

Dynamic Bargaining Markets and the Negative Swap Spread

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Sven Klingler*

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The difference between the yield of a government bond and the fixed rate in an interest rate swap is commonly referred to as swap spread. In 2008 the US swap spread for 30-year contracts turned negative. This is surprising because negative swap spreads are a theoretical arbitrage opportunity and unlike most other crisis phenomena the negative swap spread is very persistent.

* Department of Finance and Center for Financial Frictions (FRIC). Copenhagen Business School, Solbjerg Plads 3, DK-2000 Frederiksberg, Denmark. E-mail: sk.fi@cbs.dk.

1. Introduction

During the financial crisis of 2007–2009 many pricing anomalies occurred in the financial market. A common explanation for most of these anomalies is that a deterioration in funding liquidity kept arbitrageurs from reinforcing the law of one price. Further, Lehman Brothers was a large counterparty in the market for over-the-counter (OTC) derivatives. The default of Lehman Brothers caused many derivatives dealers and end users to lose their counterparty and put additional pressure on derivatives prices. The pricing anomaly that I study in this paper is the negative swap spread. In September 2008, shortly after the default of Lehman Brothers, the difference between the swap rate of a 30-year interest rate swap (IRS) and the yield of a treasury bond with the same maturity, commonly referred to as swap spread, turned negative. In contrast to other pricing anomalies, the 30-year swap spread is very persistent, still trading at -10 basis points in February 2015.

Normally, swap spreads are a measure of uncertainty in the economy and increase in times of market distress. The reason for this is twofold. First, in an IRS a fixed payment is exchanged against a floating payment, which is typically based on Libor. Hence, even though IRS are collateralized and viewed as free of counterparty credit risk, the swap rate should be above the (theoretical) risk-free rate because of the credit risk in Libor. Hence, an increase in bank credit risk, which increases the Libor rate, should increase the swap spread. Second, treasuries have a status as safe and liquid assets and therefore carry a “convenience yield,”¹ which means that the treasury yield is below the (theoretical) risk-free rate. If the uncertainty in the economy increases, investors value the safety and liquidity of treasuries more, thereby increasing the convenience yield. A higher convenience yield of treasuries causes the swap spread to increase.

Given these considerations there are three puzzles regarding the negative swap spread. First, why did the swap spread turn negative shortly after the default of Lehman Brothers? This timing is surprising because both, Libor rates and the demand for safe and liquid assets were at all-time heights which, according to the above considerations, should have *increased* the swap spread. Second, why is the negative swap spread so persistent? Phrased differently, what keeps arbitrageurs from reinforcing the law of one price here? It is difficult to explain this long persistence with a lack of funding liquidity only, especially given that most other pricing anomalies receded. Third, how can we explain the magnitude of the negative swap spread? Since there is an arbitrage opportunity in negative swap spreads, the question is who is willing to receive a swap rate below the corresponding treasury yield and why?

I argue that the solution to these puzzles is twofold. First, there is a difference in the funding requirement for treasuries and IRS. The treasury requires initial funding while the IRS has zero net present value. While this difference is almost irrelevant for sophisticated investors who can use leverage and the repo market, it matters for less-sophisticated end-users

¹See, for instance Krishnamurthy and Vissing-Jorgensen (2012) or Feldhütter and Lando (2008) for more details.

of the IRS. For example, corporations and pension funds could prefer IRS over treasuries. Hence, the funding difference explains why there are customers willing to receive a swap rate below the treasury yield. Second, selling IRS and hedging them using treasuries leaves derivatives dealers exposed to a residual risk. In normal times, derivatives dealers would enter the market and arbitrage the negative swap spread away. However, the default of Lehman brothers can be interpreted as a severe shock to dealers' risk-bearing capacity, which kept them from selling IRS. Further, the possibility of such a severe shock, where it becomes extremely costly to unwind existing IRS, explains why the swap spread did not converge back to its original level.

I develop a model that explains negative swap spreads based on a supply-demand imbalance. Derivatives dealers engage into IRS with customers to satisfy their demand. Customers benefit from engaging in IRS by saving a certain hedge cost. This hedge cost could be interpreted as the funding cost of a leverage-constrained investor buying treasuries instead of using IRS. In normal times, the customer can get in contact with a dealer almost immediately and is only willing to give a small fraction of c as a fee to the dealer. In a crisis, the dealer's risk-bearing capacity decreases and he is less able to provide the IRS. In this case, it is more difficult for the customer to get in contact with a dealer. I interpret this difficulty in obtaining an IRS as waiting time and build a search-theoretic model around this supply-demand imbalance. The longer the waiting time, the more valuable the swap becomes for the customer and the fraction of c that he is willing to pay as fee increases. Once the fee increases above the theoretical frictionless swap spread, we observe negative swap spreads.

I provide four empirically findings to shed more light on the negative swap spread. First, I show that the negative swap spread is an international phenomenon that also occurred in Germany and Great Britain shortly after the default of Lehman Brothers. Second, using quarterly macro-data in a regression analysis, I show that supply and demand variables affect swap spreads. Third, I regress weekly changes in swap spreads after 2007 on several explanatory variables, including sovereign CDS premia. It turns out that sovereign credit risk, as measured by the CDS premium,² does not explain 30-year swap spreads. Finally, I use principal components analysis (PCA) to confirm that, after the default of Lehman Brothers, the 30-year swap spread significantly differs from the other swap spreads.

