CIP deviations and the foreign demand for US Treasuries: portfolio-level evidence from European banks

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Abstract

Using micro data on individual banks' balance sheets and a novel instrumental variable strategy, I show that European banks adjust their sovereign bond portfolios consistently with a carry trade in response to CIP deviations between US Treasuries and domestic bonds. Whenever CIP deviations are large, that is US Treasuries pay a lower yield with respect to a synthetic Treasury payoff, banks reduce their exposure to US Treasuries relative to domestic bonds. This suggests that, to the extent that CIP deviations reflect the safety and liquidity attributes of US Treasuries, European banks are among investors who do not value US Treasuries for their convenience yield. Instead, they exploit CIP deviations to make a profit. A possible explanation for this behaviour is the delayed adoption of Basel III binding leverage requirements. This relaxed the leverage constraint of European banks relative to other investors, affording them enough balance sheet space to engage in carry trades with their sovereign portfolio.

1 Introduction

US Treasuries are the safe asset of choice for the world economy. Several key issues in international macroeconomics, such as declining interest rates (Caballero and Farhi (2018)) and the US "exorbitant privilege" (Gourinchas et al. (2010)) can be cast in terms of the demand and supply of Treasuries. Their unique features allow Treasuries to earn a lower return with respect to both other dollar assets (Krishnamurthy and Vissing-Jorgensen (2012)), and foreign government bonds swapped into dollars (Du, Im, and Schreger (2018)). This discrepancy has been attributed to their safety and liquidity, which makes them similar to money (Nagel (2016)). The CIP deviation between US Treasuries and foreign government bonds, swapped into dollars through FX derivatives has been used to quantify this 'specialness'. Du, Im, and Schreger (2018) use this approach and argue that, absent and frictions in derivatives markets and sovereign default risk, CIP deviations measure the Treasury convenience yield. However, regardless of its origin and interpretation, the presence of a CIP deviation in theory leaves money on the table in the form of a profitable carry trade. An investor could profit by shorting US Treasuries while going long higher yielding government bonds swapped into dollars. This strategy could even represent an outright riskless arbitrage if the assumptions of Du, Im, and Schreger (2018) hold exactly.

This naturally leads to asking whether some investors, who perhaps do not value the safety and liquidity attributes of Treasuries as much as other market participants, use the carry trade strategy to profit from CIP deviations, and what prevents them from closing the gap completely. We can imagine a market populated on one side by agents with a large and inelastic demand for the special qualities of US Treasuries, which generates CIP deviations. On the other side stands a smaller set of investors who do not assign a convenience yield to US Treasuries, and short them while going long domestic bonds to take advantage of CIP deviations. In this paper, I argue that European banks fit the profile of the latter type of investor. They can and do exploit the return differential between domestic and US government bonds to make profitable carry trades, but their exposure is too small compared to the enormous size of the global Treasury market to completely trade away the CIP deviation.

Firstly, I provide a detailed look at the role of US Treasuries in the sovereign bond portfolios of European banks. Using the European Banking Authority (EBA) transparency and stress test exercise data, I document that European banks held in aggregate between €300 bn. and €500 bn. worth of US Treasuries between 2011 and 2020. US Treasury positions are about one order of magnitude smaller than domestic sovereign bond positions, consistently with the well-documented home bias. This amount, while not negligible compared to the size of the banks' balance sheets, is hardly significant with respect to total supply of US Treasuries, close to $20 trn. as of November 2021. This can explain why European banks cannot close the CIP gap even if they trade to exploit it. However, US Treasuries are an important part of banks' sovereign portfolio:

their average share of around 10% is close to the portfolio share of large foreign Eurozone countries.

Then, I test how European banks adjust their sovereign debt portfolios in response to CIP deviations between US Treasuries and domestic sovereign bonds. I use two identification strategies relying on time fixed effects and instrumental variables to recover the slope of the demand curve for US Treasuries relative to domestic bonds. Under both specifications, I find that European banks decrease their relative exposure to US Treasuries in response to a widening of CIP deviations. I interpret this result as consistent with a carry trade, with US Treasuries as the short leg and domestic bonds as the long leg.

I also find that banks with riskier or less liquid balance sheets do not respond differently to CIP deviations. Combined, these results suggest that European banks do not value US Treasuries for their liquidity and safety attributes as measured by CIP deviations. Rather, they exploit CIP deviations to make profitable carry trades.

Since my analysis uses CIP deviations with respect to individual Eurozone countries, rather than Germany as in Du, Im, and Schreger (2018), a possible concern is that the trading strategy of banks is driven entirely by sovereign default risk differentials. I provide evidence that carry trades are not entirely risk-driven by showing that my core results are robust to excluding countries with high default risks; to restricting the sample to after the European sovereign debt crisis; and to controlling for sovereign Credit Default Swap (CDS) rates.

Finally. I propose a regulatory arbitrage interpretation of the banks' behaviour. The European Banking Authority did not impose a binding minimum leverage ratio requirement until June 2021, contrarily to other jurisdictions such as the US or the United Kingdom, where minimum leverage requirements were introduced or tightened after the 2008 financial crisis. This institutional framework also stands in contrast to that faced by other investors in Europe, such as mutual and pension funds. They operate under a tight regulatory leverage constraint all throughout the sample period. As a consequence, European banks had a slacker regulatory leverage constraint relative to other investors. This allowed them more balance sheet space to engage in carry trades with their sovereign bond portfolio.

1.1 Related literature

This paper is mainly related to two topics in the literature: CIP deviations for US Treasuries and their connection to the dollar convenience yield; and the sovereign portfolios of European banks.

Longstaff (2004) documents a liquidity premium for US Treasuries by showing that they pay lower yields than equally safe Refcorp bonds. Krishnamurthy and Vissing-Jorgensen (2012) distinguish between the specific attributes of liquidity and safety by measuring spreads between equally safe assets with different liquidity; and equally liquid assets with different safety. They also show that several spreads, such as AAA-rated corporates bonds versus Treasuries, fall in response to an increase in the supply of US Treasuries. Some articles focus on the specific 'moneyness' qualities of short-term safe debt, arguing that this drives a further wedge between returns of long- and short- term Treasuries. Greenwood et al. (2015) show a large spread between actual Treasury bill yields and a synthetic yield fitted by extrapolating the Treasury yield curve, and attribute it to the unique money-like attributes of T-bills. Du, Im, and Schreger (2018) argue that the relative convenience yield between US Treasuries and other sovereign bonds can be measured by the CIP deviations between the two, assuming no default risk and no frictions in forex swap markets.

The source of CIP deviations and the associated convenience yields is mainly identified in the global demand for the unique safety and liquidity features of US Treasuries. For example, Gourinchas and Jeanne (2012) argue that demand for safe US assets by foreign financial institutions and official agencies has been increasing since 2002, while Jiang et al. (2021) and Krishnamurthy and Lustig (2019) present the inelastic demand for Treasuries by foreign investors as evidence that they assign a non-monetary convenience yield to US Treasuries. Based on this notion, Adrian and Xie (2020) use CIP deviations as an instrument for shifters in the foreign bank demand for safe dollar assets to identify the slope of the supply curve.

On the other hand, recent evidence by Tabova and Warnock (2021) offers a radically different perspective on the foreign demand for US Treasuries. They show that, in the aggregate, foreign private investors increase their holdings of US Treasuries when their own sovereign returns are low relatively to the US (or equivalently when CIP deviations are small), consistently with a carry trade. However, their results rely on aggregate data from the TIC database, which only allows them to distinguish between foreign or domestic, and official or private sector. Therefore, the question of exactly which investors trade against CIP deviations and what drives their behaviour remains open. Furthermore, their direct evidence on flows relies on simple OLS regressions that do not address endogeneity issues, save for using lagged CIP deviations. I contribute to this line of inquiry by providing a plausible estimate of the slope of the demand curve of a specific class of investors, European banks, and by offering a detailed individual-level view of their US Treasury portfolio and an explanation for their yield-seeking behaviour.

Du, Tepper, and Verdelhan (2018) link the emergence of Libor-based CIP deviations to the introduction of non-risk-weighted capital requirements in Basel III after the 2008 financial crisis. They argue that, even if nearly riskless, trades that aim at exploiting CIP deviations require balance sheet space as they involve borrowing and lending. Therefore, a minimum leverage ratio requirement that constrains the absolute size of the balance sheet limits bank' ability to engage in such trades. The same argument has been applied to CIP deviations in Treasury markets too, although they existed even before 2008 (see Duffie (2020) and He et al. (2021)). In this vein, I show how the delayed adoption of Basel III leverage requirement in Europe can contribute to explaining the ability of European banks to exploit the Treasury CIP margin.

Studies on the sovereign portfolio of banks, particularly in the European context, have focused so far either on home bias, or on the European sovereign debt crisis of the early 2010s. As highlighted by De Marco (2019) and Popov and Van Horen (2015) among others, it is crucial to understand the drivers behind banks' trading in sovereign bonds because the profit, losses and risk of their bond portfolios can transmit to the real economy through effects on credit provision.

The first strand of the literature finds that banks are significantly home biased in government bond holdings, consistently with long-established results for several other investors and asset classes (see Coeurdacier and Rey (2013) for a survey). This home bias has been linked to pressure by domestic government to absorb their debt, especially for peripheral Eurozone countries, via the "moral suasion" channel (see for example , Horváth et al. (2015), DeMarco and Macchiavelli (2016), Becker and Ivashina (2018) and Ongena et al. (2019)). De Marco et al. (2018) characterise the sovereign bond portfolio of European banks as heavily home biased, with relatively small exposures to a few foreign countries and no clear tilt toward any of them. Consistently with my findings, Manna and Nobili (2021) show that banks in a sample of 21 advanced economies have large holdings in domestic government bonds, which they manage flexibly in response to changes in yields.

The literature on the European sovereign debt crisis places banks at the centre of the narrative. In this context, Acharya and Steffen (2015) find evidence of carry trade behaviour in sovereign debt portfolios. Using the same EBA dataset employed in this study, they show that the sovereign exposures of European banks from 2007 to 2013 can be explained as a carry trade with German bonds as the short leg and distressed sovereign bonds (Greece, Italy, Ireland, Portugal and Spain) as the long leg. They also point out that regulatory features such as the zero risk weight assigned to all Eurozone sovereigns affect the incentive of banks to use their sovereign portfolio for carry trades.

Using micro data for Eurozone banks from 2005 to 2017, Altavilla et al. (2017) find that public, bailed-out, and poorly capitalised banks responded to sovereign stress by purchasing domestic public debt more than other banks, consistent with both "moral suasion" and carry trade hypotheses. In a related study, Frey and Weth (2019) show that large German banks engaged in a yield-seeking strategy consisting of being long risky Eurozone sovereign bonds between 2008 and 2011. Other studies focusing on specific countries or testing channels such as informational advantage and risk-shifting find evidence of yield-seeking behaviour in the management of sovereign portfolios by European banks during the European sovereign debt crisis (Battistini et al. (2014),Andreeva and Vlassopoulos (2019), Lamas and Mencia (2018), Saka (2020)). On the other hand, Buch et al. (2016) show that German banks in particular rebalanced their sovereign portfolio away from high-yield countries after the European sovereign debt crisis. I contribute to this literature firstly by providing a detailed analysis of the exposures to US Treasuries compared to both domestic and other foreign sovereigns. Secondly and more importantly, this paper establishes that European banks engage in yield-seeking carry trades in normal times as well, and not only with bonds issued by distressed Eurozone countries, but also by exploiting the return margin between US and domestic bonds.

The paper is structured as follows. Section 2 presents the data and descriptive statistics on European bank balance sheets and CIP deviations. Section 3 introduces the two main empirical specifications and estimation strategies, and lays out the core results on the reaction of banks' sovereign portfolios to CIP deviations. Section 4 includes an analysis of the effect of sovereign default risk. Section 5 discusses and provides evidence on the regulatory arbitrage hypothesis as a possible explanation for the carry trade behaviour. Section 6 concludes.

2 Data and descriptive statistics

2.1 Bank balance sheet data

Data on banks' balance sheets results from combining all iterations of the transparency and stress test exercises databases published by the European Banking Authority as a part of regulatory disclosures. The dataset features 177 banks from the European Union, the European Economic Area and the UK. Since it covers only banks subject to EBA reporting, the dataset is biased by construction toward sizeable banks operating in large economies. However, it covers circa 70% of European banking assets, which makes it a fairly representative sample nonetheless. The frequency is biannual from December 2011 to June 2020, following EBA reporting dates. Not all banks are present in each iteration of the transparency and stress test exercises, so the panel is unbalanced. As a result, there is a total of 1602 bank-semester level observations.

