Where Did The Liquidity Go?

The Cost of Financial Regulation to Foreign Exchange Markets

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1: Motivation

In financial markets, the terms "bull" and "bear" markets are used to describe the cyclicality of asset prices. Similar to asset price cycles, there are cycles in regulatory scrutiny. Beginning in the 1980's, regulatory scrutiny diminished, cumulating in the repeal of the Glass-Steagall Act in 1999, allowing commercial banks and securities firms to be housed under the same roof for the first time since the 1930's. In the aftermath of the global financial crisis in 2008 and 2009, the tides have reversed on financial regulation. With the Dodd-Frank reforms in the United States, and similar regulation being signed into law around the world, it is unknown how new regulation will affect financial markets. Legislators wrote the new rules in hopes that they would create safer financial institutions, but at what cost?

A large concern with new financial regulation surrounds the prohibition of proprietary trading by banks and the implications that those rules have for the trading of over-the-counter (OTC) financial instruments. The regulations surrounding proprietary trading, known as "The Volcker Rule" after Federal Reserve Chairman Paul Volcker who is said to have inspired said rule, have prompted concern that market making in certain instruments may have become impaired as the rule has goes into effect. While the Volcker Rule in theory has exceptions for trading related to market making, the distinction between holding inventory required to make markets and holding positions in a proprietary capacity is extremely difficult to make.

The financial media focuses on corporate credit markets as the center of liquidity problems. In order to run a fixed income market making operation, banks historically have held large inventories of securities in order to satisfy client trading demand. With new regulation, data has shown that the inventories of the Federal Reserve Primary Dealer banks have gone down (Rennison, 2015). With lower inventories comes a more limited ability to make markets, and many suggest that liquidity, especially in high yield securities which are more capital-intensive, has gone down (Baert, 2015).

With this, I was curious about the effects of new rules in the foreign exchange (FX) market. The FX market has traditionally been considered the most liquid market in the world, with transaction costs in the spot (for immediate delivery) market typically as low as single-digit basis points on trades of many millions of dollars notional. In addition, there is an explicit exception in the Volcker Rule regulation for spot FX trading. That being said, anecdotally, market participants have complained about reduced liquidity in that market as well. Over the summer of 2015, I had the opportunity to work intimately in the FX markets during my stint on the CIBC Institutional FX Sales desk and the Corporate Commodities, Interest Rates, and FX Sales desk in New York, and observed instances where clients and traders were frustrated with liquidity. Through my thesis, I wanted to examine data from the FX spot market to see if there is any evidence that liquidity has deteriorated as a result of new regulation. My investigation focuses on the most commonly traded currencies, the so-called "Majors": the Euro, British Pound, Australian Dollar, New Zealand Dollar, Canadian Dollar and Japanese Yen, against the U.S. Dollar.

2: Document Review

The intentions behind passing the Volcker Rule component of the Dodd-Frank reforms remain unclear. Senator Jeff Merkley, a co-sponsor of the Senate version of the bill, placed “blame [for the financial crisis] squarely on proprietary trading,” (Whitehead, 2011). This contrasts with chairman Volcker's own view that "proprietary trading in commercial banks was … not central" to the crisis, as well as U.S. Treasury Secretary Geithner's testimony that stated "most of the losses that were material … did not come from [proprietary trading] activities", but were related to traditional banking activities, especially loans relating to real estate (Whitehead, 2011).

Since the passing of Dodd-Frank regulation in 2010, much has been said about the implications of the new laws on market liquidity and the role that banks will play in providing liquidity across geographies and asset classes. Broadly speaking, the concern is that banks will change their market-making behavior in ways that adversely affect liquidity, driving trading focus away from already less-liquid products towards more-liquid products.

While market making and hedging are both considered exempt from Volcker Rule restrictions, in the writing of the law, neither term is defined. Within the financial markets, market makers ease stress by taking on risk while waiting for natural counterparties to come in and take the other side of the trade. Whitehead emphasizes that market makers make money by profiting off the difference in buying and selling prices. Crucially, it is a market maker's job to decide which positions to take on and at what price. Proprietary traders, similarly, accumulate positions with the expectation of profiting from that transaction. As Whitehead states "Identifying which trades are part of market-making and which are proprietary may be quite difficult – both involve principal trading with customers and counterparties, where the firm may gain or lose as a result of short-term changes in asset price," (Whitehead, 2011). In addition to short-term proprietary trading not being a main driver of the financial crisis, the Volcker Rule and Dodd-Frank regulation as a whole does little to address larger issues brought to light through the financial crisis, most notably subprime real estate lending and longer-term investment commitments (Whitehead, 2011).

Whitehead continues to emphasize the key issue with the Volcker Rule: its enforcement. If the enforcement standards are too loose, the whole purpose of the rule – to prevent losses derived from proprietary trading activities – may be moot as too few activities are covered under it. On the other hand, if the regulation is too restrictive, there may be significant adverse effects on market liquidity (Whitehead, 2011).

In 2012, Oliver Wyman released a report outlining its views on how the Volcker Rule would affect market liquidity, focusing primarily on effects on corporate bond markets. It outlines potential Volcker enforcement methods and how each of them would affect trading in the corporate bond market. It goes on to argue that, especially with more thinly traded corporate bond securities, the primary role of large banks is to deploy capital to intermediate between buyers and sellers through time (Oliver Wyman, 2012). The report goes to note that large swaths of the corporate bond universe trade on fewer than 50 of 252 trading days each year meaning that market makers often have to hold onto positions for extended periods of time. Regardless of the metrics chosen by the Federal Reserve to distinguish whether a position was taken on in a proprietary capacity or not, there will likely be trades that banks will avoid, despite being legitimate market making transactions and are thus beneficial to liquidity, because they produce worse metrics and are thus avoided on account of regulatory risk (Oliver Wyman, 2012).

When looking at the FX market, the report notes that while there is an exemption for spot FX transactions in new regulation, FX forwards and FX swaps do not share the same exemption, and are therefore covered under the Volcker Rule. The Oliver Wyman report hypothesizes that this will result in reduced liquidity in FX spot markets alongside FX forward and swap markets, despite the distinction made under the rule. In addition to FX spot, forward, and swap markets, the FX option markets face even larger headwinds with regard to new regulation. In this market, transactions are highly customizable, and typically dealt with in a principal manner, in which market makers keep the position on their book, and hedge the aggregate risk of the portfolio. Very rarely are these trades offsetting because of their customizability (Oliver Wyman, 2012).

The bulk of the Oliver Wyman report analyzes the implications of a number of potential Volcker Rule enforcement metrics. These metrics include limits on inventory holding period, limits on inventory size, and limits on inter-dealer trading. The report went to show, using examples from the corporate bond market, that all of these limits would result in significant amounts of trading being blocked that otherwise could have occurred (Oliver Wyman, 2012).