1.1. Literature Review

Will be included in the next version.

²It is not obvious that CDS premia of safe sovereigns are a clean measure of credit risk. Klingler and Lando (2015) argue that safe-haven CDS premia are to a large extent driven by regulatory frictions.

2. Institutional Details

In an interest rate swap two parties agree on exchanging interest payments. The first party, the fixed payer, receives a floating interest payment based on Libor every quarter. In turn, he pays a fixed rate which is called the swap rate. This payment is typically done semi-annually. The other party is called fixed receiver and has the opposite position, receiving the swap rate and paying the Libor rate in turn. The position for the fixed receiver can be thought of as a long position in a risk-free bond financed by a credit given at Libor rate which is rolled over every quarter. The reason why the bond is viewed as risk-free is twofold. First, the swap is typically collateralized. If the swap becomes a liability for one of the counterparties, he has to post collateral to insure the other counterparty against losses in case of his default. Second, there is no notional exchanged in the transaction. Hence, even if the counterparty defaults and there is not enough collateral posted, the loss is much lower than in a comparable bond. However, theory predicts that the fixed rate is slightly higher than a theoretical risk-free rate because the bond purchase is financed at Libor, which contains a credit risk component.

Treasury securities on the other hand carry a “convenience yield”,³ meaning that they trade below the theoretical risk-free rate. The arbitrage argument in Table 1 illustrates that there should be a positive swap spread. The fixed payer in an IRS buys a treasury bond with the same maturity as the interest rate swap. To finance this transaction he uses a repo transaction, where he uses the treasury as security to get a loan. He rolls over this repo position every three months. Assuming no other frictions, that would give the following two payment streams. A fixed stream of payments, receiving the treasury yield and paying the swap rate and a floating stream of payments, receiving the Libor rate and paying the repo rate. The swap rate should be determined such that the fixed and floating payment streams are equal. Since the difference between Libor and repo rate is always positive, the difference between treasury yield and swap rate should be negative.

2.1. Limits to Negative Swap Spreads Arbitrage

The arbitrage strategy in Table 1 is subject to several frictions, most notably a funding friction. In order to buy the treasury the arbitrageur has to borrow money using a repo agreement. Treasuries with a maturity longer than 10 years are typically subject to a haircut of approximately 6%,⁴ which means that the arbitrageur has to use some uncollateralized funding for the position. Additionally to that, rolling over the repo agreement is subject to the risk that the treasury security might decrease in value, in which case the arbitrageur

³See, for instance Krishnamurthy and Vissing-Jorgensen (2012) or Feldhütter and Lando (2008) for more details.

⁴This number is a first approximation that I obtained from <http://www.cmegroup.com/clearing/financial-and-collateral-management/>. They analyze haircuts for securities posted as collateral in cleared derivatives transactions. However, market participants confirm that 6% is a reasonable proxy for haircuts of treasuries with 30 years to maturity.

needs to use more uncollateralized funding to finance the strategy.⁵ Further, rolling over the repo transaction relies on a smooth functioning of the repo market. If the arbitrageur's own funding liquidity deteriorates and his funding cost rises above Libor, this funding friction becomes more binding.

The prospect of credit risk in US treasuries is often offered as another argument against the above arbitrage strategy. But, even if this was a plausible prospect, it is not clear how an increase in credit risk in US treasuries might affect the swap spread. Clearly, an increase in treasury credit risk would increase the treasury yield and assuming all else equal, a decrease in the swap spread would result. However, it is not obvious that swap rates would be unaffected by the increase in treasury credit risk since US interbank lending rates would presumably increase sharply when US credit risk increases. Therefore, it is just as likely that the swap rate would be elevated.

Finally, assume that the above strategy is indeed a textbook arbitrage opportunity. As pointed out by Shleifer and Vishny (1997), Liu and Longstaff (2004) and many others, even textbook arbitrage opportunities are subject to a risk. The risk is the possibility that the mispricing increases before it vanishes, thereby forcing the arbitrageur out of his position. In the above strategy we know that the mispricing will vanish after 30 years. We do not know whether the mispricing will vanish in the close future. As Figure 1 shows, the mispricing did not vanish over the past 6 years, making it unclear whether the swap spread will converge to a positive level before maturity. Overall, this consideration indicates that only arbitrageurs with a very long investment horizons and the necessary funding liquidity can take advantage of swap spread arbitrage.

To illustrate this point, assume that the arbitrageur does not hold the short position in the negative swap spread until maturity. Instead, he only holds his position for 3 months, thereby earning the the Libor-Repo spread plus the negative swap spread. After 3 months he closes his position.⁶ This strategy earns him a strictly positive cash flow from the payments in the swap and bond but is prone to the risk of a further decrease in swap spreads. For example, if the swap spread drops by 5 basis points, offsetting his short position in the swap spread would cost him approximately 85 basis points.⁷ The monthly and accumulated gains from this strategy are exhibited in Figure 2. Analyzing the accumulated gains leads to two main findings. First, the "arbitrage strategy" is risky and the accumulated gain is negative for most of the time before 2013. Second, comparing the accumulated gains from the arbitrage strategy to the swap spread shows that the positive cash flows from the bond and swap are

⁵A decrease in the price of the treasury could be due to, for example, a higher debt-to-GDP ratio which, following the arguments of Krishnamurthy and Vissing-Jorgensen (2012), increases the supply of treasuries and thereby lowers its convenience yield. As discussed before, a lower convenience yield results in a lower swap spread.

