Dollar Illiquidity and Central Bank Facilities During the U.S. Sub-Prime Crisis

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Abstract

While the global financial crisis was centered in the United States, it led to a surprising appreciation in the dollar, suggesting dollar illiquidity in international financial markets. In response, the Federal Reserve, in cooperation with other central banks, engaged in efforts to inject dollar liquidity into the international financial system. Empirical studies of the success of these efforts have yielded mixed results, in part because their timing is likely to be endogenous. In this paper, we examine the cross-sectional impact of the central bank interventions. Theory consistent with U.S. dollar appreciation in the crisis suggests that the impact of these injections should be greater among countries that have greater exposure to the United States through trade and financial channels, less transparent holdings of dollar assets, and greater illiquidity difficulties. We examine these predictions for observed cross-sectional changes in CDS spreads, using a new proxy for innnovations in perceived changes in sovereign risk based upon Google-search data. Looking at the impact of both the auctions of dollar assets by foreign central banks, as well as announcements concerning changes in these programs, we find robust evidence that the auctions disproportionately benefited countries that were more exposed to the United States through trade linkages. However, we failed to find similar evidence for linkages through financial channels. We obtain weaker results for national differences in the impact of the auctions by the transparency of dollar asset holdings and measures of illiquidity. However, we do find evidence that the impact of several of the important announcements concerning the international swap programs disproportionately benefited countries exhibiting greater illiquidity.

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1 Introduction

Although the recent crisis exposed fragilities throughout the global economy, there can be no doubt that it originated and was centered in the United States. When difficulties arose in sub-prime mortgages in early 2007, investors became concerned about a wide set of U.S. assets, resulting in fire sales and the failure or near-failure of a number of systemically important U.S. financial firms that triggered a broad sell-off of U.S. financial markets [Bernanke (2009)]. Between October 2007 and October 2008, there was a $8 trillion sell off in U.S. equity values [Brunnermeier (2009)].

However, a wholly unforeseen feature of the recent financial crisis is that the American dollar actually rose in value. Going into the crisis, most thought that the adjustment process to undo the large global imbalances that had built up during the boom would include a sharp dollar depreciation [e.g. Krugman (2007)]. Instead, the crisis country currency appreciated [Engel (2009)]. For example, see Figure 1, which plots the VIX and VSTOXX measures of US and European equity market volatility respectively against the dollar-euro exchange rate at a daily frequency through the crisis period of late 2008. The dollar exchange rate moved quite closely with volatility in equity markets, as can be seen by examining plots of the VIX and VSTOXX indices. Further, the decline in volatility in global financial markets at the end of the year coincided with a decline in the value of the dollar.

Figure 1 leads us to the view that the appreciation of the dollar resulted from a flight to liquidity. There is a tight correlation between American and European volatility indices, measured by the VIX and the VSTOXX respectively, throughout the crisis. It therefore seems unreasonable to ascribe the sharp appreciation of the dollar against the euro solely to a flight to safety. Moreover, while it is probably true, as Fratzscher (2009) suggests, that there was an overall movement away from equities and towards securities, it is unclear that US securities should have been considered safer than their European counterparts, *especially since the crisis began in the United States!* Indeed, Cairns, Corinne, and McCauley (2007) find that the euro has tended historically to appreciate

against the dollar during episodes of increased turbulence, suggesting that if anything, we would expect a flight to safety to result in a euro *appreciation,* rather than a depreciation.

While the appreciation may have reflected both a flight to safety and a flight to liquidity [e.g. McCauley and McGuire (2009)], we concentrate on the illiquidity issue here. Most existing empirical studies of the period [e.g. Baba and Packer (2009b)] characterize the illiquidity as a shortage in dollar funding suffered by financial institutions worldwide. We argue that viewed from the prism of a global dollar liquidity shortage due to the unique role still enjoyed by the dollar in global financial markets, the temporary appreciation of the dollar is unsurprising.[1]

The aggressive response taken by the Federal Reserve and other central banks suggests that officials also perceived the dollar appreciation as reflective of a liquidity shortage. At the height of the crisis, the Federal Reserve extended dollar assets to major industrial countries, and several emerging markets' central banks to allow them to lend them to their domestic financial institutions experiencing dollar shortages. In discussing the transactions, Obstfeld, Shambaugh, and Taylor (2009) note that desirable alternatives to the swap arrangements did not exist, as increased domestic currency extensions from local central banks could have led to undesirable currency depreciation, and the use of foreign central bank dollar reserves would have seriously reduced their holdings, leading to further anxiety about that country's prospects.[2] Obstfeld, Shambaugh, and Taylor

[1]Goldberg and Tille (2008) show that the dollar plays a prominent role in invoicing in international transactions, even in many that do not involve agents from the United States. The motivations for invoicing in dollars include reducing transactions costs [Swoboda (1968), mitigating exposure to macroeconomic volatility [Giovannini (1988), Goldberg and Tille (2009)] and network effects [Rey (2001) and Goldberg and Tille (2008)]. Similar concerns drive currency invoicing decisions in debt issuance [Chinn and Frankel (2007)]. Firms typically balance currency mismatch decisions, which favor issuing in domestic currencies to match domestic currency dominated revenue streams, against the transactions cost savings available from issuing in high volume currencies such as the dollar. The impact of scale effects on currency issuance decisions has been demonstrated in the case of the advent of the euro, where the volume of issuance in euro immediately swamped issuance in any of the national currencies prior to the launch of the monetary union. Coeurdacier and Martin (2009) estimate that this reduced the cost of issuance by 14%-17%. Hale and Spiegel (2008) find that this substantially influenced issuance decisions in favor of issuing in euro.

[2]Unlike the transactions with the industrial country central banks, some of the swap arrangements with emerging market economies reflected the desire to provide liquidity to countries unwilling to obtain funds from the International Monetary Fund, and may have more reflected the need for hard currency reserves rather than the need for dollars [e.g. Engel (2009)].

(2009) claim that these transactions were "... one of the most notable examples of central bank cooperation in history ..." This underscores the severity of dollar illiquidity that was perceived to have existed at the height of the crisis.

The success of liquidity injection efforts is more uncertain. We review the literature to date on the success of these liquidity injections in the following section. Some of the studies [e.g. Taylor and Williams (2009)] find no impact of these auctions, while others, such as McAndrews, Sarkar, and Wang (2008), find significant but small impacts. More recent studies, such as Baba and Packer (2009b), concentrate on the most turbulent portion of the crisis and find larger effects. Overall, however, it is safe to characterize the evidence on the impact of central bank interventions as mixed. A portion of the challenges associated with evaluating the impacts of these liquidity injections is likely attributable to the endogeneity of the central bank actions, providing liquidity injections where and when they are most needed. If financial turmoil is persistent, as appeared to be the case in the preceding crisis, this could leave it difficult to assess the impacts of those interventions.

Given these difficulties, we examine the cross-sectional impacts of central bank efforts to address dollar-funding shortages.[3] We begin with a descriptive overview of the central bank responses to the global financial crisis, reviewing a number of the relevant empirical regularities that have been found in the literature. We then discuss the implications of a theoretical model derived in a companion paper [Rose and Spiegel (2011)] – and summarized in the appendix – that describes the crisis as stemming from toxic American assets but still predicts the observed dollar appreciation. We bring the cross-sectional predictions of the model to the data to reassess the impact of the attempts by the Federal Reserve and others to inject dollar liquidity into the global financial system. Theory suggests that the impact of these injections should be greater among countries that have greater exposure to the United States through trade and financial channels, less transparent holdings of dollar assets, and greater illiquidity difficulties.

[3] D'Amico and King (2011) also examine the impact of large scale asset purchases (LSAPs) by the Federal Reserve using a cross-section of individual firm issues.

We test these hypotheses by examining the impact of both announced U.S. dollar auctions and announcements of changes in the international swap arrangements in CDS spreads for a large cross-section of countries. We take as our event dates both the auctions conducted by foreign central banks using TAF auction proceeds and the announcements of changes in these international swap arrangements. We find robust evidence that the auctions disproportionately benefited countries that were more exposed to the United States, either through trade or financial channels, as the theory predicts. We obtain weaker or incorrect results for national differences in the impact of the auctions by the transparency of their dollar holdings and measures of illiquidity. However, we do find evidence that the impact of several of the important announcements concerning the international swap programs disproportionately benefited countries exhibiting illiquidity.

The following section reviews the evidence in the literature on the impact of the central bank swap lines on global financial conditions. Section three introduces our model. Section 3 discusses the theoretical implications of country characteristics for the relative impact of dollar injections in the cross section and motivates our empirical specification. Section 4 discusses the results of our "base" specifications. Section 5 conducts a battery of robustness tests on the data. Lastly, section 6 concludes.

2 Evidence on the impact of central bank responses to dollar illiquidity

Central bank swap lines were first extended in December 2007. The size of the swap lines and the number of countries involved in swaps changed markedly over the course of the crisis. Initially, the Federal Reserve established temporary reciprocal currency arrangements with the European Central Bank (ECB) and the Swiss National Bank allowing for the drawing of $20 billion and $4 billion respectively. However, as growing numbers of foreign banks exhibited liquidity shortages, the

programs were expanded. By October of 2008, the program became "uncapped" for the European Central Bank (ECB), the Swiss National Bank (SNB), the Bank of Japan (BOJ), and the Bank of England (BOE). [4] The range of swap lines was also broadened over this period from longer-term offers (one to three months) to also include one week and overnight offers, and from primarily repos and collateralized loans to also include foreign exchange swaps [Ho and Michaud (2008)]. In the turbulent fall of 2008, the swap programs were also extended to other countries, including Australia, Brazil, Denmark, Korea, Mexico, New Zealand, Norway, Singapore and Sweden. Other nations, including the Swiss National Bank and the ECB, also entered into swaps arrangements with other countries with funding needs in those countries' currencies.

These swap lines allowed these foreign central banks to access dollar-denominated assets which they could then lend to their financial institutions that were experiencing dollar illiquidity. At the height of the program at the end of 2008, draw downs reached $291 billion at the ECB, $122 billion at the BOJ, and $45 billion at the Bank of England [Goldberg, Kennedy, and Miu (2010)].

Other central bank efforts to inject dollar liquidity also emerged. The term auction facility (TAF) program, aimed at providing funds to financial institutions, was also introduced in December of 2007. Through this facility, depository institutions were able to borrow directly from the Federal Reserve without using the discount window [Taylor and Williams (2009)].[5] The ECB also conducted dollar term funding auctions. These were supported by the swap lines with the Federal Reserve and provided dollar funds to institutions in the European Union with ECB-eligible collateral [Baba and Packer (2009a)].

See Figure 2. The volume of TAF auctions increased dramatically during the fall of 2008, coinciding with the dates of the Lehman failure and the subsequent market turmoil. As financial

[4] See Ho and Michaud (2008) and Goldberg, Kennedy, and Miu (2010) for reviews of the details of the central bank swap programs during the crisis.

[5] As Taylor and Williams (2009) point out, it is important to remember that the liquidity effects of the TAF auctions are not due to any increase in total bank reserves of the amount of "high-powered money" in the financial system, as bank borrowing from the Fed was offset by open market sales of securities.

conditions improved, however, the terms offered under the overseas swap facilities became less desirable. Offer rates for dollar swap facility funds reached about 100 basis points higher than terms available to US and some foreign financial institutions under the TAF program. Moreover, by the first quarter of 2009 the market terms had improved to the point that participation in central bank swaps would only have been attractive to institutions lacking access to funds in private markets or lacking collateral necessary to participate in the TAF program [Goldberg, Kennedy, and Miu (2010)]. The volume of draw-downs decreased quickly as conditions improved.

The swap arrangements were designed to address exceptional circumstances, and the quick decline in draw-downs with improved financial conditions is not surprising. Still, at their peak they represented a crucial part of efforts by global officials to restore liquidity to the financial system, as evidenced by the enormous draw downs at the end of 2008 reported above. See Table 1, which reports the volume and average tenor of the TAF funds auctioned by the four major central banks over the course of our sample. It is clear that this injection of dollar-denominated capital was large and accessed, with volumes peaking in the fall 0f 2008 for all of the four major foreign central banks.

In response, a number of studies have emerged attempting to gauge the success of the programs in improving global dollar liquidity. In an early study, Taylor and Williams (2009) examine the impact of the TAF auctions. They find no impact of these auctions on the 3-month spread of unsecured LIBOR lending rates over overnight index swaps (OIS), which they take as a proxy for interest rate expectations. There work was followed by a number of researchers, including McAndrews, Sarkar, and Wang (2008), who argued that a proper assessment of the impact of the TAF auctions required looking only at changes in the LIBOR-OIS spreads on days of announcements and auction operations. Using this methodology, they find that the TAF auctions and announcements accounted a cumulative reduction of more than 50 basis points in the OIS-LIBOR spread. Moreover, they find that international TAF auctions also had a statistically significant and even larger impact

on spreads than domestic auctions. Interestingly, both McAndrews, Sarkar, and Wang (2008) and subsequent work by Taylor and Williams (2008) based on spreads find that announcements had larger impacts on spreads than actual auctions.

Other efforts to characterize the impact of the central bank dollar injections concentrate on evidence from the FX swap market. As discussed in Baba and Packer (2009b), disruptions in the FX swap market began appearing at the height of the financial crisis. FX swap prices began to reflect increases in perceived counter-party risk among European financial institutions, as doubts grew about the abilities of these institutions to fulfill their dollar obligations. This resulted in deviations from short-term covered interest parity. Baba and Packer (2009b) find that the establishment of the international fund lines, as well as the dollar term funding auctions financed by these swaps had a significant downward impact on observed deviations from covered interest parity in the FX swap market. They obtain mixed results, as US dollar auctions are found to have had a robust negative impact on deviations to covered interest parity, subsequent to the Lehman failure, but not before. Similar results are reported in Baba and Packer (2009a) and Hui, Genberg, and Chung (2010).