More recently, PricewaterhouseCoopers released a report in February 2015 outlining all of the actual enforcement metrics that will be used to determine whether or not banks have engaged in proprietary trading. In enforcement, authorities will be looking at the "reasonably expected near-term demand of customers" (RENTD) and a number of metrics related to those numbers in order to assess proprietary trading. The concerns that the Oliver Wyman report manifest themselves in a number of ways. The enforcement will be focused on RENTD data and how it impacts limits banks set in various areas, including market making inventory size, as well as inventory holding periods. In addition to those metrics, banks also are required to define customers as "any institution with less than $50 billion in trading assets, as well as any institution that conducts trades on exchanges but only if the trades are executed anonymously and the exchange has broad customer participation" (PricewaterhouseCoopers, 2015). This customer vs. non-customer distinction directly limits the amount of interdealer trade that occurs. While the Oliver Wyman research pertains specifically to the corporate bond market, it is not farfetched to suggest that similar restrictions will have similar effects on different markets.

In addition to academics' and consultants' analyses of liquidity issues revolving around new regulation, there has been no shortage of anecdotal evidence given by practitioners. Chief Credit Strategist at Goldman Sachs, Charles Himmelberg, commented in the fall of 2015 that net corporate bond inventories held by dealers falling to negative levels was indicative of changing behaviors on corporate bond trading desks (Eddings, 2015). In J.P. Morgan CEO Jamie Dimon's annual letter to shareholders last year, Dimon dug into the evidence of limited liquidity and the problems caused by it. Dimon mentioned that while observed differences between bid and ask prices in many markets have stayed constant, or even declined (indicating greater levels of liquidity), market depth, or the amount that buyers and sellers are willing to transact at various prices, has decreased noticeably. He notes that "The likely explanation for the lower depth in almost all bond markets is that inventories of market-makers' positions are dramatically lower than in the past". Later, he emphasizes that it is not just bond markets that have shown decreases in liquidity, but also indicates reduced liquidity in FX, arguing that large jumps in currency price volatility are indicative of lower levels of liquidity (Dimon, 2015).

However, not all of the literature available suggests that new regulation is detrimental to liquidity. As academics and practitioners discuss the implications of these new rules, regulators have also weighed in. U.S. regulators have come out with their own studies indicating that liquidity concernes are at worst, misplaced, and at best, overstated. The Federal Reserve's *Liberty Street Economics* blog released a series of posts specifically addressing worries about bond market liquidity. They note that in corporate bonds, bid-ask spreads have narrowed to levels lower than they were prior to the financial crisis. In addition, the post uses price impact, or the impact that large transactions have on prices, to show that liquidity is better than it was even before the crisis (Adrian, 2015). Beyond that specific article, it is telling that the fact that there are 22 posts specifically dedicated to address issues of market liquidity between August 17 2015 and February 19 2016. Those 22 posts are specifically in response to concerns over the corporate, treasury, and mortgage-backed securities liquidity situations. Overwhelmingly, they conclude that liquidity in those assets is better today than it was before the financial crisis. In addition to the Federal Reserve blog posts, other regulators have come out arguing that the new regulations should have limited effects on the markets. In February 2015, SEC Commissioner Kara Stein, in a speech in Tokyo, outlined the benefits of the new regulation, and argued that "The Volcker Rule is not designed to prevent U.S. firms or the U.S. financial system from taking every form of risk. Nor should it be. It is designed to decrease *excessive* risk-taking and reasonably increase systemic resilience" (Stein, 2015).

The bulk of the *Liberty Street Economics* blog posts address the concern that aggregate liquidity is worse than it was before, and largely dispels it. One last source, however, indicates the concern is not necessarily that markets are less liquid than they were before, but that liquidity is more fragile than it was before. By "fragile", I mean that in times of stress, the worry is that market liquidity will not be present at the levels that participants have come to expect. In the IMF's *Global Financial Stability Report* in October 2015, the fund discussed at length concerns that it had with the resilience of the corporate bond market. The IMF noted that, looking at the 2013 "taper tantrum" as a case study, the key factors that affected liquidity were the number of market makers, the size of the issue, and the credit quality of the issue (IMF, 2015).

From the literature discussed above, it is unclear which side will ultimately be correct. While the views of the Federal Reserve and those of academics, practitioners, and the IMF appear at first glance to differ, it is possible to reconcile them. The Federal Reserve may well be correct that observed levels of liquidity are better today than they have ever been before, while at the same time risks are heightened because liquidity is more fragile in times of stress than it has been in recent history.

3: Experiment

3.1: Examining the Data

For the purposes of running a liquidity experiment, I looked at FX bid-ask spread data, retrieved from Bloomberg, over the last 10 years. This encompasses the entire progression of Dodd-Frank regulation, the financial crisis, and significant trading data before the financial crisis. It was important to take a sample size of this length to compare how more recent liquidity activity compares with liquidity observed in these markets leading up to the financial crisis, when there was comparatively less regulation on bank trading, allowing market makers to behave in whatever capacity they found most effective and profitable.

The FX data from Bloomberg is calculated by taking the offer price in each currency, and subtracting it from the bid price. These bids and offers are taken daily, at 5PM Eastern Standard Time. The currency pairs used in this experiment are the so-called “major” currencies of the Australian Dollar (AUD), Canadian Dollar (CAD), Swiss Franc (CHF), Euro (EUR), British Pound (GBP), Japanese Yen (JPY) and New Zealand Dollar (NZD), all against the U.S. Dollar (USD). When the bid price is subtracted from the ask price, the difference is the transaction cost, measured in units of quote currency per unit base currency traded. After this data was collected, it was standardized into a number measuring how many U.S. dollars were paid per $1mm USD traded, or in other words, how much it would cost, in USD, to buy $1mm worth at the bid and sell $1mm at the offer simultaneously, a so called “round trip." In times of greater liquidity, the cost of doing this is lower, and when liquidity is impaired, the transaction cost is much higher.

Across those currencies, I found the transaction costs, measured in dollars, showed the following summary statistics:

	AUD	CAD	CHF	EUR	GBP	JPY	NZD
Mean Transaction Cost	$479.22	$337.99	$556.92	$170.31	$244.30	$271.31	$996.45
Standard Deviation	$511.37	$345.68	$693.87	$168.68	$205.06	$270.50	$1,049.57

Table 1: Transaction costs across USD-Major pairs in the FX Spot Markets. Costs measured in USD paid per $1mm USD notional traded

This revealed, as might be expected, that liquidity is best in EUR and worst in NZD. This is not inconsistent with the concept that liquidity improves with volume, and in terms of volume, EUR has the most volume traded, while the NZD has the lowest volume of currencies studied in this sample. In 2013, EUR/USD traded an average of US$1.3 trillion notional every day, versus a mere $82 billion daily in NZD/USD (BIS, 2013).

Over different years and currencies, the distributions of the transaction costs change, but overall, they illustrate a common characteristic of liquidity: most of the time, liquidity is present and abundant, but when it is not, extreme values occur. As a result of this, when I construct histograms of transaction costs for each currency pair, distributions of data are largely clustered around the mean, with right tails illustrating the presence of datapoints where liquidity is impaired. Illustrations of data in the most liquid currency, EUR, and the least liquid currency, NZD, in 2006, 2008, and 2015 can be seen below.

