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DOES PUBLIC DEBT OWNERSHIP STRUCTURE MATTER FOR A BORROWING COUNTRY?

By Carlos Alberto Piscarreta Pinto Ferreira[1]

KEYWORDS

Public Debt, Government Bonds, Debt Structure, Investor Base, Sovereign Risk, VAR

JEL CODES

C32, C33, E43, G12, F34, G11, G12, H63

ABSTRACT

We assess the investor base impact on government borrowing costs and examine how investors react to shocks in sovereign bond yields, across 24 countries and 3 maturities between 2004Q1-2019Q2. Our VAR approach has the advantage of modelling bi-directional causality between yields and investor base. We find that higher foreign holdings are associated with lower yields but link these effects exclusively to foreign banks and mainly to 10-years maturity. Yields in GIIPS and EA core countries react in opposite directions to foreign holdings shocks. Foreign investment is procyclical, namely at the long end and where fundamentals are weaker. Thus, an EA sovereign debt crisis re-run cannot be dismissed requiring readiness to use supporting mechanisms to prevent contagion and an escalation that may jeopardize the monetary union itself. Yields' response to domestic investment shocks is heterogeneous and seems to bear no significant relation with home bias. No cyclical trading pattern can be clearly associated to each type of domestic investor.

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1. INTRODUCTION

In advanced economies (AE), fiscal support to mitigate the economic downturn and job losses brought about by the Covid-19 pandemic is estimated at 6 percent of GDP in 2021 (IMF, 2021). In 2020, average budget deficits reached 11.7 percent in AE. Gross government debt is expected to reach a staggering 122.5 percent of GDP in 2021. Klaus Reading, ESM Managing Director, in a speech at the 2021 EIB Annual Economics Conference, tops these already high debt levels with the long-term costs of ageing and climate change. Furthermore, as corporate and household borrowers struggle to pay their loans due to the Covid-19 pandemic, potential bailout costs of banks' hit by non-performing loans cannot be entirely dismissed.

Although government bond yields have remained subdued, benefiting from a downward trend in market interest rates and supportive government bond purchases by central banks, high debt levels and the unusually uncertain fiscal outlook leave the sovereign bond market vulnerable to changes in investors' beliefs regarding debt sustainability.

In the specific case of the Euro Area (EA), the lack of national control over monetary policy leaves sovereigns more exposed to default risk. Moreover, common financial vulnerabilities to external shocks risk contagion effects (Calvo, et al., 2004). These factors combined represent a threat to the monetary union itself.

As was shown by the EA sovereign debt crisis, not all government debt investors react likewise to the same shock. Hence, a better understanding of behavioural responses of different types of investors is helpful to improve public debt risk management, macro-prudential policy decision-making and the operational design of fall-back mechanisms and collateral polices.

This paper has an empirical focus. More than five years after the EA sovereign debt crisis, we build on the empirical literature and make use of the most recent IMF data to assess the investor base impact on government borrowing costs and examine how investors react to shocks in sovereign bond yields.

The novelty of our VAR approach lies in the explicit recognition of bi-directional causality between yields and investor base and the interactions of the different types of investors. We also extend the assessment of relationships to 5- and 2-years yields on top of the more common appraisal for the 10-years benchmark yield. Furthermore, by treating individually 24 advanced economies, we provide a distributional view of responses to shocks, adding to the group evidence given by a panel VAR approach.

Panel econometric results confirm previous findings that higher foreign holdings are associated with lower long-term yields (Andritzky, 2012; Arslanalp & Poghoysan, 2014; Manna & Nobili, 2018), but link these effects exclusively to foreign banks and to 10-years yields or, 10- and 5-years yields in the EA specific case. When negative, yields' responses seem to be stronger when yield levels are higher. Differently from other geographies, foreign investors in the EA treat government debt as a risky asset. Yields in GIIPS[2] and

[2] Greece, Italy, Ireland, Portugal, and Spain.

core countries react in opposite directions to shocks in foreign holdings. Foreign investment is procyclical, namely at the long end and where fundamentals are weaker. The combination of these ingredients means an EA sovereign debt crisis re-run cannot be dismissed, requiring readiness to use supporting mechanisms to prevent contagion and an escalation that may jeopardize the monetary union itself.

Yields response to domestic investors holdings is heterogeneous across geographies. At panel level, only our third panel of 8 countries[3] that did not experience unconventional monetary policy bond purchases supports the findings of Andritzy (2012) and Jaramillo & Zhang (2013) that lower yields are associated with higher domestic non-bank holdings' share. On the other hand, this same panel is the only one that does not support Manna & Nobili (2018)[4] association of higher domestic banks' share with lower yields. Country-level results point to a majority of positive responses by domestic investors. No cyclical trading pattern can be clearly associated to each type of non-official domestic investor.

The remainder of the paper is structured as follows. Section 2 reviews the relevant literature. Section 3 introduces the data on government debt holdings and some descriptive statistics. Sections 4 and 5 detail our modelling and econometric approach, respectively. Section 6 presents panel VAR and country-by-country VAR results. Conclusions are drawn in Section 7.

2. LITERATURE REVIEW

2.1 Investor Base and Borrowing Costs

The relevance of the dynamics of the investor base draws support from the work in preferred-habitat theory pioneered by Culbertson (1957) and Modigliani and Sutch (1966). Vayanos & Vila (2009) show that specific clientele shocks have the potential to affect the term structure of interest rates by assuming that arbitrageurs, being exposed to fundamental (change in short-term rates) and non-fundamental risks (shocks to demand of preferred-habitat players) have a limited risk tolerance. Kaminska et al. (2011) use the same model to explain the steep fall of US long-term interest rates since 2000 on the interaction of the demand of such preferred-habitat investors as foreign central banks and risk sensitive arbitrageurs. Under this framework and the assumption that the set of substitutable assets exhibit different risk levels and investors face different market frictions[5], shifts in the composition of a heterogeneous investor base have an impact on prices. The empirical papers of Andritzky (2012), Jaramillo & Zhang (2013) and Manna &

[3] Australia, Canada, Czechia, Denmark, Korea, Norway, New Zealand, Switzerland. Switzerland is here an exception in the sense that quantitative easing was indeed pursued but by expanding banks sight deposits (from CHF 30 billion to CHF 200 billion, successively announced at 3, 10 and 17 of August 2011) and not through government bond purchases.

[4] The relation holds only in the long-run since in the short-run equation of the ECM the relation is not statistically significant. Orpiszewski (2015) also finds a negative relation in regressions with yield levels but not when first differences are used.

[5] See for example Burger et al. (2015) or Lane (2005) on factors affecting international capital allocation.

Nobili (2018)[6] build on the previous theoretical results regarding the investor base impact on yields.

Arslanalp & Tsuda (2014a) and Arslanalp & Poghosyan (2014) empirical work have a perspective closer to the literature on capital flows and the theory of financial disequilibrium that relates deviations from fundamental values with the flow of funds. The former authors support their view on the impact of the investor structure on government borrowing costs on the short-term inelasticity of supply: "in the short run, the supply of sovereign debt is set by the government and, therefore, the price (or inversely yield) of debt is set primarily by demand through auctions and other means. Hence, as new investors, such as foreign or institutional investors, join the investor base, demand for government debt can increase (either at the auction or the secondary market) and the government's borrowing costs can decline" (Arslanalp & Tsuda, 2014a). Those views agree with several other authors that see in demand the "short" side of the market and echoes the model of Fernández-Arias & Montiel (1996) for emerging markets' debt.

FitzGerald & Krolzig (2005) give supply a dynamic that is absent in the previous view. They see "supply" as describing the characteristics or quality (rating, debt levels, growth rates …) of sovereign bonds and demand as a function of return and risk variables of foreign investors' home-country. This perspective highlights the need to estimate jointly demand and supply, as original demand and supply parameters cannot be extracted from reduced form estimates, instead of the more common approach in the literature of estimating a reduced form "demand function". This general specification of demand fits well with the prevailing literature consensus on the importance of the cross-border spill over effects of US monetary policy (Lim et al., 2014; Bhattarai et al., 2015; Bowman et al., 2015; Lim & Mohapatra, 2016; Chen et al., 2016)[7], the supply of global liquidity and global risk aversion in explaining surges in capital flows. According with this consensus view (Ghosh et al., 2014 and Montiel & Reinhart, 1999) domestic factors only explain the magnitude of such episodes in each country.

2.2 Investor Base and Refinancing Risk

The studies on the investor base relationship with risk often focus on either foreign participation or on differences in investor balance-sheet structures or constraints.

Foreign investors are more sensitive to political and macroeconomic risk factors and therefore exhibit less stable holdings (OECD, 2019). Arslanalp & Tsuda (2014) relate this lower stability to the availability to these investors of larger pool of alternative assets and to sudden stops. Calvo & Talvi (2005) link sudden stops to foreign investors' strong

[6] Manna & Nobili (2018) also draw on (i) portfolio balance theory which explains asset demand impact on long-term yields by changes in the available duration in the market and typically relates to central banks operations and (ii) market microstructure literature suggesting investor base breakdown is not neutral.

[7] ECB asset purchases spill over effects seem to have been contained to AE with no significant impact in EM according with the findings of Bergant et al. (2020) and Fratzscher et al. (2016). The latter relate this disparity to the global role of the dollar and/or to the postcrisis decline in the relative importance of banking vs. bonds.

reaction to changes in global risk aversion. Ebeke & Kyobe (2015) show that foreign participation and investor concentration amplify the impact of global risk factors, whereas good domestic fundamentals dampen adverse global spill over effects. Albuquerque (2003) and Levchenko & Mauro (2006) add that sudden movements are an optimal response to high volatility and low persistence of foreign flows, a response that the risk of exchange rate fluctuations may amplify (Hau & Rey, 2004). Procyclical trading, herding and contagion are other mechanisms proposed in the literature, all of them related to informational frictions. Brennan & Cao (1997) explain return-chasing by the relatively higher reliance of foreign investors on public information due to an informational disadvantage regarding domestic investors. Gravity models (Portes et al., 2001; Martin & Rey, 2004; Portes & Rey, 2005) support this view by showing that proximity drives stronger international asset flows. Herding behaviour and contagion (correlation of investments decisions across investors and across markets) are explained by a combination of payoff externalities, principal-agent problems, and informational cascades[8]. Peiris (2010), on the opposite side, quote arguments in favour of a stabilizing role of foreign demand put forward by Prasad & Rajan (2008) – increase in market liquidity and added pressure for corporate governance and institutional reform – and Burger et al. (2009) – reduction of currency mismatches and alternative source of funding when domestic investors divest.

Intermediary pricing theory[9] focus on moral hazard frictions and on the role of intermediaries as marginal investors in setting equilibrium prices. He & Krishnamurthy (2012, 2013) show that capital shocks to the intermediaries' wealth, namely losses that deplete equity capital or investor withdrawals from investment funds, impact asset prices in a nonlinear fashion. Losses reduce intermediaries risk tolerance prompting asset sales and a fall in prices, the effect being larger if their equity capital constraint starts binding. Thus, capital shocks can explain intermediaries procyclical behaviour. Shleifer & Vishny (1992) stress the role of collateral and the difference between levered and unlevered investors. The former being potentially forced to sell assets to respond to margin calls from lenders and unlevered institutional investors buying countercyclically distressed-sold assets in the hope of higher future returns. Adrian & Shin (2010, 2014) show that marked-to-market leverage is strongly procyclical.

[8] Payoff externalities occur when payoff to an agent taking an action is positively related to the number of agents taking the same course of action (FitzGerald & Krolzig, 2005). Principle-agent considerations arise from the design of incentive structures for institutional investors based on benchmarking against the market or peers to overcome monitoring problems. Thus, a manager to maintain or gain reputation when markets are imperfectly informed, may prefer either to 'hide in the herd' to avoid evaluation or 'ride the herd' to improve reputation (Frenkel & Menkhoff, 2004; Gelos, 2011; and Calvo & Mendonza, 2000; empirically backed by Miyajima & Shim, 2014). Informational cascades identify the case where foreign agents have an informational disadvantage (e.g., high gathering costs, as in Calvo & Mendonza, 2000, or a signal-extraction problem, as in Calvo, 1999) but can observe the actions of other investors, and optimally decide to infer information from their actions, and ignore their own information (Devenow & Welch, 1996; and Borensztein & Gelos, 2003).

[9] See Adrian & Boyarchenko (2012); Brunnermeier & Pedersen (2009); or He & Krishnamurthy (2012, 2013 and 2018).

Timmer (2018) highlights insurance companies and pension funds countercyclical investment. The different cyclical behaviour is attributed to this sector's more stable liabilities and equity prices less responsive to losses on security holdings (Chodorow-Reich et al., 2021) which make it better equipped to withstand short-term losses and take advantage of falling asset prices[10].

This view, however, is not consensual. In Battistini et al. (2014 [11] banks exhibit countercyclical investment behaviour[12]. Regarding insurance companies and pension funds, several studies (Domanski et al., 2017; Duijm & Bisschop, 2018)[13] also point in a different direction, in this case procyclical investment behaviour.

3. GENERAL GOVERNMENT DEBT HOLDINGS

3.1 Data Description

Quarterly data on holdings of general government gross debt by type of investor between 2004 Q1 and 2019 Q2 (62 quarters), for 24 advanced economies (listed in the Appendix A, Table A - I), comprise the core of our data set.

Holdings of general government gross debt are defined as the consolidated sum of liabilities represented by SDRs, currency and deposits, debt securities and loans, at face value or adjusted for valuation changes to remove price fluctuations. General government encompasses central government, state and local governments and social security funds. In consolidated figures cross holdings are netted out. The investor base is decomposed in six types of investors: foreign banks, foreign non-banks, foreign official sector, domestic banks, domestic non-banks, domestic central bank.

Data on holdings is taken from sovereign investor base estimates by Arslanalp & Tsuda (2014).

[10] However, Timmer (2018) suggests that larger negative duration gaps associated with a low interest rate environment may weaken this countercyclical behaviour.

[11] Yield shocks are decomposed in a common risk factor and a country risk factor. Holdings' relation is mostly positive to the former. Regarding the latter, an increase in country risk prompts local banks to significantly reduce their domestic exposures in core countries (except Austria) and to increase it in the periphery (except for Spain).

[12] Through secondary markets operations (as in Broner et al., 2006; and Broner et al., 2014) banks absorb unwanted sovereign debt holdings of foreign investors (Cafiso, 2016), having thereby a stabilizing effect on refinancing risk (Lamas & Mencía, 2018; Cornand et al., 2014), and even on the conditions of their own balance sheet (Affinito et al., 2016). Notwithstanding, banks loading on their sovereign-debt increase the potential haircut for other private investors as government, central bank and banking system can be treated as single entity in a sovereign debt crisis (Belke & Gros, 2019) and, by crowding-out private credit, reduce economic growth. The increased amount of contingent liabilities associated with a potential bailout of their own banking system, other private investors higher losses in case of default and lower growth expectations, all may weigh on sovereign debt sustainability beliefs, increasing refinancing risk and chances of self-fulfilling crises.

[13] Investigating the equity and fixed income portfolios of Dutch non-life insurers, life insurers and pension funds, find evidence of procyclical behaviour by insurance companies and of countercyclical behaviour during market upturns for pension funds.

3.2 Descriptive Statistics

3.2.1 Holdings' Analysis

Table I shows summary statistics regarding each type of investor share in general government debt holdings (GGDH).

TABLE I - SHARE IN GENERAL GOVERNMENT GROSS DEBT HOLDINGS (% TOTAL)

Variables		Mean	Std. Dev.	Min	Max	Observations	
Foreign Banks	overall	0.074	0.068	0.001	0.413	N =	1488
	between		0.055	0.005	0.187	n =	24
	within		0.041	-0.055	0.309	T =	62
Foreign Non-Banks	overall	0.199	0.146	0.000	0.661	N =	1488
	between		0.120	0.039	0.464	n =	24
	within		0.087	-0.100	0.520	T =	62
Foreign Non-Official	overall	0.274	0.178	0.003	0.743	N =	1488
	between		0.151	0.057	0.595	n =	24
	within		0.098	-0.005	0.640	T =	62
Domestic Banks	overall	0.204	0.104	0.002	0.605	N =	1488
	between		0.090	0.046	0.388	n =	24
	within		0.054	0.032	0.484	T =	62
Domestic Non-banks	overall	0.301	0.188	0.009	0.819	N =	1488
	between		0.178	0.064	0.660	n =	24
	within		0.071	-0.027	0.566	T =	62
Domestic Non-Official	overall	0.505	0.199	0.065	0.907	N =	1488
	between		0.186	0.182	0.831	n =	24
	within		0.080	0.229	0.806	T =	62
Foreign Official	overall	0.165	0.140	0.016	0.820	N =	1488
	between		0.110	0.029	0.435	n =	24
	within		0.089	-0.234	0.550	T =	62
Domestic Central Bank	overall	0.056	0.071	0.000	0.422	N =	1488
	between		0.046	0.000	0.191	n =	24
	within		0.055	-0.105	0.287	T =	62

Note: between = country averages; within = deviations from country average plus global mean

Source: Author calculations on data from Sovereign Investor Base estimates by Arslanalp and Tsuda (2014)

The biggest investors on general government debt are domestic non-official entities with slightly more than a 50% share. Foreign banks share in foreign holdings is less representative than the corresponding figure for domestic banks, suggesting a higher degree of "home bias" in banks' investment allocation than in the case of non-banks. The bias is even more expressive in the EA (see Appendix B). This is likely a consequence of the 2010-14 sovereign debt crisis since we would expect to find lower "home bias" in a common currency area without significant barriers to the free flow of capital.

Despite capital markets integration of AE, investor base heterogeneity between countries is high. Foreign non-official share in total holdings range from 6% to 60%, and domestic non-official holdings' share lies between 18% to 83%. Foreigners tend to be more representative investors in small markets. On the other hand, domestic investors, namely non-banks, tend to have higher weight in non-EA countries.

