The Private Production of Safe Assets*

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Abstract

Do claims on the private sector serve the role of safe assets? We answer this question using high-frequency panel data on prices and quantities of certificates of deposit (CDs) issued in Europe. We find that only very short-term private securities benefit from a premium for safety. Further, we show that the issuance of short-term CDs strongly responds to measures of safety demand. Our identification strategy uses a combination of (1) exclusion restrictions in a structural model of demand/supply equations, and (2) an instrumental variables approach. The private production of safe assets is stronger for issuers with high creditworthiness, and breaks down during episodes of market stress even though the market does not freeze. We conclude that even very short-term private assets are sensitive to changes in the information environment.

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1 Introduction

A *safe asset* is an asset that is immune to adverse selection concerns and can thus be valued without expensive and prolonged analysis (Gorton, 2016). Such an asset, for example a Treasury bill, has money-like attributes and can serve as a store of value (Nagel, 2016). Over the past two decades, the demand for safe assets has surged worldwide, due to the combined effects of fast-growing savings in developing economies and increasing needs for collateral in financial markets. At the same time, the supply of government-issued safe assets in developed countries did not increase equally fast. The resulting excess demand has been shown to explain phenomena such as global imbalances, historically low levels of real interest rates, or bubbles (Caballero, 2006; Caballero, Farhi, and Gourinchas, 2016; Caballero and Farhi, 2018).

The unmet demand for safe assets has paved the way for private financial institutions to issue debt securities, such as asset-backed securities, with safety attributes similar to those of Treasuries (Bernanke et al., 2011; Gennaioli et al., 2013; Sunderam, 2015). However, the private production of safe assets can be problematic, as it induces issuers to grow their liabilities, potentially to the point where financial stability is endangered (Greenwood, Hanson, and Stein, 2016). Thus, understanding the private production of safe assets is important to explain the role of financial markets, central banks, or Treasury authorities in maintaining macroeconomic stability.

In this paper, we test whether private debt securities are perceived as safe, and study the determinants of their production. We do so using detailed high-frequency data on 1.36 million Euro-denominated certificates of deposit (CDs) issued by commercial banks. Our data set covers most of the European short-term private debt and Treasury bill (T-bill) markets between 2008 and 2014. All these assets are reasonable candidates for safe assets: They have short maturities, of up to one year, and are issued in liquid markets by borrowers with high credit quality.

We make three contributions to the literature. First, we show that privately issued securities offer a *safety premium* as their interest rates are below the risk-free rate. The premium captures the non-pecuniary benefits associated with holding a safe asset (Krishnamurthy and Vissing-Jorgensen, 2012; Sunderam, 2015). To the best of our knowledge, we are the first to directly measure safety premia on private assets. We find significant variation across issuers: -15 basis points per year for one-month T-bills, and -8 basis points for one-week CDs. These premia are economically large, as the average risk-free rate over our sample period equals 40 basis points. The existence of a safety premium on CDs is surprising since these securities are uncollateralized. However, while T-bills enjoy a premium at all times, private assets lose their safety status in times of market stress.

We document that safety premia have interesting term structure properties. While T-bills benefit from safety premia across the entire maturity spectrum, the premia on CDs disappear for maturities above one week. This term structure is consistent with the view that assets with shorter maturities are less sensitive to the arrival of new information. Furthermore, the term structure of the CD safety premium exhibits a sharp discontinuity precisely at the one-week maturity, consistent with the view that investors clearly distinguish between safe and non-safe assets.

Our second contribution is to causally identify the determinants of private safe asset production. The main challenge for identification is to obtain a measure of exogenous variation in the demand for safe assets that is uncorrelated with supply conditions. To address this issue, existing papers have postulated and estimated a univariate relationship between the issuance of public and private assets (Sunderam, 2015; Lei, 2012). The idea is that an exogenous drop in the issuance of public assets should boost the unmet demand, that the private sector can fill in. We take a different approach and micro-found this relationship by setting up a structural model of safe asset demand and supply. The system relates the issuance of T-bills and CDs to safety premia on both assets. In the model, the unmet demand for T-bills moves both the T-bill and the CD safety premia, and ultimately induces banks to issue more CDs. The system enables us to derive four economically motivated exclusion restrictions that are necessary for identification of the reduced-form relationship between CD and T-bill issuance. We argue that these restrictions plausibly hold in our setting.

We then estimate the relationship between CDs issued and changes in the quantity of public assets. We find that when the aggregate supply of T-bills goes down, the quantity of new short-term CDs goes up. Given that short-term CDs are precisely the ones that benefit from significant safety premia, this result is consistent with the view that the shortage of publicly issued safe assets creates a demand for privately issued assets with similar safety attributes. Notably, this relationship does not hold for longer-term CDs, which do not benefit from any safety premium. We further show that the negative relationship between quantities of publicly and privately produced safe assets also holds with issuer fixed effects. Hence, the observed effects cannot be explained by differences in the selection of specific private issuers conditional on the availability of T-bills. We also find consistent results when regressing net CD issuance on the T-bill safety premium, as predicted by the model: high safety premia of T-bills affect the supply of short-term private assets.

We further address the main identification challenge—that is, finding a good measure of safety demand—using an instrumental variables (IV) approach. Specifically, in the price-quantity regression, we instrument the safety premium on private safe asset using the bid-to-cover ratio in T-bill auctions, that is, the ratio between total demand and T-bills eventually allotted. Our IV approach relies on the idea that the bid-to-cover ratio is a good measure for the excess demand for T-bills, and that the excess demand directly affects the demand, but not the supply, of CDs. This instrument is supported by several features of T-bill auctions. Our IV estimates point to a statistically significant response of the private safe assets' supply to the exogenous variation in the demand for safety.

Our final contribution is to provide new evidence on the time-series and cross-sectional variations in the data. We find that the negative relationship between the issuance of public and private safe assets weakens when market stress is high. This result provides empirical support for claims in the macroeconomic literature that public and private safe assets are not perfect substitutes in periods of stress (Gorton and Ordonez, 2014). While the above findings are consistent with a *flight-to-quality* interpretation, they are not driven by a collapse of CD issuance, or by a general shortening of maturities in periods of stress. Thus, the time-series variation in our results is in line with a demand-driven mechanism:

CDs continue to be issued, but investors no longer perceive them as substitutes for T-bills in periods of stress. In our cross-sectional tests, we find that even issuers with the highest credit quality stop being seen as safe in periods of stress.

Our paper belongs to the fast-growing literature on safe assets, recently surveyed by Gorton (2016). Theoretically, the demand for safe assets arises from information asymmetries about the quality of the traded assets (Gorton and Pennacchi, 1990; Dang, Gorton, and Holmström, 2012). Relatedly, Holmstrom and Tirole (1998) model the link between the shortage of government bonds, the liquidity premium, and the production of private substitutes. Stein (2012) argues that privately issued safe assets may impose negative externalities on financial stability, which justifies the use of public asset supply as a policy tool. Krishnamurthy and Vissing-Jorgensen (2015) model the response of financial intermediaries to a shortage of government safe assets and increased safety premium. Moreira and Savov (2017) model the issue of safe assets via the shadow banking system, and collapses of shadow banks when uncertainty rises.

Empirically, a vast majority of studies examine safety in government assets (Krishnamurthy and Vissing-Jorgensen, 2012; Greenwood, Hanson, and Stein, 2015, 2016). A smaller literature analyzes privately issued assets. Gorton, Lewellen, and Metrick (2012) show that government debt and privately produced safe assets in the U.S. are strongly negatively correlated. Sunderam (2015) studies the determinants of aggregate net issuance of U.S. ABCP contracts prior to the 2008 crisis. Lei (2012) and Carlson et al. (2014) examine the issuance of private debt in response to changes in expected safety premium on T-bills. In contrast to these studies, we use a more structural identification approach and exploit unique micro-level data to shed light on the cross-sectional and time-series properties of the safety premium and the demand for safe assets.

2 Model and hypotheses development

In this section, we formulate our testable hypotheses and set up a structural system of demand and supply of safe assets to guide our empirical identification.

2.1 Safe asset prices

A key premise of theories of safe assets is the existence of non-pecuniary benefits associated with the holding of certain securities. Such benefits arise from the information insensitivity of assets (Gorton and Pennacchi, 1990; Gorton, 2016). In this sense, safety is a valuable attribute for uninformed lenders who fear being adversely selected in markets for risky assets, that is, fear that informed investors will buy high-quality assets and that they will be left with lemons. The information insensitivity of assets implies that they have money-like features (e.g., they can easily be pledged as collateral) and are good stores of value (Nagel, 2016).

Following Krishnamurthy and Vissing-Jorgensen (2012) and Sunderam (2015), we define the safety premium on a security as the difference between its interest rate and a reference risk-free rate, r_f, which does not provide any such non-pecuniary benefits. Safety premia on T-bills and CDs are thus defined as

$$P_{TB} = r_{TB} - r_f \quad \text{and} \quad P_{CD} = r_{CD} - r_f, \tag{1}$$

where r_{TB} and r_{CD} are respectively the interest rates on T-bills and CDs. A security is said to bear a safety premium whenever this quantity is *negative*.[1] Ample evidence suggests that government-issued securities can benefit from safety premia, that is, $P_{TB} < 0$ (Greenwood, Hanson, and Stein, 2015). Prior research also suggests that private agents can produce safe assets, for example, through securitization (Sunderam, 2015). However, there is no direct evidence of a safety premium on privately issued assets. Our first hypothesis relates to this premium.

Hypothesis 1. *Privately issued assets can benefit from a safety premium, that is,* $P_{CD} < 0$. *This safety premium decreases with maturity.*

While publicly issued assets can benefit from a safety premium because they are backed by the taxing power of governments, privately issued assets can exhibit a safety premium

[1]We follow the literature when discussing the sign of safety premia: a *larger* safety premium refers to a *more negative* value of P_{TB} or P_{CD}.

if they are backed by collateral. However, we also expect to find a safety premium on uncollateralized securities, such as CDs, if their maturity is short enough. Indeed, a short maturity implies that a security is *de facto* senior relative to all other debt claims issued by an agent. In this sense, there are similarities between the tranching process in securitization and the issuance of short-term debt. In both cases, the allocation of early cash flows implies that securities can be made safe. Safety should therefore increase as the maturity of new issues shortens, as stated in Hypothesis 1.

2.2 Safe asset quantities

Apart from the existence of safety premia, the second key idea of safe asset theories is that quantities of assets are economically relevant, while they are not in standard asset pricing models. Indeed, investors demanding safety form a clientele and are willing to pay a premium for assets they perceive as safe (Holmstrom and Tirole, 1998; Krishnamurthy and Vissing-Jorgensen, 2015), relative to assets that are marginally non-safe. Our second hypothesis focuses on the quantity of private assets issued.

Hypothesis 2. *A higher demand for safety is associated with a higher issuance of private safe assets.*

While Hypothesis 2 is arguably the main prediction of theories of private safety production, any test of this prediction raises significant identification issues. The main challenge for identification is that the demand curve for safe assets is not observed, so that it is hard to disentangle demand and supply factors. To address this problem, existing papers have estimated the relationship between the issuance of public and private assets (Sunderam, 2015; Lei, 2012). The idea is that an exogenous decrease in the supply of T-bills leaves part of the safe asset demand unmet. This should increase the T-bill safety premium. If private assets are perceived by investors as providing safety, then the safety premium on private assets should also increase. Ultimately, this should induce private entities to issue more safe assets. To summarize, in the literature until now, supply shocks on T-bills are used as a measure of the unmet demand for safety. Instead, in our empirical approach, we explicitly consider demand shocks.

Overall, Hypothesis 2 implies that a decrease in the quantity of public assets is associated with an issuance of private assets, if these are considered safe. A corollary should be a negative relationship between the safety premium on T-bills and the issuance of private CDs. Finally, a related prediction is that private issuers may cater to safety demand by shortening the maturity of new debt issues. Indeed, if short-term claims are better able to satisfy investors' safety demand (because they are de facto more senior), then issuers may cater to safety demand not by issuing larger quantities but by tilting issuances towards safer securities.

2.3 Structural model

In the absence of a structural model of demand and supply, it remains unclear under what conditions the reduced-form relationship between public and private issuance of assets is identified. We now provide such conditions.

Considering two assets (T-bills and CDs), and assuming linearity of demand and supply functions, we can write

$$\begin{aligned}
Q^d_{TB} &= \alpha^d_{TB} + \beta^d_{TB} \cdot P_{TB} + \gamma^d_{TB} \cdot P_{CD} + \epsilon^d_{TB} \\
Q^s_{TB} &= \alpha^s_{TB} + \beta^s_{TB} \cdot P_{TB} + \gamma^s_{TB} \cdot P_{CD} + \epsilon^s_{TB} \\
Q^d_{CD} &= \alpha^d_{CD} + \beta^d_{CD} \cdot P_{TB} + \gamma^d_{CD} \cdot P_{CD} + \epsilon^d_{CD} \\
Q^s_{CD} &= \alpha^s_{CD} + \beta^s_{CD} \cdot P_{TB} + \gamma^s_{CD} \cdot P_{CD} + \epsilon^s_{CD}, \qquad \text{(System 1)}
\end{aligned}$$

where Q^d_j and Q^s_j are the quantities of asset $j \in \{TB,\ CD\}$ demanded and supplied. Without loss of generality, we express demand and supply functions as functions of safety premia (P_{TB} and P_{CD}) rather than of interest rates. In the system, all error terms ϵ^d_{TB}, ϵ^s_{TB}, ϵ^d_{CD}, and ϵ^s_{CD} have zero means, finite variances, and are independently distributed. Finally, in equilibrium, the two market clearing conditions hold

$$Q^d_{TB} = Q^s_{TB} \quad \text{and} \quad Q^d_{CD} = Q^s_{CD}.$$

Thus, whenever relevant, we simply denote the quantities of assets by Q_{TB} and Q_{CD}. Finally, note that demand and supply for each asset depend on the price of the other asset. Therefore, T-bills and CDs are treated as potential substitutes to satisfy the demand for safety. Whether a private asset is perceived as safe by investors can be inferred from its *elasticity of substitution* with public safe assets. This elasticity, implicitly embedded in System 1, is our key object of interest.

