Erasmus University Rotterdam

Erasmus School of Economics (Msc Behavioral Economics)

THE OSTRICH EFFECT ON THE FIXED INCOME MARKET

Diederik Polman

Name student: Diederik Polman

Student ID number: 481553

Supervisor: Xiao Yu

Second assessor:

Date final version: 24-08-2018

Abstract

There is a persistent gap between the returns of certificates of deposit and treasury bills that cannot be explained risk and liquidity. Investors are sacrificing returns to not receive information, which is a likely explanation for this anomaly. I develop a methodology that controls for monetary policy and focuses on the difference between these two instruments at 6 different sizes and maturities. It identifies market movements in correlation with uncertainty on the financial market, which would be supportive of an ostrich effect. I do not find enough evidence to support the theory that investors behave like ostriches in times of uncertainty, namely, avoiding information that might be unsettling. Expected stock market volatility had a reverse causal effect on the illiquidity premium, not the other way around like the ostrich effect would predict.

Table of Contents

1. Introduction and Literature Review

When two similar assets of equal value are in the market, the one that is easier to resell should be more favorable. In financial markets, the more liquid an asset is, the more favorable it should be for the investors and the higher its price should be. In other words, liquidity premiums should be positive. It is reported that such liquidity preference has led investors to pay a premium for liquidity that makes up to 15% of the value of bonds (Longstaff, 2002). In stock markets the preference for liquidity is also well-covered. Acharya & Pedersen (2005) show that stock returns have a strong dependence on liquidity, and stress that liquidity measures should be taken into account in asset pricing models.

However, there are cases where the liquidity preference does not exist. The results of Galai and Sade (2006) showed that investors are also willing to pay a premium for illiquidity. In contrast to what theory and logic expects, investors in Israel were willing to demand lower returns for an illiquid security whilst there was a liquid security available that yields significantly larger returns. The investors in the article had two 'identical' instruments available to them, a certificate of deposit and an Israeli treasury bill both with a maturity of 1 year. The interest rates between these two instruments differed significantly. Certificates of deposit (CDs[1]) are issued by a bank to investors. CDs pay interest at a pre-determined level and pay back the original deposit at maturity (Mishkin, 2007). It is impossible to withdraw the CD before maturity without incurring a penalty. The treasury bills are zero-coupon bonds, so the return that you make is known at purchase, since it is simply the difference between purchase price and face value. Yield to maturity for a zero-coupon bond: $YTM = (\frac{FV}{P})^{1/n} - 1$ where FV denotes face value, P is the price you pay, and n is the number of years. In the Israeli investor example, the treasury bills had a n of 1. The treasury bills were considered the most liquid instrument available on the Israeli market and would give the investor opportunity to liquidize their position.

Risk could not explain the difference between the two rate as the risk appears to be equal between the two instruments. Moreover, the CD is more likely to have a higher risk than the treasury bill (further explained in section 2.1.1). Furthermore, this effect was magnified in times of uncertainty in the market. When markets are uncertain, the investors shift from bonds towards CDs causing the difference in the interest rates to grow (meanwhile sacrificing their own returns).

Galai and Sade (2006) attribute this shift to the ostrich effect since bonds are marked to market and the CDs are not. Thus, bonds will update you daily on price movements while CDs

[1] Not to be confused with credit default swaps which have the same abbreviation.

will not offer you any information. The ostrich effect in this situation can be defined as: avoiding uncertain scenarios by pretending they do not exist. The investors are sticking their heads in the metaphorical sand of ignorance, as an ostrich would do too in a dangerous situation[2].

Literature in mental accounting provides insights on the mechanism behind the ostrich effect (Thaler, 1999). Mental accounting can be dissected into three major parts: outcome evaluation, account assignment, and frequency of evaluation. Thaler (1999) discussed a gamble that gives 50% chance of winning 200 and 50% of losing 100 (Samuelson, 1963). He pointed out that when a decision maker rejects the gamble if it is played once but accepts if it is played twice, it is that in the latter case the gamble is perceived as two games at once. In other words, by updating the information the utility of the bet would change. When an agent only evaluates one bet at a time, and updates the reference point frequently, the agent is framing their decisions narrowly.

Frequent evaluation changes the perspective of an investor towards that investment. Therefore, any information that is consumed will make a difference (Benartzi & Thaler, 1995). Based on historical returns of a bond portfolio and a stock index portfolio, the study simulates the influence of evaluation time on investor behaviour, given the investor behaves in line with prospect theory. If you would have two identical portfolios: one you would check once a month and see the occasional occurred loss, and the other you would check once a year which will likely report a gain. While the underlying returns would be the same, the re-evaluation would make the first case seem riskier than the latter. Frequent re-evaluation could make a high return seem less attractive. Myopic loss aversion causes the registration of losses to affect the utility of those two portfolios. Since losses cause greater disutility than gains of an equal amount, the portfolio which is only evaluated once would be preferred even though they have the exact same cash flows underlying it. Benartzi & Thaler (1995) do not compare two equally risky portfolios, as is done in this study. They compare stocks to bonds. They aim to find something that could explain the gap in returns that exists between these types of investments.

The traders are exposing themselves to negative market information when they invest in bonds during times of uncertain markets. The treasury bill gets an updated price daily

[2] Side note: Ostriches do not actually stick their heads in the sand. According to the Canadian museum of nature: http://www.nature.ca/notebooks/English/ostrich/htm: "If threatened while sitting on the nest, which is simply a cavity scooped in the earth, the hen presses her long neck flat along the ground, blending with the background. Ostriches, contrary to popular belief. do not bury their heads in the sand."

(marking to market) and will cause the investor to update his or her reference point frequently. For example, you buy a bond at a price of 95 (with a face value of 100), the week after you get information that the price has dropped to 90. This leaves you missing out on 5% yield to maturity. Depending on your reference point, you could see that as a loss. The combined effects of frequency of evaluation and perception of losses make up for Myopic Loss Aversion (MLA), which can leave investors accepting a lower return. By investing in the deposit, an investor could avoid that information from reaching them. The only information they would receive is the gain at the end of the maturity.

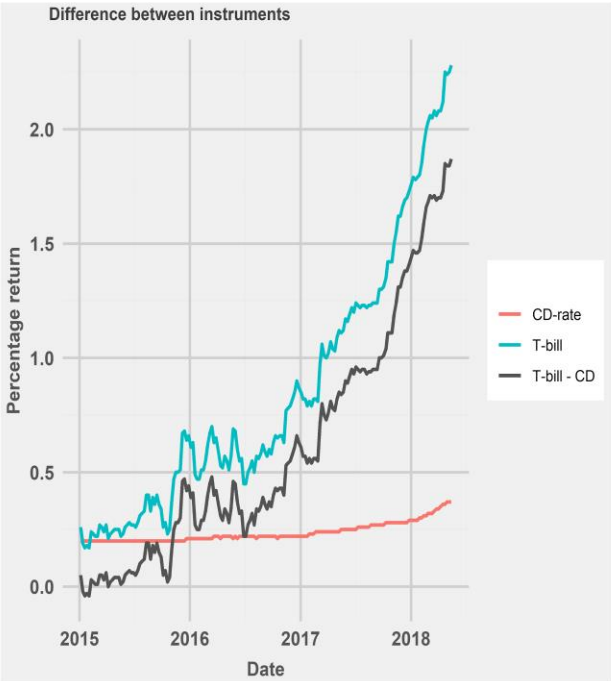
There are two alternative explanations other than Myopic Loss Aversion. The first one is that the consequences of MLA intensifiy the uncertainty during the times that the information is consumed. This makes the consumption costlier, and adds to the utility of ignoring the information (Andries and Haddad, 2017). Another one is proposed by Köszegi (2010) and relates to disappointment aversion which means that people get more disutility from bad news than utility from good news of an equal magnitude. Essentially, they react more strongly to bad news.

Evidences of ostrich effects have been reported both in laboratory and in field. I will give a brief overview. Karlsson et al. (2009) find strong evidence for the ostrich effect. They looked at the Swedish and U.S. investor behaviour, and display behaviour according to what the ostrich effect would predict. People check their portfolios significantly more often in bull markets and significantly less often in bear markets, in this way shielding themselves from information. In another study on investor information seeking, Sicherman et al. (2015) found evidence for ostrich behaviour in a sample of 401k paperless accounts. People were significantly less likely to login after days where the Dow Jones was down. In medical situations the ostrich effect can also play a role, as people avoid information about possible treatments (Caplin & Eliaz, 2003). In an experimental design Eil and Rao (2011) elicited that when participants received bad signals about characteristics of a person, their willingness to investigate whether these signals were correct was lower compared to when they were presented with good signals. Overall, they found 53% (of 100.000) of their subjects to display the ostrich effect. Ofir and Wiener (2012) tested the ostrich effect in an experimental setting in which the subject was offered the option between two instruments that yield equal guaranteed returns. Only one of the options was resaleable (liquid) at current market value. This included the possibility of reselling at a loss. The other option was a deposit which was fixed (illiquid). In this experiment the liquid option was superior to the illiquid option. However, whilst the liquid option was more popular amongst the subjects, a substantial amount (33%) still chose the illiquid option.