The impact of the central bank actions on a broader set of countries is examined by Aizenman and Pasricha (2010). They concentrate on emerging market economies that were granted swap arrangements by the Federal Reserve at the height of the crisis. They find that the set of emerging market economies that received swap arrangements were selected in part on the basis of having exceptionally large outstanding obligations to the Federal Reserve. They find that the establishment of swap arrangements had little impact on national credit default swap spreads, but did contribute to exchange rate appreciation, or at least stemmed the depreciation of the exchange rate.

More recently, there have been in efforts to assess the impact of the large scale asset purchase (LSAP) program conducted by the Federal Reserve. These studies, including Ham (????), Krishnamurthy and Vissing-Jorgensen (2011), and D'Amico and King (2011) all find substantial impacts of the LSAP programs had substantial impacts on interest rates.

Overall, then, it is safe to characterize the evidence on the impact of central bank interventions as mixed. Even the work of McAndrews, Sarkar, and Wang (2008), which was subsequently confirmed by Taylor and Williams (2008), only finds about a 2 basis point impact of TAF events on LIBOR-OIS spreads. While it may not be surprising that the dollar auctions had their greatest effect during the height of the turmoil, it is safe to say that the observed responses during the pre-Lehman period was disappointing. Indeed, it was during this period that the unprecedented policies were adopted, providing a reminder that while this period was not turbulent relative to what immediately followed, it was still exceptional relative to recent historical data.

A number of difficulties have been pointed out with the time series-based evidence. One problem is that these approaches implicitly ascribe all movements not covered by measured changes in counter-party risk to the policy action, while a substantial number of other developments were simultaneously taking place [Taylor and Williams (2009)]. Another is that there is clear evidence that central bank swap policies have been endogenous: Aizenman and Pasricha (2010) find that the set of emerging market economies chosen as candidates for swap arrangements are notable in the magnitude of their outstanding US debt obligations. Similarly, one would think that private agents would consider an announcement concerning the design of the international swap program as revealing something about the central banks' views about the severity of the crisis situation. The time series evidence above has difficulty separating the direct impact of the program from its impact through private sector expectations.[6]

For these reasons, combined with the mixed results discussed above, it would be desirable to identify restrictions that one could make in the cross-section to take to the data to identify the impact of the central bank actions. That would allow one to identify a single policy intervention, and then examine the relative impact across a cross-section of countries to this single event. This

[6]One notable exception is D'Amico and King (2011) who identify significant impacts of the LSAP programs in a cross-section of securities. Moreover, they identify effects of pre-announced asset purchases, which they term "flow effects," which are related to the pre-announced injections of dollar liquidity on auction dates that we study below.

avoids a number of the timing and endogeneity issues associated with an event-study approach.

3 Empirical specification

3.1 Theoretical motivation

It seems natural to turn to the literature on money demand based on microeconomic frictions to examine the role of dollar illiquidity in the surprising dollar appreciation during the recent crisis. Early studies, such as Kiyotaki and Wright (1993) and Trejos and Wright (1995) established that a role for money that leads to positive money demand can be motivated within a search model where money acts as a convenient medium of exchange due to its superior liquidity, avoiding the need for a double coincidence of wants.[7]

More recently, Lagos and Wright (2005) develop a very tractable search-based monetary model by dividing each period into two sub-periods: In the first, agents enter a centralized market in which all goods and assets clear in a very standard manner. However, agents then move on to a decentralized market with anonymous bilateral matching and a double-coincidence problem reminiscent of the search literature. The combination of these two markets allows for the incorporation of bargaining under interesting conditions, including the possibility of illiquidity, with tractability ensured by the fact that the next period all agents reunite in the centralized market where outcomes are degenerate and in particular do not depend on the distribution of money holdings across agents. This useful methodology was extended further in Lester, Postlewaite, and Wright (2009b), who develop a closed-economy model where assets differ in their general acceptability, and hence liquidity. In their model, assets may be of high or low quality, and agents that are uninformed refuse to accept low quality assets in exchange.[8]

[7] Indeed, Kiyotaki and Wright (1993) argued long ago that such search-based models could be used for a wide variety of applications, beyond determining " ... which objects serve as media of exchange or to prove the existence of valued fiat money ..."

[8] See Lester, Postlewaite, and Wright (2009a) for a demonstration that equilibria in which agents reject assets that

In a companion paper [Rose and Spiegel (2011)], whose details are summarized in the appendix of this paper, we develop an international version of the search-based asset model of Lagos and Wright (2005).[9] In this model, assets differ both in their returns and in their liquidity, and are valued based on both of these characteristics. The possibility of illiquidity arises because, as in Lester, Postlewaite, and Wright (2009b), agents trading in decentralized markets reject assets whose value they don't recognize.

We then examine the implications of a once and for all decline in the yield on the opaque US asset. This reduces the value of opaque US assets that agents have in their portfolio, implying that in the event that they find themselves facing a coincidence of wants in a bilateral meeting with a US national, holding US dollar holdings constant, they will be more liquidity constrained. As a result, their demand for the other U.S. asset, in this case US currency, increases. This raises its value relative to other assets, including the other national currency, resulting in an appreciation of the dollar exchange rate.

Broadly, we interpret the decline in the yield on the opaque asset as analogous to the fall in the perceived value of exotic US assets during the global financial crisis, and the appreciation of the dollar relative to the value of the other national currency as analogous to an increase in the relative yield of safe US assets. In this manner, our model yields the result observed in the data that a decline in the value of the opaque US asset can result in a dollar appreciation. The intuition behind this result is that the decline in the yield on the opaque US asset reduces the total value of dollar-denominated assets in agents' portfolios, reducing their dollar liquidity. This raises their demand for the liquidity services provided by US currency. When assets become illiquid, demand increases for assets that are substitutes for those assets in exchange. This would be particularly true for a "reserve currency," such as the dollar, as one would expect that agents would have numerous

they do not recognize at any price are feasible.

[9] Geromichalos and Simonovska (2010) and Liu (2010) also develop international versions of the Lagos and Wright model.

liabilities outstanding that are denominated in that currency that would necessitate raising dollar liquidity to meet those obligations.

We do not want to suggest that the channel we model in Rose and Spiegel (2011) was the only source of dollar illiquidity during the crisis. Brunnermeier (2009) discusses the "liquidity spirals" that resulted from declines in asset prices because of the influence of those asset price declines on bank balance sheet positions. During the crisis, the losses experienced by banks on their balance sheets led them to tighten their lending standards further. This led to fire sales and further reductions in liquidity. Emerging market countries also had a need for foreign currency reserves. We view the results here as complementary to these other potential sources of illiquidity, because they are all related to the exceptional role played by the dollar in world financial markets. We would not expect a similar paradoxical outcome for a non-reserve currency whose nation experienced a similar crisis.

We next turn to our empirical work by assessing the implications of our model for the predicted impact of the central bank auctions conducted with dollar funds obtained from the Federal Reserve. In terms of the model above, we consider the capital injections as analogous to an increase in the stock of dollar assets held by agents on entering the market that exhibits dollar illiquidity (the "decentralized market" in our model). In the appendix, we demonstrate that the benefits of this injection are increasing in three characteristics: The first is the probability of needing to transact in US dollars in the decentralized market, which we proxy with alternative measures of exposure, as agents with greater exposure to the United States are more likely to find themselves in need of dollars for transactions or servicing liabilities. The second is the probability of being paired with an uninformed agent, which we interpret as reflected in the "opaqueness" of a country's aggregate dollar holdings. Finally, the impact is predicted to be increasing in the severity of dollar illiquidity in the country.

The contention that exposure will matter is also in Peter and McGuire (2009), who argue

that differences in financial system balance sheet exposure to US assets are likely to be positively correlated with dollar shortage vulnerabilities, and hence also more sensitive to central bank actions. While our model literally looks at liquidity shortages in trade, suggesting that the impact of the auctions will be greater with increased trade exposure, we also consider financial exposure to the United States, such as the exposure measures found to improve economic performances in Rose and Spiegel (2009).

To evaluate the impact for a cross-section, we follow Aizenman and Pasricha (2010) in examining the responses to central bank actions for a broad set of countries. However, our analysis differs from Aizenman and Pasricha (2010) in an important dimension. Their paper concentrates specifically on swap arrangements between a select set of emerging market economies (Brazil, Mexico, Korea, and Singapore) and the Federal Reserve. As they freely admit, this group that they dub the "selected four" was hardly chosen at random. All have disproportional liabilities to the United States, and there are other obvious considerations as well. For example, Korean officials were reportedly reluctant to obtain funds from the International Monetary Fund during the crisis due to its experience with that institution during the 1997 Asian Financial Crisis. Whatever the reason, the fact that only four emerging market countries were privy to such special treatment from the Federal Reserve demonstrates that they were not chosen at random. Moreover, while Aizenman and Pasricha (2010) try to condition for the selection stage in their work, they are limited to data that is available for a large cross section in their first stage specification.

As in Baba and Packer (2009b), we take as our event dates both the auctions conducted by foreign central banks using TAF auction proceeds and the announcements of changes in the international swap arrangements. Major announcements concerning international swap lines by the Federal Reserve during this period are shown in Table 1. The first is December 12, 2007, when the Federal Reserve announced its swap arrangements with the ECB and the Swiss National Bank. These were initially capped at $20 and $4 billion respectively.

With the increased turmoil in global financial markets in the fall of 2008, swap lines were extended and expanded. On September 18, 2008, lines were introduced for the BOE, the BOJ and the Bank of Canada, while lines with the ECB and the SNB were increased. Less than a week later, on September 24, swap facilities were introduced for the Reserve Bank of Australia, the Swiss Riksbank, the Denmark National Bank, and the Norwegian Central Bank. In October of the same year, existing lines were "uncapped," on October 13 for the BOE, the ECB and the SNB, and on October 14 for the BOJ. Finally, on October 28, 2008, lines were introduced for New Zealand, and on October 29, for Brazil, Mexico, Korea, and Singapore.

3.2 Data

3.2.1 Standard data

Our full sample is based on weekly data, and runs from December 10, 2007 to December 31, 2009, and includes 30 OECD and 38 non-OECD countries. Data on Foreign central bank auctions was obtained for the Federal Reserve Board of Governors, as were the details of announcements concerning changes in the Federal Reserve's swap program. We condition auction "events" for two characteristics: volume in overall dollar value and average tenor in length of contracts auctioned in days. The latter adjustment is important because securities auctioned varied from high maturities of 95 days to maturities as low as 1 day, representing substantially different levels of effective liquidity injections per dollar issued (See Table 2 for summary statistics for major central banks).

The bulk of our data is obtained from standard sources. We obtain CDS spread data, and S&P500 returns from Bloomberg. We obtain data on trade exposure to the United States from the IMF Direction of Trade statistics, and data on US asset holdings from the TIC or the IMF CPIS data set, as indicated. Other variables are constructed from these, as noted below.

3.2.2 Default risk proxy from Google search

Our primary non-standard data source concerns a proxy for indicators of perceived changes in country creditworthiness. Since LIBOR rates are limited to a small set of developed nations, we follow Aizenman and Pasricha (2010) in using differences in CDS spreads as our indicator of liquidity risk.[10] Of course, changes in country creditworthiness will also affect CDS spreads, so we need to condition on country creditworthiness. This is problematic for the broad cross section that we use in our study, as many of the countries in our sample do not have widely-traded instruments that one might typically consider as potential indicators of changes in a country's creditworthiness. Aizenman and Pasricha (2010) use Economist Intelligence Unit data for their sample of emerging market economies, but such data is only available monthly.

In response, we use weekly search data obtained from Google Insights for Search. Based on their own description [e.g. Google (2011)], Google Insights for Search analyzes a portion of worldwide Google web searches from all Google domains to compute how many searches have been done for a chosen group of terms relative to the total number of searches done on Google over time.

Google search data has now been used in a number of studies, such as Choi and Varian (2009)], who use search data results to predict levels of economic activity for automobile sales and unemployment figures. Use of such real-time data is most often used to describe current economic conditions, rather than forecast future ones, in a growing application commonly referred to as "nowcasting." Studies to date have verified a number of cases where the Google search data [e.g. Varian (2010) and Kholodin, Podstawski, and Siliverstovs (2010)].

This is the sense in which we use the Google search data in our study. To measure changes in the perceived sovereign risk of a country, we use the relative incidence of searches of words related to default risk combined with that country's name. The percentage change in search volume for a given country combined with these default-related terms is then used as as a proxy for changes in

[10] Aizenman and Pasricha (2010) provide a theoretical model that links liquidity with CDS spreads.

concerns about default risk about that country.

A number of features of Google Insights should be pointed out: Responses are plotted on a scale of 0 through 100. Figures are scaled by the highest volume response, which is given score 100. Remaining figures are then scored as their values as a share of the top reported value. Google also normalizes its series by a common variable, so values represent likelihoods of searches for a given country, rather than the absolute number of searches. This leaves all series country-specific. However, these series suit our purposes because we are only interested in the changes in our series over time, and the normalizations drop out.

One potential problem with our use of Google Insights as a proxy for changes in perceived default risk is that for proprietary reasons it does not provide numerical values for responses when they fall below a certain threshold. For our purposes here, we proxy the numerical value for such observations as equivalent to the lowest reported value, which is clearly an upper-bound estimate of its true value.

One might naturally be concerned about the potential value of this proxy, and therefore the possibility that our empirical model is underspecified. We therefore choose a set of credit-risk related words that are at least correlated with observed changes in perceived creditworthiness. Obviously, other estimates of changes in perceived country risk are not available at the high frequency that we use in our cross-section panel. This is what drove us to consider using the Google search data in the first place.