This dataset has the unique advantage of breaking down sovereign exposure by maturity, issuing country and accounting portfolio [1]. Thanks to these features, I can observe the exposure to domestic and US sovereign debt for every bank, allowing to test directly the implications of CIP deviations for sovereign portfolios. The maturity dimension is also important, as the literature has shown that convenience yields tend to be larger for shorter tenors, especially after the 2008 financial crisis (Du and Schreger (2021)). Furthermore, the breakdown by accounting portfolios allows to observe exposure to sovereigns both directly, through government bonds held on the balance sheet; and indirectly, through derivatives. Since we cannot observe all the variables involved in potential carry trades (for example interest rate swap positions), total exposures including derivatives offer a better proxy for carry trade positions than the simple amount of government bonds. Even proprietary databases do not allow such a level of disaggregation for sovereign portfolios. For example, the Individual Balance Sheet Items dataset from the ECB used in Altavilla et al. (2017) does not break down sovereign debt exposures by issuer. Therefore, the EBA datasets appear to be the most suitable to answer the question at hand.

In addition to sovereign exposures, the dataset includes bank-level information on individual balance sheet items such as total and financial assets, capital, leverage, loans, risk exposures, and country-specific credit exposures. This level of detail is crucial to testing whether banks value Treasuries for their convenience yield by analysing the response to CIP deviations of banks with different levels of liquidity and risk on their balance sheets.

Before proceeding to the econometric analysis of responses to CIP deviations, it is useful to lay out some stylised facts on the exposure of European banks to US Treasuries. The literature has devoted significant attention to the

[1] The 2016 and 2017 iterations only include breakdowns by either issuer, maturity or accounting portfolio

exposure of European banks to their own domestic government and to distressed sovereigns, especially in the context of the European sovereign debt crisis in the early 2010's. However, to my knowledge, no study has analysed the holdings of US government bonds by European banks. This is an interesting exercise in its own right, as US Treasuries play a key role as global safe assets.

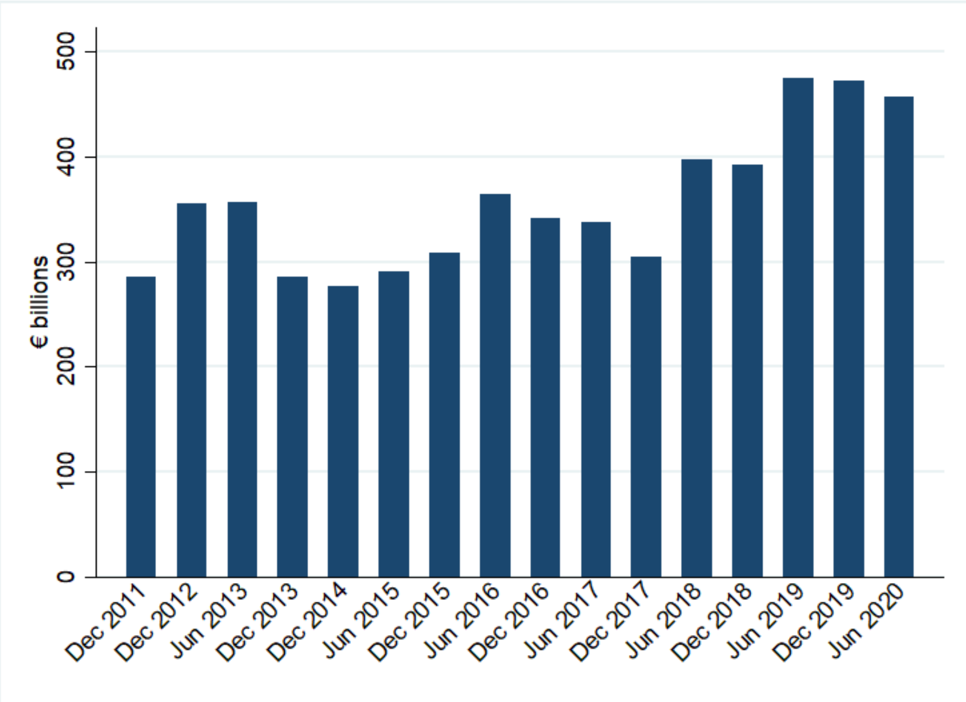
Table 1: Summary statistics for bank balance sheets

	N	Mean	Median	Std. dev.	Min	Max
Domestic bonds/assets	1187	0.08	0.05	0.10	0	0.86
US Treasuries/assets	1193	0.01	0.00	0.01	0	0.16
Domestic bonds/capital	1594	1.69	0.83	3.60	0	36.87
US Treasuries/capital	1600	0.11	0.00	0.27	0	3.98
Total assets (€ bn.)	1194	293.70	78.43	502.52	0	4000.69
Leverage ratio	1143	0.07	0.06	0.06	0	0.77
Loans/assets	759	0.39	0.51	0.30	0	0.91
Risk exposure/assets	1193	0.01	0.01	0.02	0	0.34
Cash/assets	481	0.10	0.08	0.09	0	0.57

Table 1 reports summary statistics for US and domestic sovereign exposures as a fraction of total assets and capital, and the main balance sheet variables of interests. We observe that both domestic and US bonds make up a small share of total assets, with the former roughly an order of magnitude larger than the latter. This is expected since the sample is comprised of mainly commercial banks whose core business is maturity transformation of deposits into loans, as confirmed by the figures for loans over total assets. However, US government bond holdings add up to a significant portion of capital for many banks in the sample, with an average of 11% and even exceeding total tier 1 capital in a few cases. Therefore, assuming banks operate under a leverage constraint, the valuation and returns of US Treasuries are liable to play a role in decisions on the allocation of scarce capital. Note that the distribution of US bond holdings over total assets is heavily right skewed, with a median very close to zero. Therefore, the results presented in the paper will be driven by the right tail of the distribution, although the effect of extreme outliers is limited through winsorisation.

Overall, banks in the sample are large, with a median €78 billion in total assets. They are also well-capitalised: the median bank has a leverage ratio (tier 1 capital/assets) of 6%, double the 3% regulatory threshold set by Basel III rules. I also report summary statistics, as a fraction of total assets, for loans, cash, and risk exposure(measured as the sum of assets weighed by the EBA regulatory risk weights). These variables are used as proxies for the liquidity and safety of balance sheets in the econometric analysis. Appendix B lists all banks in the dataset and their residence countries.

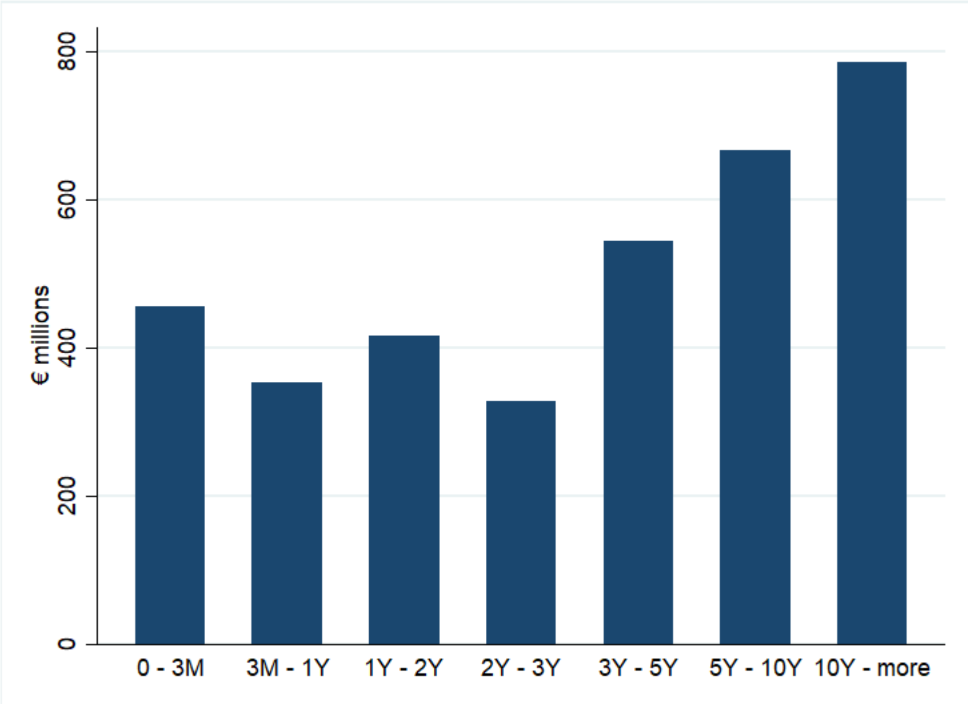
Figure 1: Aggregate holdings of US Treasuries over time



To get a sense of the magnitudes involved, Figure 1 plots the sum of total exposures to US Treasuries over time for all banks. The amount grows rather steadily throughout the sample period, from just shy of €300 billion in December 2011, to around €450 billion in June 2020. This is not an insignificant amount as a ratio of total assets from the point of view of banks, but it constitutes only a small fraction of the total issuance of US Treasuries, which stood at around $20 trillion at the end of the sample period.

Figure 2 plots the cross-sectional mean of balance sheet exposures to US Treasuries over maturity groups. European banks hold US Treasuries in the order of magnitude of hundreds of millions of euro across the whole maturity spectrum, but longer-maturity Treasuries play a larger role. As discussed in Du, Im, and Schreger (2018), the safety and liquidity features of US Treasuries vary by maturity. These differences are reflected in their convenience yields as measured by CIP deviations. For example, CIP deviations with respect to Germany tend to be higher at shorter maturities. Therefore, analysing the reaction of banks' sovereign portfolios across maturities can be informative for understanding the nature of CIP deviations. Appendix C reports results for my main econometric specifications using exposures to short- and long-maturity bonds.

Figure 2: Average US Treasury holdings across maturities



To compare the relative importance of US and other sovereign bonds, Table 2 displays total sovereign portfolio shares for major Eurozone countries and the United Kingdom. Each column represents a bank residence country, while each row the country issuing the sovereign bonds. On the diagonal, we can read the home bias widely reported in the literature. The sovereign portfolio shares of US Treasuries are very similar in magnitude to the shares of large Eurozone country, and much larger than the share of safe sovereign bonds issued by other non-European advanced economies such as Japan. Banks in the United Kingdom, however, hold an even larger share of US Treasuries: an order of magnitude larger than the average US portfolio share of other countries, and very close to their own sovereign share. This discrepancy can be explained by the markedly international nature of some of the UK-based banks in the sample, such as HSBC and Standard Chartered.

Overall, descriptive statistics show that US Treasuries are a substantial component of the sovereign debt portfolios of European banks, but their aggregate demand absorbs only a small fraction of the total supply of US Treasuries. As it will become clear later, these features make European banks an appropriate laboratory to study reactions to CIP deviations.

Table 2: Sovereign portfolio shares

	France	Germany	Italy	Spain	United Kingdom
France	0.49	0.04	0.02	0.005	0.04
Germany	0.05	0.61	0.03	0.002	0.06
Italy	0.1	0.06	0.79	0.1	0.02
Spain	0.03	0.03	0.05	0.73	0.01
United Kingdom	0.04	0.02	0.002	0.01	0.35
United States	0.08	0.05	0.03	0.02	0.25
Japan	0.03	0.01	0.002	0.003	0.05
Euro area average	0.04	0.04	0.05	0.04	0.01

2.2 CIP deviations

I calculate CIP deviation $\phi_{i,k,n,t}$ for US Treasuries compared to bonds issued by sovereign i in currency k at tenor n on day t as follows

$$\phi_{i,k,n,t} = y^{Govt}_{i,k,n,t} - \rho_{k,n,t} - y^{Govt}_{USD,n,t}$$

Where $\rho_{k,n,t}$ is the forward premium $\frac{1}{n}(f_{k,n,t} - s_{i,y})$ between the dollar and currency k. For 3 month tenors, I calculate $\rho_{k,n,t}$ directly using forward and spot exchange rates. For tenors of 1 to 10 years, I construct as $irs_{k,n,t} + bs^{USD}_{k,n,t} - irs_{USD,n,t}$ using interest rate swaps $irs_{k,n,t}$ and basis swaps $bs^{USD}_{k,n,t}$ between the dollar and currency k. As a consequence, $\phi_{i,k,n,t} > 0$ means that investing in a Treasury bond pays a lower interest rate than investing in country i's sovereign bond and converting the currency k cash flow synthetically into dollars on the swap or forward market.

This definition follows Du, Im, and Schreger (2018) , but it differs in that, for Eurozone countries, I calculate the CIP deviation with respect to government bonds issued by individual country i $y^{Govt}_{i,,n,t}$, rather than German government bonds $y^{Govt}_{DE,,n,t}$. Therefore, $\phi_{i,k,n,t}$ represents a country-specific rather than currency-specific CIP deviation. As shown by Du, Im, and Schreger (2018), CIP deviations represent purely a convenience yield only if there are no frictions in forward and swap markets; and if there is no government bond default risk. While the former assumption seems innocuous in the context of the market for derivatives on the Euro, the latter clearly does not hold in the present application, as the sample includes the European sovereign debt crisis.