⁶In my simple example, I assume that closes his position by engaging in an offsetting 30-year swap contract, ignoring the fact that he would need a contract with 29 years and 9 months to maturity.

⁷Moving forward with this project, I will be more precise on how to offset the short position in the swap spread and study the robustness to different computation methods. However, given the results in Figure 2, I doubt that the results will be changed significantly by different computations

dwarfed by the costs of exiting the short position in the negative swap spread.

2.2. The Demand and Supply of Interest Rate Swaps

Engaging in an interest rate swap with a new counterparty is subject to several requirements. For instance, both parties need to set up an ISDA master agreement which takes time. Therefore, customers usually establish a trading relationship with one or several derivatives dealers and do not trade directly with each other. If the demand for paying fixed and receiving fixed is balanced, the dealer simply acts as an intermediary. In this case there would be no demand pressure and the dealer simply extracts a bid-ask spread. If there is an excess demand for one of the two positions the dealer takes the other side of the transaction, thereby warehousing the swap and supplying swaps to investors.

Investors use IRS for speculation or hedging purposes. In both cases the demand for IRS can depend on the level and the slope of the yield curve. The level of the yield curve matters, for instance, for agencies issuing Mortgage-Backed Securities (MBS). Agencies aim to balance the duration of their assets and liabilities. When interest rates fall, mortgage borrowers tend to execute their prepayment right, thereby lowering the duration of the agencies' mortgage portfolio. Hence agencies want to receive fixed in an IRS to hedge this mortgage prepayment risk.⁸ The slope of the yield curve matters for non-financial firms. According to Faulkender (2005), these firms tend to use IRS mostly for speculation, preferring to pay floating when the yield curve is steep. Faulkender (2005) also finds that firms tend to prefer paying fixed when macro-economic conditions worsen.

Overall, the above examples show that there could be demand and supply effects in the interest rate swap market. Customers, like non-financial firms, could have a demand for paying or for receiving fixed. However, it is unlikely that firms have a large demand for IRS with a maturity of 30 years, where the negative swap spread still persists. The most important customers in the long end of the swap curve are pension funds and insurance companies, who have a natural demand for receiving fixed for longer tenors. Pension funds have long-term liabilities towards their clients and the Pension Protection Act of 2006 requires them to match the duration of their asset portfolios with the duration of these liabilities. Increasing the duration of their asset portfolios could be achieved by receiving fixed in an IRS or by buying bonds with long maturities.⁹ However, Ang, Chen, and Sundaresan (2013) find that many US pension funds are underfunded and tend to more risky investments. To this end, they prefer to use the funding required to buy long-term bonds for buying risky assets. Hence, they have a demand for receiving fixed in an IRS.

Another common argument for negative swap spreads is that buying treasuries requires capital while an IRS has zero present value. For a sophisticated investor with full access to

⁸Feldhütter and Lando (2008) argue that using IRS is the predominant way for doing this as opposed to using treasuries.

⁹Greenwood and Vayanos (2010) provide evidence from the 2004 pension reform in the United Kingdom where pension funds started buying long-dated gilts.

repo financing, buying a treasury requires a minor initial funding of approximately 6%, as discussed before. At the same time, engaging in an IRS could also require an initial margin and regular collateral posting. Therefore, this funding difference is not a limit to the above arbitrage strategy. However, for less-sophisticated investors who need to balance their asset-liability duration and do not have access to repo financing or have severe leverage constraints, this argument is important. These investors value IRS more than treasuries because IRS are a cheaper way for them to balance their asset-liability duration. Therefore, they are willing to receive a swap rate which is below the fair swap rate. I argue in the following section that the size of this “fee” depends on how easily they can find a trader that is willing to provide them with an IRS.

3. The Model

The market for IRS is dominated by a small amount of dealers and finding a dealer is straight forward. In normal times a customer calls his dealer(s) and they start negotiating the swap rate without much delay.¹⁰ When the dealer is in financial distress, or his risk-bearing capacity is low, the customer has to wait before he starts negotiating the rate with his dealer. One interpretation is that the dealer needs to check with his risk-management if he is able to provide the swap before he trades. If risk management does not allow the dealer to trade there will be a significant waiting time for the customer. In this case, the customer either tries calling his dealer again later or establishes a new trading relationship with another dealer. As noted before, establishing a new trading relationship takes time.

The mechanism that explains negative swap spreads in my model is as follows. Customers benefit from engaging in IRS by saving a cost c . This cost could be interpreted as the funding cost of a leverage-constrained investor buying treasuries instead of using IRS. In normal times, the customer can get in contact with a dealer almost immediately and is only willing to give a small fraction of c as a fee to the dealer. When dealers’ risk-bearing capacity decreases or when there is an excessive demand for IRS by customers, it takes longer for the customer to get in contact with a dealer. The longer the waiting time, the more valuable the swap becomes for the customer and the fraction of c that he is willing to pay as fee increases. Once the fee increases above the fair swap spread we observe negative swap spreads.