My thesis will contribute to the existing literature in a couple of ways: firstly I will expand the research done by Galai and Sade (2006) to the U.S market, which is, in terms of volume, a lot bigger than the Israeli market. Secondly I improve their methodology by adding a measure for economic policy uncertainty plus by adding the Federal funds rate I will be able to control for monetary policy; finally, rather than using the average of 2 CD rates at 1 maturity, I am able to look at the average of 46000 different locations at 3 maturities which greatly improves the robustness of the results.

2. Research Question

What I aim to accomplish in this study is to test whether investors in the U.S. market display the ostrich effect, in the similar manner of what Galai & Sade (2006) reported in the Israeli market. I will take two similar financial instruments across 3 maturities and 2 sizes. These instruments differ in only couple of ways: liquidity, risk, and information. The two formers should tip the scale in favour or the Treasury bill, which in turn is expected to cause the returns to be lower since it is a better investment which makes investors willing to sacrifice some returns for it. Galai & Sade (2006) exploited the market anomaly in the Israeli market that the instrument that has more liquidity, treasury bill, yields better returns than a bank deposit. I have found that the same market anomaly also exists in the U.S. market as can be seen in graph 1 below[3].



Graph 1: Development of the difference in percentage points over time between the 12-month non-jumbo CD-rate, and the 12 month treasury bill return.

[3] I chose the 12-month non-jumbo CD-rate in this case. Another maturity or size would have only changed the outlook marginally.

In explaining this anomaly, my hypothesis is that lower frequency of information makes the less favorable (less liquid) investment more attractive in the market and thus yields a higher demand. Information has proven to be influential on behaviour, specifically in times of uncertainty. Uncertainty can cause people to shield themselves from information, pretending the threat does not exist. It would be interesting to see whether that could be the case on financial markets too. I pose the following questions in this research:

In what way does information influence the investors to demand lower premiums from the CDs compared to the treasury bills?

But more importantly:

Can uncertainty cause the investors to shift from information providing investments (T-bills) to non-information providing investments (CDs)?

An increase between CD rate and T-Bill rate would not prove the existence of an ostrich effect. I need to show that if it increases, it happens in times of uncertainty. I define uncertainty using several measures: inflation, stock market uncertainty, economic policy uncertainty, and exchange rate uncertainty. I assume all of these variables to be exogenous and I identify monetary policy as the most important confounding factor that could influence both my dependent and independent variables and therefore must be controlled for. My proxies for information are expected to have a positive relationship with the difference between T-bills and CDs. It is important to keep in mind since I am dealing with debt instruments that an increased demand for either instrument, ceteris paribus, will lead the rate to drop and vice versa.

3. Description of data

My study is based on financial data from the U.S market, all data is gathered from the publicly available St. Louis fed database also known as FRED[4]. Two types of assets with a relative difference in liquidity are under study here. The first type is the illiquid assets, including the Jumbo- and Non-Jumbo -national 12-month, 6-month and 3-month Certificate of Deposit (CDs). These are calculated by surveying more than 49000 different locations and averaging the results to get the national rate (Thompson, 2009). The second type is the liquid assets, including the 1-year, 6-month, and 3-month U.S Treasury bill (T-bill) issued by the Fed. The CDs and T-Bill will be matched according to equal maturity. The period I am examining goes from 5th of May 2015 to the 14th of May 2018. (176 weekly observations).

[4] Can be accessed through: https://fred.stlouisfed.org/

The CDs are impossible to trade without penalty once you have purchased them (Bodie et al., 2014). T-bills are very liquid, on average about 84 million dollars worth of T-Bills of all maturities are traded per week since 2015 (Federal reserve bank of New York, 2018). Both the rate for the liquid assets and illiquid assets are nominal due to data limitations. Furthermore, the returns would be evaluated in nominal terms (Benartzi and Thaler, 1995). Investments are evaluated in nominal terms since returns are reported in nominal terms.

It has been recorded that CDs are riskier than T-Bills. Bodie et al. (2014) show that the spread between 3-month CD and treasury bill rates of similar maturity dramatically spiked in times of economic distress in the past 40 years. The spread increased from 0.5% to 2%-4.5% during the OPEC crisis, Penn Square and most recently the credit crisis, with the CD rate rising more showing that investors were worried about the default for banks but not governments.

Additional to the observation on the U.S. Market prices, a set of measurements are included in this analysis in order to assess the existence of an ostrich effect correctly. Below I give a detailed explanation to the variables for measuring uncertainty.

3.1 Inflation

The first measure for uncertainty is the expected inflation and is derived from yields on two different types of bonds: ones that are adjusted for inflation, and ones that are not. The difference between these two is the implied expected inflation. Sudden changes of inflation can cause serious uncertainty about the future purchasing power of your wealth (Bodie et al. 2014).

The 5 year expected inflation that I will use is calculated by the following equation:

$$\frac{\left(1+\frac{(DGS_{10}-DFII_{10})}{100}\right)^{10^{0.2}}}{\left(1+\frac{(DGS_{5}-DFII_{5})}{100}\right)^{5}} - 1) * 100$$

Where DGS_n denotes the yield of the US Treasury bond that is not adjusted for inflation with n year maturity. And $DFII_n$ denotes the yield of the US treasury bond that is adjusted for inflation with n year maturity. The data I gathered was a monthly series, I transformed the series into a weekly one by assuming that the changes in expected inflation over that month were spread evenly across the month.

3.2 Uncertainty on the market

The second measure for uncertainty is the Chicago Board Options Volatility Index (VIX). At first a stock market measure might not seem relevant to this study, but in a study on the stock-bond price relationship in times of uncertain markets Connolly et al. (2005) make use of the VIX. Uncertainty on the stock market also trickles down into the bond market. The VIX is also known as the Fear Gauge, since it gauges Investors expectation of the market volatility in the near future (Ackert & Deaves, 2009). It manages to calculate an implied volatility by using current option prices of S&P 500 companies[5]. In periods that investors are expecting the market to move, the VIX will rise. Theoretically the VIX should only reflect the expected volatility over the life of the option (30 days; Whaley, 2008). Jackwerth & Rubinstein (1996), however, show that Black-Scholes implied volatilities, which the VIX uses, are consistently higher than the realized volatilities over the life of the options. Thus leaving a proportion of the implied volatility unexplained. Buraschi & Jiltsov (2006) find a similar difference, especially over longer timeframes, and show that this difference can be explained by a “difference in beliefs” index that aims to capture the uncertainty of the market. Therefore, the VIX is able to capture future expected volatility in combination with the uncertainty about fundamentals among investors. These properties make the VIX suitable to study the ostrich effect, like Sicherman et al. (2015) did in theirs. There was a negative relationship between the number of logins and the VIX, which is consistent with the ostrich effect. Investors, even after controlling for individual fixed effects, disengage from the market once they suspect their investments are at high risk (both positively and negatively). Although a bear market not just brings misery but also opportunity. When the volatility information was combined with trading data it showed that investors are looking for a good deal since they are also more likely to trade.

3.3 Exchange rate uncertainty

Following the methodology of Galai and Sade (2006), I use the CBOE Eurocurrency Volatility Index (Euro VIX) as another measure of uncertainty on the market. Using the same methodology as the VIX (section 2.2), the CBOE Eurocurrency Volatility Index yields the markets expectation of the future volatility of the USD/EUR exchange rate (CBOE, 2008). It could be a source of uncertainty for investors with foreign investments since devaluation of the Euro could diminish the (net) returns of an investment (Bodie et al., 2014)[6]. The amount invested in foreign currencies is of great importance for the effect that sudden shifts in Euro VIX would have. If you do not have any foreign investments, investors will not care about currency uncertainty. Furthermore, Bodie et al. (2014) note that exchange rate risk is diversifiable since exchange rates have relatively low correlations with each other. In a study on home bias, Bodart and Reding (1999) find that U.S investors have the largest home bias in debt securities of the mature economies. However, they do find evidence that home bias is a

5 For further information on the construction see: Whaley (2000)

[6] Baker & Wurgler (2007) do not consider the exchange rate in their proxy for investor sentiment which indicates that they did not see enough evidence for the exchange rate to have a major influence on the sentiment of investors.

result of exchange rate volatility and that investors allocate their resources this way because they want to avoid the risk. The (expected) volatility will have an influence on the demand of fixed income securities[7] and uncertainty about exchange rate changes might lead investors to display an ostrich effect.