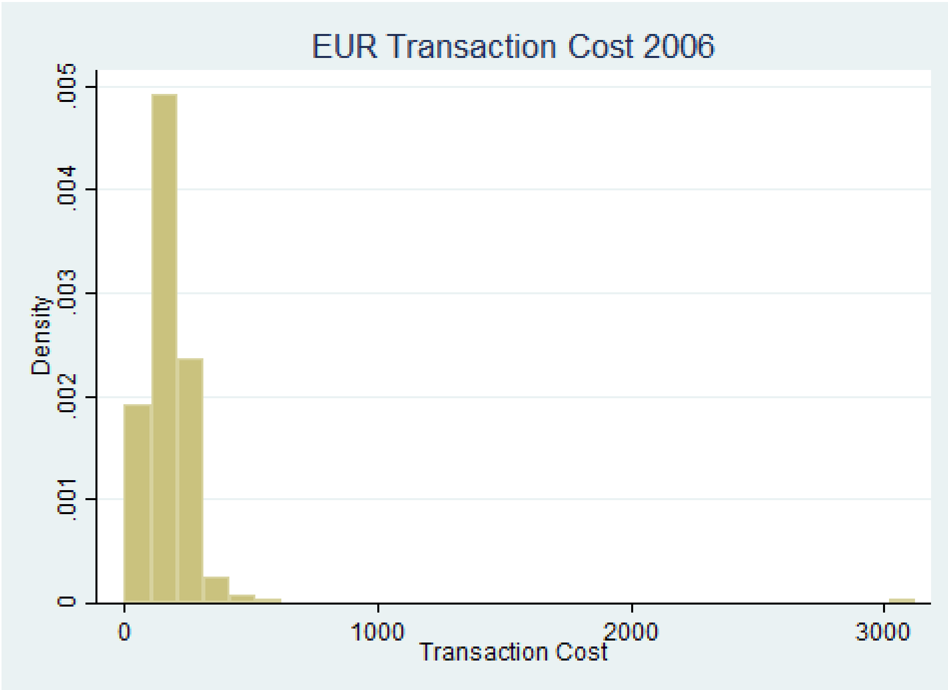

Figure 1: EUR Transaction Cost Data, 2006

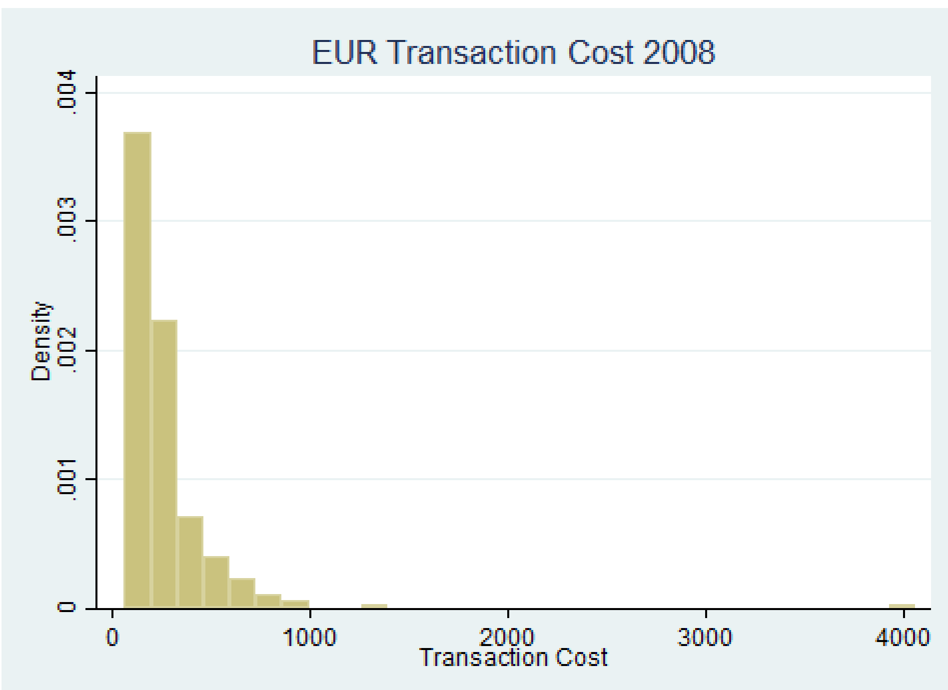

Figure 2: EUR Transaction Cost Data, 2008

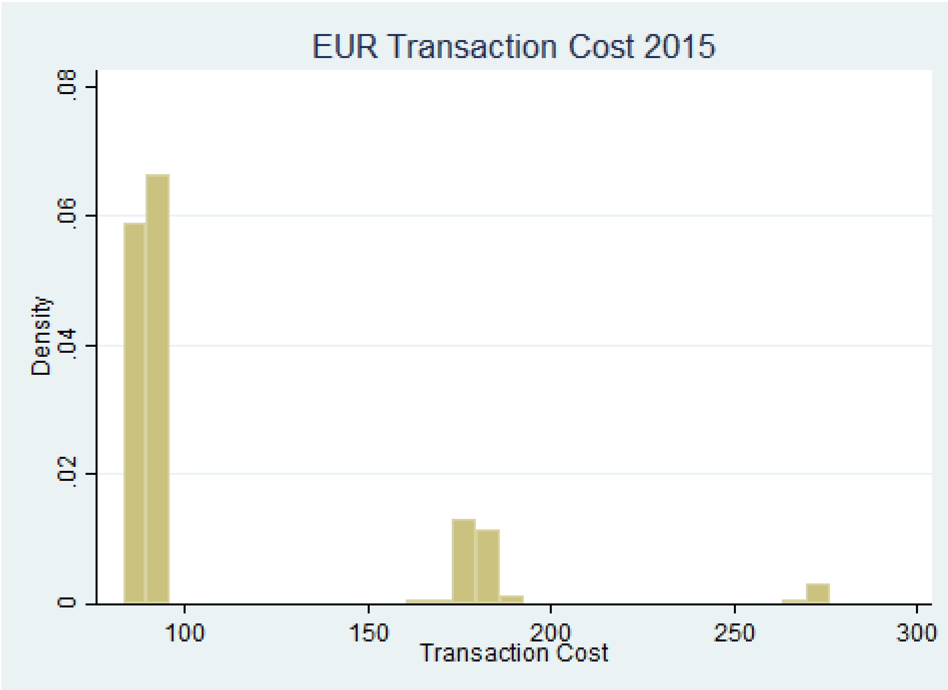

Figure 3: EUR Transaction Cost Data, 2015

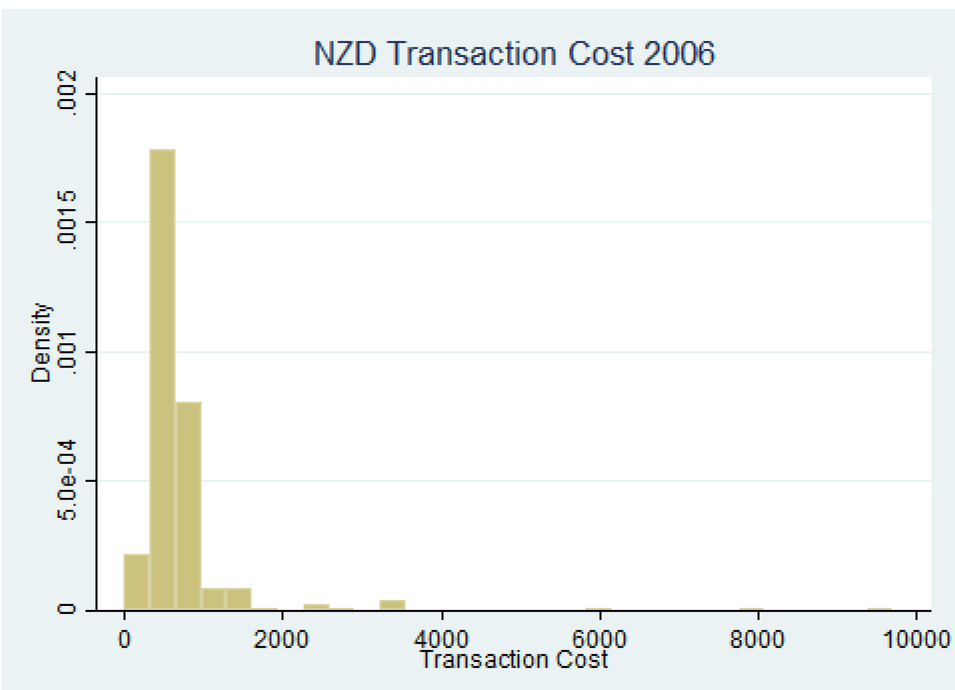

Figure 4: NZD Transaction Cost Data, 2006

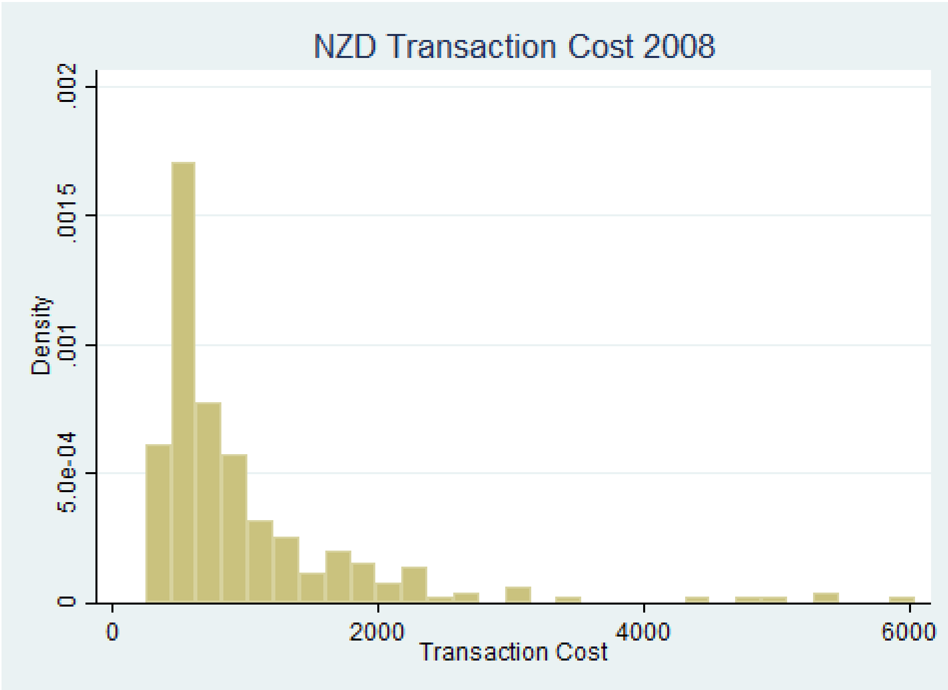

Figure 5: NZD Transaction Cost Data, 2008

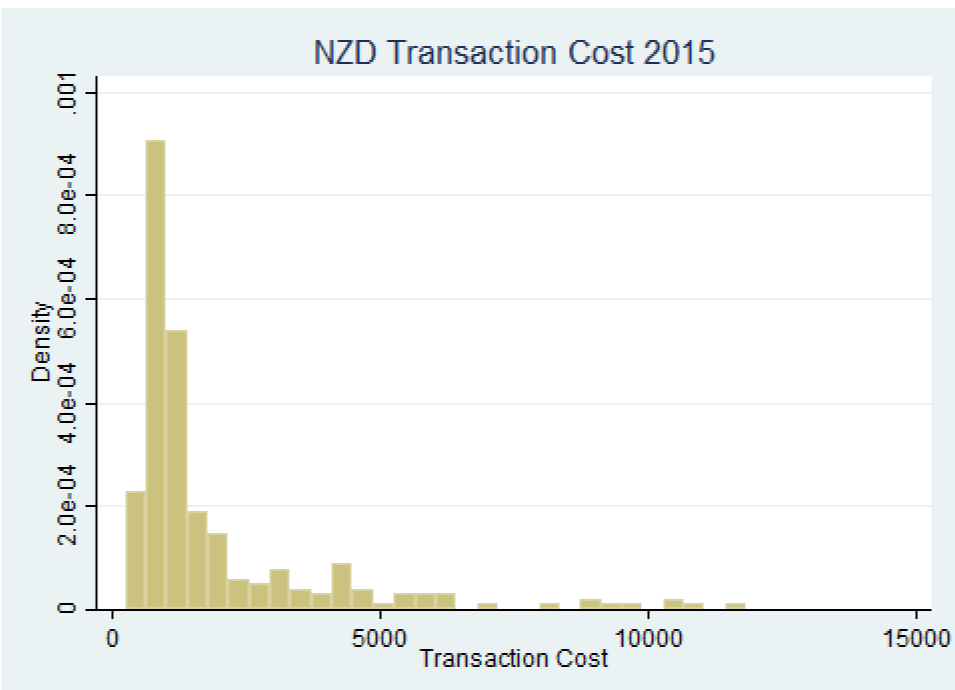

Figure 6: NZD Transaction Cost Data, 2015

In Figures 1 through 3, it is clear that in EUR, transaction costs are concentrated in the left side of the distribution with relatively few "outlier" cases in the right tails. This is especially clear when looking at 2015, where the highest transaction costs recorded are below $300 per $1mm traded. In both currencies, during the financial crisis, the distributions are more right-skewed, with larger tails than in 2015 or 2006, as can be seen in Figure 2 and Figure 5. In NZD, in 2006 (Figure 4), although you do have some outliers just below $10,000, the bulk of the data is concentrated with transaction costs below $2,000, with little registering between $4,000 and almost $10,000. In comparison, in 2008 (Figure 5), the data is a lot more spread out, with significant data beyond $2,000, which is not the case in 2006. In 2015, while a clear bulk of the data shows relatively low transaction costs, there is still a sizable portion of the data falling between $5,000 to past $10,000 per $1mm traded, a clear deterioration in liquidity even from the height of the financial crisis. These figures suggest two stories in liquidity: one that is that, as observed in EUR, liquidity may be getting better, while the other, as observed in NZD, is that liquidity may be impaired as a result of something beyond typical fluctuations normally observed. I took the data collected and ran regressions to try and uncover what is going on in liquidity across various currencies.

