inflation Expectations

4.4 Conclusion

This chapter focuses on the proposed market-based way of measuring changes in long-run inflation expectations using Turkish lira denominated nominal and inflation-linked bonds with similar maturities. Besides measuring changes in inflation expectations, this methodology enables the user to report the sum of average 10-year expected inflation and inflation risk premium, 5.38 percent for the period between October 2012 and March 2015. It is also reported that inflation expectations in addition to the level of inflation risk premium fluctuate around this average by hitting to 4.54 percent minimum and 7.38 percent maximum. The present study contributes to the literature by proposing this novel methodology to extract the relative liquidity premium embedded in treasury bonds. Nevertheless, this methodology stays silent in decomposing inflation risk premium from inflation expectations despite its above-mentioned capabilities.

CHAPTER V

THE RELATIVE LIQUIDITY PREMIUM ACROSS US TREASURY SECURITIES

This chapter checks the robustness of the methodology proposed in the previous chapter by applying it to the US Treasury bond market, which is the most actively traded fixed income market preferred by the investors for its liquidity and safety. Despite the US bond market's liquidity, the violation of one-price law was extreme during the global financial crisis. The academic literature reports mispricing across all classes of US Treasury securities during the 2008-2009 financial crisis. Using different methodologies, the academic studies report the level of mispricing between the maturity-matched Treasury Inflation-Protected Securities (TIPS) and nominal Treasury securities being between 100 basis points to 200 basis points. More interestingly, the mispricing between the maturity-matched nominal Treasury bonds and notes is reported to have reached 80 basis points during the financial crisis.

The empirical methodology prosed measures the level of the relative liquidity premium between maturity-matched US Treasury security pairs. It is then applied to the bond pairs used in Fleckenstein et al. (2014) to check the level of mispricing that can be attributed to the liquidity premium. The choice of the time period and the securities used in Fleckenstein et al. (2014) are appropriate for the application of our methodology as Fleckenstein et al. (2014) find mispricing, which they cannot attribute to the liquidity premium, across the maturity-matched Treasury securities during the Global Financial Crisis, where the market liquidity was reportedly very low. They form a TIPS-Treasury arbitrage strategy by converting the inflation-linked cash flows from a TIPS issue to fixed cash flows using inflation swaps. The replicating portfolio exactly matches the cash flows of a Treasury bond with the same maturity date as the TIPS issue. It appears that the proposed empirical methodology attributes a substantial amount of the reported mispricing of Fleckenstein et al. (2014) to the relative liquidity premium across US Treasury securities.

The price of liquidity for a given maturity is estimated by using maturity-matched securities of similar types. Specifically, the difference between the yields of two securities, which (i) belong to the same class[41], (ii) are issued by the same entity, (iii) are issued in the same currency and (iv) have original maturities very close to each other, is used as dependent variable in the price of liquidity regression estimations. Hence, the dependent variable does not contain currency risk as both securities are denominated in the same currency. The yield difference can also be

[41] The yield difference is calculated for the maturity-matched fixed-coupon paying nominal securities and maturity-matched TIPS separately. The term ´maturity-matched´ refers to the matching of the original maturities and it is not confined to matching of the time to maturity.

claimed to possess no credit risk since these securities are issued by the same entity. Also inflation risk premium and real rate risk premium are cancelled out with differencing as these two securities have very close (usually long-term) original maturities. In a given security pair, the yield difference between any two maturity-matched TIPS, or two maturity-matched nominal bonds, is assumed to reflect only the liquidity premium between these securities[42]. When this dependent variable is regressed on the bond-specific liquidity measures, the estimated coefficients can be claimed to reflect price of liquidity at a certain maturity. One notable property of this technique is that the resulting estimations enable one to directly measure the level of the liquidity premium without resorting to any kind of normalization.

TIPS have often been perceived to be less liquid than nominal Treasuries, but the level of the relative liquidity premium between these Treasury pairs is hard to measure due to the empirical restrictions. Unlike the methodology used in this chapter, the dependent variables used either in affine term structure models or in empirical studies contain premia other than the liquidity premium. Hence, to be able to report the level of the liquidity premium, the existing literature resorts to the technique of normalization (i.e. measuring the level of the liquidity premium relative to a point in time[43]). As a matter of fact, the regressions, where the regressand possesses premia[44] other than the liquidity premium, can only measure

[42] In the estimations, the model is controlled for the security-specific properties.
[43] Affine term structure models are estimated with Kalman filter techniques that necessitate the use of initial parameters either for the coefficients or the variance-covariance matrices.
[44] In most of the studies, the yield difference between the maturity-matched TIPS and nominal bonds is regressed on several liquidity measures to estimate the effect of liquidity. However, this yield difference, which is called as inflation compensation, contains an expected inflation term and an inflation risk premium in addition to the liquidity premium. As none of the components of the inflation compensation is observable, a starting point has to be set as reference in order to obtain the level of the liquidity premium.

the portion of the variation in the dependent variable explained by the liquidity measures used as regressors. However, these regressions are not capable of identifying the level of the liquidity effect.

Using the yield differences across maturity-matched and similar type of securities that are issued by the same entity as dependent variable makes it possible to isolate the liquidity premium. The application of this methodology to calculate the liquidity premium across a subset of 29 maturity-matched US TIPS and nominal bonds used in Fleckenstein et al. (2014) reveal interesting results. To start with, the calculated liquidity premium indicates that almost 70 percent of the mispricing reported by Fleckenstein et al. (2014) can be attributed to the liquidity premium. These findings are also in line with the literature. Similar to the findings of Musto et al. (2015), the liquidity premium across nominal securities takes values close to 0 in normal times and reaches 75 basis points during the global financial crisis. Parallel to the findings of Pflueger and Viceira (2011), the present results show a time-varying liquidity premium across TIPS and nominal bonds. The average level of this liquidity premium is also in agreement with what is reported in the literature. The liquidity premium across TIPS and nominal bonds reaches up to 140 basis points during the 2008-2009 financial crisis and hovers around 40 to 80 basis points during normal times.

To ensure that the liquidity premium is actually measured, the findings of the study are compared with the Resolution Funding Corporation (Refcorp) spread, a direct measure of the liquidity premium used in the literature for US bond markets. Indeed, this step calculates the correlation of the Refcorp spread with the average liquidity premium across maturity-matched nominal bonds, across maturity-matched

TIPS and across maturity-matched TIPS and nominal bonds respectively. For the April 2005-November 2009 period, these correlations are calculated as 0.83 for the liquidity premium on nominal bonds, 0.83 for the liquidity premium on TIPS, and 0.67 for the liquidity premium between TIPS and nominal bonds. Such high correlations may indicate that the measured premium indeed reflects the liquidity premium across these bonds.

The organization of this chapter is as follows: section 2 briefly reviews the recent literature on measuring market-wide and security-specific liquidity in general and on measuring the liquidity premium in US Treasury securities in particular; section 3 introduces the methodology of the paper and the data set used; section 4 presents the results, and the final section concludes.

5.1 Literature Review

Brunnermeier and Pedersen (2009) classify the concept of liquidity into two: the funding liquidity and the market liquidity. In their rationale, the former is associated with the difficulties or costs that a trader confronts while generating cash to fulfill capital and margin requirements. On the other hand, the latter is associated with the cost of trading in an asset. The first part of the literature review provides a non-exhaustive summary of the studies on measuring the market liquidity of a security. The studies for measuring liquidity either use the information on prices or the information on the volume, or both. It first presents the methods that make use of the information on prices to calculate a security's liquidity, then summarizes the methods that use volume to obtain the liquidity measures.

Investors demand an ex-ante premium for the securities that are not readily tradable or have high transaction costs. For instance, investors confront costs while executing their transactions. These costs capture the frictions in trade and typically drive a wedge between the bid (buy) and ask price (sell) of an asset. Hence, bid-ask price (or yield) spread is one of the most commonly used measures that are calculated by using prices alone and give information about the cost of transaction[45].

Roll (1984) proposes a method to infer the effective bid-ask spread for an asset simply using the first order serial covariance of the price changes. The main idea is simple but very appealing: if the market is informationally efficient and there is no trading cost involved, then the returns on an asset should be serially independent as daily prices should contain all the available and relevant information. The returns are expected to exhibit serial correlation as transaction costs inhibit the execution of new information. Roll presents $2\sqrt{-cov(R_i, R_{i-1})}$ as the measure of the effective transaction cost on an asset[46].