3.4 Uncertainty on policy.

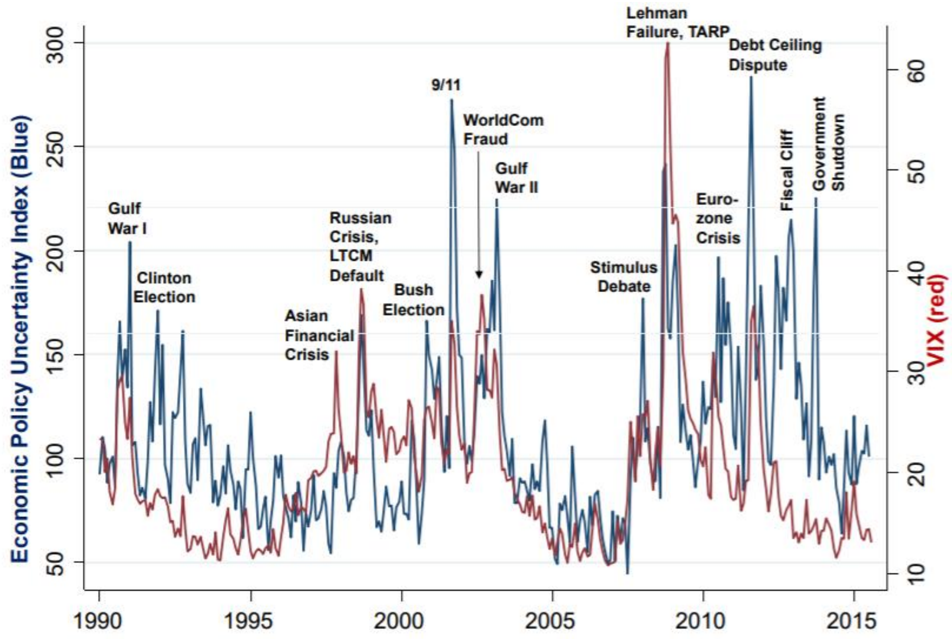
I extend the gauge for inflation, stock market uncertainty, and exchange rate uncertainty with a fourth parameter regarding uncertainty on a federal level. Baker et al. (2016) introduced a measure that analyses the 10 leading US newspapers[8] and scans for the numbers of links that are being made between economic, uncertainty, and government[9]. The Economic Policy Uncertainty (EPU) index is constructed by counting the number of articles fulfilling the condition relative to the total number of articles in that newspaper standardized to the newspaper standard deviation (=T). The average T of 10 papers yields the EPU score for that month by indexing (=100) it to the average month of the entire time-series. The higher the score, the more uncertainty. The EPU index is able contribute to the VIX. The VIX and EPU historically have a correlation of 0.58, so they do capture similar events but also vary. The VIX reacted more strongly to crises on the global financial market (like the Asian Financial crisis) whereas the EPU is exposed to political events (new president, government spending). Therefore, two measures complement each other. Graph 2 illustrates this by showing the differences between the VIX (red) and EPU (blue) during major news events between 1990 and 2016.

---

[7] Interest rates and exchange rates are closely related, when the local interest rate is expected to rise (e.g. the 1 year U.S treasury bond) the local currency will be expected to appreciate (Mishkin, 2007). These expectations will cause the Euro VIX to shift so there could be some reverse causality.

[8] The newspapers are: USA Today, Miami Herald, Chicago Tribune, Washington Post, Los Angeles Times, Boston Globe, San Francisco Chronicle, Dallas Morning News, New York Times, and Wall Street Journal respectively.

[9] The index registers articles when it contains one of the following combinations of words: "economic" or "economy"; "uncertain" or "uncertainty"; and "congress", "deficit", "federal reserve", "legislation", "regulation" or "White House".



Graph 2 taken from Baker et al. (2016)

3.5 Monetary policy

In the wake of the financial crisis of 2008 the U.S Federal Reserve System had started buying mortgage-backed securities in late November 2008 and continued doing this until June 2010. This period is also known as QE1. The FED then began another round of quantitative easing in august 2010 (Federal Reserve, 2008; Federal Reserve, 2010).

The objective of quantitative easing was stated to decrease long term interest rates, which would in turn stimulate economic activity. The FED has various instruments to conduct its monetary policy. The three main instruments are: open market operations, discount rate, and reserve requirements (Mishkin, 2007). Quantitative easing mainly concerns the first of these but will target discount rates and reserve requirements too.

There has been evidence that FED announcements regarding developments in favour of quantitative easing caused large declines in interest rates (Gagnon et al., 2010; Joyce et al., 2012). When the FED engages in open market operations, market demand goes up for bonds that are not deemed to be risky, hence yield decreases on those particular assets (Gagnon et al., 2010; Krishnamurthy and Vissing-Jorgensen, 2010; Joyce et al., 2012). U.S Treasury Bills are one of the least risky assets on the financial markets, and indeed, the yield of the 1-year treasury bills almost halved in the two weeks after the first announcement (From 0.93 to 0.49; Board of Governors of the Federal Reserve System, 2018). Following those first movements, the effects spill over to the whole market, also known portfolio-rebalance effect. The investors now are looking for substitutes that will still yield significant returns, causing those securities to spike in price as well (Gagnon et al., 2010).

It is important to choose a measure that does not skew results, since I am using a variable that consists of two rates. Ideally you choose one that influences both equally. The FED has several tools at its disposal to influence the market. However, the aim is often clear. A lot of the policies can be boiled down to one rate: the federal funds rate (Mishkin, 2007). The federal funds rate is the overnight rate that indicates the interest rate that banks offer each other to meet reserve requirements.

The federal funds rate and T-bill yields show a strong correlation over the long-run and furthermore is consistent across different monetary policy reigns (Sarno and Thornton, 2003). Edgar and Swanson (1984) look at the role of monetary policy on both CD rates and T-Bill rates. They find that CDs in comparison to Treasury Bills reflect the conditions on the money market more clearly. The CD rates are not influenced as much by monetary policy by the Federal Reserve.

In a later study, Duffie & Krishnamurty (2016) report that changes of federal funds rate has asymmetrical effects on treasury bill yields and deposit rates. When federal funds rate lowers, banks are quick to lower their own interest rates, however when federal funds rate increases, banks show a lagged reaction to offer better rates to investors. The banks exploit 'slow' investors that have not updated their own required rate yet, 'fast' investors respond by moving from CDs to Treasury securities and money market funds. In turn, T-Bill returns will also lower as a result of that, the sign of both securities in response to changes in FFR will be the same.

In another study Schnabl (2017) supports that view that the effect size of changes in federal funds rate ends up being of similar size for deposits and T-Bills. Overall, this appears to be sufficient evidence to choose the federal funds rate (ffr) as the proxy for monetary policy.

4. Methodology & Results

4.1 Liquidity Premium

The difference between interest rates in percentage points between treasury securities (T-Bills, R_{im}) and both small and large certificate of deposits (CDs, R_{is} and R_{il}) with maturity denoted by i (3-, 6-, 12-months) is denoted by the following equation. In this equation i is always equal between R_{im} and R_{is} and R_{il}

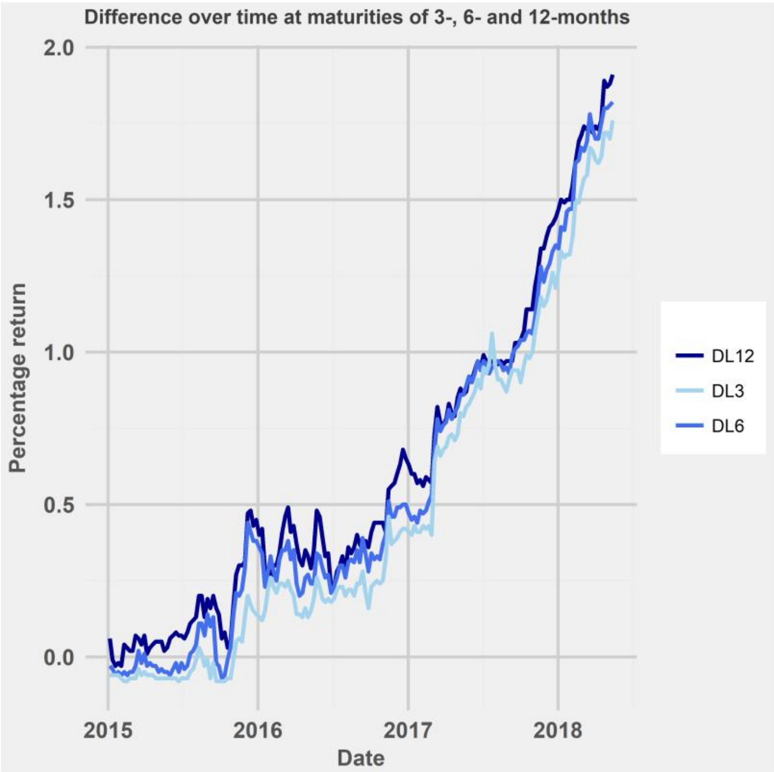
$$D_{il} = R_{im} - R_{il}$$

$$D_{is} = R_{im} - R_{is}$$

I perform a simple t-test with $H_o: D_{il} = 0$ and $H_o: D_{is} = 0$. In the subperiod week 1 2015 to week 20 2018 D_{il} is significantly different for all i (in ascending order), in ascending order of

i D_{il} = (0.48%, 0.56%, 0.62%) with corresponding t values of (12, 13.8 and 15.6). D_{is}= (0.49%, 0.57%, 0.6%) with corresponding t values of (12.2, 14, 15.4). Looking at a longer period (2009 to 2018) I find similar results but for all statistical analyses I will report below I will look at the period week 1 2015 to week 20 2018. I can conclude that the yield from T-Bills with 3 different maturities are significantly higher than CDs of matched maturity.