3.2: Regression Analysis

3.2.1: Regressors

Looking past the summary statistics, this experiment sought to either prove or disprove the notion that liquidity has changed, for the worse, since the introduction of new financial regulation in the United States. The null hypothesis is that liquidity is not impacted by new regulation, and that the regression coefficients for the regulatory variables will be zero, while the alternate is that liquidity is worse, and the regression coefficients for the regulatory variables are positive. To do that, explanatory variables were created to explain variations in liquidity, beyond changes that could be attributable to changes in regulatory climate. The factors chosen are by no means exhaustive, but often do explain variation in liquidity caused by market makers' willingness to take on risk. These factors are, in no particular order: the absolute value of the return in that currency pair (the currency vs. the U.S. dollar) on that day, a dummy variable as to whether or not that day was the end of the quarter (last business day in March, June, September, or December), a dummy for whether or not the U.S. Federal Reserve had a federal funds interest rate decision release on that day, a dummy for whether or not the local central bank had an overnight borrowing interest rate release on that day, a dummy for whether or not that day was in the financial crisis, measured from the day following the peak of the S&P 500 in 2007 (October 9 2007) until the day following the low of the S&P 500 in 2009 (March 3 2009), as well as a time variable, starting at 1 on January 1 2006 and increasing by 1 on every trading day until the end of the study. In addition to those explanatory variables, 3 variables were chosen to represent changes in financial regulation: a dummy marking the passing of the Dodd-Frank Wall Street Reform and Consumer Protection Act, which is 0 prior to July 21 2010 and 1 from that date forward, a dummy marking the approval and finalization of the Volcker Rule by all necessary financial regulatory agencies, which is 0 prior to December 10 2013 and 1 from that day forward, and a dummy marking the end of the Volcker Rule compliance period and the beginning of enforcement for banks, which is 0 prior to July 21 2015 and 1 from that date forward (Federal Reserve Board, 2013).

3.2.2: Regression Models

In each set of currency data, three regressions were run. First, a linear regression was run, with the transaction cost data as the dependent variable, and the set of explanatory variables as independent variables. Second, the transaction cost data was sliced it up, such that if a datapoint fell in the top third of transaction cost data for that currency's transaction costs, it registered as a 1. If it was in the bottom two thirds of the data, the value was zero. This was meant to split up the transaction cost data, which by nature is a wide range of values, into days of which liquidity was impaired, and days in which liquidity was not. The top third was an arbitrary choice, but when the data was tested at different cutoffs, similar regression results occurred. From that data, logit and probit regressions were run to estimate how the independent variables affected the probability of liquidity being impaired, registering a "1" in the data. The signs and statistical significances of each of the regressions run can be found in the tables 2 through 4 in section 3.2.4, while the general regression equations in the equations below.

$$
\begin{aligned}
TransactionCost
&= \beta_0 + \beta_1[Time] + \beta_2[\,|Currency\ Move|] + \beta_3\,[End\ of\ Quarter\ Dummy] \\
&+ \beta_4\,[Fed\ Release\ Dummy] + \beta_5[Local\ C.B.\ Release\ Dummy] \\
&+ \beta_6[Dodd - Frank\ Approval\ Dummy] \\
&+ \beta_7[Volcker\ Rule\ Approval\ Dummy] \\
&+ \beta_8[Volcker\ Rule\ Enforcement\ Dummy]
\end{aligned}
$$

Equation 1: Linear Regression

$$
\begin{aligned}
\Pr(Liquidity\ Impairment) = 1/(1 + e\hat{}(-(a_0 + a_1[Time] + a_2[\,|Currency\ Move|] \\
+a_3\,[End\ of\ Quarter\ Dummy] + a_4\,[Fed\ Release\ Dummy] \\
+ a_5[Local\ C.B.\ Release\ Dummy] + a_6[Dodd - Frank\ Approval\ Dummy] \\
+ a_7[Volcker\ Rule\ Approval\ Dummy] \\
+ a_8[Volcker\ Rule\ Enforcement\ Dummy])))
\end{aligned}
$$

Equation 2: Logit Regression

$$\begin{aligned} \Pr(Liquidity\ Impairment) \\ &= \Phi(\gamma_0 + \gamma_1[Time] + \gamma_2[\,|Currency\ Move|] \\ &+ \gamma_3\,[End\ of\ Quarter\ Dummy] + \gamma_4\,[Fed\ Release\ Dummy] \\ &+ \gamma_5[Local\ C.B.\ Release\ Dummy] + \gamma_6[Dodd - Frank\ Approval\ Dummy] \\ &+ \gamma_7[Volcker\ Rule\ Approval\ Dummy] \\ &+ \gamma_8[Volcker\ Rule\ Enforcement\ Dummy]) \end{aligned}$$

Equation 3: Probit Regression. Note: Φ is the cumulative distribution model.

From each of these regressions, the important concept to observe is not necessarily the magnitude of the coefficients, but their sign and their statistical significance. In this regression, positive coefficients in the linear regressions denote higher transaction costs as the values (or values of 1 for dummy variables) of the variable increase. In the case of the logit and probit models, positive coefficients mean an increase in the variable (or a dummy value of 1) increases the probability of an instance of impaired liquidity, as defined above.

3.2.3: Regression Expectations

Before running the regressions, a number of expectations were made about what the signs on each of the coefficients should be. I expected that the data would show that as the "time" increased, as the data moved forward into the future, liquidity would improve, and would result in the time coefficient having a negative sign. This assumption was based on the premise that with the passage of time, traders would have better technology and risk management systems, allowing them to make tighter markets and enhance market liquidity.

The absolute value of the currency's move measured against the USD should capture increased risk aversion by market makers. The underlying rationale that is that when there are large swings in the market, market makers will be less likely to take on risk, and thus will respond by not making markets as aggressively, resulting in a reduction of liquidity. If this were the case, the regression coefficients on the daily move would be positive.

With regards to the Fed and the local central bank release dummy variables, around overnight lending rate releases, there may be a period of reduced liquidity where market participants find a new equilibrium price, and during that time, market makers may be less aggressive about making tight markets, resulting in lower levels of liquidity observed. According to that logic, positive regression coefficients are expected. During the financial crisis, there were both large market swings, but also bank funding constraints and bank failures. These events may impair market makers' risk appetites and thus aggressiveness making markets. Positive regression coefficients are expected for that variable.

Moving to the three regulation-related variables, the logic surrounding those is as follows: as new regulation is written into law, approved, and eventually enforced, banks wind down their proprietary trading desks, and their risk appetite in their market making activities declines, resulting in lower levels of liquidity, and therefore positive regression coefficients for all of those variables. Of the three variables, the most important is the last one, the date that the Volcker Rule is enforced. In theory, just because the law was passed and the various agencies finalized it, banks could, and did, continue to engage in proprietary trading well after the law was finalized (Copeland, 2014). Despite evidence of continued proprietary trading after the law was introduced and approved, there is no reason to believe, as of the date of this writing, that there are any large banks in violation of this rule. As a result, the hypothesis that the prohibition of proprietary trading has impacted liquidity hinges on the sign of the coefficient attached to this dummy variable.