The demand system embeds two families of asset pricing models. First, if all elasticity coefficients in System 1 are equal to zero, $\beta^d_{TB} = \beta^s_{TB} = \beta^d_{CD} = \beta^s_{CD} = \gamma^d_{TB} = \gamma^s_{TB} = \gamma^d_{CD} = \gamma^s_{CD} = 0$, it boils down to standard asset pricing models, such as the CAPM. Indeed in such models, quantities do not play any role and security prices only depend on their payoffs. In contrast, finding evidence that some of the coefficients are statistically different from zero would be consistent with asset pricing models in which quantities are relevant, such as safe asset models (Holmstrom and Tirole, 1998; Krishnamurthy and Vissing-Jorgensen, 2015). Distinguishing between these two families of models is an empirical challenge. In fact, System 1 is generally not identified: in the absence of additional restrictions, the role of demand and supply shocks cannot be disentangled.

A univariate relation between Q_{CD} and Q_{TB}, as featured in Hypothesis 2, can be identified only if four exclusion restrictions hold:

$$\beta^s_{TB} = 0, \tag{R1}$$

$$\gamma^s_{TB} = 0, \tag{R2}$$

$$\beta^s_{CD} = 0, \tag{R3}$$

$$\gamma^d_{TB} = 0. \tag{R4}$$

Indeed, whenever (R1) to (R4) hold, we obtain

$$Q^d_{TB} = \alpha^d_{TB} + \beta^d_{TB} \cdot P_{TB} + \epsilon^d_{TB} \tag{2}$$

$$Q^s_{TB} = \alpha^s_{TB} + \epsilon^s_{TB} \tag{3}$$

$$Q^d_{CD} = \alpha^d_{CD} + \gamma^d_{CD} \cdot P_{CD} + \beta^d_{CD} \cdot P_{TB} + \epsilon^d_{CD} \tag{4}$$

$$Q^s_{CD} = \alpha^s_{CD} + \gamma^s_{CD} \cdot P_{CD} + \epsilon^s_{CD}, \tag{5}$$

which is an exactly identified system. From this system, we can obtain the relationship between CD supply and T-bill supply using the following two steps. First, from (2) and (3), we can express the T-bill safety premium as:

$$P_{TB} = A + \frac{\epsilon^s_{TB} - \epsilon^d_{TB}}{\beta^d_{TB}}, \tag{6}$$

that is, a constant plus a combination of demand and supply shocks on T-bills, with $A = (\alpha^s_{TB} - \alpha^d_{TB})/\beta^d_{TB}$. Second, from (4), (5), and (6), we obtain the relationships hypothesized in previous research,

$$Q^s_{CD} = C + D \cdot P_{TB} + \nu_p, \tag{7}$$

and

$$Q^s_{CD} = E + F \cdot Q^s_{TB} + \nu_q, \tag{8}$$

which we derive formally in Appendix A. In equations (7) and (8), the quantity of CDs issued is expressed only as a function of exogenous variables. Furthermore, P_{TB} and Q^s_{TB} are respectively uncorrelated with ν_p and ν_q, so a least square estimator is consistent. The coefficients D and F capture the elasticity of substitution between T-bills and CDs from the investors' perspective. If public and private assets are perceived as substitutes, we expect $\hat{D} < 0$ and $\hat{F} < 0$.

We can attach clear economic interpretations to restrictions (R1)-(R4).[2] To begin

[2]We defer to Section 5.1 the question of whether these restrictions are likely to hold empirically.

with, (R1) and (R2) imply that the supply of T-bills is exogenously determined: It does not depend on either T-bill or CD safety premia. This restriction corresponds to a situation in which public assets are issued to meet stochastic government needs but not to cater to safety demand. Restriction (R3) states that issuers of CDs directly respond only to changes in the CD safety premium. This restriction implies that private issuers set the quantity supplied by comparing their expected return on investment with their own cost of funds P_{CD}, regardless of other prices in the market. This is a form of market segmentation. Finally, restriction (R4) states that the demand for T-bills depends only on the T-bill safety premium, and not on the CD safety premium. This is true if T-bills are a preferred form of safe assets for investors. This means that T-bills are effectively more senior than T-bills, in the sense that they absorb the safest part of cash flows in the economy, due to the taxing power of governments.

2.4 Cross-sectional and time-series variations

We can rewrite System 1 to allow for variation across issuers and over time, by indexing asset quantities, asset prices, coefficients, and error terms by i and t, respectively. In our next hypotheses, we exploit these two sources of heterogeneity. Starting with heterogeneity in the time series, we formulate:

Hypothesis 3. *The private sector no longer supplies substitutes for public safe assets when aggregate market stress is high.*

This hypothesis should hold if investors seek information-insensitive assets to store value. Indeed, in this case, the release of negative aggregate news can imply that uninformed investors no longer buy privately issued short-term debt without concerns about the quality of issuers (Dang, Gorton, and Holmström, 2012). Instead of repricing debt securities based on the new information, they may simply stop demanding these assets. If public and private assets are no longer perceived as substitutes, shocks to the supply of public safe assets are no longer compensated by the private sector. This corresponds to a shift in the structural coefficients in System 1—which later appears more clearly when working with the reduced-form equations. While the collapse of securitization in 2007-2008 can be interpreted as supporting Hypothesis 3, evidence at the aggregate level remains ambiguous. For example, the pool of issuers may change between calm and stress periods, for reasons unrelated to safety demand. Furthermore, it is also unclear whether all private issuers stop providing safe assets in times of stress, or whether the aggregate effects are driven by a subset of issuers.

Finally, if the demand for information-insensitive assets is an economically important component of the safety demand, we expect to find, at any given date, a cross-sectional heterogeneity in the ability of private agents to supply safe assets. This is the object of our last hypothesis.

Hypothesis 4. *Private issuers with high credit quality are better able to produce safe assets.*

Hypothesis 4 builds on the idea that low-creditworthiness issuers are not able to cater to safe asset demand. This is true even though very short-term debt arguably carries limited credit risk. Whether an issuer can produce safe assets or not should depend on publicly observable information, easily interpreted by uninformed investors. Empirically, Hypothesis 4 implies that structural coefficients in System 1 vary in the cross-section of issuers.

3 Data

We build a data set with information on quantities and prices of public and private debt securities between January 1, 2008 and December 31, 2014. Our sample of private assets includes certificates of deposit (CDs) issued by European banks, and our sample of public assets includes European T-bills.

3.1 Certificates of deposit

We obtain daily issuance data on euro-denominated CDs from the Banque de France. CDs are unsecured short-term debt securities, with maturities ranging from one day to one year (see Pérignon, Thesmar, and Vuillemey, 2017, for a description of this market). We analyze the universe of CDs issued in the French market, representing over 80% of the global market for euro-denominated CDs.[3] The sample covers 271 individual issuers. More than 90% of CDs are bought by money market funds; other buyers include pension funds or insurance companies. Our data include a number of security characteristics, such as the issuance and maturity dates, issuers' names, debt amounts, and yields. We further match issuance data with balance sheet and credit rating data from Bankscope. The data set contains 1,360,272 issues.

We provide details on the sample of CD issuers in Table 1. In Panel A, we present the geographic distribution of all issuers. French banks account for a significant fraction of the European CD market: 72.3% of issuers and 72.8% of issuances by volume. The second largest country by volume is the UK followed by the Netherlands. In Panel B, we provide information related to the issuers' balance sheets. Most issuers have high Tier-1 and total regulatory capital ratios, consistent with the view that CD issuers, on average, have strong balance sheets. Finally, Panel C shows that CDs make up an important part of banks' balance sheets, especially relative to equity and repo funding. In terms of total liabilities, the share remains significant at 10% on average.

3.2 Treasury bills

We also collect data on publicly issued assets. We restrict our attention to securities with maturities below one year, that is, T-bills, in order to match them with comparable privately issued securities. In our baseline analysis, we focus on French T-bills for the following reasons. First, the French government is the largest issuer of T-bills in the Euro area.[4] Second, most issuers in the European CD market are French. Third, CDs and French T-bills share a common investor base, primarily composed of money market funds. Fourth, the French Treasury is the only major European Treasury authority to

[3] The French market is the second largest market worldwide for CDs, behind the US but ahead of the London market. It is the largest market for CDs denominated in euros (see Banque de France, 2013).

[4] As of year-end 2015, the outstanding amount of French T-bills was EUR174 Bn. In contrast, the outstanding amounts of German, Italian, and Spanish T-bills equaled EUR19 Bn, 122 Bn, and 82 Bn, respectively. Data on these outstanding amounts are obtained from national Treasury administrations.

issue one-month T-bills, which are directly comparable to CDs in terms of their maturity at origination.

We append these data with information on 1,141 T-bill auctions between 2008 and 2014, obtained from the *Agence France Trésor*—the government authority in charge of the management of public debt in France. T-bills are auctioned every Monday for multiple maturities. For each of the 358 auction days, we record the maturity and volume of each issue and also retrieve the bid-to-cover ratio, further discussed below. Finally, for additional tests, we collect similar T-bill data for Germany, Italy, and Spain.

3.3 Summary statistics

We provide summary statistics on the issuance of public and private securities. In Panel A of Figure 1, we show the time-series variation in the outstanding amount of CDs and T-bills over our sample period. We observe that the CD market is significantly larger than the T-bill market (EUR 369 Bn versus 169 Bn, on average, between 2008 and 2014). The CD market started declining in size only towards the end of our sample period, when the ECB policy rate dropped to zero. When breaking down volumes by maturity, in Panel B, we find that CDs with maturities below one month exhibit a significant variation in total volume over time. Among them, securities with maturities below or equal to one week are most prevalent. Most T-bills have maturities below or equal to 3 months.

In Table 2, we report additional details on the distribution of aggregate amounts outstanding (Panel A) and net issuance (Panel B) of T-bills and CDs. The amounts outstanding vary between EUR 249 Bn and EUR 466 Bn for CDs, and between EUR 78 Bn and EUR 210 Bn for T-bills. These statistics indicate a significant variation in aggregated quantities. Furthermore, issuance of CDs with maturities up to one week also displays a strong time-series variation at a weekly frequency: net issuance ranges from EUR -29 Bn to EUR 27 Bn.

Finally, Panel C shows the distribution of maturities for each asset type. The median maturity for T-bills equals 154 days, and 33 days for CDs. Panel A of Figure 2 presents the distribution of maturities. We observe significant heterogeneity in CD maturities, with clustering at 1 day, 1 week, 1 month, and 3 months.

4 How safe are privately issued assets?

In this section, we test Hypothesis 1. We document the existence of a safety premium on privately issued assets and discuss its term-structure properties.

4.1 Measuring safety

We test Hypothesis 1 by assessing whether safety premia on privately issued assets are significantly different from zero. The main empirical challenge is one of measurement. Indeed, while r_{TB} and r_{CD} in equation (1) are observed, the reference rate, r_f, must be carefully chosen. As in Sunderam (2015), we use overnight interest-rate swap rates for the following reasons. First, credit risk on interest rate swaps is extremely low, since no cash is exchanged upfront, and the notional amount of a swap contract is never exchanged. Moreover, interest rate swaps are fully collateralized an/or centrally cleared, which alleviates any remaining credit risk concerns. Second, the interest-rate swap market is very liquid. Therefore, liquidity premia are close to zero. Finally, the swap rate is not a rate at which investors can save, and swap contracts cannot be pledged as collateral. For these reasons, overnight interest rate swap rates are risk free, but they do not benefit from any safety premium.

Specifically, we use the Euro OverNight Index Average (Eonia) swap rate for the risk-free reference rate r_f. The Eonia swap rate is the European equivalent of the Overnight Indexed Swap (OIS) rate. While OIS rates are based on Libor, Eonia swap rates are based on Eonia, that is, the average rate on all overnight unsecured transactions within a sample of banks.[5] An Eonia swap is an interest rate swap in which one party agrees to receive or pay a fixed rate to another party, against paying or receiving Eonia. At a given maturity, the Eonia swap rate measures the market expectation of the average overnight unsecured rate.

[5] In contrast with Libor, Eonia is based on actual transaction prices.

To measure safety premia, we collect interest rate data for French T-bills and Eonia swap rates at multiple maturities (1w, 1m, 3m, 6m, 9m, and 12m) from Bloomberg. We obtain weekly data on CD interest rates at issuance from the Banque de France. We always match a security with the Eonia swap rate of the same maturity. Figure A1 shows the time-series evolution of the various Eonia rates.

4.2 Safety premia on CDs and T-bills

We begin by showing average safety premia on CDs and T-bills for various maturities in Panel A of Table 3, and their time-series variation in Figure 3.[6] The safety premium for CDs with a one-week maturity is negative for most of the sample period, and equals -8.1 basis points, on average. Hence, issuers of these assets borrow at a rate below the risk-free rate. Furthermore, the magnitude of the safety premium on private assets is economically large: The average level of the risk-free rate over our sample period equals 40 basis points. Overall, the result indicates that very short-term private assets, even if uncollateralized, can be treated as safe by investors.