The three different maturities (3-,6- and 12-months) have similar trajectories as can be seen in graph 3 below[10]. I plotted D_{il} of the different maturities, not in combination with D_{is} , so it is easier to overview. This indicates that they are exposed and influenced by the same effects. So, if there is an ostrich effect, you would expect it to be the same across maturities.



Graph 3 Percentage levels D_{3l} , D_{6l} *and* D_{12l} over time.

4.2 Granger Causality

In order to make a first assessment about whether the illiquidity premium that is present since the beginning of 2015 could be caused by the uncertainty measures, I perform a Granger causality test. A granger causality test lets you test whether after controlling for past Y, X

[10] The difference is generally larger for longer maturities. This is mainly due to R_{im} being higher for longer maturities which indicates that investors expect that short-term rates are going to be higher in the future than when standing at point t (Bodie et al. 2014).

predicts Y (Wooldridge, 2015). A significant Granger causality test result would indicate that (lags of) uncertainty measure X has an significant influence on the difference between T-bills and CDs. The ostrich effect would predict these movements to take place, to shield themselves from the information. However, we should interpret the result of Granger test with caution, as it does not indicate a clear causality - instead it is just an indication on whether lags of X can predict Y. Furthermore, it does not indicate whether the relationship is positive or negative, for the ostrich effect to be present it would have to be positive. I will focus on the results that granger cause D_{il} *and* D_{is}, or ΔD_{il} *and* ΔD_{is}. I will test 1) if D_{il} *and* D_{is} can be predicted by the levels [Federal funds rate, inflation, stock market volatility, exchange rate volatility, and economic policy uncertainty] of *ffr, inf, vix*, *exc,* and *epu.* (table 1); and 2) if ΔD_{il} *and* ΔD_{is} is Granger caused by Δ*ffr,* Δ*inf,* Δ*vix*, Δ*exc*, and Δ*epu* (table 3).

Results that stem from my linear models (in section 4.3) suggest that I have to reassess the direction of the causality for the *vix* (table 2 and 4). The resulting p-values will be presented in the tables below with the corresponding χ^2 (with d.f. = 4) between brackets.

Granger causality	D_{12l}	D_{12s}	D_{6l}	D_{6s}	D_{3l}	D_{3s}
ffr	0.25	0.25	0.082*	0.11	0.348	0.269
	(5.43)	(5.38)	(8.27)	(7.5)	(4.45)	(5.18)
inf	0.533	0.569	0.567	0.670	0.402	0.386
	(3.15)	(2.93)	(2.95)	(2.36)	(4.02)	(4.15)
vix	0.869	0.837	0.916	0.849	0.982	0.981
	(1.25)	(1.44)	(0.96)	(1.37)	(0.40)	(0.42)
exc	0.975	0.992	0.894	0.869	0.381	0.416
	(0.48)	(0.27)	(1.1)	(1.26)	(4.19)	(3.93)
epu	0.440	0.447	0.558	0.560	0.11	0.1*
	(3.76)	(3.70)	(3)	(2.99)	(7.52)	(7.76)

Table 1: Granger causality test results with reported p-values and (chi-squared values)

a: Granger causality (estimated at four lags) between the following variables: the difference between the Jumbo and Treasury bill rates (D_{il}) with maturities of 3, 6 and 12 months and the certificate of deposit rates of equal maturities; the difference between the Non-Jumbo and Treasury bill rates (D_{is}) with maturities of 3, 6 and 12 months and the certificate of deposit rates of equal maturities; the level of the Federal funds rate (ffr) ;the 5 year expected inflation rate (inf); the level of the Chicago Board Options Volatility Index; the level of the Eurocurrency ETF Volatility Index (exc); and the level of Economic Policy Uncertainty (epu) *b:* the variables (D_{il} *and* D_{is}) that is being caused is categorized by columns and the variable that is tested if it causes D_{il} *and* D_{is} is categorized by rows. *Significant at 10 % level. **Significant at 5 % level. ***Significant at 1 % level.

Granger Causality	vix
$\boldsymbol{D_{12l}}$	0.002*** (16.58)
$\boldsymbol{D_{12s}}$	0.001*** (18.25)
$\boldsymbol{D_{6l}}$	0.004*** (15.32)
$\boldsymbol{D_{6s}}$	0.006*** (14.48)
$\boldsymbol{D_{3l}}$	0.286 (5.01)
$\boldsymbol{D_{3s}}$	0.344 (4.48)

Table 2 *a:* Granger causality (estimated at four lags) between the following variables: the difference between the Jumbo and Treasury bill rates (D_{il}) with maturities of 3, 6 and 12 months and the certificate of deposit rates of equal maturities; the difference between the Non-Jumbo and Treasury bill rates (D_{is}) with maturities of 3, 6 and 12 months and the certificate of deposit rates of equal maturities; the level of the Chicago Board Options Volatility Index; *b:* the variable (vix) that is being caused is categorized by columns and the variable that is tested if it causes vix is categorized by rows.
*Significant at 10 % level. **Significant at 5 % level. ***Significant at 1 % level.

The lags of the federal funds rate (*ffr),* inflation (*inf),* stock market uncertainty (*vix)*, exchange rate uncertainty (*exc),* and economic policy uncertainty (*epu)* are generally unable to predict future changes of D_{il} *and* D_{is}. Notably, the results of the Granger causality indicate that *vix* is granger caused by D_{6l} , D_{6s}, D_{12l}, *and* D_{12s} at a 1% level, and not the other way around. I can reject that D_{3l} *and* D_{3s} is Granger caused by *vix.*

Granger causality	$\Delta\boldsymbol{D_{12l}}$	$\Delta\boldsymbol{D_{12s}}$	$\Delta\boldsymbol{D_{6l}}$	$\Delta\boldsymbol{D_{6s}}$	$\Delta\boldsymbol{D_{3l}}$	$\Delta\boldsymbol{D_{3s}}$
$\Delta\boldsymbol{ffr}$	0.05* (9.24)	0.065* (8.84)	0.152 (6.70)	0.047** (9.64)	0.874 (1.22)	0.128 (7.16)
$\Delta\boldsymbol{inf}$	0.651 (2.46)	0.714 (2.11)	0.123 (5.26)	0.033 (10.5)	0.358 (4.37)	0.607 (2.71)
$\Delta\boldsymbol{vix}$	0.039** (10.09)	0.022** (11.40)	0.528 (3.18)	0.450 (3.68)	0.002*** (17.47)	0.001*** (23.72)
Δ**exc**	0.028** (10.88)	0.030** (10.71)	0.312 (4.77)	0.045** (9.71)	0.917 (0.95)	0.156 (6.65)
$\Delta\boldsymbol{epu}$	0.524 (3.20)	0.376 (4.23)	0.633 (2.56)	0.897 (1.08)	0.715 (2.11)	0.119 (7.34)

Table 3 Granger causality test results with reported p values and (chi-squared values)
a: Granger causality (estimated at four lags) between the following variables for each weekly observation (*t)* : the percentage change between *t and t-1* of the difference between the Jumbo and Treasury bill rates (ΔD_{il}) with maturities of 3, 6 and 12 months and the certificate of deposit rates of equal maturities; : the percentage change between *t and t-1* of the difference between the Non-Jumbo and Treasury bill rates (ΔD_{is}) with maturities of 3, 6 and 12 months and the certificate of deposit rates of equal maturities; : the percentage change between *t and t-1* of the level of the Federal funds rate (Δffr) ; : the percentage change between *t and t-1* of the 5 year expected inflation rate (Δinf); the percentage change between *t and t-1* of the level of the Chicago Board Options Volatility Index; the percentage change between *t and t-1* of the level of the Eurocurrency ETF Volatility Index (Δexc); and : the percentage change between *t and t-1* of the level of Economic Policy Uncertainty (Δepu) *b:* the variables (ΔD_{il} *and* ΔD_{is}) that is being caused is categorized by columns and the variable that is tested if it causes

ΔD_{il} *and* ΔD_{is} is categorized by rows.
*Significant at 10 % level. **Significant at 5 % level. ***Significant at 1 % level.

Granger Causality	Δvix
$\Delta \boldsymbol{D_{12l}}$	0.532 (3.16)
$\Delta \boldsymbol{D_{12s}}$	0.555 (3.02)
$\Delta \boldsymbol{D_{6l}}$	0.499 (3.36)
$\Delta \boldsymbol{D_{6s}}$	0.209 (5.86)
$\Delta \boldsymbol{D_{3l}}$	0.04 ** (10.04)
$\Delta \boldsymbol{D_{3s}}$	0.191 (6.10)

Table 4 *a:* Granger causality (estimated at four lags) between the following variables for each weekly observation (t): the percentage change between *t and t-1* of the difference between the Jumbo and Treasury bill rates (ΔD_{il}) with maturities of 3, 6 and 12 months and the certificate of deposit rates of equal maturities; : the percentage change between *t and t-1* of the difference between the Non-Jumbo and Treasury bill rates (ΔD_{is}) with maturities of 3, 6 and 12 months and the certificate of deposit rates of equal maturities; the percentage change between *t and t-1* of the level of the Chicago Board Options Volatility Index (Δvix) ; *b:* the variable (Δvix) that is being caused is categorized by columns and the variable that is tested if it causes vix is categorized by rows.
*Significant at 10 % level. **Significant at 5 % level. ***Significant at 1 % level.