3.1. Model Setup

There are two kinds of agents in the baseline model, derivatives dealers and customers. Both agents are impatient at the same rate r . A fraction μ of the customers needs to engage in a receiver IRS to heighten their portfolio duration. I abstract from the dealer’s role as intermediary and focus on the case where the dealer provides the IRS as fixed payer to a

¹⁰In practice, dealers post indicative quotes at which they are willing to trade. After customers get in contact with a dealer the indicative quote typically gets adjusted. I interpret this as a bargaining game.

customer. Hence, μ can be interpreted as excess demand for receiving fixed in an IRS by customers. If a customer successfully engages in a IRS he avoids a constant stream of costs c .¹¹ A fraction ν of dealers is in the market and ready to provide the IRS to the customers. Customers get in contact with dealers at a rate $\alpha(\theta)$, which depends on the amount of available dealers relative to the demand for IRS ($\theta = \nu/\mu$). For providing the IRS to the customer, the derivatives dealer charges a fee ϕ .

Assume that a customer needs a derivative with a certain maturity M . Then $V_M(0, t)$ denotes the customer's value function at time t if he does not hold the derivative and $V_M(1, t)$ his value function if he does hold the derivative. To simplify the analysis, I assume that the maturity of the derivative T_M is a stopping time with intensity λ_M . Further, I let T_D denote the (stopping) time of a customer meeting a dealer. This stopping time has an intensity $\alpha(\theta)$. The following lemma summarizes the customers value function.

Lemma 1. *The customers value functions are given as*

$$\begin{aligned} V_M(1, t) &= \mathbb{E}_t \left[\int_t^{T_M} ce^{-r(s-t)} dt \right] = \frac{c}{r + \lambda_M} \\ V_M(0, t) &= \mathbb{E}_t \left[1_{\{T_D < T_M\}} e^{-r(\min(T_D, T_M) - t)} (V(1, t) - \phi) \right] \\ &= \frac{\alpha(\theta)(V(0, t) - \phi)}{r + \lambda_M + \alpha(\theta)}. \end{aligned}$$

Once a customer gets in contact with a dealer, they start bargaining over ϕ . In this bargaining game, the customer has a reservation value of $\Delta V_M(t) := V_M(1, t) - V_M(0, t)$. The derivatives dealer's reservation value is ϕ , meaning that he gets the fee if the bargaining is successful and nothing otherwise. The bargaining game can be thought of as an alternating offers game with small time steps $\Delta t \rightarrow 0$ between the offers. Every time step, the dealer makes an offer with probability \hat{z} and the customer with probability $1 - \hat{z}$. Further, I assume that the customer cannot search for new dealers while bargaining with the dealer. On the other hand, the dealer can still get approached by a new customer while bargaining. If the dealer gets approached by a new customer he starts bargaining with the new customer and the bargaining game with the old customer breaks down. The intensity of a dealer getting approached by a new customer is $q(\theta) = \alpha(\theta)/\theta$. Further, a breakdown occurs for both agents with intensity λ_M , when the derivative matures. The dealer's bargaining power in this game can be computed using a result from Coles and Wright (1994).

Lemma 2. *The dealer's bargaining power in the above game can be computed as:*

$$z = \frac{\hat{z}(r + \lambda_M + q(\theta))}{\hat{z}(r + \lambda_M + q(\theta)) + (1 - \hat{z})(r + \lambda_M)}.$$

¹¹Moving forward with this project, I plan to study c more carefully. If the customer does not face any funding constraint, the benefit from engaging in an IRS would be very small compared to buying treasuries.

3.2. The Equilibrium Fee

As described by Coles and Wright (1994) the bargaining game with the new bargaining power z can be interpreted and solved as a Nash bargaining game, where ϕ is given as

$$\operatorname{argmax}_{\phi} [\Delta V_M(t) - \phi]^{1-z} \phi^z. \quad (1)$$

Plugging this new bargaining power in Equation (1) yields our first main result for ϕ .

Proposition 1.

$$\phi = \frac{c}{r + \lambda_M} \left(\frac{\hat{z}(r + \lambda_M + q(\theta))}{r + \lambda_M + \hat{z}q(\theta) + (1 - \hat{z})\alpha(\theta)} \right). \quad (2)$$

With Equation (2) we can compute the annual fee φ , given such that $\phi = \mathbb{E}_t \left[\int_t^{T_M} \varphi e^{-r(s-t)} ds \right]$:

$$\varphi = c \left(\frac{\hat{z}(r + \lambda_M + q(\theta))}{r + \lambda_M + \hat{z}q(\theta) + (1 - \hat{z})\alpha(\theta)} \right).$$

To get a better understanding of this result we first set $r = 0$ and assume that the maturity of the derivative is ∞ . Then the expression simplifies to:

$$\varphi = c \left(\frac{\hat{z}q(\theta)}{\hat{z}q(\theta) + (1 - \hat{z})\alpha(\theta)} \right). \quad (3)$$

Equation (3) shows the main mechanism. If there are more customers demanding the derivative, the dealer gets approach more frequently, which increases $q(\theta)$ and thereby his bargaining power. If it becomes easier for the customer to obtain the derivative, which corresponds to a higher $\alpha(\theta)$, the dealer's bargaining power decreases, thereby decreasing the fee. In the limiting case where it is impossible for the customer to obtain the derivative, the dealer's bargaining power is equal to one and the customer is willing to pay the full cost c that he saves from engaging in the IRS.