For T-bills, we observe an average premium of -15 basis points for one-month T-bills. The safety premium on T-bills is negative over the entire time period, but displays a significant time-series variation. The absolute value of T-bill safety premium is highest during the Lehman crisis and in the second half of 2011 during European sovereign debt crisis. In turn, it is relatively low in the second half of 2009, and from 2013 onwards. In terms of magnitudes, this premium is smaller than the one documented by Greenwood, Hanson, and Stein (2015) for U.S. T-bills: around -40 basis points at a one-month maturity. Relatedly, Krishnamurthy and Vissing-Jorgensen (2012) find an average premium on Treasuries (across maturities) of -73 basis points over the 1926-2008 period. The difference in magnitudes with our estimates may be due to the fact that French government securities are perceived as less safe than U.S. T-bills, or due to the difference in sample period. Indeed, our sample period includes both the global financial crisis and the

[6] One-week T-bill rates are unavailable due to the lack of liquidity of the T-bill market for near-maturity securities. Data for 12-month CDs are too limited to compute the moments of interest.

European sovereign debt crisis.

Overall, our results are in line with Hypothesis 1: Private assets can benefit from a safety premium, but this premium is lower than that on otherwise similar public assets.

4.3 The term structure of safety premia

Next, we show evidence on the term structure of safety premium, for both T-bills and CDs. For T-bills, Panel A of Table 3 shows that the difference in premia between the shortest and longest maturities equals 12.6 basis. For CDs, this difference reaches an economically large 46.1 basis points. This term structure of the safety premium is consistent with theory, and with Hypothesis 1: Shorter-term securities are *de facto* more senior, and are therefore less information sensitive.

This term structure has important implications: While T-bills benefit from a safety premium throughout the entire maturity spectrum, this is not the case for CDs. Specifically, the safety premium disappears for CDs with maturities beyond one week, that is, financial institutions borrow at a positive spread over the risk-free rate. Therefore, only short-term CDs can be considered as safe in an exact sense.

Next, we examine the time-series variation in the term structure of safety premia. To this end, for each maturity bucket and asset type, we estimate a time-series regression model with the safety premium as a dependent variable and a set of indicator variables for each individual year as regressors. We report the estimated coefficients in Panel B of Table 3. First, the previously reported term structure of the safety premium can be observed for almost all years, both for T-bills and CDs. Second, we observe a significant variation in the magnitude of the safety premium for each maturity and asset type.[7] For T-bills, the safety premium is generally larger around periods of stress. For CDs, the biggest retrenchment from safety can be observed in 2008, which is one of the years in which T-bills have enjoyed the largest safety premium. In summary, we show that only

[7] To assess whether the cross-sectional patterns in safety premia may be due to differences in respective Eonia swap rates, we separately investigate the time-series variation in the rates. Figure A1 shows no significant differences across swap rates with different maturities. Hence, we conclude that the patterns in the data cannot be explained by the variation in the swap rates.

some short-term private assets benefit from a safety premium which, however, does not persist at all times.

Finally, a prediction of safe asset models is that safe assets should be priced discretely away from marginally non-safe assets. In other terms, there must be a discontinuity in the term structure at the point at which safety disappears. To examine this hypothesis, we first plot in Figure 4 the average term structure for CD and T-bill safety premia and for the Eonia swap rate. We see a large steepening of the CD term structure precisely between the 1 week and 1 month maturities, which is the point at which CDs stop to be perceived as safe. To formally test whether the change in slopes is significant, we compute linear slopes of the term structure over three intervals: [1 week; 1 month], [1 month; 3 months], and [3 months; 6 months]. In Panel C of Table 3, we report these slopes and test for differences using *t*-tests. We see that the largest steepening of the CD safety premium term structure, both in magnitude and significance, occurs precisely over the [1 week; 1 month] interval. The latter is the maturity at which CDs stop being perceived as safe.

5 Private production of safe assets

In this section, we turn to quantities and study the substitution effect between the production of public and private assets. We test Hypothesis 2 in two steps. First, we argue that exclusion restrictions (R1) to (R4) are likely to hold empirically and directly estimate equation (8). Second, we empirically identify the model using an instrumental variables approach. We find that the issuance of private short-term debt responds to the excess demand for public safe assets.

5.1 Discussion of exclusion restrictions

In this section, we argue that the exclusion restrictions of Section 2 plausibly hold in our setting. Therefore, we can directly estimate equation (8).

Restrictions related to the exogeneity of the government's debt policy (R1 and R2) can be rationalized with evidence that T-bills are supplied primarily to manage stochastic government cash needs, and not to cater to safety demand. Within our context of French data, about 5,000 public accountants draw on the government's account, making short-term cash needs unpredictable.[8] We verify this claim by regressing T-bills issued on the T-bill safety premium, and find no significant effect (see Appendix Table A3). Furthermore, T-bill auctions are such that the quantity supplied is determined one business day before the auction (for technical details, see here). Therefore, consistent with the restrictions, it is indeed the case that equilibrium quantities in the T-bill market are determined prior to prices. Finally, one may still be concerned that T-bill issuance responds to some extent to prices. While this may be a legitimate concern over longer horizons, this is unlikely at the shorter frequencies we use. Indeed, our regressions exploit a within-quarter variation.

Next, restriction (R3) is likely to hold, given the short-term maturity of CDs (see Figure 2). For a given expected return on investments, short-term CD issuance decisions can exploit any gap between this expected return and P_{CD}, regardless of other prices in the market. For longer-term assets, instead, there could be a concern that issuance decisions respond to other variables, as the capital structure of the bank may then be altered for a longer period of time.

Finally, restriction (R4) is realistic whenever T-bills are backed by a credible taxing power of governments. This restriction is plausible in our case, since we focus primarily on French T-bills. Over our sample period, in spite of the European sovereign debt crisis in 2011-2012, France was always considered a core rather than a periphery country. Its S&P credit rating never fell below AA and its 5-year CDS spread never went above 250 basis points. Furthermore, as already shown, French T-bills benefited from a safety premium throughout the entire sample period, unlike Spain and Italy (see Figure 3). Thus, it is reasonable to assume that, in our case, T-bills enjoy greater absolute safety than CDs.

5.2 Estimation results

We turn to the estimation of equation (8). While this equation reflects the market equilibrium at a given date, it can only be identified from the time-series variation in asset

[8] In 2016, the average daily cash outflow from the main State Account was EUR 17.8 Bn (see here).

demand or supply. A concern for inference when turning to time-series or panel data is the potential autocorrelation of error terms. We address this concern in three ways. First, we estimate (8) in first differences, so as to isolate time variation from persistent level effects. Second, we account for potential autocorrelation when computing standard errors. Third, we add the following control variables: $\log(Q_{CD,t-1})$, $\Delta\log(Q_{CD,t-1})$, $\log(Q_{TB,t-1})$, and $\Delta\log(Q_{TB,t-1})$. This leads to the following specification,

$$\Delta\log(Q_{CD,i,t}) = \phi\cdot\Delta\log(Q_{TB,t}) + \rho\cdot Controls_{i,t-1} + \mu_i + \mu_t + \epsilon_{i,t}, \tag{9}$$

in which issuer and year-quarter fixed effects are also included.

We first estimate the model by aggregating all issuers and all maturities, and present the results in Panel A of Table 4. Using CDs with all maturities, we find that the coefficient ϕ is not statistically different from zero, both in the univariate and multivariate models. However, the results change when we focus on short-term CDs (that is, with maturity below one week). We find that ϕ is negative and statistically significant across specifications. Moreover, the effect is economically large: A one-standard-deviation decrease in the issuance of T-bills is associated with an increase by about 5% in the issuance of CDs, which corresponds to about 70% of the weekly standard deviation. When focusing on longer-term CD contracts (that is, above one week), we find that the coefficient switches sign. Collectively, these results are consistent with Hypothesis 2.

Another legitimate question is whether our results hold for a given issuer over time, or hold in aggregate due to selection of issuers over time. To address this concern, we estimate equation (9) at the issuer level in Panel B. We restrict our sample to short-term CDs. The panel approach allows us to control for time-invariant differences across issuers using issuer fixed effects, and to control for time-varying issuer characteristics.[9] We cluster standard errors at the week level.[10] We find a negative and statistically significant effect of T-bill issuance on CD issuance. The effect is also economically significant: A

[9]Our issuer-level control variables are total assets, return on assets, loans over assets, customer deposits over assets, common equity over assets, and impaired loans over total loans.

[10]We estimated the model with clustering at the issuer-, month-, quarter-level, and double clustering at issuer- and week-level. Clustering at the week level gives the most conservative standard errors.

one-standard-deviation decline in T-bill issuance is associated with about 8-10% increase in CD issuance. The results are again consistent with the hypothesis that investors substitute into short-maturity CDs at times when public assets are less widely available in the market.[11]

There are two potential alternative explanations of our results. First, the negative relationship between public and private asset issuance may be driven by standard crowding-out effects of public debt on private debt (Barro, 1974). Second, our results could be due to a "gap-filling" mechanism (Greenwood, Hanson, and Stein, 2010): When the government issues less debt at a given maturity, the private sector increases issuance at this maturity to cater to this neglected clientele. However, both explanations are unlikely to apply here. Indeed, the substitution effect we observe only affects short maturities, whereas the alternative two explanations should also apply to longer maturities.

Finally, as a consistency check, we test whether our relationship also holds when regressing CD quantities on the T-bill safety premium. This relation comes out of the model (equation 7) and can be interpreted as the channel through which public and private issuance decisions are linked: it is because T-bill issuance decisions move the T-bill safety premium that CD prices also move, and induce private agents to issue more or less. Specifically, we estimate

$$\Delta \log(Q_{CD,i,t}) = \delta \cdot P_{TB,t} + \rho \cdot Controls_{i,t-1} + \mu_i + \mu_t + \epsilon_{i,t}, \tag{10}$$

and present the coefficient estimates in Table 5.

We start with an aggregate relationship in Panel A, in which all CDs are aggregated across issuers. We observe that the estimate of δ is not different from zero in the full sample of all CDs (column 1). However, when we focus on CDs with maturity below one week, we find that δ is negative and statistically significant (column 2). In turn, when we

[11] We further explore whether substitutability between public and private assets depends on the initial maturity of T-bills. We define short-term and long-term CDs as having maturity below and above 3 months, respectively. The magnitude of the effect varies markedly with T-bill maturity: It is twice as large for short-term T-bills, which suggests that issuers of private assets react more to changes in assets with similar maturity (see Table A2).

restrict the sample to longer-maturity CDs, in column (3), the results become statistically insignificant. Hence, only short-term CDs can be considered as substitutes to public safe assets. This is consistent with our results on quantities.

In Panel B of Table 5, we revisit the relationship using panel data with issuer fixed effects. Again, we find a negative and statistically significant effect of T-bill safety premium on the issuance of private CDs. The magnitude of the effect is twice as large as the aggregate effect. Furthermore, the impact of the CD safety premium remains statistically insignificant. Overall, the results are consistent with the hypothesis that issuers of private safe assets respond positively to an increased demand for safety.

We finally address the concern that our results could be driven by mismeasurement of the T-bill safety premium, for example due to frictions in short-term debt markets (Duffie and Krishnamurthy, 2016). To this end, we re-estimate equation (10) using an alternative definition of the T-bill safety premium. Specifically, we follow Greenwood, Hanson, and Stein (2015) and compute the safety premium as the difference between the one-month T-bill rate and the rate predicted by the term-structure model by Gürkaynak, Sack, and Wright (2007). If safety demand is most important for short-term T-bills, pricing errors should be higher at the short-end of the yield curve. The estimates, presented in the last two columns of Table 5 (Panel B), are consistent with our previous estimates.

5.3 Identification using an instrumental variable

We then use an alternative approach to address our main identification problem: the absence of exogenous variation in the demand for safety. Specifically, we use an instrumental variables approach, which relies on much fewer exclusion restrictions. In this section, instead of focusing on the entire system of T-bill and CD demand and supply equations, we focus on a simpler system of two CD equations

$$Q^d_{CD} = \alpha^d_{CD} + \gamma^d_{CD} P_{CD} + \epsilon^d_{CD} \tag{11}$$

$$Q^s_{CD} = \alpha^s_{CD} + \gamma^s_{CD} P_{CD} + \epsilon^s_{CD}. \tag{12}$$

One instrument is sufficient to identify this system. Our strategy is to introduce a measure of excess demand for T-bills in the CD demand equation (11). By construction, excess demand for T-bills does not directly affect CD supply.

Our proxy for the excess demand for T-bills is the weekly measured bid-to-cover ratio, which we denote as BTC. This ratio contrasts the aggregate demand for T-bills with the T-bills eventually allotted in a given auction, that is, it measures the degree of oversubscription by investors. Formally, it is defined as

$$BTC_t = \frac{\text{Bids for T-bills at } t}{\text{T-bills alloted at } t}. \tag{13}$$

Furthermore, BTC displays significant variation over time, as seen in Panel A of Table 6. There are several reasons why BTC is a good measure of excess safety demand and does not merely capture auction-specific anomalies. First of all, even though French T-bill auctions are such that investors pay their bids, they cannot post bids for more than 1 billion euros at each quoted price. As a result, investors with high demand for T-bills must break down their demand into several bids. When doing so, they become more likely to be rationed. Indeed, the price listed in the secondary market is an upper bound on the auction price, so that additional bids are made at lower prices. This constraint is economically meaningful, since the increment between two listed prices is coarse (0.5 cents). Second, another concern could be that bids submitted at prices below the final auction price were unrealistically low, so that the corresponding bids cannot be treated as rationed. This concern is minor in our case, due to the specifics of French T-bill auctions. Indeed, participants in T-bill auctions are only 16 specialists who have strong incentives to send reasonable bids.[12] Among other incentives, each specialist receives an annual assessment by the Banque de France, based on whether their bids indeed enable them to buy T-bills. If the assessment is not successful, banks may lose their access to the auction. Taken together, these arguments suggest that BTC is a good measure of excess demand.

