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The fundamentals of safe assets

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Abstract

We study what makes government bonds a safe asset. Building on a sample of monthly changes in government bond yields in 40 advanced and emerging countries, we analyse the sensitivity of yields to country specific fundamentals interacted with changes in global risk (VIX). We find that inertia (whether the bond behaved as a safe asset in the past) and good institutions foster a safe asset status, while the size of the debt market is also significant, reflecting the special role of the US. Within advanced and emerging markets, drivers are heterogeneous, with external sustainability in particular being relevant for the latter countries after the global financial crisis. Finally, the safe asset status does not appear to depend on whether the change in global risk is driven by financial shocks rather than by US monetary policy.

JEL classification: E42, E52, F31, F36, F41

Keywords: Safe assets, global risk, fundamentals, monetary policy

Non-technical summary

There is growing academic and policy interest in so called "safe assets", that is assets that have stable nominal payoffs, are highly liquid and carry minimal credit risk. They are particularly valuable during periods of stress in financial markets, as they maintain their nominal value while the value of other assets typically falls. In order to hold such assets, investors are typically willing to pay a premium, often referred to as "convenience yield", a term usually used with reference to US Treasuries.

After the global financial crisis, the demand for safe assets has increased well beyond its supply, leading to an increase in the convenience yield and therefore to the interest that these assets pay. High demand for safe assets has important macroeconomic consequences. The equilibrium safe real interest rate may in fact decline well below zero and below the actual rate, as nominal rates hit the zero lower bound and central banks find it difficult to further decrease rates. In this situation, one of the adjustment mechanisms is the appreciation of the currency of issuance of the safe asset, the so called paradox of the reserve currency. Moreover, when prices and exchange rates fail to clear the market for safe assets, a "safety trap" equilibrium may emerge in which, due to the zero lower bound, adjustment takes place through a contraction of global demand.

This paper analyses empirically the economic fundamentals that make government bonds safe, using a sample of monthly changes in government bond yields in 40 advanced and emerging countries between 1990 and 2018. The geographical breadth of our sample ensures that the analysis is less US-centric than the rest of the literature, offering a truly global perspective on the determinants of a safe asset. Given the length of the sample (from 1990 to 2018) the study also cuts through a number of episodes of global financial turbulence, including the speculative attacks on currencies in the European Exchange Rate Mechanism in the early 1990s, the Asian and Russian crises in the late Nineties, the burst of the dot com bubble in the early 2000s and the Great Recession.

The empirical analysis uses an interaction of country fundamentals with a measure of tensions in financial markets (the VIX) to isolate the country characteristics that robustly predict whether a government bond appreciates or depreciates in periods of stress. The shortlist of the ''safe asset fundamentals", which are found to exert a statistically and economically significant influence, contains an inertial term (namely whether the asset behaved like a safe asset in the past), the political risk rating (quality of institutions of the issuing country), and the size of the debt market, the latter mainly reflecting the special role of the US. The relevant fundamentals are

significantly different between advanced and emerging countries. The political risk rating and the size of the debt market are important for advanced countries only, and inertia, real GDP and external sustainability (measured by the current account) for emerging markets only. There is no single fundamental that summarizes the special role of the US as a safe haven. For instance, both the size of its debt market as well as the dominance of the US dollar in foreign currency reserves capture somewhat the special role played by the US economy in global financial markets in times of stress.

Finally, the paper studies whether the protection offered to global investors in bad times by safe assets depends on the type of shock that generated financial tensions. The results indicate that the safe asset status is largely independent from the source of financial turbulence.

The policy implications of our work is that country fundamentals do play some role in explaining the safe asset status of government and that some of them (for example, the political risk rating, or public debt) can be influenced by policy makers. Our paper gives, in particular, a quantification of the benefits of changing these policy-amenable variables for the cost of financing the government debt, in particular when financial market volatility rises. The relevance of the size of the debt market indicates that, at least as regards the role of this fundamental, only a limited number of actors can act as safe haven, with key implications for the developments of the international monetary system, thinking in particular at the emergence of an international role of the Chinese renminbi or the creation of a euro area safe asset.

1 Introduction

There is growing academic and policy interest in safe assets, i.e. liquid assets that maintain or increase their nominal value even in the worst state of the world, say a crisis (Gorton, 2017; Gourinchas and Jeanne, 2012). Importantly for our work, safe assets are considered to be *information insensitive* especially in bad times (Gorton, 2017) and have a negative beta (namely appreciating in market downturns). They are therefore particulary attractive as collateral, for instance in repo transactions, and command a premium, often referred to as "convenience yield", a term usually used for US Treasuries.

A scarcity of safe assets has emerged since the global financial crisis, with important macroeconomic implications (Caballero et al., 2017). In the presence of excess demand for such assets, the "equilibrium" safe real interest rate declines well below zero and below the actual rate, as nominal rates hit the zero lower bound and central banks find it difficult to decrease real rates. In this situation, one of the adjustment mechanisms is the appreciation of the currency of issuance of the safe asset, the so-called "paradox of the reserve currency".[1] However, Caballero et al. (2016) note that, when prices and exchange rates fail to clear the market for safe assets, a "safety trap" equilibrium emerges: in the presence of the zero lower bound, adjustment takes place through a contraction of (global) demand.

Despite their importance, there is still relatively little literature on the features and determinants of safe assets. On the theory side, He et al. (2016) highlight coordination among investors as a key driver of safeness. In their model, a large absolute debt size is crucial as safe asset investors have "nowhere else to go" in equilibrium (and the effect becomes stronger in crisis periods). The empirical work is also limited and mostly focused on US liabilities only, in particular the recent literature on the "convenience yield". Krishnamurthy and Vissing-Jorgensen (2012) prove that investors value both the liquidity and safety attributes of US Treasuries, whose equilibrium price is driven by changes in their supply. One exception to the strict focus on US liabilities is Du et al. (2018), who quantify the difference in the "convenience yield" of US Treasuries and government bonds of other advanced countries and document a secular decline in this

[1] For an analysis of the driver of safe haven currencies see Habib and Stracca (2012).

premium. They also show that the premium is higher when the supply of Treasuries (excluding central bank holdings) is lower. Finally, these findings are mostly driven by the global financial crisis; in the post crisis period, only Treasury bills retain a premium, suggesting that safeness also has a conditional and time-varying nature to some extent.

Our contribution to this growing literature is twofold. First, our analysis relies on a sample of monthly changes in government bond yields in 40 advanced and emerging countries, and is therefore less US-centric than previous studies, offering a truly global perspective on the determinants of a safe asset. Given the length of the sample (from 1990 to 2018) our study also cuts through a number of episodes of global financial turbulence, including the speculative attacks on currencies in the European Exchange Rate Mechanism in the early 1990s, the Asian and Russian crises in the late Nineties, the burst of the dot com bubble in the early 2000s and the Great Recession. Second, we study whether the protection offered to global investors in bad times is *conditional* on the source of financial turbulence. Using a structural econometric model we disentangle different shocks driving global risk aversion: namely US monetary policy shocks, financial shocks - that is an exogenous tightening of financial conditions independent of monetary policy - and geopolitical risk. We then use these structural shocks applying an instrumental variables (IV) approach in order to check whether, in periods of high risk aversion, investors pay attention to the source of financial turbulence when looking for safe assets. Throughout the analysis we use the VIX to measure risk aversion, although the results are robust to other measures of financial volatility.

Our empirical analysis reaches three main results. First, only a short list of variables explains the change in government bond yields when interacted with a rise in the VIX, with the theoretically expected sign: an inertial term (namely whether the asset behaved like a safe asset in the past), the political risk rating, which is a proxy for the quality of institutions of the issuing country, and the size of the debt market. Remarkably, these "fundamentals of safe assets" are not only statistically, but also economically significant. Second, the relevant fundamentals are significantly different between advanced and emerging countries, with political risk rating and size of the debt market important for advanced countries only (again the latter reflecting the US special role), while inertia, real GDP growth and external sustainability (measured by the current account) for emerging markets. Third we dig deeper into the special role of the US and find that it is multifaceted, manifesting itself via the size of its debt market or the dominance of the dollar in central bank foreign currency reserves. Fourth and finally, we find little influence from the nature of the shock driving the change in global risk (monetary policy, financial and geopolitical risk) for the identification of the key drivers of safe asset status, although some variables predictably lose statistical significance when applying IV.

The paper is structured as follows. Section 2 describes our decomposition of global risk in its underlying fundamentals. Section 3 describes the data and Section 4 our empirical model. Results are presented in Section 5, and Section 6 concludes.

2 The structural drivers of global risk

We follow a well established literature and use the VIX, i.e. the expected volatility of the S&P 500 Index measured from option prices, as a measure of global risk, see Habib and Stracca (2012), Bruno and Shin (2015a) and Avdjiev et al. (2017). Increases in the VIX are associated with a rise in risk aversion and therefore with states of the world in which safe assets become relatively more appealing. We stress that the use of the VIX does not make our analysis particulary *US centric*. Given how interconnected financial markets are, changes in the VIX largely reflect shocks that are global. For example, a recent study shows that bouts of volatility are immediately transmitted across financial markets generating a strong correlation across measures of implied volatility. The correlation is so strong that a "global measure", computed as the market-value-weighted average of the equity option-implied volatility in the United States, the United Kingdom, Germany, Japan, France, the Netherlands, and Switzerland, has a correlation of 0.98 with the VIX.[2] A robustness exercise, where we replace the VIX with the global index of financial conditions in use at the IMF (Arregui et al., 2018), leaves the main results of our analysis unaffected.

