Preliminary Evidence on the Relation between Economic Uncertainty, Financial Stress and Liquidity Risk

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Abstract

This study examines the relation between economic uncertainty, financial stress, and liquidity risk. The empirical evidence suggests that the inner dynamics of settlement fails for a given type of security are not likely to change in isolation from similar events for alternative securities, nor are they independent from the perceived levels of financial stress. There are limited signs of market segregation as the volumes of fails for various types of securities including treasury notes and corporate securities tend to follow similar patterns. The repurchase market does not seem to be a place where failure paves the way for success. It may be argued that near-zero interest rates and quantitative easing programs are reshaping the behaviour of financial institutions faced with increasingly complex trade-offs in the repurchase markets. It is increasingly difficult to reconcile the regulatory demands for larger holdings of safe assets with the imperative of generating incremental income from risk-free assets, and with the economic function of liquidity provision. Thus, it is important to manage risk in ways that recognize uncertainty as inherent to all economic activities and promote equity over debt financing. It is important for financial institutions and financial regulators to draw lessons from the recurrence of financial crises and shift away from debt-financing toward equity-linked securities and partnership agreements, which are conducive to sustainable finance and economic development.

1. Introduction

Conventional wisdom from development economics suggests that poverty can be explained by chronic underinvestment in education, health, land, and equipment. There is also strong evidence from economic history that economic development has deep historical roots. Hysteresis effects, which denote the propensity of a system to revert to its past status, may partly explain the persistence of the prevailing state of poverty even after the decay of positive shocks and development programs. Path dependence may be also useful in explaining poverty traps and the

recurrence of financial crises. Thus, despite repeated attempts by many nations to achieve higher rates of economic growth, economic development may remain rather elusive.

In order to better understand the prospects of economic growth and likelihood of economic recession, it is important to consider the interrelations between economic uncertainty, financial instability, and income inequality. Indeed, economic policymaking and business strategies cannot be designed and implemented in the absence of an objective assessment of the sources of economic uncertainty and their impact. Uncertainty is the primary concern of policymakers and corporate managers because risk permeates all economic activities. Since real investment is the source of economic growth and development, it is imperative that the risk-return trade-offs related to various investment projects are well assessed and understood. Thus, shocks to the financial systems are bound to permeate the economic sectors and affect real investment and financing decisions. Virtually, every aspect of economic endeavour, investment, production, commerce, and consumption is wrapped in a shroud of uncertainty.

With reference to the U.S. credit and financial crisis, much attention is usually drawn to subprime mortgage problems. As argued by the National Commission on the Causes of the Financial and Economic Crisis in the United States (2011), the corrosion of mortgage-lending standards and mortgage securitization were responsible for the contagion and crisis. However, on closer look, the U.S. financial crisis seems to represent just another classical case of debt problems, where falling asset prices and rising defaults are conducive to severe liquidity problems and counterparty risks. Despite claims that the crisis was unforeseen and unavoidable, there were clear signs of looming problems, including early warnings provided by debt accumulation, and short-term repo lending markets, among others. The recurrence of financial crises is indeed symptomatic of inherent problems in the structure and architecture of the financial system.

It may be argued that the U.S. financial crisis presented two stark and painful choices between inaction leading to the collapse of the financial system and rising unemployment, and the alternative of a costly bailout of too-big-to-fail financial institutions using public funds.[1] But if debt is at the origin of financial crises, it cannot be part of the solution Part of the explanation for the formation of the debt problems and ensuing financial crises has to do with a conducive environment characterized by low interest rates, credit expansion, high leverage, weak market discipline, and ineffective regulation. It seems however that such precarious conditions leading to heightened systemic risk and financial crises have little changed. Indeed, near-zero interest rates

[1] The Financial Crisis Inquiry Report (2011, p. xvii) notes also that the financial crisis was avoidable as it "was the result of human action and inaction, not of Mother Nature or computer models gone haywire. The captains of finance and the public stewards of our financial system ignored warnings and failed to question, understand, and manage evolving risks within a system essential to the well-being of the American public."

and quantitative easing programmes have become the new normal.

This environment raises concerns about the formation of new asset bubbles and the prospects of liquidity traps.[2] Following the initial arguments about liquidity traps advanced by John Maynard Keynes and John Hicks, Paul Krugman developed the notion that it may be possible for governments to sustain high levels of borrowing, and for central banks to raise expectations about high inflation rates. In addition to the Keynesian view, there are alternative views of the liquidity trap, including the Austrian and monetarist perspectives. The Austrian school argues that reliance on monetary and fiscal stimulus is rather misplaced. Without addressing the structural problems related to the banking system, slow growth and deflation may ensue. In contrast, the market monetarist perspective holds that demand is a monetary phenomenon. Thus, unlike Keynesian views that consider fiscal policy as a remedy to liquidity traps, it may be argued that monetarist perspectives regard quantitative easing as a solution to liquidity problems. The divergence of theoretical arguments is reflective of the complexity of the problems posed by debt crises in terms of liquidity traps and poverty traps.