Nonetheless, CIP deviations still represent an opportunity for carry trade profits. In this particular case, the presence of default risk would only imply that a trade with US Treasuries as the short leg and domestic bonds as the long leg is not a riskless arbitrage opportunity. However, a bank with sufficient balance sheet space could still have incentives to engage in this profitable trade consistently with its risk-return profile. This incentive might be especially relevant for European banks, who tend to hold a disproportionate amount of domestic government bonds. Furthermore, if the ”moral suasion” hypothesis holds, it is even more important for these banks to employ the balance sheet space occupied by domestic bonds in a profitable manner. Therefore, country-specific CIP deviations seem consistent with a carry trade interpretation, as long as default risk does not explain entirely the cross-country differences. Conversely, the presence of default risk is not compatible pure with a convenience yield interpretation of CIP deviations, hence muddling the identification of this channel. Therefore, to test the two competing hypotheses as cleanly as possible, I perform robustness checks that control for default risk in Section 4.

Figure 3: Country-level CIP deviations at the 10 year tenor

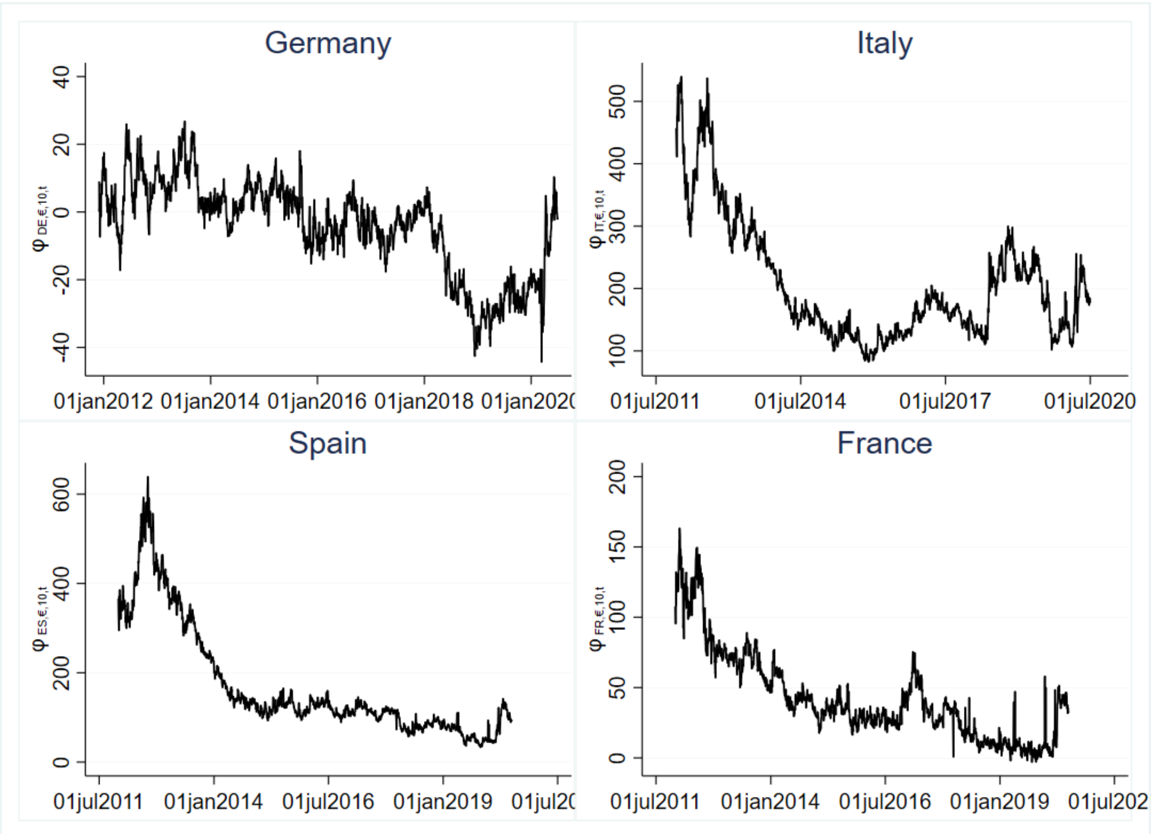


Figure 3 plots the 10-year CIP deviation for Germany, France, Italy and Spain from December 2011 to June 2020 at a daily frequency. Consistently with Du, Im, and Schreger (2018), it shows that CIP deviations for German bonds have been very small and stable in the last decade, and even turned negative since 2019. Instead, Italian and Spanish bonds display sizeable and volatile CIP deviations, staying positive throughout the sample and peaking at more than 600 basis points at the height of the sovereign debt crisis. This picture highlights that much variability is lost in focusing solely on CIP deviations with respect to the safest Eurozone sovereign, and that there is significant margin for carry trade profit in other European sovereign bonds. Notably, after the sovereign debt crisis the CIP deviations for Italy and Spain are in the same range as those for France, suggesting that default risk does not play an outsized role for most of my sample. Therefore, the country-specific CIP deviation emerges as the natural variable of interest, both because the home bias in the sovereign portfolios of European banks makes the US/domestic carry trade margin particularly relevant; and because it provides enough magnitude and variability for meaningful carry trades.

Figure 4: Country-level CIP deviations at the 1 year tenor

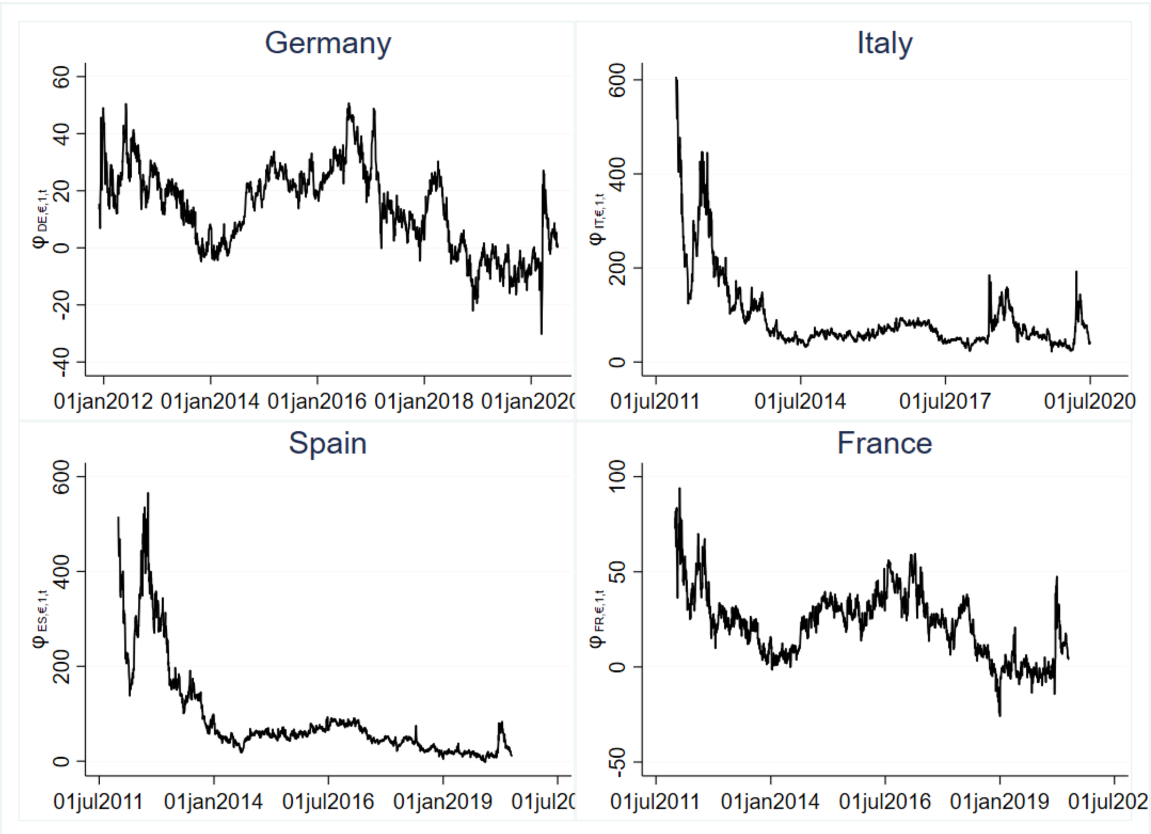


Figure 4 plots the 1-year CIP deviation for Germany, France, Italy and Spain from December 2011 to December 2020 at a daily frequency. The overall trends are quite similar at this shorter tenor, but it is interesting to observe how the result that longer-maturity CIP deviations shrank in recent years, as noted in Du, Im, and Schreger (2018), does not carry over to a country-level measure. For example, CIP deviations for France are larger at the 10-year maturity in the whole sample.

Table 3: Average CIP deviations for Eurozone countries for all maturities

	$\phi_{i,3m,t}$	$\phi_{i,1y,t}$	$\phi_{i,2y,t}$	$\phi_{i,3y,t}$	$\phi_{i,5y,t}$	$\phi_{i,7y,t}$	$\phi_{i,10y,t}$
Belgium	21.74	25.25	29.02	30.54	36.71	47.48	52.27
	(19.36)	(27.22)	(42.68)	(49.23)	(55.37)	(56.03)	(50.72)
Finland	59.80		15.33	15.35	15.30	301.14	18.17
	(28.49)		(15.77)	(18.25)	(19.54)	(52.48)	(15.71)
France	21.07	22.20	22.24	24.61	30.61	34.81	42.34
	(17.38)	(17.53)	(19.62)	(24.86)	(30.91)	(34.95)	(31.84)
Germany	13.11	13.77	8.91	5.13	0.67	-1.86	-4.23
	(13.51)	(14.67)	(14.31)	(14.13)	(13.62)	(14.57)	(13.78)
Greece	364.75	456.19	13017.89	5340.19	2143.85	3112.71	816.48
	(217.81)	(173.43)	(16211.81)	(6592.52)	(2413.87)	(1673.61)	(683.60)
Ireland	38.16	91.21	94.26	104.65	111.79	124.46	130.73
	(25.99)	(140.67)	(163.88)	(173.58)	(166.40)	(176.63)	(156.72)
Italy	58.92	95.36	122.86	143.53	175.50	194.21	206.10
	(50.92)	(81.89)	(100.98)	(110.12)	(116.77)	(105.19)	(96.02)
Lithuania	112.14	88.68		73.60	72.86	505.82	62.53
	(26.49)	(19.77)		(13.34)	(23.88)	(27.57)	(23.01)
Malta	71.57	91.57	228.17	88.95	107.93	312.54	120.15
	(37.41)	(87.53)	(34.20)	(62.35)	(82.80)	(52.48)	(65.81)
Netherlands	15.30	46.92	13.65	14.22	12.19	18.62	16.55
	(16.23)	(29.47)	(15.77)	(18.42)	(22.03)	(24.86)	(21.21)
Portugal	62.00	119.69	220.01	258.34	302.58	333.85	318.63
	(42.13)	(154.34)	(328.91)	(379.40)	(371.08)	(355.90)	(275.05)
Slovenia	56.18	452.75	128.86	26.70	159.64	33.91	177.25
	(39.21)	(294.38)	(129.96)	(20.29)	(170.80)	(19.17)	(165.98)
Spain	52.48	91.77	105.99	122.57	291.02	156.44	170.49
	(47.97)	(100.60)	(118.11)	(132.95)	(144.26)	(136.83)	(125.14)
Austria		25.36	21.59	22.87	22.50	27.61	28.68
		(20.18)	(23.57)	(28.83)	(32.77)	(36.05)	(29.62)
Cyprus		686.94	611.65	592.86	119.26	377.84	236.10
		(709.95)	(587.92)	(657.19)	(55.98)	(302.38)	(101.91)
Slovakia		147.24	68.70	77.98	65.84		86.37
		(381.13)	(60.04)	(94.17)	(77.94)		(86.67)
Latvia			333.16	68.86	84.19		
			(318.23)	(15.21)	(31.43)		
Observations	26429	30689	34637	34071	34399	30071	33335

Standard deviations in parenthesis

Table 3 reports CIP deviations at the 3 month and 1,2,3,5,7 and 10 year tenor, reinforcing the conclusions that there is significant variability in CIP deviations from US Treasuries within the Eurozone, both cross-sectionally and along the maturity spectrum. Credit risk differentials explain most of the variation, although it is interesting to note how some small differences persist even for countries with similar credit ratings. For example, CIP deviations are markedly higher at shorter maturities for Germany, while the term structure for the Netherlands is rather flat. Furthermore, notice that small differences in the level of CIP deviations still exist for countries with very similar, and low, default risk such as Germany, the Netherlands and Belgium. This is consistent with international evidence on CIP deviations. Small differences in perceived default risk exist even between the United States and Germany; as well as between Germany and other countries such as the UK for which CIP deviations are routinely calculated. As long as these differences do not entirely drive CIP deviations, the latter offer a reasonable measure for low-risk carry trade opportunities although not entirely riskless arbitrage.