[2]See Table 1 in Londono, Juan M. and Beth Anne Wilson (2018). "Understanding Global Volatility", IFDP Notes. Washington: Board of Governors of the Federal Reserve System, January 2018, available at https://doi.org/10.17016/2573-2129.40.

Changes in the VIX, however, can originate from different underlying shocks, each with distinct implications for asset prices. Take, for instance, a US monetary policy tightening. This will induce a contraction in equity prices, a fall in inflation compensation and an appreciation of the dollar exchange rate. Such a shock also leads to a rise in the VIX, as implied volatility moves counter-cyclically with respect to stock prices. Crucially, for our analysis, US government bond yields generally *rise* following such a shock, even though their increase is typically milder than that of short-term rates. Such a configuration of asset price movements, for instance, has characterized the response of financial markets to the monetary policy decisions by the Fed towards the end of 2018 when, despite worries of a slowdown in the global business cycle and a protracted tightening of financial conditions, the Fed announced the intention to keep normalizing interest rates and reducing the balance sheet. Other shocks, however, can raise the VIX but have different implications for asset prices. A case in point is a spike in the VIX due to an unexpected fall in the risk appetite of global investors. While such a shock also generates a fall in equity prices, it typically leads to flight to safety dynamics that induce a *fall* in government bonds yields and an appreciation of some currencies that have safe haven properties (Habib and Stracca, 2012). In this case, the *conditional* correlation between the VIX and US government bond yields is therefore negative, rather than positive as in the case of a monetary policy shock, a difference that can bear important implications for investors behaviour and therefore for the safety property of some assets.

To identify the structural shocks we use a parsimonious Vector Autoregressive (VAR) model. The VAR model includes seven variables, namely the one-year interest rate in the US, consumer price inflation, US stock prices, the US dollar index, the yield of US High-Yield Corporate Bonds, the price of oil and the VIX. The model resembles closely the one used by Habib and Venditti (2019) to analyze the relationship between the structural drivers of the global financial cycle on the one hand, and capital flows on the other hand. There is, however, a difference between their framework and the one hereby used. Habib and Venditti (2019) use a Global Stock Market Factor as a measure of global risk aversion, while here we use the VIX. The two concepts are related but different, as the former is driven by shocks to the *conditional expectation* of stock returns, while the latter is more closely related to *uncertainty* about stock returns. Empirically, the time varying premium of safe haven assets, the central object of interest of our analysis, appears to be more closely related to sudden increases in the uncertainty of the economic environment than to changes in expected stock returns, which justifies the use of the VIX in this paper. We refer the reader to the Supplementary Appendix for details on the data, on the model specification and on the estimation strategy. Here we offer a description of the structural shocks . In particular we focus our attention on (i) a US monetary policy shock; (ii) a global financial shock; (iii) a US demand shock; and (iv) a geopolitical risk shock.

US Monetary policy shocks. Following a now well established tradition, US monetary policy shocks are identified using an external instrument, namely the change in interest rate around policy announcements (so called interest rates surprises) as in (Jarocinski and Karadi, 2018).[3] We find that the effects of a monetary policy shock estimated via external instruments are qualitatively in line with those predicted by the theory. First, following a monetary tightening the VIX, the central variable for our analysis, rises. This shock also induces higher US short term rates, a fall in stock prices and in the prices of consumer goods, a rise in corporate bond yields and an appreciation of the exchange rate.

US Demand Shocks. Negative US demand shocks are identified via sign restrictions, by assuming that they generate a fall in interest rates, a drop in stock prices and a reduction in oil and consumer prices. The VIX rises, as risk aversion increases due to worsened economic conditions. Crucially, we assume that, conditional on this shock, the yield on High Yields Corporate bonds decreases, corresponding to a *loosening* in financing conditions for risky borrowers. Recessionary headwinds lead to higher risk premia, but these are more than offset by the reduction in the safe leg of the interest rate. Finally, the US dollar depreciates.

Financial shocks. A financial shock is identified using a mixture of sign and *narrative* restrictions, see Antolin-Diaz and Rubio-Ramirez (2016). Sign restrictions are consistent with those employed by Cesa Bianchi and Sokol (2017), who assume that, following a financial shock, the VIX rises and stock prices fall. Central banks

[3]We thank Marek Jarocinski for making these shocks available to us.

respond by loosening their stance, inducing a fall in government bonds yields. However, despite monetary policy accommodation, the financing costs for risky borrowers *rise*, as the increase in compensation required to bear the increased risk of default more than offsets the fall in safe interest rates. Also, the US dollar appreciates due to flight to safety. The different effects on the yields of corporate bonds and on the US dollar distinguish a financial shock from a demand shock. On top of these sign restrictions, we add the following two narrative restrictions:

1. The sharp rise in the VIX in September and October 2008, that is the onset of the global financial crisis, was mostly due to the financial shock.
2. The financial shocks in September and October 2008, were *positive* shocks, namely shocks leading to a deterioration of financing conditions.

Geopolitical uncertainty. We posit that a geopolitical uncertainty shock has similar macroeconomic consequences as a financial shock. In particular, increased geopolitical uncertainty has recessionary effects, as the VIX rises and equity prices fall. Short term interest rates also fall, as investors rotate from risky to safe assets and shift their portfolio exposure to short term bills, causing their yields to fall. A similar rationale leads to an appreciation of the US dollar. The peculiar features of such a shock is that it raises pressure on the price of oil and as a consequence on the inflation rate. This stagflationary effect distinguishes such a shock from a financial and a demand shock.[4]

Identification of the geopolitical shock is further refined by imposing the following narrative restrictions:

1. The rise in the VIX in August 1990 (related to the invasion of Kuwait by Iraq) and in September 2001 (related to the terrorist attacks in New York), was mostly due to a geopolitical shock.

[4]The signs used for this identification are obtained by running an exercise similar to the one used by Piffer and Podstawski (2017). In particular, we instrument the unexpected change in our global risk measure with the change in the price of gold in given dates identified with a narrative approach by Piffer and Podstawski (2017) but restricted to days also related to terrorist attacks and related concerns on the supply of oil (e.g. the invasion of Kuwait in 1990 or the 9/11 terrorist attack). The signs of the resulting IRFs are then used to identify geopolitical risk shocks.

2. The geopolitical shocks in August 1990 and September 2001, were *positive* shocks.

Table 1 summarizes the impact response of the variables included in our VARs to the four identified shocks.[5]

(Table 1 here)

2.1 Structural VAR results

To set the stage for the main analysis in Section 4, we briefly comment on some of the results obtained with the estimated structural VAR. First, in Figure 1 we show the estimated structural shocks. For those that are identified also through "narrative" restrictions (the financial and geopolitical shock), a red and a green vertical line mark the episodes of interest, namely: (i) the two months at the onset of the great financial crisis for the financial shock; and (ii) the invasion of Kuwait and the 9/11 attacks for the geopolitical risk shock. The narrative restrictions are effective in ensuring that in these periods these shocks contribute positively to the VIX. While the size of the remaining shocks is typically contained, financial shocks display some abrupt jumps, in particular in 2008, but also in May 2010 (around the downgrade of Greek bonds to the status of junk and the so called "flash crash" in the US stock market) and in late 2011, when the euro area sovereign debt crisis reached its peak.

Next we look at two results strictly related to the VIX, namely its Forecast Error Variance Decomposition (FEVD) and its historical decomposition in the contribution of structural shocks. Although related, the two concepts convey different information. Broadly speaking, the FEVD measures the average share (over the whole sample period) of fluctuations of a given variable, the VIX in our case, that is accounted for by the identified shocks. It therefore gives a broad idea of how much a given shock is relevant for explaining VIX fluctuations. The historical decomposition, instead, allows us to gauge whether a given shock was particularly relevant for the VIX *at a given point in time* and can therefore unveil some interesting historical patterns.

[5] For the monetary policy shock, where no signs are imposed *ex ante*, we report those resulting from the use of the external instrument.

Figure 2 shows the Forecast Error Variance Decomposition (FEVD) of the VIX, our measure of global risk. Financial shocks account for the largest share (around 40 percent) of variations in the VIX. US monetary policy and geopolitical shocks have a lower but nonetheless non-negligible impact, estimated at around 20 percent each. Next, in Figure 3, we turn to the historical decomposition of the VIX. The results confirm the dominant role of the financial shocks for explaining changes in global risk appetite. Indeed (i) the increase in the VIX in the second half of the 1990s, when the world economy was hit by the Asian crisis in 1997 and the Russian default in 1998, and (ii) the spike at the onset of the global financial crisis are mainly captured in our model by this shock. US monetary policy, on the other hand, gave a non-negligible support to global risk appetite in the early Nineties (when the Fed Fund rates were progressively cut from 8 to 3 percent). Notably, in the run up to the 2008 crisis, the contribution of monetary policy was counter-cyclical with respect to the VIX. Between 2003 and 2008 the VIX fell and remained at historically low levels, while the Federal Reserve raised official interest rates from 1 percent in 2004 to over 5 percent. At that time, a decisive boost to global risk appetite came from a sequence of benign financial shocks, which reflect the relaxation of credit standards that fuelled asset price bubbles, not only in the US, but also in a number of European countries.

Summing up, US monetary policy, financial and geopolitical risk shocks account for around 80 percent of the variance of the VIX. Their relevance is also time varying, with financial shocks having played a prominent role in the late Nineties and in the global financial crisis. US demand shocks, on the other hand, play a marginal role, and will therefore be dropped in the analysis in Section 4.