Thus, it is difficult to exaggerate the importance of economic uncertainty and the impact of income distribution and income inequalities. This paper focuses on economic uncertainty and financial stress and their relation with liquidity risk and financial markets. The focus is placed on the repurchase markets as shocks to the financial system tend to emanate, rather predictably, from the credit cycle, leading to the accumulation of debt, which in turn increases default risk, financial stress, and liquidity risk. Given the purposes of this study, the next section discusses the importance of economic uncertainty and financial stress. Section 3 examines the relationship between debt financing and liquidity risk. Section 4 provides some preliminary evidence on the empirical relation between the dynamics of liquidity provision in the repurchase market and financial stress. Section 5 concludes the paper.

2. Economic Uncertainty and Financial Stress

A century ago, Frank K. Knight (1921) provided unique insights on the relation between risk, uncertainty, and profit. Knight argued that in order to understand the inner dynamics and workings of the economic system, it is imperative to understand the significance of uncertainty, and thus the nature and function of knowledge. A distinction is made between three types of uncertainty

[2] There are diverging views about a working definition of liquidity traps. Reference is sometimes made to the zero-boundary of interest rates below which nominal rates cannot be reduced. Alternatively, liquidity trap conditions may be understood in terms of the incapacity of monetary policies to push price levels higher despite the increase in money supply.

or probability situations, including *a priori* probability, statistical probability, and estimates. The first form of probability refers to "chances" that can be calculated based on general principles on the same logical place as mathematical propositions. The second type of probability is based on the empirical evaluation of the frequency distribution derived from past observations. The third form of probability is based on the premise that there is no valid basis for a logical classification of instances.

It may be argued that judgements and probability estimates may not be accurate, and are subject to error, as is the case with statistical calculations based on sampling methods. It should be noted as in Knight (1921, p. 218) that "[t]he fundamental fact underlying probability reasoning is generally assumed to be our ignorance. If it were possible to measure with absolute accuracy all the determining circumstances in the case it would seem that we should be able to predict the result in the individual instance, but it is obtrusively manifest that in many cases we cannot do this." Thus, without accurate and timely information, it is difficult to assess probability distributions, make inferences and pronounce judgments on the objective course of actions. Uncertainty reflects the existence of multiple scenarios and possible future states of the world. The distinction between the available options in decision-making depends necessarily on the accuracy of information gathered about the different states of nature.

The distributional properties will determine the perceived levels of risk, and shape the individual attitudes toward risk. For instance, the focus in the mean-variance analysis leading to the formulation of the standard capital asset pricing model is placed on the measures of co-variance between efficient portfolios with the market portfolio. Systematic risk measured with respect to market portfolio risk is essential for optimal portfolio selection. The risk analysis may be extended to include the third moment of the return distribution, and the focus can be then placed also on co-skewness with the market portfolio. Measures of risk can, thus, differ depending on whether co-variance is sufficient or co-skewness is also essential to capture co-variations in the market risk.

Tail risk is also of particular importance in the assessment of systemic risk and banking regulation. Rajan (2010, p. 152) argues that "[t]he market should theoretically encourage good risk management and penalize excessive risk taking. But tail risks are difficult to control for two reasons. First, they are hard to recognize before the fact, even for those who are taking them. But second, once enough risk is taken, the incentive for the authorities to intervene to mitigate the fallout is strong. By intervening, the authorities reduce market discipline, indeed inducing markets to support such behavior. Bankers may in fact have been guided into taking tail risks as markets anticipated government intervention in the housing market and liquidity and lending

support from the Fed and the FDIC."[3] Thus, it is the market that should in principle promote good risk management and discourage excessive risk taking, but the threshold beyond which risk taking becomes excessive is not clear. It may be argued that tail risks are hard to identify, but these very difficulties should constitute a legitimate reason for greater risk aversion not greater risk taking. In the absence of reliable measures of tail risks, prudence should be the rule rather than the exception. Bank regulation may be ineffective if intervention is warranted only when an "excessive" amount of risk is taken. Also, government bailouts tend to strengthen moral hazard, where systematic governmental intervention to save too-big-to-fail institutions is conducive to lower market discipline.

The notion that "too much" risk-taking should be avoided is intrinsically related to our understanding of uncertainty at the heart of the inner workings of the economic system, and to the evolving probabilities of debt default. It should be noted that financial stress is not defined with respect to equity markets but essentially with respect to default risk and the ensuing liquidity risk. As with increasing stock prices that may reflect market expectations of higher firm profitability, a benchmark of financial stress can be useful in measuring perceptions of higher or lower stress levels in financial markets. Inflation risk and default risk are used to measure some aspects of financial stress, in addition to liquidity risk, which reflects the ability of financial institutions to secure funding by trading short-term liabilities in repurchase markets. The methodology underlying the construction of the St Louis Fed Financial Stress Index (STLFSI2) is the principal component analysis, which useful in identifying several common factors that determine the co-movement of a set of relevant variables. The calculation of the STLFSI2 is based on weekly observations of several variables that capture some aspects of financial stress such as interest rates, and yield spreads, among others. The average value of the index is set to zero, which is assumed to represent normal market conditions. Thus, positive values are reflective of increased financial stress beyond average levels whereas sub-zero values are indicative of below average financial stress.[4]

The level of financial stress is estimated using Friday observations of the St Louis Fed Financial Stress Index over the sample period from January 2015 to November 2021. It is clear from Figure 1 that since the financial stress benchmark tends to fluctuate over prolonged periods between negative and positive values. It is also noted that the level of financial stress did not vary

[3] It is noted that the mission of the Federal Reserve Board (Fed) is to promote the stability, integrity and efficiency of the monetary, financial and payment systems, while that of the Federal Deposit Insurance Corporation (FDIC) as the primarily federal regulator of banks is to maintain stability and public confidence in the financial system.