Feldhütter (2012) provides the Imputed Roundtrip Cost (IRC) as an alternative measure that solely uses price data to capture the transaction cost of a security. The proposed measure is formulated essentially for corporate bonds, where the bond trade takes place infrequently. Feldhütter defines a trade as imputed round trip (IRT) if two or three same-size trades happen for a bond on the same day and there is no other trade on that day. Then, IRC is given as $\frac{P_t^{MAX} - P_t^{MIN}}{P_t^{MAX}}$, where P_t^{MAX} is the highest price and P_t^{MIN} is the lowest price in an IRT. This measure gives a clue

[45] Amihud and Mendelson (1986) and Constantinides (1986) are early studies on the effects of the transaction costs on asset prices.

[46] The observation is neglected whenever the covariance of the consecutive returns is negative.

about the size of transaction cost as such a trade occurs only if a dealer matches a buyer and a seller and collects the bid--ask spread as a fee.

The proportion of the days, on which an asset does not trade, to the total number of trading days in a given period is proposed as a measure for the transaction costs associated with the trading of that asset. Bekaert, Harvey and Lundblad (2003) found this to be an effective measure of liquidity in the emerging market for equities. Lesmond, Ogden and Trzcinka (1999) do not use the frequency of zero trading days as a direct measure of liquidity. Instead, they develop a limited dependent variable specification which endogenously estimates the transaction costs based on the realization of zero returns.

The market efficiency coefficient, proposed by Hasbrouck and Schwartz (1988), is another price-based measure that indicates the continuity of trade in a given security or market. The rationale behind this measure is that price changes should be more smooth and continuous for the more liquid securities such that the volatility of long-term price changes should be equal to the sum of the volatility of the changes within the periods that form the long-term. The ratio of the variance of long-term return to the sum of the variances of short-term returns should be equal to one for a perfectly liquid asset that is continuously traded.

Pertaining to the volume based measures, the trading volume indicates the breadth[47] of a security, and according to Blume, Easley and O'hara (1994), it provides information that cannot be extracted from price-based measures. Instead of using the trading volume as a direct measure of the liquidity, one can normalize it by the

[47] The availability of large and frequent orders that have minimal price impact on a given asset.

notional amount outstanding of a security in order to have a measure that enables comparison across different securities. The turnover ratio, which is the ratio of the trading volume to the notional amount outstanding, is one of the most popular volume based measures. It measures the number of times the outstanding stock of a security is exchanged. In that regard, turnover ratio hints at the portion of the hold-to-maturity investors for a given security.

Several studies exist in literature focusing on measurement of price impact of a trade in a specific security. Those measures simultaneously use the information on a security's price and volume to calculate the price impact. Amihud (2002) computes a measure by dividing the daily average of absolute returns to the trade size of the consecutive transactions. By relating the volume of a trade to its impact on the prices, this measure aims to capture the breadth of trading in a security. Hui and Huebel (1984) measure the price impact of trading in a given security by dividing the security's largest price change to its turnover ratio in a given period. Typically, the Hui-Huebel measure is calculated over a five day period.

The literature review extends to cover the studies that measure the liquidity premium across US Treasury securities. The recent literature tries to quantify the liquidity premium between the US TIPS and nominal bonds. For instance, by adding a fourth factor, which accounts for the liquidity premium, to a three-factor affine term structure model for US TIPS and nominal bonds, D'Amico et al. (2010) report a liquidity premium that was around 100 basis points at the initiation of the TIPS program. Normalizing the level of the liquidity premium to zero for 2005, Gurkaynak et al. (2010) report a liquidity premium that reached 140 basis points for the 5-year TIPS and 70 basis points for the 10-year TIPS during the 2008-09 financial crisis. Similar to D'Amico et al. (2010), they also report a liquidity premium close to 100 basis points at the initiation of the TIPS program. Again normalizing their liquidity variables to zero in a world of perfect liquidity, Pflueger and Viceira (2011) attain results similar to Gurkaynak et al. (2010). They show that the liquidity premium for 10 year TIPS takes values between 70 and 120 basis points during the early years of TIPS program and reaches 250 basis points during the 2008-09 financial crisis[48]. More importantly, Pflueger and Viceira (2011) report that the measured liquidity premium is time-varying and hovers around 40 to 80 basis points during normal times.

The last two studies mentioned employ the methodology first used by Chen et al. (2007), who study the effect of bond-specific liquidity on the corporate yield spread. To this end, they use three separate liquidity measures: the bid--ask spread, the zero trading day measure, and the limited dependent variable model proposed by Lesmond et al. (1999). The regressand used by Chen et al. (2007) contains a credit risk premium in addition to the liquidity premium. The dependent variable of Gurkaynak et al. (2010) and Pflueger and Viceira (2011) contains inflation risk premium and an expected inflation term in addition to the liquidity premium. The fitted values from these regressions can give a clue about the portion of the variation in the dependent variable explained by the liquidity measures used as regressors. However, these regressions cannot precisely identify the level of the liquidity effect.

[48] Campbell, Sunderam and Viceira (2009) attribute the observed illiqudity in the TIPS market after the Lehman Brothers' bankruptcy to the downward price pressure that TIPS market faced due to the depletion of Lehman Brothers its large TIPS inventory.

As a result, these studies resort to normalization. That is, they measure the effect of the liquidity relative to a point in time.

Using a Gaussian affine term structure model, which adjusts for the illiquidity of TIPS, Abrahams, Adrian, Crump and Moench (2012) jointly price the TIPS and nominal Treasuries. Similar to D'Amico et al. (2010), the authors model the liquidity premium as if it is only priced in TIPS. They estimate the model with three-stage linear regressions and obtain the liquidity premium for the 10-year TIPS. The estimated relative liquidity premium takes values slightly above 0 basis points during normal times. However, the liquidity premium is reported to reach up to 200 basis points during the global financial crisis.

Fleming and Krishnan (2012) provide an excellent work on the relative liquidity of the US TIPS market compared to the nominal bond market. Using tick data from the interdealer market, they show that the liquidity of the TIPS differ substantially from that of the nominal bonds. More importantly, they report that neither bid-ask spreads nor quoted-depth constitutes a good indicator of liquidity for the TIPS market. Instead, the trading activity and the incidence of posted quotes serve as better cross-sectional measures of the TIPS liquidity.

Recently, Musto et al. (2015), show that even within the class of fixed-coupon paying nominal securities, there exists liquidity premium across US bonds and notes. US bonds, namely bonds with 30 year maturity, trade at a relative discount compared to US notes when the maturity time for both securities are matched. They compare the yields on a typical US note and a replicating portfolio, comprised of a bond and the bond's principal STRIP. The authors report a yield differential that reached up to 80 basis points during 2008-2009 financial crisis and wanders slightly above 0 basis points during normal times. Musto et al. (2015) relate the mispricing among US bonds and notes to several security characteristics, i.e. coupon, maturity time, and notional amount outstanding. They use market-based measures (including the bid/ask spread and trading volume) of liquidity rather than bond-specific liquidity measures like the ones used in this paper. They report that more aged securities with smaller notional amount outstanding and lower trading volume and higher-spreads trade at discount, especially when market-wide liquidity is low. In the paper, the part of the mispricing that cannot be explained by the security-specific characteristics is attributed to the funding constraints of dealers and arbitrageurs during the financial crisis.

A similar type of limits to arbitrage capacity is shown by Fleckenstein et al. (2014). The authors report a mispricing between the US TIPS and nominal bonds during the 2008-2009 financial crisis. The authors form a TIPS-Treasury arbitrage strategy by converting the inflation-linked cash flows from a TIPS issue to fixed cash flows using inflation swaps. The replicating portfolio exactly matches the cash flows of a Treasury bond with the same maturity date as the TIPS issue. Fleckenstein et al. (2014) report a persistent mispricing across 29 maturity-matched pairs of US Treasury bonds and TIPS issues from 2004 to 2009. They measure the mispricing as 54.5 basis points, on average, and as 200 basis points at its maximum during the crisis period. More interestingly, the existing mispricing is always in favor of the nominal bonds.