3 Data

We use long-term government bond yields in local currency terms for 40 advanced and emerging countries, on a monthly basis, from 1990 to 2018 (see Table 2 for the country sample).[6] The yields come from Global Financial Data, Thomson Reuters

[6]Note that the panel is unbalanced as bond yields are not available for a number of economies, in particular emerging markets, in the 1990s.

and Bloomberg.[7]

(Table 2 here)

The focus of our analysis is on the monthly *change* in government bond yields. The variability of government bond yields may be particularly high in some countries, especially in some emerging markets where yields may be structurally more volatile than in advanced economies.[8] Therefore, to ensure comparability of the results, we standardise the change in bond yields, Δy_{it}, dividing it by each country's standard deviation, σ_i.[9] This will be eventually our dependent variable in the empirical exercise. Formally:

$$\Delta \bar{y}_{it} = \Delta y_{it}/\sigma_i * 100 \tag{1}$$

Despite this standardisation, a number of outliers are still present in the dataset and may distort the results. This is also reflected in the elevated kurtosis of the change in bond yields. In order to deal with these outliers, we winsorise the standardised change in government bond yields at the 1% level. We use a similar procedure for the level of yields and for inflation, which also have very large outliers in emerging markets.

Control variables. We include the level of government bond yields in the previous month as a proxy of a "carry trade" type of behaviour, since high yielding currencies tend to receive capital flows when the volatility is low. Indeed, spikes in global financial market volatility are associated with sudden stops in capital flows (Forbes and Warnock, 2012) that penalise currencies and economies that have received large flows when the volatility was low. While this is traditionally associated with currencies, it may likewise matter for the government bond markets, since a lot of the inflows and outflows are concentrated in this asset segment.

[7]For most countries the benchmark maturity is the 10 year rate.

[8]See Table 3 for summary statistics for the whole sample. The standard deviation of the change in bond yields is around 50 basis points. Among advanced economies, this volatility measure drops to 40 basis points, whereas among emerging markets it increases to around 75 basis points.

[9]We exclude countries where bond yields are unusually flat, which normally denotes highly illiquid or inactive markets.

Second, we control for the presence of the classical policy trilemma in international macroeconomics and, more specifically, the possibility that countries that are open and adopting a less flexible exchange rate regime may experience capital flows reversals and a stronger transmission of risk shocks. Therefore, similarly to Obstfeld et al. (2018), we include the updated *de jure* Chinn and Ito (2006) index of capital account liberalisation and two dummies distinguishing strict pegs from soft pegs and from flexible exchange rate arrangements, using the *de facto* exchange rate arrangement classification by Obstfeld et al. (2010).

Finally, following Habib and Stracca (2012), we consider the possibility that the change in yields, Δy_{it}, is the outcome of a self-fulfilling prophecy or "inertia" in its historical relationship with global risk, which we measure through the change in the VIX, Δv_t. The idea here is that, in a crisis, investors flock to bonds that have proved themselves in previous crises, over and above the country fundamentals. Habib and Stracca (2012) show that this term is highly significant for currencies. Empirically, we recursively compute the following variable between the beginning of the sample t_0 and time $t-1$:

$$z_{it} = Correl_{t_0,t-1}(\Delta y_i, \Delta v) \tag{2}$$

A *negative* value for this variable identifies safe haven government bonds as it indicates that, in the past, yields decreased when the VIX increased.

Fundamentals. A number of economic fundamentals may influence the response of government bond yields to risk shocks. Uncovering these fundamentals is indeed the main objective of this paper.

First, we include variables capturing *recent macroeconomic developments*, namely real GDP growth and inflation, as these may unearth concerns about the underlying fiscal fundamentals, challenge debt sustainability and drive the reaction of yields to risk shocks.

Second, we control for *fiscal fundamentals*: the level of the government deficit and the size of public debt - including its squared term to control for a possible non-linear impact of this crucial variable - as a ratio to GDP.

Third, we consider indicators of *external sustainability*, including the current account balance and the stock of net foreign assets over GDP, since investors may rather buy government bonds of countries that have solid positions vis-à-vis non-residents when global risk is rising.[10]

The source of these variables is the IMF, with the exception of net foreign assets that are taken from the updated External Wealth of Nations dataset of Lane and Milesi-Ferretti (2007) and extended with the IMF Balance of Payments of Statistics.[11]

Fourth, *political risk and the quality of institutions* can further exacerbate debt sustainability concerns and affect the reaction of investors when risk aversion changes. We use the political risk rating index from the International Country Risk Group, a synthetic index measuring variables such as political unrest and the presence of conflicts, government stability, the investment climate, corruption, the rule of law and the quality of bureaucracy.[12]

Finally, the *size* of the debt market in each issuing country may be an important hallmark of a safe asset, as global investors may prefer to invest in large and potentially liquid markets; in particular, this might be the case for the US Treasuries market. To consider this fundamental, we use the countries' share of world public debt.[13]

With the exception of the *de jure* Chinn and Ito (2006) index of capital account liberalisation, all variables are measured in percentage terms.[14] Observe that not all variables are available at monthly frequency. For variables that are available at lower frequency, notably annual, we use a cubic spline interpolation lagging 12 months. Table 3 provides summary statistics for our database.

(Table 3 here)

[10]Other popular external sustainability measures, such as the level of foreign currency reserves as a ratio to imports or short-term external debt, are relevant for emerging markets, which are not the main (or at least the only) focus of our paper. Habib and Stracca (2012) find that external sustainability is the most consistent driver of safe haven currency status.

[11]Moreover, for public debt, IMF data have been complemented with OECD data for a number of countries, including in particular the United States.

[12]Note that an increase in the index indicates lower political risk.

[13]The inclusion of a specific bond market liquidity measure which is available for our panel of countries since the beginning of the 1990s is challenging. Therefore, we assume that the relative size of the debt market correlates positively with liquidity.

[14]The political risk rating is an index ranging from 0 (higher risk) to 100 (lower risk).

4 An empirical model of asset safety

We run fixed effects panel regressions on monthly data for a sample of 40 economies since 1990 as follows:

$$\Delta\bar{y}_{it} = \alpha_i + \lambda_t + \beta X_{i,t-1} + \gamma X_{i,t-1}\Delta v_t + \epsilon_{it} \tag{3}$$

where the dependent variable, $\Delta\bar{y}_{it}$, is the standardised monthly change in (local currency) government bond yields, α_i and λ_t are country and time fixed effects, Δv_t is the change in the VIX or, alternatively, another measure of global risk, and $X_{i,t-1}$ is a vector of "controls" *and* "country fundamentals" in the previous month (for variables with monthly frequency) or in the previous year (for variables at annual frequency that have been interpolated with a cubic spline). As explained in the previous section, controls include the level of yields and variables testing for the potential presence of a policy trilemma and self-fulfilling prophecies. These controls are always present in our regressions. Country fundamentals include real GDP growth, inflation, fiscal fundamentals, the external surplus and the external position, a measure of political risk in the form of rating, and the relative size of the government bond market. Fundamentals are included one by one and, eventually, all together.

The main parameter of interest is the coefficient γ that is associated with the interaction term, which indicates whether the control variables or the fundamentals in X may help explaining the response of government bond yields to an increase in global risk or one of its underlying drivers (structural shocks).

Is the safe asset status *conditional* on the shock driving the global risk change? In order to measure the role of the underlying shocks driving the observed change in global risk (DVIX), we apply an instrumental variables (IV) approach. We use each estimated structural shock as an *instrument* for DVIX in the baseline regression – more precisely for the interaction terms of DVIX with the fundamentals – in an exactly identified equation. The spirit of the exercise is to understand whether changes in DVIX that are driven by different structural shocks (by regressing DVIX on these shocks in the first stage regression) lead to different country characteristics being relevant as determinants of safe asset status.[15]

[15] Note that although estimated shocks are generated regressors, no adjustment of the standard

5 Results

Before describing the results in detail, it is useful to first provide an overview, also supported by Table A. Overall, the main results of our analysis are three. First, we find that a handful of variables predict the change in government bond yields when interacted with a rise in the VIX, with the theoretically expected sign: an inertial term (whether the asset behaved like a safe asset in the past), the political risk rating (a proxy for the quality of institutions of the issuing country) and the size of the debt market, mainly reflecting the special role of the US. Other traditional safe bonds, such as those issued by Germany, Switzerland, Japan and the United Kingdom, also do punch above their fundamentals in their safe asset behaviour. These "fundamentals of safe assets" are not only statistically, but also economically significant. However, and this is the second main result, the relevant fundamentals are significantly different between advanced and emerging countries. The political risk rating and the size of the debt market are important for advanced economies. In particular, the former appears to be a key variable for investors to discriminate between advanced and emerging markets. For emerging markets, instead, inertia, real GDP growth and external sustainability, in particular measured by the current account balance, are the fundamentals explaining their change in yields when risk aversion is on the rise. Third, we investigate the reasons that make the US special and find that many aspects of the US economy, from the size of its debt market to the dominance of the US dollar in central bank foreign currency reserves, play a role. Fourth and finally, we find that the shock driving the change in global risk (monetary policy, financial and geopolitical risk) have surprisingly little influence on the identification of the key drivers of safe asset status, although some variables (such as size of the debt market) predictably lose statistical significance when using IV.

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errors is needed. In general, the fact that an instrument z used for a regressor x is measured with error does not pose a problem as long as z satisfies the usual assumptions: being well correlated with x, but not correlated with the error process (Wooldridge, 2010).