[4] For further information about the methodology underlying the calculation of the old and new versions of the St Louis Fed Financial Stress Index, reference can be made to Kliesen and Smith (2010) and Kliesen and McCracken (2020), among others.

Figure 1. The behaviour of financial stress index

Source: Federal Reserve Bank of St. Louis

significantly before sudden surges in association with the onset of the Asian currency crisis and default of the hedge fund Long-Term Capital Management (LTCM) in the late 1990s. Also, the highest increase in financial stress is observed in relation to the U.S. credit and financial crisis in 2007–08. Another significant jump but of lower magnitude is associated with the onset of the covid-19 disease outbreak.

Thus, it appears that perceived levels of financial stress tend to increase rather abruptly and fall also significantly, reflecting the short-term dynamics of major shocks in financial markets. It is the tendency for financial stress to regress back to below-average levels in the aftermath of crises that should be also a matter of concern for regulators and market participants. The precipitous fall to below-average levels of financial stress is symptomatic of short memory in financial markets, where pre-crisis levels are indicative of the accumulation of debt, higher leverage, increased liquidity risk, and higher probability of default.

Judging from more recent observations in Figure 1, it may be argued that the current level of financial stress is rather low by historical standards. Past experience with similarly low levels suggests that a surge in the collective measure of financial market stress may not be a distant future event. Part of the explanation for an increase in financial stress may have to do with the changing market perceptions of risk, and signs of a general malaise stemming from a narrow room for policy manoeuvre. Advanced economies are typically characterized by weak prospects of economic growth, high debt levels, lower productivity, and historically low interest rates. Indeed, as noted above, despite increased liquidity through asset-purchasing programs, near-zero interest rates have become the new normal for monetary policies.

The adoption of unconventional monetary policies in the aftermath of asset bubbles and

financial crises was aimed at providing ample liquidity to the financial system, and achieving inflation targets. Conventional wisdom suggests indeed that a significant increase in money supply can entrench expectations about higher inflation rates. But while there is a failure to create an inflationary environment, as in the case of the Bank of Japan, the pursuit of economic recovery by lowering the cost of borrowing to boost demand is also associated with the risk of liquidity traps and the formation of new asset bubbles. In this respect, Thornton (2012) argues that insofar that investment remains insensitive to variations in policy rates and the impact of the Federal Reserve on interest rates remains weak, the net effect of zero-interest rate policies may be rather negative.

Thus, the natural question arises as to whether the unprecedented measures taken to provide ample liquidity to the financial system have been exhausted and have become rather counterproductive. It is important to understand the empirical relation between debt accumulation and the likelihood of a "flight to liquidity" that is reminiscent of the LTCM and U.S. financial crises. The accumulation of public and private debt is facilitated by zero-interest rate policies and quantitative easing programs (QE) aimed at increasing liquidity. The issue is that QE measures adopted in response to the latest financial crises may raise risk-taking attitudes and create new problems of their own. It may be, thus, useful to examine the dynamics of failures to deliver and failures to receive in repurchase markets in order to understand the relation between financial stress and liquidity problems.

3. Debt Financing and Liquidity Risk

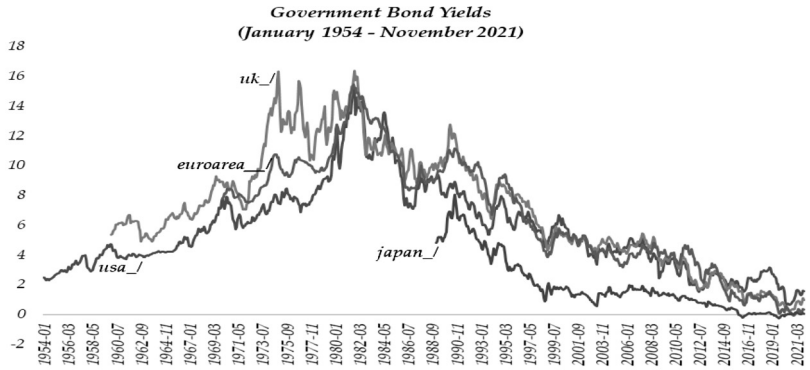
The unconventional monetary policies adopted by several central banks following the burst of the Japanese asset bubble, and in the aftermath of the U.S. financial crisis are accompanied with a significant growth in public debt. Japanese government bonds are at unprecedented levels relative to the gross domestic product. There are growing concerns that such levels of public debt are rather unsustainable. As noted by Filardo and Hofmann (2014), forward guidance at the zero lower bound were conducive to lower volatility of expected policy rates.[5] However, to what extent forward guidance is affecting the level of expected rates and the sensitivity of financial markets to the arrival of new information remains unclear.