3 Response of banks' sovereign portfolios to CIP deviations

3.1 Data and hypothesis

The main objective of this study is understanding how European banks adjust their sovereign debt portfolios in response to CIP deviations for US Treasuries. I am interested in testing two competing hypotheses. The "carry trade" hypothesis postulates that banks manage their sovereign bond portfolio by going long bonds with higher returns, and short bonds with lower returns. Therefore, under this hypothesis I expect banks to decrease their exposure to US Treasuries relative to domestic sovereign bonds whenever CIP deviations are large. On the contrary, the "convenience yield" hypothesis maintains that banks' demand for US Treasuries is motivated by the unique safety and liquidity of the latter. If this is the case, I expect banks to increase their relative holdings of US Treasuries whenever CIP deviations between US Treasuries and domestic sovereign bonds are large. This is because CIP deviations can be interpreted as a proxy of the relative convenience yield attached to US Treasuries by investors who value their safety and liquidity. Furthermore, under the "convenience yield" hypothesis, I expect banks with a riskier and less liquid balance sheets to both hold more US Treasuries, and to react to CIP deviations by increasing their US Treasuries exposures more strongly. This would be consistent with a view of US Treasuries as hedges against illiquidity and risk due to their unique safe asset properties.

My approach to testing these hypotheses consists of estimating a bank-period panel linear regression with the following baseline specification.

$$\bar{r}^{US/i}_{j,i,t} = \beta_0 + \beta_1 \bar{\phi}_{i,k,t} + \beta_2 X_{j,i,t} + \beta_3 \bar{\phi}_{i,k,t} \times X_{j,i,t} + \beta_4 e^{USD}_{k,t} + \varepsilon_{j,i,t}$$

Where $\bar{r}^{US/i}_{j,i,t}$ is the total exposure to US Treasuries relative to domestic bonds across all tenors in month t for bank j domiciled in country i; $\bar{\phi}_{i,k,t}$ is the CIP deviation in month t, averaged across all tenors, between US Treasuries and government bonds issued by country i in currency k; $X_{j,i,t}$ is a proxy for the risk/illiquidity (or safety/liquidity) in month t of the balance sheet of bank j domiciled in country i; and $\beta_4 e^{USD}_{k,t}$ is the natural logarithm of the average exchange rate in month t between currency k and the dollar.

It is necessary to control for the dollar exchange rate because exposures to US Treasuries and domestic bonds are both reported in euro. Therefore, the ratio $\bar{r}^{US/i}_{j,i,t}$ varies mechanically with movements in the dollar exchange rate. Since CIP deviations are strongly correlated with the dollar exchange rate (see for example Engel and Wu (2018)), neglecting $e^{USD}_{k,t}$ as a control would bias the estimated coefficients.

Note that bank balance sheet data are released at a biannual frequency, but they represent a snapshot of the balance sheet in a given month (June or December). Therefore, all other variables are also calculated as averages for that same month, and time t in the regression is a month, with observations spaced six months apart.

If the "convenience yield" hypothesis holds, I expect coefficient β_1 to be positive and significant, while coefficients β_2 and β_3 should be positive (negative) and significant if $X_{j,i,t}$ is a proxy for the riskiness/illiquidity (safety/liquidity) of banks' balance sheets. On the other hand, under the "carry trade" hypothesis, I expect coefficient β_1 to be negative and significant, while β_3 should be insignificant.

Note that $\bar{r}^{US/i}_{j,i,t}$ represents demand for US Treasuries relative to domestic bonds, while $\bar{\phi}_{i,k,t}$ is proportional to the relative price of the two bonds. Therefore, if I tried to estimate this equation by simple OLS I would run into the classical problem of supply and demand estimation, as summarised in Angrist and Krueger (2001). If we assume that CIP deviations and sovereign bond holdings are the results of market equilibrium, the observed price-quantity pairs can be driven by shifts in either the demand or the supply curve. Therefore, in order to estimate β_1 as the slope of the banks' relative demand curve for US Treasuries consistently, I require an identification strategy to ensure that my estimate only uses variation in exogenous supply shifters. I adopt two approaches: time fixed effects and instrumental variables.

3.2 Fixed effects model

The first identification strategy relies on the panel structure of the data and uses time fixed effects (FE) combined with two identifying assumptions. The estimated model is the following

$$\bar{r}_{j,i,t}^{US/i} = \beta_0 + \beta_1 \bar{\phi}_{i,k,t} + \beta_2 X_{j,i,t} + \beta_3 \bar{\phi}_{i,k,t} \times X_{j,i,t} + \beta_4 e_{k,t}^{USD} + \gamma_t + \varepsilon_{j,i,t}$$

Where γ_t represents a time fixed effect.

In my setup, I relate demand at the individual-level demand to a price. As explained in Berry and Haile (2021) , this does not exempt from the need of an identification strategy, because the fundamental problem of demand estimation arises from the presence of aggregate level demand shocks whose effects are confounded with those of aggregate level supply shocks and prices. However, the use of bank-level data combined with the appropriate fixed effects and assumptions can yield a plausibly consistent estimate of β_1.

Imagine that individual demand $\bar{r}_{j,i,t}^{US/i}$ is hit by unobserved individual-level shocks $\xi_{j,i,t}^{D}$, country-level shocks $\kappa_{i,t}^{D}$, and aggregate shocks ν_t^D . Note that in this setting ν_t^D includes both global demand shocks and shocks at the level of the whole European banking sector. At the same time, aggregate supply is hit by unobserved country-level shocks $\kappa_{i,t}^{S}$ and global shocks ν_t^S .

In order to estimate β_1 consistently as the slope of a demand curve, I need to ensure that observed changes in prices and quantities are only driven by supply shocks. By adding time fixed effects, I can control for both ν_t^D and ν_t^S. Then, the necessary identifying assumption is that $\xi_{j,i,t}^{D}$ and $\kappa_{i,t}^{D}$ do not affect prices. That is, unobserved bank- and country-level shifters of the relative demand for US Treasuries are exogenous with respect to CIP deviations. Considering that the during the sample period the aggregate holdings of US Treasuries by European banks never exceed €500 bn., roughly 2.5% of the total amount of US Treasuries outstanding, this assumption appears plausible.

Table 4 reports results from 3 specifications of the fixed effects model and its OLS counterparts. In these regressions, standard errors are clustered at the bank level, due to the panel setting. The level of aggregation for clustering is motivated by the large number of clusters (177) available for banks . Since asymptotics for standard errors rely on the number of clusters tending to infinity, clustering on a variable with too few distinct values leads to inconsistency. Simulation exercises in Kezdi (2005) show that at least 50 distinct clusters are necessary for consistency in panel data fixed effects models. Therefore, clustering at the time (16 clusters) or country (28 clusters) level would yield inconsistent estimate of standard errors.

The first panel contains a baseline regression that estimates the slope of the demand curve without balance sheet variables. Both the OLS and FE specification show that there is a negative relationship between CIP deviations and the exposure to US Treasuries relative to domestic government bonds. The preferred FE model shows that a 1 percentage point increase in the CIP deviation is associated with a 0.4 percentage point decrease in the share of US to domestic

Table 4: Fixed effects models

	Baseline		Liquidity		Risk	
	(1)	(2)	(3)	(4)	(5)	(6)
$\bar{\phi}^{US}_{i,t}$	-0.446***	-0.447***	-6.572***	-5.762***	-5.316**	-5.822***
	(0.115)	(0.127)	(1.721)	(1.486)	(2.062)	(1.989)
Loans Tot Assets			-0.462***	-1.129**		
			(0.123)	(0.434)		
$\bar{\phi}^{US}_{i,t}$ × Loans Tot Assets			-0.0504	-0.0563		
			(0.0418)	(0.0466)		
Risk Exposure Tot Assets					4.009	4.454
					(3.351)	(3.466)
$\bar{\phi}^{US}_{i,t}$ × Risk Exposure Tot Assets					-0.0743	-0.208
					(0.518)	(0.520)
$e^{USD,k}_t$	0.0966	0.311	-4.721	-5.072	-4.200	-4.179
	(4.238)	(4.282)	(3.560)	(3.651)	(3.467)	(3.482)
Time FE	No	Yes	No	Yes	No	Yes
Observations	1458	1458	688	688	1068	1068
R^2	0.005	0.025	0.084	0.123	0.028	0.052

Standard errors in parentheses

Standard errors clustered at the bank level

In all regressions, the dependent variable is $\bar{r}^{US/i}_{j,i,t}$

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

government bond exposure. I interpret this result as consistent with a carry trade in which the lower-yield US Treasury is the short leg, and the higher-yielding domestic bond (once swapped in the same currency), is the long leg. Therefore, European banks appear to be trading against the convenience yield, exploiting the gap to make a profit.

The second panel uses loans over total assets as a proxy for the illiquidity of banks' balance sheets. The dataset is comprised mainly of commercial and retail banks, so loans are by far the largest asset item. To the extent that European banks did not engage in substantial loan securitisation during my sample period [2], loans over total assets can provide a good proxy for the illiquidity of banks' balance sheets. Unfortunately, I cannot observe loan securitisation in the EBA datasets, so I have to assume that that European banks do not engage substantially in it. The liquidity regressions display a negative and significant coefficient on $\bar{\phi}_{i,k,t}$, about an order of magnitude larger than in the baseline specification. Both the OLS and the fixed effects regressions show that banks with more liquid balance sheets hold fewer US Treasuries relative to domestic bonds, contrary to the convenience yield hypothesis. In the preferred FE specification, a 1 percentage point increase in loans over total assets is associated with a 1.12 percentage points decrease in the ratio of US to domestic bond holdings. Furthermore, there is no significant effect of loans over total assets on the intensity of the reaction to CIP deviations.

Note that the significant negative correlation between loans over total assets and US/domestic government bond holdings could also be due to differences in business model. Banks with fewer loans over total assets might hold more US Treasuries because they operate as broker/dealers rather than commercial banks. To alleviate concerns that loans over total assets do not provide an ideal proxy for illiquidity, I present robustness checks employing cash over total assets in Appendix D. Results from these regressions, despite suffering from a smaller sample size due to data availability for cash, are consistent with those obtained using loans over total assets in the preferred IV specification.

The third and final panel uses risk exposure over total assets as a measure of the riskiness of banks' balance sheets. Risk exposures are measured as the average of assets weighted by the EBA regulatory risk weights [3], and therefore reflect the regulator's view of the overall riskiness of a bank's assets. These regressions still show a negative and significant coefficient for $\bar{\phi}_{i,k,t}$, with roughly the same magnitude as in the liquidity column. Furthermore, there is no significant relation between the riskiness of bank's balance sheet and either the US/domestic relative sovereign bond exposure, or the reaction to CIP deviations.

[2]Figures from Kirschenmann et al. (2018) suggest that loan securitisation in Europe was large before the crisis, but has significantly declined since

[3]For details on risk weights and the calculation of regulatory risk exposures, consult the EBA Single Rulebook at https://www.eba.europa.eu/regulation-and-policy/single-rulebook/interactive-single-rulebook/100427

In summary, these results lend evidence to the "carry trade" hypothesis, and against the "convenience yield" hypothesis. In response to CIP deviations between US and domestic bonds, banks decrease their exposure to US Treasuries relative to domestic government bonds. On the other hand, if banks valued US Treasuries for their safety and liquidity, they would increase their exposure whenever these features are more valuable, as measured by CIP deviations. Furthermore, an illiquidity and risk hedging motive would lead them to buy relatively more US Treasuries if their balance sheets are riskier or less liquid. However, I find that banks increase their relative US Treasuries holdings when they have liquid balance sheets as measured by loans over total assets. In addition, there is no statistically significant association between balance sheet risk and the ratio of US to domestic government bond holdings. Furthermore, assuming that CIP deviations measure the convenience yield of US Treasuries, banks that value this convenience attributes would adjust more intensely in response to CIP deviations if they have more risk and less liquidity on their balance sheet. Instead, I find no significant difference in the reaction to CIP deviations across banks with different risk and liquidity indicators.

3.3 Instrumental variables model

The identification strategy in the previous section required assuming that relative demand for US and domestic at the individual and country level does not affect CIP deviations. It might be a credible assumption to the small size of the global US Treasuries market, and evidence from the literature that CIP deviations are driven by global factors. However, it is still plausible that demand from banks in country i does affect $\bar{\phi}_{i,k,t}$ through its effect on $y^{Govt}_{i,k,n,t}$, as banks in Europe are large players in the sovereign debt market.