Planned Procedure

The next step is to provide an equilibrium value for c . This can be done by comparing the margin requirements for engaging in an IRS and buying treasuries from insurance companies and pension funds.¹²

¹²Moving forward with this project, I also plan to shed more light on the hedging practice of insurance companies and pension funds.

4. Empirical Evidence

4.1. The Data

Figure 1 shows the 5-year and 30-year swap spread over the past 12 years and compares them to the difference between the 3-month Libor and 3-month general collateral repo rate. There are two main observations from the Figure. First, the two swap spreads track each other closely until 2007 where the 30-year swap spread could be above or below the other maturities. In 2007 the 30-year swap spread starts decreasing while swap spreads of the other maturities increase. The disconnect becomes stronger shortly after the default of Lehman Brothers, indicated by the grey bar. During this period we can observe a downward jump in the 30-year and 10-year swap spreads and the 30-year spread goes below zero. Second, the Libor-Repo spread starts increasing at the beginning of 2007. According to the arbitrage strategy outlined above, this spread should be related to swap spreads. We can see from the graph that this arbitrage relation breaks down for the 30-year swap spread which decreases while the Libor-Repo spread increases.

Next, I take a look at the international evidence. Figure 3 shows the term structure of swap spreads in the United States, Great Britain, Germany, and Japan. For the case of Germany, I compare the yield on German bonds to swaps written on Euribor. As we can see from these graphs, all four have in common that the 30-year swap spread turned negative shortly after the default of Lehman Brothers. However, there are several differences regarding the magnitude and persistence of the phenomenon. First, negative swap spreads seem to be more common in Japan where we can see inversions in the short end and long before the default of Lehman Brothers as well. Second, in the case of Germany, the 30-year swap spread turned positive again in 2010 and stayed positive most of the time since. Third, Great Britain is most similar to the US Swap spread, with the 30-year swap spread staying negative since 2008 and short episodes of negative swap spreads for the 10-year maturity.

Focusing on the 30-year swap spread, all three time series exhibit a sharp decline in this rate around the default of Lehman Brothers. All three time series turned negative in 2008. Further, negative swap spreads are very persistent in Great Britain and the US with US swap spreads still being around -10 and British swap spreads still being around -30 basis points today. Negative German swap spreads are less persistent, especially at the beginning of 2015 when the ECB started launching its massive bond purchase program, German swap spreads increased sharply.¹³

¹³ECB is still not purchasing long-term bonds, but it might start soon.

4.2. Regression Analysis

Macro Variables

To take a first look at the evidence, I regress changes in the 5-year, 10-year, and 30-year swap spread on three different explanatory variables. First, the difference between the 3-month Libor and 3-month treasury yield, commonly referred to as TED spread. This variable captures the Libor-repo spread and a specialness component of treasuries. As we can see from Table 3, swap spreads tend to increase when the TED spread increases. Further, we can see that the effect is less significant for the long end. Second, following the logic of Feldhütter and Lando (2008), I argue that mortgage issuers need IRS to balance their asset-liability duration when mortgage refinancing rates change. This demand is proxied by the mortgage refinancing rate, measured by the mortgage banker association. The regression shows that an increase of mortgage refinancing rates corresponds to a decrease in swap spreads, indicating that a higher demand for receiving fixed decreases the swap spread. Finally, I use the US Debt-to-GDP ratio as a proxy for the convenience yield in treasuries. Following Krishnamurthy and Vissing-Jorgensen (2012), the idea is that when there is more supply of treasuries the convenience yield decreases, thereby decreasing the swap spread. We can see from Table 3 that an increase in the debt-to-GDP ratio indeed lowers the swap spread.

CDS and other Market Variables

Table 4 shows the results of regressing changes in swap spreads of different maturities on three explanatory variables. First, changes in the difference between the 3-month Libor rate in the respective currency and the 3-month government bond yield. Second, the implied volatility of the local stock market return and third, the respective sovereign CDS premium. There are two main findings from this analysis. First, the local TED spread tends to be a significant explanatory variable for short-term swap spreads. Surprisingly, for 30-year swap spreads the local TED spread is significant for Germany and Great Britain but with a negative coefficient. This implies that increases in the local TED spread coincide with decreases in the 30-year swap spread. This is a surprising finding and goes against the arbitrage argument provided above. Second, sovereign credit risk is not a significant explanatory variable for most of the swap spreads. In the case of the United States and Germany, the coefficient of the CDS premium has the wrong sign, but is insignificant.

4.2.1. Changes in Regressions Before and After Lehman

Will be included in the next version.