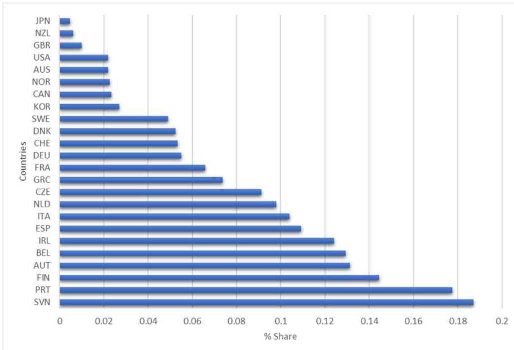


FIGURE 1 - FOREIGN BANKS AVERAGE SHARE IN TOTAL HOLDINGS (2014 Q1-2019 Q2)

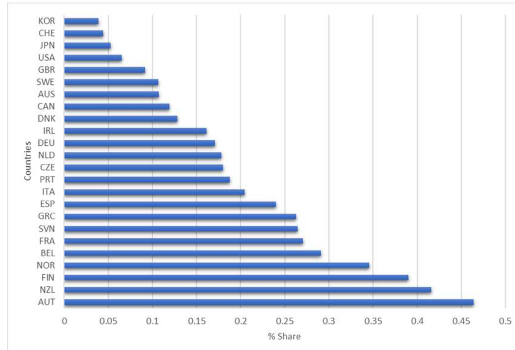


FIGURE 2 - FOREIGN NON-BANKS AVERAGE SHARE IN TOTAL HOLDINGS (2014 Q1-2019 Q2)

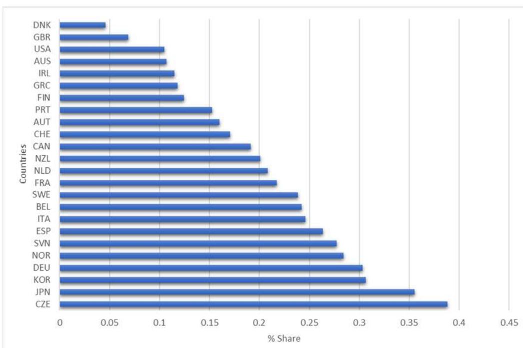


FIGURE 3 - DOMESTIC BANKS AVERAGE SHARE IN TOTAL HOLDINGS (2014 Q1-2019 Q2)

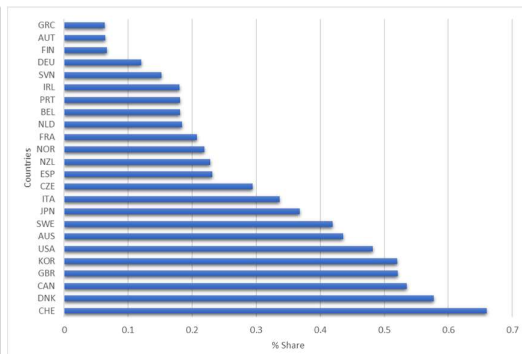
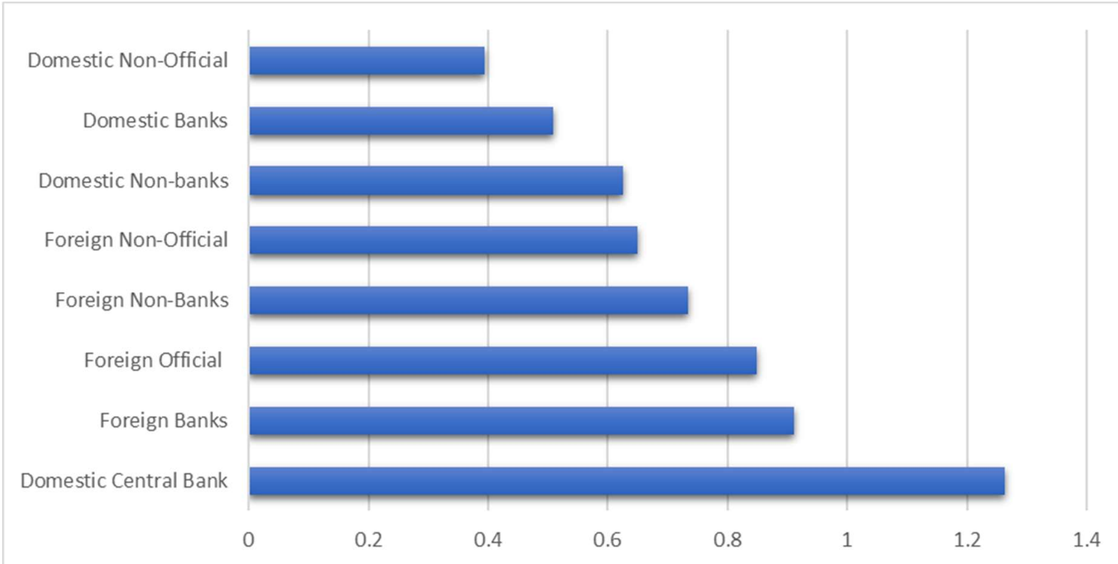


FIGURE 4 - DOMESTIC NON-BANKS AVERAGE SHARE IN TOTAL HOLDINGS (2014 Q1-2019 Q2)

Source: Author calculations on data from Sovereign Investor Base estimates by Arslanalp & Tsuda (2014)

The coefficient of variation (see Source: Author calculations on data from Sovereign Investor Base estimates by Arslanalp & Tsuda (2014)

Figure *5*) is higher for foreign than domestic non-official GGDH shares indicating higher heterogeneity and/or instability.



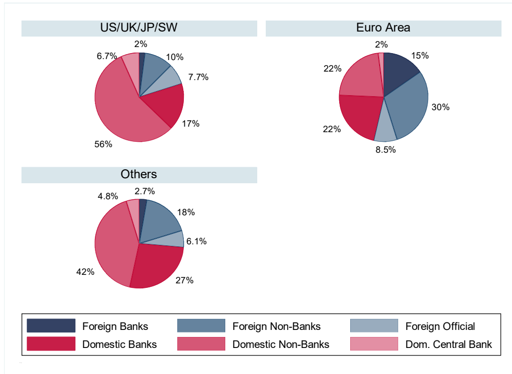
Source: Author calculations on data from Sovereign Investor Base estimates by Arslanalp & Tsuda (2014)

FIGURE *5* - SHARE IN GG DEBT HOLDINGS - COEFFICIENT OF VARIATION

Variance across countries is more significant than across time for every type of investor with the single exception of domestic central banks. This exception highlights the structural break nature of government bonds purchase programmes put in place by various central banks at the ZLB. Foreign banks exhibit the lowest ratio of "between" and "within" standard deviations of theirs GGDH share, which in the specific case of the EA is even below 1. This result suggests again important changes in foreign banks holdings during the EA sovereign debt crisis. It is well documented in the literature[14] the transition from an overly optimistic view of sovereign default risk prevalent up to 2006 to an overly pessimistic assessment of the same risk after 2008, as well as changes in the determinants of bond yield spread. Banks´ tighter equity capital constraints may explain the stronger reaction by this specific type of investors.

Figure 6 and Figure 7 depict how the investor base has changed during the sample period. A distinctive shift is the increase in the share of outstanding government debt in the hands of the official sector. In the U2JS panel this is offset mainly by a reduction in the share of domestic non-banks. In the EA, the reduction is widespread among the non-official sector, with foreign and domestic banks losing half their share.

[14] See for example Afonso et al. (2012), Klepsch & Wollmershäuser (2011), Schuknecht et al. (2010), D'Agostino & Ehrmann (2014) and Aristei & Martelli (2004).



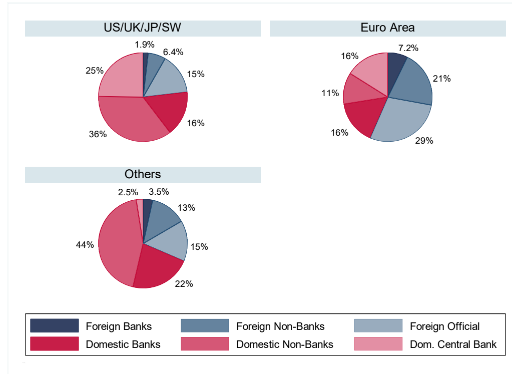


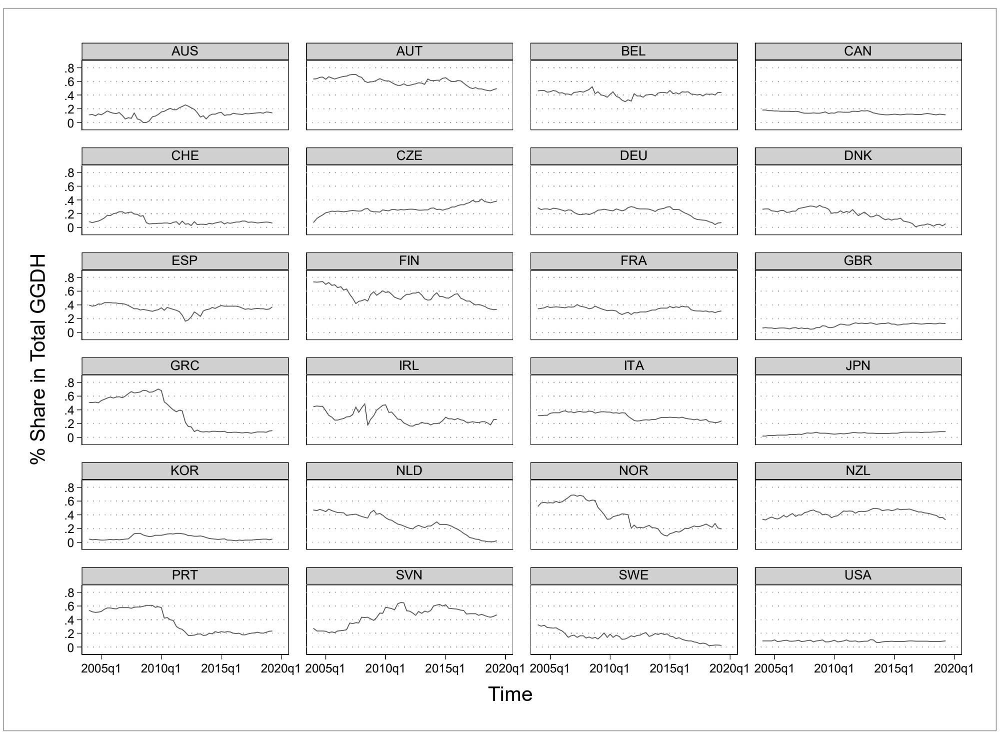
FIGURE 6 – INVESTOR BASE IN 2004 Q1 FIGURE 7 – INVESTOR BASE IN 2019 Q2

Source: Author calculations on data from Sovereign Investor Base estimates by Arslanalp & Tsuda (2014)

Another important trend regards the participation of foreign investors. In Source: Author calculations on data from Sovereign Investor Base estimates by Arslanalp & Tsuda (2014)

Figure 9Source: Author calculations on data from Sovereign Investor Base estimates by Arslanalp & Tsuda (2014)

Figure 8 is possible to see a general trend towards the reduction of such participation.

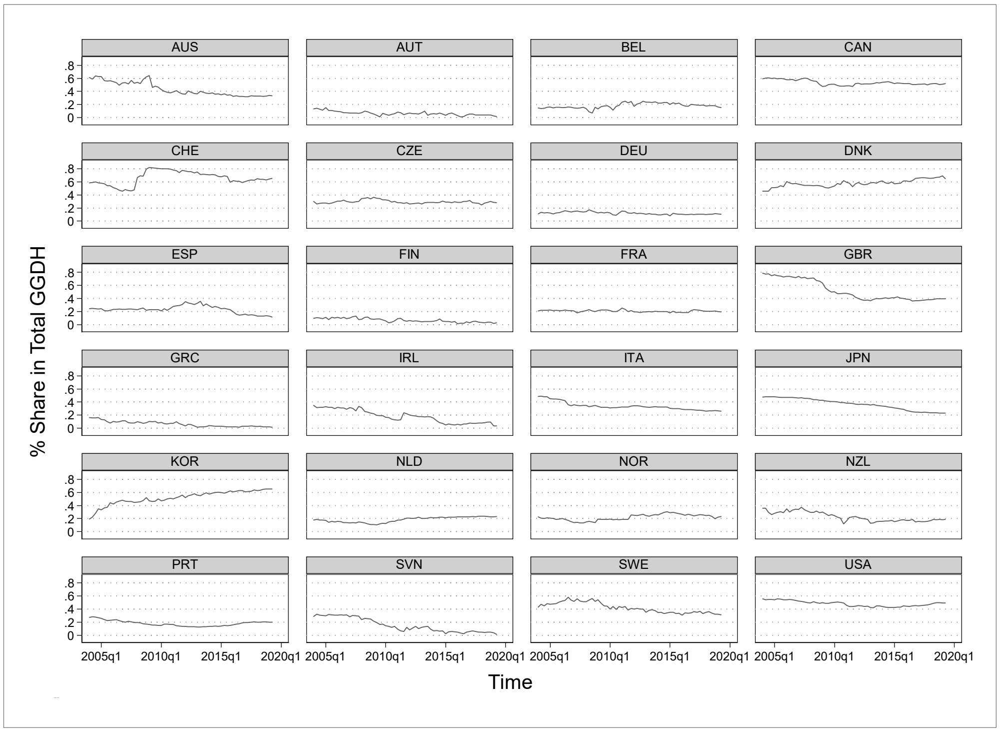


Source: Author calculations on data from Sovereign Investor Base estimates by Arslanalp & Tsuda (2014)

FIGURE 8 – TRENDS IN INDIVIDUAL COUNTRIES FOREIGN NON-OFFICIAL SHARE IN TOTAL GGDH

The biggest drops in foreign non-official holdings' share occur not only in countries struck by the euro sovereign debt crisis like Greece (-41 p.p.) or Portugal (-30 p.p.) but also, in northern countries such as the Netherlands (-44 p.p.), Finland (-40 p.p.), Norway (-30 p.p.), and Sweden (-30 p.p.).

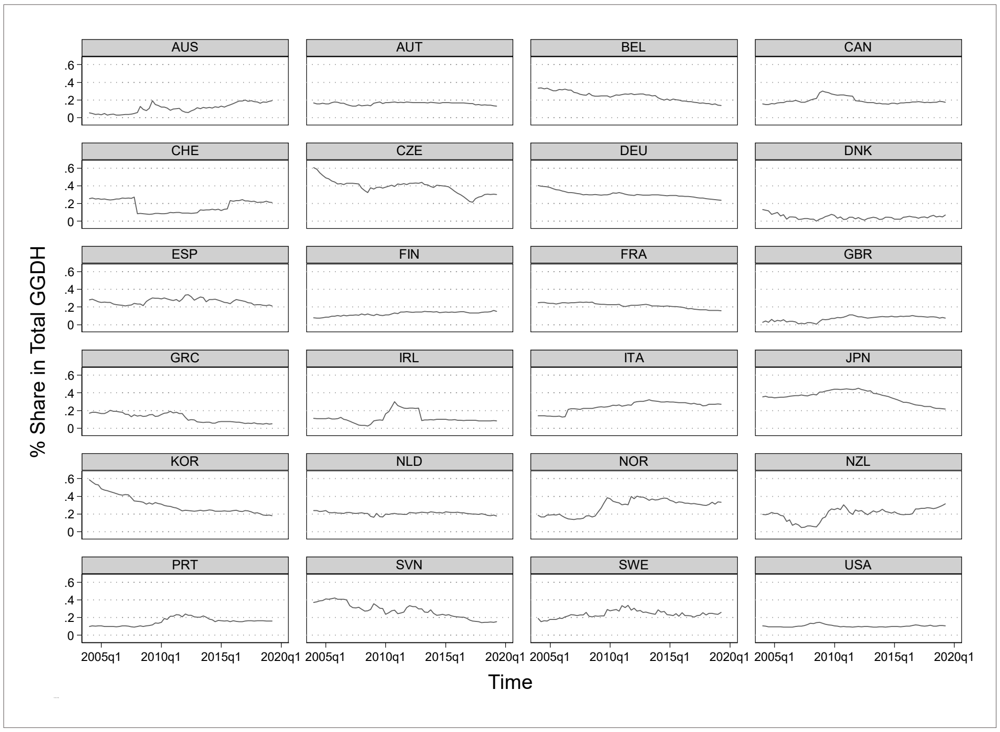
The share of domestic non-banks falls in most countries, including some like Australia (-28 p.p.), New Zealand (-17 p.p.) and Canada (-7 p.p.) that were not affected by central banks' asset purchases programmes (APP).



Source: Author calculations on data from Sovereign Investor Base estimates by Arslanalp & Tsuda (2014)

FIGURE 9 - TRENDS IN INDIVIDUAL COUNTRIES DOMESTIC NON-BANKS SHARE IN TOTAL GGDH

Domestic banks' government debt holdings increased in Italy (+13 p.p.) and Portugal (+6 p.p.) among others. Although holdings of domestic banks subsided from the peaks reached during the euro sovereign debt crisis, in contrast with Spain, they remained above beginning of sample levels.



Source: Author calculations on data from Sovereign Investor Base estimates by Arslanalp & Tsuda (2014)

FIGURE 10 - TRENDS IN INDIVIDUAL COUNTRIES DOMESTIC BANKS SHARE IN TOTAL GGDH

3.2.1 Transactions Analysis

In this section we focus on transactions, that is net sales or net purchases computed from the change in holdings. Manna & Nobili (2018) classify transactions in “large” and “intermediate”. The former corresponds to changes in holdings that fall in the top or bottom 5% of the distribution of quarterly changes for all sectors in one single country. Intermediate changes are those that fall between the 10th and the 40th percentile as well as those that fall in the 60th to 90th percentile of the same distribution. Here we take the same approach to have comparable results, examining a larger sample[15].

TABLE II - TRANSACTIONS SIZE

Transactions Size	Foreign			Domestic			# Hld. Chg.
	Banks	Non-Banks	Official	Banks	Non-Banks	Central Bank	
Large	7.8%	31.1%	10.4%	13.3%	31.2%	6.2%	913
Intermediate	19.3%	15.4%	17.7%	18.5%	15.8%	13.3%	5371
Avg Holdings	7.4%	19.9%	16.5%	20.4%	30.1%	5.6%	-

Source: Author calculations on data from Sovereign Investor Base estimates by Arslanalp & Tsuda (2014)

Our dataset has 8 784 quarterly changes in holdings of which 913 have been classified as large. Large transactions are conducted mainly by non-banks, both domestic and foreign, with a similar share of 31%. The active role of foreign non-banks is clear when

[15] Our sample ends in 2019 Q2 and Manna & Nobili (2018) sample ends in 2016 Q2.

we compare their large trades share with their 20% holdings share. These figures highlight how important this sector[16] is for price setting in the public debt market and suggest close monitoring and appropriate communication to mitigate possible informational frictions. Foreign banks probably take a double role as intermediators and investors, having both a very high relative share of intermediate transactions and a share of large trades above their mean holdings share. The relative low share in both large and intermediate trades of domestic banks may mean they take predominantly an intermediary role.