To address this concern, I adopt an instrumental variables (IV) approach, which requires a shifter of the relative supply of US/country i government bonds that is exogenous with respect to demand.

I use $\frac{Debt/GDP^{US}_t}{Debt/GDP^i_t}$, outstanding government debt/GDP in the US relative to country i in month t, as an instrument for CIP deviations. The identifying assumption is that changes in the US debt to GDP ratio relative to country i affect relative demand for US/country i government bonds by European banks only through CIP deviations (i.e. relative prices). This condition seems credible if we think that the issuance of US government debt is mainly driven by fiscal policy decisions in the US, which should be plausibly exogenous with respect to the demand for US Treasuries by European banks.

Furthermore, the IV approach requires $\frac{Debt/GDP^{US}_t}{Debt/GDP^i_t}$ to be a strong instrument, that is correlated with $\bar{\phi}_{i,k,t}$. Krishnamurthy and Vissing-Jorgensen (2012), Nagel (2016), Du, Im, and Schreger (2018), and Krishnamurthy and Lustig (2019) find that an increase in the supply of Treasuries is negatively correlated with different measures of the convenience yield. Furthermore, Engel and Wu (2018) use the US debt to GDP ratio as an instrument for CIP deviations, with the goal of identifying the effects of the latter on exchange rates. My approach differs from theirs because I employ the US debt to GDP ratio *relative* to country i. Since my observations for CIP deviations vary at the country-semester level, I need an instrument that varies at the same level to ensure enough variation in my explanatory variable. This precludes using US debt/GDP. Furthermore, consider that CIP deviations measure relative convenience yields between US Treasuries and country i's government bonds. Therefore, if we adopt a framework in which relative supply of these assets affects their relative price (i.e. $\bar{\phi}_{i,k,t}$), as in Krishnamurthy and Vissing-Jorgensen (2012), then the relative debt/GDP ratio seems a more appropriate instrument.

Note that in my setting aggregate demand does not stem from all global investors in US Treasuries, but rather only from all European banks. While shocks to global demand for Treasuries might well be correlated with shifts in Treasury supply, it seems plausible to assume that this is not the case for demand from a set of investors that makes up such a small fraction of the global Treasuries market. A possible concern for endogeneity remains in the form of the "moral suasion" mechanism. In distressed Eurozone countries, evidence suggests that governments might have put pressure on domestic banks to absorb sovereign bonds when they faced difficulties in placing them on markets during the sovereign debt crisis. This would generate endogeneity between drivers of supply of domestic debt and demand by banks. In turn, this endogeneity would be transmitted to demand and supply *relative* to US Treasuries. However, this is limited only to few high-debt countries in my sample and to the period of the European sovereign debt crisis, both of which are excluded in Section 4.

Table 5 reports results from first stage regressions with the following form

$$\bar{\phi}_{i,k,t} = \delta_0 + \delta_1 \frac{Debt/GDP_t^{US}}{Debt/GDP_t^{i}} + \delta_2 X_{j,i,t} + \delta_3 \frac{Debt/GDP_t^{US}}{Debt/GDP_t^{i}} \times X_{j,i,t} + \delta_4 e_{k,t}^{USD} + \varepsilon_{j,i,t}$$

Since both the instrument and the endogenous regressor vary at the country-period level, I use robust standard errors rather than clustering at the bank level. As expected, the coefficient of the first-stage regression of $\bar{\phi}_{i,k,t}$ on $\frac{Debt/GDP_t^{US}}{Debt/GDP_t^{i}}$ is negative and significant across all specifications. In the baseline model, a 1 percentage point increase in the relative debt to GDP ratio is associated with a 4.5 basis point decrease in the CIP deviation. This result is closest to Du, Im, and Schreger (2018), who find a negative association between the US debt to GDP ratio and CIP deviations for Treasuries in a simple OLS regression. From a theoretical perspective, the first-stage outcomes are consistent with liquidity and safety yields of Treasuries decreasing in their supply, as in Vila and Vayanos (1999) and Rocheteau (2009)

Table 5: Instrumental variable models - first stage

	(1)	(2)	(3)
$\frac{Debt/GDP_t^{US}}{Debt/GDP_t^i}$	-4.466***	-1.835***	-0.896***
	(0.778)	(0.376)	(0.150)
$e_t^{USD,k}$	1.176***	0.232***	0.174***
	(0.274)	(0.0559)	(0.0335)
Loans Tot Assets		-0.0326***	
		(0.0113)	
$\frac{Debt/GDP_t^{US}}{Debt/GDP_t^i}$ × Loans Tot Assets		0.0148***	
		(0.00554)	
Risk Exposure Tot Assets			0.199
			(0.196)
$\frac{Debt/GDP_t^{US}}{Debt/GDP_t^i}$ × Risk Exposure Tot Assets			-0.0933
			(0.0979)
Constant	8.407***	3.831***	1.844***
	(1.396)	(0.744)	(0.286)
Observations	1394	644	1021
R^2	0.065	0.234	0.189

Robust standard errors in parentheses

In all regressions, the dependent variable is $\bar{\phi}_{i,k,t}$

$^{*}p < 0.10, ^{**}p < 0.05, ^{***}p < 0.01$

For all my IV specifications, I perform underidentification and weak instruments tests. I test for underidentification using the Kleibergen and Paap (2006) LM statistic, and I reject the null hypothesis that the minimal correlation between the instrument and the dependent variable is 0 at the 1% significance level for all three models. I test for weak instruments using the Kleibergen-Paap Wald statistic because it is robust to heteroskedasticity. Comparing it to the Stock and Yogo (2005) critical values I can reject, at the 5% significance level, the null hypothesis that the true size of tests carried out on β_1 and β_2 is larger than 10% . Therefore, there is no concern of instrument weakness.

Table 6 reports the results from instrumental variable regressions. Column 1 presents the baseline regression without balance sheet variables. The sign of the coefficient on $\bar{\phi}_{i,k,t}$ remains the same, but it is one order of magnitude larger. A one percentage point increase in the CIP deviation is associated with a 1.72 percentage point reduction in the ratio of US to domestic government bond exposures. The higher absolute value of the coefficient can be interpreted as evidence that the IV approach does correct for some bias compared to the FE specification. Assuming a framework with a downward-sloping demand curve and an upward-sloping supply curve, confounding shifts in demand would introduce positive correlation between $\bar{\phi}_{i,k,t}$ and $\bar{r}_{j,i,t}^{US/i}$, hence biasing the estimate towards 0. Column 2 displays results for liquidity, which are consistent with those of the FE specification . On the other hand, results for risk in column 3 show that there is a significant positive association between balance sheet risk and relative exposure to US Treasuries. However, the coefficient for the interaction term is not significant, suggesting that, despite the baseline correlation between risk exposures and US Treasury holdings, banks do not react more strongly to CIP deviations if they have riskier balance sheets.

Table 6: Instrumental variable models

	(1)	(2)	(3)
$\bar{\phi}_{i,t}^{US}$	-1.725***	-7.004**	-6.926**
	(0.561)	(3.560)	(3.307)
$e_t^{USD,k}$	-0.789	-4.638**	-4.328***
	(1.476)	(2.014)	(1.514)
$\bar{\phi}_{i,t}^{US}$ × Loans Tot Assets		0.0408	
		(0.0730)	
Loans Tot Assets		-0.525***	
		(0.0899)	
$\bar{\phi}_{i,t}^{US}$ × Risk Exposure Tot Assets			0.574
			(1.070)
Risk Exposure Tot Assets			4.321***
			(1.672)
Constant	27.66***	56.33***	24.83***
	(1.946)	(5.800)	(2.650)
N	1348	629	983
Underidentification (KP LM)	31.08	21.38	57.70
Weak identification (KP Wald)	32.99	13.85	34.87
Stock-Yogo critical value	16.38	7.030	7.030

Robust standard errors in parentheses

In all regressions, the dependent variable is $\bar{r}_{j,i,t}^{US/i}$

$^{*}p < 0.10, ^{**}p < 0.05, ^{***}p < 0.01$

4 The role of sovereign credit risk

The analysis so far has used $\bar{\phi}_{i,k,t}$ as a measure of country-specific CIP deviations, but it could be driven partly by differences in sovereign credit risk. Therefore, a carry trade with US Treasuries as a short leg and country i's government bonds as a long leg would not be riskless. Ideally, one would compare risk-free rate of returns for both countries when computing CIP deviations. However, risk-free rates are a theoretical concept, and even the safest government bonds carry some degree of risk, as evidenced by credit default swaps (CDS) contracts being traded even for, say, Germany.

In my sample, I could use German bonds as country i for banks domiciled in the Eurozone. Since Germany is the safest issuer of euro-denominated government bonds, presumably the resulting CIP deviations $\bar{\phi}_{DE,€,t}$ would not be driven by differences in sovereign risk with respect to the US. However, this approach would not be appropriate for my setting for two reasons.

Firstly, $\bar{\phi}_{DE,€,t}$ would take the same value for all Eurozone banks in the sample. Therefore, I could only exploit time-series variation to identify the reaction of relative bond holdings to $\bar{\phi}_{DE,€,t}$ for these banks. Since I only have 16 periods in my biannual sample, and Eurozone banks make up the vast majority of the EBA database, this would likely not be enough to obtain precise estimates.

Secondly, the relevant bond exposure ratio for $\bar{\phi}_{DE,€,t}$ would be $\bar{r}^{US/DE}_{j,i,t}$ for all Eurozone banks. While German bonds are amongst the most widely-held foreign bonds for banks in my sample, they are not nearly as prevalent as domestic bonds. The domestic/US margin is then a more relevant and interesting variable in the context of European banks. Furthermore, as shown in Manna and Nobili (2021), European banks tend to employ different management strategies for their domestic and foreign sovereign debt portfolios. This implies that for a meaningful exercise we would have to use $\bar{\phi}_{DE,€,t}$ and $\bar{r}^{US/DE}_{j,i,t}$ for non-Eurozone banks too, further exacerbating the problem of insufficient variation in our independent variable.

Using the country-specific CIP deviation then seems appropriate for this study, but it does leave open the question of sovereign credit risk. In the main specifications in Section 3, my interpretation of the banks' behaviour implicitly assumes that the interest rate differences are not driven mainly by default risk, so that the carry trades are seen by the banks as near riskless.

If this is not the case, the carry trades would still be profitable, albeit risky. As a consequence, my findings would be more consistent with a risky yield-seeking narrative in the vein of the literature showing that European banks engaged in risky carry trades with government bonds from distressed Eurozone countries during the crisis (Altavilla et al. (2017), Acharya and Steffen (2015), Lamas and Mencia (2018)).

In order to disentangle the "risky yield-seeking" and the "near riskless CIP arbitrage" channels, in this section I repeat the analysis carried out in Section 3, adopting three different strategies to account for sovereign credit risk: controlling for CDS rates, excluding riskier sovereigns, and excluding periods of sovereign risk spikes.

4.1 Controlling for CDS rates

I control for sovereign credit risk by adding $C\bar{D}S_{i,t}$, the average CDS rate of country i across 1,2,3,5,7, and 10 year tenors, to the fixed effects and instrumental variables models of Section 3. Table 7 reports results from these regressions, with fixed effects models in odd-numbered columns and instrumental variable models in even-numbered ones.

Columns 1 and 2 show that the baseline result of the paper holds even when controlling for the domestic country's sovereign risk. In fact, column 2 shows that under the instrumental variables specification the reduction in relative US Treasuries exposures is roughly twice as large after controlling for CDS rates. An 1 percentage point increase in CIP deviations results in a 15 percentage point decrease in the ratio of US Treasuries to domestic government bond in the sovereign portfolios of European banks on average. This result corroborates the "near-riskless CIP arbitrage" hypothesis: the carry trade behaviour is not driven only by differences in credit risk between the US and domestic governments.

However, the regressions for liquidity and risk show no significant results across all coefficients, except for the interaction between loans and $\phi_{i,k,n,t}$. Overall, these results show no support for the "convenience yield" hypothesis: there is no significant evidence that European banks increase their relative exposure to US Treasuries when their balance sheets are riskier or less liquid. Note that the loss of significance can be explained by the fewer observations for which risk and liquidity data is available; and by the reduced independent variability in $\phi_{i,k,n,t}$ introduced by CDS rates.

Cross-country sovereign debt yield differences are highly correlated with differences in CDS rates. Therefore, controlling for CDS rates directly might soak up too much of the variation in CIP deviations, not only for Eurozone countries, but also for other countries in my dataset (e.g. Denmark, Sweden, United Kingdom). Note that, perhaps for this reason, Du, Im, and Schreger (2018) do not control for credit risk in their regressions of CIP deviations on government debt supply.