To get further reassurance that BTC measures the demand for safety, we also show that BTC is primarily moved by demand, and not by supply, as the standard deviation

[12]The specialists include ten European banks, five American banks, and one Japanese bank.

of the numerator (demand) is more than three times as large as that of the denominator (supply), equal to EUR 4.7 and 1.4 Bn, respectively. Separately, we also regress monthly changes in average BTC and in T-bill bids (the numerator in BTC) on monthly flows into European money market funds.[13] In Panel B of Table 6, we report positive and significant coefficients (at the 5% level), even in specifications with year-quarter fixed effects that control for macroeconomic conditions. Therefore, changes in BTC are driven by changes in demand.

Using BTC as an instrument yields the following system

$$Q^d_{CD} = \alpha^d_{CD} + \gamma^d_{CD} P_{CD} + \omega^d_{CD} \cdot BTC + \epsilon^d_{CD} \tag{14}$$

$$Q^s_{CD} = \alpha^s_{CD} + \gamma^s_{CD} P_{CD} + \epsilon^s_{CD}. \tag{15}$$

We can rewrite Q_{CD} and P_{CD} as functions of the exogenous variable BTC and of the error terms. We estimate the model using two-stage least squares, where the first-stage equation is

$$P_{CD} = \eta_1 + \pi_1 \cdot BTC + \epsilon_1, \tag{16}$$

and the second-stage equation is

$$Q_{CD} = \eta_2 + \pi_2 \cdot \hat{P}_{CD} + \epsilon_2. \tag{17}$$

In (17), $\hat{P}_{CD}$ is the predicted value of the CD safety premium from the first-stage equation.

The idea behind our instrument is that a high bid-to-cover ratio indicates high excess demand for safe assets and should therefore lead to a more negative CD safety premium. To support this relevancy condition, we expect a negative coefficient on BTC in the first stage. The identifying assumption (exclusion restriction) is that changes in the bid-to-cover ratio are not correlated with changes in supply of CDs, other than via the excess demand for safety. We consider this assumption natural, especially in the context of high-frequency data.

[13]Public data on fund flows are obtained from the ECB's Statistical Data Warehouse.

In Panel C of Table 6, we show that the first-stage estimates are highly significant, with the expected negative sign, and with a high F-statistic, of at least 11. In the second stage, we find a negative and statistically significant estimate of π_2, that is, changes in the CD safety premium induced by high safety demand lead banks to issue more CDs. In both models, the results hold with and without controls. Overall, the results from our IV identification strategy corroborate Hypothesis 2.

Finally, we get further reassurance that BTC is a measure of excess safety demand to which investors respond by running a test that exploits the price timing of T-bill auctions. In France, quantities issued in T-bill auctions are announced every Friday, auctions are held on the next Monday, and results are announced immediately at 2:50pm. Therefore, investors first learn about *potential* rationing on Friday and about *actual* rationing on Monday afternoon. If CD issuers cater to safety demand, then the demand for CDs must be particularly high on Fridays and Mondays whenever rationing in the T-bill auction—as measured by the bid-to-cover ratio—is large. We test this idea by computing the average CD issuance growth (measured as $\log(Q_{CD,t}) - \log(Q_{CD,t-1})$) every day of the week, for both weeks with high and low BTC (defined by a ratio above or below its quarterly median). The results, displayed in Figure 5, show that the largest difference in issuance between high-BTC and low-BTC weeks is indeed realized on Mondays. The second largest difference is realized on Fridays. We separately check whether these differences are significant using two-sample t-tests, and find that the difference is statistically significant only on Mondays (p-value of 0.082) and near-significant on Fridays (p-value of 0.166). This result lends additional support to Hypothesis 2.

5.4 Additional tests

In this section, we provide three auxiliary tests that further support the idea that CD issuers cater to the excess demand for safe assets.

Issuers' maturity choices. We examine whether issuers internalize investors' demand in their maturity choices. To the extent that investors' demand for private assets increases when T-bill issuance is reduced, one should expect that private issuers shorten the maturity of new issues exactly at these times to serve the increased demand for safety. We test this hypothesis by looking at the share of new CDs with maturity below one week among all CD issues. Table 7 shows that the share of short-term assets goes up when the issuance of public safe assets drops. This result provides additional support to Hypothesis 2: Issuers of private safe assets respond strategically to the void created by the reduction in availability of public safe assets by shortening maturities of their new issues.

Commercial paper market. A potential concern is that we capture a relationship that holds for any private short-term asset, regardless of whether there exists a safety demand for it. To rule out this concern, we study whether our results on CDs also hold for commercial paper (CP). While CPs and CDs are similar in all respects in Europe (maturity, absence of collateral, types of investors), they differ in that CPs are issued by non-financial firms. We obtain data from the Banque de France covering all CP issues at a weekly frequency over 2008-2014. Our sample includes 123 issuers and 157,910 firm-week observations.

Panel A of Table A4 shows that CPs represent, on average, 34% of firms' short-term debt and 10% of their total debt. Furthermore, the average maturity of CP issues is 42 days (vs. 40 days for CDs). In Panel B, we report a statistically significant safety premium for one-week CP contracts but its magnitude is significantly smaller than the one for CDs (-2.5 vs. -8.1 basis points).

We next study whether investors substitute into safe CPs when the public supply of safe assets goes down. We estimate the model in equation (9). In Panel A of Table 9, we report the coefficients from a time-series regression, and find no evidence of the substitutability effect previously reported for CDs. This is true even when we restrict our sample to CPs with maturity below one week (columns 3 and 4). If anything, CP demand tends to decline when the availability of T-bills goes down. In Panel B, we further corroborate the results using a pooled regression model.

In sum, short-maturity CPs seem to enjoy a safety premium, but investors do not consider them as substitutes for T-bills. The differences in patterns between CDs and CPs can be interpreted as evidence that banks maintain relationships with investors and directly cater to their demand. We conclude that the intermediation channel plays an important role in the production of private safe assets.

International evidence. We test for the external validity of our findings by collecting T-bill data from Germany, Spain, and Italy. While there is a large T-bill safety premium for German assets, we show evidence of a *risk premium* for T-bills from Italy and Spain. The result is consistent with the idea that these two countries are not perceived as safe by investors and borrow at a rate higher than the risk-free rate (see Panel C of Figure 3). Furthermore, in Table 10, we show that our main result continues to hold if we include German T-bills in our measure of the supply of public safe assets. In turn, the negative relationship between the supply of public and private safe assets disappears when using the supply of Italian or Spanish T-bills as independent variables. This result gives further reassurance that the effects we identify are due to safety demand rather than to a more general gap-filling or crowding-out mechanism.

6 Time-series and cross-sectional variations

The granularity of our data enables us to explore several dimensions of heterogeneity in the relationship between public and private assets. In System 1, heterogeneity corresponds to cross-sectional or time-series changes in the structural coefficients. To motivate our study of cross-sectional heterogeneity, we plot in Figure 6 the histogram of the coefficients from issuer-level regressions of CD issuance on T-bill issuance. While the levels of coefficients are generally negative, consistent with our previous results, a significant heterogeneity requires further explanation. In this section, we show that investors' perceptions of public and private assets vary over time and across issuers.

6.1 Time-series variation

We start by examining the time-series variation in the ability of private assets to serve as substitutes for public assets. We test Hypothesis 3 by estimating equation (9) with interaction terms between $\Delta \log(Q_{TB})$ and indicators of market stress. Exploiting the variation with regard to market stress seems natural in the context of asset safety. We classify periods of market stress using option implied market volatility (VIX), past returns on Euro stoxx 50 index, or Euribor-Eonia swap spread. To account for different levels of stress, we divide each measure of market stress into quartiles, based on its own conditional distribution in our sample. Notably, our sample is well suited to study the economic consequences of market stress as it includes episodes of unconditionally high market stress. We report the results in Table 11.

Consistent with Hypothesis 3, we find that the relationship between changes in issuance of T-bills and issuance of CDs is most negative during periods of low market stress. In turn, the relationship is close to zero in times of high market stress, regardless of the measure we use. This result suggests that privately issued safe assets are considered close substitutes to T-bills mostly at times of low aggregate market uncertainty.

Finally, we check that our time-series results are not driven by a flight-to-quality episode in which the CD market freezes. To see this, we plot in Figure 1 the aggregate volume in the European CD market. As can be seen, lenders continued to be active in the European CD market throughout both the global financial crisis and the European sovereign debt crisis. Furthermore, one may be concerned that our results are driven not by a general collapse of the CD market, but by a collapse of all CD segments, except those with the shortest maturity. This is not the case, as Panel B of Figure 2 shows. Indeed, the average maturity of bank CDs did not shorten significantly in 2008 and 2011, when bank credit spreads spiked, as measured by the 5-year credit default swap spread index on EU banks. We conclude that our time-series results are solely driven by a change in investors' views about the substitutability between T-bills and CDs. Hence, our results identify a time-series change in the structural parameters in System 1. This alternative definition of a flight-to-quality is consistent with models of safe asset demand.

6.2 Cross-sectional variation

Next, we test whether the relationship between public and private assets depends on the characteristics of private issuers (Hypothesis 4). Specifically, we focus on the following characteristics, all measured at the issuer level: asset size, equity, impaired loans, ROA, and credit rating. We split the distribution of each conditioning variable into quartiles to account for the possibility that the effect may be nonlinear with respect to issuer characteristics. Formally, we estimate equation (9) with interaction terms between the respective quartiles and changes in T-bill issuance.[14]

Results in Table 12 indicate that the substitution effect exhibits a very limited cross-sectional variation across issuers with different characteristics. Most interaction terms are insignificant. The only exception is the negative and statistically significant effect for issuers with highest level of equity, indicating that well-capitalized issuers respond more to safety demand.

In our subsequent tests, we examine whether the effect of balance sheet characteristics varies in the time series. For example, it could be that balance-sheet characteristics become more relevant in times of high market stress. Therefore, we estimate the previous model by splitting our sample into observations with high and low levels of uncertainty, measured by levels of the VIX above or below its sample median. Our results, in Table 13, show that the effect of bank characteristics on the substitution between public and private assets is economically and statistically important in periods of low uncertainty (Panel A) and irrelevant in periods of high uncertainty (Panel B). In particular, we find that issuers with larger assets size, equity, and ROA are more likely to cater to the demand for safety. Furthermore, issuers with higher percentages of impaired loans respond significantly less to safety demand. These findings are consistent with the hypothesis that investors discriminate among issuers and select those with better balance sheets, especially at times when the substitution effect is stronger. More broadly, this result suggests that studies of safe assets should pay more attention to issuer heterogeneity. At a given point in time, not all issuers are considered equally safe. Our results are consistent with the hypothesis

[14] We do not consider the impact of CDS spreads due to the lack of data for most issuers.

that investors shun assets with poor fundamentals during periods of high market stress, consistent with Pérignon, Thesmar, and Vuillemey (2017). Overall, our results indicate that investors do not consider private assets as equally safe at all times and therefore lend support to Hypothesis 4.

7 Conclusion

Our study of private safe assets generates several important findings. We show that privately issued debt securities can benefit from a safety premium, but only if their maturity remains very short. Consistent with the existence of a demand for safe stores of value, we show that the private sector produces more safe assets when the demand for public safe assets goes up. We study the heterogeneity in the relationship between public and private issuance of safe assets, both over time and in the cross-section, and show that the private production of safe assets breaks down in times of high market stress. Finally, we find that the production of safe assets is driven by banks, not by non-financial firms. Among banks, high-quality institutions are more likely to provide safe assets. Overall, these results are consistent with investors seeking information-insensitive stores of value.

Our structural model of safe assets demand and supply appropriately describes the market for CDs. However, it is not specific to CDs and is general enough to accommodate any short-term debt securities. As a result, researchers focusing on other types of debt may find it equally useful to guide their identification strategies.

Our results offer potentially important policy implications. The finding that the private production of safe assets can break down in periods of market stress implies that public and private safe assets are not perfect substitutes. Thus, one can observe an overproduction of private safe assets in good times. The reliance of the financial system on such assets becomes problematic when supply of public safety vanishes. As outlined by Greenwood, Hanson, and Stein (2015), the Treasury can correct externalities associated with the private production of safe assets by tilting issuances towards short maturities. Monetary policy can also play a role, and thereby contribute to a greater financial stability, as argued by Stein (2012), Gourinchas and Jeanne (2012), and Greenwood, Hanson, and Stein (2016).

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Table 1 – Description of the sample of CD issuers

This table describes the sample of CD issuers. Panel A shows the share of issuers and CD amounts issued by country. Panel B provides descriptive statistics on the distribution of balance sheet characteristics of CD issuers. Means and quantiles are as of end of December of each year and are computed from the pooled sample over the period from 2008 to 2014. Panel C relates CD outstanding amounts as of end of December of each year to other balance sheet characteristics, in the pooled sample. Statistics are conditional on the issuer having a non-zero amount of CD outstanding. Calculation of CD / (CD + Repo) is also conditional on the issuer having a non-zero amount of repurchase agreements outstanding. All variables are defined in Table A1.