Historically, there is a long-term convergence between the yields on ten-year government bonds across more developed economies. As shown by Figure 2, there is a tendency for yields

[5] Forward guidance provide clarity about the future path of policy rates was adopted by the Bank of Japan in 1999 and by the Federal Reserve in 2013.

on the U.S., U.K., and the Euro Area sovereign bonds to increase monotonously until the early 1980s, but they have been generally falling afterward. While sharing the same declining trends, Japanese government bonds are associated with relatively lower yields. It is important to note also that yields dropped into negative territory for Japanese and Euro Area bonds in recent periods. Negative bond yields add to the recent history of negative interest rates that central banks continue to charge commercial banks beyond the reserve requirements. Lower interest rates constitute a strong disincentive to the investment of savings into fixed-income securities as they are meant to encourage borrowing and spending. They can be also conducive to increasing credit, higher leverage, speculative activities, rising asset prices, and ultimately to the formation of asset bubbles.

Figure 2. Government Bond Yields



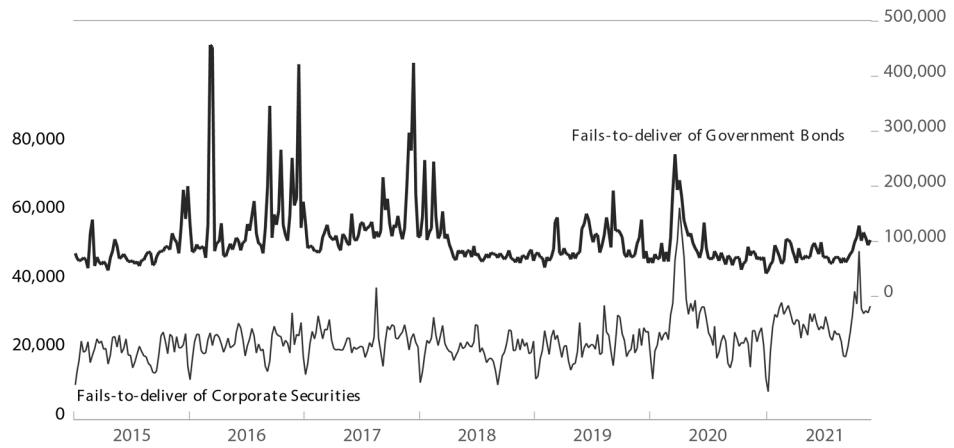
Source: Thomson Reuters Datastream database, author's calculations

As noted by Raghuram Rajan (2010, p.111), "[t]he key warning signal of unsustainable growth in asset prices is an accompanying growth in credit. Before the crash of 1929, the warning signal was the growth in margin loans against shares even as stock prices increased. Before the most recent recession, alarm bells should have sounded in every central bank meeting as a boom in real estate lending accompanied house price growth, and lending to private equity grew with ever-higher transaction prices. Indeed, credit growth has historically been one of the factors determining how central bankers set policy interest rates but in recent years, academics have persuaded many of them that such behaviour is archaic." Thus, it is usually argued that the formation of asset bubbles is symptomatic of the accumulation of unsustainable debt and leverage levels that increase the risk of default, and financial instability. The primary focus of central banks on credit growth to set monetary policy rates may be archaic, indeed, but it is because of its reliance on interest-based debt financing that the financial system is inherently unstable.

The repeated government bailouts of too-big-to-fail financial institutions in association

with the onset of credit crises are the source of significant moral hazard where bondholders can rationally expect central banks to act as lenders-of-last-resort. The tax deductibility of interest payments on debt and non-deductibility of dividend payments on equity are also reflective of a clear bias for debt over equity. Hence, it is important to focus on the essence of debt and credit *per se* rather than the sustainability of credit growth, or lack thereof, in order to prevent the formation of asset bubbles and credit crises. As argued by Shiller (2018, p. 6), among others, the absence of sovereign GDP-linked bonds is "a sort of a puzzle", because of the necessity to manage the risks associated with the uncertainty about GDP growth itself. Also, Kenneth Rogoff (2011a, 2011b) recognizes the benefits of issuing sovereign bonds with payments linked to GDP growth in terms of their ability to absorb economic shocks as state-contingent bonds. In contrast to fixed-income securities, GDP linked securities are state-dependent in the sense that income is function of the levels of economic growth, precluding thereby debt defaults. For instance, Kopf (2018) argues that GDP-linked government securities present stronger protection against default because of their ability to stabilize public debt service independent from the peaks and troughs of the economic cycle. The idea of GDP-linked securities is also consistent with GDP-linked sukuk as suggested by Rahman (2018), among others. Indeed, the principle of risk sharing in Islamic finance prohibits interest-based debt obligations on the grounds that fixed-rate income is predetermined independently from the outcome of economic activities. The focus should thus be placed on equity-financing that promotes risk sharing rather than debt-financing, which is conducive to risk transfer, and increased probability of debt defaults and financial crises.