Overview of the key results

	Inertia	Better risk rating	Large debt market	Other
Baseline	+	+	+	Low public debt to GDP ratio, Strong GDP growth
Advanced countries		+	+	Low public debt to GDP ratio (only post crisis)
Emerging countries	+			Strong GDP growth (only pre crisis), current account surplus (only post crisis)
US			+	Large share of US dollar in currency central banks foreign currency reserves
DVIX driven by financial shock	+	+		Low public debt to GDP ratio
DVIX driven by US monetary policy shock	+	+		Low public debt to GDP ratio, Strong GDP growth

Table A: A plus (+) sign in the table indicates that the characteristic indicated in each column contributes to a safe asset status of government bonds.

5.1 Baseline results for changes in the VIX

We begin by reporting, in Table 4, results for monthly changes in the VIX, without distinguishing by the shocks determining them, which we do later on. As noted, the terms that are interesting for our analysis are mostly the interaction terms between the change in the VIX and the predetermined country characteristics. The coefficients associated with the interaction terms are reported in the lower panel of the tables to facilitate the reader in identifying the variables that matter for the response of government bond yields to changes in global risk. The last column presents the results of a *best* most parsimonious benchmark model, where we include only those fundamentals that interacted with the change in the VIX remain statistically significant.

(Table 4 here)

Control variables. Among our control variables, we find that self-fulfilling prophecies, in particular, play a role in identifying safe haven government bonds, replicating an important result of Habib and Stracca (2012). The coefficient associated with the recursive correlation between the change in yields and the change in the VIX is positive and statistically significant at the 1% level. This implies that there is an important element of inertia in the reaction of yields to changes in global risk aversion, which comes on top of the impact of other fundamentals. Safe asset economies, i.e. those whose government bond prices increased and yields declined when the VIX increased in the past (a negative recursive correlation up to time $t-1$), are expected to remain a safe haven when the change in the VIX at time t is positive. In order to judge the economic significance of this result, note that a two standard deviation increase in the VIX, around 8 percentage points, would trigger a marginal decrease in yields by one basis point in a typical safe haven economy when the recursive correlation is equal to -10% (the average for the US, Germany or Switzerland) or an increase by almost 10 basis points in an emerging market, such as Brazil, where the recursive correlation is +30%.[16] Other controls are also significant in some specifications, but not when all fundamentals are jointly included in the model. In particular, higher yield economies experience a sharper increase in sovereign bond yields compared to low yield economies when financial market volatility rises, as expected, whereas the "trilemma" controls are almost always statistically insignificant.

Fundamentals. Turning to the fundamentals, we find results that are largely in line with our expectations. Political risk and the size of the economy appear to be the most robust predictors of safe haven government bonds. A higher (better) political risk rating (column 8) and a larger relative size of the debt market (insignificant in column 9, but significant in the overall best model) are associated with a decline in government bond yields after a VIX increase. Their statistical significance is robust to the inclusion of additional fundamentals (column 10). In particular, the economic significance of the coefficient associated with political risk rating is meaningful. An improvement in the risk rating by 10 points, say the difference between the level of this index in US or Japan in 2018 (85) and Italy or Spain (around 75) would imply a decline in yields by 5 basis points vis-á-vis a large shock to the VIX (again

[16] To recover the non-standardised change in yield, one needs to invert the relationship in equation (2). Among safe haven economies, the standard deviation of the change in yields is around 20 basis points, in the case of Brazil the standard deviation is much higher, 56 basis points.

8 percentage points). The differential reaction, i.e. the sharper decline, in yields to a strong global risk shock between a typical safe haven country and an emerging market like Mexico, where the risk rating is equal to 60 in 2018, would be around 13 basis points. The public debt to GDP ratio is also independently significant as a driver of safe asset status, although the coefficient is much smaller. Turning to the size of the debt market, note that an increase in the relative size of the debt market by 4 percentage points, more or less the difference between a relatively large safe haven such as Germany and an emerging market - would trigger a decline of 2 to 3 basis points for a two-standard deviation increase in the VIX. Finally, higher real GDP growth is statistically significantly associated with lower yields after a VIX increase, and the effect is relatively large and economically significant.

Other fundamentals are also important when included one by one, even though their statistical significance is weakened by the inclusion of other factors. Unsurprisingly, all fiscal fundamentals do matter in explaining the yield change when volatility rises. Apart from the result for the public debt to GDP already mentioned above, a higher fiscal deficit or a higher level of public debt is associated with an increase in government bond yields when Δv_t is positive (columns 2-4). Finally, indicators of external sustainability, the current account deficit and the net foreign asset position enter with the correct (negative) sign, but they are not statistically significant.

Table 5 gives an idea of the order of magnitudes involved in relation to historical episodes of large changes in the VIX (2 standard deviations or more). Conditional on being a month with a large shift in the VIX, we find that US yields tend to fall by 10 basis points, similar to the yields in other traditional safe bonds, whereas emerging market sovereign yields rise by 8 basis points (see upper panel 5a). In the lower panel of Table 5, we report the actual difference in the change in yields versus the US of three groups of economies – other safe havens such as Germany, Japan, Switzerland and the United Kingdom; other advanced economies and emerging markets – and the one predicted by our model, conditional on the difference in fundamentals against the US in 2018. In a typical episode of risk-off in global markets,a large positive VIX shock leads to a rise in the typical emerging market spread vs. the US by almost 20 basis points. Our baseline model estimates, reported in Table 5b, suggest that, taken together, the inertial term, size, and the risk rating *more than explain* the rise in this spread.[17]

(Table 5 here)

5.2 Some robustness analysis

In Table 6 we report some robustness analysis for the best specification in column 11 of Table 4. The robustness analysis pertains to the sample period (baseline, i.e. before the global financial crisis in 2008; and since 2010, i.e. the post crisis sample) and results are also reported separately for advanced and emerging markets. Some important differences emerge between advanced and emerging countries: the relevant fundamentals are completely different between the two groups. Whereas public debt to GDP, the political risk rating and debt size are important for advanced countries, the inertial term, growth and the current account matter for emerging countries (all with the expected sign). For emerging markets, we observe a rotation in the relevance of fundamentals in the post-crisis period, with growth becoming insignificant and a greater attention of investors to the current account balance. Some fundamentals, in particular the political risk rating, are insignificant for emerging markets, which suggests that investors treat these countries, to a large extent, as an homogeneous group at least from the standpoint of the quality of their institutions. Nevertheless, note that the political risk rating is important to distinguish advanced from emerging markets in the full sample.[18] By contrast, we find remarkable stability in the role of different fundamentals over time, in particular with the post crisis period not being very different from the previous sample, and the results not being driven by the global financial crisis.

[17] A caveat to this calculation is that, as we show later, the drivers of safe asset status are different between advanced and emerging markets. Also note that, because the regressors are not orthogonal, one cannot simply sum the contributions of each variable to summarise what the model explains.

[18] When we include both this variable and a dummy for emerging markets, only the first is significant; when excluding it, the emerging market dummy becomes strongly significant, with the expected sign: when the VIX rises on average bond yields rise in emerging markets.

Table 7 provides some further robustness analysis of the results for all countries. The first column reports again the best specifications in Table 6, while the second and the third replace the VIX as a measure of global risk with two alternatives, in order to assess the robustness to our chosen measure of global risk. The former is the excess bond premium of Gilchrist and Zakrajsek (2012), the latter is the Global Financial Condition Index by Arregui et al. (2018)[19]. The fourth column singles out large changes in the VIX by adding a triple interaction with a dummy taking value 1 if the monthly change in the VIX is above the 90th percentile ($DVIX > 90pct$). Two interesting results emerge from this robustness analysis. First, results are generally consistent when using alternative measures of global risk, at least qualitatively, which is not surprising because the alternatively measures are strongly correlated with the VIX. Second, the results are not driven by large shocks only, as the coefficients are practically the same as for all shocks and the coefficients for the triple interaction with the dummy for large shocks is insignificant.

(Tables 6 and 7 here)

5.3 How special is the US?

There is mounting evidence that the US dollar plays a special role in global financial markets as well as in international trade. The global status of the dollar is multi-faceted. It relates to the role of US global banks in cross-border financing (Cetorelli and Goldberg, 2011) as well as to the use of dollars by foreign corporates that face constraints in funding themselves in local currency (Bruno and Shin, 2015b). As a result, returns on risky assets have become increasingly correlated across markets and respond significantly to US monetary policy shocks (Miranda-Agrippino and Rey, 2015). The rising importance of the dollar is intertwined with its use as the main invoicing currency in international trade. Indeed, the fraction of goods and services invoiced in dollars is disproportionately high, compared to the role of the US economy in international trade (Goldberg and Tille, 2009; Gopinath et al., 2010). The lengthening of

[19]Note that their size is not the same as the VIX, and therefore the coefficients are not directly comparable in size.

global value chains has further reinforced this trend, as exporters that invoice in US dollars will also import in US dollars, as a natural hedge against fluctuations in the value of their revenues. Movements in the value of the dollar have therefore become increasingly correlated with global trade (Boz et al., 2017).[20] Finally, the centrality of the dollar shapes the composition of central banks reserves: as economies become more leveraged in dollars, lenders of last resort must be able to provide dollar liquidity in times of stress (Gopinath and Stein, 2018b).

The adoption of the dollar as the main invoicing and financing currency has direct consequences for the safeness of US bonds and, consequently, for our analysis. By definition, a safe asset must maintain its value (i.e. its purchasing power in a given currency) in bad states of the world. Therefore, consumers and firms tend to hold dollar denominated assets as a buffer to smooth their consumption of goods priced in dollars (Gopinath and Stein, 2018a) as well as to be able to meet dollar debt repayment in times of stress.[21].