The Granger Causality tests did not provide support for the hypothesized ostrich effect, at least not regarding inflation and economic uncertainty policy. But the Granger Causality did give support for some relationship between ΔD_{il} *and* ΔD_{is} and percentage changes in *vix* and *exc*, indicating that past changes in future stock market volatility and future exchange rate volatility can predict changes in ΔD_{il} *and* ΔD_{is}.There is no indication (after discovering a similar peculiar pattern in for level variables) that Δ *vix* is Granger caused by ΔD_{il} *and* ΔD_{is}.

4.3 Linear models

After the Granger causality tests gave a first indication of the relationships between the illiquidity premiums and uncertainty proxies, now I will further investigate by means of linear regressions in the following form:

Model 1: $D_{il} = \alpha + \beta_1 ffr + \beta_2 inf + \beta_3 vix + \beta_4 exc + \beta_5 epu + \varepsilon$

Model 2: $D_{is} = \alpha + \beta_1 ffr + \beta_2 inf + \beta_3 vix + \beta_4 exc + \beta_5 epu + \varepsilon$

Model 3: $\Delta D_{il} = \alpha + \beta_1 \Delta ffr + \beta_2 \Delta inf + \beta_3 \Delta vix + \beta_4 \Delta exc + \beta_5 \Delta epu + \varepsilon$

Model 4: $\Delta D_{is} = \alpha + \beta_1 \Delta ffr + \beta_2 \Delta inf + \beta_3 \Delta vix + \beta_4 \Delta exc + \beta_5 \Delta epu + \varepsilon$

In order to control for autocorrelation and heteroskedasticity of the time-series I am using Newey-West standard errors (Wooldridge, 2015). Newey and West (1987) suggest choosing a maximum lag to get optimal results denoted by g: $4(\frac{n}{100})^{2/9}$ where n (=176) denotes the number of observations which yields g≈4.5, Wooldridge (2015) suggests $g = n^{1/4}$ which yields g≈3.6 with n=176. Following those two formulas g= 4 seems the optimal choice.

First, I will report the results of model 1 and 2 in table 5 below.

Dep. Variable (Newey-West)	D_{12l}	D_{12s}	D_{6l}	D_{6s}	D_{3l}	D_{3s}
Constant	-0.30** (0.13)	-0.29** (0.13)	-0.28*** (0.11)	-0.29*** (0.11)	-0.41*** (0.09)	-0.41*** (0.09)
ffr	1.01*** (0.04)	1*** (0.04)	1.06*** (0.04)	1.06*** (0.04)	1.06*** (0.03)	1.06*** (0.03)
inf	0.15** (0.07)	0.15** (0.06)	0.08 (0.06)	0.08 (0.05)	0.1** (0.04)	0.1** (0.04)
vix	0.01*** (0.003)	0.01*** (0.003)	0.01*** (0.003)	0.01*** (0.003)	0.01*** (0.002)	0.01*** (0.002)
exc	-0.01* (0.007)	-0.01* (0.007)	-0.01 (0.007)	-0.01 (0.007)	-0.01 (0.005)	-0.01 (0.005)
epu	-0.01 (0.00)	-0.01 (0.00)	-0.01 (0.00)	0.01 (0.00)	-0.01 (0.00)	-0.01 (0.00)
$Adj\ R^2$	0.95	0.95	0.96	0.96	0.97	0.97
F-statistic	212	208	257	264	440	432
Probability F	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***

Table 5: OLS regression with Newey-West adjusted standard errors with a maximum lag of 4. *Significant at 10 % level. **Significant at 5 % level. ***Significant at 1 % level.
OLS Regression with Newey-West adjusted standard errors of the correlation between the level of the difference between the yields of treasury bills and certificate of deposits of equal maturity (3-, 6- and 12-months) and several uncertainty measures controlled by a proxy for monetary policy. During the period week 1 of 2015 to week 20 of 2018 I have weekly observations (t). Dependent variables: the difference between the Jumbo and Treasury bill rates (D_{il}) with maturities of 3, 6 and 12 months and the certificate of deposit rates of equal maturities; the difference between the Non-Jumbo and Treasury bill rates (D_{is}) with maturities of 3, 6 and 12 months and the certificate of deposit rates of equal maturities Independent variables (proxies for monetary policy and uncertainty): The level of the Federal funds rate (ffr) at time t; the 5 year expected inflation rate (inf) at time t; the level of the Chicago Board Options Volatility Index (vix) at time t; the level of the Eurocurrency ETF Volatility Index (exc) at time t; and the level of Economic Policy Uncertainty (epu) at time t. The standard errors are reported between the parentheses. Also I report the Adjusted R^2 and the F-statistic of the model with the corresponding p-value.

Models 1 and 2 have a lot of explanatory power, this model is almost able to explain all (over 95%) of the variance of D_{il} and D_{is}. The constant is significant for all dependent variables but does not provide a lot information, it is unlikely that all explanatory variables will turn to 0.

The level of the Federal funds rate has a both statistically and economically significant effect on D_{il} *and* D_{is}, 1 additional percent in federal funds rate would cause the difference to grow with 1 % to 1.06% depending on maturity and size, significant at a 1% level.

The first measure for uncertainty: expectations on future inflation provides a mixed result. For short and long maturities (i=3 and i=12) inflation has a positive relationship with the difference between the CD rate and T-bill rate at a 5% level. Inflation for securities with maturities of 6 months cannot be distinguished from 0. Inflation does have a large effect; however it is very uncommon to see 1 p.p. shifts in inflation so the realized effect will be smaller than the quoted number in the table.

The level of the Chicago Board Options Volatility Index (*vix*) has a consistently significant (at a 1% level) positive relation with both D_{il} *and* D_{is} for all i. A 1 p.p increase of implied volatility for options would result in a 0.01 p.p increase in D_{il} *and* D_{is}.

The level of the Eurocurrency Volatility Index has a significant effect (at a 10% level) for instruments with longer maturity, however this effect is negative so a higher uncertainty of the currency will cause the difference between CD rate and T-Bill to shrink. For shorter maturities (i=6 and i=3) exchange rate volatility does not seem to have an effect.

The measure for economic policy uncertainty (*epu)* does not have any effect on D_{il} *and* D_{is}, the effect size (0.01 is rounded up) is tiny with an even smaller std. deviation, it was not significantly different from zero for any D_{il} *and* D_{is}.

Now I will perform a similar analysis on models 3 and 4.

Dep. Variable (Newey-West)	ΔD_{12l}	ΔD_{12s}	ΔD_{6l}	ΔD_{6s}	ΔD_{3l}	ΔD_{3s}
Constant	0.08** (0.04)	0.06** (0.03)	0.01 (0.06)	0.04 (0.07)	0.01 (0.06)	0.05 (0.06)
Δffr	-0.05 (0.4)	-0.08 (0.34)	-0.41 (0.41)	-0.37 (0.58)	-0.44 (0.37)	0.24 (0.53)
Δinf	1.42 (1.2)	1.08 (1.14)	1.70 (1.83)	1.29 (1.83)	-2.77 (2.94)	1.11 (2.36)
Δvix	0.01 (0.19)	0.01 (0.16)	0.56* (0.33)	0.05 (0.37)	-1.16 (0.82)	-0.40 (0.42)
Δexc	0.4 (0.25)	0.48 (0.38)	-0.63 (0.61)	-0.15 (0.68)	-0.58 (0.38)	-0.22 (0.22)
Δepu	-0.11 (0.2)	-0.09 (0.07)	-0.06 (0.1)	0.003 (0.11)	-0.02 (0.09)	-0.047 (0.07)
$Adj\ R^2$	-0.01	-0.01	-0.01	-0.02	0.03	-0.02
F-statistic	1.36	1.32	0.69	0.57	0.86	0.9
Probability *F*	0.24	0.25	0.63	0.72	0.51	0.48

Table 6: OLS regression with Newey-west adjusted standard errors estimated with a maximum lag of 4. *Significant at 10 % level. **Significant at 5 % level. ***Significant at 1% level.
OLS Regression with Newey-West adjusted standard errors of the correlation between the percentage change of the difference between the yields of treasury bills and certificate of deposits of equal maturity (3-, 6- and 12-months) and percentage change of several uncertainty measures controlled by a proxy for monetary policy. During the period week 1 of 2015 to week 20 of 2018 I have weekly observations (t). Dependent variable: The percentage change between *t and t-1* of the difference between the Treasury bill rates and Jumbo CD rates (ΔD_{il}) with maturities of 3, 6 and 12; the percentage change between *t and t-1* of the difference between the Treasury bill rates and Non-Jumbo CD rates (ΔD_{is}). Independent variables: : the percentage change between *t and t-1* of the Federal funds rate (Δffr); the percentage change between *t and t-1* of the 5 year expected inflation rate (Δinf); the percentage change between *t and t-1* of the Chicago Board Options Volatility Index; the percentage change between *t and t-1* of the level of the Eurocurrency ETF Volatility Index (Δexc) at time *t* ;and the percentage change between *t and t-1* of the Economic Policy Uncertainty (Δepu). The standard errors are reported between the parentheses. Also I report the Adjusted R^2 and the F-statistic of the model with the corresponding p-value.