Analysing the sign of large changes in holdings by sector – see Table III – we find the balance of large transactions of official entities to be positive, a reflexion of both APPs and official assistance[17]. On a net basis, banks and foreign non-banks are the main counterparts of those operations.

TABLE III - TRANSACTIONS SIGN

Transactions Sign	Foreign			Domestic		
	Banks	Non-Banks	Official	Banks	Non-Banks	Central Bank
Decrease	41	153	34	66	143	20
Increase	30	131	61	55	142	37
Balance	-11	-22	27	-11	-1	17

Source: Author calculations on data from Sovereign Investor Base estimates by Arslanalp & Tsuda (2014)

In the specific case of GIIPS countries, responsible for 59% of foreign official net large buying activity, we come closer to the conclusions of Manna & Nobili (2018). In these countries, sellers were mostly foreign investors (both banks and non-banks) and, in a lesser degree, domestic non-banks. Domestic banks took a stabilizing role being net buyers along official foreign entities.

Matching large transactions with market conditions at the same and previous quarter of the trades provides information on the investment style of the investor base. The taxonomy is summarized in Table IV and Table V details the distribution of large trades of the different non-official investor sectors by investment style. The analysis of the results reveals two noteworthy features. Firstly, foreign banks seem more prone to "chase returns" when buying than any other sector in the EA, a feature not observed in the bloc of countries outside this area - the weight of this investment style for foreign banks in the EA is a striking 63% against a range between 31% and 35% for other sectors and against 36% of foreign banks' purchases outside the EA. Secondly, trend strengthening "herd behaviour" is more frequent among EA foreign investor when selling then among EA domestic investors - 28-35% versus 11-17% relative frequencies

[16] A word of caution is required, since this finding is not observed in emerging markets, and it may be the result of two specific factors. Firstly, the strong representation of countries of a common currency zone (EA) in our sample. The absence of exchange rate risk blurs the difference between foreign investors of the same currency area and domestic investors and fosters cross-border holdings. Secondly, the euro sovereign debt crisis, pending which the risks of euro area break-up and private investors bail-in entailed large adjustment in cross-border holdings.

[17] In Emerging Markets (EM), official entities take the opposite role, being large net sellers, during a period of gradual development and consolidation of the market for EM local currency sovereign debt.

– and this also holds true for EA foreign banks vis-à-vis Non-EA foreign banks – 35% vs 20% relative frequencies. These features suggest a more procyclical foreign investment in the EA relatively to the rest of AE in our sample.

TABLE IV - TAXONOMY OF INVESTMENT STYLES

	Net Purchases		Net Sales	
	$\Delta Y_t < 0$	$\Delta Y_t > 0$	$\Delta Y_t < 0$	$\Delta Y_t > 0$
$\Delta Y_{t-1} > 0$	Trigger Price Reversal	Against the wind (fundamentals' bet)	Opportunistically against the wind	Strengthen Trend Herd Behaviour(?)
$\Delta Y_{t-1} < 0$	Chasing Returns Herd Beavhiour(?)	Opportunistically against the wind	Profit Taking (?)	Trigger Price Reversal

Source: Manna & Nobili (2018) p. 17.

TABLE V - DISTRIBUTION OF NON-OFFICIAL INVESTORS LARGE TRADES BY INVESTMENT STYLES

	Foreign Banks				Foreign Non-Banks				Domestic Banks				Domestic Non-banks			
	Net Purchases		Net Sales		Net Purchases		Net Sales		Net Purchases		Net Sales		Net Purchases		Net Sales	
	$\Delta Y_t < 0$	$\Delta Y_t > 0$	$\Delta Y_t < 0$	$\Delta Y_t > 0$	$\Delta Y_t < 0$	$\Delta Y_t > 0$	$\Delta Y_t < 0$	$\Delta Y_t > 0$	$\Delta Y_t < 0$	$\Delta Y_t > 0$	$\Delta Y_t < 0$	$\Delta Y_t > 0$	$\Delta Y_t < 0$	$\Delta Y_t > 0$	$\Delta Y_t < 0$	$\Delta Y_t > 0$
AE																
$\Delta Y_{t-1} > 0$	23%	17%	20%	29%	24%	22%	18%	25%	18%	25%	17%	21%	18%	24%	20%	17%
$\Delta Y_{t-1} < 0$	50%	10%	32%	20%	39%	15%	40%	17%	38%	20%	35%	27%	38%	20%	43%	20%
EA																
$\Delta Y_{t-1} > 0$	25%	6%	12%	35%	28%	20%	14%	28%	20%	26%	21%	17%	19%	25%	19%	11%
$\Delta Y_{t-1} < 0$	63%	6%	27%	27%	35%	16%	40%	18%	34%	20%	38%	25%	31%	25%	45%	25%
NON-EA																
$\Delta Y_{t-1} > 0$	21%	29%	33%	20%	19%	25%	21%	23%	14%	24%	14%	24%	18%	23%	20%	23%
$\Delta Y_{t-1} < 0$	36%	14%	40%	7%	44%	12%	40%	16%	43%	19%	33%	29%	42%	17%	41%	16%

Source: Author calculations on data from Sovereign Investor Base estimates by Arslanalp & Tsuda (2014)

4. MODELLING APPROACH AND DATA

4.1 Empirical Model and Data

Our modelling approach acknowledges bi-directional causality between yields and investor base and model the simultaneous determination of both avoiding the problems often remarked in the literature of endogeneity and direction of causality.

We use a general model with the following specification,

(1) $X_t = f(X_t, Z_t, U_t)$,

where X_t is a vector of endogenous variables. X_t can partitioned in,

(2) $X_T = \begin{pmatrix} \Delta Y_t \\ \Delta H_t^j \end{pmatrix}$

where ΔY_t are yields' 1st differences and ΔH_t^j are 1st differences of the log of investor sector j holdings. Z_t is a vector of control variables used to estimate the investor base marginal impact. U_t is a vector of error terms.

The model assumes that non-official investors trade in the primary and secondary markets to adjust debt stocks to their desired level and yields change to clear the market in each period. Net issuance is deemed exogenous, and we use debt-to-GDP to control for it.

As a rule, we will treat official holdings as weakly exogenous. Three considerations underly this option. First, foreign official holdings reflect not only reserve management considerations but also discrete decisions regarding financial assistance programs. Second, central bank holdings tend to be driven by specific objectives such as liquidity and collateral management rather than by the common drivers of non-official holdings. Third, to keep the model parsimonious in face of limited data availability.

In 4 countries - US, U.K., Japan, and Sweden - central bank holdings are "endogenized" to account for government bond purchases and the inclusion of bond yields in the central bank reaction function[18]. Examples of explicit modelling of central bank reaction function linking asset purchases to other variables are hard to find. Notwithstanding, insights can be found in Fratzscher et al. (2016) and Sims & Wu (2021). To address endogeneity issues in central banks' reaction function, we lag or restrained to zero variables like short-term interest rates, inflation expectations, GDP growth, bank assets-to-GDP, credit to non-financial corporations and households, or the balance of the current account-to-GDP. We do not adjust the market risk indicator (typically the VIX), following in this regard Beck et al. (2019), nor fiscal variables[19].

The vector of control variables Z_t comprises: (i) bond yields determinants; and (ii) variables linked to agents' investment decision process, like risk appetite, international leverage conditions, market liquidity, hedging costs and alternative investments. Following the existing literature, we use as baseline determinants of bond yields inflation expectations, short-term interest rates, an international (either German or US) benchmark long-term interest-rate, economic growth, a proxy for the international price of risk (VIX and the Option-Adjusted Spread between BBB and AAA US Corporates), the bid-ask spread of the 10-years benchmark bond (liquidity measure), fiscal conditions (ratio to GDP of budget balance, gross debt, gross debt in interaction with a gross debt logit transformation dummy variable[20] to account for non-linearities, and the bank assets to GDP ratio to capture contingent liabilities), and the external current account balance to GDP ratio.

We proxy the different dimensions of the investment process with specific variables which, for presentational simplicity, are summarized in Table VI.

[18] Japan explicitly included yield curve control in its monetary policy objectives in 2016.

[19] Regime switching approaches to model asset purchases by the central bank can be found in Nyberg (2013) and Meinusch & Tillman (2014).

[20] The dummy variable takes the value zero when the debt ratio is low relatively to the sample average and converges to 1 as debt ratio grows.

TABLE VI - EXOGENOUS VARIABLES RELATED WITH THE INVESTMENT DECISION PROCESS

Dimension	Variable
Risk Appetite	VIX US BBB-AAA OAS
International Leverage	US Bank Assets to GDP ratio
Market Liquidity	10-years Benchmark Bond Bid-Ask Spread
Alternative Investments	3-months Money Market Interest Rate US or German same maturity benchmark bonds (*) Non-Financial Corporations and Households Nominal Credit Growth Nominal Economic Growth (**)

(*) Does not apply to the US.
(**) In the US and Switzerland Share Price Return is also used

We use dummies to account for structural breaks and to handle data related issues. Further details on the variables used and their data source can be found in Appendix A, Table A - II, Table A - III, Table A - IV, and Table A - V.

Appropriate cross-sectional dependence, unit root[21] and cointegration tests (see Appendix B) show that yields and investor holdings series are mostly integrated of order one, but not cointegrated. Regarding the exogenous variables, inflation expectations, bid-ask spreads, nominal GDP growth rate and risk indicators are stationary in most tests.

In face of the lack of compelling evidence supporting cointegration between yields and holdings in our panel countries and to ensure consistency and comparability across individual countries' results, we forego pursuing the Vector Error Correction Model approach in favour of a Vector Autoregressive (VAR) specification.

5. ECONOMETRIC METHODOLOGY

Our empirical analysis uses two econometric methodologies. First, we apply a homogeneous Panel Data Vector Autoregressive model with exogenous variables (PVAR-X). The model reduced form, with k dependent variables, a p autoregressive order m exogenous variables and country-specific fixed effects, is given by:

(3) $X_{it} = X_{it-1}A_1 + \cdots + X_{it-p}A_p + Z_{it}B + E_i + U_{it}$, $i \in \{1, 2,...,N\}$, $t \in \{1, 2,...,T_i\}$,

where X_{it} is a (1×k) vector of dependent variables, Z_{it} is a (1×m) vector of exogenous variables, E_i is a (1 × k) vector of country-specific panel fixed effects; U_{it} is a (1 × k) vector of idiosyncratic errors. A_j (k×k) and B (m×k) are parameters matrices to be estimated. Innovations have the following characteristics: $E(U_{it}) = 0$, $E(U'_{it}U_{it}) = \Sigma$, and $E(U'_{it}U_{is}) = 0$ for all t>s. Σ is a constant positive definite variance matrix.

[21] including under the presence of structural breaks.

Since country-specific fixed-effects are correlated with the regressors due to the lags of the endogenous variables, mean-differencing alone would result in biased estimators. To overcome this problem, we follow Arellano & Bover (1995) and use an Helmert transformation, a forward mean-differencing procedure. Estimation is carried out using a routine developed by Abrigo & Love (2016), building on previous work of Love & Zicchino (2006), that fits the model as a system of equations using interactive general method of moments (GMM) to benefit from the efficiency gains reported by Holtz-Eakin et al. (1988). Lag order selection in both PVAR-X specification and moment condition is conducted using Andrew & Lu (2001) method of model and moments selection criteria (MMSC)[22], Hansen (1982) J statistic[23] and, for just identified models, the coefficient of determination, as suggested by Abrigo & Love (2016). The lag length of over-identified models that satisfy the Hansen's overidentification criterion is based on the minimization of the $MMSC_{BIC}$, $MMSC_{HQIC}$ and $MMSC_{AIC}$, with particular focus in the latter following Ng & Perron (2001). Identification is based on a lower triangular Cholesky decomposition as proposed by Sims (1980). The ordering of variables always requires bond yields to react contemporaneously to shocks in the investor base, which makes yields the "most endogenous" of the dependent variables. We let the data determine the order among the different types of investors, using as a guide the results of Granger causality tests. We focus on the effect of orthogonal shocks to investor base holdings and to yields summed up overtime and summarized in Cumulative Orthogonal Impulse-Response Functions (COIRF). To assess the significance of the computed COIRF, confidence intervals are estimated using Monte-Carlo simulations and bootstrap re-sampling methods.

Our second econometric approach allows country heterogeneity, since by construction the parameters of individual time-series VAR-X are country-specific. The model reduced form, with k dependent variables, a p autoregressive order and m exogenous variables is given by:

(4) $X_t = X_{t-1}A_1 + \cdots + X_{t-p}A_p + Z_tB + U_t$, $\tau \in \{1, 2,...,T_i\}$

where X_t is a (1×k) vector of dependent variables, Z_t is a (1×m) vector of exogenous variables, U_t is a (1 × k) vector of idiosyncratic errors. A_j (k×k) and B (m×k) are parameters matrices to be estimated. Innovations have the following characteristics: $E(U_t) = 0$, $E(U'_tU_t) = \Sigma$, and $E(U'_tU_s) = 0$ for all t>s. Σ is a constant positive definite variance matrix.

Estimation is carried out using OLS for unrestricted models and SURE when parameter restrictions are present. Lag order is selected using Wald and likelihood-ratio tests, as well SBIC, HQIC, AIC and final prediction error lag-order selection statistics. Identification is conducted in the same way as in the PVAR-X. Our focus are again the COIRFs. The respective confidence intervals are estimated using standard errors obtained mainly

[22] The proposed MMSC are analogous to the commonly used maximum likelihood-based model-selection criteria: the Akaike information criteria (AIC) (Akaike, 1969); the Bayesian information criteria (BIC) (Schwarz, 1978; Rissanen, 1978; Akaike, 1977); and the Hannan–Quinn information criteria (HQIC) (Hannan and Quinn, 1979).

[23] Hansen's J statistic tests the correlation between instruments and the error term.

from bootstrapped residuals or, seldom, through multivariate-normal parametric bootstrapping. Alternatively, confidence-intervals are derived analytically based on the asymptotic distribution of the VAR parameters and the cross-equation error variance–covariance matrix.

In both econometric approaches, estimation is carried out in first differences, since panel unit root and cointegration tests suggest endogenous variables are non-stationary and not cointegrated.

6. RESULTS OF THE EMPIRICAL ANALYSIS

6.1 Panel VAR-X Results

The need to account for central banks asset purchase programmes determines that instead of estimating just one panel we divide our group of countries in three panels.

The first panel is composed by the US, UK, Japan, and Sweden (U2JS), grouping countries where central banks conducted government bond purchases. Hence, central bank holdings are taken as a sixth endogenous variable. The second panel brings together the EA countries in our sample (12 countries), in which case operations and announcements dummies[24] related to ECB's asset purchases/monetary policy are used but central bank's holdings remain as an exogenous variable. We treat ECB differently because its actions do not react to a single sovereign debt market but take into consideration all country members. Even the Securities Markets Programme targeted jointly several countries and the concerns transcended monetary policy since the integrity of single currency area (or at least the participation of some members) was at stake (Klose & Weigert, 2014; Di Cesare et al.,2012). Last, but not the least, we want to ensure comparability with single country VAR results for which the previous arguments are more compelling by keeping the same approach. The remaining eight countries did not integrate government debt purchases in their monetary policy toolkit during the sample period. They form a third panel, where central bank's holdings are treated as an exogenous variable. For each one of the panels one just-identified model and two over-identified models are estimated for robustness check (Table A - VI).

6.1.1 Investor Base Impact on Borrowing Costs

To assess investor base impact on borrowing costs we use yields'[25] Cumulative IRF[26] to a one standard deviation orthogonal shock to each type of investor holdings[27]. Results are presented in Table A - VII to Table A - IX.

Shocks in foreign bank holdings have a statistically significant impact on 10-years yields, a result in line with findings of Manna & Nobili (2018)[28]. The impact is stronger and more

[24] Operations dummies affect the slope of central bank's holdings and announcement dummies affect the intercept of each equation in the system.
[25] In first differences, hence, measured in percentual points.
[26] Responses are measured 4 quarters after the shock unless the response is non-statistically significant at the end of 8 quarters, in which case the maximum statistically significant effect is considered.
[27] In first difference of the logarithm of holdings, hence, measured as a percentual change.
[28] In a panel estimation over 16 countries, they find a – 4 bps long-run effect per 1 p.p. of change in foreign banks holdings in percent of GDP (see Table A - XIX).

persistent in the EA and is also observable on 5-years yields, suggesting this to be a feature more pervasive in this bloc of countries linked by a single currency[29] and strong financial and trade linkages (Lane, 2005). The effects are not statistically significant (n.s.s.) or are mixed at the short end of the yield curve.

Shocks in foreign non-banks have mostly a positive impact on yields and statistical significance concentrates in the “Other countries” (OC) panel. In this panel effects are significant across the entire yield curve and range between 2 and 4 bps.

The fact that yields respond in opposite directions when faced with shocks in foreign bank and non-bank holdings may explain why Jaramillo & Zhang (2013) and Orspiszewski (2015)[30] find no significant effect of foreign investors on yields in AE. Andritzky (2012), Arslanalp & Poghosyan (2014) and Carvalho & Fidora (2015) find negative effects on bond yields but they both include the official sector in their definition of foreign investors. Looking at the CDM of official foreign holdings not affected by financial assistance programmes[31], we find consistent and statistically significant negative responses of bond yields in the OC panel, and mixed and non-statistically significant responses in the U2JS panel. Hence, it seems plausible that previously found yields’ negative response to shocks to foreign holdings results from combination of negative responses to shocks to different types of investors in each geography.

Shocks to domestic bank holdings have a heterogeneous impact on yields. In the U2JS panel the impact is negative, consistent across the yield curve and mostly persistent. In the EA we also find negative yields response, but evidence is less compelling. It is in the intermediate and short segments of the yield curve that the effect is clearer. Yields in the OC panel respond positively to shocks at the intermediate and short segments of the yield curve. In both EA and OC cases the effects are not persistent, lasting at most one quarter. Heterogeneity of 10-years yields’ response among panels may explain why Jaramillo & Zhang (2013) does not find a statistically significant effect of shocks to domestic bank holdings in AE, and why Orspiszewski (2015) and Manna & Nobili (2018) find negative effects[32] and the results of Andritzky (2012) suggest positive effects.