3.2.4: Regression Results

	Time	Move	E.o.Q.	Fed Day	Local C.B. Day	Fin. Crisis	D.F. Approved	Volcker Approved	Volcker Enforced
AUD	+***	+***	+***	-**	-***	+***	-***	.	+***
CAD	+***	+***	+***	.	-***	+***	-***	.	-***
CHF	+***	+***	+**	.	.	+***	-***	-***	+***
EUR	+***	+***	+***	.	.	+***	-***	-***	.
GBP	+***	+***	+**	.	.	+***	-***	-***	.
JPY	+***	+***	+***	.	-**	+***	-***	-***	-**
NZD	+***	.	+***	.	+***	+***	-***	+***	+***

Table 2: Linear Regression Results. "+" Denotes positive coefficient, "-" denotes negative coefficient. "*" Denotes significant beyond a 1% level, "**" denotes significant beyond a 5% level, "*" denotes significant beyond a 10% level. "." Denotes not significantly different from zero.**

	Time	Move	E.o.Q.	Fed Day	Local C.B. Day	Fin. Crisis	D.F. Approved	Volcker Approved	Volcker Enforced
AUD	+***	+***	+***	.	-***	.	-***	-***	.
CAD	+***	+***	.	.	-**	+***	-***	-***	.
CHF	+***	+***	.	.	.	+***	-***	-***	.
EUR	+***	+***	+***	.	-***	+**	-***	-***	.
GBP	+***	+***	.	-**	.	.	-***	-***	.
JPY	+***	+***	+*	.	.	+***	-***	-***	.
NZD	+***	+***	+***	-*	+***	+***	-***	.	+***

Table 3: Logit Regression Results. "+" Denotes positive coefficient, "-" denotes negative coefficient. "*" Denotes significant beyond a 1% level, "**" denotes significant beyond a 5% level, "*" denotes significant beyond a 10% level. "." Denotes not significantly different from zero.**

	Time	Move	E.o.Q.	Fed Day	Local C.B. Day	Fin. Crisis	D.F. Approved	Volcker Approved	Volcker Enforced
AUD	+***	+***	+***	.	-***	.	-***	-***	.
CAD	+***	+***	.	.	-**	+***	-***	-***	.
CHF	+***	+***	.	.	.	+***	-***	-***	.
EUR	+***	+***	+***	-*	-***	+**	-***	-***	.
GBP	+***	+***	.	-**	.	.	-***	-***	.
JPY	+***	+***	.	.	.	+***	-***	-***	.
NZD	+***	+***	+***	-*	+***	+***	-***	.	+***

Table 4: Probit Regression Results. "+" Denotes positive coefficient, "-" denotes negative coefficient. "*" Denotes significant beyond a 1% level, "**" denotes significant beyond a 5% level, "*" denotes significant beyond a 10% level. "." Denotes not significantly different than zero.**

When looking at the regression results, as can be seen above in Tables 2 through 4, the size of the move on the day was almost always statistically significant with positive regression coefficients across all three regressions, confirming the presumption that liquidity deteriorates when there are large swings in currency values. In addition, the end of quarter dummy variable returned positive, statistically significant coefficients in the linear regression, as well as a number of positive, statistically significant coefficients in the logit and probit models. Lastly, the financial crisis dummy coefficient was almost always statistically significant and positive, indicating that liquidity was impaired during the financial crisis in most currencies.

Although I assumed that time might have a negative regression coefficient, through every single currency and every single model, time was a statistically significant positive coefficient. This may have to do with the fact that, for a period after the bottom in the financial crisis, before the passing of Dodd-Frank in 2010, traders continued to operate with limited risk appetite, not making markets as tight as they otherwise would. If there was a significant period of time between the end of the financial crisis and when traders began taking on more risk and behaving more similarly to how they did before the crisis, this may have been picked up by the Dodd-Frank dummy coefficient as opposed to the time variable coefficient. In addition, central bank meetings seemed to have constructive effects on liquidity, if any, as noted by negative statistically significant regression coefficients.

The notable exception to this is that NZD liquidity is impaired on the days of Reserve Bank of New Zealand (RBNZ) announcements, which may be as a result of the timing of the announcement versus when the liquidity observation was made. In most other instances, the central bank announcement was made hours away from the liquidity observation, whereas often times RBNZ announcements came around or shortly after the 5PM Eastern Standard Time liquidity observations. This suggests that market makers were unwilling to take on risk in NZD leading up to and around RBNZ, and thus resulted in wider observed bid-ask spreads and thus higher transaction costs.

With regards to the regulatory dummy variables, the passing of Dodd-Frank dummy had a positive statistically significant regression coefficient across all currencies and regressions. As discussed above, relationship with the time variable may have had an effect on it, allowing the dummy variables and the time trend to change what they are picking up. The finalizing of the Volcker Rule dummy also carried a negative statistically significant coefficient throughout the majority of the regressions. Looking at the Volcker enforcement dummy variable and its coefficient tells a different story than the other two regulatory variables. In the AUD, CHF, and NZD linear regressions, the enforcement of the Volcker Rule dummy was both positive, indicating worse liquidity, and statistically significant. In addition, the NZD logit and probit regressions also show positive statistically significant coefficients. CAD was the only currency that showed a statistically significant negative coefficient for the Volcker enforcement.

The coefficients attached to the Volcker Rule enforcement dummy reveal two themes: first, that liquidity has been impaired in those three currencies, beyond what could have been expected or explained by the other variables in the model, but also that the fact that the currencies that showed reduced liquidity were AUD, CHF, and NZD is a story in itself. From Table 1, the three least liquid currency pairs in the dataset were, in order of least liquid to most liquid, NZD, CHF, and AUD. The fact that there was reduced liquidity in these currencies, beyond what can be explained by other variables, after the passing of the Volcker Rule suggests that currencies which were already less liquid to begin with are becoming less liquid, whereas the liquid majors of EUR, GBP and JPY are not experiencing the same effects. This in turn indicates that market makers may be changing their behavior and how they want to take risk across different currencies. This mirrors what the Oliver Wyman report warned about in the fixed income market. In that report, Oliver Wyman cautioned that within the fixed income sphere, liquidity would deteriorate further in already illiquid bonds as market makers worry about their ability to unload positions. The regression coefficients in major currencies suggests that what the consultants at Oliver Wyman were afraid of happening in the fixed income world as a result of the Volcker rule has appeared in foreign exchange markets as well: liquidity has shifted from low-liquidity currencies to high-liquidity currencies.