Figure 3A. Volume of Delivery Fails in the Repurchase Market
(weekly cumulative values in millions of U. S. dollars)



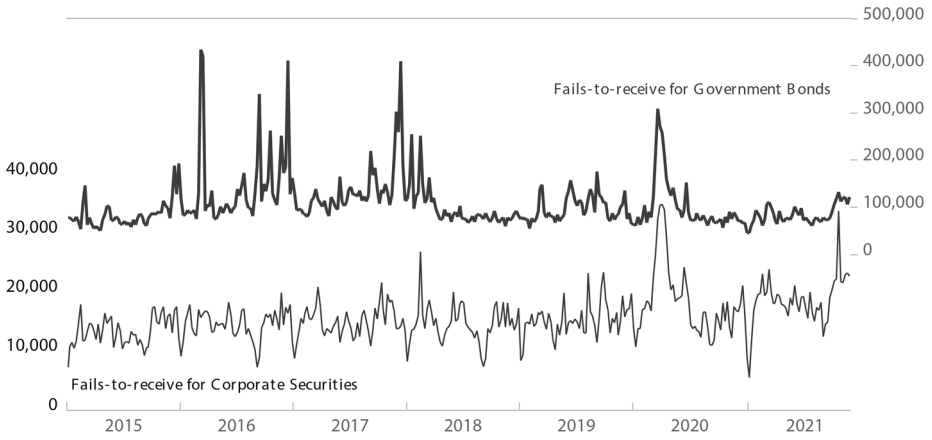
Source: New York Fed Primary Dealers database, author's calculations

Thus, the relation between credit expansion and asset prices may provide some reliable signals about the formation of asset bubbles and the making of financial crises. Strong signs of liquidity problems may emanate from the repurchase market, where the supply and demand for liquidity meet. According to the Federal Reserve Bank of New York, a settlement fail refers to the event where securities are not delivered by the buyer or seller on the scheduled settlement date. Such failures can trigger widespread losses to market participants in association with higher risks of counterparty insolvency. The inability of a seller to deliver a security may be indeed directly caused by a prior failure to receive the same security in an alternative transaction. Thus, the likelihood of "daisy chains" and "round robins" depends on the potential impact of an initial failure to deliver on the liquidity conditions of recipient parties, who may become unable to deliver the same security in subsequent transactions.

There are two types of failures that may occur with respect to various securities, including treasury bonds and corporate securities, among others. The focus is usually placed on treasury bonds, which may be assumed to be risk-free whereas corporate securities remain exposed to default risk. The analysis is based on weekly observations of the aggregate volumes of fails-to-deliver and fails-to-return for Treasury bonds excluding inflation-protected securities and corporate securities obtained from the New York Fed Primary Dealers database. The time-series of the weekly volumes of fails-to-deliver treasury bonds and corporate securities, expressed in millions of U.S. dollars, over the period from January 2015 to November 2021 is shown in Figure 3A. It is clear from the different scales of the volume of failures that treasury bonds are associated with higher volumes of fails than corporate bonds. There is a tendency for the volume of fails-to-deliver treasuries to surge significantly in the initial part of the sample period, but there are no contemporaneous jumps in association with fails-to-deliver corporate securities. It is also noted that there is a short period of historically low volumes of fails-to-deliver for government bonds in 2018. However, higher volumes of failures are observed in 2019, and more importantly in 2020, in association with the disease outbreak. In contrast to the earlier part of the sample period, it seems that fails-to-deliver corporate bonds tend to mimic the behaviour of similar events regarding treasury bonds.

With reference to Figure 3B, there is evidence that fails-to-receive follow patterns of behaviour consistent with fails-to-deliver. But it is important to note that the aggregate volumes of fails-to-deliver and fails-to-receive are not necessarily identical. Since there are two parties to every transaction, there are two parties to every fail. As explained above however, the failure of sellers to deliver securities may be due to failures to receive the same securities during the execution of alternative transactions. Also, there may be a prior consent from both parties to adhere to the International Capital Market Association (ICMA) Global Master Repurchase Agreement

Figure 3B. Volume of Failures-to-receive in the Repurchase Market
(weekly cumulative values in millions of U. S. dollars)



Source: New York Fed Primary Dealers database, author's calculations

(GMRA). This would allow the buyer to consider a failure to deliver collateral securities as an event of default, or to consider that the repo contract remains in force while the failure to deliver continues with the option of unilaterally terminating the agreement at any time. These GMRA repo agreements take into consideration the fact that failures to deliver may fall beyond the control of sellers due to infrastructure frictions, operational problems, among others.[6]

Thus, the graphical evidence from the behaviour of fails-to-deliver and fails-to-receive may differ over time and across different types of securities. The volume of failures related to government bonds is higher than that associated with corporate securities, but this evidence alone does not necessarily imply that failure is more likely to occur with respect to a certain type of securities rather than another. The likelihood of failures in short-term lending instruments may rise however with market perceptions of increased liquidity problems in the banking system. The empirical evidence from Iyer and Macchiavelli (2017) suggests that, irrespective of the types of security ranging from treasuries to corporate securities, a failure to receive a security at the dealer level during the U.S. financial crisis period is typically rolled over on a one-to-one basis as a failure to deliver the same security. It is also argued that systematic fails are indicative of patterns of rehypothecation and conditions of either inability or unwillingness to deliver securities. There are also concerns, as suggested by Mullin (2020) among others, that the repo market has exhibited signs of strain even before the disease outbreak. It is argued however that the increase in interest

[6] It is likely that parties to repurchase transactions agree also to close the repo trade when delivery takes place on the condition that payment is duly received according to the delivery-versus-payment system.

rates in repo markets observed in September 2017 is not so much reflective of market fears of economic recession, as of the impact of changes in the Fed's policy operating framework and bank regulatory and supervisory policies.