To analyse whether the US is special compared to other traditional safe havens (Germany, Japan, Switzerland and the UK), we perform two additional exercises based on our baseline regression. The results are shown in Table 8, where in the first column we report for convenience our baseline specification. First, we include two dummies, one for the US and one to identify other safe havens. In this first exercise, we keep *size* among the fundamentals, to ensure that it is not the size of these markets that is driving the results. The second column in Table 8 confirms that bonds issued by economies that are traditionally considered safe havens are indeed special, behaving as safe assets over and above what is predicted by their fundamentals, which suggests the existence of potential "branding" effects. However, the coefficient associated with the dummy for the US, although negative, is *not* statistically significant. The third column presents some evidence that market size is key in explaining the result for the US. When

[20] See, for instance "What is behind the recent slowdown?" presentation by Hyun Song Shin at the "Public Finance Dialogue" workshop arranged by German Federal Ministry of Finance and Centre for European Economic Research (ZEW), Berlin, 14 May 2019, available at https://www.bis.org/speeches/sp190514.htm.

[21] Empirical evidence confirms that investors have been willing to pay a rising premium to hold US government bonds, leading a fall in the natural rate of interest in the US (Del Negro et al., 2017)

excluding the relative size of the government bond market from the fundamentals, the US dummy is statistically significant with an impact twice as large as that of other safe havens.[22] Taken together, these regressions suggest that the special role of US bonds as safe assets is partly related to the depth and liquidity of the Treasuries market (He et al., 2016) and, on the other hand, that there are other "safe haven" countries that are disproportionately attractive (at least relative to their market size) in times of financial stress. Of course, the size of the debt market is only one of the aspects that make the US special. In the fourth column of Table 8, for instance, we replace the variable *size* with the currency share in central banks reserves (variable *cofer*), a proxy for the dominance of the US dollar in the international monetary system.[23] This regression confirms that there is a significant correlation between the value that central banks attach to some currencies (strongly skewed towards the dollar) and the tendency of assets denominated in that currency to behave as a safe haven in times of stress.

(Table 8 here)

5.4 Does the shock driving the VIX matter?

Finally, in Table 9 we turn to the question of whether the *underlying driver* of the changes in global risk matters for the determinants of safe assets. Do investors distinguish the source of the shock in global risk in pricing government bonds following the shock? Are safe assets the same whether the VIX is hit by a financial shock (say, Lehman) or by a tightening of US monetary policy, in particular?

As anticipated in Section 4, in the table we report (for all countries and advanced and emerging countries separately) the best specifications of Table 6 and then compare these estimates with instrumental variables (IV) estimates where DVIX is instrumented each time with a different shock (US monetary policy, financial and geopolitical risk). In these regressions, we therefore include the part of DVIX that is driven by each

[22]A Wald test confirms that this difference is statistically significant.

[23]On average, in our sample, more than 60 percent of total allocated official foreign exchange reserves are held in US dollars.

shock, accounting for the impact that this has on standard errors. Note that, judging from the first stage F statistic, some of these IV regressions have weak instruments, in particular those associated with the identification through geopolitical shocks. This is not surprising as changes in the VIX, as discussed earlier and shown in Figure 2, are largely explained by financial shocks and monetary policy shocks.[24] Overall, we find that results are remarkably consistent and therefore hold irrespective of the source driving the change in DVIX, although predictably statistical significance diminishes with IV estimates. In almost no case we can reject the null that the relevant coefficients are different between the OLS and the IV estimates, which of course may at least partly reflect limited statistical significance.[25]

(Table 9 here)

6 Conclusions

Motivated by the recent academic and policy interest in safe assets, in this paper we have provided novel empirical evidence on the fundamental drivers of safe asset status. Looking at a sample of monthly changes in government bond yields in 40 advanced and emerging countries between 1990 and 2018, we have interacted changes in the VIX (as a measure of global risk) with a wide array of pre-determined country fundamentals and controls, so as to uncover a set of variables that consistently predict safe asset status, in the same spirit of Habib and Stracca (2012) for safe haven currencies. Moreover, and also novel, we have decomposed the VIX in its underlying determinants by identifying a set of relevant structural shocks, notably US monetary policy, financial, and geopolitical uncertainty shocks. We then check if the relevant country fundamentals for safe asset status are shock-dependent or not.

[24]In the case of financial and monetary policy shock a weak-instrument-robust test of the relevant coefficients confirms that they are jointly statistically different from zero.

[25]Note that some coefficients for interaction terms become larger when DVIX is explaned by geopolitical risk shocks, but we tend to dismiss this result as likely due to weak instruments, given the low first stage F statistic.

The shortlist of the "safe asset fundamentals", which are found to exert a statistically and economically significant influence, contains an *inertial* term (namely whether the asset behaved like a safe asset in the past), the political risk *rating* (quality of institutions of the issuing country), and the *size* of the debt market, the latter mainly reflecting the special role of the US. At the same time, the relevant fundamentals are significantly different between advanced and emerging countries. Political risk rating and size of the debt market are important for advanced countries only, and inertia, real GDP and external sustainability (measured by the current account; only significant post crisis) for emerging markets only. There is no single fundamental that summarizes the special role of the US as a safe haven. For instance, both the size of its market as well as the dominance of the US dollar in foreign currency reserves capture somewhat the special role of the US economy in global financial markets in times of stress. Finally, we find little influence from the shock driving the change in global risk (monetary policy, financial and geopolitical risk) for the identification of the key drivers of safe asset status, although the loss of statistical significance when using IV complicates this assessment.

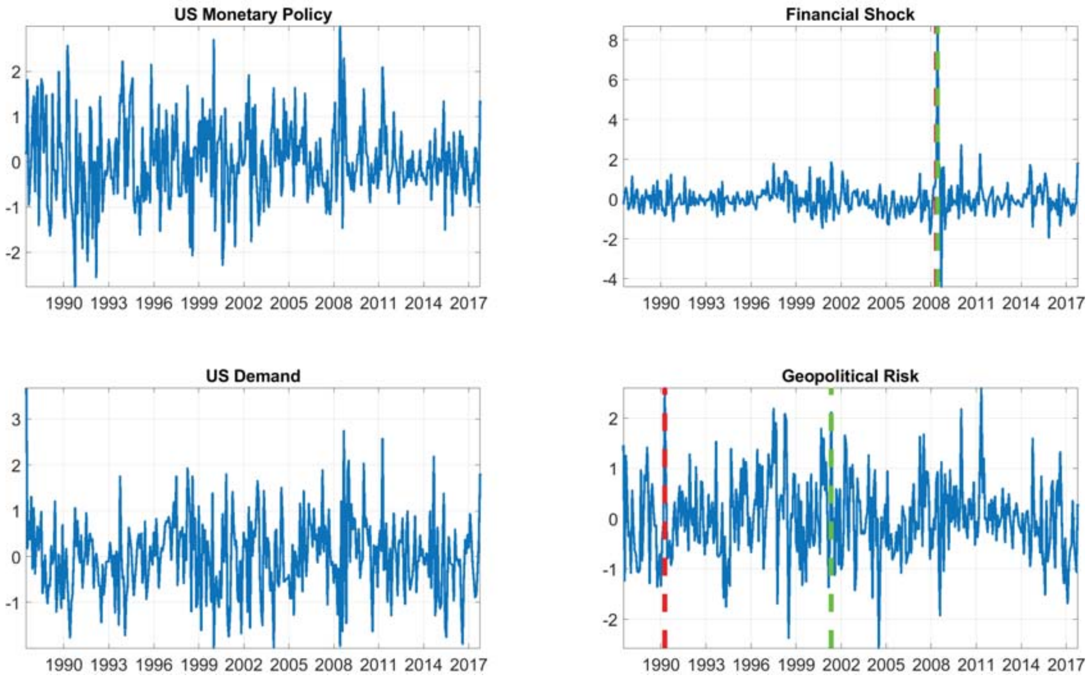
The policy implications of our work is that country fundamentals do play some role in explaining the safe asset status of government and that some of them (for example, the political risk rating, or public debt) can be influenced by policy makers. Our paper gives, in particular, a quantification of the benefits of changing these policy-amenable variables for the cost of financing the government debt, in particular when financial market volatility is on the rise. The relevance of the size of the debt market indicates that, at least as regards the role of this fundamental, only a limited number of actors can act as safe haven, with key implications for the developments of the international monetary system, thinking in particular at the emergence of an international role of the Chinese renminbi or the creation of a euro area safe asset.