As for model 3 and 4, the results are inconclusive. The model as it is formulated does not seem to have a lot of explanatory power. The amount of variance that is explained lays around 0 (all but one has negative explanatory power after adjusting for the number of variables used). All but one of the explanatory variables give significantly different results from 0. The only significant variables are the constant for the difference with 12-month maturities at a 5% level and the vix at a 10% level. It should be noted that the change in inflation does seem to have a large effect size but is combined with large amounts of variance.

5. Discussion

5.1 Ostrich toleration

Traditionally you would expect treasury bill rates to be lower than certificate of deposit rates. Finance models make a strong case for liquidity preference. Common sense also supports this view. It creates a peace of mind knowing that should you so choose, you can sell some product (or security) at any point in time. Instead, investors on the fixed income market seem to accept an inferior investment, even whilst another product is available that yields a better return, is extremely liquid, and is arguably less risky.

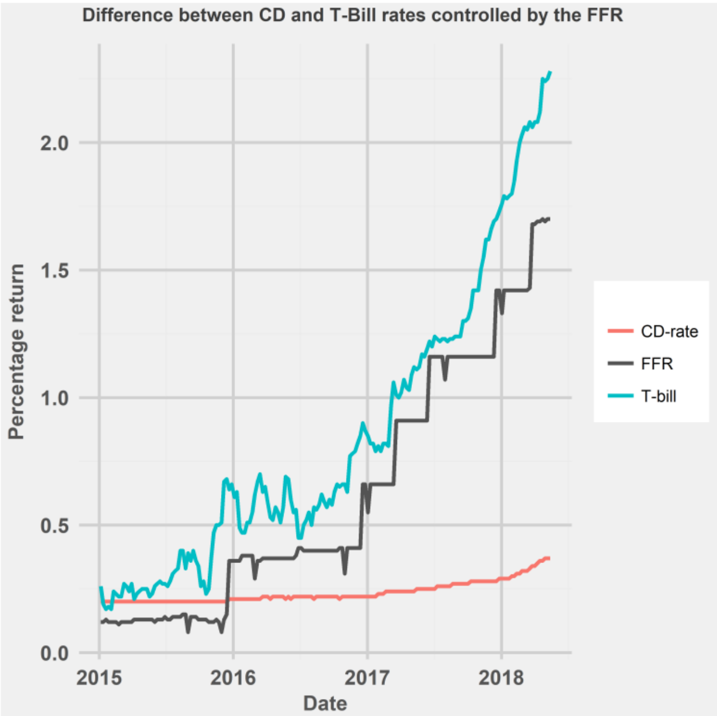
One plausible factor that could explain this difference is the frequency of information. The treasury bill gives higher returns, more liquidity and less risky security; but it also gives updated information daily, which can be confronting when you see that you could have gotten a better rate a couple of days later. Therefore, myopic loss averse investors might opt for a certificate of deposit: the less returning, less liquid, and riskier investment that does not provide any information.

My study exploited the market anomaly in the U.S. market, where two investments (the T-Bills and the CDs) with similar levels of riskiness have remained different in prices over a prolonged period of time (more than 3 years). Especially, during this period the more liquid investments treasury bills has had a higher return than the less liquid investment CD. This phenomenon seems to suggest that investors are willing to sacrifice returns to ensure that they do not receive frequent updates of information. The market seems to accept that banks offer relatively low returns for their CDs, if they would not accept this the bank inevitably would have to increase their rates so that they can still fulfil their financing needs. As it is shown in graph 3 and 4, the CD rate did increase slightly but does not come close to the treasury rate and the difference keeps growing. This confirms the lagged reaction of banks that exploit 'slow' investors described by Duffie & Krishnamurty (2016), it is unclear whether the expected effect of decreasing T-bill yields also happened. Slow investors still have not caught up witnessed by the increasing difference.

To further investigate this, I used market uncertainty as a measuring stick for the ostrich effect. My assumption is that the ostrich effect should rise if market uncertainty is high. Vice versa, in times of low uncertainty the ostrich effect should also be low. If the price anomaly that exists between the T-bill and the CDs is correlated with uncertainty, then it would support my hypothesis ostrich effect playing a role in this market anomaly. Below I give a more detailed discussion.

5.2 Models 1 & 2

Models 1 and 2 are well formulated in terms of goodness-of-fit which allows me to present the results with confidence. The federal funds rate has, as predicted, a strong and consistent effect on D_{il} *and* D_{is}, this can also be seen graphically in graph 4 reported below. It is important to remember that the monetary policy reacts to the market and not the other way around. The main value that *ffr* brings is that it allows us to control monetary policy without using any form of R_m, which would get rid of a lot the variance of the dependent variable. The ostrich effect can still manifest itself even when the CD rates stay the same, in the model of Galai and Sade (2006) this was not possible. If the difference would grow, and the CD rates remain constant, this would indicate that investors are moving away from T-Bills and towards CDs since investors would not demand a higher rate from the bank, which the bank in turn happily accepts. If you control for changes in treasury bill rate (like Galai and Sade (2006) did), these changes would not be picked up.



Graph 4: Percentage levels of D_{12s}, *ffr*, and R_{12m} over time.

Inflation is a complex construct that is influenced by and in turn influences a lot of economic activity (Mishkin, 2007). The results from the statistical analyses fit into that narrative. It was a mixed bag. I am looking for consistent results across maturities and size since the investors shifts within those categories. An investor that behaves in line with the ostrich effect is not expected to shift from a 12-month (large) treasury security to a small 6-month CD. I am not able to show proof of those consistent results. In developed markets like the U.S. inflation is not volatile on a weekly basis, perhaps larger spikes of inflation are needed to trigger a consistent ostrich effect (Berk & Demarzo, 2007).

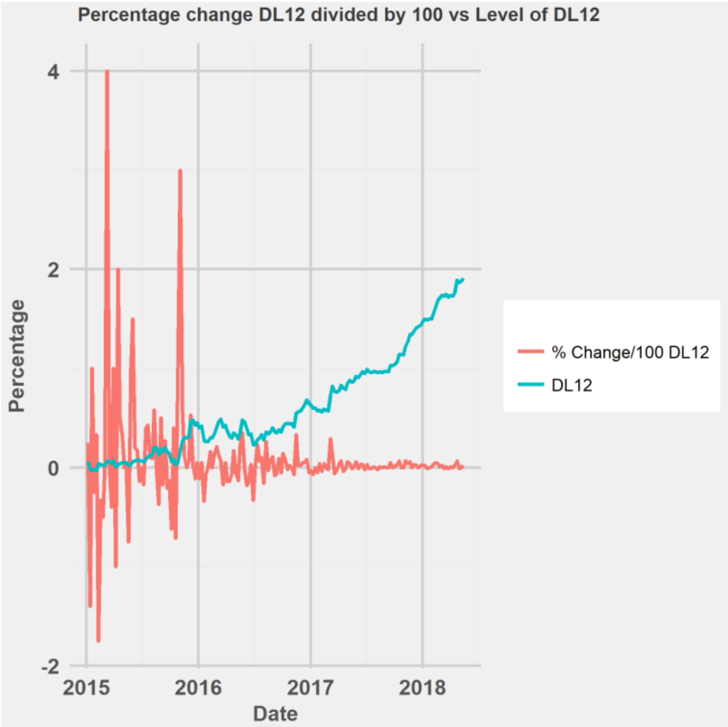
The Chicago Board Options Volatility Index (*vix)* is the only uncertainty measure that has a consistently positive effect in the linear regressions on D_{il} *and* D_{is} across maturities and size. However, according to the results of the Granger causality, there is a reverse causality at play. A possible explanation for this could be that, due to the rise of interest rates increasing the cost of capital for companies too, this results in a higher future stock volatility (Engle & Patton, 2007). Glosten et al. (1993) state that the treasury bill rate has a positive effect on stock market volatility. Another possible reason that stock market uncertainty has a significant effect on the illiquidity premium (reverse or not) and that inflation, exchange rate uncertainty, and economic policy uncertainty do not, is that the jumps in VIX are more salient than the others. Psychoyios et al. (2010) state that jumps in the Chicago Board Options Volatility Index are very noticeable on the financial markets.

Overall, the results suggest that investors do not shield themselves from information as a reaction to high expected volatility of the exchange rate. If anything, investors seem to display behaviour contrary to the ostrich effect since all the signs are negative.

The uncertainty described by newspapers are not a cause for concern. The newspapers might have a more indirect impact on some of my other measures of uncertainty like monetary policy and stock market volatility but will not directly influence investors to change their investments (Baker et al., 2016).