However, for the purposes of identifying a set of default-related words that will yield a viable Google search series, we compare the results of the Google searches with a different sets of default-related words. We begin with a set of 33 default-related words. While it would be desirable to evaluate all of the possible combinations of these words, this methodology is not possible because of restrictions placed by Google on the total number of searches that can be conducted on a single

day.[11]

In response, we developed a simple algorithm to choose the set of default-related terms we use to conduct the Google searches: First, we generated a full set of searches with each of the countries in our sample and one of the 33 default-related terms. We then regressed panels of these combinations of searches by countries and single default-related terms on monthly changes in Fitch sovereign ratings. We examine three series, foreign and domestic long term debt obligations and short-term foreign obligations. Of these, we were most interested in the results for foreign long-term obligations.

Our results for foreign long-term obligations are shown in Table 3.[12] We found three words which entered significantly for all of the Fitch series: crisis, financial, and freeze.[13] We then ran searches with these three terms and one of the remaining words. This yielded six words which improved the fit of the Google searches with in-sample changes in Fitch ratings, credit ,debt, exposure, liability, recession, and safety. We chose the set of four words that fit the best, which added the word "recession." We then examined the implications of adding a fifth word from this list. None of these improved the fit of our ratings changes regressions, so we settled on searches mentioning a country and one of four default-related terms: crisis, financial, freeze, and recession.

Correlations in the data between search volume and bond ratings changes are demonstrated in Figures 3 and 4. We plot the Google series for four countries, Iceland, Latvia, Greece and Ireland. Data availability differs by country, from as far back as 2004 for Ireland to 2008 for Iceland. However, all countries have data for the bulk of the crisis period. It can be seen that there is a lot of variability in the data, but all four countries appear to have credit downgrading episodes that correspond to local spikes in the Google series. Of course, there are lots of other spikes in

[11] We search over 112 countries for every variety of default-related terms.

[12] Results for domestic long-term and foreign short-term are avilable on request.

[13] We also found that the word "danger" entered significantly for short-term obligations, but neither of the other series. When adding this word to the 3 word base, however, the quality of fit deteriorated. In response, we continued with the 3 word base discussed in the text.

the Google data that do not correspond to a credit downgrading event, and the relationship does not always appear to be exactly contemporanous. Still, we would at least like to feel certain that changes in the Google ratings do correspond to changes in search volumes.

To investigate this question more formally, we considered the following panel specification for our entire cross-country sample:

$$\%\Delta Google_{it} = \alpha_t + \theta_i + \beta_1 \Delta Rating_{it} + \epsilon_{it}. \quad (1)$$

where $\%\Delta Google_{it}$ is the percentage change in the Google default proxy (hereafter referred to as default), α_t and θ_i are time and country dummy variables respectively, $\Delta Rating_{it}$ is the variable of interest, the change in country i's Fitch credit rating at time t, and ϵ_{it} is an independent error term, assumed to be well-behaved.

Our results are shown in Table 4. It can be seen that there is a strong negative relationship between increases in Google search volumes and ratings downgrades in our full data panel. We find it reassuring that the Google search volume data tracks this manifestation of changes in expectations about sovereign default risk in the manner we desire. We therefore use changes in the volume of Google index searches for a country name and one of the words associated with sovereign risk listed above as a proxy for changes in the public perception of default risk for that country.

3.3 Base Specification

We begin with an analysis of the impact of country characteristics on the sensitivity to the TAF auctions.[14] We consider the impact of the announcements of changes in the swap arrangements below. Our sample is a broad panel of emerging market and smaller developed economies. First,

[14] As mentioned in the previous section, the results reported here were obtained using the ad hoc list of default-related terms to form our Google search-based proxy for innovations in perceived sovereign risk.

we examine the average implications of the TAF auctions across the sample, along with interactive slope variables to capture the extra sensitivity exhibited by countries of certain characteristics suggested by the above model. The specification satisfies

$$\Delta CDS_{it} = \alpha_i + \beta_1 Exposure_{it} \cdot SP500_t + \beta_2 auction_{t-1} + \beta_3 Exposure_{it} \cdot auction_t$$
$$+\beta_4 Transp_{it} \cdot auction_{t-1} + \beta_5 Illiquid_{it} \cdot auction_{t-1} + \beta_6 \triangle Default_{it} + \beta_7 \epsilon_{it}.$$

where ΔCDS_{it} represents the change in CDS spreads on country i sovereign debt between from period $t-1$ to t; θ_i is a country time dummy; $Exposure_{it}$ represents exposure to the United States, measured in a variety of different ways discussed below; $SP500_t$ represents the annualized percentage change in the S&P 500. $auction_{t-1}$ is equal to the sum of the volume of each auction during week $t-1$ times the average tenor of that auction in weeks where auctions took place, and 0 in weeks with no auctions.[15] $Transp_{it}$ represents dollar asset transparency, measured as the share of US asset exposure comprised of either short or long-term Treasuries; $Illiquid_{it}$ represents asset illiquidity, measured as the ratio of short-term US liabilities to total exports; $\triangle Default_{it}$ represents the change in Google search volume for country i and words related to default from the list above at time t; and ϵ_{it} is a disturbance term, assumed to be well behaved.

Our three variables of interest are the interactive terms representing the relative impact of the auctions on country i dollar liquidity by exposure, asset transparency, and illiquidity: $Exposure_{it} \cdot auction_{t-1}$, $Transp_{it} \cdot auction_{t-1}$, and $Illiquid_{it} \cdot auction_{t-1}$. The remainder of the variables are nuisance parameters meant to capture other potential determinants of movements in sovereign CDS spreads, including $Exposure_{it} \cdot SP500_t$, which is meant to pick up the impact on country i of other

[15] We use lagged weeks for the auction variable because many auctions took place late in the week, requiring some time for the market response in terms of the impact on other nations to be felt. Recall that these auction events have all been previously announced, and hence are not surprises. We look at the impact of the announcements themselves below.

economic developments in the US, $auction_t$, which is meant to pick up the average impact of the TAF auctions across countries, and $\triangle Default_{it}$ which is our Google measure meant to capture changes in the public's perception of default risk in country i.

We consider two types of measures measures of "exposure" to the United States. First, we consider trade-related measures, such as $Exports$, $Imports$ and total $Trade$ with the United States, both as a share of total trade and in levels. These variables are closer to the explicit model above, in the sense that we would expect that agents with more trade with the United States would be more likely to find themselves with potentially profitable trade opportunities with US nationals.

However, we also consider a variety of measures of asset exposure, including $Assets(TIC)$, which measures total holding of US assets based on TIC data; $Assets(CPIS)$, which measures US assets as a share of total global asset holdings, according to the IMF CPIS data set; and $Debt$ and $LTdebt$, which measure total and long-term holdings of US debt according to the CPIS data set respectively.[16]

Estimation is done by OLS using robust standard errors. Results are shown in Table 5. We first consider the three interactive variables of interest. The interacted exposure variable consistently obtains its expected negative coefficient value, but is only significant for $Imports$, which enters at a 1% confidence level (Model 2). The transparency variable is more consistent, entering negatively for all exposure proxies at a 1% confidence level or higher. Unfortunately, this is exactly opposite the expected impact from the theory. Theory suggests that more transparent assets should obtain smaller asset declines as a result of the TAF auctions. Finally, the illiquidity variable consistently obtains its expected negative sign, but is insignificant throughout.

We obtain more concerning results for the $auction_{t-1}$ variable. This variable consistently enters with the wrong positive sign, in all but one of our specifications at a 1% confidence level.

[16]Below, we report results based on trade and asset exposure as separate specifications. However, we also ran specifications with a form of both types of exposure included, and obtained similar results. These are available on request.

Among the nuisance parameters, the $Exposure_{it} \cdot SP500_t$ variable consistently enters significantly with its expected negative sign, usually at a 1% confidence level, and the $\triangle Default_{it}$ consistently obtains its expected positive coefficient estimate and is significant at a 5% confidence level with all of the specifications with exposure measured by financial variables, but is insignificant in the specifications with exposure measured as the share of trade with the US.

A difficulty with this specification, and one that it shares with much of the event study literature, is the endogeneity of the TAF auctions. As discussed above, the auctions took place primarily during the most turbulent periods in our sample. As such, movements in CDS spreads may be influenced by the same shocks that drove policymakers to conduct auctions on those dates.

This may explain the disappointing results we obtain for the $auction_{t-1}$ variable. It is possible, and indeed appears to be the case, that the bulk of TAF auctions, as well as the larger auctions, took place during periods of increasing turbulence, and hence increasing CDS spreads. Regressing CDS spreads on TAF auction may therefore lead to erroneous inferences that the TAF auctions were ineffective in injecting liquidity into the global financial system. Indeed, this may explain the mixed empirical results obtained in the literature reported above.

Ideally, one would like to allow for time fixed effects in this specification. However, these fixed effects would be collinear with the $auction_{t-1}$ variable, as the timing, total volume and average tenor of auctions are common across countries.[17] We therefore insert time dummies and drop the $auction_t$ variable according to the following specification:

$$\Delta CDS_{it} = \alpha_i + \theta_t + \beta_1 Exposure_{it} \cdot SP500_t + \beta_2 Exposure_{it} \cdot auction_{t-1}$$
$$+\beta_3 Transp_{it} \cdot auction_{t-1} + \beta_4 Illiquid_{it} \cdot auction_{t-1} + \beta_5 \triangle Default_{it} + \beta_6 \epsilon_{it}.$$

where θ_t represent time dummies and all of the other variables are the same as above.[18]

[17] We examine the possibility of extra sensitivity in the countries directly receiving the auction funds below.

[18] While our specification is of weekly frequency, we only use monthly time dummies in the above specification.

Our results are shown in Table 6. Unsurprisingly, the R-squared is about twice the levels we obtained in the previous specification, as the time dummies are capturing the substantial variations in CDS spread changes over our sample period. In terms of the three variables of interest, the interactive *Exposure* variable consistently obtains a negative sign for trade-related measures of exposure (Models 1 through 3), but is very insignificant for all measures of asset exposure to the United States.

The interactive $Transp$ variable again robustly enters significantly with an unpredicted negative sign. This suggests that our model above is under specified, as the variable is likely picking up some benefit from having a relatively large stock of US Treasuries that allowed countries to fare disproportionately well on weeks with TAF auctions. It may be that those countries whose public and private agents hold a transparent US dollar portfolio – measured in our data as the share of long and short-term US treasuries in total US holdings – have a greater need for dollar liquidity during crisis periods than those that do not. This need may be time-varying, and therefore not conditioned for by our country fixed effects.

Finally, the interactive *Illiquid* variable is insignificant throughout.

Among our nuisance parameters, the $Exposure_{it} \cdot SP500_t$ variable is again significant with its predicted negative sign throughout, while the $\triangle Default_{it}$ is statistically insignificant, with the exception of Model 4 which measures exposure as the share of U.S. asset holdings using the TIC data.

Overall, because of the statistical issues discussed above, as well as the substantial increased R-squared obtained in the presence of the time dummies, we move forward with this latter specification as our "base specification." Using this specification, we conclude that the TAF auctions did seem to disproportionately benefit those countries that were more exposed to the United States through

When we use weekly time dummies, all of the variables, including both our variables of interest and the nuisance parameters are very insignificant, as can be seen in Table 1A in the appendix.

trade, but we find no statistically significant evidence of additional sensitivity due to asset exposure. Concerning the opaqueness of US asset holdings, we obtained exactly the wrong sign, suggesting that we were picking up an effect that was not predicted by our theory. Finally, we obtained insignificant results for the interactive illiquidity variable.

4 Robustness Tests

In this section, we subject our chosen base specification to a number of robustness checks, including using alternative measures of illiquidity, alternative sub-samples of the data, and examining the impact of announcements concerning the international swap arrangements, rather than the auctions themselves.

4.1 Alternative Illiquidity Measures

We consider three alternative liquidity measures to that used in our base specification. Our alternative measures include short-term debt as a share of GDP, the ration of short-term debt to international reserves, and the "Greenspan-Guidotti" illiquidity measure, which is measures as the ratio of short-term debt minus international reserves to international reserves. Except for these alternative illiquidity measures, we keep our base specification and again consider all seven exposure measures used above.

Our results are shown in Tables 7, 8, and 9. Table 7 measures illiquidity in terms of short-term debt to GDP. It can be seen that the results are qualitatively identical to those obtained with the first definition. The interactive exposure variable enters significantly with its expected negative sign for all trade-related measures, but is insignificant for exposure measured in terms of shares of asset holdings. The interactive transparency variable again enters significantly with a negative sign throughout, while the interactive illiquidity variable is insignificant. The nuisance parameters

also exhibit quite similar performances, with the default proxy only entering significantly with US exposure measured through the TIC variable.

Table 8 measures illiquidity in terms of the ratio of short-term debt to reserves. This variable again obtains a statistically significant negative sign for trade-related measures of exposure, but not for exposure measured as shares of asset holdings. The qualiative performances of all of the other variables are again quite similar to those in our base specification.

Table 9 uses the "Greenspan-Guidotti" measure of illiquidity, namely the ratio of short-term debt to reserves minus one. The interactive exposure measure again enters significantly with its expected negative sign for trade-related exposure measures, but is insignificant for the financial exposure variables. The interactive transparency variable continues to obtain a negative coefficient, but is now insignificant throughout. The interactive illiquidity variable is again insignificant, except for the Model 4 sample that measures US exposure using the Assets TIC data.[19]

Overall, the results of the base regression reported above appear to be robust to alternative illiquidity measures for the results for exposure and asset opaqueness, but the illiquidity results themselves vary in sign and significance depending on the measures used. This underscores our skepticism about the robustness of our results concerning the illiquidity measures.