Yields respond positively to shocks to domestic non-bank holdings in the U2JS and EA panels with the response being again clearer in the former, but also less persistent. The response is negative in the OC panel: around -3 bps at 5- and 10-years and stronger at 2-years. This is the only panel that matches the findings of Andritzky (2012) and Jaramillo & Zhang (2013). However, we must remark that the former found no effect in the EA and acknowledges that yields response to this type of investor shock fails to come out significant in a VAR setting.

[29] A single currency promotes a “EA bias” in portfolio allocation, matching the “home bias” also found in the US (Burger, et al., 2015).
[30] In regressions of yields’ first differences. Using yields´ levels – found to be stationary in this study – the relation is positive.
[31] In the EA statistically significant responses are found mostly at 5-years yields and are positive.
[32] Orspiszewski (2015) and Manna & Nobili (2018) results are both n.s.s. when yields’ first differences are used in an alternative specification by the former or in the short-run equation of the ECM by the latter.

6.1.2 Investors' Cyclical Behaviour

We evaluate investors' cyclical behaviour based on the impulse response functions of changes in debt holdings of each type of investors to orthogonal shocks to yields. Positive responses mean that investors are net buyers (positive change in holdings) when yields go up, that is when prices drop. Hence, a countercyclical behaviour. Negative responses indicate a procyclical behaviour, that is investors are net buyers when yields fall (prices increase).

Our results in Table A - X to Table A - XII show foreign investment is procyclical[33], but not uniform across geographies and investor type. In the U2JS and EA panels statistical significance tends to be concentrated on banks, although in the former panel non-banks gain statistical relevance as we move down the yield curve. This result confirms the procyclical pattern of foreign banks large trades in the EA presented earlier. In the OC panel, only foreign non-bank holdings display a statistically significant response to 2- and 5-years yields´ shocks, ranging between -2.8% and -3.2%. Andritzky (2012), when using a panel VAR approach, and Orspiszewski (2015) also find that lower yields attract foreign investors[34].

The cumulative dynamic multipliers (CDM) of the foreign bank holdings regarding global risk and international leverage reveal an idiosyncratic feature of the EA: foreign banks respond positively to lower global risk and higher international leverage, suggesting government debt is traded as a risky asset. In the U2JS panel, foreign banks sell government debt when global risk wanes; in the OC panel, foreign banks sell government debt when international leverage is buoyant. Foreign non-banks in the EA treat sovereign bonds likewise but their reaction is less prevalent, and comparison is made difficult by lack of statistically significant responses in other panels.

Cyclical behaviour of domestic investors is even more heterogeneous. In the EA both types of non-official domestic investors exhibit the same procyclical behaviour regarding shocks in the upper-median part of the yield curve. In the OC panel the opposite behaviour is observed in response to 10-years yields' shocks, the sole maturity with statistically significant effects. In the U2JS panel, we find bank holdings to respond positively to 5-years yields' shocks but negatively to 2-years yields' shocks. Non-banks only statistically significant response is basically zero. These results match mixed findings in the empirical literature. Andritzky (2012) reports lack of statistically significant effects for domestic institutional investors as does Cornand et al. (2014) for domestic investors in the period 2008-14, after having found positive responses in the years 2002 to 2008. Battistini et al. (2013) point to banks general countercyclical behaviour. Although, when yield shocks are decomposed in a common and country

[33] This result is agnostic relatively to the causes behind the changes in yields, which could reflect either domestic or global factors (the pull and push effects of the empirical literature on capital flows) or a combination of both.

[34] Even if the effect is not persistent, as in Andritzky (2012), or only significant post 2007, as in Orspiszewski (2015).

specific risk factors, responses to country risk by most core countries become procyclical whereas they remain countercyclical in most of the periphery. Orspiszewski (2015) and Timmer (2018) find lower yields attract banks and investment funds. Orspiszewski (2015) finds no statistically significant response from insurance companies and pension funds, but Timmer (2018) does.

Although panel evidence offers some insights, it also reveals a great deal of heterogeneity that justifies a closer look at the distribution of responses at country level.

An important question when studying the relation between sovereign bond yields and the dynamics of the ownership structure of public debt is the causality relation, as it can go both ways. Granger causality tests provide a way to test whether changes in the investor base precede yield changes ("push effect") or vice versa ("pull effect"). Results seem to point to panel- and maturity-specific relationships (see Appendix B). Notwithstanding, a few consistent results are: (i) domestic banks Granger-cause 10-years yields; (ii) the short and intermediate segments of the yield curve are Granger-caused mostly by domestic investors; (iii) changes in yields precede changes in foreign banks holdings and, although less often, also foreign non-banks' holdings; and (iv) domestic banks transactions are Granger-caused mostly by changes at the short and intermediate segments of the yield curve.

6.2 Individual Country VAR-X Results

6.2.1 Investor Base Impact on Borrowing Costs

As we have done in the previous section, we assess investor base impact on borrowing costs using yields changes' COIRF[35] to a one standard deviation shock to each type of investor holdings' percentual change (see Table A - XIII and Table A - XIV). We further combine the different responses of foreign and domestic investors in a 3x3 matrix that distinguishes positive, negative, and non-statistically significant responses for banks and non-banks.

Negative yields' responses to shocks to non-official foreign investor holdings account for most of the 47.1% of cases that are statistically significant (Table VII).

[35] Responses are measured 4 quarters after the shock unless the response is non-statistically significant at the end of 8 quarters, in which case the maximum statistically significant effect is considered.

TABLE VII

FREQUENCY DISTRIBUTION OF YIELDS CUMULATIVE RESPONSE TO ORTHOGONAL SHOCKS TO HOLDINGS OF FOREIGN NON-OFFICIAL INVESTORS

Yields	Yields Cumulative Response to Orthogonal Shocks to Holdings of Foreign Banks and Non-Banks				
	(-)	(+)	(+)/(-)	(-)/(+)	n.s.s.
10-years	16.7%	12.5%	0.0%	8.3%	62.5%
5-years	26.1%	13.0%	4.3%	4.3%	52.2%
2-years	21.7%	21.7%	8.7%	4.3%	43.5%
All	21.4%	15.7%	4.3%	5.7%	52.9%

Notes: (-) or (+) indicates responses of equal sign to shocks to both types of forein investor holdings; (-)/(+) or (+)/(-) indicates responses of opposite signs; n.s.s. indicates a non-statistically significant response at 5% significance level.

Negative responses from yields are mainly associated with GIIPS[36] and the US (Figure 11). The latter case matches the results found for U2JS panel and are in line with findings of Beltran et al. (2012) and Warnock & Warnock (2009) for the US. Positive responses are associated with just one type of private foreign investors and seem to be a feature mainly of safe-haven countries (Japan, Switzerland, or core EA). We must highlight that GIIPS and core EA will respond symmetrically to the same foreign investor shock, namely a shock to foreign non-banks. In case of a negative shock, outflows prompt higher yields in GIIPS and lower yields in core EA. Thus, although the sample period extends 6 years after the EA sovereign debt crisis and includes 4 years before it, data does not dismiss the possibility of a re-run of GIIPS's debt refinancing distress.

In a total of 16 countries with statistically significant yields' responses, only 50% exhibit some degree of consistency of impacts across maturities – Portugal is the single country where responses are consistent across all bond maturities. Taking as reference 10-years' responses, we find that only 33% are consistent with 5- and 2-years' ones, suggesting that careful should be exercised in assuming similar impacts along the entire yield curve.

[36] Greece, Ireland, Italy, Portugal, and Spain.

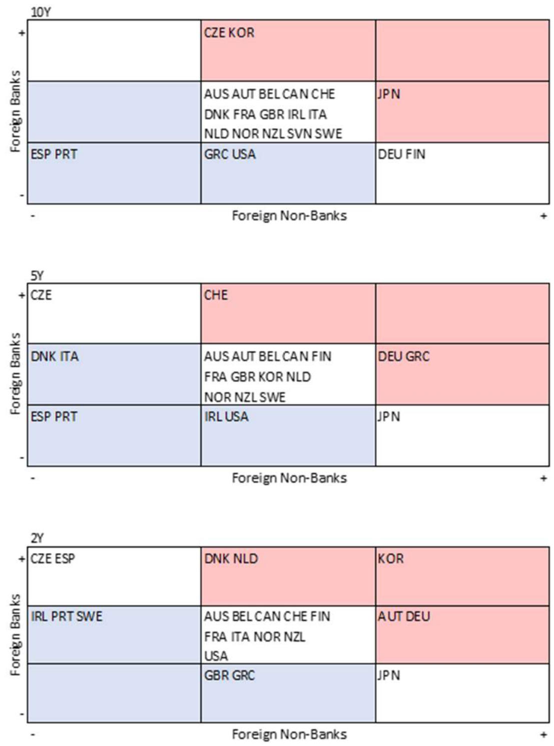


FIGURE 11 - YIELDS CUMULATIVE RESPONSE TO ORTHOGONAL SHOCKS TO HOLDINGS OF FOREIGN NON-OFFICIAL INVESTORS

We find no stable relation between overall yields' response to foreign investment shocks and the level of yields, with the exception of 10- and 5-years responses to foreign non-banks shocks (Figure 12 to Figure 17). However, when negative, yields' responses seem to be stronger in countries associated with higher yields. The strength of response is not linearly related with the size of the foreign investor share in total holdings.

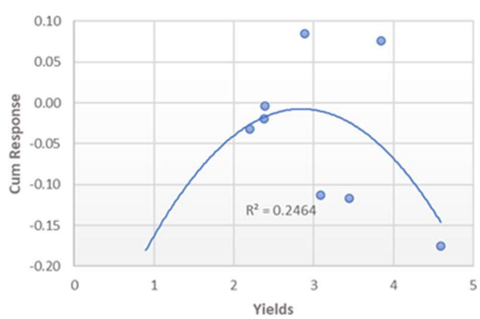


FIGURE 12 - 10-YEARS YIELDS RESPONSE TO SHOCKS TO FOREIGN BANK HOLDINGS AND LEVEL OF 10-YEARS YIELDS

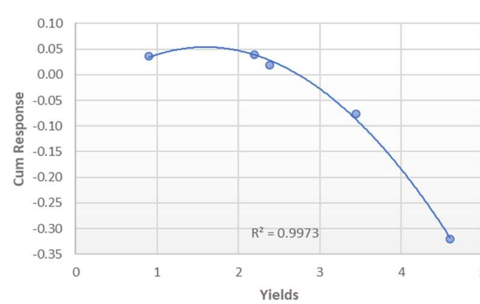


FIGURE 13 - 10-YEARS YIELDS RESPONSE TO SHOCKS TO FOREIGN NON-BANK HOLDINGS AND LEVEL OF 10-YEARS YIELDS

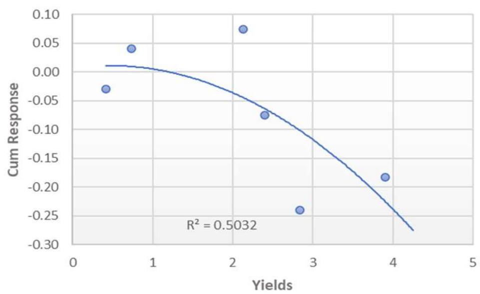


FIGURE 14 - 5-YEARS YIELDS RESPONSE TO SHOCKS TO FOREIGN BANK HOLDINGS AND LEVEL OF 5-YEARS YIELDS

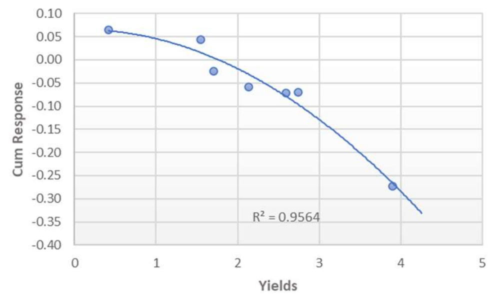


FIGURE 15 - 5-YEARS YIELDS RESPONSE TO SHOCKS TO FOREIGN NON-BANK HOLDINGS AND LEVEL OF 5-YEARS YIELDS

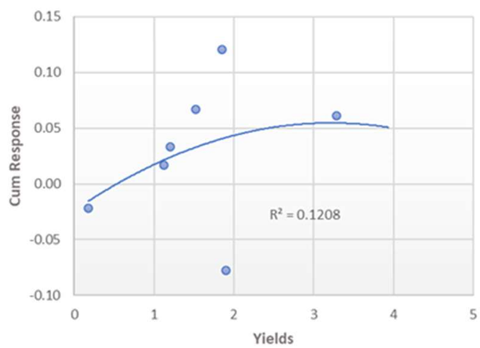


FIGURE 16 - 2-YEARS YIELDS RESPONSE TO SHOCKS TO FOREIGN BANK HOLDINGS AND LEVEL OF 2-YEARS YIELDS

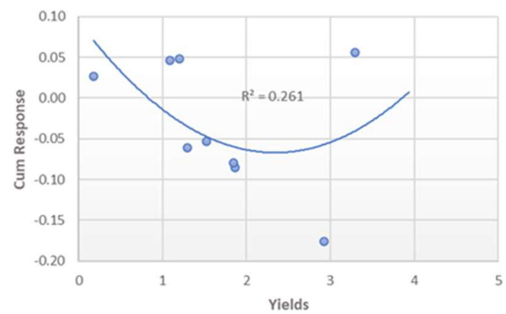


FIGURE 17 - 2-YEARS YIELDS RESPONSE TO SHOCKS TO FOREIGN NON-BANK HOLDINGS AND LEVEL OF 2-YEARS YIELDS

Source: Author own calculations. Notes: Greece is not included due to the outlier nature of its results.

Yields respond positively to shocks to holdings of domestic non-official investors in 37% of cases and positive responses are associated with a diverse group of countries (Table VIII).

TABLE VIII - FREQUENCY DISTRIBUTION OF YIELDS CUMULATIVE RESPONSE TO ORTHOGONAL SHOCKS TO HOLDINGS OF DOMESTIC NON-OFFICIAL INVESTORS

Yields	Yields Cumulative Response to Orthogonal Shocks to Holdings of Domestic Banks and Non-Banks				
	(-)	(+)	(+)/(-)	(-)/(+)	n.s.s.
10-years	16.7%	37.5%	4.2%	4.2%	37.5%
5-years	13.0%	39.1%	4.3%	8.7%	34.8%
2-years	8.7%	34.8%	0.0%	13.0%	43.5%
All	12.9%	37.1%	2.9%	8.6%	38.6%

Notes: (-) or (+) indicates responses of equal sign to shocks to both types of forein investor holdings; (-)/(+) or (+)/(-) indicates responses of opposite signs; n.s.s. indicates a non-statistically significant response at 5% significance level.

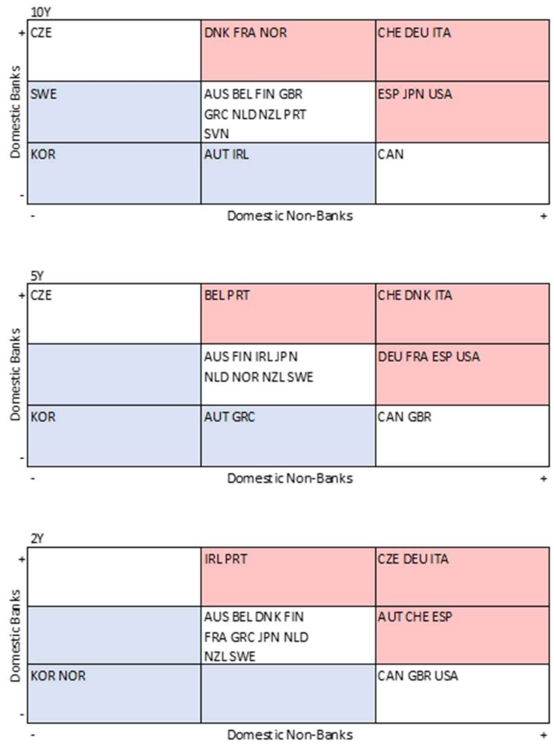


FIGURE 18 - YIELDS CUMULATIVE RESPONSE TO ORTHOGONAL SHOCKS TO HOLDINGS OF DOMESTIC NON-OFFICIAL INVESTORS

Generally, yields' response to shocks to the domestic investor base are more consistent across the yield curve than responses to shocks to the foreign investor base. Identical positive responses across the three maturities are observed in Italy and Spain. Consistency regarding the effects of shocks to non-bank holdings is also seen in Switzerland, Germany, and the US. In Denmark and Portugal, we also observe consistency of positive responses but to shocks to bank holdings. Domestic investor shocks are associated with lower borrowing costs mainly in Korea and Austria. Banks are also supportive in Ireland, Greece and Norway.

Asonuma et al. (2015) reports that banks' home bias generally reduces borrowing costs when debt levels are moderate to high. We are unable to confirm this assertion since yields response to shocks to domestic banks' holdings seem unrelated with home bias (Figure 19 to Figure 24), defined as an above sample average banks' share in total holdings[37]. Furthermore, countries with yields' stronger negative responses[38] are found across all the distribution of debt levels. No significant relation is observed for non-banks.

[37] Home bias definition is that of Acharya et al. (2014) and Cornand et al. (2014). Asonuma et al. (2015) use instead the ratio of banks' sovereign claims to bank total assets.
[38] Ireland, Korea, Canada, Austria and UK.