The reported mispricing cannot be attributed to the mispricing or a possible illiquidity in the inflation swaps market as they find no mispricing on average when the same arbitrage strategy is used for fixed-rate and inflation linked bonds issued by corporates. They also cannot attribute the extant mispricing to the liquidity risk as the market-wide liquidity measures that they employ explain a relatively small portion of the mispricing found across the US TIPS and nominal bonds. The TIPS-Treasury mispricing is observed to narrow down as the limits to arbitrage is passed over with the additional capital flows into the hedge fund sector.

5.2 Methodology and Data

This section presents the details of the methodology and the data used to calculate the relative liquidity across US TIPS and nominal bonds.

5.2.1 Methodology

The methodology is based on estimating the price of liquidity for the US Treasury securities with similar types and maturities. These estimated (maturity-specific) prices are then used with bond-level liquidity measures to construct the relative liquidity premium between any two securities of a particular maturity.

It is worth mentioning the following observation before proceeding further: other than the liquidity premium, any risk premium corresponding to the bonds with similar types and maturities will be the same as long as these bonds are issued by the same entity. More specifically, investors would demand the same expected real rate, expected inflation, the real rate risk premium, and the inflation risk premium for the two maturity-matched[49], fixed coupon-paying US nominal bonds[50]. If any credit risk is attached to these maturity-matched nominal bonds, it should be the

[49] The term 'maturity-matched' refers to the nominal security pairs, where the difference between the original maturities of the securities that form the pair is less than 31 days.
[50] Even if two bonds are matched in terms of the type and maturity, investors may prefer one to the other due to the differences in the coupon rates. During the estimations, we control for the effect of coupon rate differences on the relative liquidity premium across the two bonds.

same across the two bonds as they are issued by the US Treasury. The same logic applies to the TIPS; investors would demand the same expected real rate, the real rate risk premium, and the same credit risk for the two maturity-matched[51] US TIPS.

The construction of the relative liquidity premium between any two bonds of the same maturity requires (i) the calculation of bond-level liquidity measures, and (ii) the estimation of the price of liquidity corresponding to each liquidity measure.

5.2.2 The Liquidity Indicators

As discussed in the literature review, Blume et al. (1994) argue that the volume-based liquidity measures are superior to the price-based measures with respect to the information they provide. Besides, Fleming and Krishnan (2012) argue that the information content of the bid-ask spreads is not a good indicator of the liquidity of the TIPS. In contrast, the trading activity and the incidence of posted quotes prove to be good indicators of the US TIPS liquidity. However, due to the restrictions[52] on the daily trading volume data, it is only possible to compute the following price-based indicators of the US TIPS and nominal bonds that are used in the estimations. These measures are as follows:

- *Bid-Ask Price Spread*: This measure reveals a clue about the transaction costs that may arise while trading in a given security. The formula of the bid-ask price spread measure is as follows:

$$BA_t = \frac{P_t^{ASK} - P_t^{BID}}{(P_t^{ASK} + P_t^{BID})/2} \tag{1}$$

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[51] The term 'maturity-matched' refers to the TIPS pairs, where the difference between the original maturities of the TIPS that form the pair is less than 182 days.
[52] These restrictions are mentioned in the ′Data′ subsection of this section.

- *Proxy for the Daily Volume:* The range between the highest and lowest daily price may constitute a proxy for the daily volume of a security. The difference between the highest and lowest price realizations can be expected to be larger for the securities with lower trading volumes. In order to normalize the measure of the level of price, the min-max range is divided by the daily mid-price of that security to obtain the following proxy for the daily trading volume for time *t*:

$$PDV_t = \frac{P_t^{MAX} - P_t^{MIN}}{P_t^{MID}} \tag{2}$$

- *Volatility:* This measure is also expected to reveal a clue about the daily volume of a security. For a given month, the measure is calculated as the deviation of daily returns from the monthly average of the daily returns. The formula for the volatility measure is as follows:

$$VOL_t = \sqrt{\sum_{i=1}^{21} (R_i - \bar{R})^2} \tag{3}$$

5.3 The Estimation of the Price of Liquidity

The estimation of the price of liquidity for a given US nominal bond with original maturity of *T* days involves the following steps:

i. Open a maturity-neighbourhood for the given bond by determining all other similar type US nominal bonds with original maturities that are at most 31 days apart from *T*.

ii. For all the nominal bonds within this neighbourhood, calculate the bond specific liquidity indicators[53].

iii. On a monthly basis, calculate all possible pair wise yield differences for the nominal bonds that fall into this neighbourhood. For instance, a maturity-neighbourhood that consists of *n* different nominal bonds, there are $C_{n,2} = \frac{n!}{2!(n-2)!}$ such combined pairs.

iv. Run a monthly panel regression, where the yield differences that are calculated on the third step constitute the regressand and the liquidity indicators that are calculated on the second step form the regressors. The panel regressions, mentioned at the fourth step, can be estimated in three different forms.

First Model:

$$dR_{it} = \alpha_0 + \alpha_1 dBA_{it}^{Nom} + \varepsilon_t \tag{4}$$

Second Model:

$$dR_{it} = \alpha_0 + \alpha_1 dPDV_{it}^{Nom} + \alpha_2 dVOL_{it}^{Nom} + \alpha_3 dCpn_{it}^{Nom} + \vartheta_t \tag{5}$$

Third Model:

$$dR_{it} = \alpha_0 + \alpha_1 dPDV_{it}^{Nom} + \alpha_2 dVOL_{it}^{Nom} + \alpha_3 dCpn_{it}^{Nom} + \alpha_4 dAmnt_{it}^{Nom} + \mu_t \tag{6}$$

[53] These liquidity indicators consist of priced-based indicators, which will be discussed further in this subsection.

, where $i = 1, 2, \ldots \frac{n!}{2!(n-2)!}$ represents all different combinations of security pairs in a maturity-neighbourhood with n members. Here, dR_{it} stands for the difference between the yield to maturity of the two nominal bonds for the i^{th} pair. Accordingly, $dBA_{it}^{Nom}, dPDV_{it}^{Nom}, dVOL_{it}^{Nom}, dCpn_{it}^{Nom}$ and $dAmnt_{it}^{Nom}$ refer to the difference between the bid-ask price spreads, the proxies for the daily volume, volatilities, the coupon rates and the notional amount outstanding of the nominal bonds in each pair of the maturity-neighbourhood.

The aim of using the above equations is to estimate the price of liquidity $(\widehat{\alpha_0}, \ldots \widehat{\alpha_k})$ that corresponds to each of the *k* liquidity indicators (of a typical nominal bond) at maturity (*T*-*t*)[54]. The steps, so far, are applied to each maturity-neighbourhood of the bonds of interest. Corresponding to the time to maturity of each bond of interest, the panel estimation yields *k* number of estimated prices, which are $(\widehat{\alpha_0}, \ldots \widehat{\alpha_k})$. At this point, it should be noted that the price of liquidity is assumed to be the same for similar type nominal US Treasury bonds with similar maturities.

The estimation of the price of liquidity for a given TIPS with original maturity of *T* days involves similar steps with minor differences:

i. Open a maturity-neighbourhood for the given TIPS by determining all other similar type TIPS with original maturities that are at most 182 days apart from T[55].

[54] The maturity-neighbourhoods are formed with respect to the original maturities. However, the calculated prices of liquidity correspond to the remaining maturity, which is *T*-*t* as of time *t*.
[55] As the TIPS are not issued as frequent as the nominal bonds, the TIPS market is sparse. Therefore we choose the size of the maturity-neighbourhood as 182 days to have at least two TIPS while keeping the effect of the term premium on the yield differences at the lowest level. Having at least two TIPS in a neighbourhood is necessary for the price of liquidity estimation.

ii. For all the TIPS within this neighbourhood, calculate the bond specific liquidity indicators that are similar to those for the nominal bonds.

iii. On a monthly basis, calculate all possible pair wise yield differences for the TIPS that fall into this neighbourhood.

iv. Run a monthly panel regression, where the yield differences that are calculated on the third step constitute the regressand and the liquidity indicators that are calculated on the second step form the regressors. These panel regressions also can be estimated in three different forms.