4.3. Principal Components Analysis

In this section, I document first document that the 30 year swap spread is significantly different from the other swap spreads in the term structure. To this end, table 2 shows

the factor loadings and R^2 values of from a principal components analysis (PCA) of the swap spreads term structure for the February 2007 to February 2015 period. For all three countries, the factor loadings for the 30-year swap spread differ significantly from the other factor loadings exhibited in the table. 5-year and 10-year swap spreads are to a large extent explained by the first principal component while both the factor loading and R^2 value is much smaller for the 30-year swap spread. The 30-year swap spread for all three sovereigns in the sample is loading heavier on the second principal component than the first, indicating a different time-series behaviour.

The second empirical finding documented in this section is that the factor loading has changed over the past years, especially after the default of Lehman Brothers. To document this fact, I use a rolling-PCA approach. In particular, I use data from February 2000 until February 2015 and compute the factor loading on the first principal component for the 5, 10, and 30-year swap spread for a rolling window of 2 years. The results of this computation are exhibited in Figure 4. Again, for all three sovereigns the pattern looks similar. The three factor loadings track each other closely until 2008. Afterwards, there is a sharp decline in the factor loading of the 30-year swap spread. Overall, these PCAs document that the behaviour 30-year swap spread differs significantly from the behaviour of the other swap spreads and that this difference was not there before 2008.

5. Conclusion

Will be included in the next version.

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A. Proofs

Will be included in the next version.

B. Tables and Figures

Table 1: The arbitrage relationship between interest rate swaps and treasuries

	$t = 0$	$t = 1$	\dots	$t = T$
Pay fixed rate s_0 in IRS	0	$-s_0$	\dots	$-s_0$
Receive Libor l_t from IRS	0	$+l_t$	\dots	$+l_T$
Buy bond with coupon c_0	-1	$+c_0$	\dots	$+1 + c_0$
Borrow at repo rate r_t	+1	$-r_t$	\dots	$-1 - r_T$
Payoff	0	$-(s_0 - c_0)$ $+(l_t - r_t)$	\dots	$-(s_0 - c_0)$ $+(l_T - r_T)$

Notes: The above table provides an arbitrage argument for positive swap spreads. Since the difference between Libor and Repo rate is always positive the difference between swap rate and treasury yield should be positive too.

Table 2: Selected factor loadings and R^2 values from principal components analysis (PCA)

		5 year		10 year		30 year	
		Loading	R^2	Loading	R^2	Loading	R^2
US	Frst PC	0.472	0.98	0.314	0.82	0.085	0.46
	Scnd PC	-0.116	0.19	0.246	0.64	0.939	0.96
	Thrd PC	0.080	0.11	0.584	0.00	-0.303	0.00
GER	Frst PC	0.451	0.95	0.311	0.76	0.030	0.01
	Scnd PC	0.075	0.00	0.304	0.11	0.793	0.85
	Thrd PC	0.285	0.00	-0.008	0.03	-0.505	0.12
GB	Frst PC	0.430	0.89	0.221	0.70	-0.079	0.18
	Scnd PC	0.167	0.44	0.381	0.73	0.835	0.91
	Thrd PC	0.250	0.06	0.191	0.04	-0.441	0.08

The PCA used the term structure of 2,3,5,7,10, and 30 year swap spreads. The sample period is June 2007 until January 2015. Sampling dates are weekly Wednesdays.

Table 3: The swap spread and supply-demand effects

$$\Delta SwapSpread_t = \alpha + \beta_1 \Delta TED_t + \beta_2 \Delta Mortgage_t + \beta_3 \Delta Debt_t + \varepsilon_t$$

	TED Spread	Mortgage Refinancing	Debt to GDP	Adj. R^2
5 year SS	0.179*** (7.16)	-0.186* (-1.83)	-1.424* (-1.68)	0.41
10 year SS	0.076*** (3.21)	-0.279*** (-3.04)	-1.977** (-2.47)	0.24
30 year SS	0.068** (2.08)	-0.456*** (-3.22)	-1.764 (-1.57)	0.2

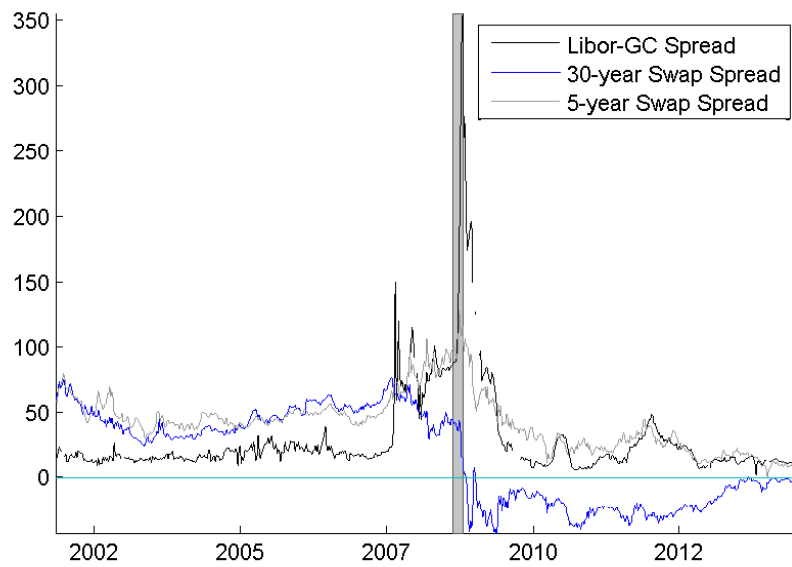
Notes: t-stats reported in parenthesis. ***significant at 1%, **significant at 5%, *significant at 10%. Quarterly data from 1990-2015.