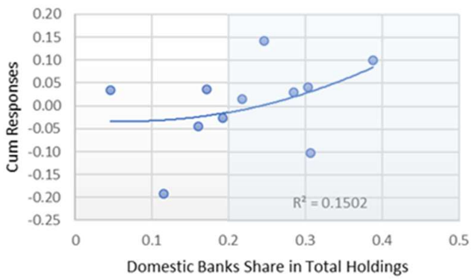


FIGURE 19 - 10-YEARS YIELDS RESPONSE TO SHOCKS TO DOMESTIC BANKS HOLDINGS AND HOME BIAS

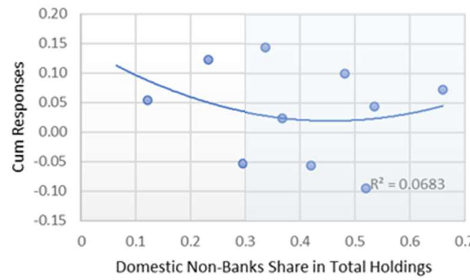


FIGURE 20 - 10-YEARS YIELDS RESPONSE TO SHOCKS TO DOMESTIC NON-BANKS HOLDINGS AND HOME BIAS

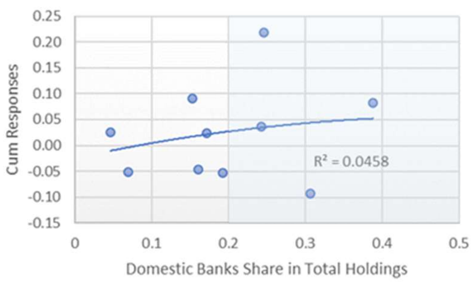


FIGURE 21 - 5-YEARS YIELDS RESPONSE TO SHOCKS TO DOMESTIC BANKS HOLDINGS AND HOME BIAS

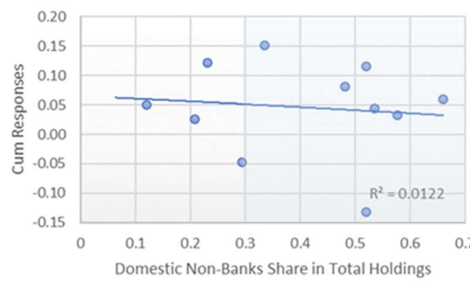


FIGURE 22 - 5-YEARS YIELDS RESPONSE TO SHOCKS TO DOMESTIC NON-BANKS HOLDINGS AND HOME BIAS

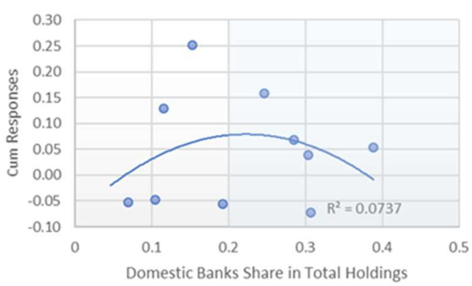


FIGURE 23 - 2-YEARS YIELDS RESPONSE TO SHOCKS TO DOMESTIC BANKS HOLDINGS AND HOME BIAS

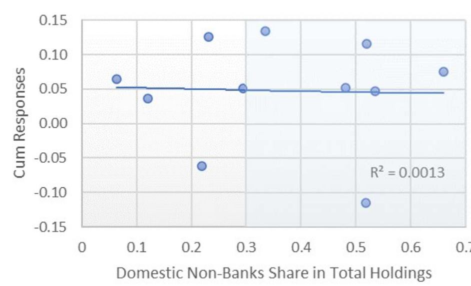


FIGURE 24 - 2-YEARS YIELDS RESPONSE TO SHOCKS TO DOMESTIC NON-BANKS HOLDINGS AND HOME BIAS

Source: Author own calculations. Blue shaded are indicates above average holdings.

6.2.2 Investors' Cyclical Behaviour

Individual country data support panel evidence that foreign investors tend to exhibit a procyclical behaviour, i.e., they are lured to the market by low yields and get out as yields inch up. In 42.9% of instances at least one type of foreign investors displays a procyclical trading pattern. However, in 20% of the cases foreign investors do lean against the wind. Countercyclical responses become more frequent as we move down the yield curve. This countercyclical behaviour is not tied down solely to the countries belonging to the OC panel. This panel countries often exhibit non statistically significant responses to shocks to yields.

TABLE IX - FREQUENCY DISTRIBUTION OF FOREIGN NON-OFFICIAL INVESTORS HOLDINGS CUMULATIVE RESPONSE TO ORTHOGONAL SHOCKS TO YIELDS

Yields	Foreign Banks and Non-Banks Holdings Cumulative Response to Orthogonal Shocks to Yields				
	(-)	(+)	(+)/(-)	(-)/(+)	n.s.s.
10-years	45.8%	12.5%	4.2%	0.0%	37.5%
5-years	26.1%	17.4%	4.3%	8.7%	43.5%
2-years	30.4%	30.4%	4.3%	4.3%	30.4%
All	34.3%	20.0%	4.3%	4.3%	37.1%

Notes: (-) or (+) indicates response of both types of forein investor holdings to shocks to yields has an equal sign; (-)/(+) or (+)/(-) indicates responses of opposite signs; n.s.s. indicates a non-statistically significant response at 5% significance level.

The countries most exposed to foreign investors procyclical responses are GIIPS without Italy, small market Nordic countries such as Norway and Sweden and, rather surprisingly, the Netherlands.

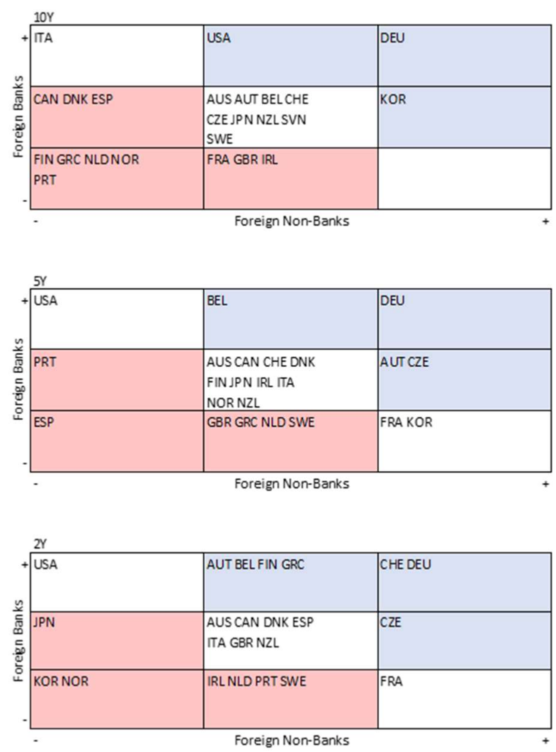


FIGURE 25 - FOREIGN NON-OFFICIAL INVESTORS HOLDINGS CUMULATIVE RESPONSE TO ORTHOGONAL SHOCKS TO YIELDS

In fact, the Netherlands and Portugal are the two single countries that are exposed across the entire yield curve to foreign procyclical trading. The US seems to benefit from a safe-haven status enjoying lower borrowing costs and foreign investor countercyclical behaviour.

EA sovereigns subjected to a common shock in interest rates are confronted with opposite reactions from foreign investors, facing thereby different refinancing risks. This feature may spell future problems, as the lack of a common cause makes political agreements aiming at preserving the stability of sovereign debt markets harder to reach.

Ebeke & Lu (2014) argue that countries with weaker fundamentals tend to suffer more from foreign investors procyclical behaviour. The literature lists such fundamental factors as economic size, stability of economic growth, breath of domestic investor base or investor base concentration, inflation level and volatility, fiscal soundness, and external position. We find evidence supporting links to sovereign debt levels[39], namely for foreign non-banks, to weaker or weakening net international investment positions[40], and to inflation volatility (Figure 26 to Figure 43 and Appendix B). Typically, these relations break-down at the short end of the yield curve.

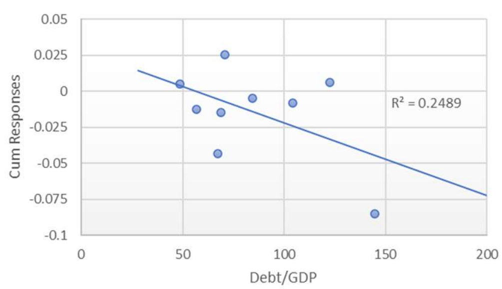


FIGURE 26 - FOREIGN BANKS HOLDINGS RESPONSE TO SHOCKS TO 10-YEARS YIELDS AND DEBT-TO-GDP

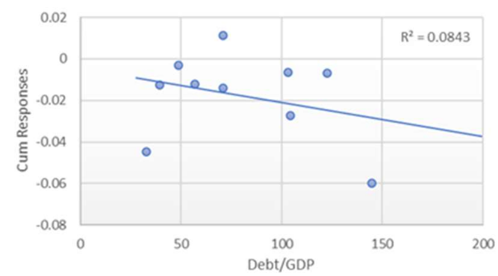


FIGURE 27 - FOREIGN NON-BANKS HOLDINGS RESPONSE TO SHOCKS TO 10-YEARS YIELDS AND DEBT-TO-GDP

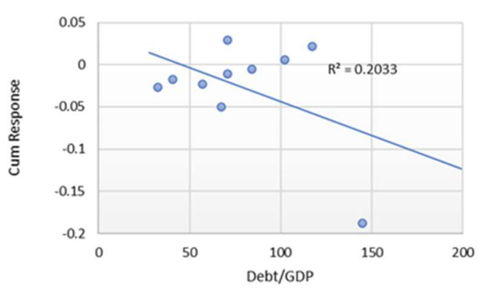


FIGURE 28 - FOREIGN BANKS HOLDINGS RESPONSE TO SHOCKS TO 5-YEARS YIELDS AND DEBT-TO-GDP

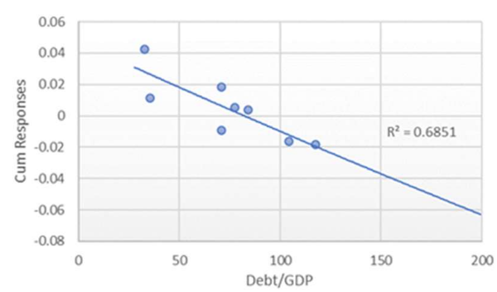


FIGURE 29 - FOREIGN NON-BANKS HOLDINGS RESPONSE TO SHOCKS TO 5-YEARS YIELDS AND DEBT-TO-GDP

[39] Variable used to assess fiscal soundness.

[40] We use the net international investment position in 2013 and its change in the period 2013-19 to assess the external position. The choice of 2013 aims to guarantee that all data matches the official BPM6-basis estimates, avoiding mixing data still using the IMF converted BPM5-basis estimates.

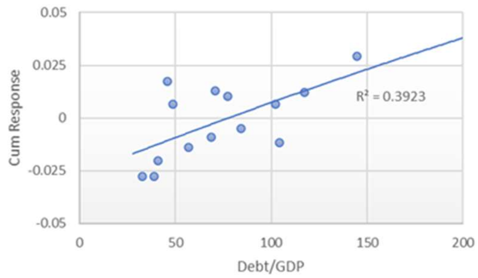


FIGURE 30 - FOREIGN BANKS HOLDINGS RESPONSE TO SHOCKS TO 2-YEARS YIELDS AND DEBT-TO-GDP

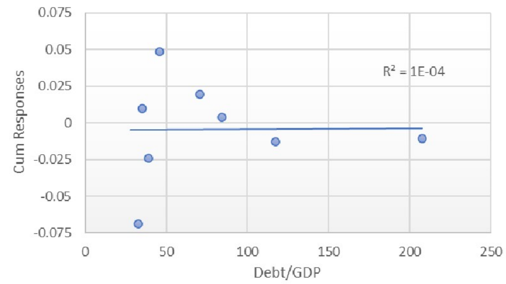


FIGURE 31 - FOREIGN NON-BANKS HOLDINGS RESPONSE TO SHOCKS TO 2-YEARS YIELDS AND DEBT-TO-GDP

Source: Author own calculations. Debt-to-GDP mean sample value (2004 Q1 – 2019 Q2).

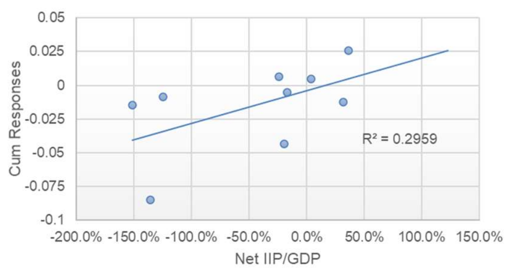


FIGURE 32 - FOREIGN BANKS HOLDINGS RESPONSE TO SHOCKS TO 10-YEARS YIELDS AND 2013 NET IIP

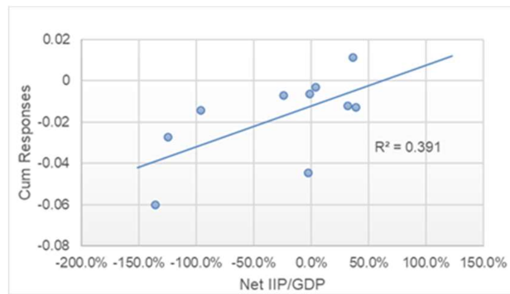


FIGURE 33 - FOREIGN NON-BANKS HOLDINGS RESPONSE TO SHOCKS TO 5-YEARS YIELDS AND 2013 NET IIP

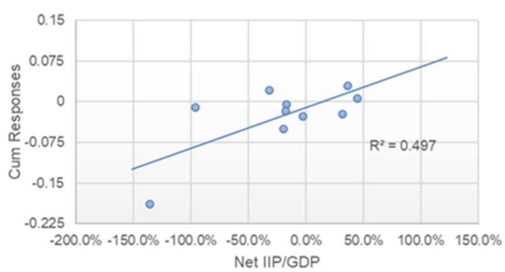


FIGURE 34 - FOREIGN BANKS HOLDINGS RESPONSE TO SHOCKS TO 5-YEARS YIELDS AND 2013 NET IIP

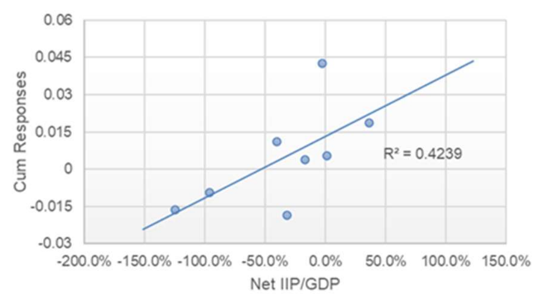


FIGURE 35 - FOREIGN NON-BANKS HOLDINGS RESPONSE TO SHOCKS TO 5-YEARS YIELDS AND 2013 NET IIP

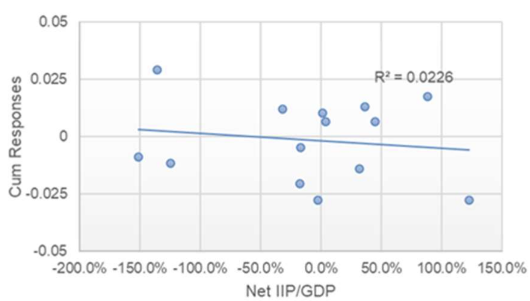


FIGURE 36 - FOREIGN BANKS HOLDINGS RESPONSE TO SHOCKS TO 2-YEARS YIELDS AND 2013 NET IIP

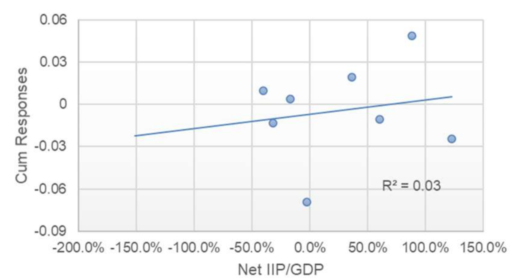


FIGURE 37 - FOREIGN NON-BANKS HOLDINGS RESPONSE TO SHOCKS TO 2-YEARS YIELDS AND 2013 NET IIP

Source: Author own calculations. Note: IIP – International Investment Position.

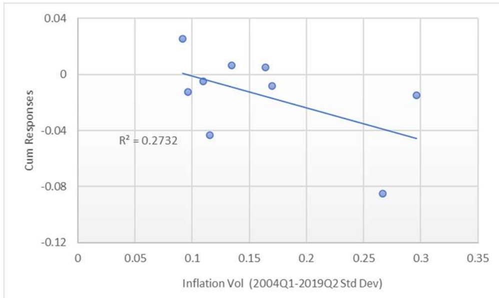


FIGURE 38 - FOREIGN BANKS HOLDINGS RESPONSE TO SHOCKS TO 10-YEARS YIELDS AND INFLATION VOLATILITY

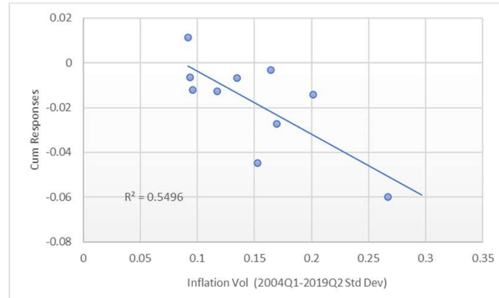


FIGURE 39 - FOREIGN NON-BANKS HOLDINGS RESPONSE TO SHOCKS TO 10-YEARS YIELDS AND INFLATION VOLATILITY

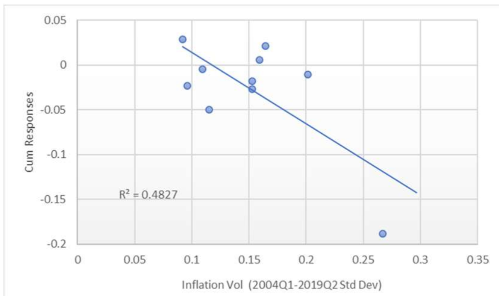


FIGURE 40 - FOREIGN BANKS HOLDINGS RESPONSE TO SHOCKS TO 5-YEARS YIELDS AND INFLATION VOLATILITY

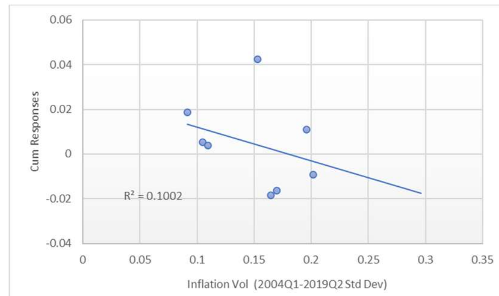


FIGURE 41 - FOREIGN NON-BANKS HOLDINGS RESPONSE TO SHOCKS TO 5-YEARS YIELDS AND INFLATION VOLATILITY

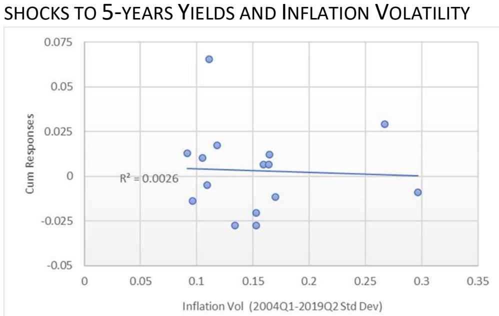


FIGURE 42 - FOREIGN BANKS HOLDINGS RESPONSE TO SHOCKS TO 2-YEARS YIELDS AND INFLATION VOLATILITY

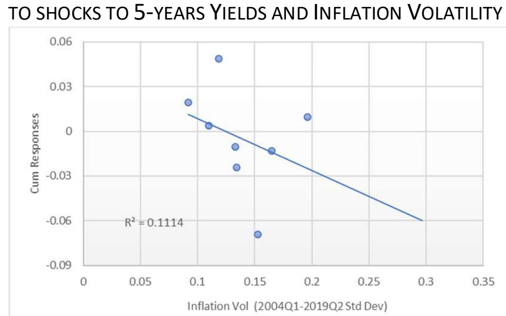


FIGURE 43 - FOREIGN NON-BANKS HOLDINGS RESPONSE TO SHOCKS TO 2-YEARS YIELDS AND INFLATION VOLATILITY

Source: Author own calculations. Note: IIP – International Investment Position. Change measured between 2013 and 2019.