The shift in liquidity away from low-liquidity currencies towards high-liquidity currencies reflects the self-reinforcing nature of the Volcker Rule enforcement metrics effect on liquidity. If market makers want to hold the position on their book for as short as possible, and trade out of it with a client if possible, thus avoiding contributing adversely to their holding period metric and to their client-facing trade ratio metric, they will aggressively compete for business in which they are confident that they can both trade out of in a short period of time, in which they are also confident that they can balance the trade against offsetting client flows. Because EUR, JPY and GBP are both the most liquid as measured by bid-ask spreads in the data, and there is the most volume in those currencies, market makers are eager to take on risk when they know they can trade out of it relatively easily and quickly, bettering their inventory holding period metric, and know that clients are likely to trade those currencies very frequently, increasing the probability that they can pair together orders, bettering their client-facing trade ratio metric. On the flip side, in a currency like NZD, market makers require additional compensation to be willing to take on the risk that they will have to hold onto the position for longer periods of time, hurting their inventory holding period metric, and increasing the likelihood they will have to trade out of their position with another dealer, hurting their client-facing trade ratio metric. The additional compensation for the market maker comes by way of wider bid-ask spreads, thus resulting in lower liquidity in that currency. In this sense, good liquidity is self-reinforcing, as more and more market makers will compete for business with tighter bid-ask spreads, while bad liquidity is also self-reinforcing, with lower liquidity causing market makers to charge more to take on the risk, only lowering liquidity further.

4: Conclusion

In conclusion, the regression coefficients from the Volcker Rule enforcement dummy variable suggest that liquidity concerns in foreign exchange markets as a result of the Volcker Rule being put into place are valid, especially in the trading of less liquid currencies. Based on this information, one could extrapolate that liquidity is even more impaired across less liquid currencies, especially in the emerging markets. If liquidity is indeed disproportionately impaired in already less liquid markets as a result of the Volcker Rule, that presents a clear unintended consequence of the law, and directly harms investors and firms around the world who need to transact in these less liquid markets.

An interesting side-effect here that both regulators and market participants need to be warry of in the FX market are effects of lower liquidity on price action. Specifically, limited market making may manifest itself in the most pronounced manner in an increase in realized volatility. Large buying and selling may have greater impact on price action, as market makers move to lay off risk faster with lower regard for price impact as they hurry to move inventory.

Moving forward from this experiment, it is important to monitor what happens as banks and traders adjust to the regulations. Indeed, if risk appetite dissipates as a result of the next crisis, what happens to these markets, especially those already with low levels of liquidity? It is entirely possible that the Volcker rule results in chronic limited liquidity in certain currencies, and simply raises the costs of trading in those currencies, without ever causing anything to break down. What will be interesting to see is how market makers react to the next crisis given these restrictions. The alternative, however, is the possibility these less liquid markets may lock up completely in the next crisis.

From a research perspective the next step from here would be to obtain proprietary data from market makers on how they are pricing various derivative products. From a data collection standpoint, it is difficult to get a read on liquidity in OTC derivative products precisely because the products, by nature, are so customizable. So while so much of FX spot market making involves maintaining inventory balanced to accommodate client trading, trading an OTC derivatives book is an entirely different beast. An FX options book, for example, involves, in most cases, holding onto all positions and hedging net exposure to risk factors of the entire portfolio. This introduces an entire layer of complexity not present in the FX spot market, which, in its interaction with Volcker Rule regulation, may cause more pronounced liquidity deterioration. As products get more complex, the more complicated their hedging is, the more difficult it is to discern between permitted and prohibited trading. Beyond vanilla options, there is often a divergence between the theoretical "perfect hedge" and practical hedges. A straightforward example of this would be a volatility swap. In a volatility swap, your exposure to volatility is the same wherever the spot price goes (unlike in vanilla options), and you have no exposures to any of the other factors you are exposed to while trading vanillas (Quayle, 2011). Unfortunately, these swaps do not trade very often in the interbank market, and so for banks that choose to trade them, they are often hedged with vanillas, resulting in an imperfect hedge.

From the perspective of a regulator, where is the line between a true market maker who has made a good-faith effort to hedge the risk and is stuck with limited exposure due to an imperfect hedge, and a market maker who chooses to hedge in a fashion that leaves exposure to risks that they believe will produce profit, and thus are using a complex book to trade proprietarily? From a bank perspective, where do you draw the line between offering a wide array of products to satisfy client demand, and limiting yourself to products that can be easily and sufficiently hedged in order to satisfy regulators beyond a shadow of a doubt that you are not breaking the law? The answer of course is that there is probably a price at which some banks are willing to take on regulatory risk to make markets in products that are complicated or impossible to hedge fully if clients are willing to pay them. The corollary of that is that those markets may be more illiquid, beyond what they otherwise would be.

Bibliography

Adrian, Tobias, Michael Fleming, Or Shachar, and Erik Vogt. "Has U.S. Corporate Bond Market Liquidity Deteriorated? Liberty Street Economics." Liberty Street Economics. October 5, 2015. Accessed April 11, 2016. http://libertystreeteconomics.newyorkfed.org/2015/10/has-us-corporate-bond-market-liquidity-deteriorated.html#.VwxdifkrLmE.

Baert, Rick. "Regulatory Changes Impacting High-yield Liquidity." Pensions & Investments. December 28, 2015. Accessed April 14, 2016. http://www.pionline.com/article/20151228/PRINT/151229939/regulatory-changes-impacting-high-yield-liquidity.

Copeland, Rob. "RBC to Close Proprietary-Trading Desk." WSJ. April 15, 2014. Accessed April 14, 2016. http://www.wsj.com/articles/SB10001424052702303887804579503770900905940.

Eddings, Cordell. "Goldman Contrarian Joins Chorus Warning on Bond-Market Liquidity." Bloomberg.com. Accessed March 2, 2016. http://www.bloomberg.com/news/articles/2015-11-10/goldman-contrarian-joins-chorus-warning-on-bond-market-liquidity.

Dimon, Jamie. "Dear Fellow Shareholders." J.P. Morgan Chase. April 8, 2015. Accessed April 11, 2016. https://www.jpmorganchase.com/corporate/investor-relations/document/ar2015-ceolettershareholders.pdf.

IMF Global Financial Stability Report October 2015. Report. Washington D.C.: International Monetary Fund, 2015.

"Joint Press Release." Federal Reserve Board. December 10, 2013. Accessed April 13, 2016. https://www.federalreserve.gov/newsevents/press/bcreg/20131210a.htm.

Quayle, John, and Chris Fuligni. *Beyond Vanilla Options*. Report. Stamford, CT: Royal Bank of Scotland, 2011.

Rennison, Joe, and Eric Platt. "US Bond Dealers Hold Net Negative Positions - FT.com." Financial Times. November 17, 2015. Accessed April 14, 2016. http://www.ft.com/cms/s/0/70cdf87e-8c81-11e5-8be4-3506bf20cc2b.html#axzz45rCABJ6c.

Stein, Kara. "The Volcker Rule: Observations on Systemic Resiliency, Competition, and Implementation." SEC.gov. February 9, 2015. Accessed April 11, 2016. https://www.sec.gov/news/speech/volcker-rule-observations-on-systemic-resiliency-competition.html.

The Volcker Rule Restrictions on Proprietary Trading: Implications for Market Liquidity. Report. New York, NY: Oliver Wyman, 2012.

Triennial Central Bank Survey Foreign Exchange Turnover in April 2013: Preliminary Global Results. Report. Basel, Switzerland: Bank for International Settlements, 2013.

Volcker Rule: Are You Really Market Making? Report. New York, NY: PricewaterhouseCoopers, 2015.