Table 4: Regression Analysis:
 $\Delta SwSp = \beta_0 + \beta_1 \Delta TED + \beta_2 \Delta Vol + \beta_3 \Delta CDS + \varepsilon_t$

	local	Stock	local	Adj.
US	TED	Vol.	CDS	R^2
5y SwSp	0.092*** (7.15)	0.139* (1.78)	0.043 (0.61)	0.12
10y SwSp	0.048*** (4.20)	0.099 (1.43)	0.031 (0.50)	0.04
30y SwSp	-0.002 (-0.17)	0.093 (1.21)	-0.076 (-1.11)	0
GB				
5y SwSp	0.011 (0.14)	0.173 (1.46)	0.196** (2.37)	0.02
10y SwSp	-0.142** (-2.52)	0.1 (1.11)	0.108* (1.72)	0.03
30y SwSp	-0.134** (-2.53)	0.119 (1.41)	0.079 (1.34)	0.03
GER				
5y SwSp	0.058** (2.43)	0.026 (0.34)	0.119* (1.85)	0.02
10y SwSp	0.022 (0.94)	-0.042 (0.56)	0.053 (0.84)	0
30y SwSp	-0.079*** (3.23)	-0.041 (0.53)	-0.044 (0.67)	0.02

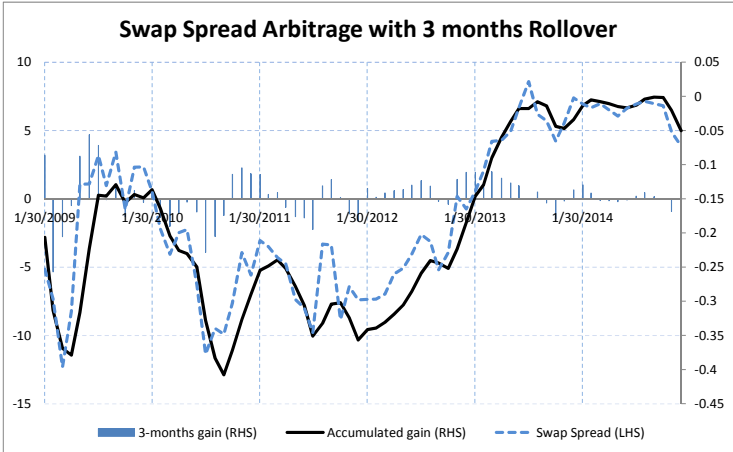
Notes: Intercept not reported for brevity. t-statistics reported in parenthesis. Data are weekly Wednesdays for the February 2007-February 2015 period. Local TED is the difference between the 3-month Libor rate in the respective currency 3-months government bond yield, Stock Vol. is the implied volatility of the local stock market, local CDS is the 5-year CDS premium for the respective country.

Figure 1: Swap Spreads and the Libor-repo spread.



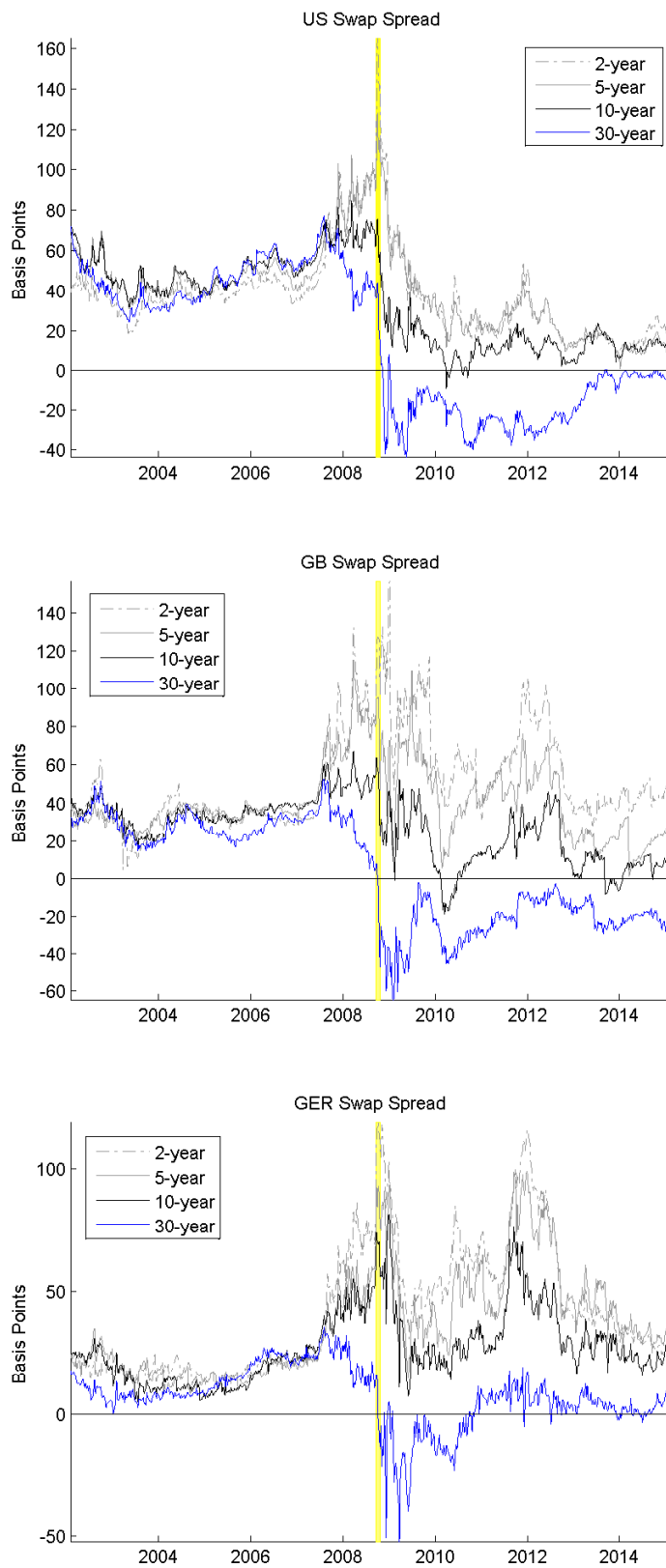
Notes: Libor-GC spread is the difference between the three-month Libor rate and general collateral repo rate. Swap spreads are measured as the difference between the fixed payment leg of an interest rate swap and the treasury yield with the same maturity. The grey bar highlights the default of Lehman Brothers and its aftermath.