Individual country data regarding domestic investors' cyclical behaviour presents a more balanced picture. Negative and positive responses carry similar weights (22.9% and 18.6%, respectively) and in 23% of instances banks and non-banks react symmetrically to yield changes. No cyclical trading pattern can be clearly associated to each type of domestic investor, although the balance of responses at 5-years suggests a more procyclical behaviour by banks at this point of the yield curve. Likewise, the balance of responses at 10-years suggests a more countercyclical behaviour by non-banks at this maturity. This heterogeneity of results may help explain the mixed results often found in the empirical literature using panel data.

TABLE X - FREQUENCY DISTRIBUTION OF DOMESTIC NON-OFFICIAL INVESTORS HOLDINGS CUMULATIVE RESPONSE TO ORTHOGONAL SHOCKS TO YIELDS

Yields	Domestic Banks and Non-Banks Holdings Cumulative Response to Orthogonal Shocks to Yields				
	(-)	(+)	(+)/(-)	(-)/(+)	n.s.s.
10-years	16.7%	25.0%	8.3%	8.3%	41.7%
5-years	26.1%	26.1%	4.3%	13.0%	30.4%
2-years	13.0%	17.4%	17.4%	17.4%	34.8%
All	18.6%	22.9%	10.0%	12.9%	35.7%

Notes: (-) or (+) indicates response of both types of domestic investor holdings to shocks to yields has an equal sign; (-)/(+) or (+)/(-) indicates responses of opposite signs; n.s.s. indicates a non-statistically significant response at 5% significance level.

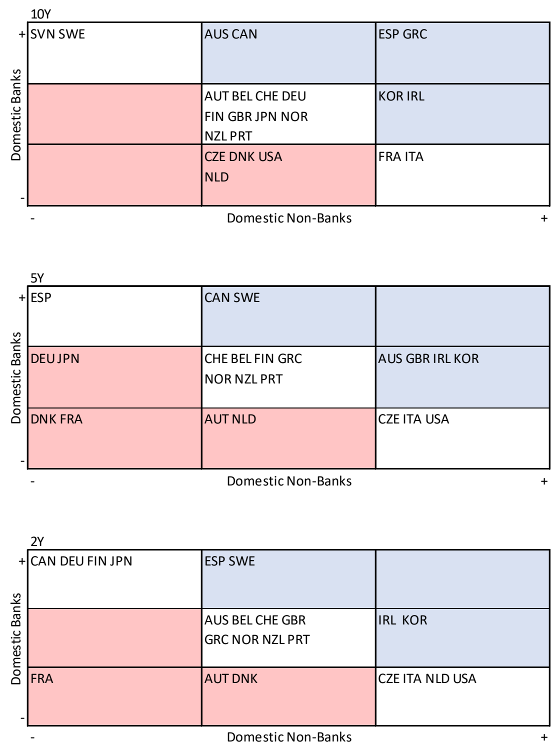


FIGURE 44 - DOMESTIC NON-OFFICIAL INVESTORS HOLDINGS CUMULATIVE RESPONSE TO ORTHOGONAL SHOCKS TO YIELDS

In GIIPS, we see consistent issuer supportive responses by Spanish banks[41] and Italian and Irish non-banks. In Greece, both types of domestic investors are supportive, but the relation only holds briefly and in response solely to changes in 10-years yields. In Portugal, we find no significant issuer domestic support.

[41] Spanish banks issuer supportive responses echoes findings of countercyclical behaviour by Battistini et al. (2013), home bias in GIIPS' banks by Acharya & Steffen (2015), and redrawing of banks' sovereign portfolios by Lamas & Mencía (2018). Slovenian banks also exhibit positive responses to shocks to 10-years yields.

This set of responses is in line with the results of Cornand et al. (2014) regarding Spain and Italy, showing higher yields attract domestic investors. Differently, however, we find the same evidence for Ireland, reported to be non-statistically significant, and we do not find domestic investor countercyclical behaviour in Portugal. While our shocks to yields do not distinguish between common and country specific drivers as in Battistini et al. (2013), we do not find neither a common response by EA banks, nor a distinction between responses in core and periphery. For instances, Spanish and Italian banks consistently across the yield curve exhibit exactly opposite cyclical behaviours.

The supportive role of Spanish banks at all points of the yield curve and the intertwin of sovereign and banking risk suggest a greater role for non-banks in Spain. The absence of any domestic support in Portugal, the country most consistently exposed to foreign investors across the entire yield curve, also points in the same direction. In core EA, banks in France, the Netherlands and in a lesser degree in Austria are consistently procyclical. The same applies to non-banks in France and Germany, but only in response to shocks to 5- and 2-years yields.

Outside the EA, we also find consistent cyclical support from banks in Canada and Sweden, highlighting the fact that this feature is not exclusive of GIIPS. Non-banks countercyclical behaviour is observed in Czechia, Korea, and the US.

Is there a relation between domestic investor responses and home bias? If higher yields at the intermediate and short end of the yield curve seem to have some attraction to banks with an above average holdings of sovereign debt, different cyclical responses within the non-bank sector may explain why the same relation does not hold for this type of investors (Figure 45 to Figure 50). Home bias may help to reduce sovereign debt refinancing risk and make a default less likely, but its association exclusively to banks risks reinforcing the sovereign-banks nexus and put further downward pressure on prices if other investors perceive a deterioration in their expected losses in case of default.

FIGURE 45 - DOMESTIC BANKS HOLDINGS RESPONSE TO SHOCKS TO 10-YEARS YIELDS AND HOME BIAS

FIGURE 46 - DOMESTIC NON-BANKS HOLDINGS RESPONSE TO SHOCKS TO 10-YEARS YIELDS AND HOME BIAS

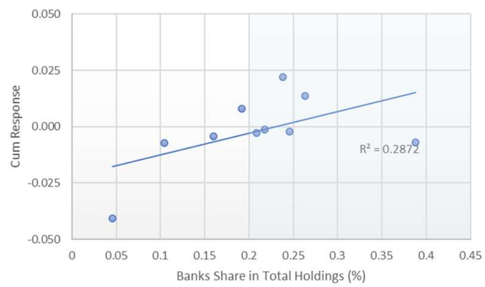


FIGURE 47 - DOMESTIC BANKS HOLDINGS RESPONSE TO SHOCKS TO 5-YEARS YIELDS AND HOME BIAS

FIGURE 48 - DOMESTIC NON-BANKS HOLDINGS RESPONSE TO SHOCKS TO 5-YEARS YIELDS AND HOME BIAS

FIGURE 49 - DOMESTIC BANKS HOLDINGS RESPONSE TO SHOCKS TO 2-YEARS YIELDS AND HOME BIAS

FIGURE 50 - DOMESTIC NON-BANKS HOLDINGS RESPONSE TO SHOCKS TO 2-YEARS YIELDS AND HOME BIAS

Source: Author own calculations. Blue shaded are indicates above average holdings.

Individual country Granger causality Wald tests' results (see Appendix B). point to a balanced bi-directional causality between sovereign bond yields and the investor base. Panel evidence that domestic banks Granger-cause 10-years yields is confirmed. In fact, domestic banks and foreign non-banks are the investor sectors that most Granger-cause 5- and 10-years yields. Domestic non-banks become relevant at the short-end of the yield curve – a result also observed at panel-level – but the two previous investor sectors continue to play a significant role. On the other hand, foreign banks seem to matter only at the long end.

Regarding pull-effects, yields precede changes in holdings mostly for domestic investors, namely at the short end of the yield curve. Foreign bank holdings are Granger-caused particularly by 5-years yields.

7. CONCLUSIONS

The paper assesses the impact of different types of investors on government borrowing costs and examine how those investors react to shocks in sovereign bond yields, using an approach that recognizes bi-directional causality, encompasses different types of foreign and domestic non-official investors, and covers different bond maturities.

Despite advanced economies' capital markets integration, our econometric study confirms descriptive statistical analysis evidence suggesting a strong degree of heterogeneity of the sovereign debt investor base across countries and reveals that this heterogeneity also applies across points of the yield curve. Thus, debt management offices have all the advantage in developing a deeper knowledge of their respective investor base behaviour.

Notwithstanding, our empirical results allow us to identify some commonalities. Foreign investment, mostly by banks, is associated with lower borrowing costs, a feature more pervasive at the long and intermediate segments of the yield curve and in the EA. When negative, yields' responses to shocks to foreign holdings seem to be stronger when yield levels are higher. Yields respond negatively to shocks to foreign holdings in GIIPS and in the US and positively in safe-haven countries such as core EA, Switzerland, or Japan. Hence, in case of a negative shock across the EA, we may see again a widening in spreads. Generally, across the yield curve, yields' response to shocks to the domestic investor base are more consistent than to shocks to the foreign investor base. Yields responses are mainly positive and seem to bear no significant relation with home bias.

Foreign investors, namely banks, often display a procyclical trading pattern. Foreign investors return-seeking seems to be stronger where fundamentals such as inflation volatility, sovereign debt levels or net international investment position are weaker. Countercyclical behaviour also occurs but tends to be more common at the short end of the yield curve.

Foreign investment in the EA is comparatively more procyclical. Another idiosyncrasy of the EA relates to foreign banks negative response to global risk and positive response to international leverage, leading sovereign debt to be traded more like a risky than a safe asset. A negative shock to these global factors, prompting foreign selling, leaves the EA exposed to wider spreads, potentially reinforced by procyclical trading. In turn, a widening spiral in bond yield spreads risks debasing investor beliefs regarding debt sustainability. Hence, most exposed countries to foreign investors must remain attentive in avoiding doubts over their debt and external position sustainability and the EA ought to keep operational an effective support mechanism to mitigate investor concerns, deter contagion and prevent an escalation that may jeopardize the monetary union itself.

Individual country data regarding domestic investors' cyclical behaviour presents a more even picture. No cyclical trading pattern can be clearly associated to each type of domestic investor, despite hints of procyclical banks at 5-years and countercyclical non-banks at 10-years. Home bias seems weakly linked to stronger countercyclical responses by banks at the intermediate and short end of the yield curve but not by non-banks. The issuer supportive role of Spanish banks at all points of the yield curve and the intertwin of sovereign and banking risk suggest a greater role for non-banks in Spain. The absence of any domestic issuer support in Portugal, the country most consistently exposed to foreign investors across the entire yield curve, also points in the same direction.

The empirical analysis could be extended in several ways. In what concerns data, the use of expectations could be expanded, and the country panel enlarged to emerging markets. In terms of econometric framework, allowing for parameter heterogeneity in PVAR estimation and using a regime switching VAR, eventually over a simplified model, to improve the modelling of central bank holdings' structural breaks. Furthermore, cross-country linkages may be better addressed by a Global VAR approach. Another potential research direction is to incorporate in the model bond yield volatilities.

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APPENDIX A

TABLE A - I - SOVEREIGN DEBT INVESTOR BASE COUNTRY LIST

#	Advanced Economies	Country Codes
1	Australia	AUS
2	Austria	AUT
3	Belgium	BEL
4	Canada	CAN
5	Czech Republic	CZE
6	Denmark	DNK
7	Finland	FIN
8	France	FRA
9	Germany	DEU
10	Greece	GRC
11	Ireland	IRL
12	Italy	ITA
13	Japan	JPN
14	Korea	KOR
15	Netherlands	NLD
16	New Zealand	NZL
17	Norway	NOR
18	Portugal	PRT
19	Slovenia	SVN
20	Spain	ESP
21	Sweden	SWE
22	Switzerland	CHE
23	United Kingdom	GBR
24	United States	USA

TABLE A - II - VARIABLES DATA SOURCES

Data	Source	Observations
Bank Assets	IMF Monetary and Financial Statistics, Bank of Canada, Reserve Bank of New Zealand, Swiss National Bank, Bank of England	IMF - Other Depository Corporations; Canada - Chartered Banks Assets; N. Zealand - Registered Banks Assets; Switzerland - Domestic Assets of Swiss Banks; U.K. - Banks and Building Socities Assets.
Bank Credit to Private Non-Financial Sector	BIS	
Banks' Claims on the General Government	IMF Monetary and Financial Statistics, Bank of Canada, Reserve Bank of New Zealand, Swiss National Bank, Bank of England	IMF - Claims on Central Government and Claims on State & Local Government; Canada - G.G. Loans and Securities; N. Zealand - Government Securities and Claims by Sector – Government Administration & Defence; Switzerland - Public Sector; U.K. -Claims on Public Sector.
Current Account	OECD and IMF	
GDP	OECD and IMF	
General Government Budget Balance and Gross Debt to GDP	Eurostat, OECD and IMF	Exceptions are: Australia - Budget Balance sourced from Australia Statistics; Canada - Budget Balance sourced from Canada Statistics; New Zealand, both variables retrieved from NZ Statistics; Switzerland - Budget Balance souced from Swiss Federal Finance Administration
Government bond yields (quarterly averages)	Bloomberg, Datastream, and OECD series	OECD series is used only for 10-years yields. For Greece and Ireland 3-years yields are used instead of 2-years yields due to data availability.
Holdings of general government gross debt	IMF, sovereign investor base estimates by Arslanalp & Tsuda (2014).	Holdings of general government gross debt are defined as the consolidated sum of liabilities represented by SDRs, currency and deposits, debt securities and loans, at face value or adjusted for valuation changes to remove price fluctuations. Saving certificates and retail bonds, typically a small share of total debt in most AE, are accounted for under currency and deposits. General government encompasses central government, state and local governments and social security funds
ICE BofA US High Yield Index Option-Adjusted Spread	Ice Data Indices, LLC; retrieved from FRED, Federal Reserve Bank St. Louis	
ICE BofAML US Corporate AAA and BBB Option-Adjusted Spread vs Treasury	Ice Data Indices, LLC; retrieved from FRED, Federal Reserve Bank St. Louis	
Inflation	OECD and IMF	
Inflation Expectations 5 years forward	Federal Reserve Bank St. Louis	U.S. only.
Maturity of Government Debt (average)	OECD Sovereign Borrowing Outlook 2004, 2007, 2013, 2016, and 2019 and annual data from the Greek Debt Management Agency	The data is for central government debt, but we assume the same data for the entire general government debt due to the lack of data on the latter's average maturity. Linear interpolations are used to bring the year end data to a quarterly frequency considering the high persistence of this type of data. Sweden, Switzerland, and United Kingdom are the only AE for which we have no data prior 2007. To fil this gap we assume no change for the period 2004Q4 to 2007Q4.
OECD Leading Indicator	OECD; retrieved from FRED, Federal Reserve Bank St. Louis	Canada only.
Share Price Return	OECD; retrieved from FRED, Federal Reserve Bank St. Louis	U.S. and Switzerland only.
Short-term interest rates and policy rates	OECD and IMF	Japan 3-month BBA Libor is an exception and is sourced from the ECB
VIX Index	Bloomberg	VIX Index is the Chicago Board Options Exchange's Market Volatility Index, a measure of constant 30-day expected volatility of the U.S. stock market, derived from real-time, mid-quote prices of call and put options on the S&P 500

TABLE A - III - DUMMY VARIABLES FOR JAPAN/SWEDEN/UK/US

Country	Type	Description	Period	Interaction	Variables	Models
Japan	APP	Asset Purchase Programme	2010 Q4 - 2012 Q1	Intercept	All	All
		Quantitative and Qualitative Monetary Easing	2013 Q2 - 2016 Q2	Intercept	All	All
		QQE with Yield Curve Control	2016 Q3 - 2019Q2	Intercept	All	All
Sweden	SB	2014 Q2	2014 Q2	Intercept	Foreign Non-Official	10- and 5-years
	Data	2017 Q3 - data uses fixed weights for foreign banks and non-banks holdings	2017 Q3 - 2019 Q2	Intercept	Foreign Non-Official	All
U.K.	APP	Asset Purchase Facility (effective net purchase periods)	2009 Q2 - 2010 Q3; 2011 Q3 - 2012 Q3; 2016 Q1 - 2017 Q3	Intercept	All	None. Dummy not statistically significant
U.S.	APP	Quantitative Easing Indicator	2009 Q2 - 2009 Q4; 2010 Q4 - 2011 Q2; 2013 Q1 - 2013 Q4	Intercept	All	All
	SB	2013 Q1	2013 Q1	Intercept	Foreign Non-Banks	All
	SB	2014 Q3 - 2015 Q4	2014 Q3 - 2015 Q4	Intercept	Foreign Non-Official	All