Panel A: Geographic distribution of issuers

	Banks		% Issued	
	# issuers	% Issuers	amount	Largest issuer
All	271	100.00	100.00	—
Austria	2	0.74	0.20	Oesterreich. Kontrollbank
Belgium	2	0.74	6.26	Dexia Credit Local
Denmark	3	1.11	0.56	Jyske Bank
France	196	72.32	72.83	BNP Paribas
Germany	12	4.43	1.08	HypoVereinsbank
Ireland	7	2.58	0.48	Allied Irish Banks
Italy	14	5.17	3.18	Unicredit
Netherlands	8	2.95	5.42	Rabobank
Spain	2	0.74	0.58	BBVA
Sweden	4	1.48	0.89	Svenska Handelsbanken
Switzerland	2	0.74	0.44	UBS
UK	11	4.06	7.36	HSBC
Others	8	2.95	1.12	—

Panel B: Balance sheet characteristics

	10th	25th	Mean	Median	75th	90th	Std.	Obs.
Size (log Total assets)	20.82	22.07	23.50	23.34	24.71	26.70	2.09	1,449
Loans / Assets	0.27	0.48	0.63	0.69	0.82	0.88	0.23	1,445
Customer deposits / Assets	0.03	0.20	0.37	0.35	0.57	0.66	0.23	1,422
Short-term debt / Assets	0.05	0.13	0.29	0.24	0.48	0.60	0.21	1,422
ROA (%)	-0.20	0.15	0.32	0.40	0.74	1.04	1.15	1,443
ROE (%)	-3.88	2.52	3.57	5.42	8.32	13.27	12.36	1,443
Net interest margin / Assets	0.00	0.01	0.01	0.01	0.02	0.03	0.01	1,411
Impaired loans / Loans (%)	1.04	2.24	5.42	3.91	6.59	11.89	5.08	1,056
Equity / Assets	0.03	0.04	0.08	0.07	0.11	0.13	0.05	1,449
Tier 1 capital (%)	7.60	9.20	13.07	11.20	14.30	18.25	7.29	458
Total regulatory capital (%)	9.90	11.60	16.12	13.70	16.91	21.4	10.27	486

Panel C: Size of CD funding

	10th	25th	Mean	Median	75th	90th	Std.	Obs.
CD / Equity	0.01	0.05	1.17	0.21	0.69	2.25	0.33	971
CD / (CD + Repo)	0.01	0.05	0.34	0.22	0.61	0.85	0.39	218
CD / Short-term debt	0.00	0.01	0.16	0.05	0.18	0.49	0.23	971
CD / Total liabilities	0.00	0.01	0.09	0.03	0.09	0.22	0.10	1,007

Table 2 – Descriptive statistics on short-term debt securities

This table describes our data on the issuance of short-term debt securities. The universe of assets includes T-bills issued by the French Treasury and CDs issued by European banks. Panel A shows the amount of securities outstanding. Panel B shows net issuances, defined as the change in outstanding amounts between Fridays of two consecutive weeks. Panel C shows the maturity of new issues, measured in days, both unweighted and weighted by the amount of the issue. Unweighted moments are computed based on the sample of all issuances. Weighted moments are computed as averages by day. Short-term CDs are defined as those with maturity below or equal to 7 days at issuance.

Panel A: Aggregate T-bill and CD amounts outstanding (in EUR Billion)

	Min	10pc	25pc	Median	Mean	75pc	90pc	Max	Std.	Obs.
Total T-bill outstanding	78.4	111.6	165.6	174.6	167.4	183.4	196.4	209.9	29.7	365
Total CD outstanding	248.9	285.3	340.2	373.8	369.7	412.2	433.0	465.9	52.5	365
Short-term CD outstanding	1.0	9.1	19.1	31.2	30.8	40.9	50.6	75.2	15.7	365

Panel B: Aggregate T-bill and CD net issuance (in EUR Billion)

	Min	10pc	25pc	50pc	Mean	75pc	90pc	Max	Std.	Obs.
Total T-bill net issuance	-15.2	-1.3	-0.5	0.0	0.3	1.2	2.3	5.9	1.8	364
Total CD net issuance	-29.0	-7.0	-3.7	-0.3	-0.4	3.0	7.1	26.9	6.5	364
Short-term CD net issuance	-28.4	-7.7	-4.2	-0.1	-0.2	3.8	7.1	29.6	7.2	364

Panel C: Maturity of new issues (in days)

	Min	10pc	25pc	50pc	Mean	75pc	90pc	Max	Std.	Obs.
Pooled data										
T-bill	7	84	91	154	185	337	357	365	111	1,145
CD	1	2	13	33	66	92	181	367	76	841,636
Volume weighted (daily)										
T-bill	53	129	154	164	161	173	182	227	23	359
CD	5	13	18	26	40	39	79	365	44	2,185

Table 3 – Safety premium on T-bills and CDs

This table displays the safety premium on T-bills and CDs with maturities between one week and one year. The safety premium is defined by equation (1). In Panel A, the safety premium is computed over the whole sample period (2008-2014) for each maturity. In each sub-panel, the last column shows the difference between the safety premium at the longest and at the shortest available maturity. In Panel B, we regress the safety premium on a set of indicator variables for each individual year, with no intercept. Standard errors are in parentheses. In Panel C, we compute linear slopes of the weekly CD safety premium over three intervals ([1 week; 1 month], [1 month; 3 months], and [3 months; 6 months]). The first three columns display the average slopes and their standard-deviations. The last two columns report differences and standard deviations obtained from a two-sample t-test. *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Whole sample period

	T-bills					CD				
	1m	3m	6m	12m	12m - 1m	1w	1m	3m	6m	6m - 1w
	-0.150***	-0.120***	-0.068***	-0.023***	0.126***	-0.081***	0.115***	0.239***	0.374***	0.461***
	(0.007)	(0.007)	(0.005)	(0.005)	(0.007)	(0.005)	(0.036)	(0.024)	(0.025)	(0.025)
Obs.	338	338	338	338	338	338	338	338	338	338

Panel B: By year

	1m	3m	6m	12m	12m - 1m	1w	1m	3m	6m	6m - 1w
2008	-0.168***	-0.162***	-0.077***	-0.029***	0.138***	0.040***	0.372***	0.639***	1.216***	1.196***
	(0.014)	(0.015)	(0.010)	(0.011)	(0.016)	(0.014)	(0.112)	(0.069)	(0.072)	(0.074)
2009	-0.089***	-0.039***	0.010	0.030***	0.120***	-0.164***	0.072	0.318***	0.394***	0.558***
	(0.014)	(0.015)	(0.010)	(0.011)	(0.016)	(0.011)	(0.088)	(0.054)	(0.050)	(0.050)
2010	-0.151***	-0.138***	-0.097***	-0.072***	0.078***	-0.115***	0.048	0.089	0.197***	0.312***
	(0.014)	(0.015)	(0.010)	(0.011)	(0.016)	(0.011)	(0.088)	(0.054)	(0.050)	(0.050)
2011	-0.278***	-0.220***	-0.133***	-0.049***	0.229***	-0.059***	0.374***	0.352***	0.404***	0.464***
	(0.014)	(0.015)	(0.010)	(0.011)	(0.016)	(0.011)	(0.088)	(0.054)	(0.050)	(0.050)
2012	-0.189***	-0.161***	-0.113***	-0.047***	0.142***	-0.091***	0.010	0.237***	0.443***	0.535***
	(0.014)	(0.015)	(0.010)	(0.011)	(0.016)	(0.011)	(0.088)	(0.054)	(0.050)	(0.050)
2013	-0.077***	-0.056***	-0.039***	-0.003	0.074***	-0.058***	-0.024	0.054	0.108**	0.167***
	(0.014)	(0.015)	(0.010)	(0.011)	(0.016)	(0.011)	(0.088)	(0.054)	(0.050)	(0.050)
2014	-0.042**	-0.007	0.012	0.031**	0.073***	-0.072***	-0.020	0.044	0.231***	0.303***
	(0.019)	(0.021)	(0.013)	(0.015)	(0.022)	(0.016)	(0.126)	(0.076)	(0.069)	(0.051)
R^2	0.735	0.615	0.599	0.232	0.584	0.604	0.068	0.361	0.627	0.673
Obs.	338	338	338	338	338	338	338	338	338	338

Panel C: Slope of CD safety premium

Average slopes			Differences in slopes	
[1w, 1m]	[1m, 3m]	[3m, 6m]	[1w, 1m] − [1m, 3m]	[1m, 3m]−[3m, 6m]
0.049***	0.024***	0.017***	0.024***	0.008***
(0.003)	(0.001)	(0.001)	(0.002)	(0.001)

Table 4 – CD issuance and T-bill issuance

In this table, we regress the change in log CDs outstanding on the change in log T-bills outstanding. The data are at a weekly frequency. Short-term (resp. long-term) CDs are defined as having a maturity below or equal to (resp. above) 7 days at issuance. Control variables include: $\log(Q_{CD,t-1})$, $\Delta\log(Q_{CD,t-1})$, $\log(Q_{TB,t-1})$, $\Delta\log(Q_{TB,t-1})$. In Panel B, we also control for total assets, return on assets, loans over assets, customer deposits over assets, common equity over assets, and impaired loans over total loans. I and YQ denote issuer and year-quarter fixed effects. The data in Panel A aggregate CD issuances of all sample banks in a given week. The time period is from January 2008 to July 2014. Robust standard errors (Panel A) and standard errors clustered at the week level (Panel B) are reported in parentheses. *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Time-series evidence

	Dependent variable: $\Delta\log(Q_{CD,t})$					
	All CD		Short-term CD		Long-term CD	
$\Delta\log(Q_{TB,t})$	0.073	0.085	-2.696**	-2.832***	0.482**	0.370**
	(0.116)	(0.132)	(1.128)	(0.868)	(0.197)	(0.179)
Controls	No	Yes	No	Yes	No	Yes
R^2	0.132	0.276	0.031	0.221	0.109	0.234
Observations	342	341	342	341	342	341
FE	YQ	YQ	YQ	YQ	YQ	YQ

Panel B: Panel evidence

	Dependent variable: $\Delta\log(\text{Short-term } Q_{CD,i,t})$					
$\Delta\log(Q_{TB,t})$	-2.772***	-3.732***	-4.534***	-3.599***	-4.208***	-5.076***
	(0.817)	(1.043)	(1.109)	(1.284)	(1.340)	(1.424)
Controls	No	No	No	Yes	Yes	Yes
R^2	0.001	0.004	0.003	0.002	0.005	0.006
Observations	16,083	16,083	16,007	9,870	9,906	9,870
FE	I	YQ	I, YQ	I	I, YQ	I, YQ

Table 5 – CD issuance and T-bill safety premium

In this table, we regress changes in the natural logarithm of CDs outstanding on the T-bill safety premium. Panel A estimates time-series regressions, where issuances are aggregated across issuers, while Panel B uses panel data. The T-bill safety premium is computed using Equation (1), where we use the Eonia swap rate as the risk-free rate r_f. In the last two columns of Panel B, the T-bill safety premia is measured using an alternative variable: the difference between the actual T-bill rate and the T-bill rate predicted using the term-structure model by Gürkaynak, Sack, and Wright (2007). Observations are at a weekly frequency. Short-term (resp. long-term) CDs are defined as having a maturity below or equal to (resp. above) 7 days at issuance. Control variables include: $\log(Q_{CD,t-1})$, $\Delta\log(Q_{CD,t-1})$, $\log(Q_{TB,t-1})$, $\Delta\log(Q_{TB,t-1})$. In Panel B, we also control for total assets, return on assets, loans over assets, customer deposits over assets, common equity over assets, and impaired loans over total loans. I and YQ denote issuer and year-quarter fixed effects. The time period is from January 2008 to July 2014. Standard errors clustered at the week level are reported in parentheses. *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Time-series evidence

	Dependent variable: $\Delta\log(Q_{CD,t})$		
	All CD issues	Short-term CDs	Long-term CDs
$P_{TB,t}$	-0.013	-0.263***	0.004
	(0.012)	(0.069)	(0.018)
Controls	Yes	Yes	Yes
R^2	0.278	0.221	0.231
Observations	336	336	336
FE	YQ	YQ	YQ

Panel B: Panel evidence

	Dependent variable: $\Delta\log(\text{Short-term } Q_{CD,i,t})$						
	Eonia					Term-structure model	
$P_{TB,t}$	-0.254***	-0.272*	-0.321**	-0.276*	-0.328**	-0.214*	-0.192*
	(0.077)	(0.150)	(0.160)	(0.152)	(0.164)	(0.131)	(0.127)
Controls	No	No	Yes	No	Yes	Yes	Yes
R^2	0.001	0.002	0.003	0.002	0.003	0.003	0.004
Observations	16,091	16,091	14,349	16,091	14,349	14,349	14,349
FE	-	YQ	YQ	I, YQ	I, YQ	YQ	I, YQ

Table 6 – Instrumental variables estimation

In this table, we regress changes in log CDs outstanding on the CD safety premium, where the CD safety premium is instrumented using the T-bill bid-to-cover ratio (BTC). Panel A displays some descriptive statistics on the BTC and on its two components (bid = T-bill demand and cover = T-bill supply). In panel B, we study the dynamics of the instrument by regressing in on the monthly aggregate flows of average BTC and in T-bill bids (the numerator in BTC) on monthly flows into European money market funds. Panel C shows the regression estimates for the two stages of the instrumental variables estimation. The CD safety premium is computed using Equation (1), in which we use the Eonia swap rate as the risk-free rate r_f. Observations are at a weekly frequency. Short-term CDs are defined as having a maturity below or equal to 7 days at issuance. Control variables include: $\log(Q_{CD,t-1})$, $\Delta \log(Q_{CD,t-1})$, total assets, return on assets, loans over assets, customer deposits over assets, common equity over assets, and impaired loans over total loans. Standard errors are reported in parentheses. *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Descriptive statistics

	Min	10pc	25pc	Median	Mean	75pc	90pc	Max	Std.	Obs.
Bid-to-cover ratio	1.62	2.14	2.37	2.67	2.69	2.94	3.36	4.41	0.47	358
Bid (EUR Bn.)	6.20	14.80	17.60	20.60	20.40	23.20	26.60	42.30	4.70	358
Cover (EUR Bn.)	2.90	6.40	7.30	8.00	7.90	8.60	9.60	11.50	1.40	358
Fund flows (EUR Bn.)	-77.80	-24.30	-15.00	-4.00	-3.40	8.30	15.50	81.50	19.80	83

Panel B: Variation in the instrument

	ΔBTC_t	ΔBTC_t	$\Delta \log(Bids_t)$
$Flow_t$	0.344*	0.708*	1.837*
	(0.161)	(0.337)	(0.852)
$\log(Cover_t)$	-0.003	-0.096	
	(0.193)	(0.317)	
R^2	0.007	0.009	0.011
Observations	83	83	83
FE	-	YQ	YQ

Panel C: Instrumental variables estimation

	First stage		*Second stage*	
	Dependent variable			
	$P_{CD,t}$		$\Delta \log(\text{Short-term } Q_{CD,i,t})$	
Bid-to-cover ratio$_t$	-0.006***	-0.005***		
	(0.002)	(0.002)		
Instrumented $P_{CD,t}$			-8.187**	-9.619*
			(4.061)	(5.315)
Controls	No	Yes	No	Yes
F statistic	11.48	55.65	-	-
R^2	0.010	0.011	-	-
Observations	14,725	14,649	14,725	14,649

Table 7 – CD maturity and T-bill issuance

In this table, we regress the share of CDs issued with maturity below one week on changes in log T-bills outstanding. Observations are at the bank-week level. Control variables include: $\log(Q_{CD,t-1})$, $\Delta\log(Q_{CD,t-1})$, $\log(Q_{TB,t-1})$, $\Delta\log(Q_{TB,t-1})$, total assets, return on assets, loans over assets, customer deposits over assets, common equity over assets, and impaired loans over total loans. I and YQ denote issuer and year-quarter fixed effects, respectively. The time period is from January 2008 to July 2014. Standard errors clustered at the week level are reported in parentheses. *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively.