First Model:

$$dR_{it} = \beta_0 + \beta_1 dBA_{it}^{TIPS} + \varepsilon_t \tag{7}$$

Second Model:

$$dR_{it} = \beta_0 + \beta_1 dPDV_{it}^{TIPS} + \beta_2 dVOL_{it}^{TIPS} + \beta_3 dCpn_{it}^{TIPS} + \vartheta_t \tag{8}$$

Third Model:

$$dR_{it} = \beta_0 + \beta_1 dPDV_{it}^{TIPS} + \beta_2 dVOL_{it}^{TIPS} + \beta_3 dCpn_{it}^{TIPS} + \beta_4 dAmnt_{it}^{TIPS} + \mu_t \tag{9}$$

, where $i = 1, 2, \ldots \frac{n!}{2!(n-2)!}$ represents all different combinations of security pairs in a maturity-neighbourhood with *n* members. Here, dR_{it} stands for the difference between the yield to maturity of the two TIPS for the i^{th} pair. Accordingly, $dBA_{it}^{TIPS}, dPDV_{it}^{TIPS}, dVOL_{it}^{TIPS}, dCpn_{it}^{TIPS}$ and $TIPS$ refer to the difference between the bid-ask price spreads, the proxies for the daily volume, volatilities, the coupon rates and the notional amount outstanding of the TIPS in each pair of the maturity-neighbourhood.

The aim of using the above equations is to estimate the price of liquidity $(\widehat{\beta_0}, \dots \widehat{\beta_k})$ that corresponds to each of the k liquidity indicators (of a typical TIPS) at maturity (*T*-*t*). The steps, so far, are applied to each maturity-neighbourhood of the TIPS of interest. Hence, corresponding to the time to maturity of each bond of interest, the panel estimation yields k number of estimated prices, which are $(\widehat{\beta_0}, \dots \widehat{\beta_k})$. The price of liquidity is again assumed to be the same for US TIPS of similar maturities.

One important caveat is that the calculated yield difference across the TIPS cannot be directly interpreted as the relative liquidity premium because it may also include a term premium due to the (up to) 182 days original maturity difference between the TIPS pairs. In order to correct the yield difference for this term premium, daily yield curves are fitted to the (real) yields on US TIPS[56]. Using the fitted yield curve on a given day, the term premium is calculated as the difference between the two generic real rates corresponding to the time-to-maturity of each TIPS that are used in the yield difference calculation. Then, this term premium is subtracted from the initially calculated yield difference to correct the relative liquidity premium for the term premium.

5.3.1 The Construction of the Relative Liquidity Premium

For any given day, the relative liquidity premium between any maturity-matched US TIPS and nominal bond can be constructed by using the estimated prices of liquidity

[56] For yield curve fitting, we use the smoothed cubic spline methodology. We let the smoothing parameter be 0.5 in order to have a balance between fidelity to the data and the smoothness of the curve.

and the corresponding liquidity indicators. In its most general form, the equation to construct the relative liquidity premium can be given as follows:

$$Rel.Liq.Prem_t = \left(\widehat{\beta_0} - \widehat{\alpha_0}\right) + \left(\widehat{\beta_1}BA_t^{TIPS} - \widehat{\alpha_1}BA_t^{Nom}\right) + \left(\widehat{\beta_2}PDV_t^{TIPS} - \widehat{\alpha_2}PDV_t^{Nom}\right) + \left(\widehat{\beta_3}VOL_t^{TIPS} - \widehat{\alpha_3}VOL_t^{Nom}\right) + \left(\widehat{\beta_4}Cpn_t^{TIPS} - \widehat{\alpha_4}Cpn_t^{Nom}\right) + \left(\widehat{\beta_5}Amnt_t^{TIPS} - \widehat{\alpha_5}Amnt_t^{Nom}\right) \quad (10)$$

The steps involved are as follows:

- First inner-multiply each set of estimated coefficients (prices of liquidity) with the corresponding liquidity indicator of each bond type; $(\widehat{\beta_0}, \dots \widehat{\beta_5})$ with $(1, BA_{it}^{TIPS}, \dots Cpn_{it}^{TIPS})$ and $(\widehat{\alpha_0}, \dots \widehat{\alpha_5})$ with $(1, BA_{it}^{Nom}, \dots Cpn_{it}^{Nom})$.
- Take the difference of these inner products to construct the relative liquidity premium on a daily basis.

5.3.2 An Application

As the methodology proposed here claims to measure the relative liquidity premium between maturity-matched Treasury securities, it is natural to expect the obtained liquidity premium to co-variate with the well-known liquidity premium measures proposed in the literature. The following are chosen to test this: (*i*) a time period and Treasury security pairs, for which the relative liquidity premium is measured, and (*ii*) a well-known liquidity premium measure to make a comparison with the obtained relative liquidity premium.

Pertaining to the first choice, we use the time period and the maturity-matched (TIPS and nominal) security pairs that are used by Fleckenstein et al. (2014). The choice of the time period and the securities used in Fleckenstein et al. (2014) are appropriate for the application of the methodology presented in this chapter, because Fleckenstein et al. (2014) find mispricing, which they cannot attribute to the liquidity premium, across the maturity-matched Treasury securities during a period where the market liquidity was reportedly very low.

Based on liquidity premium related literature, the spread between Refcorp[57] strips and Treasury strips is used. This spread, which is proposed by Longstaff (2004), measures the yield difference between the maturity-matched Treasuries and Refcorp (stripped) zero-coupon bonds. Longstaff claims that the Refcorp bonds have the same credit risk as the Treasuries as it is a US government-sponsored agency. Matching of the maturities and the equality of the credit risk across the two bonds mean that the yield difference between the two bonds is a direct measure of the liquidity premium. Investors prefer it to Treasury zero-coupon bonds[58] to hold Refcorp zero-coupon bonds.

5.4 Data

Originally, Fleckenstein et al. (2014) measure the mispricing across 29 pairs of TIPS and Treasury bonds. However, due to the restrictions of our methodology and the data[59], the present study can only calculate the liquidity premium across 14 of these 29 pairs. In total, 74 nominal securities and 19 TIPS are used in the price of liquidity estimations. Therefore, the bond-level data set includes daily bid prices,

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[57] The Resolution Funding Corporation is an enterprise that is formed to fund the the bailout of savings and loan institutions in the 80’s. The Refcorp is backed by the US Treasury.

[58] Longstaff (2004) reports that the Treasuries and Refcorp bonds are exposed to the same tax treatment in the US.

[59] These restrictions are discussed in the `Results' section.

ask prices, mid prices, lowest prices, highest prices, mid yield-to-maturity values, notional amount outstanding and coupon rates for 74 nominal securities, and 19 TIPS for the period between January 2005 and November 2009. For the same period, we also use the total notional outstanding amount of all US TIPS and nominal bonds in the calculation of the variables $Amnt_t^{TIPS}$ and $Amnt_t^{Nom}$.

The US Treasury has been issuing TIPS since 1997. Every six months, these securities pay a certain percentage of the principal amount, which is adjusted over time according to the urban consumer price index, as the coupon payment. Currently, the TIPS are issued with maturities of five, ten, and thirty years. The five and thirty year securities stay on-the-run for 8 months, and ten year securities stay on-the-run for 6 months after their first issuances.

Both for TIPS and nominal Treasury securities, the secondary-market trading takes place over-the-counter. Hence, it is hard to attain data on daily trading volume. Nonetheless, GovPX database[60] provides intraday trading data collected from several inter-dealer bond brokers for all active and off-the-run Treasury issues. The historical data on US Treasury securities is offered by GovPX per year of data bundles, and there is a fee attached for each year's bundle. Calculation of volume-based liquidity indicators for the bonds used in the estimations cannot be carried out because this data set is unavailable. . All of the data used in the paper is available on the Bloomberg terminal.

[60] The database is developed by the Center for Research in Security Prices (CRSP) at the Graduate School of Business, University of Chicago.

5.5 Results

The selection of 31 and 182 days for the sizes of the nominal and TIPS maturity-neighbourhoods, respectively, imposes constraints on the security pairs to be used out of the 29 pairs of Fleckenstein et al. (2014). In particular, we had to drop the first six and last nine TIPS and nominal security pairs of the Fleckenstein et al. (2014). Therefore, the relative liquidity premium can be calculated only for the 14 pairs left. The list of the US TIPS and nominal securities that fall into these 14 pairs are given in Table 13.