4.2 Alternative Samples

We next consider dividing up our pooled sample into OECD and non-OECD sub-samples. It is quite plausible that these groups experienced different impact of the TAF auctions. We again use our base specification with the seven different exposure measures.

The results for the OECD sub-sample are shown in Table 10. These results are quite similar to

[19] One problem with our liquidity measures is that Ireland is a major outlier. For example, Ireland's Greenspan-Guidotti illiquidity measure is standard deviations above the mean. Nevertheless, we obtained similar results after dropping Ireland.

those in our base specifications. As above, the trade exposure variables all enter significantly with their expected negative signs and the asset-holdings measures of exposure, while the coefficient estimates are insignificant for exposure measures based on asset holdings. The interactive transparency variable is insignificant throughout, while the interactive *Illiquid* variable again universally obtains a negative coefficient estimate, but is insignificant except for Model 3, where it enters with the unexpected positive sign.

Turning to the nuisance parameters, the primary change is that the Google-based default proxy is marginally improved. It consistently enters with its predicted positive sign, although it is still significant at least at a 5% level in less than half of our specifications. The $S\&P500$ variable again also enters consistently with its expected negative sign at statistically significant levels.

The results for non-OECD countries are shown in Table 11. We continue to obtain a negative and statistically significant coefficient estimate for all of the trade-related interactive exposure variables, but the coefficient estimates for financial exposure to the US are insignificant.[20] The interactive $Transp$ variable is again negative throughout, but statistically insignificant for most specifications, while the interactive *Illiquid* variable again almost universally obtains a negative coefficient estimate, but is insignificant throughout.

Turning to the nuisance parameters, the interactive $S\&P500$ variable enters consistently with its expected negative sign at statistically significant levels, while the Google-based proxy for $\triangle Default$ actually enters significantly with the wrong sign for the specifications with trade exposure measures. Comparing this result with those in the previous table, it appears that the Google proxy is performing better for the OECD countries, which may stem from greater overall volumes in searches related to these countries.

However, overall the qualitative results in our base specification appear to be robust to break-

[20] In this sample Model 3, the specification that uses overall trade as a measure of US exposure marginally misses 5% statistical significance.

ing up the sample into OECD and non-OECD sub-samples. We obtain statistically significant coefficient estimates for the trade-related interactive exposure variables for both sub-samples, but not for the specifications with asset-based exposure measures. The other interactive variables tend to behave similarly.

4.3 Announcement Effects

We also examine the impact of the announcements listed in Table 1. We divide up the seven announcements listed into those applying to the "major central banks," the ECB, the BOE, the SNB, the BOJ and the Bank of Canada, and those dealing with the central banks of other economies. We have three major bank announcement weeks: The week including December 12, 2007, when the Federal Reserve initially announced the central bank swap programs with the ECB and the SNB, the week including September 18, 2008, when swap lines were introduced with the BOJ, the BOE, the Bank of Canada and funds were increased for the ECB and the SNB, and the week including October 13 and 14, 2008, when the ceilings on swap magnitudes were lifted with the ECB, the BOE, the SNB, and the BOJ. We have two weeks with announcements concerning other central banks, including September 24, 2008, when swap lines were introduced with Australia, Sweden, Denmark, and Norway, and the week of October 28 and 29, 2008, when swap lines were introduced with the reserve banks of New Zealand, Brazil, Mexico, Korea and Singapore.

Unlike the anticipated auctions examined above, we consider the "event week" associated with the announcements as the week in which the announcement was made. The intuition behind this assumption is that information flows are likely to be close to instantaneous, while the liquidity effects of anticipated injections of capital on other countries may take some time to establish.

We examine the impacts of these announcements by interacting our three variables of interest, *Exposure*, *Transp* and *Illiquid* with two announcement date dummies, labeled by the date of the first important announcement of that week. We also include the auction information included

in the specifications above for completeness, but these coefficient values are suppressed for space reasons.[21] The remainder is our base specification, with all seven alternative exposure variables.

The results for the major central bank announcements are shown in Table 12. None of the interactive variables are statistically significant for the week including December 12, 2007. For the week including September 18, 2008, however, the interactive *Transp* variable universally enters negatively at statistically significant levels, with the exception of Model 4, as above. The illiquidity variable also universally enters with its expected negative coefficient estimate, and almost always at statistically significant levels. Unlike the auction results, the exposure variable is insignificant throughout, with the exception of Model 4 where it is signficant with the incorrect sign.

We obtain stronger results for the the week including October 13 and 14, 2008, when the ceilings on swaps with the major central banks were lifted. The interactive exposure variable enters negatively throughout, with the exception of model 4, but is only statistically significant for the trade-related exposure variables.[22] The interactive *Transp* variable again universally enters negatively, usually at statistically significant levels. Moreover, the interactive illiquidity variable consistently obtains a negative sign, but is only statistically significant for Models 2 and 4.

We next turn to the announcements concerning swap arrangements with other central banks. These are shown in Table 16. The September 24, 2008 announcement, when swap lines were introduced with Australia, Sweden, Denmark, and Norway, this announcement appears to have a weaker impact overall than those for the major central banks. The interactive exposure is insignificant throughout, except for the exposure measure in model 4. However, for the first time we observed the interactive transparency variable entering significantly with its predicted positive sign, albeit only for the models with trade-related exposure measures and the Assets(TIC) exposure measure. The interactive illiquidity variable is also universally insignificant.

[21] These values are printed in an appendix table (A2).

[22] The TIC data sample has the interactive exposure variable entering significantly with its incorrect positive sign.

The later announcement, that of October 28 and 29, 2008, when swap lines were introduced with the reserve banks of New Zealand, Brazil, Mexico, Korea and Singapore, seems to have had a greater impact. The trade-related interactive exposure variable enters negatively thoughout, with the exception of Model 4, and at statistically significant levels in Model 2. The interactive transparency variable also enters negatively for the trade-related exposure measures, and at statistically significant levels throughout.

However, the biggest distinction is the illiquidity variable, which enters with its expected negative sign at statistically significant levels for all seven specifications. These are the strongest results we have obtained for the interactive illiquidity variable. The reason may be that this announcement, which extended the swap arrangements to emerging market economies for the first time, may have been particularly important news for other illiquid emerging market economies in our sample. The extension to this broader set of countries may have been perceived by the market as setting a precedent for extensions to other emerging market economies should they find themselves experiencing liquidity shortages.

Overall, the results for the announcement dates were mixed, although the signs of coefficient estimates were largely similar to those we obtained for actual auctions above. It appears that the most important announcement dates were on the weeks of October 13 and 14, 2008, when the ceilings on swaps with the major central banks were lifted, and October 28 and 29, 2008, when swap lines were introduced with the reserve banks of New Zealand, Brazil, Mexico, Korea and Singapore. On the former week, we found that sensitivity to the announcement was increasing in trade exposure to the United States at statistically significant levels, but financial exposure measures were insignificant. On the latter week, we found that sensitivity to the announcement was related to illiquidity at statistically significant levels in all of our specifications.

4.4 Differential Impacts for Swap Partner Countries

While the evidence above suggests that the broad cross section was affected by the international swap arrangements, it seems likely that the principal countries directly involved in those swaps may have been more affected on average. To investigate that possibility, we add slope dummies for countries that were direct auction recipients. We add three interactive variables to our base specification: $Exposure_{it} \cdot direct_{t-1}$ which interacts the exposure variables with a variable $direct_{t-1}$, which takes the value of auction volume to country i times the average tenor of the securities auctioned at time $t-1$ if country i received TAF funds in period $t-1$, and 0 otherwise, $Transp_{it} \cdot direct_{t-1}$, and $Illiquidity_{it} \cdot direct_{t-1}$.

The results are shown in Table 14. The slope coefficients of the trade-related interactive direct exposure variables are usually negative, but not at statistically significant levels. We also obtain negative, but usually insignificant coefficient estimates for the direct interactive illiquidity variables, while the direct interactive transparency variable tends to enter significantly with the wrong sign, suggesting that the perverse relationship we identified in the base regression above is even more intense for those countries that were direct fund recipients. In general, the results for the overall variables from our base specification are little changed by the inclusion of these direct impact variables. As a result, we conclude that the international swaps did indeed serve to promote general dollar liquidity, and gave little measurable special assistance to those countries who were the direct recipients of the funds.

We next examine the possibility that countries explicitly named in Federal Reserve Announcements have special sensitivity to hose announcements. We ran the specification for announcements (Tables 11 and 12) with the $Exposure_{it}$, $Transp_{it}$, and $Illiquidity_{it}$ variables interacted with two new variables *major* and *other*. *major* is a dummy variable that takes value one for the "major central banks," namely the ECB, the SNB, the BOE, the BOJ, and the Bank of Canada, on dates when they are specifically mentioned in Federal Reserve Announcements, and 0 otherwise, and take

value 0 for the other central banks in our sample throughout. Similarly, dummy variable *other* takes value one for the other central banks in our sample on dates when they are specifically mentioned in Federal Reserve Announcements, and value 0 for the major central banks throughout. We pool across these two groups of central banks because there are too few mentioned in any individual announcement to obtain a reasonable point estimate for the extra sensitivity countries might have to be directly involved in announcements concerning the swap programs individually. The cost of this aggregation is that we must constrain the coefficients to be identical across countries within these groups, but our use of the two interactive variables allows for coefficient differences between countries with major central banks and the rest of our sample.

Table 15 reports the coefficient estimates on the slope coefficients. We ran the specification including both the announcement events and the actual auction data (i.e. the specifications reported in Tables 12 and 13), with the new interactive terms added.[23]

One interesting result is that the $Transp_{it} \cdot major$ variable is positive and statistically significant throughout, which would be consistent with our original interpretations for this variable. This would suggest that among the major central bank countries, there was extra sensitivity to TAF announcements given a more opaque US asset portfolio, i.e. those major central bank countries with relatively lower shares of US Treasuries in their US asset portfolios were particularly aided by the creation or extensions of swap programs between their central banks and the Federal Reserve. We also obtain a negative coefficient throughout for our $Illiquidity_{it} \cdot major$ variable, which is also statistically significant for five of our seven specifications. This suggests that there was extra sensitivity to TAF announcements given a more illiquid US asset portfolio as well among those countries that were direct fund recipients. In contrast, the direct recipient coefficient estimates for the interactive exposure variables were insignificant throughout.

Among the announcements for the minor central banks, we found little robust evidence of

[23]For space reasons, Table 15 only reports the coefficients on the new interactive variables, but the results for the full specifications are available upon request from the authors.

special impacts on direct fund recipients. We did find some models that exhibited statistically significant coefficient estimates for the interactive exposure variables (i.e. Models 1, 6, and 7), as well as a significant negative coefficient estimate on the direct interactive illiquidity variable for one of the specifications (Model 1), but these were largely not robust. Therefore, while we do observe some extra impact on transparency (again, with the wrong sign), we conclude that the minor announcements had largely homogeneous impacts on all of the countries in our cross-section.

5 Conclusion

This paper argues that the appreciation of the U.S. dollar exhibited at the height of turbulence during the recent global financial crisis suggests that there was a global dollar shortage. Models with illiquidity in dollar markets can mimic this behavior, as declines in some dollar asset values – as occurred to toxic US during the global financial crisis such as mortgage-backed securities – can result in the appreciation of other dollar assets that can serve as substitutes in the provision of liquidity services. This includes currency, whose appreciation would be manifested in the surprising dollar exchange rate appreciation that occurred at the height of the global financial crisis. These models predict that injections of dollar liquidity, as occurred during the TAF auctions of the major foreign central banks, will have a disproportionately beneficial impact on economies that are more heavily exposed to the United States through trade or financial channels, have more opaque assets, or have deeper illiquidity problems.

We take these predictions to a cross-country panel, examining the impact of the TAF auctions on CDS spreads in a format that avoids a number of the problems encountered by the event studies in the existing literature. Our results suggest that the benefits of the TAF auctions were disproportionately enjoyed by those countries with greater trade exposure to the United States, but not greater asset exposure. We obtain weaker or incorrect results for national differences in the impact of the auction by the transparency of their dollar holdings and measures of illiquidity.

Looking at announcements concerning the TAF auctions, we found a number of announcements that did not have a measurable impact on our cross-section of CDS spreads, but among those that did, the signs of coefficient estimates were largely similar to those we obtained for the actual auctions. For the week of October 13 and 14, 2008, when the ceilings on swaps with the major central banks were lifted, we found that sensitivity to the announcement was increasing in trade exposure to the United States at statistically significant levels, but financial exposure measures were insignificant. For the week of October 28 and 29, 2008, when swap lines were introduced with the reserve banks of New Zealand, Brazil, Mexico, Korea and Singapore, we found that sensitivity to the announcement was related to illiquidity at statistically significant levels in all of our specifications. However, the most notable discrepancy was that we found much stronger implications for sensitivity in the predicted direction for differences in illiquidity for the announcements. For both of the mentioned announcements mentioned above, we found that decreases in CDS spreads were measurably greater for those countries that exhibited greater levels of illiquidity difficulties.

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6 Appendix

This appendix summarizes the model in Rose and Spiegel (2011), an international version of the search-based asset model of Lagos and Wright (2005), and its implications for the empirical specification in the paper.

There are two countries in the model, u and r, which can be interpreted as representing the United States and the rest of the world with identical preferences and production technologies. Country z has world output share of $\tau_z; (z = u, r)$, where $0 \leq \tau_z \leq 1$ and $\tau_u = 1 - \tau_r$.

In each period a continuum of infinitely lived agents participate in two distinct international markets: One is a Walrasian centralized global market, and another is a decentralized market, where pairs of buyers and sellers from the two countries are randomly matched. As in Lagos and Wright (2005) transactions in the decentralized market are characterized by a double-coincidence problem, which rules out barter, and anonymity, which rules out the provision of credit between matched agents. A tangible medium of exchange is therefore required for transactions to take place.