4. The empirical relation between financial stress and repurchase markets

In light of these theoretical arguments and market conditions, it is possible at this point to empirically examine the dynamics of the repo market and its relationship with measures of financial stress. As noted above, an increase in the volumes of failures-to-deliver or failures-to-receive securities in the repo markets may be reflective of higher liquidity risk. The empirical relationship between liquidity risk and financial stress can be assessed according to the following regression model (Model-I).

$$\Delta F_t^{TB} = \mu + \beta \Delta F_{t-1}^{TB,d} + \gamma \Delta F_{t-1}^{TB,r} + \sum_{k=1}^{K} \delta_k \Delta S_{t-k} + \varepsilon_t^{TB} \qquad [1]$$

where ΔF^{TB} refers to changes in the volume of failures in the repurchase markets for treasury bonds, and ΔS denotes changes in the financial stress index.

Model equation [1] is estimated with respect to government bonds, and it assumes that variations in the fails-to-deliver $\Delta F_t^{TB,d}$ or changes in fails-to-receive $\Delta F_t^{TB,r}$ are function of past observations of similar failures as well as past changes in the financial stress index ΔS_{t-k}. In addition to the significance of drift terms μ, the focus is placed on the sign and magnitude of the estimated coefficients β and γ. Model-I can be used to understand the dynamics of failures to deliver $\Delta F_t^{TB,d}$ as a negative coefficient β associated with past failures to deliver $\Delta F_{t-1}^{TB,d}$ is indicative of mean reversion, whereas a positive sign is reflective of long memory process. The distinction is important because in the latter case, liquidity risk is likely to accumulate over time, whereas in the former case, it is likely to revert to its historical average. The relationship between financial stress and failures to deliver or failures to receive in the repo markets is expected to be positive and significant, as perceptions of higher levels of liquidity risk and financial stress are likely to feed into each other.

With respect to failures in the repo markets for corporate securities, Model-II expressed by equation [2] is inclusive of changes in the fails-to-deliver and fails-to-receive treasury bonds in addition to the explanatory variables used in Model-I. The rationale behind the inclusion of treasury notes as explanatory variables in Model-II is that the cost of borrowing corporate securities may be function also of the dynamics of borrowing treasury bonds in the repo market. It is important to note also that the cost of fails associated with treasury bonds may be lower than

that of covering a short position if the repo rate does not exceed the threshold of negative three-percent points. Also, signs of market strain are likely to appear in treasury markets, where the Federal Reserve tends to inject liquidity by buying short-term treasury bonds, inflating thereby its balance sheet.

$$\Delta F_t^{CS} = \mu + \vartheta^d \Delta F_{t-1}^{TB,d} + \varphi^r \Delta F_{t-1}^{TB,r} + \beta \Delta F_{t-1}^{CS,d} + \gamma \Delta F_{t-1}^{CS,r} + \sum_{k=1}^{K} \delta_k \Delta S_{t-k} + \varepsilon_t^{CS} \quad [2]$$

The above Model-I and Model-II are estimated using changes in the weekly volumes of failures for Treasury bonds excluding inflation protected securities and corporate securities. For these purposes, the distributional properties of relative changes in the weekly indicators of liquidity risk and financial stress are also estimated and reported in Table 1. The changes in the St Louis financial stress index are found to be, an average, negative. Given the fact that the stress index is set to have an average value of zero, the focus is made most importantly on measures of variance and skewness. The range of the financial stress values is rather wide, and the distribution seems to be left skewed with a stretched left tail. The significant levels of volatility in financial stress are primarily associated with major events such as the U.S. credit and financial crisis, and most recently with the disease outbreak.

Table 1. Distributional properties of financial stress and liquidity risk indicators

Financial Stress and Liquidity Risk	St. Louis Fed Financial Stress	Government Bonds		Corporate Securities	
		Fails-to-Deliver	Fails-to-Receive	Fails-to-Deliver	Fails-to-Receive
Mean	-0.062	0.042	0.039	0.022	0.022
Maximum	42.813	2.541	2.371	1.514	1.130
Minimum	-89.432	-0.820	-0.780	-0.499	-0.519
Std. Dev.	5.654	0.309	0.295	0.206	0.200
Skewness	-9.523	2.182	1.952	1.445	0.851
Kurtosis	185.689	16.102	14.473	10.826	5.921
Jarque-Bera	504662.11	2852.70	2196.82	1041.12	170.97
ADF test	-18.621***(a)	-16.460***(b)	-16.296***(b)	-14.604***(b)	-17.885***(b)

*Notes: ADF test refers to Augmented Dickey-Fuller unit root test performed with neither intercept nor trend terms [(a)], and with intercept only [(b)]. Significance at the 1% level is denoted by asterisks ***.*

In contrast, failures to deliver and failures to receive government bonds and corporate securities are associated with positively skewed distributions and positive averages of weekly changes. Whereas the mean values for changes in the volume of fails-to-deliver and fails-to-receive may differ for government bonds, they are more likely to be consistent with respect to corporate securities. Finally, Jarque-Bera tests of normality indicate that the null hypothesis of a normal distribution is rejected for all time-series. Also, the Augmented Dickey-Fuller tests for

unit root suggest that the return series are stationary.