Notes: APP - Asset Purchase Programs; SB - Structural Breaks; Data - Data Issues

TABLE A - IV - DUMMY VARIABLES FOR EURO AREA

Country	Type	Description	Period	Interaction	Variables	Models
Austria	APP	PSPP Operations	2015 Q1 - 2018 Q4	Slope	All	All
Belgium	APP	PSPP Operations	2015 Q1 - 2018 Q4	Slope	All	All
		CBPP1 Announcement	2009 Q2	Intercept	All	2-years
		OMT Announcement	2012 Q3	Intercept	All	5-years
		PSPP Annoucement	2015 Q1	Intercept	All	10-years
	Fin Ass	New legal text of the ESM Treaty	2012 Q1	Intercept	All	All
Finland	APP	PSPP Operations	2015 Q1 - 2018 Q4	Slope	All	10-years
		CBPP1 Announcement	2009 Q2	Intercept	Foreign Banks, Yields	All
		SMP1 Announcement	2010 Q2	Intercept	Foreign Banks, Yields	2-years
		PSPP Expectations	2014 Q3 - 2014 Q4	Intercept	Domestic Banks	All
		PSPP Duration	2015 Q1 - 2018 Q4	Intercept	Foreign Banks	5-years
France	APP	PSPP Operations	2015 Q1 - 2018 Q4	Slope	All	10-years
		CBPP1 Announcement	2009 Q2	Intercept	All	All
		SMP1, LTRO1, LTRO2 and OMT Annoucements	2010 Q2, 2011 Q4, 2012 Q1, 2012 Q3	Intercept	All	All
		PSPP Annoucement, PSPP increase in monthly pace to 80bn	2015 Q1, 2016 Q1	Intercept	All	2- and 5-years
Germany	APP	PSPP Operations	2015 Q1 - 2018 Q4	Slope	All	All
		SMP1, SMP2, PSPP Annoucements	2010 Q2, 2011 Q3, 2015Q1	Intercept		
Greece	APP	SMP1 Operations	2010 Q2 - 2011 Q2	Slope	Domestic Banks	2- and 5-years
	Restr	Debt Restructuring	2012 Q1	Intercept		
Ireland	APP	SMP1 Operations	2010 Q2 - 2011 Q2	Slope	All	10-years
		PSPP Operations	2015 Q1 - 2018 Q4	Slope	All	2- and 5-years
		CBPP1 Announcement	2009 Q2	Intercept	Foreign Non-Banks, Domestic-Banks	All
		SMP1 Announcement	2010 Q2	Intercept	Foreign Non_Banks, Yields	2- and 10-years
		SMP2 Announcement	2011 Q3	Intercept	Foriegn Banks, Yields	5 years
		LTRO1 Announcement	2011 Q4	Intercept	All	10 years
		LTRO2 Allotment date	2012 Q1	Intercept	Yields	2- and 5-years
		SMP2 Announcement	2011 Q3	Intercept	Foreign Banks, Yields	5 years
		OMT Announcement	2012 Q3	Intercept	Domestic Non-Banks, Yields	5-years
		PSPP Expectations	2014 Q3 - 2014 Q4	Intercept	Foreign Banks, Domestic Non-Banks	2- and 5-years
		PSPP Annoucement	2015 Q1	Intercept	Foreign Banks, Domestic Non-Banks	2- and 5-years
	Fin Ass	Finacial Assistance Period	2010 Q4 - 2013 Q4	Intercept	All	All
	Fin Ass	Post Financial Assistance	2014 Q1	Intercept	Foreign Banks (2Y)	All
	APP	Post PSPP period	2019 Q1	Intercept	Domestic Non-Banks (2Y)	All
Italy	APP	PSPP Operations	2015 Q1 - 2018 Q4	Slope	All	All
		LTRO2 Allotment date	2012 Q1	Intercept	All	All
		PSPP Annoucement	2015 Q1	Intercept	All	10-years
	Data	Reclassification of domestic banks holdings	2006 Q3; 2007 Q4	Intercept	All	All
Netherlands	APP	CBPP1 Announcement	2009 Q2	Intercept	Domestic Banks, Yields	10-years
		SMP1 Announcement	2010 Q2		Domestic Non-Banks	All
		SMP2 Announcement	2011 Q3		Domestic Banks	10-years
		OMT Announcement	2012 Q3		Foreign Non-Official, Yield	All
		PSPP Expectations	2014 Q3 - 2014 Q4		Domestic Banks, Yields	10-years
		PSPP Duration	2015 Q1 - 2018 Q4		All	All
		PSPP Annoucement, PSPP increase in monthly pace to 80bn	2016 Q4		Foreign Non-Banks	All
	Data	2016 Q3, 2019 Q2	2016 Q3, 2019 Q2	Intercept	Foreign Non-Official	All
Portugal	APP	SMP1 Operations	2010 Q2 - 2011 Q2	Slope	All	10-years
		PSPP Operations	2015 Q1 - 2018 Q4	Slope	All	2- and 5-years
		SMP1 Announcement	2010 Q2	Intercept	Domestic Non-Banks, Foreign Banks	2- and 5-years
		LTRO1 Announcement	2011 Q4	Intercept	Domestic Banks	All
		LTRO2 Allotment date	2012 Q1	Intercept	Yields	2-years
		OMT Announcement	2012 Q3	Intercept	Yields	5-years
		PSPP Annoucement	2015 Q1	Intercept	Foreign Banks, Yields	All
	Fin Ass	Finacial Assistance Period	2010 Q4 - 2013 Q4	Intercept	Foreign Banks	All
Slovenia	APP	LTRO1 Announcement	2011 Q4	Intercept	All	10-years
	APP	OMT Announcement	2012 Q3	Intercept	Yields	
	APP	PSPP Expectations	2014 Q3 - 2014 Q4	Intercept	Domestic Banks	
	APP	PSPP Annoucement	2015 Q1	Intercept	Foreign Banks, Doestic Non-Banks, Yields	
	Data	2005Q3, Euro replaces Tolar	2005Q3, 2007 Q1	Intercept	Foreign Non-Official	
		2015 Q2	2015 Q2	Intercept	Domestic Non-Banks, Yields	
		2016 Q3	2016 Q3	Intercept	Domestic Non-Banks	
		2016 Q4	2016 Q4	Intercept	Foreign Banks, Doestic Non-Banks	
		2019 Q2	2019 Q2	Intercept	Domestic Non-Banks	
Spain	APP	PSPP Operations	2015 Q1 - 2018 Q4	Slope	All	All
		LTRO1 Announcement	2011 Q4	Intercept	Foreign Banks	
		LTRO2 Allotment date	2012 Q1	Intercept	Foreign Non-Banks, Domestic-Banks, Yields	
		OMT Announcement	2012 Q3	Intercept	Foreign Banks, Domestic Banks	
		PSPP Expectations	2014 Q3 - 2014 Q4	Intercept	Foreign Non-Official, Domestic Banks	
	Fin Ass	Beginning of Financial Assistance Period	2012 Q4	Intercept	All but Foreign Banks	

Notes: APP - Asset Purchase Programs; SB - Structural Breaks; Data - Data Issues; Fin Ass - Financial Assistance; Restr - Debt Restructure

TABLE A - V - DUMMY VARIABLES FOR OTHER COUNTRIES

Country	Type	Description	Period	Interaction	Variables	Models
Australia	Data	2008 Q1, 2008 Q3, 2009 Q1, 2009 Q2 - data outliers	2008 Q1, 2008 Q3, 2009 Q1, 2009 Q2	Intercept	Foreign Non-Official	All
Canada	-					
Czechia	SB	2 Structural Break Points under the Innovational Outlier Scheme	2017 Q1, 2017 Q3, 2018 Q2	Intercept	Domestic Non-Official	All
Denmark	SB	2 Structural Break Points under the Innovational Outlier Scheme	2015 Q4, 2016 Q2, 2016 Q3, 2016 Q4, 2017 Q4, 2018 Q1	Intercept	Foreign Non-banks	All
Korea	-					
New Zealand	APP	US QE2 - Quantitative Easing Spillover Effects	2010 Q3 - 2011 Q2	Intercept	All	All
	APP	Post - EA PSPP Announcement	2015 Q1 - 2019 Q2	Intercept	All	10-years
	Data	2010 Q4	2010 Q4	Intercept	Domestic Non-Banks	All
		2011 Q1	2011 Q1	Intercept	Domestic Non-Banks	All
		2014Q1-2014 Q3	2014Q1-2014 Q3	Intercept	Foreign Banks	2-years
Norway	APP	Pre - EA PSPP Announcement (2 Quarters)	2014 Q3 - 2014 Q4	Intercept	Foreign Non-Banks	5-years
		Post - EA PSPP Announcement (2 Quarters)	2015 Q1 - 2015 Q2	Intercept	Foreign Non-Banks	5-years
Switzerland	APP	Bank Reserve Expansion Announcement	2011 Q3	Intercept	All	All
	Data	2008 Q1	2008 Q1	Intercept	Domestic Non-Official	All
		2015 Q4	2015 Q4	Intercept	Domestic Non-Official	All

Notes: APP - Asset Purchase Programs; SB - Structural Breaks; Data - Data Issues.

TABLE A - VI - PVAR-X MODELS

Panels	10-years yields				5-years yields				2-years yields			
	Lags		Overidentification Restriction Test		Lags		Overidentifying Restriction Test		Lags		Overidentifying Restriction Test	
	Endog. Var.	Instruments	Hansen J	p-value	Endog. Var.	Instruments	Hansen J	p-value	Endog. Var.	Instruments	Hansen J	p-value
USA,GBR,JPN, SWE	3	3	-		3	3	-	-	3	3	-	-
	1	3	67.84	0.617	1	3	58.33	0.878	1	3	70.94	0.513
	1	2	42.13	0.223	1	2	39.23	0.327	1	2	42.22	0.220
Euro Area	3	3	-		3	3	-	-	3	3	-	-
	1	4	84.91	0.203	1	4	87.19	0.159	1	4	79.65	0.335
	1	3	59.67	0.164	1	3	56.66	0.240	1	3	51.05	0.432
Other Countries	4	4	-		3	3	-	-	3	3	-	-
	1	4	67.13	0.730	1	4	62.86	0.840	1	4	65.97	0.762
	1	2	18.25	0.831	1	2	19.05	0.795	2	4	44.76	0.683

Notes: For each panel, the first row describes the just-identified model and the second and third rows the overidentified models. All models do not reject Hansen's overidentification restriction at the 5% significance level. EA 2-years models exclude Greece to ensure model stability.

TABLE A - VII - 10-YEARS YIELD CHANGE RESPONSE TO A ONE STANDARD DEVIATION SHOCK TO EACH TYPE OF INVESTOR HOLDINGS' PERCENTUAL CHANGE

Lags		Foreign			Foreign			Domestic			Domestic		
Endog. Var.	Instruments	Banks		Qtr	Non-banks		Qtr	Banks		Qtr	Non-banks		Qtr
US/GB/JP/SW													
3	3	-0.03	**	0	0.00		-	-0.06	**	-	0.06	**	1
1	3	-0.02		-	0.03		-	-0.11	**	-	0.06	**	-
1	2	-0.02		-	0.01		-	-0.12	**	-	0.04	**	0
Euro Area													
3	3	0.10		-	0.15		-	0.08	**	2	0.06	**	1
1	4	-0.12	**	-	0.04	**	0	-0.12	**	0	0.10	**	-
1	3	-0.15	**	-	0.04		-	0.06	**	1	0.11	**	-
Other countries													
4	4	-0.04	**	4	0.03	**	2	0.00		-	-0.04	**	3
1	4	0.00		-	0.03	**	-	0.02		-	-0.03	**	-
1	2	0.00		-	0.02		-	0.02		-	-0.01		-

Note: The asterisks ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively. The change in yields response to a one standard deviation shock in the percentual change in holdings of each type of investor is measured in percentual points. Hence, -0.03 means -3 basis points. It is measured four quarters after the shock if it persists significant at least 8 quarters. Otherwise the maximum impact is reported and its date is printed in"Qtr".

TABLE A - VIII - 5-YEARS YIELD CHANGE RESPONSE TO A ONE STANDARD DEVIATION SHOCK TO EACH TYPE OF INVESTOR HOLDINGS' PERCENTUAL CHANGE

Lags Endog. Var.	Instruments	Foreign Banks		Qtr	Foreign Non-banks		Qtr	Domestic Banks		Qtr	Domestic Non-banks		Qtr
US/GB/JP/SW													
3	3	0.00		-	0.01		-	-0.08	**	1	0.08	**	2
1	3	-0.01		-	0.04		-	-0.17	**	-	0.05	**	0
1	2	0.00		-	0.01		-	-0.16	**	-	0.04	**	0
Euro Area													
3	3	-0.17	**	1	0.30		-	-0.10	*	1	-0.25		-
1	4	-0.27	**	-	0.01		-	-0.07		-	-0.11		-
1	3	-0.34	**	-	0.03		-	-0.14		-	-0.05		-
Other countries													
3	3	0.01		-	0.03	**	1	0.03	**	1	-0.01		-
1	4	0.00		-	0.04	**	-	0.01		-	-0.03	*	-
1	2	0.00		-	0.03	**	-	0.03	*	1	0.00		-

Note: The asterisks ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively. The change in yields response to a one standard deviation shock in the percentual change in holdings of each type of investor is measured in percentual points. Hence, -0.03 means -3 basis points. It is measured four quarters after the shock if it persists significant at least 8 quarters. Otherwise the maximum impact is reported and its date is printed in"Qtr".

TABLE A - IX - 2-YEARS YIELD CHANGE RESPONSE TO A ONE STANDARD DEVIATION SHOCK TO EACH TYPE OF INVESTOR HOLDINGS' PERCENTUAL CHANGE

Lags Endog. Var.	Instruments	Foreign Banks		Qtr	Foreign Non-banks		Qtr	Domestic Banks		Qtr	Domestic Non-banks		Qtr
US/GB/JP/SW													
3	3	0.01		-	0.03		-	-0.08	**	1	0.07	**	1
1	3	0.00		-	-0.01		-	-0.13	**	-	0.03	**	0
1	2	0.01		-	-0.01		-	-0.15	**	-	0.05		-
Euro Area													
3	3	0.01		-	0.02		-	0.04		-	0.00		-
1	4	0.02		-	-0.01		-	-0.03	*	0	0.05	**	-
1	3	0.00		-	0.03	*	0	-0.01		-	0.07	**	-
Other countries													
3	3	0.02	*	2	0.03	**	2	0.02		-	-0.01		-
1	4	0.00		-	0.02	**	1	0.03	**	1	-0.12	**	-
2	4	-0.01	*	2	0.02		-	0.03	**	-	-0.05	**	-

Note: The asterisks ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively. The change in yields response to a one standard deviation shock in the percentual change in holdings of each type of investor is measured in percentual points. Hence, -0.03 means -3 basis points. It is measured four quarters after the shock if it persists significant at least 8 quarters. Otherwise the maximum impact is reported and its date is printed in"Qtr".

TABLE A - X - INVESTOR HOLDINGS PERCENTUAL CHANGE RESPONSE TO ONE STANDARD DEVIATION SHOCK TO 10-YEARS YIELDS

Lags		Foreign			Foreign			Domestic			Domestic		
Endog. Var.	Instruments	Banks		Qtr	Non-banks		Qtr	Banks		Qtr	Non-banks		Qtr
US/GB/JP/SW													
3	3	-0.044	**	-	-0.021		-	-0.003		-	0.001		-
1	3	-0.016	**	-	-0.023		-	-0.003		-	0.000		-
1	2	-0.021	**	-	-0.019	**	-	-0.005		-	0.000		-
Euro Area													
3	3	-0.013		-	-0.005		-	-0.006		-	0.005		-
1	4	-0.027	**	-	0.003		-	-0.005		-	-0.016	**	2
1	3	-0.038	**	-	0.012		-	-0.009	**	-	-0.023	**	-
Other countries													
4	4	0.000		-	-0.032		-	0.019	**	2	0.004	**	1
1	4	0.005		-	-0.008		-	0.007		-	0.003		-
1	2	0.008		-	-0.002		-	0.010		-	0.004		-

Note: The asterisks ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively. The percentual change in holdings response to a one standard deviation shock in yields is measured in units. Hence, -0.04 means -4%. It is measured four quarters after the shock if it persists significant at least 8 quarters. Otherwise the maximum impact is reported and its date is printed in"Qtr".

TABLE A - XI - INVESTOR HOLDINGS PERCENTUAL CHANGE RESPONSE TO ONE STANDARD DEVIATION SHOCK TO 5-YEARS YIELDS

Lags		Foreign			Foreign			Domestic			Domestic		
Endog. Var.	Instruments	Banks		Qtr	Non-banks		Qtr	Banks		Qtr	Non-banks		Qtr
US/GB/JP/SW													
3	3	-0.025	**	1	-0.039	**	2	0.028	*	2	0.001		-
1	3	-0.023	**	-	-0.032	**	-	-0.009		-	0.000	**	-
1	2	-0.029	**	-	-0.040		-	-0.015		-	-0.001		-
Euro Area													
3	3	-0.035	**	2	-0.001		-	-0.023	**	4	-0.015	**	2
1	4	-0.047	**	-	-0.021		-	-0.020		-	-0.006		-
1	3	-0.051	**	-	-0.018	**	-	-0.020	**	-	-0.008		-
Other countries													
3	3	0.014		-	-0.020	*	1	0.004			0.004		-
1	4	0.004		-	-0.018	*	-	0.004		-	0.002		-
1	2	0.008		-	-0.012		-	0.007		-	0.003		-

Note: The asterisks ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively. The percentual change in holdings response to a one standard deviation shock in yields is measured in units. Hence, -0.04 means -4%. It is measured four quarters after the shock if it persists significant at least 8 quarters. Otherwise the maximum impact is reported and its date is printed in"Qtr".

TABLE A - XII - INVESTOR HOLDINGS PERCENTUAL CHANGE RESPONSE TO ONE STANDARD DEVIATION SHOCK TO 2-YEARS YIELDS

Lags		Foreign			Foreign			Domestic			Domestic		
Endog. Var.	Instruments	Banks		Qtr	Non-banks		Qtr	Banks		Qtr	Non-banks		Qtr
US/GB/JP/SW													
3	3	-0.073	**	5	-0.052	*	2	0.018		-	0.013		-
1	3	-0.016	**	1	-0.051	**	-	-0.048	**	-	-0.003		-
1	2	-0.016	**	2	-0.056	**	-	-0.029	**	1	0.003		-
Euro Area													
3	3	-0.007	**	1	0.005		-	0.008		-	-0.001		-
1	4	-0.006	*	-	-0.001		-	-0.003		-	-0.006		-
1	3	-0.010	**	0	0.004		-	-0.005		-	0.001		-
Other countries													
3	3	0.003		-	-0.031	**	1	-0.002		-	0.003		-
1	4	-0.002		-	-0.022	**		0.003		-	0.000		-
1	2	-0.004		-	-0.032	**		0.001		-	0.004		-

Note: The asterisks ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively. The percentual change in holdings response to a one standard deviation shock in yields is measured in units. Hence, -0.04 means -4%. It is measured four quarters after the shock if it persists significant at least 8 quarters. Otherwise the maximum impact is reported and its date is printed in"Qtr".