Table 1: Sign Restrictions used to identify shocks in the Structural VAR model

Shock	*Monetary Policy (signs implied by external instrument)*	US Demand	Financial	Geopolitical Uncertainty
US Treasury Rate (one-year)	+	-	-	-
SP500 (log)	-	-	-	-
US Consumer Price Index (log)	-	-	-	+
High Yield USD Corporate Bonds (yield)	+	-	+	
Trade Weighted US Dollar index (log)	+	-	+	+
Oil Price (Brent Quality, log)		-	-	+
VIX	+	+	+	+

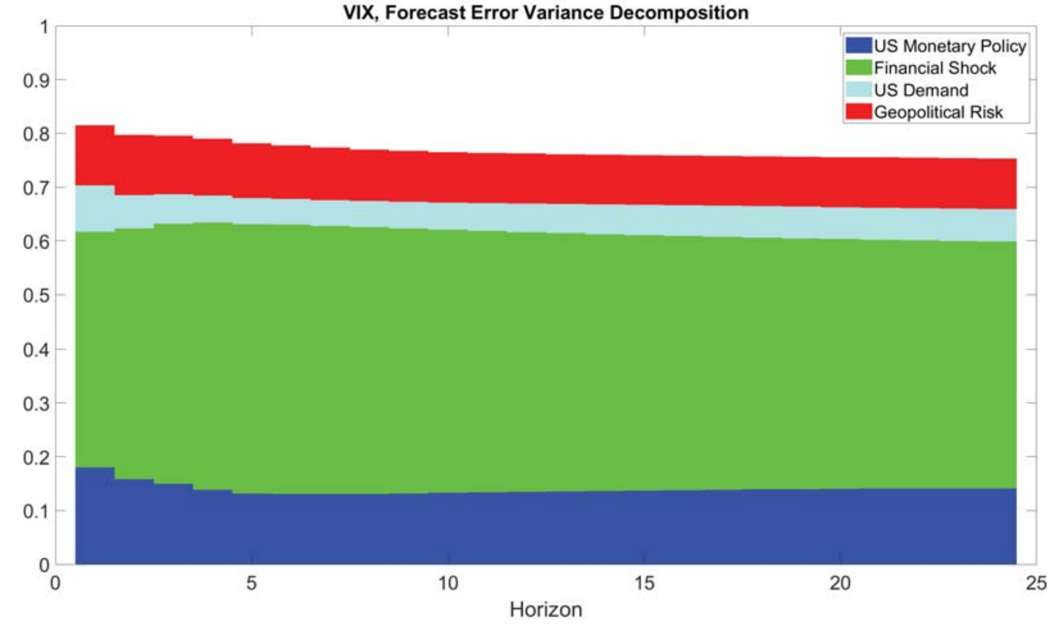
Notes: sign restrictions to identify US demand, Financial and Geopolitical Uncertainty shocks are imposed on impact. The first column reports the signs of the responses generated by the monetary policy shocks estimated via an external instrument.

Figure 1: Estimated structural shocks



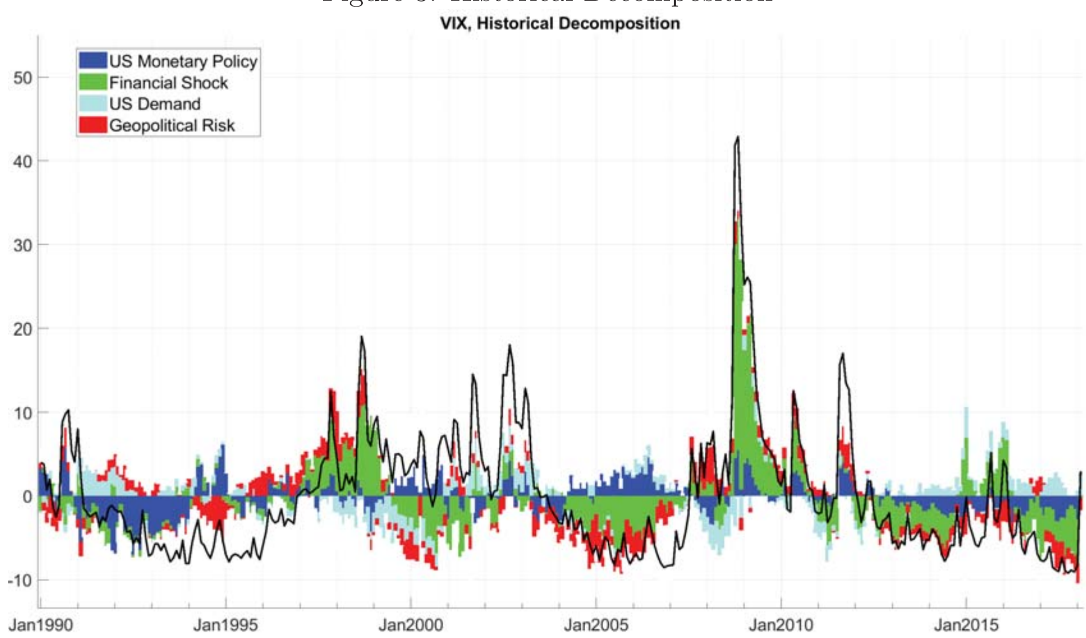
Notes: the red and green dashed lines in the "Financial Shock" panel mark the September and October 2008 observations, the dates on which we impose "narrative restrictions" to identify this shock. The red and green dashed lines in the "Geopolitical Risk" panel mark the August 1990 and September 2001 observations, the dates on which we impose "narrative restrictions" to identify this shock. Median shocks across posterior draws.

Figure 2: Forecast Error Variance Decomposition (FEVD)



Notes: the Figure shows the mean FEVD across posterior draws of the VAR.

Figure 3: Historical Decomposition



Notes: the Figure shows the median contribution of the identified shocks to the history of the VIX across posterior draws of the VAR.

Table 2: Country sample

Advanced economies	United States, United Kingdom, Austria, Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Sweden, Switzerland, Canada, Japan, Finland, Greece, Ireland, Portugal, Spain, Australia, New Zealand, Hong Kong, Singapore
Emerging economies	Turkey, South Africa, Brazil, Chile, Colombia, Mexico, Peru, Israel, India, Indonesia, Republic of South Korea, Malaysia, Pakistan, Thailand, Russian Federation, China, Czech Republic

Table 3: Summary statistics

	Mean	SD	Min	Max	p1	p99	Skewness	Kurtosis	Obs.
Long-term government bond yield, %	5.88	3.86	-0.57	48.62	0.21	16.63	1.79	11.98	11,802
Yield change, basis points	-2.37	53.93	-1,563	3,211	-112.0	107.0	16.73	1,205	11,339
Yield change/St.Dev, % (DYIELD)	-8.01	100.5	-1,056	1,419	-281.3	267.7	0.16	11.88	11,339
VIX, index	19.31	7.43	9.51	59.89	10.41	44.84	1.72	7.61	13,920
VIX change, index (DVIX)	0.00	4.15	-15.28	20.50	-11.04	16.31	0.84	7.90	13,880
Recursive correl. (DYIELD, DVIX), %	5.72	16.24	-73.9	74.9	-28.43	51.53	0.61	4.45	11,198
Capital account liberalisation, index	0.74	0.34	0.00	1.00	0.00	1.00	-0.83	2.08	13,671
Strict peg, dummy	0.35	0.48	0.00	1.00	0.00	1.00	0.63	1.40	13,848
Soft peg, dummy	0.28	0.45	0.00	1.00	0.00	1.00	0.96	1.92	13,848
Domestic GDP growth, %	3.09	2.98	-14.07	22.32	-5.01	10.37	-0.06	5.59	13,334
Inflation, %	6.04	19.18	-4.58	308.0	-0.99	61.88	10.80	141.6	13,370
General govt. deficit, % of GDP	1.90	4.37	-20.24	32.00	-13.58	11.10	-0.64	7.03	12,976
Public debt, % of GDP	59.95	36.62	0.05	237.1	0.89	183.3	1.47	6.74	12,143
Current account, % of GDP	0.80	5.35	-14.48	26.06	-9.96	17.36	1.05	4.93	13,719
Net foreign assets, % of GDP	-6.49	63.74	-199.3	415.9	-129.7	271.8	2.33	11.53	13,430
Political Risk Rating, index	74.73	12.08	27.00	97.00	43.00	93.50	-0.72	2.95	13,408
Share of world public debt (%)	2.45	6.19	0.00	49.23	0.00	30.85	4.18	21.55	12,143