Furthermore, recall that one of the aims of the paper is to establish whether European banks manage their US Treasuries holdings consistently with assigning a convenience yield to them. CIP deviations are commonly interpreted as a measure of this convenience yield relative to country i's government bonds, which is

Table 7: Models with CDS

	Baseline		Liquidity		Risk	
	(1) OLS	(2) IV	(3) OLS	(4) IV	(5) OLS	(6) IV
$\bar{\phi}_{i,t}^{US}$	-5.337***	-15.51***	-3.132	-38.69	0.107	51.73
	(1.862)	(3.782)	(2.347)	(56.48)	(3.534)	(65.33)
Loans Tot Assets			-0.968**	-0.574***		
			(0.450)	(0.151)		
$\bar{\phi}_{i,t}^{US}$ × Loans Tot Assets			-0.00645	-0.106		
			(0.0411)	(0.199)		
Risk Exposure Tot Assets					1.385	0.862
					(2.512)	(1.471)
$\bar{\phi}_{i,t}^{US}$ × Risk Exposure Tot Assets					0.146	-0.674
					(0.359)	(2.094)
$e_t^{USD,k}$	0.945	-0.773	-3.082	-6.449	-1.674	1.926
	(4.564)	(1.539)	(3.984)	(5.117)	(3.658)	(5.280)
$C\bar{D}S_{i,t}$	0.0261***	0.0825***	-0.0340	0.414	-0.0779	-0.676
	(0.00956)	(0.0210)	(0.0333)	(0.717)	(0.0472)	(0.740)
Time FE	Yes	No	Yes	No	Yes	No
Observations	1266	1157	594	535	934	849
R^2	0.043	.	0.112	.	0.045	.

Standard errors in parentheses

Standard errors clustered at the bank level for OLS regressions, and robust for IV regressions

In all regressions, the dependent variable is $\bar{r}_{j,i,t}^{US/i}$

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

partly due to the unique safety of US Treasuries. Then, since CDS rates incorporate information about the safety of country i's sovereign debt, their inclusion as a control could muddle the interpretation of $\bar{\phi}_{i,k,t}$ as a convenience yield. In my IV specification, this could also amplify any residual bias in the estimated coefficient on $\bar{\phi}_{i,k,t}$,if the instrument exogeneity condition does not hold perfectly and CDS rates are more correlated with $\bar{\phi}_{i,k,t}$ than with $\bar{r}^{US/i}_{j,i,t}$ [4].

Therefore, in the following sub-sections I adopt a more nuanced approach, with the goal of excluding large spikes in default risk that would dwarf other components of CIP deviations, while maintaining enough variation in $\bar{\phi}_{i,k,t}$ across countries.

4.2 Excluding countries with non-investment grade rating

With the goal of excluding countries that markets perceive as high-risk, I perform a robustness check that excludes countries that received a non-investment grade credit rating, defined as BB or lower on the Fitch and Standard & Poor's scales, at any point between December 2011 and June 2020. The excluded countries according to this criterion are Bulgaria, Croatia, Cyprus, Greece, Portugal and Romania.

I choose the credit rating threshold strategy to obtain a market-driven definition of a risky country. However, this approach leads to retaining countries such as Italy and Spain which, despite never dropping below BBB, did experience spikes in CIP deviations (up to 600 bps as shown in Figures 3 and 4), and relatively high average CDS rates in the last decade. They were also at the centre of the European sovereign debt crisis narrative as part of the GIIPS (Greece, Ireland, Italy, Portugal and Spain) group, and are classified among distressed countries on this basis in the literature (for example Acharya and Steffen (2015), Saka (2020)). Therefore, I also present results that exclude GIIPS countries specifically in Appendix E.

Table 8 displays results from these regressions, with fixed effects models in odd-numbered columns and instrumental variable models in even-numbered ones.

Similarly to the CDS regressions, column 1 shows that the coefficient for $\bar{\phi}_{i,k,t}$ remains negative, and about two orders of magnitude larger than in the Section 3 model. In the instrumental variable specification, the coefficient is negative but insignificant. The same pattern holds for the liquidity and risk regressions. Interestingly, there is a positive and significant coefficient for the interaction term between $\bar{\phi}_{i,k,t}$ and the liquidity measure. However, it is accompanied by a negative coefficient for both $\bar{\phi}_{i,k,t}$ and the liquidity measure taken individually; and it becomes insignificant in the instrumental variable specification. Therefore,

[4]See Pearl (2011) for an analytical treatment of bias amplification in an IV setting, or Stokes et al. (2020) for results from simulations

Table 8: Models without non-investment grade countries

	Baseline		Liquidity		Risk	
	(1) OLS	(2) IV	(3) OLS	(4) IV	(5) OLS	(6) IV
$\bar{\phi}_{i,t}^{US}$	-12.73***	-3.477	-44.95***	1.346	-15.76*	-7.964
	(4.339)	(3.729)	(13.56)	(26.68)	(8.848)	(9.230)
Loans Tot Assets			-1.233***	-0.514***		
			(0.452)	(0.116)		
$\bar{\phi}_{i,t}^{US}$ × Loans Tot Assets			0.412**	0.0131		
			(0.174)	(0.411)		
Risk Exposure Tot Assets					6.415	3.829**
					(5.872)	(1.938)
$\bar{\phi}_{i,t}^{US}$ × Risk Exposure Tot Assets					-2.567	4.968
					(7.174)	(6.155)
$e_t^{USD,k}$	-2.287	-1.287	-7.106*	-4.528**	-5.830	-4.951***
	(3.727)	(1.453)	(4.017)	(2.199)	(3.638)	(1.810)
Time FE	Yes	No	Yes	No	Yes	No
Observations	1309	1233	611	569	966	908
R^2	0.056	.	0.152	.	0.068	.

Standard errors in parentheses

Standard errors clustered at the bank level for OLS regressions, and robust for IV regressions

In all regressions, the dependent variable is $\bar{r}_{j,i,t}^{US/i}$

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

I do not interpret this as convincing evidence of a convenience yield motive for holding US Treasuries.

4.3 Excluding periods of sovereign risk spikes

As an additional method to account for credit risk, I repeat the estimation of the models in Section 3 by excluding observations from 2011 to 2013 , corresponding to the height of the European sovereign debt crisis. As evident in Figures 3 and 4, CIP deviations for distressed Eurozone sovereigns took on extreme values only during this period, while they hovered around levels comparable to other European countries such as France in the rest of the sample. Therefore, this sample split can achieve the goal of eliminating cases in which CIP deviations are plausibly driven mostly by sovereign default risk, while keeping a sufficient amount of cross-country variation. This approach enjoys the added advantage of not having to pick specific countries to exclude.

Table 9 displays results from these regressions, with fixed effects models in odd-numbered columns and instrumental variable models in even-numbered ones. The results are very similar to those in Section 3 across all specifications.

Table 9: Models without the European sovereign debt crisis period

	Baseline		Liquidity		Risk	
	(1) OLS	(2) IV	(3) OLS	(4) IV	(5) OLS	(6) IV
$\bar{\phi}_{i,t}^{US}$	-5.374***	-5.474**	-5.762***	-7.004**	-5.822***	-6.926**
	(1.564)	(2.243)	(1.486)	(3.560)	(1.989)	(3.307)
Loans Tot Assets			-1.129**	-0.525***		
			(0.434)	(0.0899)		
$\bar{\phi}_{i,t}^{US}$ × Loans Tot Assets			-0.0563	0.0408		
			(0.0466)	(0.0730)		
Risk Exposure Tot Assets					4.454	4.321***
					(3.466)	(1.672)
$\bar{\phi}_{i,t}^{US}$ × Risk Exposure Tot Assets					-0.208	0.574
					(0.520)	(1.070)
$e_t^{USD,k}$	-2.454	-2.851*	-5.072	-4.638**	-4.179	-4.328***
	(3.533)	(1.458)	(3.651)	(2.014)	(3.482)	(1.514)
Time FE	Yes	No	Yes	No	Yes	No
Observations	1149	1057	688	629	1068	983
R^2	0.039	.	0.123	.	0.052	.

Standard errors in parentheses

Standard errors clustered at the bank level for OLS regressions, and robust for IV regressions

In all regressions, the dependent variable is $\bar{r}_{j,i,t}^{US/i}$

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In summary, these three approaches deliver a broadly consistent message: the portfolio rebalancing away from US Treasuries in response to widening convenience yields is not driven mainly by domestic credit risk. Therefore, the carry trade with US Treasuries as the short leg and domestic government bonds as a long leg appears to have a predominant "near-riskless arbitrage" character, rather than exploiting risk-driven interest rate differentials. It is not possible to exclude the latter motive completely, especially in the full sample, but this aspect does not drive the main result of the paper. Furthermore, there is no evidence that European banks respond to changes in CIP deviations consistently with valuing US Treasuries for their safety and liquidity.

5 Leverage constraints and regulatory arbitrage

So far, this paper has established that European banks adjust their sovereign portfolio to make a profit from CIP deviations between US Treasuries and domestic sovereign bonds. Recent findings by Tabova and Warnock (2021) that foreign private investors decrease their US Treasury holdings when CIP deviations are large suggest that this behaviour might be far from unique. However, it is still interesting to ask whether any feature of European banks or the institutional environment they operate in can explain why they do not trade with CIP deviations, but rather against them to make a carry trade profit. This question is particularly relevant in the context of a literature that emphasises demand from international investors who value the safety and liquidity of Treasuries as the primary source of CIP deviations.

Two features of the regulatory environment under which European banks operate might contribute to explain why they are better placed than other investors to exploit CIP deviations for a profitable carry trade. Firstly, during my sample period European banks were not subject to a binding minimum leverage ratio requirement. They were then relatively free to expand their balance sheet to engage in carry trades with their sovereign portfolio, at least from a regulatory point of view. Du, Tepper, and Verdelhan (2018) argue that the emergence of CIP deviations in money markets after the 2008 financial crisis can be attributed to Basel III minimum leverage requirements, which constrained the balance sheet capacity of broker-dealers to arbitrage away the CIP gap. Since leverage requirements concern the absolute size of the balance sheet, they have bite even if trades against CIP deviations are riskless, since they involve borrowing on FX markets. Recent studies have applied this reasoning to Treasury markets, attributing the decreasing convenience yield of US Treasuries observed in the past decade to tighter non-risk-weighted leverage constraints (Duffie (2020), He et al. (2021)) . If Basel III leverage rules constrained the capacity of investors to expand their balance sheet for profitable carry trades, their delayed adoption in Europe made European banks particularly well-suited to take advantage of CIP deviations. However, the small size of their Treasury holdings relative to the total amount outstanding prevents them from closing the gap completely.

The EU implemented regulation on leverage ratios according to Basel III guidelines in the following steps: in 2014, it mandated banks to report their leverage ratio to regulators (European Commission, 2013). Starting in 2015, it required banks to publicly disclose their leverage ratio, along with information on the process used to manage excessive leverage risk, factors that impacted it (European Commission, 2013), and plans to bring it above 3%. Regulatory plans foresaw the introduction of a binding leverage ratio starting in 2018 (European Commission (2013)). However, the 3% leverage ratio became a fully binding minimum requirement only in June 2021 (European Commission (2019)). The regulatory picture is rather different for banks in some other non-US advanced economies. For example, the United Kingdom implemented a binding 3% leverage ratio requirement in January 2016 (Prudential Regulation Authority (2015)). Similarly, other classes of investors within Europe were subject to tighter leverage regulation in the sample period. For example all investment funds, many of which hold government bonds as part of their mandates, have been subject to a stringent minimum 90% leverage requirement since 2010 (European Parliament and Council (2009)). Therefore, banks under EBA regulation are subject to less stringent regulatory constraints on the absolute size of their balance sheet, with respect to both banks in other European jurisdictions and other classes of investors in Europe.