Given these distributional and stationarity properties, it is possible to estimate the regression Models I and II to understand the empirical relation between changes in the volume of fails and financial stress index. With reference to Panel-A in Table 2, the evidence from the estimation of Model-I for fails-to-deliver treasury bonds suggests that these dynamics do not depend so much on past changes in fails-to-deliver or fails-to-receive as on the history of changes in financial stress levels. Indeed, failures to deliver government bonds follow a significant drift and do not seem to be influenced by historical observations. The tendency for failures to deliver to accumulate over time through a long memory process is not statistically significant. Its tendency to diminish in association with higher fails-to-receive is not statistically significant either. As indicated by the negative coefficient δ_2, an increase in financial stress levels over the past two weeks is, however, likely to be associated with lower volumes of fails-to-deliver treasury bonds.

In contrast, weekly changes in the fails-to-receive treasury notes are characterized by a negative relation with variations in financial stress but they are more likely to be governed by past changes in both fails-to-deliver and fails-to-receive. Indeed, the negative and significant coefficient γ suggests that fails-to-receive are likely to be associated with a long memory process, which implies that past increases in the weekly volume of fails-to-deliver are likely to be amplified. Also, changes in fails-to-receive are found to be negatively related to past changes in fails-to-deliver. This evidence suggests that falling volumes of fails-to-deliver are not likely to be followed by decreasing volumes but by rising volumes of fails-to-receive.

The results of Model-II estimation with respect to similar failures to deliver or receive corporate securities are reported in Panel-B of Table 2. The evidence suggests that changes in the volume of fails-to-deliver are governed by a drift term, albeit significant only at the 10% level, and a negative relation with changes in the level of financial stress over the past three weeks. The negative but insignificant coefficient β suggests that changes in fails-to-deliver are not strongly driven by mean reversion. Although, the coefficient γ is found to be positive, and its statistical insignificance implies that past changes in the volume of fails-to-receive are not likely to significantly affect subsequent changes in fails-to-deliver. This evidence does not lend support to the proposition that failure to receive necessarily feeds into subsequent failures to deliver. The result is rather consistent with the argument that the dynamics of failures to deliver and failures to receive are intrinsically related but not necessarily identical.

It is also noted that variations in the volume of fails-to-receive for corporate securities tend to be associated with stochastic dynamics partly similar to those governing fails-to-deliver. There is evidence indeed of a positive but weakly significant drift term μ, and insignificant coefficients β and γ, which reflect the level of sensitivity to past changes in the fails-to-deliver and fails-to-

Table 2. The relation between financial stress and transactions failures in repurchase markets

Regression Models	Drift term μ	Government Bonds		Corporate Securities		St. Louis Fed Financial Stress			Adj-R^2
		Fails-to-Deliver $\Delta F_{t-1}^{TB,d}$	Fails-to-Receive $\Delta F_{t-1}^{TB,r}$	Fails-to-Deliver $\Delta F_{t-1}^{CS,d}$	Fails-to-Receive $\Delta F_{t-1}^{CS,r}$	δ_1	δ_2	δ_3	
Panel A- Treasury Bonds Model-I- $\Delta F_t^{TB} = \mu + \beta\Delta F_{t-1}^{TB,d} + \gamma\Delta F_{t-1}^{TB,r} + \sum_{k=1}^{K}\delta_k\Delta S_{t-1} + \varepsilon_t^{TB}$									
Fails-to-Deliver $\Delta F_t^{TB,d}$	4.654*** (0.005)	0.204 (0.408)	-0.335 (0.195)			0.001 (0.641)	-0.006** (0.046)	-0.004 (0.124)	0.018
Fails-to-Receive $\Delta F_t^{TB,r}$	4.298*** (0.000)	-0.699*** (0.005)	0.563** (0.016)			0.001 (0.678)	-0.007** (0.017)	-0.004 (0.175)	0.035
Panel B- Corporate Securities Model-II- $\Delta F_t^{CS} = \mu + \vartheta^d\Delta F_{t-1}^{TB,d} + \varphi^r\Delta F_{t-1}^{TB,r} + \beta\Delta F_{t-1}^{TB,d} + \gamma\Delta F_{t-1}^{TB,r} + \sum_{k=1}^{K}\delta_k\Delta S_{t-1} + \varepsilon_t^{CS}$									
Fails-to-Deliver $\Delta F_t^{CS,d}$	1.912* (0.081)	-0.126 (0.156)	0.087 (0.344)	-0.151 (0.358)	0.198 (0.251)	0.000 (0.885)	0.001 (0.719)	-0.005*** (0.007)	0.018
Fails-to-Receive $\Delta F_t^{CS,r}$	1.994* (0.058)	-0.326*** (0.000)	0.258*** (0.003)	-0.091 (0.567)	0.151 (0.363)	0.000 (0.969)	0.000 (0.973)	0.003* (0.068)	0.036