TABLE A - XIII - YIELDS RESPONSE TO AN ORTHOGONAL SHOCK TO NON-OFFICIAL FOREIGN HOLDINGS OF GOVERNMENT DEBT

Country	Yields																	
	10-years						5-years						2-years					
	Banks		Qtr	Non-Banks		Qtr	Banks		Qtr	Non-Banks		Qtr	Banks		Qtr	Non-Banks		Qtr
AUS	-0.01			-0.10			-0.03			-0.05			0.01			0.00		
AUT	0.01			0.02			-0.02			0.03			-0.01			0.05	**	1
BEL	0.00			0.02			0.02			0.02			-0.02			0.02		
CAN	-0.01			0.03			0.00			0.05			0.01			0.01		
CHE	0.01			0.00			0.04	**		0.02			0.03			0.02		
CZE	0.08	**		-0.02			0.07	**	2	-0.06	**		0.07	**	2	-0.05	**	
DEU	-0.03	**	2	0.04	**		0.02			0.04	**	0	0.00			0.05	**	
DNK	0.00			-0.01			0.01			-0.02	**	1	0.03	**	5	-0.01		
ESP	-0.12	**	3	-0.08	**		-0.04			-0.07	**		0.12	**	1	-0.08	**	
FIN	-0.02	**	1	0.02	**		0.02			0.01			0.00			0.00		
FRA	-0.01			0.00			0.01			0.00			0.00			0.00		
GBR	0.05			0.01			-0.05			-0.01			-0.08	**	3	0.02		
GRC	-0.73	**		0.28			-0.63			0.57	**	1	-11.50	**		-8.00		
IRL	0.04			-0.04			-0.24	**		-0.06			-0.01			-0.09	**	5
ITA	-0.02			-0.04			0.01			-0.07	**	1	0.00			-0.05		
JPN	0.00			0.04	**	3	-0.03	**		0.06	**		-0.02	**	1	0.03	**	
KOR	0.08	**	2	-0.01			0.00			0.01			0.06	**	2	0.06	**	1
NLD	0.00	**		0.01			0.02			0.00			0.02	**	1	-0.01		
NOR	0.01			0.00			-0.04			-0.01			0.03			0.02		
NZL	-0.05			0.03			-0.06			0.02			0.00			0.01		
PRT	-0.18	**		-0.32	**		-0.18	**		-0.27	**		0.02			-0.18	**	0
SVN	0.01			-0.06			-			-			-			-		
SWE	0.02			0.01			-0.01			0.00			-0.01			-0.06	**	1
USA	-0.11	**	2	-0.02			-0.08	**		0.00			-0.02			0.01		

Notes: The asterisks ** denote statistically significant responses at 5% significance level. Responses are cumulative and are measured 4 quarters after the shock, except if response is non-statistical significant at the end of 8 quarters. In this case the maximum effect and corresponding quarter is reported.

TABLE A - XIV - YIELDS RESPONSE TO AN ORTHOGONAL SHOCK TO NON-OFFICIAL DOMESTIC HOLDINGS OF GOVERNMENT DEBT

Country	Yields											
	10Y						5Y						2Y					
	Banks		Qtr	Non-Banks		Qtr	Banks		Qtr	Non-Banks		Qtr	Banks		Qtr	Non-Banks		Qtr
AUS	0.07			-0.01			0.05			-0.03			0.08			0.03		
AUT	-0.05	**		0.03			-0.05	**	4	0.01			-0.03			0.07	**	1
BEL	0.01			0.03			0.04	**		0.00			0.01			0.03		
CAN	-0.03	**	0	0.04	**		-0.05	**	2	0.04	**		-0.06	**		0.05	**	1
CHE	0.04	**		0.07	**		0.02	**		0.06	**		0.01			0.08	**	
CZE	0.10	**	1	-0.05	**		0.08	**	1	-0.05	**	2	0.05	**		0.05	**	1
DEU	0.04	**	2	0.05	**		0.03			0.05	**		0.04	**	2	0.04	**	
DNK	0.04	**	1	-0.02			0.03	**	1	0.03	**		-0.01			0.01		
ESP	-0.01			0.12	**		-0.02			0.12	**		-0.04			0.13	**	2
FIN	-0.01			-0.01			0.00			0.01			0.00			0.00		
FRA	0.02	**	1	0.01			-0.01			0.03	**		0.00			0.01		
GBR	-0.04			0.07			-0.05	**	1	0.12	**		-0.05	**	1	0.12	**	1
GRC	-0.20			0.44			-2.70	**	3	-0.18			-18.29			-5.28		
IRL	-0.19	**		0.01			-0.08			0.07			0.13	**		0.02		
ITA	0.14	**		0.14	**		0.22	**		0.15	**		0.16	**		0.13	**	
JPN	0.01			0.02	**	0	0.01			0.02			0.01			0.02		
KOR	-0.10	**		-0.09	**		-0.09	**		-0.13	**		-0.07	**		-0.11	**	
NLD	0.00			0.00			0.00			0.03			0.00			-0.01		
NOR	0.03	**	1	-0.01			0.05			-0.01			0.07	**		-0.06	**	1
NZL	0.03			-0.06			0.03			0.04			0.01			-0.03		
PRT	-0.01			0.04			0.09	**	0	0.02			0.25	**		0.05		
SVN	-0.04			0.03			-			-			-			-		
SWE	0.00			-0.06	**		-0.01			0.00			0.03			-0.02		
USA	-0.02			0.10	**	1	-0.02			0.08	**	1	-0.05	**	2	0.05	**	

Notes: The asterisks ** denote statistically significant responses at 5% significance level. Responses are cumulative and are measured 4 quarters after the shock, except if response is non-statistical significant at the end of 8 quarters. In this case the maximum effect and corresponding quarter is reported.

TABLE A - XV - RESPONSE OF NON-OFFICIAL FOREIGN HOLDINGS OF GOVERNMENT DEBT TO AN ORTHOGONAL SHOCK TO YIELDS

Country	Yields																	
	10-years						5-years						2-years					
	Banks		Qtr	Non-Banks		Qtr	Banks		Qtr	Non-Banks		Qtr	Banks		Qtr	Non-Banks		Qtr
AUS	0.028			0.015			0.055			0.062			0.061			0.056		
AUT	0.001			0.001			0.003			0.005	**	2	0.010	**	4	0.003		
BEL	0.005			-0.003			0.006	**		-0.004			0.007	**		-0.003		
CAN	0.000			-0.006	**	1	0.002			-0.004			0.000			0.002		
CHE	0.005			-0.023			0.012			0.003			0.017	**	1	0.049	**	
CZE	0.007			0.008			0.006			0.011	**		0.004			0.010	**	
DEU	0.026	**		0.011	**	1	0.029	**		0.019	**	1	0.013	**		0.020	**	1
DNK	0.004			-0.013	**	1	0.005			-0.002			0.008			-0.004		
ESP	-0.009			-0.014	**		-0.011	**	4	-0.009	**	4	-0.005			-0.005		
FIN	0.005	**		-0.003	**		0.008			-0.005			0.007	**		-0.003		
FRA	-0.005	**		0.001			-0.005	**		0.004	**		-0.005	**	1	0.004	**	
GBR	-0.043	**	1	0.005			-0.050	**	1	0.007			0.010			0.016		
GRC	-0.085	**		-0.060	**		-0.188	**		-0.040			0.029	**	1	-0.012		
IRL	-0.015	**		-0.003			0.000			-0.016			-0.009	**		0.004		
ITA	0.006	**		-0.007	**	1	0.002			0.000			0.000			0.002		
JPN	0.035			0.005			0.015			0.004			0.018			-0.011	**	2
KOR	-0.004			-0.045	**	2	-0.027	**	2	0.043	**	2	-0.028	**	2	-0.069	**	
NLD	-0.013	**		-0.012	**	3	-0.023	**		-0.015			-0.014	**		-0.002		
NOR	-0.001			-0.013			0.003			-0.013			-0.028	**	1	-0.024	**	1
NZL	0.123			-0.004			0.094			-0.003			0.018			-0.004		
PRT	-0.008	**		-0.027	**		-0.003			-0.016	**		-0.012	**		-0.003		
SVN	0.032			-0.026			-			-			-			-		
SWE	-0.005			-0.003			-0.018	**	2	0.002			-0.020	**	2	-0.002		
USA	0.024			-0.017			0.022	**		-0.018	**	1	0.012	**		-0.013	**	1

Notes: The asterisks ** denote statistically significant responses at 5% significance level. Responses are cumulative and are measured 4 quarters after the shock, except if response is non-statistical significant at the end of 8 quarters. In this case the maximum effect and corresponding quarter is reported.

TABLE A - XVI - RESPONSE OF NON-OFFICIAL DOMESTIC HOLDINGS OF GOVERNMENT DEBT TO AN ORTHOGONAL SHOCK TO YIELDS

Country	Yields																	
	10Y						5Y						2Y					
	Banks		Qtr	Non-Banks		Qtr	Banks		Qtr	Non-Banks		Qtr	Banks		Qtr	Non-Banks		Qtr
AUS	0.032	**	1	0.004			0.031			0.014	**	2	0.026			0.003		
AUT	0.000			-0.011			-0.004	**	2	-0.018			-0.006	**	2	0.005		
BEL	-0.002			-0.001			-0.002			-0.001			-0.002			-0.003		
CAN	0.005	**		0.000			0.008	**		-0.001			0.009	**		-0.003	**	
CHE	0.003			0.000			0.003			-0.001			0.000			-0.001		
CZE	-0.004	**	1	-0.003			-0.007	**		0.005	**	1	-0.007	**		0.004	**	
DEU	-0.002			-0.001			0.002			-0.013	**	2	0.002	**	3	-0.014	**	2
DNK	-0.032	**		0.000			-0.041	**		-0.002	**	1	-0.046	**		0.000		
ESP	0.010	**		0.011	**	1	0.014	**		-0.016	**	2	0.007	**	4	-0.004		
FIN	-0.001			0.001			-0.001			0.015			-0.001	**		0.013	**	2
FRA	-0.001	**		0.064	**		-0.001	**		-0.005	**		-0.002	**	2	-0.005	**	
GBR	-0.002			0.007			-0.009			0.011	**	6	-0.002			0.004		
GRC	0.055	**	3	0.018	**	1	-0.047			0.018			0.008			0.008		
IRL	0.004			0.024	**		0.005			0.040	**		-0.005			0.009	**	2
ITA	-0.003	**	1	0.002	**		-0.002	**		0.002	**		-0.003	**		0.003	**	1
JPN	0.000			0.002			0.001			-0.003	**	8	0.003	**		0.000		
KOR	-0.003			0.015	**		-0.004			0.017	**		0.001			0.019	**	
NLD	-0.002	**	2	0.001			-0.003	**		0.001			-0.002	**		0.003	**	2
NOR	0.001			0.000			0.001			0.001			0.002			0.000		
NZL	0.006			0.020			0.010			0.014			0.011			0.007		
PRT	0.005			0.001			0.003			0.002			0.003			0.005		
SVN	0.026	**		-0.090	**		-			-			-			-		
SWE	0.023	**		-0.008	**		0.022	**		-0.006			0.011	**		0.000		
USA	-0.015	**	2	0.008			-0.007	**		0.005	**	4	-0.005	**	3	0.004	**	1

Notes: The asterisks ** denote statistically significant responses at 5% significance level. Responses are cumulative and are measured 4 quarters after the shock, except if response is non-statistical significant at the end of 8 quarters. In this case the maximum effect and corresponding quarter is reported. In Greece, Banks and Non-Banks responses to shocks to 10-years yields change signs and the changes are statistically significant: -0.064 (Qtr 8) for Banks and -0.054 (Qtr 8) for Non-Banks.

TABLE A - XVII - SUMMARY OF EMPIRICAL LITERATURE USING PERCENTUAL CHANGE IN HOLDINGS

Study	Dep. Variables	Sample Period	Countries	Methodology	Findings
Orpiszewski (2015)	Yields (10-years) ΔYields (10-years)		18 AE, EM	Pooled OLS, Country FE	Yields relate (+) with Δ%NOFH and (-) with Δ%DBH. Both Δ%NOFH and Δ%DBH nss.
				Panel Arellano-Bond GMM estimator	All types of holdings are nss.
	Δ% Holdings	2001 Q1-2011 Q4	25-27 AE, EM	Pooled OLS, Country FE	NOFH relates (-) with yields and Δyields post 2007 Q1. Pre 2007 Q1, relates (+) with yields and relation with Δyields is nss.. DBH relates (-) with yields and Δyields post 2007 Q1. Pre 2007 Q1, relation in both cases is nss. IF relates (-) with Δyields, and is nss with yields. ICPF only pre 2007 Q1 relation with yields is ss and is zero.
Timmer (2018)	Price returns	2005 Q4-2014 Q4	- -	Pooled OLS, Security and Time FE	Price returns relate (+) with Δ Bank and IF Holdings in previous quarter and relation is nss regarding ICPF Holdings. After 3-6 or 6-8 quarters prices of securities bought respectively by Banks and IF fall, and fall by more than the initial increase. Prices of securities bought by ICPF increase after 10-12 quarters.
	Δ% Holdings Security j				Bank and IF Holdings relate (-) with previous quarter returns. ICPF's Holdings relate (+) with previous quarter return.

Notes: Δyields - Yields first differences; Δ% Holdings - Percentual change in Holdings; FE - Fixed Effects; (n)ss - (not) statistically significant; Δ%NOFH - Percentual Change in Non-Official Foreign Holdings; DBH - Domestic Bank Holdings; IF - Investment Funds; ICPF - Insurance Companies and Pension Funds.

TABLE A - XVIII - SUMMARY OF EMPIRICAL LITERATURE USING INVESTOR SHARE IN TOTAL HOLDINGS

Study	Dep. Variables	Sample	Countries	Methodology	Findings
Peiris (2010)	Yields	2000 Q1 2009 Q1	10 EM	Pooled OLS	Yields relate (-) with FH share (-6 bps)
Andritzky (2012)	Yields (10-years)	1969-2011	9-11 AE	Pooled OLS	Yields relate (-) with FH share (-3 bps; -4bps for period 2000-11) Yields relate (-) with DNBH share (-2.6 bps)
	Yields (10-years)			PVAR, 3 lags, 90% CI, MC(200)	Yields response to shocks to investor holdings is nss in all cases
	Holdings Share				FH share instantaneous response to shocks to yields -0.2, nss thereafter. DNBH response is nss.
Arslanalp & Poghosyan (2014)	Yields (10-years)	2004 - 2012	22 AE	Pooled OLS, Country FE	Yields relate (-) with FH share (-8.5 bps)
Ebeke & Lu (2014)	Yields (5-years)	2009 Q1 - 2013 Q1	12 EM	Pooled OLS, Country FE	Yields relate (-) with FH share (-6.8 bps)
				Pooled 2SLS IV	Yields relate (-) with FH share (-3.9 bps)

Notes: CI - Confidence Interval; MC(200) - 200 Monte Carlo replications; FE - Fixed Effects; IV - Instrumental Variables; FH - Foreign Holdings; DNBH - Domestic Non-Bank Holdings

TABLE A - XIX - SUMMARY OF EMPIRICAL LITERATURE USING INVESTOR HOLDINGS IN PERCENTAGE OF GDP

Study	Dep. Variables	Sample	Countries	Methodology	Findings
Jaramillo & Zhang (2013)	Yields (10-years)	2004 H1 - 2012 H2	40 AE, EM	Hausman-Taylor Model	Yields relate (-) with FBH%GDP but relation is nss. Yields relate (+) with DBH%GDP but relation is nss. Separately, AE and EM present (-) relation also nss. Yields relate (-) with DNBH%GDP (-3.3 bps; -3bps AE only). Yields relate (+) with ECB SMP holdings(%GDP) and IMF programme countries
Manna & Nobili (2018)	Yields (10-years)	2004 Q1 - 2016 Q2	16 AE	PECM -CCE LR	Yields relate (-) with FBH%GDP (-4 bps) in the LR. Yields relate (-) with DBH%GDP (-3 bps) in the LR. Yields relate (-) with FNBH%GDP but relation is nss in the LR.
	ΔYields (10-years)			PECM - PMG SR	Yields relate (-) with ΔFBH%GDP (-9 bps) in the SR. Yields relate (-) with ΔFNBH%GDP (-4 bps) in the SR. Yields relation with ΔDBH%GDP is nil and nss in the SR. Yields relate (-) with ΔDFNBH%GDP but is nss in the SR.

Notes: PECM - Panel Error Correction Model; CCEP - Common Correlated Effect estimator (Pesaran, 2006); PMG - Pooled Mean Group estimator (Pesaran et al., 1999); LR - long-run equation; SR - short-run equation; (+) positive; (-) negative; nss - not statistically significant; FBH%GDP - Foreign Bank Holdings in percentage of GDP; FNBH - Foreign Non-Bank Holdings; DBH - Domestic Bank Holdings; DNBH - Domestic Non-Bank Holdings; ΔFBH%GDP - Foreign Bank Holdings in percentage of GDP first differences.

TABLE A - XX - SUMMARY OF EMPIRICAL LITERATURE USING HOLDINGS' LEVELS

Study	Dep. Variables	Sample	Countries	Methodology	Findings
Battistini et al. (2013)	Bank Holdings	2008 Oct - 2012 Aug	10 AE	VECM	DBH respond (+) to shocks to yield differentials, in all countries but three. In Belgium, France and the Netherlands the response is (-). Decomposing yield shocks in a common risk factor and a country risk factor, the relation is mostly (+) to the former but differs considerably to the latter: in core countries (except Austria), an increase in country risk prompts local banks to reduce significantly their domestic exposures and to increase in the periphery (except for Spain, where the effect is positive but nss).
	Yield Differentials				Yield differentials respond (-) to shocks to DBH, except Spain, Italy and Germany. In Spain and Italy the reponse is (+) suggesting government bank bailout concerns.

Notes: VECM - Vector Error Correction Model; (+) positive; (-) negative; nss - not statistically significant; DBH - Domestic Bank Holdings.

APPENDIX B

Supplementary material associated with this article is available upon request: cferreira@iseg.ulisboa.pt.