On each date, agents from country z $(z = u, r)$ can produce a tradable homogeneous good for the centralized market, x, using labor, h_z, according to the production function $x_z = h_z$. Utility is assumed to be concave in x and negatively linear in h according to $U(x_z) - h_z$ and $U'(0) = \infty$, so that x_z^*, the optimal production of x in each country satisfies $U(x_z^*) = 1$.

Agents also produce a good, q_z, which is tradable in the international decentralized market. q_z is produced at disutility $c(q_z)$, where $c' > 0$, $c" > 0$, and $c(0) = c'(0) = 0$. Agents value q_z according to the concave function $\upsilon(q_z)$, where $\upsilon' > 0$, $\upsilon" < 0$, $\upsilon(0) = 0$, and $\upsilon'(0) = \infty$, so that q_z^*, the optimal production of q_z satisfies $\upsilon'(q_z) = c'(q_z)$. To highlight the role that differences in information sets and asset illiquidity play in determining outcomes, we assume that both x and q are homogeneous across countries.

Each country has a domestic money supply, which is in fixed supply, and a real asset that yields a dividend in the centralized market the following period. There are good and bad assets. Bad assets yield a zero dividend, while good assets yield a dividend of δ_z units of x; $z = u, r$. Bad assets can be produced at zero cost.

Let ϕ_z and ψ_z represent the values of money and real assets of country z in the centralized market in terms of x respectively. As in Lester, Postlewaite, and Wright (2009b), agents can distinguish between bad and good assets in the centralized market, but in the decentralized market only informed agents can. Sellers who do not know the value of an asset will refuse to accept it at a positive price. As a result, bargaining only takes place where both agents are informed.

We focus on steady state equilibria. There is a fixed supply of trees in each country, A_z, and the supplies of both currencies grow at a constant rate, γ_z. Let $\widehat{k}$ represent the next period value of any variable k, so that $\widehat{M}_z = \gamma_z M_z$. Agents worldwide are assumed to share a common discount factor, β, and we assume that $\gamma_z > 1 > \beta$ for both countries.[24].

[24]If allowed, agents may choose to keep some of their assets out of the bargaining process in the decentralized market [Lagos and Rocheteau (2008)]. We rule this out for simplicity

Agents' centralized market portfolios are comprised of $m_{z,u}$ units of country u currency, $m_{z,r}$ units of country r currency, $a_{z,u}$ units of country u real assets, and $a_{z,r}$ units of country r assets. Let y_z represent income of an agent from country z in the centralized market, which satisfies

$$y_z = \phi_u m_{z,u} + \phi_r m_{z,r} + (\delta_u + \psi_r)a_{z,u} + (\delta_r + \psi_r)a_{z,r}. \tag{2}$$

Let $W(y_r)$ be the value function of an agent from country z in the centralized market, and define $V_z(m_{z,u}, m_{z,r}, a_{z,u}, a_{z,r})$ as the value function of an agent from country z in the decentralized market with portfolio $(m_{z,u}, m_{z,r}, a_{z,u}, a_{z,r})$. An agent from country z solves

$$\max_{x_z, h_z, \widehat{m}_{z,u}, \widehat{m}_{z,r}, \widehat{a}_{z,u}, \widehat{a}_{z,r}} W(y_z) = \{U(x_z) - h_z + \beta V_{z,u}(\widehat{m}_{z,u}, \widehat{m}_{z,r}, \widehat{a}_{z,u}, \widehat{a}_{z,r})\} \tag{3}$$

subject to

$$x_z \leq h_z + y_z - \phi_u \widehat{m}_{z,u} - \phi_r \widehat{m}_{z,r} - \psi_u(\widehat{a}_{z,u}) - \psi_r(\widehat{a}_{z,r}) + T_z, \tag{4}$$

where T_z is a lump-sum transfer returned to private agents in country z from revenues generated by money creation, $T_z = (\gamma_z - 1)M_z$. We demonstrate in Rose and Spiegel (2011) that y_z does not enter into the first order conditions. This is the mechanism through which the degenerate portfolio solutions are recovered each time the agents return to the centralized market in the Lagos and Wright (2005) framework. There are also four asset market clearing conditions, as the representative agent from each country holds his country's share of each asset.

In the decentralized market, agents are randomly paired into bilateral meetings. Let z and k represent the countries of origin of the buyer and seller respectively in the decentralized market $(z, k = u, r)$. To allow for international liquidity differences we assume that sellers in the decentralized market only accept assets denominated in their domestic currencies. The probability of landing in a meeting in which there is a coincidence of wants is exogenous, but is proportional to the share of output of country k, τ_k, and is greater among agents originating from the same country by an exogenous parameter $\alpha > 1$. Let $\lambda_{z,k}$ represent the probability that an agent from z is paired with an agent from k from whom he wants to buy, and $\widetilde{\lambda}_{z,k}$ represent the chance that an agent from z is paired with an agent from country k to whom he wants to sell. We assume that $\lambda_{z,k} \equiv \lambda\tau_k$ when $z \neq k$ and $\lambda_{z,k} \equiv \lambda\alpha\tau_k$ when $z = k$, and that $\widetilde{\lambda}_{z,k} \equiv \widetilde{\lambda}\tau_k$ when $z \neq k$ and $\widetilde{\lambda}_{z,k} \equiv \widetilde{\lambda}\alpha\tau_k$ when $z = k$, where λ and $\widetilde{\lambda}$ are exogenous constants.

All agents from country k are informed about the value of their domestic currency, but only a fraction ρ_k are informed about the value of a_k. We label meetings where the seller is informed about a_k "type 2," and meetings where the seller is uninformed "type 1." The type of meeting that is taking place is known to all.

Consider a type n meeting $(n = 1, 2)$ where there is a coincidence of wants between a buyer from country z and a seller from country k. Let $p_{z,k,n}$ represent the price paid by the buyer from country z to a seller from country k for $q_{z,k,n}$ units of the good, and let y_z and y_k represent the

wealth of the buyer and the seller respectively. Finally, let $\omega_{z,k,n}$ be the value of acceptable funds possessed by the buyer, i.e. those recognized by the seller and denominated in the seller's domestic currency. Given our assumptions above, $\omega_{z,k,1} = \phi_k m_{z,k}$, and $\omega_{z,k,2} = \phi_k m_{z,k} + (\psi_k + \delta_k) a_{z,k}$.

Assuming that the buyer has bargaining power θ and threat points are given by continuation values, the generalized Nash bargaining solution is similar to that in Lagos and Wright (2005):

$$\max_{q_{z,k,n}, p_{z,k,n}} [[\upsilon(q_{z,k,n}) + W(y_z - p_{z,k,n})] - W_z(y_z)]^{\theta} [[-c(q_{z,k,n}) + W(y_k + p_{z,k,n})] - W(y_k)]^{1-\theta} \quad (5)$$

subject to $p_{z,k,n} \leq \omega_{z,k,n}$.

The first order conditions satisfy

$$p_{z,k,n} = \frac{\theta \upsilon'(q_{z,k,n}) c(q_{z,k,n}) + (1-\theta) \upsilon(q_{z,k,n}) c'(q_{z,k,n})}{\theta \upsilon'(q_{z,k,n}) + (1-\theta) c'(q_{z,k,n})} \equiv \eta(q_{z,k,n}), \quad (6)$$

and

$$-\theta[-c(q_{z,k,n}) + p_{z,k,n}] + (1-\theta)[\upsilon(q_{z,k,n}) - p_{z,k,n}] - \varphi[-c(q_{z,k,n}) + p_{z,k,n}]^{\theta} [\upsilon(q_{z,k,n}) - p_{z,k,n}]^{(1-\theta)} = 0. \quad (7)$$

If the buyer's liquidity constraint is not binding $q_{z,k,n} = q^*$, where $\upsilon'(q^*) = c'(q^*)$, and $p_{z,k,n} = \eta(q^*)$, which satisfies 6. However, if the liquidity constraint is binding $p_{z,k,n} = \omega_{z,k,n}$ and $q_{z,k,n}$ satisfies 6 for $p_{z,k,n} = \omega_{z,k,n}$. Note that in either case the terms of trade only depend on the buyer's portfolio.

The value function of an agent from country z in the decentralized market then satisfies

$$V_z = \sum_{n=1}^{2} [\lambda_{u,n}[\upsilon(q_{z,u,n}) + W(y_z - p_{z,u,n})] + \lambda_{r,n}[\upsilon(q_{z,r,n}) + W(y_z - p_{z,r,n})]] + (1-\lambda) W(y_z) + \Psi_k \quad (8)$$

where $\lambda_{k,1} = \lambda_k(1-\rho_k)$, $\lambda_{k,2} = \lambda_k \rho_k$, and Ψ_k represents the extra utility of an agent from country k associated with being a seller relative to having no trade opportunities.

Let $\widetilde{q}_{z,k,n}$ and $\widetilde{p}_{z,k,n}$ represent the volume and proceeds of selling q to an agent from country z. Ψ_k satisfies

$$\Psi_k = \{\widetilde{\lambda}_i[-c(\widetilde{q}_{i,k,1}) + \widetilde{p}_{i,k,1}] + \widetilde{\lambda}_j[-c(\widetilde{q}_{j,k,1}) + \widetilde{p}_{j,k,1}]\}(1-\Phi_k) + \{\widetilde{\lambda}_i[-c(\widetilde{q}_{i,k,2}) + \widetilde{p}_{i,k,2}] + \widetilde{\lambda}_j[-c(\widetilde{q}_{j,k,2}) + \widetilde{p}_{j,k,2}]\}\Phi_k \quad (9)$$

where Φ_k is an indicator variable that takes value 1 if agent k is informed about a_k, and 0 otherwise. It can be easily seen that Ψ_k is invariant to the portfolio decision of the agent from country k.

We follow Lagos and Wright (2005) in defining $\ell(q_{z,k,n}) \equiv [\upsilon'(q_{z,k,n})/\eta'(q_{z,k,n}]-1$ as the liquidity premium in a type n meeting with a buyer from country z and a seller from country k. $\ell(q_{z,k,n})$ represents the increase in the buyer's utility from bringing an additional unit of country k currency into a type n meeting above its value in the next centralized market. We also follow Lagos and Wright (2005) in assuming that $\ell'(q_{z,k,n}) \leq 0$, which holds under usual conditions.

Differentiating V_z and combining the results with the centralized market solution conditions yields individual agents' demand for currencies u and r, as well as assets ψ_u and ψ_r. Equilibrium is defined as a solution for asset holdings, asset prices, the terms of trade in the decentralized markets, and leisure choices that satisfy the maximization conditions of each agent, the bargaining solutions in the decentralized markets, and market clearing in the centralized market. In the steady state, real variables are constant over time, and ϕ_z and M_z grow at a constant rate γ_z $(z = u, r)$. The steady state versions of the money and asset demand equations satisfy

$$\frac{\gamma - \beta}{\beta \lambda_u} \geq (1 - \rho_u)\ell(q_{z,u,1})I\{\widehat{\omega}_{z,u,1} < \eta(q^*)\} + \rho_u \ell(q_{u,2})I\{\widehat{\omega}_{z,u,2} < \eta(q^*)\}, \tag{10}$$

$$\frac{\gamma - \beta}{\beta \lambda_r} \geq (1 - \rho_r)\ell(q_{z,r,1})I\{\widehat{\omega}_{z,r,1} < \eta(q^*)\} + \rho_r \ell(q_{r,2})I\{\widehat{\omega}_{z,r,2} < \eta(q^*)\}, \tag{11}$$

$$\frac{(1 - \beta)\psi_u - \beta\delta_u}{\beta(\psi_u + \delta_u)\lambda_u} = \rho_u \ell(q_{z,u,2})I\{\omega_{z,u,2} < \eta(q^*)\}, \tag{12}$$

and

$$\frac{(1 - \beta)\psi_r - \beta\delta_r}{\beta(\psi_r + \delta_r)\lambda_r} = \rho_r \ell(q_{z,r,2})I\{\omega_{z,r,2} < \eta(q^*)\}, \tag{13}$$

where the conditions hold with equality when positive levels of money or assets are held. Existence and uniqueness of the equilibrium is demonstrated in Rose and Spiegel (2011).

We next examine the comparative static impact of a decline in δ_u. First by equation 12, the change in ψ_u with a decline in δ_u satisfies

$$\frac{\partial \psi_u}{\partial \delta_u} = \frac{\delta_u - \beta(\psi_u + \delta_u)\lambda_u \rho_u \ell'(q_{z,u,2})I\{\omega_{z,u,2} < \eta(q^*)\}}{\psi_u - \beta(\psi_u + \delta_u)\lambda_u \rho_u \ell'(q_{z,u,2})I\{\omega_{z,u,2} < \eta(q^*)\}}. \tag{14}$$

The numerator of equation 14 is unambiguously positive, but the denominator is ambiguous in sign. The necessary condition for $\partial\psi_u/\partial\delta_u \geq 0$ is that $\ell'(q_{z,u,2})$ is not "too large". We require the restriction $\psi_u \geq \beta(\psi_u + \delta_u)\lambda_u \rho_u \ell'(q_{z,u,2})I\{\omega_{z,u,2} < \eta(q^*)\}$, which implies that asset values fall with declines in their dividend streams, which we adopt.