Table 13. Selected US TIPS-Nominal Treasury Pairs

TIPS	Coupon	Nominal Treasury	Coupon	Mismatch (in days)
April 15, 2011	2.375	March 31, 2011	4.750	15
January 15, 2012	3.375	January 15, 2012	1.125	0
April 15, 2012	2.000	April 15, 2012	1.375	0
July 15, 2012	3.000	July 15, 2012	1.500	0
April 15, 2013	0.625	March 31, 2013	2.500	15
July 15, 2013	1.875	June 30, 2013	3.375	15
January 15, 2014	2.000	December 31, 2013	1.500	15
April 15, 2014	1.250	March 31, 2014	1.750	15
July 15, 2014	2.000	June 30, 2014	2.625	15
January 15, 2015	1.625	February 15, 2015	4.000	31
July 15, 2015	1.875	August 15, 2015	4.250	31
January 15, 2016	2.000	February 15, 2016	4.500	31
July 15, 2016	2.500	June 30, 2016	3.250	15
January 15, 2017	2.375	February 15, 2017	4.625	31

For each of the TIPS and nominal securities within these 14 pairs, we open 14 nominal maturity-neighbourhoods, each with a diameter of 31 days, and 14 TIPS maturity-neighbourhoods, each with a diameter of 182 days. The TIPS that fall into the 14 TIPS maturity-neighbourhoods and the nominal securities that fall into the 14 nominal maturity-neighbourhoods are presented in Table 14 and 15, respectively[61].

Table 14. TIPS Maturity-Neighbourhoods

Group Number	Maximum Maturity Mismatch (in months)	TIPS in Each Maturity-Neighbourhood
1	3	January 15, 2011; April 15, 2011
2	6	January 15, 2012; April 15, 2012; July 15, 2012
3	3	April 15, 2013; July 15, 2013
4	6	January 15, 2014; April 15, 2014; July 15, 2014
5	6	January 15, 2015; April 15, 2015; July 15, 2015
6	6	January 15, 2016; April 15, 2016; July 15, 2016
7	6	January 15, 2017; April 15, 2017; July 15, 2017

The nominal maturity-neighbourhood with the smallest number of securities has 4 nominal bonds, and the one with the largest number of securities possesses 9 nominal bonds. On the other hand, the TIPS maturity-neighbourhood with the smallest number of securities has 2 TIPS and the one with the largest number of securities possesses 3 TIPS. In total, 74 nominal securities fall into these 14 nominal maturity-neighbourhoods, and 19 TIPS fall into 14 TIPS maturity-neighbourhoods. The liquidity indicators and all possible pair wise yield differences are calculated for the nominal bonds and TIPS that fall into these 14 nominal maturity-neighbourhoods and 14 TIPS maturity-neighbourhoods respectively.

[61] In fact, there are 7 groups for the TIPS, which include all of the 14 maturity-neighbourhoods. The TIPS and nominal bonds, for which the maturity-neighbourhood is formed, are high-lighted in Table 14 and 15.

Table 15. Nominal Maturity-Neighbourhoods

Group Number	Maximum Maturity Mismatch (in days)	Nominal Treasuries in Each Maturity-Neighbourhood
1	31	February 28, 2011; February 28, 2011[Cpn: 4.500]; March 31, 2011; March 31, 2011[Cpn: 4.750]
2	31	December 31, 2011; December 31, 2011[Cpn: 4.625]; January 15, 2012; January 31, 2012;January 31, 2012[Cpn: 4.500]
3	30	March 31, 2012; March 31, 2012[Cpn: 4.500]; April 15, 2012; April 30, 2012; April 30, 2012[Cpn: 4.500]
4	31	June 30, 2012; June 30, 2012[Cpn: 4.875]; July 15, 2012; July 31, 2012; July 31, 2012[Cpn: 4.625]
5	31	March 15, 2013; March 31, 2013; March 31, 2013[Cpn: 2.500]; April 15, 2013
6	30	June 15, 2013; June 30, 2013; June 30, 2013[Cpn: 3.375]; July 15, 2013
7	31	December 15, 2013; December 31, 2013; December 31, 2013[Cpn: 1.500]; January 15, 2014
8	31	March 15, 2014; March 31, 2014; March 31, 2014[Cpn: 1.750]; April 15, 2014
9	30	June 15, 2014; June 30, 2014; June 30, 2014[Cpn: 2.625]; July 15, 2014
10	28	January 31, 2015; January 31, 2015[Cpn: 2.250]; February 15, 2015; February 15, 2015[Cpn: 4.000]; February 15, 2015[Cpn: 10.25]; February 28, 2015; February 28, 2015[Cpn: 2.375]
11	31	July 31, 2015; July 31, 2015[Cpn: 1.750]; August 15, 2015; August 15, 2015[Cpn: 4.250]; August 15, 2015[Cpn: 10.625]; August 31, 2015; August 31, 2015[Cpn: 1.250]
12	29	January 31, 2016; January 31, 2016[Cpn: 2.000]; February 15, 2016; February 15, 2016[Cpn: 4.500]; February 15, 2016[Cpn: 9.250]; February 29, 2016; February 29, 2016[Cpn: 2.125]; February 29, 2016[Cpn: 2.625]
13	30	June 15, 2016; June 30, 2016; June 30, 2016[Cpn: 1.500]; June 30, 2016[Cpn: 3.250]; July 15, 2016
14	28	January 31, 2017; January 31, 2017[Cpn: 0.875]; January 31, 2017[Cpn: 3.125]; February 15, 2017; February 15, 2017[Cpn: 4.625]; February 28, 2017; February 28, 2017[Cpn: 0.875]; February 28, 2017[Cpn: 3.000]

A total of 14 separate panel estimations are run for the Treasuries located in each nominal maturity-neighbourhood and the estimated prices of liquidity corresponding to the time to maturity represented by each nominal maturity-neighbourhood[62] are obtained. Of the three different models for the nominal bonds, Table 16 and 17 only report the results for the equations (4) and (5), respectively[63].

Table 16. Estimation Results (Nominal treasuries – First Model)

Nominal	BA	R^2
Group 1 M.N. of March 31, 2011	15.74 0.420	0.42
Group 2 M.N. of January 15, 2012	116.96* 0.000	0.51
Group 3 M.N. of April 15, 2012	64.76* 0.000	0.37
Group 4 M.N. of July 15, 2012	23.45* 0.020	0.26
Group 5 M.N. of March 31, 2013	142.74* 0.020	0.37
Group 6 M.N. of June 30, 2013	6.32 0.890	0.37
Group 7 M.N. of December 31, 2013	49.18 0.110	0.03
Group 8 M.N. of March 31, 2014	25.43 0.390	0.3
Group 9 M.N. of June 30, 2014	-233.13 0.110	0.05
Group 10 M.N. of February 15, 2015	21.5* 0.000	0.05
Group 11 M.N. of August 15, 2015	17.63* 0.010	0.02
Group 12 M.N. of February 15, 2016	11.82* 0.030	0.01
Group 13 M.N. of June 30, 2016	-10.89** 0.520	0.72
Group 14 M.N. of February 15, 2017	30.81* 0.000	0.57

First rows exhibit the estimated coefficients and the second rows show the probabilities.
* shows significance at the 95 percent level and ** shows significance at the 90 percent level. M.N. stands for the maturity-neighbourhood.

[62] Using daily data, we run panel estimations both for nominal US Treasuries and TIPS on a monthly basis. We use "Fixed Effects" and "Random Effects" panel-estimation methods according to the results of the Hausman test. Stationarity of the variables are checked by the Im, Pesaran, Shin (IPS) unit root test. Finally, all the estimated variances are transformed via the generalized least squares (GLS) estimation procedure to be able to get rid of cross-sectional heteroscedasticity and correlations among the residuals across security pairs.

[63] The $Amnt_{i,t}$ variable cannot be included in the estimations as most of the times it turns out to be non-stationary. On the other hand, it does not make material difference on the estimation results when it is stationary and included in the estimations.