Figure 2: Gains from rolling over the negative swap spreads arbitrage every 3 months.



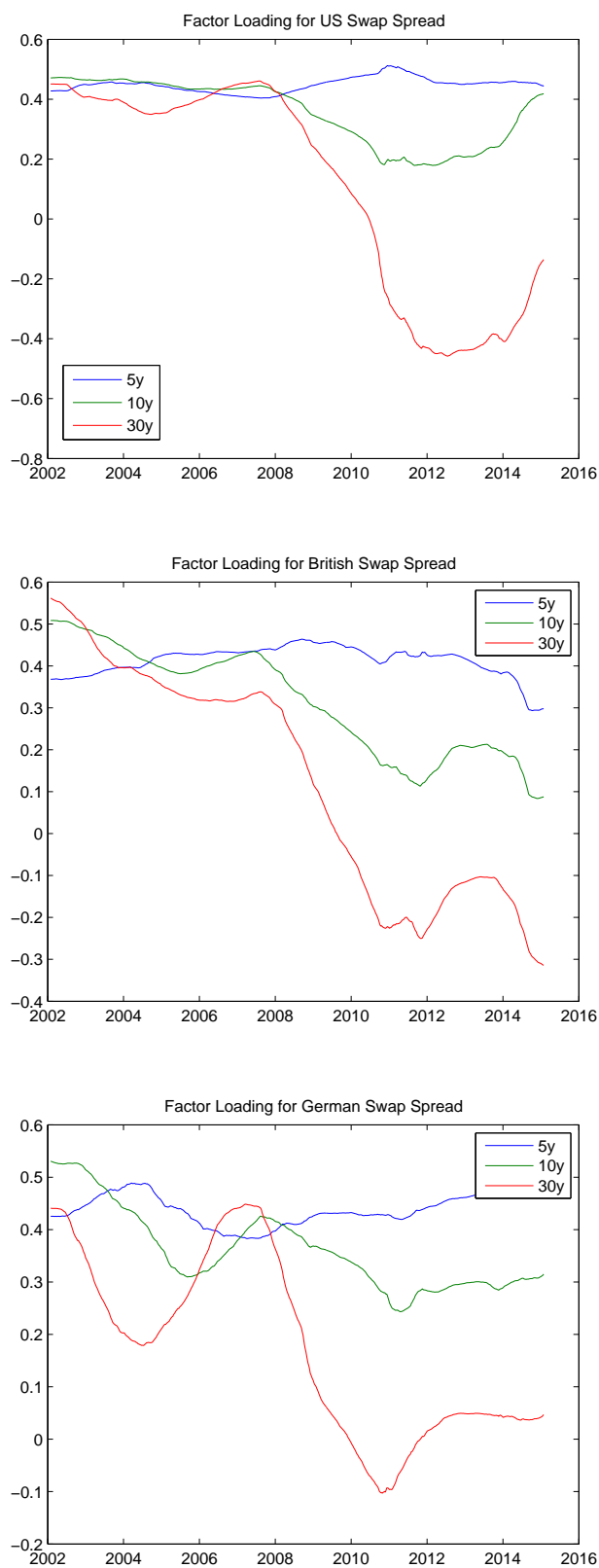
Notes: Units on the y-axis are in percent. The axis on the left-hand side indicates the gains of the arbitrage strategy, the axis on the right-hand side indicates the level of the 30-year swap spread. Gains are computed for starting the arbitrage strategy every months. Accumulated gains are the gains of an investor who engages in a short position in the negative swap spread every month and rolls over every 3 months.

Figure 3: Term structure of international swap spreads.



Notes: The yellow bar indicates the month after the default of Lehman Brothers.

Figure 4: Factor loading of Swap Spreads with different maturities on the first principal component.



Notes: Data are weekly Wednesdays for the February 2000 to February 2015 period. The factor loading is computed using a 2-months rolling window.