Substituting from equation 12 into equation 10 and totally differentiating with respect to $\phi_u m_{z,u}$ and δ_u yields

$$\frac{\partial \phi_u m_{z,u}}{\partial \delta_u} = \frac{\psi_u + \delta_u \frac{\partial \psi_u}{\partial \delta_u}}{(\psi_u + \delta_u)^2 \beta \lambda_u (1-\rho_u) \ell'(q_{z,u,1}) I\{\widehat{\omega}_{z,u,1} < \eta(q^*)\}} \leq 0, \tag{15}$$

as $\frac{\partial \psi_u}{\partial \delta_u}$ can be signed as positive given the restriction above.

In contrast, it can be seen by inspection of equations 13 and 11 that ψ_r and $\phi_r m_{z,r}$ are invariant to changes in δ_u. This implies that a decline in δ_u will lead to an appreciation in country u's exchange rate, ϕ_u/ϕ_r.

A formal proof is in Rose and Spiegel (2011). Intuitively, as $m_{z,u}$ is exogenous, any change in real balances, $\phi_u m_{z,u}$ must come from an increase in ϕ_u. In contrast, since $\phi_r m_{z,r}$ is unchanged ϕ_r must be unchanged as well.

We next turn to our empirical work by assessing the implications of our model for the predicted impact of the U.S. dollar auctions by foreign central banks. We assume that dollar injections are surprise interventions that take place in the decentralized market subsequent to the fall in δ_u. As was the case empirically, the dollar injections are assumed to be loans which for tractability we assume are repaid in the next entry into the centralized market.

The impact of the liquidity injection on an agent from a foreign country can then be represented in terms of the change in the decentralized market value function with an increase in US currency holdings. The influence of country characteristics on the relative impact of the injections can then be shown in terms of the cross-partials of the decentralized market value function with respect to dollar holdings and these characteristics. We examine three: $\lambda_{r,u}$, ρ_u, and $\ell(q_{r,u,1})$. By equation 8, $\partial^2 V_r/\partial m_{r,u}\partial \lambda_{r,u}$, $\partial^2 V_r/\partial m_{r,u}\partial \rho_u$ and $\partial^2 V_r/\partial m_{r,u}\partial \ell(q_{r,u,1})$ satisfy

$$\frac{\partial^2 V_r}{\partial m_{r,u}\partial \lambda_{r,u}} = \phi_u[(1-\rho_u)\ell(q_{r,u,1})I_{r,u,1} + \rho_u \ell(q_{r,u,2})I_{r,u,2}] \geq 0, \tag{16}$$

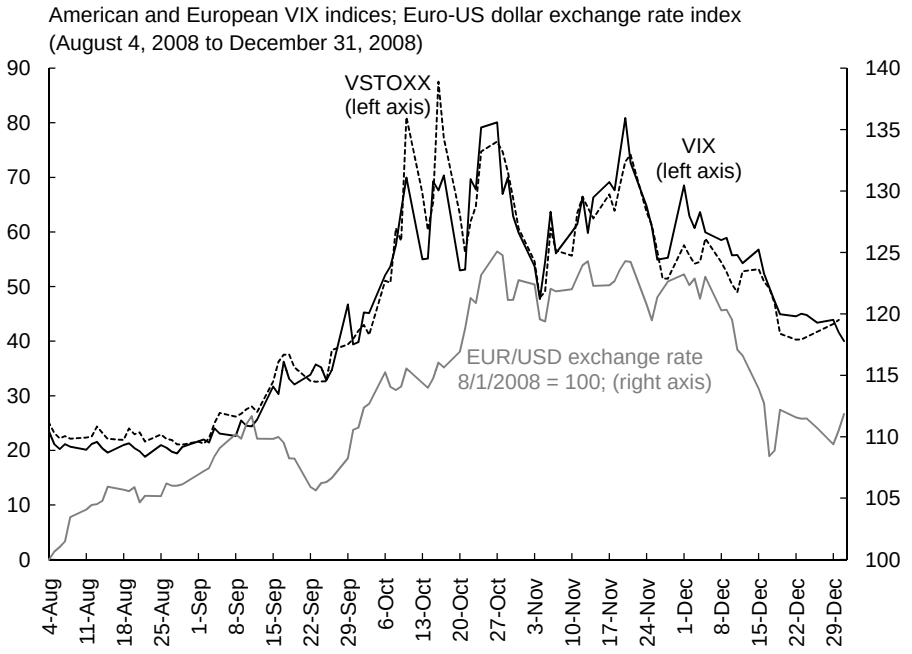
$$\frac{\partial^2 V_r}{\partial m_{r,u}\partial \rho_u} = \phi_u \lambda_{r,u}[-\ell(q_{r,u,1})I_{r,u,1} + \ell(q_{r,u,2})I_{r,u,2}] < 0, \tag{17}$$

and

$$\frac{\partial^2 V_r}{\partial m_{r,u}\partial \ell(q_{r,u,1})} = \theta_u \lambda_{r,u,1} I_{r,u,1} > 0. \tag{18}$$

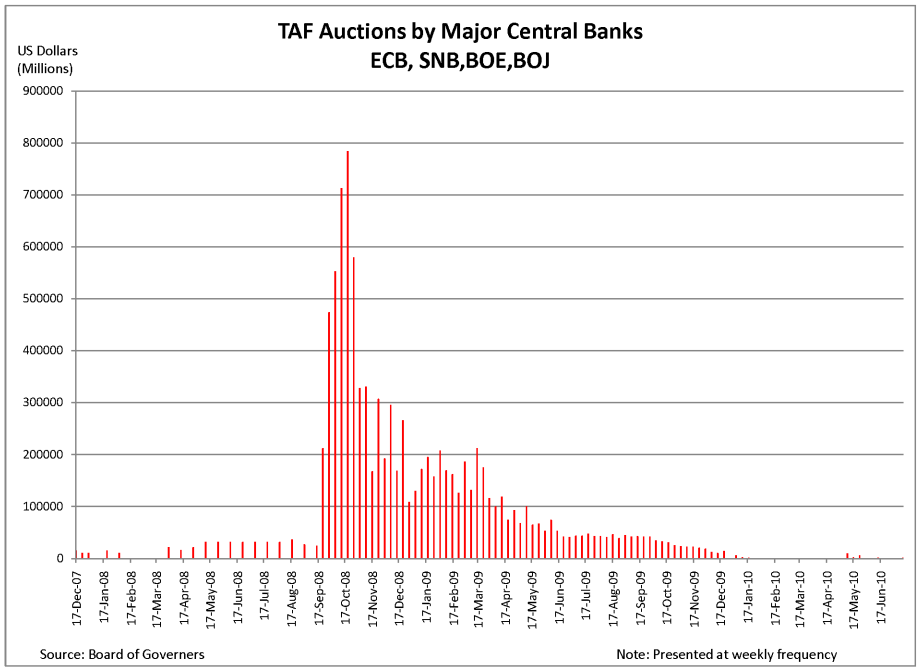
Our interpretation is of these results is discussed in the text.

Figure 1: Stock Market Volatility and Bilateral Exchange Rate



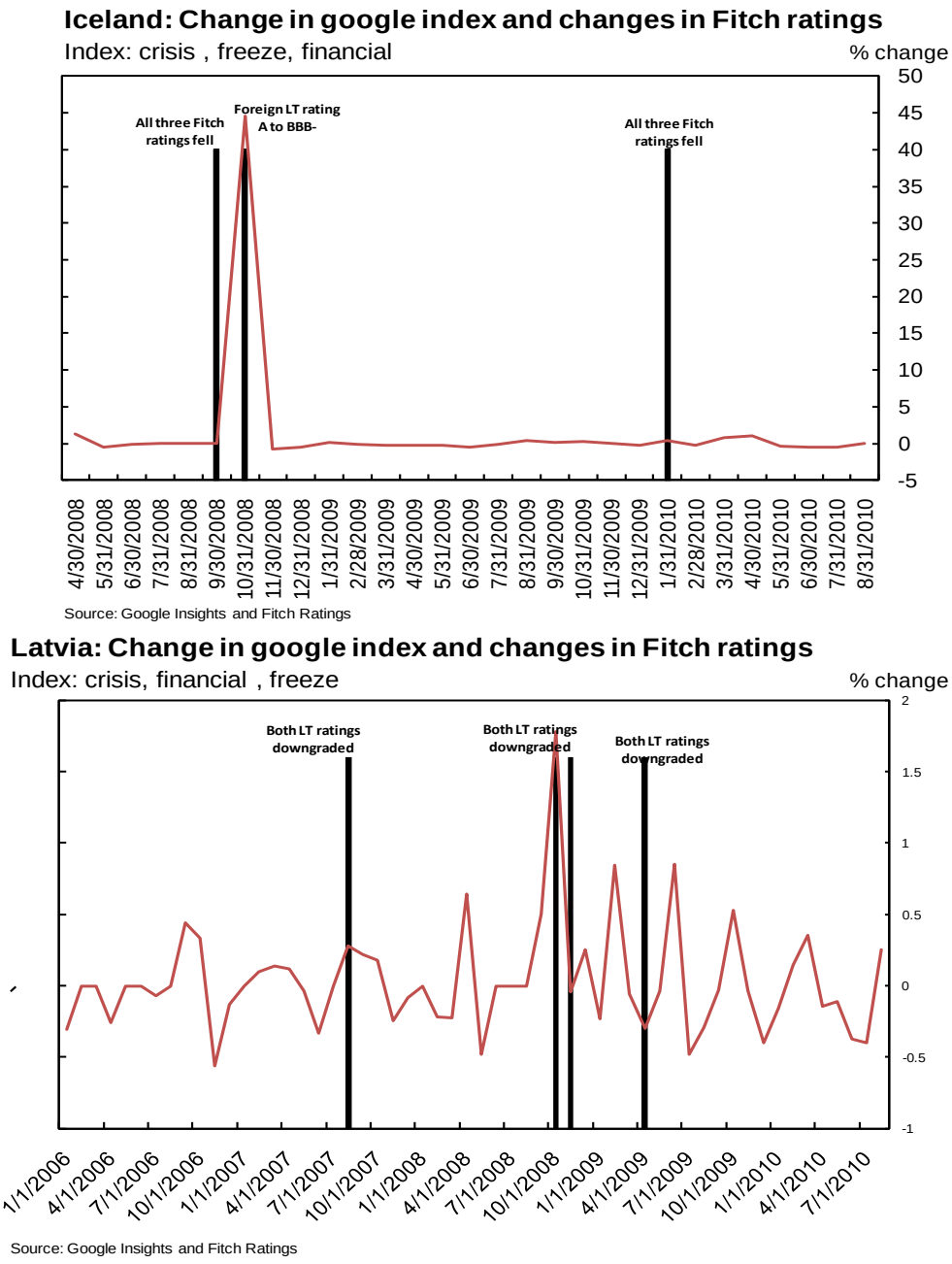
Sources: Bloomberg and DistFAME
VIX and VSTOXX indicies of equity market volatility in United States and European exchanges respectively.
Dollar-euro exchange rate indexed to 100 on August 1, 2008.

Figure 2: Weekly Major Central Bank TAF Auction Volumes



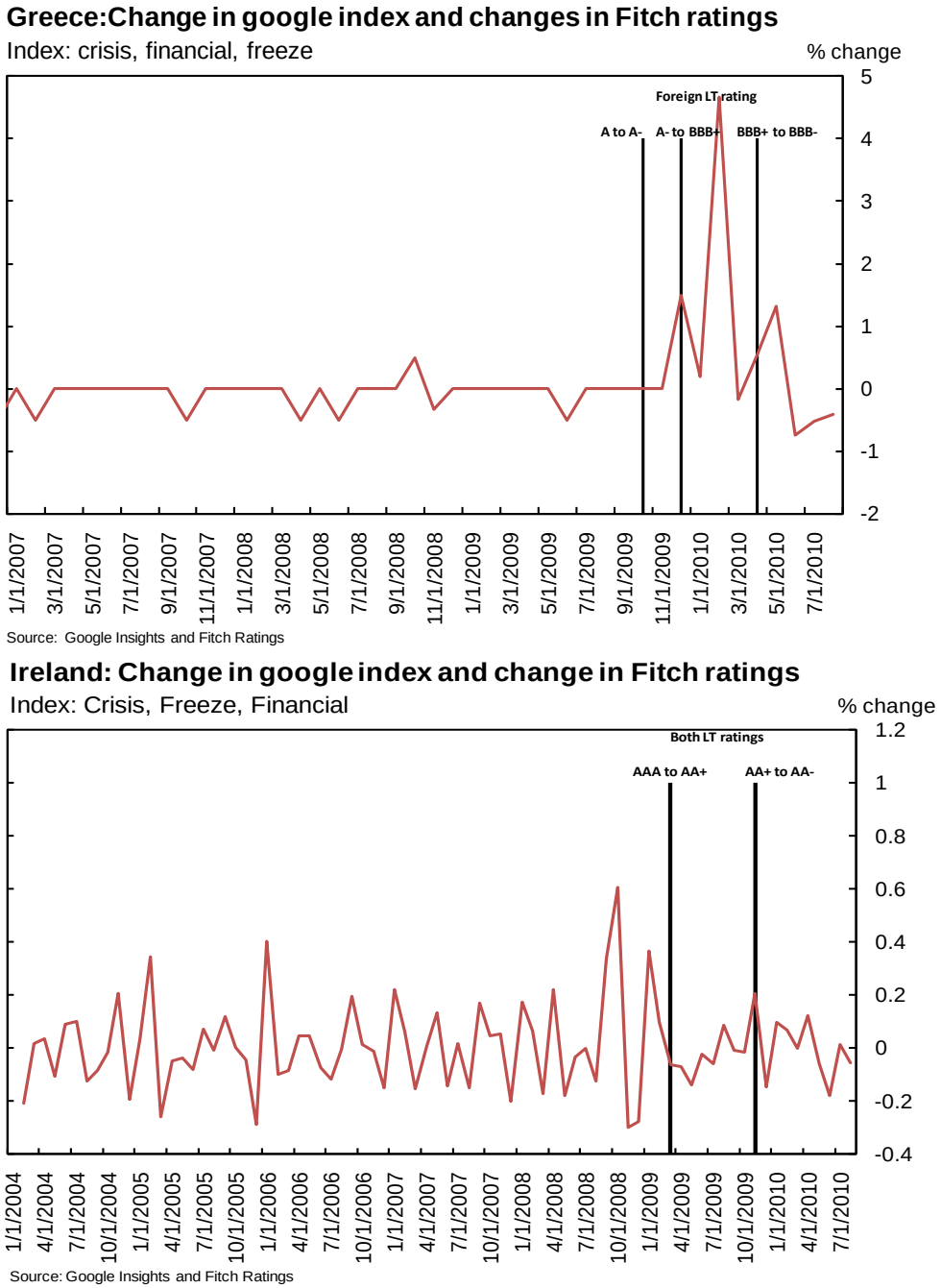
Source: Board of Governors
Total weekly volume of TAF auctions by major central banks.