Table 17. Estimation Results (Nominal treasuries – Second Model)

Nominal	PDV	VOL	Coupon	R^2
Group 1	57.3**	-2.19	-0.0044*	0.27
M.N. of March 31, 2011	0.053	0.300	0.010	
Group 2	108.02*	0.72	-0.0087*	0.06
M.N. of January 15, 2012	0.000	0.660	0.000	
Group 3	83.3*	-1.89	-0.003*	0.18
M.N. of April 15, 2012	0.000	0.110	0.000	
Group 4	28.03*	-	-0.001*	0.06
M.N. of July 15, 2012	0.020	-	0.000	
Group 5	255.55*	-	-0.004*	0.17
M.N. of March 31, 2013	0.000	-	0.020	
Group 6	128.32*	3.34	-0.003*	0.4
M.N. of June 30, 2013	0.000	0.190	0.000	
Group 7	60.7*	2.22	-0.001*	0.15
M.N. of December 31, 2013	0.000	0.210	0.000	
Group 8	111.77*	-0.48	-0.00008**	0.18
M.N. of March 31, 2014	0.000	0.800	0.1	
Group 9	75.22*	-6*	-0.0006	0.49
M.N. of June 30, 2014	0.045	0.040	0.157	
Group 10	-5.66	1.89*	0.00007	0.02
M.N. of February 15, 2015	0.11	0.003	0.560	
Group 11	18.74*	1.36	-0.001*	0.1
M.N. of August 15, 2015	0.020	0.270	0.000	
Group 12	9.24*	0.65	-0.0013*	0.07
M.N. of February 15, 2016	0.010	0.290	0.000	
Group 13	35.17	3.67*	-0.0027*	0.04
M.N. of June 30, 2016	0.120	0.030	0.000	
Group 14	101.43*	1.59	-0.002*	0.37
M.N. of February 15, 2017	0.000	0.190	0.000	

First rows exhibit the estimated coefficients and the second rows show the probabilities.
* shows significance at the 95 percent level and ** shows significance at the 90 percent level. M.N. stands for the maturity-neighbourhood.

Similarly, using equations (7) and (8), 14 separate panel estimations for the TIPS located in each TIPS maturity-neighbourhood are run and the estimated prices of liquidity corresponding to the time to maturity represented by each TIPS maturity-neighbourhood are obtained. The results of the first and second TIPS model are displayed in Table 18 and 19 respectively[64].

Table 18. Estimation Results (TIPS – First Model)

Linker	BA	R^2
Group 1 M.N. of April 15, 2011	594.57* 0.01	0.07
Group 2 M.N. of January 15, 2012 & April 15, 2012 &July 15, 2012	144.61 0.67	0.01
Group 3 M.N. of April 15, 2013 &July 15, 2013	22.50 0.950	0.00
Group 4 M.N. of January 15, 2014 & April 15, 2014 &July 15, 2014	-10.39 0.91	0.00
Group 5 M.N. of January 15, 2015 &July 15, 2015	-582.10* 0.000	0.25
Group 6 M.N. of January 15, 2016 &July 15, 2016	853.72 0.65	0.01
Group 7 M.N. of January 15, 2017	-95.70* 0.050	0.02

First rows exhibit the estimated coefficients and the second rows show the probabilities.
* shows significance at the 95 percent level and ** shows significance at the 90 percent level. M.N. stands for the maturity-neighbourhood.

[64] Both for the nominal securities and TIPS, we drop those observations where the security is on-the-run. In order to get rid of the severe seasonality effects on the real yield of the TIPS, we also drop the observations pertaining to the final six months remaining to the maturity of the TIPS.

Table 19. Estimation Results (TIPS – Second Model)

Linker	PDV	VOL	Coupon	R^2
Group 1 M.N. of April 15, 2011	117.8* 0.027	0.22 0.88	- -	0.72
Group 2 M.N. of January 15, 2012 & April 15, 2012 &July 15, 2012	158.83* 0.000	4.255* 0.000	-0.074* 0.020	0.35
Group 3 M.N. of April 15, 2013 &July 15, 2013	402.5* 0.000	- -	- -	0.56
Group 4 M.N. of January 15, 2014 & April 15, 2014 &July 15, 2014	152.10* 0.000	13.569* 0.000	-0.160* 0.001	0.43
Group 5 M.N. of January 15, 2015 &July 15, 2015	50.235* 0.020	11.490** 0.0522	-0.13* 0	0.46
Group 6 M.N. of January 15, 2016 &July 15, 2016	-4.67 0.870	10.95** 0.065	- -	0.86
Group 7 M.N. of January 15, 2017	114.6* 0.001	-4.05 0.22	0.008 0.31	0.08

First rows exhibit the estimated coefficients and the second rows show the probabilities.
* shows significance at the 95 percent level and ** shows significance at the 90 percent level. M.N. stands for the maturity-neighbourhood.

The results indicate that the second model is effective in explaining both the liquidity premium in TIPS pairs and nominal treasury pairs. In the first model, the bid-ask spread variable appears to be insignificant especially in explaining the liquidity premium across TIPS. This finding is consistent with the findings of Fleming and Krishnan (2012), who report that bid-ask spread is not a good liquidity indicator for US TIPS. On the other hand, the coefficients of the variables $dPDV_{it}$ and $dVOL_{it}$ are highly significant and intuitive both for nominal bonds and TIPS. These are indicative of the fact that either a decrease in the security's trading volume, which is proxied by *PDV* variable, or an increase in its return volatility, shown by *VOL*, results in an increase in its liquidity premium.

As the first model cannot effectively explain the TIPS liquidity premium and the variable $Amnt_{it}$ turns out to be non-stationary in the estimation of the third model, the second model is selected as benchmark to construct the relative liquidity premium between maturity-matched TIPS and nominal securities. Estimated coefficients ($\widehat{\alpha_0}, \widehat{\alpha_1}, \widehat{\alpha_2}, \widehat{\alpha_3}$) and ($\widehat{\beta_0}$, $\widehat{\beta_1}$, $\widehat{\beta_2}$, $\widehat{\beta_3}$) are used together with the corresponding liquidity indicators for each bond type, and the liquidity premium for nominal bonds and TIPS are calculated. The calculated liquidity premium across the nominal securities and TIPS are presented in Figure 11 and 12, respectively. The relative liquidity premium between the maturity-matched TIPS and nominal bonds is presented in Figure 13.

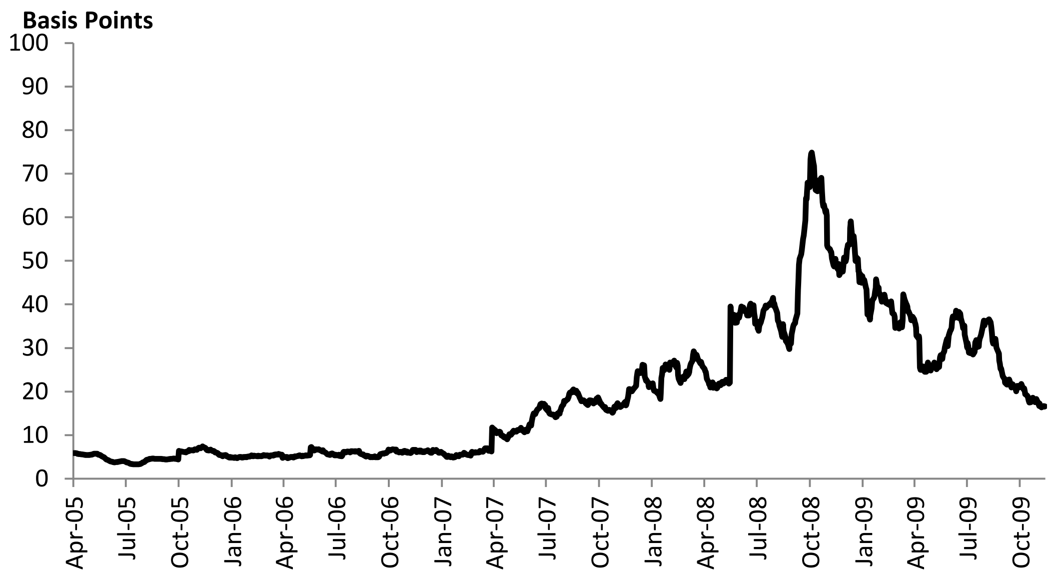

Figure 11. Average Liquidity Premium Across US Nominal Treasuries (Apr. 2005-Nov. 2009)