Table 4: Change in yields and fundamentals

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Govt. bond yield, t-1 (YIELD)	-4.43***	-4.67***	-4.45***	-4.74***	-4.89***	-4.88***	-4.78***	-4.57***	-4.73***	-5.12***	-4.31***
	(1.01)	(1.04)	(1.02)	(1.14)	(1.14)	(1.04)	(1.01)	(0.99)	(1.12)	(1.12)	(0.94)
De jure capital account openness, t (KAOPEN)	-1.24	-0.68	-6.97	-8.21	-8.34	-6.68	-6.36	-4.82	-8.42	-5.98	
	(9.90)	(10.54)	(8.95)	(9.93)	(10.02)	(9.53)	(9.54)	(9.68)	(9.79)	(10.54)	
Strict peg, t (STRICT PEG)	-6.12	-6.03	-7.62*	-9.16**	-9.61**	-6.68	-8.05*	-6.94	-8.90**	-8.86*	
	(3.96)	(4.08)	(4.06)	(4.09)	(4.14)	(4.18)	(4.61)	(4.20)	(4.10)	(4.51)	
Soft peg, t (SOFT PEG)	-2.89	-2.77	-3.44	-3.23	-3.47	-2.37	-3.65	-3.20	-3.15	-2.08	
	(2.46)	(2.48)	(2.84)	(2.80)	(2.79)	(2.79)	(2.86)	(2.75)	(2.75)	(2.90)	
Correl.[DYIELD, DVIX] t0,t-1 (INERTIA)	-0.14	-0.13	-0.17	-0.17*	-0.18*	-0.22**	-0.24**	-0.23**	-0.18*	-0.21**	-0.19*
	(0.09)	(0.09)	(0.10)	(0.10)	(0.10)	(0.11)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)
Real GDP growth, t-12 (GROWTH)	0.46									0.44	0.50
	(0.55)									(0.54)	(0.55)
Inflation, t-12 (INFLATION)		0.24								-0.20	
		(0.28)								(0.58)	
Fiscal deficit, % of GDP, t-12 (DEFICIT)			-0.24							-0.30	
			(0.30)							(0.28)	
Public debt, % of GDP, t-12 (DEBT)				0.01						-0.22**	-0.00
				(0.07)						(0.11)	(0.08)
DEBT squared, t-12 (DEBT SQ)					0.00					0.00***	
					(0.00)					(0.00)	
Current account, % of GDP, t-12 (CA)						-1.06***				-1.00***	
						(0.24)				(0.21)	
Net foreign assets, % of GDP, t-12 (NFA)							-0.06*			-0.03	
							(0.03)			(0.03)	
Political risk rating , t-12 (RATING)								0.09		-0.18	-0.02
								(0.20)		(0.24)	(0.24)
Share of world debt market, %, t-12 (SIZE)									0.30	1.02***	0.63***
									(0.31)	(0.31)	(0.21)
DVIX * YIELD	0.44***	0.48***	0.44***	0.44***	0.45***	0.46***	0.48***	0.36***	0.43***	0.17	
	(0.12)	(0.11)	(0.12)	(0.12)	(0.12)	(0.13)	(0.12)	(0.11)	(0.12)	(0.12)	
DVIX * KAOPEN	-1.17	0.08	0.29	-0.27	-0.21	0.03	0.22	3.41**	0.14	2.42	
	(1.16)	(1.10)	(1.01)	(1.02)	(1.04)	(1.02)	(1.02)	(1.65)	(1.03)	(1.62)	
DVIX * STRICT PEG	0.33	0.33	0.05	0.11	0.21	0.23	0.20	-0.00	0.11	-0.64	
	(0.58)	(0.61)	(0.63)	(0.58)	(0.57)	(0.62)	(0.63)	(0.54)	(0.61)	(0.46)	
DVIX * SOFT PEG	0.59	0.31	0.41	0.32	0.40	0.47	0.34	0.13	0.20	0.11	
	(0.60)	(0.60)	(0.64)	(0.60)	(0.59)	(0.64)	(0.63)	(0.60)	(0.58)	(0.56)	
DVIX * INERTIA	0.06***	0.06***	0.06***	0.06***	0.06***	0.06***	0.06***	0.04**	0.06***	0.05**	0.07***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
DVIX * GROWTH	-0.24**									-0.17	-0.28***
	(0.11)									(0.11)	(0.10)
DVIX * INFLATION		0.03								-0.13	
		(0.07)								(0.12)	
DVIX * DEFICIT			0.12**							0.02	
			(0.05)							(0.06)	
DVIX * DEBT				0.01**						0.00	0.01**
				(0.00)						(0.01)	(0.01)
DVIX * DEBT SQ					0.00***					0.00	
					(0.00)					(0.00)	
DVIX * CA						-0.05				-0.04	
						(0.04)				(0.04)	
DVIX * NFA							-0.00			-0.00	
							(0.00)			(0.00)	
DVIX * RATING								-0.16***		-0.18***	-0.16***
								(0.05)		(0.05)	(0.03)
DVIX * SIZE									-0.02	-0.12***	-0.10***
									(0.05)	(0.02)	(0.02)
Observations	10,666	10,666	10,791	10,458	10,458	10,928	10,928	10,919	10,458	10,292	10,351
Countries	40	40	40	40	40	40	40	40	40	40	40
R-squared	0.37	0.37	0.37	0.38	0.38	0.37	0.37	0.37	0.38	0.38	0.38

Notes: the dependent variable is the standardised change in government bond yields (DYIELD). The sample includes monthly observations from 1990 to 2018 for 40 advanced and emerging economies. The model includes country-specific fixed effects and time fixed effects. Robust standard errors are reported in parentheses. The asterisks ***, ** and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

Table 5a: Actual change in yields conditional to large VIX shock and the underlying fundamentals in 2018

	When DVIX > 2 St. Dev.	Fundamentals in 2018				
	Change in yields (bp)	Inertia (%)	Real GDP growth (%)	Debt (% of GDP)	Political risk rating (index)	Size (% of world debt)
US	-10	-11	2.5	136.6	85.0	33.6
Other safe havens	-9	-7	1.7	106.5	83.9	5.1
Other advanced	-3	-2	2.6	76.3	81.9	0.8
Emerging	8	11	3.6	46.4	63.9	1.0

Table 5b: Impact of a large VIX shock on yields: actual difference with the US versus that predicted by fundamentals

	Change in yields (basis points)					
	Actual difference vs. US	Predicted difference by fundamentals vs. the US				
		Inertia	Growth	Debt	Rating	Size
Other safe havens	1	0.5	0.4	-0.5	0.3	5.0
Other advanced	7	2.4	0.0	-2.2	1.8	12.0
Emerging	18	9.5	-1.8	-5.6	21.0	20.3

Notes: "Other safe havens" reports the average for Germany, Japan, Switzerland and the United Kingdom; "Other advanced" includes the remaining advanced economies excluding the US and "Other safe havens". To obtain the predicted difference of the change in yield versus the US conditional to a large shock, we calculate the partial differential with respect to a two standard deviation change in the VIX, corresponding to 8.3 percentage points. Formally, following the notation in equation (3) in the main text:

$$\Delta \bar{y}_j = \gamma(X_j - X_{US}) * 8.3$$

where the subscript j indicates the average of the three groups (other safe havens, other advanced and emerging economies), $\Delta \bar{y}_j$ is the standardised change in yields, X are the fundamentals and γ the coefficients for the interaction terms in column 11 of Table 4. As our dependent variable has been standardized, to recover the original change in yields, it is necessary to invert the terms in equation (1) and use the standard deviation of the change in yields within each group (21 bps for safe havens, 44 bps for other advanced economies, 75 bps for emerging markets):

$$\Delta y_j = \sigma_j * \Delta \bar{y}_j / 100$$

Table 6: Change in yields and fundamentals:robustness across groups and time

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Full sample			Advanced			Emerging		
	1990 2018	1990 2007	2010 2018	1990 2018	1990 2007	2010 2018	1990 2018	1990 2007	2010 2018
Govt. bond yield, t-1 (YIELD)	-4.31***	-6.38***	-6.45***	-3.54**	-5.90***	-5.86***	-5.87***	-7.00**	-6.82***
	(0.94)	(1.05)	(0.96)	(1.26)	(1.80)	(1.45)	(1.30)	(2.62)	(1.92)
Correl.[DYIELD, DVIX] t0,t-1 (INERTIA)	-0.19*	-0.61**	-0.84***				-0.00	0.20	-0.47*
	(0.10)	(0.25)	(0.25)				(0.14)	(0.39)	(0.24)
Real GDP growth, t-12 (GROWTH)	0.50	1.77***	-0.05				0.50	0.69	2.08**
	(0.55)	(0.63)	(1.00)				(0.67)	(1.41)	(0.94)
Public debt, % of GDP, t-12 (DEBT)	-0.00	-0.04	-1.12***	0.01	-0.03	-1.17***			
	(0.08)	(0.14)	(0.21)	(0.08)	(0.13)	(0.23)			
Political risk rating , t-12 (RATING)	-0.02	-0.07	0.08	-0.22	-0.67*	0.89			
	(0.24)	(0.46)	(0.69)	(0.22)	(0.34)	(0.91)			
Share of world debt market, %, t-12 (SIZE)	0.63***	1.41**	1.64	0.49	0.76	1.70			
	(0.21)	(0.68)	(2.27)	(0.37)	(0.86)	(2.66)			
Current account, % of GDP, t-12 (CA)							-0.22	1.04**	-1.43
							(0.39)	(0.47)	(1.02)
DVIX * INERTIA	0.07***	0.06*	0.06***				0.07***	0.07***	0.05**
	(0.02)	(0.03)	(0.02)				(0.01)	(0.02)	(0.02)
DVIX * GROWTH	-0.28***	-0.31	0.01				-0.40***	-0.81***	0.11
	(0.10)	(0.21)	(0.13)				(0.12)	(0.18)	(0.14)
DVIX * DEBT	0.01**	-0.00	0.03***	0.02**	0.01	0.02**			
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)			
DVIX * RATING	-0.16***	-0.23***	-0.16***	-0.25***	-0.02	-0.39***			
	(0.03)	(0.03)	(0.04)	(0.05)	(0.08)	(0.08)			
DVIX * SIZE	-0.10***	-0.10***	-0.17***	-0.11***	-0.11***	-0.16***			
	(0.02)	(0.03)	(0.03)	(0.02)	(0.04)	(0.03)			
DVIX * CA							-0.14**	0.09	-0.15*
							(0.05)	(0.19)	(0.07)
Observations	10,351	5,191	4,277	7,230	4,196	2,482	3,479	1,353	1,795
Countries	40	35	40	23	23	23	17	12	17
R-squared	0.38	0.42	0.33	0.53	0.55	0.47	0.28	0.30	0.28

Notes: the dependent variable is the standardised change in government bond yields (DYIELD). The model includes country-specific fixed effects and time fixed effects. Robust standard errors are reported in parentheses. The asterisks ***, ** and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

Table 7: Change in yields and fundamentals:different proxies of global risk and large shocks