5.3 Model 3 & 4

Models 3 & 4 that, instead of looking at the level of all variables, looked at the percentage change per week of the difference and uncertainty measures. In the two different regressions run for this study, contrasting results were obtained for each. Models 3 & 4 gave no clear results. It is likely that the results of models 3 & 4 would have provided stronger evidence for an ostrich effect since this time series is less likely to suffer from auto correlation. Taking a percentage change metric (or growth rate) removes any linear time trend (Wooldridge, 2015). However, the percentage change is metric is also a potential explanation for the poor results of the OLS delta models (ΔD_{il} *and* ΔD_{is}) is that the differences in absolute terms would be very small, especially at the beginning of the time series, but that the corresponding relative change would register as very large. This will cause small movements to create huge spikes when the two rates are very close to each other. Those spikes will cause a lot of variance to go unexplained since the independent variables will not show differences as large[11]. You can see this graphically in graph 5 below.



Graph 5: ΔD_{12l} divided by 100 (so it could be plotted on 1 y-scale) and D_{12l} during the period week 1 of 2015 to week 20 of 2018 in weekly observations *(t).*

5.4 Comparing results with Galai and Sade (2006)

To ensure that the results could be compared to the study of Galai and Sade (2006), their analysis of Israeli market data was replicated with the US market in this study. The results of the regression are presented in table 6 below with the results from the Israeli next to it. The variables are matched to their Israeli counterparts.

[11] I have tried transforming the ΔD_{il} *and* ΔD_{is} into a logarithmic function of the form: $\Delta D_{is} = \ln(D_{is_t} + 1) - \ln(D_{is_{t-1}} + 1)$ (and the same for ΔD_{il}) but that bring up other issues since a lot of the values at the beginning are 0 or approximate both positively and negatively 0. As Wooldridge (2012) denotes that would be acceptable if it contained relatively few zeros.

Dep. Variable (OLS)	$\Delta \boldsymbol{D_{12l}}$	$\Delta \boldsymbol{D_{12s}}$	Isreali study results	$\Delta \boldsymbol{D_{12s}}$
Constant	0.02 (0.03)	0.02 (0.03)	Constant	0.014 (t=1.103)
$\Delta \boldsymbol{R_{12m}}$	3*** (0.36)	2.18*** (0.32)	$\Delta \boldsymbol{R_{12m}}$	0.498*** (t=9.212)
$\Delta \boldsymbol{inf}$	-0.93 (1.36)	-0.57 (1.2)	$\Delta \boldsymbol{inf}$	0.048** (t=2.312)
$\Delta \boldsymbol{vix}$	0.14 (0.25)	0.1 (0.23)	$\Delta \boldsymbol{vix}$	0.07 (t=1.573)
Δexc	0.41 (0.33)	0.48 (0.3)	**Δexc**	0.324 (t=0.248)
$\boldsymbol{Adj\ R^2}$	0.29	0.2	$\boldsymbol{Adj\ R^2}$	0.409
F-statistic	18.76	12.03	F-statistic	32.155
Probability *F*	0.001***	0.001***	Probability ***F***	0.001***

Table 6 *Significant at 10 % level. **Significant at 5 % level. ***Significant at 1% level.
Comparison of Israeli results to the OLS Regression of the correlation between the percentage change of the difference between the yields of treasury bills and certificate of deposits of equal maturity (12-months) and percentage change of several uncertainty measures controlled by the change in the T-Bill yield to maturity. During the period week 1 of 2015 to week 20 of 2018 I have weekly observations (*t*). Dependent variable: The percentage change between *t and t-1* of the difference between the Treasury bill rates and Jumbo CD rates (ΔD_{il}) with maturities of 3, 6 and 12; the percentage change between *t and t-1* of the difference between the Treasury bill rates and Non-Jumbo CD rates (ΔD_{is}). Independent variables: the percentage change between *t and t-1* of the 12-month treasury bill yield to maturity (ΔR_{12m}); the percentage change between *t and t-1* of the 5 year expected inflation rate (Δinf); the percentage change between *t and t-1* of the Chicago Board Options Volatility Index; The standard errors are reported between the parentheses. Also I report the Adjusted $\boldsymbol{R^2}$ and the F-statistic of the model with the corresponding p-value.

The results are qualitatively very similar to the ones that resulted from my adjusted methodology. The only significant independent variable is ΔR_{12m} ,which is to be expected since it makes up half the equation of D_{il} *and* D_{is}. This can also be observed in the dramatic increase in $Adj\ R^2$ (from -0.011 to 0.29). Basically, what you are looking for in this model is if D_{il} *and* D_{is} change more than what the T-bill rate does in times of uncertainty, that is in this model not the case. None of the uncertainty measures are found to be significantly different from 0.

The results from this methodology are different from the ones from Galai and Sade (2006). The effect of controlling for ΔR_{12m} is similar, but inflation does trigger the ostrich effect in Israel, and stock market volatility is right around the rejection zone.

6. Limitations

There are several limitations to the data and methodology in this paper. Firstly, the Certificate of Deposit rate was used is the aggregate of 49000 different locations (Thompson, 2009). This means that even though they are likely to show correlation between subjects, all of them will set their own rates and will have their own distributions which is unknown at the moment. If two banks out of the 49000 change their rates equally (while the rest keeps the rate equal), but one increases the rate and one decreases the offered rate, this will not register on the CD rate that I am using. This is also notable in the data; the standard deviation of the CD rates is about half of the standard deviation of the Treasury bills. Graph 3 also displays this perfectly; the CD rate rarely moves and if it does it is only in small increments. This could mean that the conclusion that is reached is true for most locations but does not mean that it is true for all due to the heterogeneity within the sample. Garrett (2003) warns for the use of aggregated data since it can lead you to draw the wrong conclusions on an individual level. Furthermore, there is evidence that banks indeed behave heterogeneously: in a study in bank lending rates Bogoev & Sergi (2012) find that by using individual bank data they come to different conclusions than studies based on aggregate data.

Secondly, in the analysis of the data transaction costs are not considered, which will influence the 'real' return of treasury bills (Bodie et al. 2014). Namely, it will diminish some of the returns that the investor makes and will make the illiquidity premium smaller. It may even diminish the premium. However, the exact amount of cost that would occur when purchasing a treasury bill is unclear, and the literature provides mixed views. Harris (2015) estimates customer transaction cost to be between 84 and 52 bp depending on the size of the trade. Schultz (2001) comes to a different estimate of an average of $0.27 per $100 (27 bp) and adds that transaction cost for treasury securities are likely to be below that average. This is because the security is so liquid, the bid-ask spread will be lower compared to less liquid instruments. To be able to better answer this question, additional analysis was performed, whereby the test in section 4.1 of this paper was ran with some approximation of transaction cost included. 50bp is a subjective approximation since it hard to estimate the exact transaction cost, it could be higher, it could be lower. D_{il} *and* D_{is} are now defined as follows:

$$D_{il} = [R_{im} - 0.5\%] - R_{il}$$

$$D_{is} = [R_{im} - 0.5\%] - R_{is}$$

Again, a simple t-test was performed with $H_o: D_{il} = 0$ and $H_o: D_{is} = 0$. D_{il} *and* D_{is} does turn insignificantly different from 0 for $i = 3$, but it is still significant at a 10% level for $i = 6$ and at a 1% level for $i = 12$. For shorter maturities transaction costs have a big impact on whether there is an illiquidity premium or not, and could shift it the other way since the differences between market rate and CD rate were smaller there from the start. However, there is evidence that individual investors do not take transaction cost (and other trading cost) into account when evaluating investments, otherwise we would see a lot less trading amongst investors (Barber and Odean, 2000; Barber et al., 2008).

Finally, it is impossible to tell using this methodology if individual investors indeed shift from T-Bills to CDs. A definitive conclusion cannot be reached as to whether investors who would have chosen a treasury bill, choose a certificate of deposit in times of uncertainty instead. The exact choices of investors are not being made clear by looking at market movements, only the choices that are implied by the market movements. The evidence would be a lot stronger if there was evidence of individual investors displaying different investing behaviour during times of uncertainty within themselves. For example, future studies could use a panel study, like that which was used by Karlsson et al. (2009), in combination with the methodology used in this paper, to better determine individual investor behaviour.

7. Conclusion

One novelty of this paper is to apply a series of variables to measure market uncertainty. As I have shown in my results, they add a lot of explanation power to the models without weakening the methodology. A previous study by Galai and Sade (2006) did use a part of the dependent variable as a control measure for monetary policy. By adding the federal funds rate to the regression, I can control for monetary policy without reducing a lot of the variance of my dependent variable.

The anomaly persists of investors willing to hold illiquid, non-information providing instruments at a discount. Banks are not forced to increase their rates and this situation is accepted by investors. Information providence appears to be the key factor in creating this phenomenon. In relation to information avoidance in uncertain times, I have found mixed evidence in support of the notion that investors stick their heads in the sand by choosing Certificate of Deposits instead of Treasury bills in times of uncertainty. However, the evidence against the ostrich effect outweighs the evidence in support.