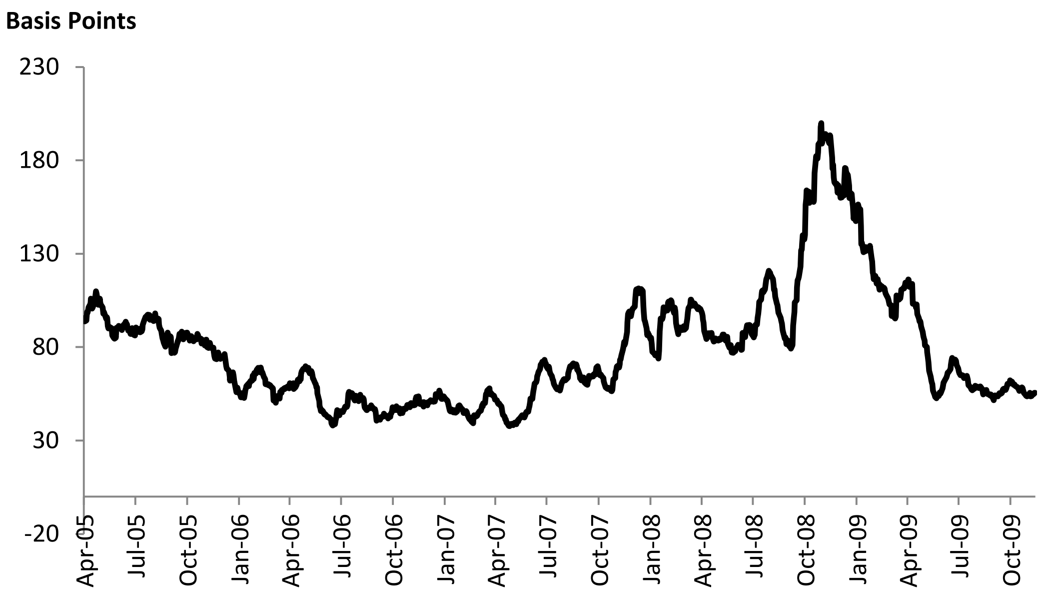

Figure 12. Average Liquidity Premium Across US TIPS (Apr. 2005-Nov. 2009)

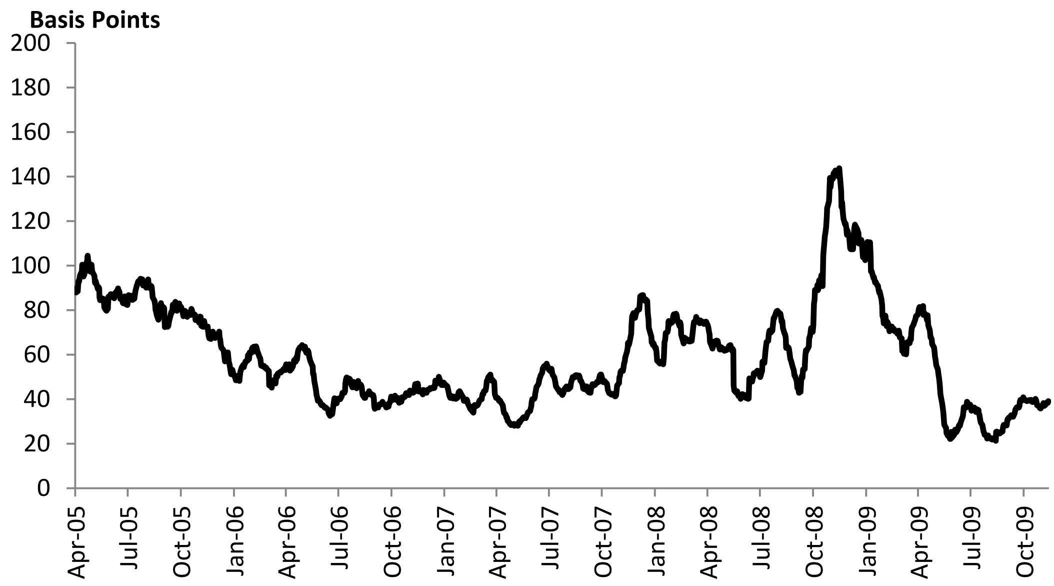

Figure 13. Average Relative Liquidity Premium Across US TIPS and Treasuries (Apr. 2005-Nov. 2009)

Similar to the results of Musto et al. (2015), our results also indicate that the average liquidity premium across the securities in 14 nominal maturity-neighbourhoods reached up to 75 basis points during 2008-2009 global financial crisis and wandered around 0 other times. The average liquidity premium across the TIPS in 14 TIPS maturity-neighbourhoods exhibits a pattern similar to that of nominal bonds. The average liquidity premium for US TIPS also hit its peak at around 200 basis points during the global financial crisis and hovered around 70 basis points in other times. However, the peaks of the liquidity premium for the nominal securities and TIPS do not coincide. The nominal securities bottomed in terms of liquidity in October 2008, whereas the TIPS fell to bottom in November 2008. Therefore, the average relative liquidity premium across maturity-matched TIPS and nominal securities realized its peak around 140 basis points in November 2008. These results are very close to what is reported in Gurkaynak et al. (2010) but less than what is found in Pflueger and Viceira (2011). However, as reported by Pflueger and Viceira (2011), the relative liquidity premium is time-varying and takes values between 40 and 80 basis points during normal times.

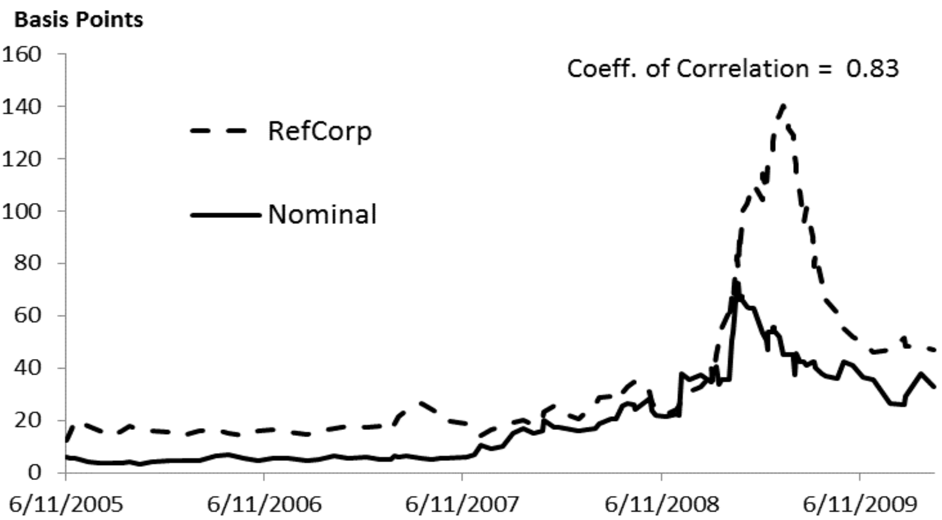

Figure 14. Average Liquidity Premium Across US Nominal Treasuries vs. Refcorp Spread (Apr. 2005-Nov. 2009), 21 days MA

Figures from 14 through 16 exhibit the co-variation of the nominal liquidity premium, TIPS liquidity premium and relative liquidity premium with the well-known Refcorp spread respectively. The calculated coefficient of correlation during April 2005 - November 2009 period is 0.83 for the nominal liquidity premium, 0.83 for the TIPS liquidity premium and 0.67 for the relative liquidity premium. The correlation coefficients also indicate that the methodology proposed in this chapter indeed measures the relative liquidity premium across maturity-matched securities.