	Dependent variable: Share of CDs issued with maturity below 1 week				
$\Delta\log(Q_{TB,t})$	0.115	-0.467**	-0.507**	-0.468***	-0.509***
	(0.164)	(0.214)	(0.227)	(0.148)	(0.157)
Controls	No	No	Yes	No	Yes
R^2	0.000	0.010	0.010	0.027	0.027
Observations	45,046	45,046	44,695	45,046	44,695
FE	-	YQ	YQ	I, YQ	I, YQ

Table 8 – Descriptive statistics and safety premium on CPs

This table shows descriptive statistics on issuance in the CP market and on the CP safety premium. Panel A shows the amount of securities outstanding, net issuances, and the maturity of new issues, measured in days. These moments are defined as in Table 2. Panel B describes the safety premium on CP, defined by Equation (1). Short-term CDs are defined as those with maturity below or equal to 7 days at issuance. Standard errors are reported in parentheses. *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively.

Panel A: CP amounts outstanding, net issuance and maturity

	Min	10pc	25pc	Median	Mean	75pc	90pc	Max	Std.	Obs.
Aggregate amount outstanding										
Total (in Bn)	29.8	37.7	40.4	44.1	50.8	52.9	80.3	89.7	15.3	365
1-week (in Bn)	0.1	0.2	0.5	1.5	3.3	4.3	8.8	19.2	4.1	365
Aggregate net issuance										
Total (in Bn)	-32.7	-1.6	-0.6	0.06	-0.0	0.78	1.4	31.3	2.8	364
1-week (in Bn)	-10.5	-1.3	-0.4	-0.0	-0.0	0.3	1.3	8.3	1.5	364
Maturity of new issues										
Pooled data	1	2	7	25	60	70	150	365	76	157,909
Volume-weighted	9	21	28	38	42	55	68	120	19	502

Panel B: Safety premium

	1w	1m	3m	6m	6m - 1w
	-0.025***	0.159***	0.201***	0.157***	0.180***
	(0.006)	(0.011)	(0.008)	(0.020)	(0.020)
Observations	233	233	233	233	233

Table 9 – CP issuance and T-bill issuance

In this table, we regress changes in log CPs outstanding on changes in log T-bills outstanding. Observations are at a weekly frequency and aggregate CP issuances of all sample firms. One-week CPs are defined as having a maturity below or equal to 7 days at issuance. Control variables include: $\log(Q_{CP,t-1})$, $\Delta\log(Q_{CP,t-1})$, $\log(Q_{TB,t-1})$, $\Delta\log(Q_{TB,t-1})$. In Panel B, we also control for total assets, return on assets, total debt over assets, and common equity over assets. YQ denotes year-quarter fixed effects. The time period is from January 2008 to July 2014. Robust standard errors (Panel A) and standard errors clustered at the week level (Panel B) are reported in parentheses. *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Time-series evidence

	Dependent variable: $\Delta\log(Q_{CP,t})$					
	All CP		Short-term CP		Long-term CP	
$\Delta\log(Q_{TB,t})$	2.014	4.990*	7.019	2.378	2.098	8.717***
	(3.065)	(2.547)	(4.276)	(3.075)	(4.713)	(3.104)
Controls	No	Yes	No	Yes	No	Yes
R^2	0.019	0.397	0.030	0.289	0.023	0.486
Observations	342	341	342	341	342	341
FE	YQ	YQ	YQ	YQ	YQ	YQ

Panel B: Panel evidence

	Dependent variable: $\Delta\log(Q_{CP,i,t})$				
$\Delta\log(Q_{TB,t})$	2.552	4.107	2.469	5.026***	3.398*
	(2.116)	(2.502)	(2.708)	(1.647)	(1.850)
Controls	No	No	Yes	No	Yes
R^2	0.001	0.007	0.027	0.008	0.028
Observations	2,063	2,063	2,051	2,063	2,051
FE	-	YQ	YQ	I, YQ	I, YQ

Table 10 – T-bill volume and CD issuance with other European T-bills: Panel evidence

In this table, we regress changes in log CDs outstanding at the bank level on changes in log T-bills outstanding. Observations are at the bank-week level. One-week CDs are defined as having a maturity below or equal to 7 days at issuance. Control variables include: $\log(Q_{CD,t-1})$, $\Delta\log(Q_{CD,t-1})$, $\log(Q_{TB,t-1})$, $\Delta\log(Q_{TB,t-1})$, total assets, return on assets, loans over assets, customer deposits over assets, common equity over assets, and impaired loans over total loans. I and YQ denote issuer and year-quarter fixed effects. The time period is from January 2008 to July 2014. Standard errors clustered at the week level are reported in parentheses. *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively.

	Dependent variable: $\Delta\log(Q_{CD,i,t})$					
	France + Germany			Italy + Spain		
$\Delta\log(Q_{TB,t})$	-2.285***	-3.605***	-4.456***	-0.492	-0.127	-0.225
	(0.779)	(1.045)	(1.078)	(0.849)	(0.911)	(0.949)
Controls	No	No	Yes	No	No	Yes
R^2	0.001	0.003	0.005	0.000	0.002	0.003
Observations	16,083	16,083	16,007	16,083	16,083	16,007
FE	I	I, YQ	I, YQ	I	I, YQ	I, YQ

Table 11 – CD issuance and T-bill issuance conditional on measures of stress

In this table, we regress changes in log short-term CDs outstanding at the bank level on changes in log T-bills outstanding, interacted with measures of market stress. Short-term CDs are defined as having a maturity below or equal to 7 days at issuance. Observations are at the bank-week level. The baseline coefficients are for "Low stress" periods, defined as a VIX, 50-days past stock returns on the Euro stoxx 50, or the Euribor-Eonia swap spread in their first quartile over the sample period. Other interaction terms are for the three top quartiles. Control variables include: $\log(Q_{CD,t-1})$, $\Delta\log(Q_{CD,t-1})$, $\log(Q_{TB,t-1})$, $\Delta\log(Q_{TB,t-1})$, total assets, return on assets, loans over assets, customer deposits over assets, common equity over assets, and impaired loans over total loans. I and YQ denote issuer and year-quarter fixed effects. Each regression also includes fixed effects associated with quartiles of the market stress variable used to construct interaction terms. The time period is from January 2008 to July 2014. Standard errors clustered at the week level are reported in parentheses. *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively.

	Dependent variable: $\Delta\log(\text{Short-term } Q_{CD,i,t})$					
	VIX		Past returns Euro stoxx 50		Euribor - Eonia swap spread	
$\Delta\log(Q_{TB,t})$	-11.188***	-11.891***	-7.477***	-8.179***	-6.861**	-7.403**
	(3.263)	(3.295)	(2.060)	(2.076)	(3.099)	(3.097)
$\Delta\log(Q_{TB,t}) *$ Mid-low stress	2.666	2.927	-2.970	-2.108	-2.219	-1.728
	(4.548)	(4.544)	(3.355)	(3.363)	(3.969)	(3.969)
$\Delta\log(Q_{TB,t}) *$ Mid-high stress	7.218**	7.096**	4.584*	4.357	3.651	3.640
	(3.663)	(3.660)	(2.754)	(2.772)	(3.646)	(3.670)
$\Delta\log(Q_{TB,t}) *$ High stress	10.322***	10.074***	7.459***	7.359***	4.568	3.875
	(3.568)	(3.573)	(2.587)	(2.631)	(3.371)	(3.386)
Controls	No	Yes	No	Yes	No	Yes
R^2	0.004	0.005	0.004	0.006	0.004	0.005
Observations	16,083	16,007	16,083	16,007	15,901	15,825
FE	I, YQ	I, YQ	I, YQ	I, YQ	I, YQ	I, YQ

Table 12 – CD issuance and T-bill issuance, interacted with balance sheet quartiles

In this table, we regress changes in log short-term CDs outstanding at the bank level on changes in log T-bills outstanding, interacted with balance sheet characteristics. Observations are at the bank-week level. Short-term CDs are defined as having a maturity below or equal to 7 days at issuance. Control variables include: $\log(Q_{CD,t-1})$, $\Delta\log(Q_{CD,t-1})$, $\log(Q_{TB,t-1})$, $\Delta\log(Q_{TB,t-1})$, total assets, return on assets, loans over assets, customer deposits over assets, common equity over assets, and impaired loans over total loans. I and YQ denote issuer and year-quarter fixed effects. Each regression also includes fixed effects associated with quantiles (above or below median) of the balance sheet variable used to construct interaction terms. The time period is from January 2008 to July 2014. Standard errors clustered at the week level are reported in parentheses. *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively.

	Dependent variable: $\Delta\log(\text{Short-term } Q_{CD,i,t})$				
	Size	Equity	Impaired	ROA	Rating
$\Delta\log(Q_{TB,t})$	-5.312	-4.575**	-5.190**	-3.998*	-4.694*
	(3.324)	(1.903)	(2.459)	(2.168)	(2.483)
$\Delta\log(Q_{TB,t}) * \text{Q2}$	1.711	1.009	0.283	-0.449	-0.936
	(4.145)	(2.477)	(3.135)	(2.784)	(2.818)
$\Delta\log(Q_{TB,t}) * \text{Q3}$	-2.664	-0.708	-0.990	-1.789	-11.926
	(3.873)	(3.361)	(2.926)	(2.832)	(7.902)
$\Delta\log(Q_{TB,t}) * \text{Q4}$	1.385	-6.819*	2.857	-3.634	-8.281
	(3.541)	(4.022)	(3.523)	(4.020)	(12.915)
Controls	Yes	Yes	Yes	Yes	Yes
R^2	0.007	0.007	0.007	0.007	0.008
Observations	9,870	9,870	9,870	9,870	7,629
FE	I, YQ	I, YQ	I, YQ	I, YQ	I, YQ

Table 13 – CD issuance and T-bill issuance, interacted with balance sheet quartiles: High and low VIX periods

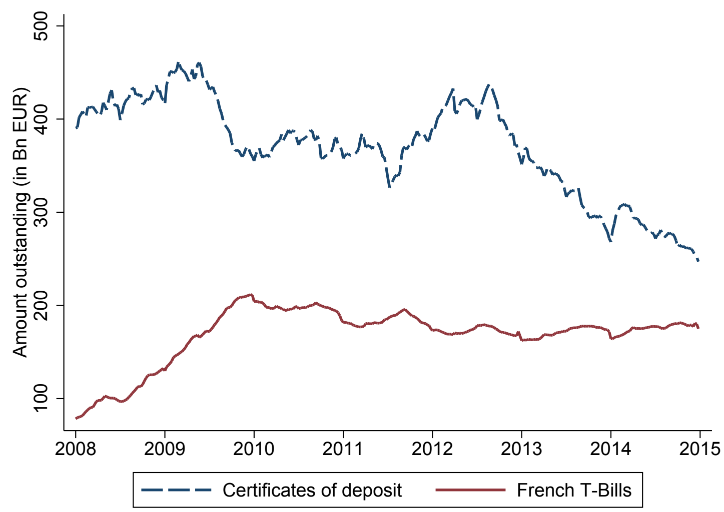
In this table, we regress changes in log short-term CDs outstanding at the bank level on changes in log T-bills outstanding, interacted with balance sheet characteristics. In Panels A and B, we restrict attention to, respectively, low VIX and high VIX periods. "Low VIX" and "High VIX" are defined as levels of the VIX above or below the sample median. Observations are at the bank-week level. Short-term CDs are defined as having a maturity below or equal to 7 days at issuance. Control variables include: $\log(Q_{CD,t-1})$, $\Delta\log(Q_{CD,t-1})$, $\log(Q_{TB,t-1})$, $\Delta\log(Q_{TB,t-1})$, total assets, return on assets, loans over assets, customer deposits over assets, common equity over assets, and impaired loans over total loans. I and YQ denote issuer and year-quarter fixed effects. Each regression also includes fixed effects associated with quartiles of the balance sheet variable used to construct interaction terms. The time period is from January 2008 to July 2014. Standard errors clustered at the week level are reported in parentheses. *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively.