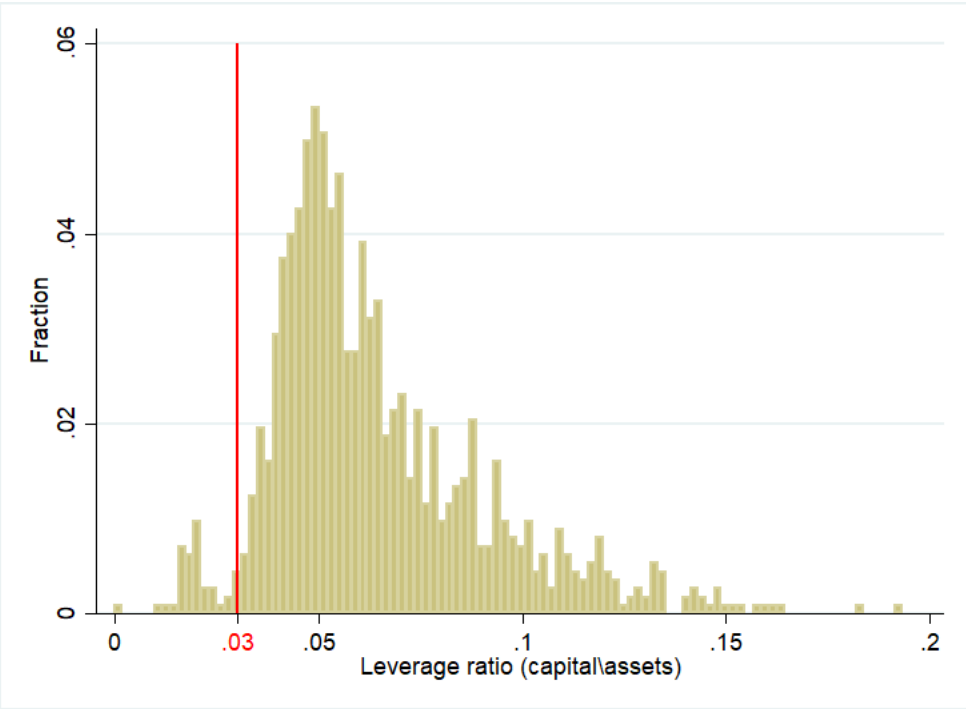
Secondly, both domestic and US sovereign bonds have a weight of zero for the purpose of calculating risk exposures relevant for the EU Capital Requirement Regulation. The former are assigned a zero risk weight regardless of their credit rating because they are issued in the banks' domestic currency, while the latter by virtue of their AAA rating [5]. Therefore, even if some amount of risk is embedded in the carry trades, it does not contribute to the regulatory measure of risk-weighted assets. European banks are then free to adjust the relative holdings of US and domestic government bonds portfolio without hitting any risk regulation threshold. Of course, this institutional feature does not imply that banks value domestic bonds as completely riskless in their investment decisions, but it does ease a possible constraint. Acharya and Steffen (2015) argue that the zero risk weights on all euro-area sovereign bonds constituted an important incentive for Eurozone banks to engage in carry trades with German and GIIPS bonds during the sovereign debt crisis. This mechanism hinges on the wedge between market-based and regulation-based risk measures, so it does not play a central role in the US-domestic carry trade analysed here, which as we have seen does not rely mainly on risk differentials. However, it can still provide a further incentive to engage in the US-domestic carry trade when there is some (perhaps small) risk in the domestic bond.

I provide empirical support for the laxness of the EBA regulatory framework on leverage in columns 1 and 2 of Table 10. The goal is to test whether the introduction of leverage disclosure in 2015 affected the capacity of banks under EBA

[5] see European Commission (2013) for details on sovereign bond risk weights

supervision to engage in carry trades with their sovereign portfolios. I estimate the baseline model linking $\bar{r}^{US/i}_{j,i,t}$ and $\bar{\phi}_{i,k,t}$, under both fixed effects and instrumental variable specifications, adding a dummy variable for post-2015, and an interaction term between a post-2015 dummy variable and $\bar{\phi}_{i,k,t}$.These regressions exclude banks domiciled in the United Kingdom, as they operate under a different regulatory regime. My hypothesis is that the leverage disclosure requirement did not constitute a binding constraint for banks. Therefore, I expect the coefficient on the interaction term to be insignificant. It is indeed the case in the instrumental variable specification, while the coefficient is significant and negative in the FE model. However, this implies that the reaction to CIP deviations is actually stronger (i.e. more negative) after 2015, while I would expect the reaction to be attenuated (i.e. positive sign on the interaction coefficient) if the leverage disclosure requirement acted as an effective constraint on carry trade activities. Note that is at best preliminary evidence of the effect of regulation, as it simply compares the situation before and after the introduction of the leverage requirement without reference to a control group or a counterfactual.

Figure 5: Regulatory leverage ratio distribution



Given this institutional setup, it is also interesting to ask whether banks did in fact have enough balance sheet space, as measured by leverage, to engage in carry trades with their sovereign portfolio. Figure 5 plots a histogram of the regulatory leverage ratio (defined as Tier 1 capital over total assets) for all observations in the sample. Around 97% of the banks are above the minimum 3% threshold, and the median sits at 6%, double the Basel III regulatory threshold. So, even if we assumed that leverage reporting and disclosure measures did constitute a potential constraint, the vast majority of banks in the sample has a comfortable enough margin above the regulatory minimum that they are unlikely to hit the constraint by adjusting their sovereign portfolio in response to CIP deviations.

Table 10: Leverage constraints and regulatory arbitrage

	EBA disclosure (excluding UK)		Leverage (since 2015)	
	(1) OLS	(2) IV	(3) OLS	(4) IV
$\bar{\phi}_{i,t}^{US}$	-0.226***	-1.798**	-16.93*	-2.819
	(0.0793)	(0.913)	(10.15)	(10.73)
Post_{2015}=1				
$\text{Post}_{2015}=1 \times \bar{\phi}_{i,t}^{US}$	-3.467***	-1.335		
	(1.220)	(4.472)		
Leverage $\text{Ratio}_{i,j,t}$			-278.9***	-220.3***
			(103.9)	(65.53)
$\bar{\phi}_{i,t}^{US} \times$ Leverage $\text{Ratio}_{i,j,t}$			121.6	-5.846
			(86.45)	(94.12)
$e_t^{USD,k}$	0.751	-0.0243	-4.197	-3.317**
	(4.204)	(1.372)	(3.395)	(1.592)
Time FE	Yes	No	Yes	No
Observations	1381	1271	1019	934
R^2	0.036	.	0.059	.

Standard errors in parentheses

Standard errors clustered at the bank level for OLS regressions, and robust for IV regressions

In all regressions, the dependent variable is $\bar{r}_{j,i,t}^{US/i}$

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Columns 3 and 4 of Table 10 test this hypothesis more formally by adding regulatory leverage and an interaction term with $\bar{\phi}_{i,k,t}$ to the baseline fixed effects and instrumental variable models. These regressions exclude observations from 2011 to June 2014, as banks are obliged to disclose their leverage ratio only from the 2015 iteration of the EBA transparency exercise. If leverage imposed an effective constraint on banks, we would expect worse-capitalised banks to react less strongly to CIP deviations. This would translate to a negative and significant coefficient on the interaction term. However, the coefficient is insignificant in both specifications.

These results stand somewhat in contrast to Breckenfelder and Ivashina (2021), who find that the introduction of the leverage ratio reporting requirement in 2013 constituted an effectively binding leverage constraint for European broker-dealers. They show that corporate bonds intermediated by a dealer closer to the regulatory threshold had higher bid-ask spreads, implying worse liquidity. Their analysis concerns broker-dealers and corporate bonds, so it is possible that the discrepancy is simply due to the different environment of commercial banks and their sovereign portfolios considered here. However, a more detailed investigation of the effect of Basel III regulation on European commercial banks would be an interesting direction for future research, as the models in this section report essentially simple correlations and do not identify a causal effect.

Overall, these results offer some preliminary evidence that the EBA leverage regulation in my sample period was lax enough not to constitute an effective constraint for European banks. Furthermore, I showed that their capitalisation is sufficient to allow balance sheet expansions in response to CIP deviations without hitting the regulatory leverage threshold. These features could explain why European banks are particularly suited to exploit CIP deviations to make carry trade profits.

6 Conclusion

In this paper, I show that European banks react to higher CIP deviations between US Treasuries and domestic government bonds by reducing their relative US/domestic sovereign exposure. This result can be interpreted as banks in Europe not valuing US Treasuries for their safety and liquidity as measured by the convenience yield embedded in CIP deviations. My findings are consistent with Tabova and Warnock (2021), but my analysis pins down the behaviour of individual investors using balance-sheet level data, and identifies the slope of their demand using fixed effects and instrumental variable approaches.

Furthermore, I contribute to the literature on the sovereign portfolios of European banks by showing that they engage in carry trades with US Treasuries as the short leg, and domestic bonds as the long leg. This result echoes findings from Acharya and Steffen (2015), Altavilla et al. (2017) and Frey and Weth (2019), who show that European banks used their sovereign bond holdings for carry trades on the German-distressed country dimension during the European sovereign debt crisis.

I also propose a regulatory arbitrage interpretation of my findings: the delayed introduction of Basel III binding minimum leverage requirements made banks supervised by the EBA better suited to trade against CIP deviations with respect to both banks in other European regulatory regimes, and other types of investors in Europe such as mutual and pension funds.

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A Data sources

Bank balance sheets

I build a dataset of European bank balance sheet data from 2011 to 2020 at the biannual frequency by harmonising and merging all iterations of the EBA transparency exercise datasets, and by merging the "sovereign", "market", "credit", "risk" and "other" templates at the bank-period level within each iteration. I fill gaps in the data by using the 2011, 2014 and 2016 iterations of the EBA stress test exercise database. Sovereign bond exposures are winsorised at the 5% level to account for extreme outliers. Variables are defined as follows

- *Exposures to sovereign bonds:* Item 2020810 "Direct exposures - On balance sheet - Total gross carrying amount of non-derivative financial assets" for 06/2018 to 06/2020. Item 1820806 "Financial assets: Carrying Amount of which: debt securities - broken down by country" for 06/2016, 12/2016 and 06/2017. Item 1690501 "GROSS DIRECT LONG EXPOSURES (accounting value gross of provisions)" for 12/2015, 06/2015, and 12/2014. Item 150901 "GROSS DIRECT LONG EXPOSURES (accounting value gross of provisions)" for 12/2011, 12/2012, 06/2013, and 12/2013.

- *Total assets:* Item 2020903 "Total leverage ratio exposures - using a transitional definition of Tier 1 capital" for all years except for 2012, 2013, and 2016. Item 1690111 "Total leverage ratio exposures" for 2016.

- *Capital:* Item 2020901 "Tier 1 capital - transitional definition".

- *Leverage ratio:* Item 2020905 "Leverage ratio - using a transitional definition of Tier 1 capital".

- *Loans:* Item 2021017 "Gross carrying amount: Financial assets at fair value through other comprehensive income, Loans and advances" + item 2021019 "Gross carrying amount: Financial assets at amortised cost, Loans and advances" for 06/2018 to 06/2020. Item 1820803 "Financial assets: Carrying Amount / of which: loans and advances" for periods before 06/2018.

- *Risk exposure:* Item 2020401 "TOTAL RISK EXPOSURE AMOUNT" for 12/2015 to 06/2020. Item 993104 "Risk exposure amount for market risk" for 12/2013. Item 200300 "RWAs for market risk " for 12/2012 and 06/2013

- *Cash:* Item 2021001 "Cash, cash balances at central banks and other demand deposits".

CIP deviations

CIP deviations for Denmark, Germany, Hungary, Norway, Poland, Sweden, and the United Kingdom come from the Du, Im, and Schreger (2018) database. CIP deviations for Eurozone countries and Romania are calculated using the formula in Du, Im, and Schreger (2018). The variables used and their sources are listed below

- *Government bond yields* 3 months and 1,2,3,5,7 and 10 year maturities. Source: Datastream
- *Interest rate swaps:* 1,2,3,5,7 and 10 year maturities. Source: Eikon Refinitiv
- *Basis swaps:* 1,2,3,5,7 and 10 year maturities. Source: Eikon Refinitiv
- *Exchange rates:* Spot and 3 month forward rate. Source: Eikon Refinitiv
- *Robor benchmark interest rate:* Source: Eikon Refinitiv

Macroeconomic variables

The macroeconomic variables used and their sources, collected for all bank residence countries in the sample and for the United States, are listed below.

- *General government debt/GDP:* Sources: Eurostat for EU countries. FRED for US government debt. ONS for UK government debt
- *Credit default swap rates:* Source: Eikon Refinitiv.