Figure 3: Fitch Ratings changes and Google search volumes



Sources: Google Search Insights and Bloomberg

Figure 4: Fitch Ratings changes and Google search volumes (continued)



Sources: Google Search Insights and Bloomberg

Table 1: TAF Auctions by major central banks

Announcement Type	Date	Details
Swap lines introduced with ECB and SNB	12/12/2007	Authorization of temporary reciprocal currency arrangements with the European Central Bank and Swiss National Bank, providing $20 billion and $4 billion respectively.Arrangements authorized for up to six months.
Swap lines introduced with BOJ, BOE, and Bank of Canada. Funds increased for the ECB and SNB.	9/18/2008	New swap facilities authorized with the Bank of Japan for amounts up to $60 billion, the Bank of England for up to $40 billion, and the Bank of Canada for up to $10 billion. In addition, swap line provisions increased to $110 for the European Central Bank and $27 billion to the Swiss National Bank. Arrangements authorized through January 30,2009
Swap lines introduced with Australia, Sweden, Denmark, and Norway.	9/24/2008	Currency swap facilities established in amounts of up to $10 billion each by the Reserve Bank of Australia and Sveriges Riksbank and amounts of up to $5 billion each by Danmarks Nationalbank and the Norges Bank. Arrangements authorized through January 30,2009
Unlimited swaps announced with ECB, BOE, and SNB.	10/13/2008	Funds provided to swap facilities with the Bank of England, the European Central Bank, and the Swiss National Bank increased to "accommodate whatever quantity of U.S. dollar funding is demanded". Arrangements were authorized through April 30,2009.
Unlimited Swaps announced with the BOJ	10/14/2008	Unlimited swap arrangement announced with the Bank of Japan a day after the same announcement was made regarding swap lines with major central bank in Europe. Arrangements authorized though April 30,2009
Swap lines introduced with the Reserve Bank of New Zealand	10/28/2008	New swap line of up to $15 billion with the Reserve Bank of New Zealand announced. Arrangement authorized through April 30, 2009.
Swap Line Introduced with Brazil, Mexico, Korea, and Singapore.	10/29/2008	New swap facilities established in amounts of up to $30 billion each by the Banco Central do Brazo, the Banco de Mexico, the Bank of Korea, and the Monetary Authority of Singapore. Authorized through April 30, 2009.

Source: UPDATE)
Notes: UPDATE

Table 2: TAF Auctions by major central banks

	ECB		BOE		BOJ		SNB	
Quarter	Dollars Auctioned (Millions)	Average Tenor (Days)	Dollars Auctioned (Millions)	Average Tenor (Days)	Dollars Auctioned (Millions)	Average Tenor (Days)	Dollars Auctioned (Millions)	Average Tenor (Days)
2007q4	20000	31.5	-	-	-	-	4000	28.0
2008q1	35000	28.0	-	-	-	-	10000	28.0
2008q2	130000	28.0	-	-	-	-	30000	28.0
2008q3	589742	11.3	216044	2.1	29622	28.0	132139	11.8
2008q4	3608841	8.3	667737	9.7	205635	54.2	196948	11.3
2009q1	1937722	7.4	30956	50.6	106253	59.1	51702	20.0
2009q2	865642	9.5	3503	59.7	36243	49.4	41006	18.7
2009q3	542729	7.5	538	26.4	8100	31.5	18	28.0
2009q4	259478	7.5	52	7.0	1300	32.4	-	-
2010q1	6575	7.0	-	-	100	29.0	-	-

Source: Board of Governors)

Notes: Size (millions of dollars) and average tenor (days) of dollar auctions by major central banks.

Table 3: Single Word Google Search Results, Foreign Long-Term Debt

Word	Coeff	T-stat	R-sq	# of countries	# of obs
arrears	0.00263	0.63969	0.00007	4	89
balance	-0.00804	-0.78951	0.00037	73	3103
bankruptcy	0.00482	0.34133	0.00010	48	1081
bond	-0.03614	-1.37083	0.00767	83	3342
collapse	-0.00289	-1.01006	0.00030	56	1140
contraction	-	-	-	5	77
credit	-0.04056	-1.14338	0.00494	100	4705
crisis	-0.01548	-30.78583	0.07466	96	3779
currency	-0.01646	-1.11072	0.00107	105	6703
danger	-0.00613	-1.33332	0.00079	52	1352
debt	-0.01316	-1.15926	0.00142	82	2866
deficit	0.01410	1.15733	0.00159	56	1443
depression	0.00430	0.38199	0.00012	55	1814
disaster	-0.00028	-0.35360	0.00000	68	2321
downturn	0.00212	0.88936	0.00002	10	159
equity	-0.00429	-1.03095	0.00015	67	2694
exposure	-0.01607	-0.71277	0.00163	34	769
failure	-0.01601	-0.53411	0.00175	62	2014
financial	-0.06121	-2.26033	0.03905	100	4910
freeze	-0.02815	-3.51057	0.00332	43	807
insolvency	0.00227	0.89918	0.00004	15	356
liability	-0.00110	-0.07959	0.00000	41	1136
liquidity	0.01442	1.23534	0.00092	16	332
market	-0.03413	-1.07742	0.00426	104	5908
overdue	-	-	-	2	33
recession	0.00103	0.28506	0.00002	55	910
risk	-0.01965	-1.01747	0.00172	86	3503
safety	-0.01318	-1.24273	0.00058	93	4365
shortage	-0.00072	-0.27161	0.00002	42	1005
stock	-0.04151	-1.52674	0.02512	97	5093
tax	-0.01440	-1.00984	0.00067	101	5635
unpaid	-0.01309	-1.27611	0.00037	13	230

OLS estimation with robust standard errors.

Table 4: Google searches and sovereign ratings

Regression: Percent change in Google index on rating changes			
Regressor	Observations	Coefficient	T-value
Local LT	8773	-3.08	-6.85
Foreign LT	8738	-6.26	-11.43
Foreign ST	8961	-6.36	-5.71

Source: Google Search Insights, Bloomberg)
Notes: OLS panel estimation with country and time fixed effects included. Monthly data. Regression of Google index on changes in Fitch ratings.

Table 5: Base specification without time dummies

	(1) Exports	(2) Imports	(3) Trade	(4) Assets(TIC)	(5) Assets(CPIS)	(6) Debt	(7) LTdebt
ExposureXSP500	-8.79**	-7.57**	-10.05**	-0.01*	-0.04**	-0.04**	-0.04**
	(-5.87)	(-4.70)	(-6.84)	(-2.38)	(-5.67)	(-5.30)	(-5.14)
auction	0.55**	0.63**	0.57**	0.54**	0.48*	0.47*	0.43*
	(2.85)	(3.39)	(2.73)	(3.07)	(2.49)	(2.40)	(2.11)
ExposureXauction	-1.55	-2.34**	-2.17	0.00	-0.01	-0.00	-0.00
	(-1.36)	(-4.07)	(-1.62)	(1.15)	(-1.06)	(-0.95)	(-0.83)
TranspXauction	-0.68*	-0.67*	-0.65*	-0.86**	-0.67*	-0.68*	-0.62*
	(-2.58)	(-2.66)	(-2.57)	(-2.75)	(-2.39)	(-2.39)	(-2.19)
IlliquidXauction	-2.35	-1.21	-1.38	-0.91	-1.38	-1.44	-1.39
	(-1.69)	(-1.50)	(-1.69)	(-1.11)	(-1.35)	(-1.52)	(-1.47)
Δ Default	0.12	0.29	-0.00	2.42**	1.40	1.48	1.48
	(0.18)	(0.47)	(-0.00)	(3.16)	(1.78)	(1.86)	(1.85)
N	4196	4196	4196	3837	3693	3680	3603
R^2	0.108	0.105	0.126	0.016	0.120	0.114	0.114

t statistic in parentheses; OLS with country fixed effects and robust standard errors.

* $p < 0.05$, ** $p < 0.01$

Table 6: Base specification

	(1) Exports	(2) Imports	(3) Trade	(4) Assets(TIC)	(5) Assets(CPIS)	(6) Debt	(7) LTdebt
ExposureXSP500	-6.99**	-6.07**	-8.21**	-0.01*	-0.03**	-0.03**	-0.03**
	(-5.34)	(-4.66)	(-6.34)	(-2.24)	(-5.00)	(-4.61)	(-4.46)
ExposureXauction	-2.77*	-2.48**	-3.09**	-0.00	-0.01	-0.01	-0.01
	(-2.10)	(-4.50)	(-2.83)	(-0.13)	(-1.81)	(-1.64)	(-1.53)
TranspXauction	-0.51*	-0.53**	-0.46*	-0.80**	-0.46*	-0.50*	-0.52*
	(-2.15)	(-3.10)	(-2.19)	(-3.89)	(-2.07)	(-2.18)	(-2.24)
IlliquidXauction	0.70	-0.15	0.06	-0.76	0.16	-0.01	-0.06
	(0.40)	(-0.21)	(0.06)	(-1.47)	(0.16)	(-0.01)	(-0.06)
Δ Default	-0.07	0.08	-0.15	1.41*	0.84	0.89	0.91
	(-0.17)	(0.21)	(-0.40)	(2.51)	(1.40)	(1.49)	(1.49)
N	4196	4196	4196	3837	3693	3680	3603
R^2	0.198	0.197	0.210	0.148	0.205	0.202	0.200

t statistic in parentheses; OLS with country fixed effects, monthly time dummies, and robust standard errors.

* $p < 0.05$, ** $p < 0.01$

Table 7: Illiquidity proxied by ST Debt/GDP

	(1) Exports	(2) Imports	(3) Trade	(4) Assets(TIC)	(5) Assets(CPIS)	(6) Debt	(7) LTdebt
ExposureXSP500	-6.98**	-6.05**	-8.19**	-0.01*	-0.03**	-0.03**	-0.03**
	(-5.29)	(-4.67)	(-6.32)	(-2.24)	(-4.99)	(-4.58)	(-4.43)
ExposureXauction	-2.71*	-2.51**	-3.18**	-0.00	-0.01	-0.01	-0.01
	(-2.58)	(-4.46)	(-2.82)	(-0.20)	(-1.93)	(-1.73)	(-1.61)
TranspXauction	-0.51*	-0.52**	-0.44*	-0.79**	-0.45*	-0.48*	-0.50*
	(-2.37)	(-3.05)	(-2.10)	(-3.86)	(-2.08)	(-2.17)	(-2.23)
ill_gdpXauction	499852.96	197438.14	454241.92	-166203.06	343764.95	295236.08	290473.33
	(0.91)	(0.64)	(1.00)	(-0.57)	(0.89)	(0.77)	(0.77)
Δ Default	-0.07	0.09	-0.15	1.42*	0.86	0.90	0.91
	(-0.16)	(0.22)	(-0.39)	(2.52)	(1.41)	(1.50)	(1.50)
N	4144	4144	4144	3785	3641	3628	3551
R^2	0.198	0.197	0.210	0.148	0.205	0.201	0.200

t statistic in parentheses; OLS with country fixed effects, monthly time dummies, and robust standard errors.

* $p < 0.05$, ** $p < 0.01$

Table 8: Illiquidity proxied by ST Debt/Reserves

	(1) Exports	(2) Imports	(3) Trade	(4) Assets(TIC)	(5) Assets(CPIS)	(6) Debt	(7) LTdebt
ExposureXSP500	-6.99**	-6.07**	-8.21**	-0.01*	-0.03**	-0.03**	-0.03**
	(-5.33)	(-4.66)	(-6.33)	(-2.24)	(-4.99)	(-4.61)	(-4.46)
ExposureXauction	-2.66**	-2.49**	-3.13**	-0.00	-0.01	-0.01	-0.01
	(-2.71)	(-4.51)	(-2.88)	(-0.12)	(-1.96)	(-1.76)	(-1.64)
TranspXauction	-0.53*	-0.53**	-0.46*	-0.81**	-0.46*	-0.50*	-0.52*
	(-2.46)	(-3.09)	(-2.17)	(-3.89)	(-2.13)	(-2.22)	(-2.27)
ill_resXauction	0.07	-0.00	0.07	-0.07	0.04	0.04	0.03
	(0.60)	(-0.04)	(0.63)	(-0.83)	(0.39)	(0.33)	(0.25)
Δ Default	-0.07	0.08	-0.16	1.41*	0.84	0.89	0.91
	(-0.16)	(0.21)	(-0.40)	(2.51)	(1.40)	(1.49)	(1.49)
N	4196	4196	4196	3837	3693	3680	3603
R^2	0.198	0.197	0.210	0.148	0.205	0.202	0.200

t statistic in parentheses; OLS with country fixed effects, monthly time dummies, and robust standard errors.