	Dependent variable: $\Delta\log(\text{Short-term } Q_{CD,i,t})$				
	Panel A: Low-VIX periods				
	Size	Equity	Impaired	ROA	Rating
$\Delta\log(Q_{TB,t})$	-0.953	-10.739***	-13.268***	-9.871**	-11.181***
	(9.408)	(3.797)	(3.748)	(4.818)	(4.283)
$\Delta\log(Q_{TB,t}) * $ Q2	0.048	6.091	9.974**	2.145	1.025
	(10.820)	(5.430)	(6.036)	(6.102)	(4.526)
$\Delta\log(Q_{TB,t}) * $ Q3	-15.450	2.046	-2.993	-0.288	-1.837
	(10.559)	(7.648)	(6.544)	(6.331)	(5.527)
$\Delta\log(Q_{TB,t}) * $ Q4	-10.763	-18.288**	13.475	-10.587	-4.699
	(9.811)	(9.339)	(8.216)	(9.766)	(13.798)
Controls	Yes	Yes	Yes	Yes	
R^2	0.016	0.016	0.016	0.015	0.022
Observations	4,930	4,930	4,930	4,930	3,307
FE	I, YQ	I, YQ	I, YQ	I, YQ	I, YQ
	Panel B: High-VIX periods				
$\Delta\log(Q_{TB,t})$	-5.662	-3.715	-2.716	-3.529	-1.802
	(3.756)	(2.358)	(2.433)	(2.580)	(3.313)
$\Delta\log(Q_{TB,t}) * $ Q2	1.583	0.290	-2.559	0.074	-2.571
	(4.761)	(2.909)	(3.445)	(3.293)	(3.589)
$\Delta\log(Q_{TB,t}) * $ Q3	-0.603	-0.781	-1.227	-1.150	2.147
	(4.402)	(3.896)	(3.254)	(3.338)	(5.421)
$\Delta\log(Q_{TB,t}) * $ Q4	3.119	-3.912	-3.771	-2.884	-3.124
	(4.023)	(4.749)	(4.085)	(4.675)	(7.415)
Controls	Yes	Yes	Yes	Yes	Yes
R^2	0.009	0.009	0.009	0.009	0.009
Observations	4,940	4,940	4,940	4,940	4,940
FE	I, YQ	I, YQ	I, YQ	I, YQ	I, YQ

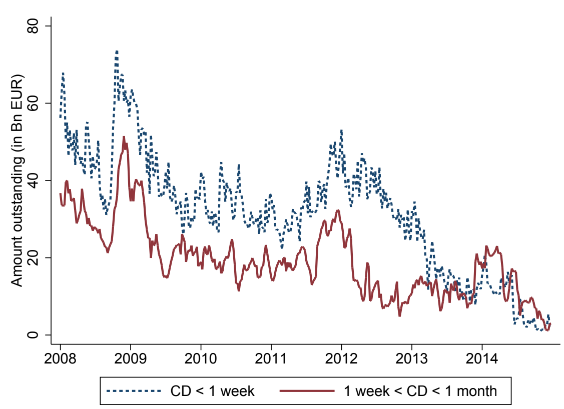
Figure 1 – Outstanding amounts of safe securities

This figure plots the outstanding amounts of safe securities in the European market. We plot certificates of deposit issued by European banks and T-bills issued by the French government. Panel A plots amounts aggregated over all maturities, and Panel B a breakdown across maturities.

Panel A: Aggregate amounts



Panel B: Breakdown by maturity



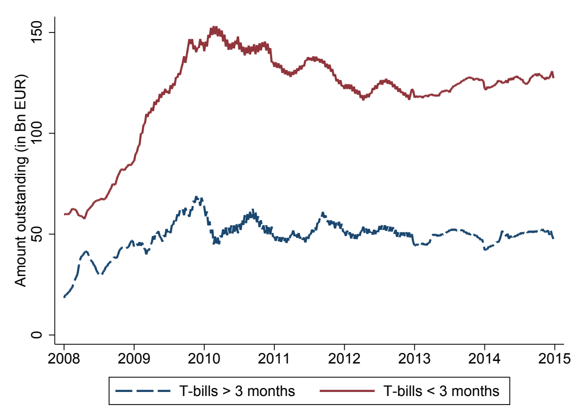
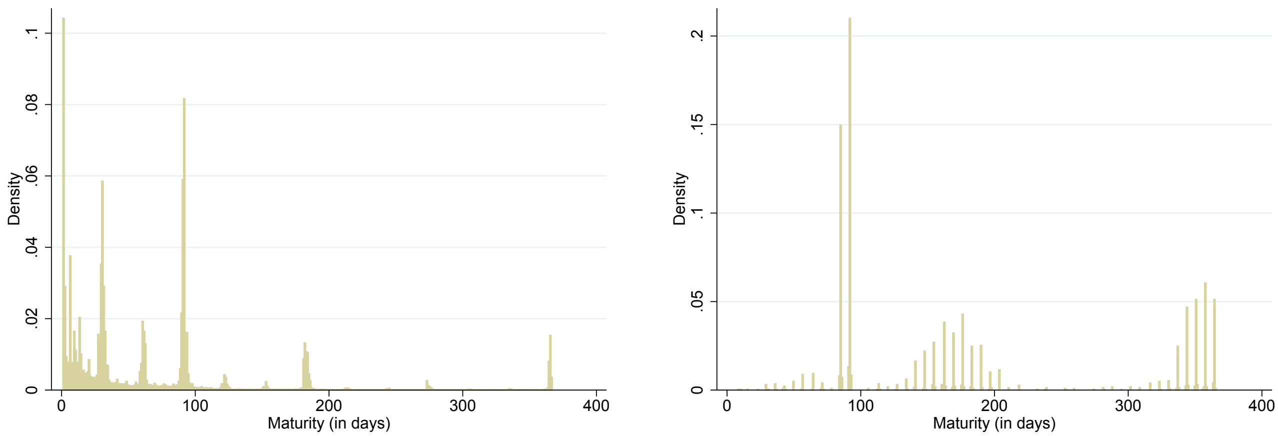


Figure 2 – Distribution of the maturity of short-term debt securities

This figure plots the maturity at issuance of short-term securities in the European debt market. In Panel A, we plot histograms of maturity at issuance for certificates of deposit issued by European banks and for T-bills issued by the French government, both in the pooled sample. Panel B plots the weighted average maturity of CDs at issuance at a monthly frequency (solid line). We superimpose the spread on the 5-year EU Banks credit default swap Index (dotted line).

Panel A: Pooled sample



Panel B: Time-series

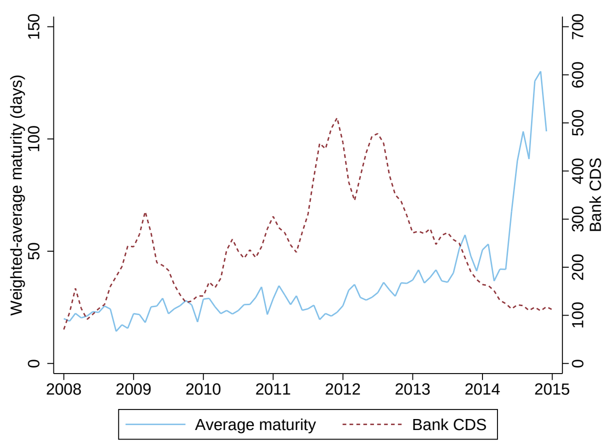
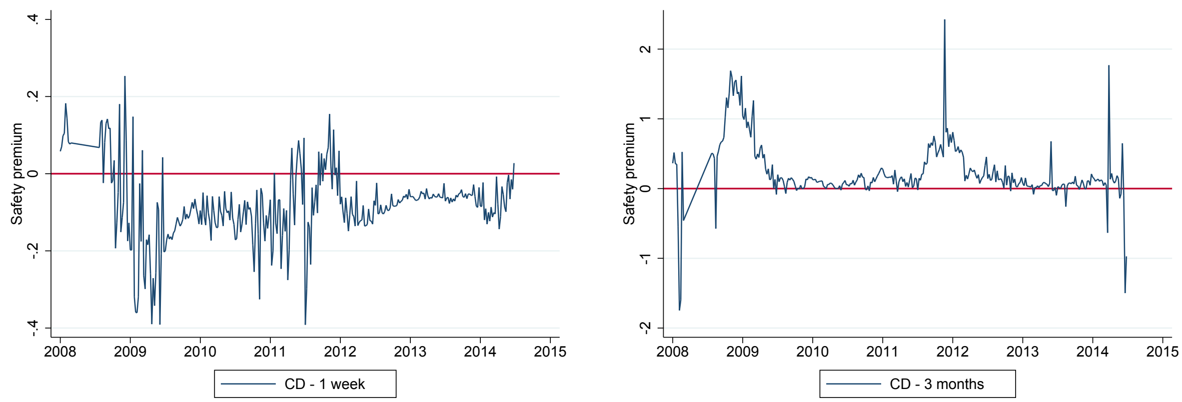


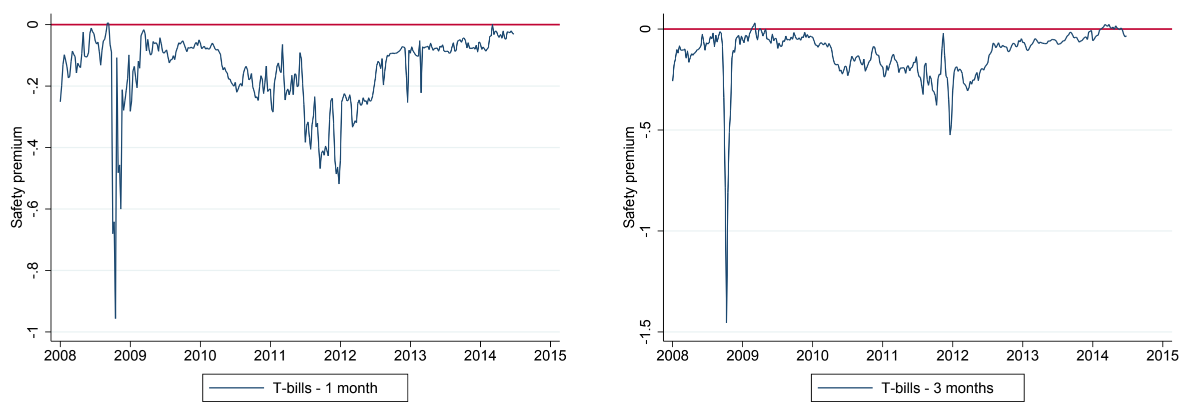
Figure 3 – Safety premium across maturities and countries

This figure plots the safety premium on safe securities in the European market. We plot the safety premium for certificates of deposit issued by European banks and T-bills issued by the French, German, Italian and Spanish governments.

Panel A: Certificates of deposit



Panel B: T-Bills (France)



Panel C: T-Bills (Germany, Italy, Spain)

Figure 4 – Term structure of safety premia and Eonia swap

This figure plots the term structure of the safety premia on CDs (solid line) and T-bills (dotted line). It also plots the term structure of the Eonia swap rate (dashed line). All values are averages over the entire sample period (2008-2014). The one-year safety premium on CD and the one-week safety premium on T-bills are not available.

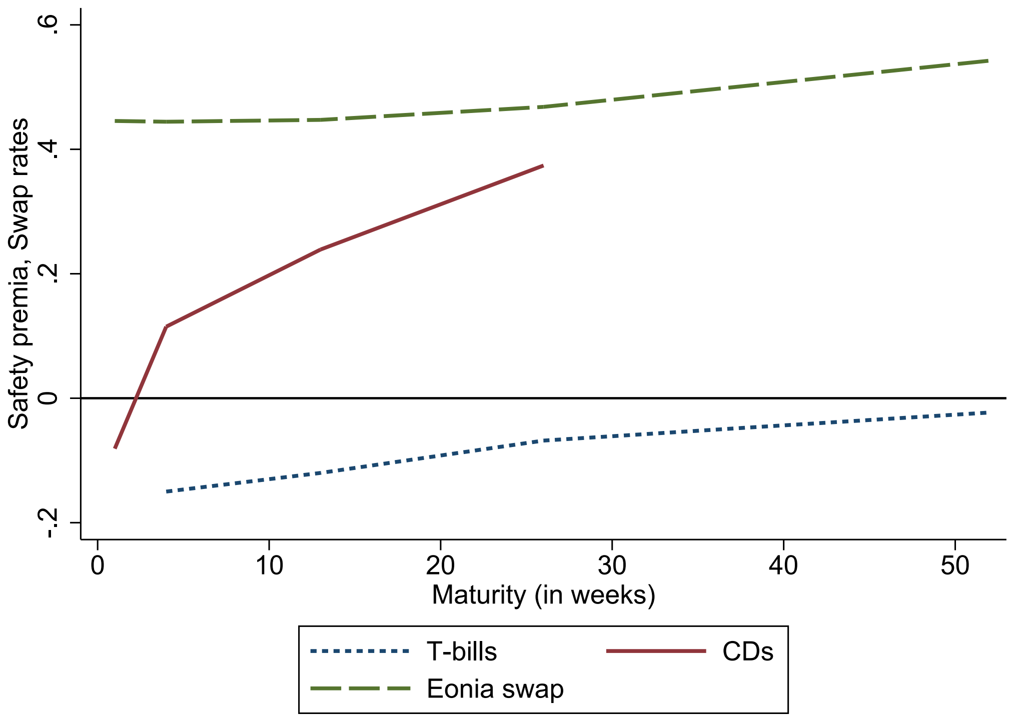


Figure 5 – CD issuance on T-bill auction days

This figure plots the average CD issuance, measured as $\log(Q_{CD,t}) - \log(Q_{CD,t-1})$, for every day of the week. We further break down the data between weeks in which the T-bill bit-to-cover ratio (BTC) is above or below its quarterly median. Monday corresponds to the day on which T-bill auctions are held. The time period is from January 2008 to July 2014.