B Banks in EBA dataset

Table 11: List of all banks in the EBA dataset

Bank country	Bank name
Austria	Volksbanken Verbund
Austria	Raiffeisen Niederösterreich
Austria	Erste Group Bank AG
Austria	VTB Bank (Austria) AG
Austria	Raiffeisen Bank International AG
Austria	Raiffeisen-Landesbanken-Holding GmbH
Austria	Österreichische Volksbanken AG
Austria	BAWAG Group AG
Austria	Raiffeisenbankengruppe OÖ Verbund eGen
Austria	Sberbank Europe AG
Belgium	Investeringsmaatschappij Argenta
Belgium	Belfius Bank
Belgium	KBC Groep
Belgium	AXA Bank Belgium
Belgium	Dexia
Belgium	The Bank of New York Mellon
Bulgaria	First Investment Bank
Cyprus	Bank of Cyprus Holdings Public Limited Company
Cyprus	Hellenic Bank Public Company Ltd
Cyprus	RCB Bank Ltd
Cyprus	Co -operative Central Bank Ltd
Denmark	Sydbank A/S
Denmark	Nykredit Realkredit A/S
Denmark	Jyske Bank A/S
Denmark	Danske Bank A/S
Estonia	AS LHV Group
Estonia	Luminor Holding AS
Finland	OP Osuuskunta
Finland	Kuntarahoitus Oyj
Finland	Nordea Bank Abp
Finland	Säästöpankkiliitto osk

Bank country	Bank name
France	RCI Banque
France	Groupe BPCE
France	BNP Paribas
France	Banque centrale de compensation
France	HSBC France
France	Bpifrance S.A. (Banque Publique d'Investissement)
France	SFIL
France	Groupe Crédit Agricole
France	Société générale
France	La Banque Postale
France	Confédération Nationale du Crédit Mutuel
France	Banque PSA Finance
France	C.R.H. - Caisse de refinancement de l'habitat
Germany	Deutsche Pfandbriefbank AG
Germany	NRW.Bank
Germany	Münchener Hypothekenbank EG
Germany	Landesbank Hessen-Thüringen Girozentrale
Germany	IKB Deutsche Industriebank AG
Germany	Bayerische Landesbank
Germany	HASPA Finanzholding
Germany	Wüstenrot Bank AG Pfandbriefbank
Germany	Norddeutsche Landesbank -Girozentrale-
Germany	Deutsche Bank AG
Germany	J.P. Morgan AG, Frankfurt am Main
Germany	Erwerbsgesellschaft der S-Finanzgruppe mbH & Co. KG
Germany	UBS Europe SE, Ffm
Germany	State Street Europe Holdings Germany S.a.r.l. & Co. KG
Germany	VW Financial Services AG
Germany	Wüstenrot Bausparkasse AG
Germany	DZ Bank AG
Germany	Landeskreditbank Baden-Württemberg–Förderbank
Germany	Commerzbank AG
Germany	Deutsche Apotheker- und Ärztebank EG
Germany	Aareal Bank AG
Germany	DekaBank Deutsche Girozentrale
Germany	WGZ Bank AG
Germany	Landwirtschaftliche Rentenbank
Germany	KfW IPEX-Bank GmbH
Germany	Volkswagen Bank Gesellschaft mit beschränkter Haftung
Germany	Hamburg Commercial Bank AG
Germany	Landesbank Baden-Württemberg

Bank country	Bank name
Greece	Alpha Bank, S.A.
Greece	National Bank of Greece, S.A.
Greece	Piraeus Bank, S.A.
Greece	Eurobank Ergasias Services and Holdings S.A.
Hungary	OTP Bank Nyrt.
Iceland	Arion banki hf
Iceland	Íslandsbanki hf.
Iceland	Landsbankinn hf.
Ireland	Depfa Bank Plc
Ireland	Bank of Ireland Group plc
Ireland	Bank of America Europe Designated Activity Company
Ireland	Barclays Bank Ireland Plc
Ireland	AIB Group plc
Ireland	Ulster Bank Ireland Designated Activity Company
Ireland	Citibank Holdings Ireland Limited
Ireland	Permanent TSB Group Holdings Plc
Italy	Banca Carige SpA - Cassa di Risparmio di Genova e Imperia
Italy	Banca Popolare di Vicenza SCpA
Italy	Intesa Sanpaolo S.p.A.
Italy	Banco BPM S.p.A.
Italy	Credito Valtellinese
Italy	Banca Popolare di Sondrio, Società Cooperativa per Azioni
Italy	Banca Popolare di Milano Scarl
Italy	ICCREA Banca S.p.A. – Istituto Centrale del Credito Cooperativo
Italy	BPER Banca S.p.A.
Italy	UniCredit S.p.A.
Italy	ICCREA Holding
Italy	Banca Monte dei Paschi di Siena S.p.A.
Italy	Banco Popolare Società Cooperativa
Italy	Mediobanca – Banca di Credito Finanziario S.p.A.
Italy	Credito Emiliano Holding S.p.A.
Italy	Veneto Banca SCpA
Italy	Unione di Banche Italiane S.p.A.
Italy	Cassa Centrale Banca - Credito Cooperativo Italiano SpA

Bank country	Bank name
Latvia	ABLV Bank
Latvia	Akciju sabiedrība "Citadele banka"
Lithuania	Akcinė bendrovė Šiauliu bankas
Luxembourg	State Street Bank Luxembourg S.C.A.
Luxembourg	Precision Capital S.A.
Luxembourg	Banque et Caisse d'Epargne de l'Etat, Luxembourg
Luxembourg	RBC Investor Services Bank S.A.
Luxembourg	Banque Internationale à Luxembourg
Luxembourg	J.P. Morgan Bank Luxembourg S.A.
Malta	MDB Group Limited
Malta	Bank of Valletta Plc
Malta	Commbank Europe Ltd
Malta	HSBC Bank Malta p.l.c.
Netherlands	Coöperatieve Rabobank U.A.
Netherlands	ABN AMRO Group N.V.
Netherlands	ING Groep N.V.
Netherlands	ABN AMRO Bank N.V.
Netherlands	de Volksbank N.V.
Netherlands	BNG Bank N.V.
Netherlands	Nederlandse Waterschapsbank N.V.
Norway	Sparebank ASA
Norway	DNB Bank ASA
Norway	Sparebank SMN
Poland	Bank Polska Kasa Opieki SA
Poland	Bank Ochrony Srodowiska SA
Poland	Getin Noble Bank SA
Poland	Powszechna Kasa Oszczedności Bank Polski SA
Poland	Bank BPH SA
Poland	Alior Bank SA
Poland	Bank Handlowy w Warszawie SA
Portugal	Caixa Económica Montepio Geral, Caixa Económica Bancária, S.A.
Portugal	Banco BPI SA
Portugal	Caixa Geral de Depósitos, SA
Portugal	Caixa Central - Caixa Central de Crédito Agrícola Mútuo, CRL
Portugal	Banco Comercial Português, SA
Portugal	Novo Banco, SA
Portugal	LSF Nani Investments S.à r.l.

Bank country	Bank name
Romania	Banca Transilvania
Slovenia	Nova Ljubljanska Banka d.d., Ljubljana
Slovenia	Biser Topco S.à.r.l.
Slovenia	Abanka d.d.
Slovenia	SID - Slovenska izvozna in razvojna banka
Spain	Banco Mare Nostrum
Spain	Ibercaja Banco, S.A.
Spain	Banco Santander, S.A.
Spain	Liberbank, S.A.
Spain	Banco Popular Español SA
Spain	CaixaBank, S.A.
Spain	Unicaja Banco, S.A.
Spain	Abanca Corporación Bancaria S.A.
Spain	Banco de Sabadell, S.A.
Spain	Banco de Crédito Social Cooperativo, S.A.
Spain	Bankinter, S.A.
Spain	BFA Tenedora de Acciones, S.A.U.
Spain	Banco Bilbao Vizcaya Argentaria, S.A.
Spain	Catalunya Banc
Spain	Kutxabank, S.A.
Sweden	Swedbank - group
Sweden	Länsförsäkringar Bank AB - group
Sweden	Nordea Bank - group
Sweden	Svenska Handelsbanken - group
Sweden	SBAB Bank AB - group
Sweden	Kommuninvest - group
Sweden	Skandinaviska Enskilda Banken - group
United Kingdom	HSBC Holdings Plc
United Kingdom	Lloyds Banking Group Plc
United Kingdom	Barclays Plc
United Kingdom	Standard Chartered Plc
United Kingdom	Nationwide Building Society
United Kingdom	Natwest Group plc

C Responses to CIP deviations along the yield curve

Short-maturity models

Table 12: Short-maturity models

	Baseline		Liquidity		Risk	
	(1) OLS	(2) IV	(3) OLS	(4) IV	(5) OLS	(6) IV
$\phi^{US}_{i,1,t}$	-1.315	-0.999	-20.68	3862.9	1.316	-11.71
	(1.243)	(2.425)	(24.30)	(11305.4)	(3.351)	(9.285)
Loans Tot Assets			-0.338*	1.945		
			(0.195)	(6.937)		
$\phi^{US}_{i,1,t}$ × Loans Tot Assets			0.360	-55.03		
			(0.319)	(160.8)		
Risk Exposure Tot Assets					2.474	0.321
					(1.775)	(0.893)
$\phi^{US}_{i,1,t}$ × Risk Exposure Tot Assets					-3.997	6.798
					(2.570)	(4.340)
$e^{USD,k}_t$	-1.777	-1.679		-29.02	-2.568	-3.318**
	(1.300)	(1.085)		(72.79)	(1.621)	(1.631)
Time FE	Yes	No	Yes	No	Yes	No
Observations	1002	930	356	378	779	722
R^2	0.012	.	0.084	.	0.033	.

Standard errors in parentheses

Standard errors clustered at the bank level for OLS regressions, and robust for IV regressions

In all regressions, the dependent variable is ${r^{US/i}}s_{j,i,1,t}$

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Long-maturity models

Table 13: Long-maturity models

	Baseline		Liquidity		Risk	
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	IV	OLS	IV	OLS	IV
$\phi^{US}_{i,10,t}$	-1.894***	-1.782**	5.221	113.7***	-6.681**	-4.800
	(0.644)	(0.824)	(17.50)	(40.00)	(2.812)	(3.139)
Loans Tot Assets			-0.303	-0.451***		
			(0.251)	(0.117)		
$\phi^{US}_{i,10,t}$ × Loans Tot Assets			-0.00562	-1.730***		
			(0.221)	(0.594)		
Risk Exposure Tot Assets					5.253**	5.305***
					(2.089)	(1.168)
$\phi^{US}_{i,10,t}$ × Risk Exposure Tot Assets					-1.137	0.965
					(1.663)	(1.984)
$\mathrm{e}^{USD,k}_{t}$	-5.495**	-5.507***		-7.967***	-8.139**	-7.223***
	(2.131)	(0.763)		(1.551)	(3.170)	(1.136)
Time FE	Yes	No	Yes	No	Yes	No
Observations	1022	968	346	360	734	693
R^2	0.037	.	0.043	.	0.090	.

Standard errors in parentheses

Standard errors clustered at the bank level for OLS regressions, and robust for IV regressions

In all regressions, the dependent variable is $r^{US/i}_{j,i,\geq 10,t}$

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

D Robustness check: cash as proxy for balance sheet liquidity

Table 14: Cash as balance sheet proxy

	(1) OLS	(2) OLS	(3) IV
$\bar{\phi}_{i,t}^{US}$	7.829	7.741	-16.57**
	(5.280)	(5.273)	(8.253)
Cash Tot Assets	3.642***	3.668***	3.889***
	(0.498)	(0.500)	(0.271)
$\bar{\phi}_{i,t}^{US}$ × Cash Tot Assets	-3.297***	-3.259***	1.625
	(0.430)	(0.436)	(1.693)
$e_t^{USD,k}$	-5.791*	-5.727*	-5.288***
	(2.975)	(3.004)	(1.727)
Time FE	No	Yes	No
Observations	437	437	401
R^2	0.276	0.277	.

Standard errors in parentheses

Standard errors clustered at the bank level for OLS regressions, and robust for IV regressions

In all regressions, the dependent variable is $\bar{r}_{j,i,t}^{US/i}$

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

E Robustness check: excluding GIIPS countries

Table 15: Models without GIIPS countries

	Baseline		Liquidity		Risk	
	(1) OLS	(2) IV	(3) OLS	(4) IV	(5) OLS	(6) IV
$\bar{\phi}^{US}_{i,t}$	-5.444**	71.10***	-26.54***	300.2**	-6.958*	-196.0*
	(2.471)	(22.06)	(8.126)	(142.7)	(3.532)	(106.1)
Loans Tot Assets			-1.147**	-0.0112		
			(0.455)	(0.254)		
$\bar{\phi}^{US}_{i,t}$ × Loans Tot Assets			0.0296	-2.451		
			(0.156)	(1.883)		
Risk Exposure Tot Assets					4.412	-11.25*
					(4.877)	(6.643)
$\bar{\phi}^{US}_{i,t}$ × Risk Exposure Tot Assets					1.763	223.7**
					(13.63)	(92.05)
$e^{USD,k}_t$	-3.269	-6.141**	-8.058*	-5.557	-6.874	-37.82***
	(4.070)	(2.742)	(4.273)	(6.368)	(4.267)	(11.97)
Time FE	Yes	No	Yes	No	Yes	No
Observations	1018	908	489	430	756	671
R^2	0.033	.	0.131	.	0.044	.

Standard errors in parentheses

Standard errors clustered at the bank level for OLS regressions, and robust for IV regressions

In all regressions, the dependent variable is $\bar{r}^{US/i}_{j,i,t}$

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$