* $p < 0.05$, ** $p < 0.01$

Table 9: Illiquidity proxied by Greenspan-Guidotti measure

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Exports	Imports	Trade	Assets(TIC)	Assets(CPIS)	Debt	LTdebt
ExposureXSP500	-6.98**	-6.06**	-8.21**	-0.01*	-0.03**	-0.03**	-0.03**
	(-5.32)	(-4.66)	(-6.34)	(-2.24)	(-4.99)	(-4.60)	(-4.45)
ExposureXauction	-2.15*	-1.99**	-2.41*	-0.00	-0.01	-0.00	-0.00
	(-2.13)	(-3.94)	(-2.14)	(-0.52)	(-1.21)	(-1.04)	(-0.91)
TranspXauction	-0.22	-0.26	-0.22	-0.31	-0.22	-0.24	-0.26
	(-1.01)	(-1.21)	(-0.98)	(-1.23)	(-0.96)	(-1.00)	(-1.10)
ill_GGXauction	0.32	0.30	0.29	0.42*	0.29	0.31	0.30
	(1.86)	(1.77)	(1.75)	(2.38)	(1.71)	(1.77)	(1.65)
Δ Default	-0.07	0.07	-0.16	1.38*	0.83	0.88	0.89
	(-0.17)	(0.19)	(-0.41)	(2.44)	(1.39)	(1.48)	(1.48)
N	4196	4196	4196	3837	3693	3680	3603
R^2	0.198	0.198	0.210	0.149	0.206	0.202	0.201

t statistic in parentheses; OLS with country fixed effects, monthly time dummies, and robust standard errors.

* $p < 0.05$, ** $p < 0.01$

Table 10: OECD countries only

	(1) Exports	(2) Imports	(3) Trade	(4) Assets(TIC)	(5) Assets(CPIS)	(6) Debt	(7) LTdebt
ExposureXSP500	-10.93**	-4.72**	-8.68**	-0.14**	-0.04**	-0.03**	-0.03**
	(-5.13)	(-3.92)	(-6.00)	(-2.89)	(-5.67)	(-5.66)	(-5.74)
ExposureXauction	-5.19*	-1.97**	-4.00**	-0.01	-0.01	-0.01	-0.01
	(-2.67)	(-3.27)	(-3.65)	(-0.13)	(-1.67)	(-1.87)	(-1.69)
TranspXauction	-0.82	-0.75	-0.64	-1.22	-0.74	-0.72	-0.80
	(-1.75)	(-1.72)	(-1.46)	(-1.93)	(-1.83)	(-1.80)	(-1.77)
IlliquidXauction	3.96	1.02	2.72*	-0.04	1.24	1.33	1.35
	(1.87)	(1.09)	(2.36)	(-0.05)	(0.91)	(0.99)	(1.01)
Δ Default	2.07	2.04	1.99	2.39*	2.22*	2.22*	2.23
	(1.84)	(1.98)	(1.89)	(2.21)	(2.07)	(2.08)	(2.03)
N	2245	2245	2245	2245	2245	2245	2168
R^2	0.184	0.179	0.191	0.162	0.196	0.192	0.191

t statistic in parentheses; OLS with country fixed effects, monthly time dummies, and robust standard errors.

* $p < 0.05$, ** $p < 0.01$

Table 11: Non-OECD countries only

	(1) Exports	(2) Imports	(3) Trade	(4) Assets(TIC)	(5) Assets(CPIS)	(6) Debt	(7) LTdebt
ExposureXSP500	-6.50**	-8.23**	-8.18**	-0.01*	-0.03**	-0.03**	-0.03**
	(-4.71)	(-5.65)	(-4.36)	(-2.83)	(-3.29)	(-3.04)	(-2.92)
ExposureXauction	-2.88*	-2.97**	-2.72	-0.00	-0.01	-0.01	-0.01
	(-2.12)	(-3.12)	(-1.91)	(-0.26)	(-1.28)	(-1.11)	(-1.03)
TranspXauction	-0.52	-0.59*	-0.56*	-0.82**	-0.44	-0.49	-0.51
	(-1.90)	(-2.62)	(-2.12)	(-3.73)	(-1.43)	(-1.64)	(-1.71)
IlliquidXauction	0.68	-0.59	-0.66	-1.18	-0.30	-0.57	-0.66
	(0.36)	(-0.71)	(-0.73)	(-1.77)	(-0.24)	(-0.54)	(-0.65)
Δ Default	-0.55*	-0.50*	-0.65**	0.78	-0.03	0.03	0.05
	(-2.16)	(-2.35)	(-2.85)	(1.40)	(-0.06)	(0.07)	(0.10)
N	1951	1951	1951	1592	1448	1435	1435
R^2	0.270	0.271	0.277	0.177	0.274	0.274	0.270

t statistic in parentheses; OLS with country fixed effects, monthly time dummies, and robust standard errors.

* $p < 0.05$, ** $p < 0.01$

Table 12: Swap announcements with major central banks

	(1) Exports	(2) Imports	(3) Trade	(4) Assets(TIC)	(5) Assets(CPIS)	(6) Debt	(7) LTdebt
ExposureX121207	-12.76	11.08	3.81	-0.00	0.06	0.04	0.04
	(-1.62)	(1.14)	(0.37)	(-0.00)	(1.21)	(0.84)	(0.85)
TranspX121207	7.71	4.76	4.49	10.31	5.60	6.24	6.20
	(1.91)	(1.38)	(1.20)	(1.38)	(1.19)	(1.33)	(1.31)
IlliquidX121207	-8.08	-2.83	-3.58	16.20	-18.21	-15.37	-16.77
	(-0.42)	(-0.32)	(-0.34)	(1.11)	(-1.91)	(-1.43)	(-1.47)
ExposureX91808	1.23	-28.51	-18.79	0.07*	-0.16	-0.11	-0.10
	(0.04)	(-1.47)	(-0.58)	(2.67)	(-1.86)	(-0.97)	(-0.92)
TranspX91808	-21.36**	-16.89**	-16.81**	-31.78**	-19.54**	-21.94**	-21.34**
	(-3.78)	(-3.81)	(-2.95)	(-4.73)	(-3.95)	(-4.68)	(-4.54)
IlliquidX91808	-109.83*	-99.64**	-95.98**	-135.65**	-56.53	-73.74*	-73.65*
	(-2.20)	(-4.42)	(-3.48)	(-4.97)	(-1.69)	(-2.04)	(-2.20)
ExposureX101308	-97.25**	-93.23**	-119.22**	0.13**	-0.20	-0.15	-0.14
	(-4.75)	(-4.64)	(-5.68)	(4.11)	(-0.63)	(-0.49)	(-0.46)
TranspX101308	-14.57*	-15.69*	-10.83	-34.73**	-22.21	-23.57	-23.93
	(-2.05)	(-2.42)	(-1.72)	(-3.61)	(-1.86)	(-1.88)	(-1.90)
IlliquidX101308	29.39	-101.27*	-63.40	-159.32**	-98.37	-109.20	-113.82
	(0.64)	(-2.56)	(-1.15)	(-4.61)	(-1.20)	(-1.34)	(-1.48)
N	4195	4195	4195	3834	3689	3676	3599
R^2	0.275	0.283	0.287	0.249	0.281	0.277	0.275

t statistic in parentheses; OLS with country fixed effects, monthly time dummies, and robust standard errors.

Major central banks include: European Central Bank, Swiss National Bank, Bank of Japan, Bank of England, and Bank of Canada.

* $p < 0.05$, ** $p < 0.01$

Table 13: Swap announcements with other central banks

	(1) Exports	(2) Imports	(3) Trade	(4) Assets(TIC)	(5) Assets(CPIS)	(6) Debt	(7) LTdebt
ExposureX92408	42.58	57.09	72.01	-0.14**	0.54	0.47	0.49
	(0.88)	(1.49)	(1.42)	(-2.98)	(1.92)	(1.93)	(1.97)
TranspX92408	27.30*	26.01**	23.15*	39.02**	16.22	17.99	17.02
	(2.67)	(2.83)	(2.35)	(3.42)	(1.40)	(1.63)	(1.60)
IlliquidX92408	226.81	262.78	247.73	283.39	130.73	148.45	150.36
	(0.82)	(1.05)	(1.03)	(1.11)	(0.45)	(0.53)	(0.53)
ExposureX102808	-6.41	-36.45*	-30.93	0.24**	-0.25	-0.21	-0.22
	(-0.27)	(-2.42)	(-1.31)	(4.74)	(-1.37)	(-1.18)	(-1.22)
TranspX102808	-96.89**	-94.05**	-90.53**	-116.34**	-88.49**	-90.01**	-88.93**
	(-10.52)	(-11.26)	(-10.94)	(-10.86)	(-9.52)	(-9.26)	(-9.59)
IlliquidX102808	-167.02*	-262.34**	-229.95**	-323.00**	-167.60*	-181.72**	-183.68**
	(-2.11)	(-5.53)	(-3.53)	(-7.18)	(-2.54)	(-2.72)	(-2.88)
N	4195	4195	4195	3834	3689	3676	3599
R^2	0.275	0.283	0.287	0.249	0.281	0.277	0.275

t statistic in parentheses; OLS with country fixed effects, monthly time dummies, and robust standard errors.

Other central banks include: Reserve Bank of Australia, Danmarks Nationalbank, Bank of Korea

Bank of Mexico, Norges Bank, Sveriges Riksbank.

* $p < 0.05$, ** $p < 0.01$

Table 14: Base with direct auction

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Exports	Imports	Trade	Assets(TIC)	Assets(CPIS)	Debt	LTdebt
ExposureXSP500	-6.98**	-6.05**	-8.20**	-0.01*	-0.03**	-0.03**	-0.03**
	(-5.33)	(-4.65)	(-6.33)	(-2.24)	(-4.98)	(-4.59)	(-4.44)
direct	1.89	1.94*	1.89	2.41*	2.08*	2.05*	2.04*
	(1.98)	(2.06)	(1.98)	(2.56)	(2.18)	(2.18)	(2.17)
ExposureXauction	-2.65*	-2.48**	-2.98**	-0.00	-0.01	-0.01	-0.01
	(-2.02)	(-4.90)	(-2.74)	(-0.76)	(-1.85)	(-1.71)	(-1.60)
ExposureXdir	2.72	-13.25	-7.52	-2.98**	0.01	0.02	0.02
	(0.19)	(-1.85)	(-0.62)	(-3.26)	(0.28)	(0.45)	(0.45)
TranspXauction	-0.41	-0.45**	-0.38	-0.67**	-0.31	-0.33	-0.36
	(-1.92)	(-2.83)	(-1.94)	(-3.78)	(-1.38)	(-1.49)	(-1.56)
TranspXdir	-5.00	-3.73**	-3.84	-4.63**	-4.81**	-5.12**	-5.07**
	(-1.78)	(-2.77)	(-1.81)	(-3.57)	(-3.75)	(-3.19)	(-3.13)
IlliquidXauction	0.41	-0.36	-0.17	-0.97*	0.03	-0.09	-0.15
	(0.24)	(-0.54)	(-0.19)	(-2.06)	(0.03)	(-0.10)	(-0.17)
IlliquidXdir	-226.39**	-37.27	-116.28	-47.59	-193.52	-222.34	-225.24
	(-3.54)	(-0.44)	(-1.50)	(-0.42)	(-1.16)	(-1.32)	(-1.32)
Δ Default	-0.08	0.07	-0.16	1.39*	0.82	0.87	0.88
	(-0.20)	(0.19)	(-0.43)	(2.47)	(1.37)	(1.46)	(1.46)
N	4196	4196	4196	3837	3693	3680	3603
R^2	0.200	0.199	0.212	0.151	0.207	0.204	0.202

t statistic in parentheses; OLS with country fixed effects, monthly time dummies, and robust standard errors.

* $p < 0.05$, ** $p < 0.01$

Table 15: Slope coefficients for recipients in announcements

	(1) Exports	(2) Imports	(3) Trade	(4) Assets(TIC)	(5) Assets(CPIS)	(6) Debt	(7) LTdebt
ExposureXmajor	-2.46	79.33	49.31	4.99	-0.46	-0.19	-0.19
	(-0.10)	(0.62)	(0.64)	(0.70)	(-1.97)	(-0.56)	(-0.61)
TranspXmajor	31.91**	41.84**	38.52**	37.90**	31.68**	34.89**	34.53**
	(3.89)	(4.26)	(3.65)	(4.62)	(3.95)	(5.28)	(4.95)
IlliquidXmajor	-2591.08**	-3366.12**	-2814.21**	-3634.95**	-1267.00	-2257.00*	-2228.45*
	(-7.86)	(-3.77)	(-5.93)	(-7.62)	(-1.60)	(-2.42)	(-2.53)
ExposureXminor	-1282.43**	125.11	-136.93	4.66	-1.02	-3.22**	-3.12**
	(-4.11)	(0.55)	(-0.57)	(0.35)	(-0.23)	(-2.86)	(-2.99)
TranspXminor	-54.49	-199.95**	-140.60**	-264.09	-187.88**	-223.04**	-244.75**
	(-1.24)	(-3.03)	(-3.00)	(-1.36)	(-6.13)	(-6.93)	(-6.67)
IlliquidXminor	-17436.32**	-20777.43	-6034.69	-23922.69	-9941.78	-29.41	286.61
	(-4.53)	(-0.94)	(-0.53)	(-1.38)	(-0.47)	(-0.00)	(0.04)
N	4195	4195	4195	3834	3689	3676	3599
R^2	0.229	0.219	0.232	0.176	0.231	0.233	0.233

t statistic in parentheses; OLS with country fixed effects, monthly time dummies, and robust standard errors.

Major central banks include: European Central Bank, Swiss National Bank, Bank of Japan, Bank of England, and Bank of Canada.

* $p < 0.05$, ** $p < 0.01$