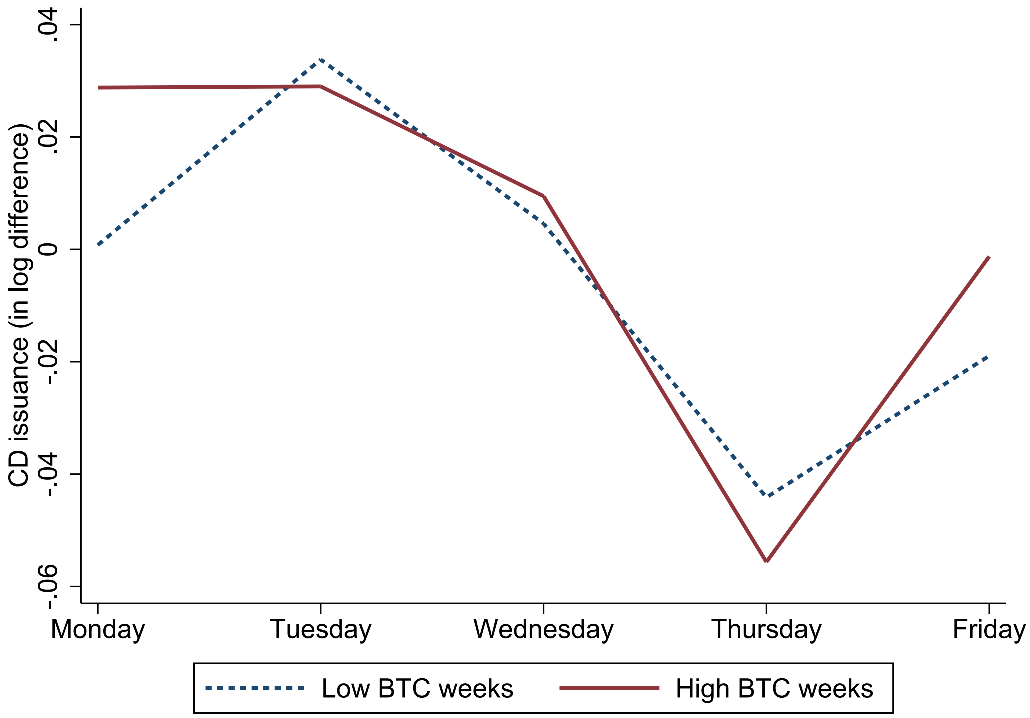
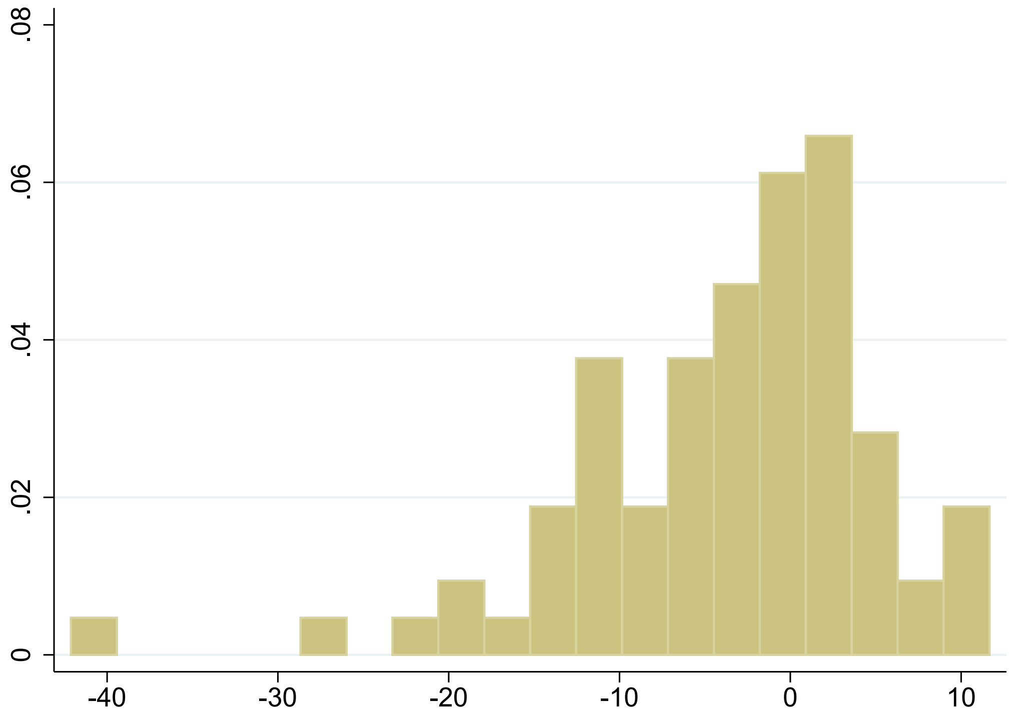


Figure 6 – Cross-sectional variation in CD issuance response to T-bill issuance

This histogram plots the distribution of the coefficients estimated by regressing the change in log CDs outstanding at the issuer level on the change in log T-bills outstanding. The regression is estimated separately for each issuer. The time period is from January 2008 to July 2014.



Online appendix–Not for publication

A Derivation of equations (7) and (8)

From equations (4) and (5), we can rewrite the CD safety premium as:

$$P_{CD} = B + \frac{\beta^d_{CD}}{\gamma^s_{CD} - \gamma^d_{CD}} P_{TB} + \frac{\epsilon^d_{CD} - \epsilon^s_{CD}}{\gamma^s_{CD} - \gamma^d_{CD}}, \tag{18}$$

where $B = (\alpha^d_{CD} - \alpha^s_{CD})/(\gamma^s_{CD} - \gamma^d_{CD})$. In addition to a constant and shocks to CD demand and supply, equation (18) shows the link between the safety premium on CDs and T-bills. They co-move more if CDs and T-bills are treated as substitutes by investors, that is, if β^d_{CD} is positive and large. Plugging in (18) into (5), we obtain equation (7),

$$Q^s_{CD} = C + D \cdot P_{TB} + \nu_p,$$

where

$$C = \alpha^s_{CD} + \gamma^s_{CD} B$$
$$D = \frac{\gamma^s_{CD}\beta^d_{CD}}{\gamma^s_{CD} - \gamma^d_{CD}}$$
$$\nu_p = \gamma^s_{CD} \frac{\epsilon^d_{CD} - \epsilon^s_{CD}}{\gamma^s_{CD} - \gamma^d_{CD}} + \epsilon^s_{CD}.$$

Equation (8) is obtained by noting that P_{TB} and Q^s_{TB} are deterministically related: when combined, equations (2) and (3) solely pin down P_{TB} as a function of Q^s_{TB}. Therefore, equation (7) can be rewritten with Q^S_{TB} instead of P_{TB} as a regressor.

Table A1 – Variable definitions

This table defines the variables used in the empirical analysis, for both CD and CP issuers. The "id" code is the index number in Bankscope or to the variable tickers in Bloomberg. Variables related to issuer profitability and asset quality are winsorized at the 1st and 99th percentiles. We also provide the source for macroeconomic data.

Variable	Definition	Data source
	Data on CD issuers	
Assets	Total assets (id: 11350).	Bankscope
Book equity	Common Equity (id: 11800).	Bankscope
Loans	Gross loans (id: 11100).	Bankscope
Customer deposits	Total customer deposits: Current + Savings + Term (id: 11550).	Bankscope
Net income	Net income (id: 10285).	Bankscope
ROA	Return on average assets (id: 4024).	Bankscope
Impaired loans / Gross loans	Impaired Loans over Gross Loans (id: 18200).	Bankscope
Short-term credit rating	Encoded on a scale from 1 to 5 ("B"=1; "F3"=2; "F2"=3; "F1"=4; "F1+"=5)	Fitch Ratings / Moody's or S&P if Fitch unavailable
	Data on CP issuers	
Assets	Total assets (id: *BS_TOT_ASSET*).	Bloomberg
Equity	Total equity (id: *TOTAL_EQUITY*).	Bloomberg
Total debt	Short-term debt (id: *BS_ST_BORROW*) + Long-term debt (id: *BS_LT_BORROW*).	Bloomberg
Net debt	Net debt (id: *NET_DEBT*).	Bloomberg
ROA	Net income (id: *NET_INCOME*) divided by total assets.	Bloomberg
ROE	Net income (id: *NET_INCOME*) divided by total equity.	Bloomberg
	Macroeconomic data	
VIX	CBOE Volatility Index: VIX (id: *VIXCLS*)	FRED
Eonia swap rates	Eonia swap rates at all maturities between 1 week and 1 year	Bloomberg
Euribor - Eonia swap spread	Euribor from EMMI minus Eonia swap rate, both with 1 month maturity	European Money Market Institute (EMMI)
Eurostoxx 50	Eurostoxx 50 Index	Bloomberg

Table A2 – CD issuance and T-bill issuance by maturity

In this table, we regress changes in log CDs outstanding on changes in log T-bills outstanding. We break down the supply of CD and T-bills in two maturity buckets. Observations are at a weekly frequency and aggregate CD issuances of all sample banks. Short-term (resp. long-term) CDs are defined as having a maturity below or equal to (resp. above) 7 days at issuance. Short-term (resp. long-term) T-bills are defined as having a maturity below or equal to (resp. above) 3 months at issuance. Control variables include: $\log(Q_{CD,t-1})$, $\Delta\log(Q_{CD,t-1})$, $\log(Q_{TB,t-1})$, $\Delta\log(Q_{TB,t-1})$, total assets, return on assets, loans over assets, customer deposits over assets, common equity over assets, and impaired loans over total loans. I and YQ denote issuer and year-quarter fixed effects. The time period is from January 2008 to July 2014. Standard errors clustered at the week level are reported in parentheses. *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively.

	Dependent variable:			
	$\Delta\log$(Short-term $Q_{CD,i,t}$)		$\Delta\log$(Long-term $Q_{CD,i,t}$)	
$\Delta\log$(Short-term $Q_{TB,t}$)	-1.048***		0.284***	
	(0.251)		(0.071)	
$\Delta\log$(Long-term $Q_{TB,t}$)		-0.540**		0.008
		(0.035)		(0.029)
Controls	Yes	Yes	Yes	Yes
R^2	0.004	0.009	0.002	0.003
Observations	16,007	16,007	16,007	16,007
FE	I, YQ	I, YQ	I, YQ	I, YQ

Table A3 – T-bill issuance and T-bill safety premium

In this table, we regress T-bill issuance (the numerator in BTC) over the T-bill safety premium. Observations are at a weekly frequency. YQ denotes year-quarter fixed effects. The time period is from January 2008 to July 2014. Robust standard errors are reported in parentheses. *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively.

	Dependent variable: T-bill cover	
$p_{TB,t}$	0.078	-0.294
	(0.107)	(0.187)
Controls	No	No
R^2	0.001	0.520
Observations	351	351
FE	-	YQ

Table A4 – Description of the sample of CP issuers

This table describes the sample of CP issuers. Panel A shows the share of issuers and CP amounts issued by country. Panel B provides descriptive statistics on the distribution of balance sheet characteristics of CP issuers. Means and quantiles are as of end of December and are computed from the pooled sample over the period from 2008 to 2014. Panel C relates CD outstanding amounts as of end of December of each year to other balance sheet characteristics, in the pooled sample. Statistics are conditional on the issuer having a non-zero amount of CP outstanding. All variables are defined in Table A1.

Panel A: Description of issuers

	N. issuers	% Issuers	% Issued	Largest issuer
All	123	100.00	100.00	—
France	101	82.11	82.69	Engie
Netherlands	6	4.88	0.89	Aegon NV
Switzerland	4	3.25	1.16	Holcim
Germany	3	2.44	4.12	BMW Finance
United States	3	2.44	8.75	General Electric
Luxembourg	2	1.63	2.02	ArcelorMittal
Others	4	3.25	0.37	—

Panel B: Balance sheet characteristics

	10th	25th	Mean	Median	75th	90th	Std.	N. Obs.
Size (log Total assets)	21.18	22.23	23.35	23.27	24.36	25.35	1.64	915
Equity / Assets	0.12	0.22	0.34	0.34	0.45	0.57	0.18	914
Total debt / Assets	0.09	0.17	0.28	0.25	0.38	0.50	0.16	889
Net debt / Assets	-0.04	0.04	0.17	0.15	0.26	0.44	0.19	892
ROA (%)	-0.01	0.00	0.01	0.01	0.03	0.04	0.03	915
ROE (%)	-0.02	0.02	0.04	0.05	0.08	0.11	0.07	894

Panel C: Size of CP funding in balance sheets

	10th	25th	Mean	Median	75th	90th	Std.	N. Obs.
CP / Short-term debt	0.02	0.07	0.34	0.22	0.45	0.74	0.41	677
CP / Total debt	0.01	0.02	0.10	0.05	0.12	0.22	0.13	671
CP / Total assets	0.00	0.00	0.02	0.01	0.02	0.05	0.03	808

Figure A1 – Eonia swap rate

This figure displays the Eonia swap rate measured in percentage points between 2008 and 2014. We consider Eonia swap rates with 1-week, 1-month, 3-month, 6-month, and 12-month maturities.