The results indicate that inflation can cause information shielding behaviour, however not consistently enough to give a clear answer. Larger jumps in expected inflation might be needed to trigger the ostrich effect. Exchange rate uncertainty has a marginal influence on the difference between T-Bills and CDs, however not in the direction which would support the ostrich effect. Expectations about future volatility on the stock market did provide some interesting results. In the linear models the vix had a significant effect on D_{il} and D_{is} but not on ΔD_{il} and ΔD_{is} (likely due to methodological limitations). Upon closer inspection of the Granger test results, it showed that there was a reverse causality at play. It was not an increase in vix that causes the difference to grow, but an increase in the difference causes the vix to rise. This was also confirmed in the literature. Furthermore, uncertainty about economic policy that stems from newspaper articles, does not lead investors to shift from treasury bills to CDs.

Ostrich-like behaviour is tolerated by the market, investors are accepting that non-information providing investments yield worse returns than a superior alternative. However, uncertainty does not cause those tendencies to spike, at least not on a market-wide scale.

Reference List

Acharya, V. V., & Pedersen, L. H. (2005). Asset pricing with liquidity risk. Journal of financial Economics, 77(2), 375-410.

Ackert, L., & Deaves, R. (2009). Behavioral finance: Psychology, decision-making, and markets. Cengage Learning.

Andries, M., & Haddad, V. (2017). Information aversion(No. W23958). National Bureau of Economic Research.

Baker, M., & Wurgler, J. (2007). Investor sentiment in the stock market. Journal of economic perspectives, 21(2), 129-152.

Baker, S. R., Bloom, N., & Davis, S. J. (2016). Measuring economic policy uncertainty. The Quarterly Journal of Economics, 131(4), 1593-1636.

Barber, B. M., Lee, Y. T., Liu, Y. J., & Odean, T. (2008). Just how much do individual investors lose by trading?. The Review of Financial Studies, 22(2), 609-632.

Barber, B. M., & Odean, T. (2000). Trading is hazardous to your wealth: The common stock investment performance of individual investors. The journal of Finance, 55(2), 773-806.

Benartzi, S., & Thaler, R. H. (1995). Myopic loss aversion and the equity premium puzzle. The quarterly journal of Economics, 110(1), 73-92.

Berk, J. B., & demarzo, P. M. (2007). Corporate finance. Pearson Education.

Board of Governors of the Federal Reserve System (US), 1-Year Treasury Bill: Secondary Market Rate [TB1YR], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/TB1YR, June 23, 2018.

Bodart, V., & Reding, P. (1999). Exchange rate regime, volatility and international correlations on bond and stock markets. Journal of International Money and Finance, 18(1), 133-151.

Bodie, Z., Kane, A., & Marcus, A. J. (2014). Investments 10th Global Edition. Mcgraw-Hill.

Bogoev, J., & Sergi, B. S. (2012). Investigating aggregation bias in the case of the interest rate pass-through. Intereconomics, 47(6), 361-367.

Buraschi, A., & Jiltsov, A. (2006). Model uncertainty and option markets with heterogeneous beliefs. The Journal of Finance, 61(6), 2841-2897.

Caplin, A., & Eliaz, K. (2003). Aids policy and psychology: A mechanism-design approach. RAND Journal of Economics, 631-646.

CBOE, Press contacts. (2008, July 31). CBOE CREATES TWO NEW VOLATILITY INDEXES TIED TO GOLD AND EURO CURRENCY[Press release]. Retrieved July 26, 2018, from http://ir.cboe.com/press-releases/2008/31072008.aspx

Connolly, R., Stivers, C., & Sun, L. (2005). Stock market uncertainty and the stock-bond return relation. Journal of Financial and Quantitative Analysis, 40(1), 161-194.

Duffie, D., & Krishnamurthy, A. (2016). Passthrough efficiency in the Fed's new monetary policy setting. In Designing Resilient Monetary Policy Frameworks for the Future. Federal Reserve Bank of Kansas City, Jackson Hole Symposium (pp. 1815-1847).

Edgar, S. M., & Swanson, P. E. (1984). The relationship between selected domestic and external dollar denominated asset yields. Review of World Economics, 120(3), 454-459.

Eil, D., & Rao, J. M. (2011). The good news-bad news effect: asymmetric processing of objective information about yourself. American Economic Journal: Microeconomics, 3(2), 114-38.

Engle, R. F., & Patton, A. J. (2007). What good is a volatility model?. In Forecasting Volatility in the Financial Markets (Third Edition) (pp. 47-63).

Federal Reserve. (2008, November 25). Federal Reserve announces it will initiate a program to purchase the direct obligations of housing-related government-sponsored enterprises and mortgage-backed securities backed by Fannie Mae, Freddie Mac, and Ginnie Mae [Press release]. Retrieved March 4, 2018, from https://www.federalreserve.gov/newsevents/pressreleases/monetary20081125b.htm

Federal Reserve. (2010, August 10). Federal Reserve announces it will initiate a program to purchase the direct obligations of housing-related government-sponsored enterprises and mortgage-backed securities backed by Fannie Mae, Freddie Mac, and Ginnie Mae [Press release]. Retrieved March 4, 2018, from https://www.federalreserve.gov/newsevents/pressreleases/monetary20100810a.htm

FEDERAL RESERVE BANK of NEW YORK. (2018). Newyorkfed.org. Retrieved 10 May 2018, from https://markets.newyorkfed.org/api/pd/get/SBN2015/timeseries/PDTRGS-EXTB.xlsx

Gagnon, Joseph, Matthew Raskin, Julie Remache, and Brian Sack, "Large-Scale Asset Purchases by the Federal Reserve: Did They Work?" Federal Reserve Bank of New York Staff Report no. 441, March 2010.

Galai, D., & Sade, O. (2006). The "ostrich effect" and the relationship between the liquidity and the yields of financial assets. The Journal of Business, 79(5), 2741-2759.

Garrett, T. A. (2003). Aggregated versus disaggregated data in regression analysis: implications for inference. Economics Letters, 81(1), 61-65.

Glosten, L. R., Jagannathan, R., & Runkle, D. E. (1993). On the relation between the expected value and the volatility of the nominal excess return on stocks. The journal of finance, 48(5), 1779-1801. Harris, L. (2015). Transaction costs, trade throughs, and riskless principal trading in corporate bond markets. Browser Download This Paper.

Jackwerth, J. C., & Rubinstein, M. (1996). Recovering probability distributions from option prices. The Journal of Finance, 51(5), 1611-1631.

Joyce, M., Miles, D., Scott, A., & Vayanos, D. (2012). Quantitative easing and unconventional monetary policy–an introduction. The Economic Journal, 122(564).

Karlsson, N., Loewenstein, G., & Seppi, D. (2009). The ostrich effect: Selective attention to information. Journal of Risk and uncertainty, 38(2), 95-115.

Kőszegi, B. (2010). Utility from anticipation and personal equilibrium. Economic Theory, 44(3), 415-444.

Krishnamurthy, Arvind and Annette Vissing-Jorgensen, 2010, "The Aggregate Demand for Treasury Debt," working paper, Northwestern University.

Longstaff, F. A. (2002). The flight-to-liquidity premium in US Treasury bond prices (No. W9312). National bureau of economic research.

Newey, W. K., & West, K. D. (1987). Hypothesis testing with efficient method of moments estimation. International Economic Review, 777-787.

Mishkin, F. S. (2007). The economics of money, banking, and financial markets. Pearson education.

Ofir, M., & Wiener, Z. (2012). Investment in Financial Structured Products from Rational and Behavioral Choice Perspectives.

Psychoyios, D., Dotsis, G., & Markellos, R. N. (2010). A jump diffusion model for VIX volatility options and futures. Review of Quantitative Finance and Accounting, 35(3), 245-269.

Samuelson, P. A. (1963). Risk and uncertainty: A fallacy of large numbers.

Sarno, L., & Thornton, D. L. (2003). The dynamic relationship between the federal funds rate and the Treasury bill rate: An empirical investigation. Journal of Banking & Finance, 27(6), 1079-1110.

SCHNABL, P. (2017). THE DEPOSITS CHANNEL OF MONETARY POLICY ITAMAR DRECHSLER ALEXI SAVOV. The Quarterly Journal of Economics, 1819, 1876.

Schultz, P. (2001). Corporate bond trading costs: A peek behind the curtain. The Journal of Finance, 56(2), 677-698.

Sicherman, N., Loewenstein, G., Seppi, D. J., & Utkus, S. P. (2015). Financial attention. The Review of Financial Studies, 29(4), 863-897.

Thaler, R. H. (1999). Mental accounting matters. Journal of Behavioral decision making, 12(3), 183.

Thompson, S. L. (2009, May 29). Federal Deposit Insurance Corporation. Retrieved May 10, 2018, from https://www.fdic.gov/news/news/financial/2009/fil09025.html

Whaley, R. E. (2000). The investor fear gauge. The Journal of Portfolio Management, 26(3), 12-17.

Whaley, R. E. (2008). Understanding vix.

Wooldridge, J. M. (2015). Introductory econometrics: A modern approach. Nelson Education.