*Notes: The estimation of Models I and II are based on the regression equations [1] and [2], respectively. Significance at the 1, 5, and 10% levels is denoted by asterisks *, **, and ***, respectively.*

receive corporate securities. There is however a weak but positive correlation with financial stress over the preceding three weeks. It is important to note also that instances of fails-to-receive in the repurchase market for corporate securities are sensitive to the dynamics of failures with respect to treasury bonds. Indeed, both regression coefficients ϑ^d and φ^r are found to be significant at the one-percent level. The negative coefficient ϑ^d implies that an increase in the fails-to-receive in the repurchase market for corporate securities is likely to be preceded by higher volumes of fails-to-deliver in the repurchase market for treasury bonds. In contrast, judging from the positive coefficient φ^r, it seems that increasing volumes of fails-to-receive of treasury bonds are likely to be associated with higher volumes of fails-to-receive in the repurchase market for corporate securities.

Thus, the empirical relation between fails-to-receive in the repurchase markets for treasury notes and corporate securities warrant further examination, particularly during periods of heightened financial stress. It is clear from the empirical evidence that the inner dynamics of delivery failures and reception failures for a given type of security are not likely to change in isolation from similar events for alternative securities, nor are they independent from the perceived levels of financial stress. There are signs of market integration and herding behaviour as the volumes of fails for various types of securities including treasury notes and corporate securities tend to follow similar patterns across repo markets. There is also evidence from Hüser, Lepore,

and Veraart (2021) of significant changes in trading volumes and spreads in the overnight gilt repurchase market during the covid-19 crisis relative to normal conditions. There is a stronger tendency for banks and dealers to trade in the cleared or tri-party segment of the market than on bilateral basis, and for spreads to increase when these market participants lend rather than borrow from non-banks.

The onset of the compounded healthcare and economic crises has, indeed, serious implications for the stability of the financial system and developments in the repurchase markets. Also, uncertainty about the future path of policy rates and monetary easing programs may drive market participants to sell treasury bonds and push the cost of borrowing in the repurchase markets toward negative rates if expectations about aggressive casing programs persist. Forward-looking indicators of future shifts in monetary policy and economic conditions are bound to play a critical role in shaping expectations about liquidity risk and financial stress.

5. Conclusion

The repurchase market does not seem to be a place where failure paves the way for success. The preliminary evidence presented in the present study suggests that the inner dynamics of transaction failures for a given type of security cannot be understood in isolation of failures to deliver or receive alternative securities. Nor can these transaction-failures be conceived independent from the perceived levels of financial stress. Indeed, failures to deliver and failures to receive securities in the repurchase markets can be explained, to some extent, by past changes in the perceived levels of financial stress. Failures in the repurchase markets for treasury bonds and corporate securities may, thus, provide vital signals about the likelihood of debt defaults, increased liquidity risk, and financial instability.

Thus, it is important to understand potential asymmetries in the behaviour of participants in repurchase markets under normal conditions and under higher levels of financial stress. It may be argued that under normal conditions, repurchase agreements constitute an essential instrument of open market operations, which allow central banks to implement monetary policies more effectively by regulating the money supply and bank reserves. However, it may be argued also that unconventional monetary policies with near-zero interest rates and quantitative easing programs are affecting repurchase markets in unconventional ways. The primary objective of monetary easing is to increase liquidity and decrease the cost of borrowing in order to promote real investment and economic growth, but quantitative easing programs seem to be reshaping the behaviour of participants in bond, equity and repurchase markets for short-term lending in important but less understood ways.

Indeed, quantitative easing programs have de facto added a new role for central banks as market-makers of last resort, strengthening thereby the incentive for behaviour marked by serious moral hazard. With low interest rates and negative bond yields, it is increasingly difficult for financial institutions to generate profits from traditional business models based on the differentials between long-term lending and short-term borrowing rates. Regulatory strictures introduced in the aftermath of the U.S. financial crisis require large banks to maintain large holdings of safe fixed-income securities that are associated with low yields. The new monetary and regulatory environment is exerting pressure on large financial institutions to reconcile the need for larger holdings of safe assets with the demands for higher return on assets, as well as with the necessity to mitigate liquidity risks.

Thus, there are stronger incentives for financial institutions to use repurchase markets to generate returns on safe assets that should be held in compliance with regulatory requirements. However, the increasingly complex trade-offs between the regulatory demands for larger holdings of safe assets, the imperative of generating higher income from risk-free assets, and market demands for liquidity provision cannot be addressed without recognizing the limits of debt financing. It is important for financial institutions and financial regulators to draw lessons from the recurrence of financial crises and reflect on the imperative shift away from financing modes based on debt and borrowing toward equity financing and partnership agreements, which are conducive to economic development and financial stability.

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