Appendix: Regression Coefficients and Significance Statistics

	Time	Move	E.o.Q.	Fed Day	Local C.B. Day	Fin. Crisis	D.F. Approved	Volcker Approved	Volcker Enforced	Constant	R-Squared
AUD	0.1967	7780	291.5	-121.5	-173.8	84.20	-358.4	-3.038	177.4	350.7	0.0807
CAD	0.0621	4044	162.2	-24.84	-87.70	151.5	-286.9	-173.9	-33.62	416.7	0.2804
CHF	0.3102	13574	255.2	-100.1	-151.1	278.0	-255.5	-165.4	261.0	200.8	0.0671
EUR	0.0576	3674	125.2	-8.717	-27.29	60.50	-129.4	-83.21	-3.423	158.3	0.1520
GBP	0.0460	6244	60.90	1.622	-25.27	90.85	-117.1	-139.6	-14.62	221.3	0.2192
JPY	0.0954	5597	155.8	-22.61	-48.52	125.2	-154.6	-214.1	-52.22	230.5	0.1947
NZD	0.4010	5320	685.8	-166.5	305.8	189.8	-557.3	319.2	603.6	584.2	0.1271

Table 5: Linear Regression Coefficents and R-Squared Values

	Time	Move	E.o.Q.	Fed Day	Local C.B. Day	Fin. Crisis	D.F. Approved	Volcker Approved	Volcker Enforced	Constant
AUD	5.65	5.13	3.72	-2.19	-3.37	2.67	-8.16	-0.08	3.91	12.96
CAD	2.99	2.98	3.46	-0.75	-2.67	8.08	-10.86	-7.87	-1.24	25.26
CHF	6.58	6.07	2.39	-1.32	-1.50	6.53	-4.29	-3.29	4.22	5.44
EUR	5.25	5.08	5.05	-0.49	-1.84	6.11	-9.35	-7.11	-0.24	18.21
GBP	3.57	6.76	2.10	0.08	-1.51	7.85	-7.19	-10.19	-0.87	21.70
JPY	5.56	6.53	4.03	-0.82	-2.25	8.09	-7.14	-11.73	-2.33	16.98
NZD	5.78	1.62	4.38	-1.48	2.73	3.04	-6.34	4.32	6.64	10.47

Table 6: Linear Regression Coefficient t-statistics

	Time	Move	E.o.Q.	Fed Day	Local C.B. Day	Fin. Crisis	D.F. Approved	Volcker Approved	Volcker Enforced	Constant	Pseudo R-Squared
AUD	0.0015	41.31	1.106	-0.1956	-1.202	0.1285	-2.930	-0.5543	0.0819	-1.284	0.1165
CAD	0.0013	40.73	0.4756	-0.2281	-0.7420	0.8984	-2.993	-3.333	-0.9242	-0.7419	0.2993
CHF	0.0018	48.99	0.4842	-0.1010	-0.5052	0.9363	-1.440	-1.144	0.2522	-2.443	0.0704
EUR	0.0014	81.00	1.073	-0.4429	-0.6204	0.2812	-3.091	-1.794	0.4416	-0.9677	0.1993
GBP	0.0011	86.72	0.0522	-0.6324	-0.3163	0.0976	-2.072	-3.798	0*	-0.9388	0.1836
JPY	0.0011	61.15	0.6524	-0.3219	-0.1223	0.8257	-2.251	-3.653	0*	-1.037	0.2212
NZD	0.0020	25.43	1.178	-0.4550	0.7969	0.5038	-2.534	-0.2657	0.8921	-2.320	0.1222

Table 7: Logit Regression Coefficients. Note: * denotes that there were no instances of impaired liquidity while the dummy = 1

	Time	Move	E.o.Q.	Fed Day	Local C.B. Day	Fin. Crisis	D.F. Approved	Volcker Approved	Volcker Enforced	Constant
AUD	9.42	5.33	3.19	-0.74	-4.03	0.96	-13.82	-3.16	0.41	-10.25
CAD	8.02	3.33	1.16	-0.76	-2.44	6.10	-13.83	-8.74	-1.16	-6.00
CHF	10.54	5.27	1.44	-0.44	-1.42	6.82	-7.36	-6.85	1.32	-15.83
EUR	8.42	6.98	2.89	-1.55	-2.60	2.07	-14.46	-8.07	1.64	-7.84
GBP	7.30	6.71	0.14	-2.17	-1.39	0.73	-10.44	-10.03	N/A*	-7.65
JPY	7.36	6.55	1.68	-1.11	-0.54	5.86	-11.27	-9.61	N/A*	-8.31
NZD	11.61	3.44	3.40	-1.65	3.18	3.70	-12.01	-1.59	4.24	-15.07

Table 8: Logit Regression z-statistics. Note: N/A* denotes that there were no instances of impaired liquidity while the dummy = 1

	Time	Move	E.o.Q.	Fed Day	Local C.B. Day	Fin. Crisis	D.F. Approved	Volcker Approved	Volcker Enforced	Constant	Pseudo R-Squared
AUD	0.0009	24.93	0.6501	-0.1133	-0.7257	0.0902	-1.711	-0.3418	0.0608	-0.7604	0.1151
CAD	0.0007	23.57	0.2606	-0.1306	-0.4569	0.5598	-1.712	-1.693	-0.4232	-0.4063	0.2961
CHF	0.0011	29.80	0.2909	-0.0656	-0.3254	0.5721	-0.8612	-0.7052	0.1666	-1.484	0.0712
EUR	0.0008	46.56	0.5825	-0.2838	-0.3787	0.1882	-1.812	-1.020	0.2220	-0.5584	0.1976
GBP	0.0006	52.50	0.0226	-0.3829	-0.1764	0.0666	-1.227	-1.986	0*	-0.5585	0.1821
JPY	0.0007	36.27	0.3697	-0.2108	-0.0763	0.5131	-1.322	-1.885	0*	-0.6072	0.2194
NZD	0.0012	15.03	0.6931	-0.2728	0.4655	0.2971	-1.473	-0.1556	0.5591	-1.370	0.1209

Table 8: Probit Regression Coefficients. Note: * denotes that there were no instances of impaired liquidity while the dummy = 1

	Time	Move	E.o.Q.	Fed Day	Local C.B. Day	Fin. Crisis	D.F. Approved	Volcker Approved	Volcker Enforced	Constant
AUD	9.32	5.43	3.13	-0.73	-4.25	1.09	-14.07	-3.29	0.50	-10.23
CAD	7.52	3.38	1.11	-0.74	-2.53	6.40	-13.99	-10.23	-1.39	-5.43
CHF	10.84	5.28	1.43	-0.43	-1.51	6.82	-7.10	-6.97	1.41	-16.89
EUR	8.26	7.00	2.74	-1.68	-2.67	2.26	-14.81	-8.43	1.53	-1.54
GBP	7.05	6.82	0.10	-2.21	-1.31	0.81	-10.36	-12.04	N/A*	-7.44
JPY	7.04	6.63	1.59	-1.21	-0.56	6.02	-11.20	-11.43	N/A*	-8.05
NZD	11.80	3.36	3.36	-1.66	3.15	3.56	-12.07	-1.55	4.49	-15.99

Table 9: Probit Regression z-statistics. Note: N/A* denotes that there were no instances of impaired liquidity while the dummy = 1