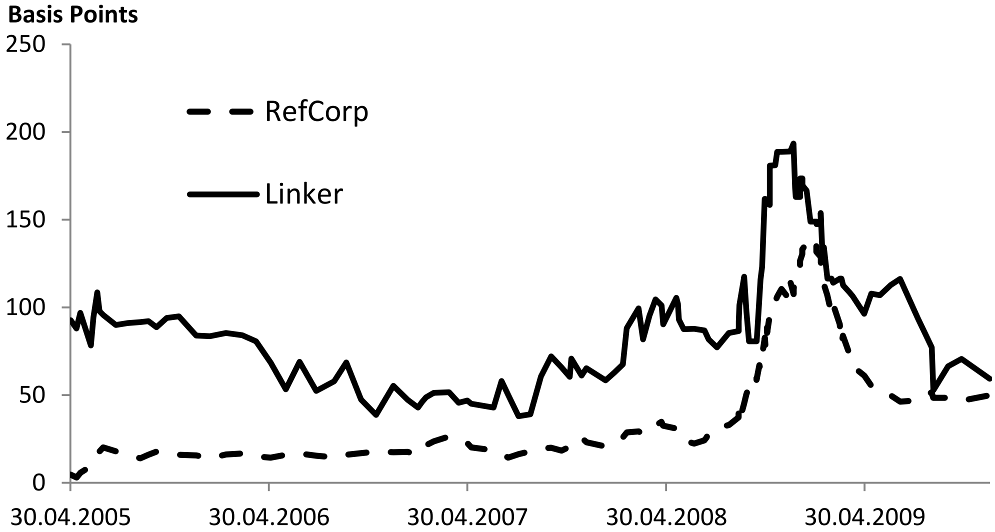

Figure 15. Average Liquidity Premium Across US TIPS vs. Refcorp Spread (Apr. 2005-Nov. 2009), 21 days MA

Finally, Table 20 compares the average relative liquidity premium, calculated for each of the 14 maturity-matched TIPS and nominal pairs, with the average mispricing reported by Fleckenstein et al. (2014) for the same pairs. On average, the calculated relative liquidity premium across 14 selected-pairs explains 70 percent of the average mispricing reported by Fleckenstein et al. (2014). The average mispricing across 29 maturity-matched TIPS and nominal pairs made its peak around 175 basis points by the end of 2008. Similarly, the relative liquidity premium calculated in this chapter reached its maximum in November 2008. However, the attained maximum is 140 basis points, which is almost 80 percent of the maximum average mispricing of Fleckenstein et al. (2014).

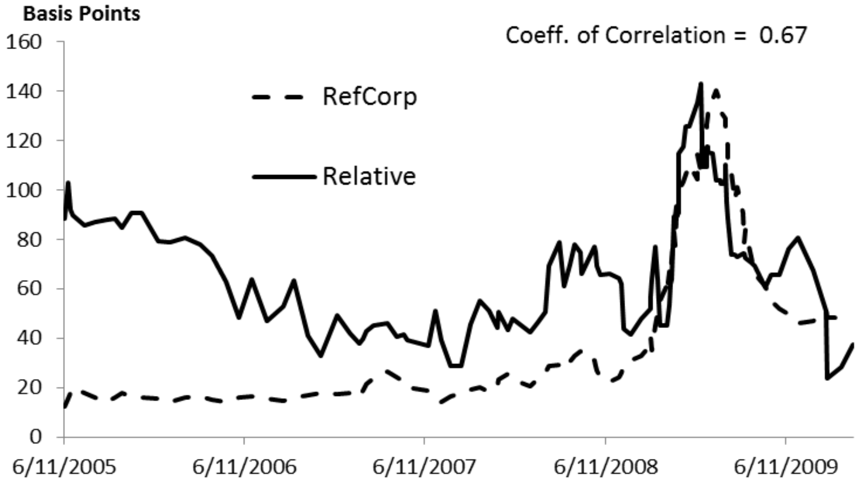

Figure 16. Average Liquidity Premium Across US TIPS & Nominal Treasuries vs. Refcorp Spread, (Apr. 2005-Nov. 2009), 21 days MA

Table 20. Average Liquidity Premium vs. Mispricing Estimates of Fleckenstein et al. (2014)

TIPS	Nominal Treasuries	Average Relative Liquidity Premium in basis points (April 2005–November 2009)	Average Mispricing Reported by Fleckenstein et al. (2014) in basis points (July 2004–November 2009)	Explained Percentage
April 15, 2011	March 31, 2011	15.3	56.0	27.4
January 15, 2012	January 15, 2012	37.8	72.0	52.4
April 15, 2012	April 15, 2012	21.5	54.0	39.9
July 15, 2012	July 15, 2012	38.6	60.0	64.3
April 15, 2013	March 31, 2013	50.6	55.0	91.9
July 15, 2013	June 30, 2013	145.6	96.0	151.7
January 15, 2014	December 31, 2013	95.8	103.0	93.0
April 15, 2014	March 31, 2014	32.0	41.0	78.1
July 15, 2014	June 30, 2014	72.9	67.0	108.9
January 15, 2015	February 15, 2015	53.6	55.0	97.4
July 15, 2015	August 15, 2015	53.8	56.0	96.0
January 15, 2016	February 15, 2016	32.1	59.0	54.5
July 15, 2016	June 30, 2016	15.8	62.0	25.5
January 15, 2017	February 15, 2017	6.7	58.0	11.6

5.6 Conclusion

This chapter attempts to calculate the relative liquidity premium across maturity-matched US TIPS and nominal securities. The methodology used for this purpose is based on using a dependent variable, which is thought to be an indicator of the pure liquidity premium, in the estimation of the price of liquidity. For a specific maturity, the estimated price of liquidity is then used to construct the relative liquidity premium across maturity-matched bond pairs. This methodology is applied to calculate the liquidity premium across a subset of the 29 maturity-matched US TIPS and nominal bonds used in Fleckenstein et al. (2014). The calculated liquidity premium indicates that almost 70 percent of the mispricing reported by Fleckenstein et al. (2014) is due to pricing of the liquidity premium.

The calculated relative liquidity premium across TIPS and nominal bonds is time-varying, reaches up to 140 basis points during 2008-2009 financial crisis and hovers around 40 to 80 basis points during normal times. In line with Musto et al. (2015), the liquidity premium across nominal securities is also found to rise levels close to 75 basis points during the global financial crisis. Our results also indicate that the average liquidity premium across these maturity-matched security pairs highly co-variates with a very well-known liquidity measure: Refcorp spread. In particular, the calculated coefficient of correlation is 0.67 for the April 2005-November 2009 period.

CHAPTER VI

CONCLUSION

With a special interest in Turkey, this thesis aims to shed light on the factors that affect the yields on the emerging local-currency debt instruments.

All of the chapters serve our understanding of the features of the emerging economy local currency debt instruments. Moreover, the thesis contributes to the literature by proposing an empirical methodology for extracting the liquidity premium between any two maturity-matched fixed income securities of similar types. The international macroeconomic model sheds light on the underlying fundamentals that cause the differences in the emerging economies' interest rate dynamics. However, our empirical findings point out new areas where emerging economy debt instruments differ from those of developed economies, i.e. the inflation-linkers can sometimes be more liquid than nominal bonds with same maturity, and swap spreads are usually negative.

This thesis analyzes the emerging economy local currency denominated fixed income securities with a particular focus on Turkey. In an attempt to form a theoretical base, an international macroeconomic framework is established to price the emerging country local currency bonds in general. The proposed model, in which emerging economy households are assumed to be more impatient, can competently match the high, volatile and counter-cyclical emerging economy bond premium. The results of the model also indicate that the real exchange rate volatility drives much of the volatility in the emerging country bond premium.

The following chapters involve empirical analyses that have a special focus on Turkish lira denominated fixed income securities. First, the spread between the Turkish lira denominated nominal bonds and cross currency assets with similar maturities is analyzed. Using the variables from the literature as explanatory variables, the third chapter empirically tests the factors that affect the USDTRY cross currency swap spreads. The results reveal that the slope of the yield curve and the credit risks of the parties involved in the swap affect the swap spread in Turkey. The next empirical investigation involves the extraction of the relative liquidity premium and inflation risk premium embedded in the inflation compensation obtained from the maturity-matched nominal and inflation-linked Turkish lira bonds. One of the results presented in the fourth chapter is noteworthy: the inflation-linked Turkish lira bonds can sometimes be more liquid relative to the nominal bonds. This finding contrasts with what is reported for the developed currency bonds. In most of the developed countries, the nominal bonds are reported to be more liquid than inflation-linked bonds.

The fifth chapter tests the robustness of the liquidity extraction methodology proposed in the fourth chapter. The proposed methodology is tested for the most actively traded fixed income market: US bond market. The methodology yields results that are in line with the existing literature. Moreover, the US TIPS-nominal bond relative liquidity premium, which is calculated by the proposed methodology, co-variates with a very well-known liquidity measure: RefCorp spread. In particular, the calculate coefficient of correlation is 0.67 for the April 2005-November 2009 period.

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