	(1)	(2)	(3)	(4)
	Change in VIX	Excess bond premium	Global financial conditions	Large shocks
Proxy of Global Risk	DVIX	DEBP	DGFCI	DVIX
Govt. bond yield, t-1 (YIELD)	-4.31***	-4.46***	-3.88***	-4.35***
	(0.94)	(0.94)	(1.03)	(0.91)
Correl.[DYIELD, DVIX] t0,t-1(INERTIA)	-0.19*	-0.21**	-0.14*	-0.24**
	(0.10)	(0.09)	(0.08)	(0.10)
Real GDP growth, t-12 (GROWTH)	0.50	0.56	0.67	0.64
	(0.55)	(0.57)	(0.65)	(0.55)
Public debt, % of GDP, t-12 (DEBT)	-0.00	0.00	-0.02	0.00
	(0.08)	(0.08)	(0.07)	(0.08)
Political risk rating , t-12 (RATING)	-0.02	-0.04	0.11	-0.03
	(0.24)	(0.25)	(0.30)	(0.23)
Share of world debt market, %, t-12 (SIZE)	0.63***	0.59***	-0.20	0.62***
	(0.21)	(0.21)	(0.47)	(0.20)
Global Risk * INERTIA	0.07***	0.29	-0.06	0.04*
	(0.02)	(0.29)	(0.41)	(0.02)
Global Risk * GROWTH	-0.28***	-4.99***	-9.77**	-0.17*
	(0.10)	(1.50)	(4.61)	(0.10)
Global Risk * DEBT	0.01**	0.19**	0.88***	0.02**
	(0.01)	(0.09)	(0.20)	(0.01)
Global Risk * RATING	-0.16***	-2.02***	-5.77***	-0.17***
	(0.03)	(0.41)	(1.15)	(0.04)
Global Risk * SIZE	-0.10***	-2.67***	-7.69***	-0.09***
	(0.02)	(0.56)	(1.82)	(0.02)
Global Risk * INERTIA * DVIX>90pct				0.06*
				(0.03)
Global Risk * GROWTH * DVIX>90pct				-0.24
				(0.27)
Global Risk * DEBT * DVIX>90pct				-0.00
				(0.01)
Global Risk * RATING * DVIX>90pct				0.01
				(0.05)
Global Risk * SIZE * DVIX>90pct				-0.04
				(0.03)
Observations	10,351	10,351	9,641	10,351
Countries	40	40	40	40
R-squared	0.38	0.38	0.37	0.38

Notes: the dependent variable is the standardised change in government bond yields (DYIELD). The model includes country-specific fixed effects and time fixed effects. DEBP is the change in the excess bond premium from Gilchrist, S. and E. Zakrajsek (2012) "Credit Spreads and Business Cycle Fluctuations" American Economic Review, Vol. 102, pp. 1692-1720. DGFCI is the change in the global financial condition index calculated similarly to Arregui N., S. Elekdag, R. G Gelos, R. Lafarguette and D. Seneviratne (2018), "Can Countries Manage Their Financial Conditions Amid Globalization?", IMF Working Paper No. 18/15. DVIX>90pct is a dummy equal to 1 when the change in VIX is above the 90^{th} percentile of its distribution. The asterisks ***, ** and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

Table 8: Change in yields and fundamentals: the United States, the dollar and other safe haven economies

	(1)	(2)	(3)	(4)
	Benchmark model	Safe havens	Safe havens excluding size	Including currency share in int. reserves
Govt. bond yield, t-1 (YIELD)	-4.31***	-4.31***	-4.35***	-4.31***
	(0.94)	(0.94)	(0.94)	(0.93)
Correl.[DYIELD, DVIX] t0,t-1 (INERTIA)	-0.19*	-0.19*	-0.18*	-0.21**
	(0.10)	(0.10)	(0.10)	(0.10)
Real GDP growth, t-12 (GROWTH)	0.50	0.49	0.48	0.49
	(0.55)	(0.55)	(0.55)	(0.54)
Public debt, % of GDP, t-12 (DEBT)	-0.00	-0.00	-0.00	-0.01
	(0.08)	(0.08)	(0.08)	(0.07)
Political risk rating , t-12 (RATING)	-0.02	-0.02	-0.03	-0.08
	(0.24)	(0.24)	(0.24)	(0.25)
Share of world debt market, %, t-12 (SIZE)	0.63***	0.64***		
	(0.21)	(0.21)		
Currency share in int. reserves, % t-12 (COFER)				-0.45**
				(0.20)
DVIX * INERTIA	0.07***	0.06***	0.06***	0.06***
	(0.02)	(0.02)	(0.02)	(0.02)
DVIX * GROWTH	-0.28***	-0.30***	-0.30***	-0.30***
	(0.10)	(0.11)	(0.11)	(0.11)
DVIX * DEBT	0.01**	0.01*	0.01**	0.01*
	(0.01)	(0.01)	(0.00)	(0.00)
DVIX * RATING	-0.16***	-0.16***	-0.16***	-0.16***
	(0.03)	(0.03)	(0.03)	(0.03)
DVIX * SIZE	-0.10***	-0.03		
	(0.02)	(0.07)		
DVIX * US		-1.98	-2.89***	
		(1.79)	(0.36)	
DVIX * OTHER SAFE		-1.35**	-1.51***	
		(0.59)	(0.48)	
DVIX * COFER				-0.06***
				(0.01)
Observations	10,351	10,351	10,351	10,351
Countries	40	40	40	40
R-squared	0.38	0.38	0.38	0.38

Notes: the dependent variable is the standardised change in government bond yields (DYIELD). The model includes country-specific fixed effects and time fixed effects. US is a dummy equal to 1 for the United States. OTHER SAFE is a dummy equal to 1 for Germany, Japan, Switzerland and the United Kingdom. Robust standard errors are reported in parentheses. The currency share in international reserves is obtained from the IMF Currency Composition of Foreign Exchange Reserves (COFER) dataset, downloaded from Haver. Currency shares are obtained as a share of total "allocated" reserves. For the following euro area countries, Germany, France and the Netherlands, this variable includes the share of their respective legacy currencies including their weight in reserves denominated in ECU until 1998 and the share of the euro since 1999. For all other euro area countries, the currency share is set to zero. The asterisks ***, ** and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

Table 9: Change in yields and fundamentals: instrumenting the change in VIX with the underlying shocks

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Full sample				Advanced				Emerging			
Estimator	FE	IV	IV	IV	FE	IV	IV	IV	FE	IV	IV	IV
Instrument		Mon. policy shock	Financial shock	Geopolitcal shock		Mon. policy shock	Financial shock	Geopolitcal shock		Mon. policy shock	Financial shock	Geopolitcal shock
Govt. bond yield, t-1 (YIELD)	-4.31***	-4.08***	-4.28***	-4.40***	-3.54**	-3.37**	-3.44***	-2.80*	-5.87***	-5.99***	-5.87***	-5.85***
	(0.94)	-0.91	(0.89)	(0.94)	(1.26)	-1.34	(1.32)	(1.47)	(1.30)	(1.03)	(1.02)	(1.04)
Correl.[DYIELD, DVIX] t0,t-1 (INERTIA)	-0.19*	-0.15	-0.17	-0.24*					-0.00	0.07	0.07	0.07
	(0.10)	-0.13	(0.12)	(0.14)					(0.14)	(0.15)	(0.16)	(0.17)
Real GDP growth, t-12 (GROWTH)	0.50	0.33	0.64	0.27					0.50	0.04	0.30	0.33
	(0.55)	-0.56	(0.53)	(0.59)					(0.67)	(0.79)	(0.75)	(0.79)
Public debt, % of GDP, t-12 (DEBT)	-0.00	0	-0.00	0.00	0.01	0	0.00	0.00				
	(0.08)	-0.06	(0.05)	(0.06)	(0.08)	-0.06	(0.06)	(0.07)				
Political risk rating , t-12 (RATING)	-0.02	0.07	-0.05	-0.13	-0.22	-0.19	-0.26	-0.21				
	(0.24)	-0.28	(0.27)	(0.31)	(0.22)	-0.3	(0.29)	(0.35)				
Share of world debt market, %, t-12 (SIZE)	0.63***	1.03	0.83	0.49	0.49	1.2	0.51	-0.07				
	(0.21)	-1.46	(0.86)	(1.17)	(0.37)	-1.41	(0.74)	(1.13)				
Current account, % of GDP, t-12 (CA)									-0.22	-0.16	-0.10	-0.07
									(0.39)	(0.50)	(0.49)	(0.50)
DVIX * INERTIA	0.07***	0.21***	0.17***	-0.13					0.07***	0.08	0.21***	0.23**
	(0.02)	-0.07	(0.05)	(0.14)					(0.01)	(0.06)	(0.07)	(0.10)
DVIX * GROWTH	-0.28***	-1.57***	-0.04	-1.45					-0.40***	-2.05***	0.04	0.29
	(0.10)	-0.4	(0.36)	(0.89)					(0.12)	(0.58)	(0.47)	(1.27)
DVIX * DEBT	0.01**	-0.01	0.02	0.03	0.02**	0.07*	0.03*	0.10				
	(0.01)	-0.03	(0.02)	(0.06)	(0.01)	-0.04	(0.02)	(0.06)				
DVIX * RATING	-0.16***	-0.22***	-0.15**	-0.68***	-0.25***	-0.16	-0.38***	-1.14*				
	(0.03)	-0.08	(0.06)	(0.21)	(0.05)	-0.23	(0.13)	(0.64)				
DVIX * SIZE	-0.10***	-0.22	-0.11	-1.19*	-0.11***	-0.41	-0.22**	-1.35**				
	(0.02)	-0.36	(0.11)	(0.61)	(0.02)	-0.38	(0.10)	(0.64)				
DVIX * CA									-0.14**	-0.33*	-0.24	-0.54
									(0.05)	(0.20)	(0.18)	(0.39)
Observations	10351	9,637	9951	9951	7230	6,676	7000	7000	3479	3309	3309	3309
Countries	40	39	40	40	23	22	23	23	17	17	17	17
R-squared	0.38	0.35	0.38	0.26	0.53	0.52	0.53	0.38	0.28	0.24	0.26	0.25
F first stage	.	6.86	23.83	1.57	.	13.40	15.75	3.04	.	13.73	16.11	3.20

Notes: the dependent variable is the standardised change in government bond yields (DYIELD). The model includes country-specific fixed effects and time fixed effects. When the change in the VIX is instrumented with the US monetary policy shock, the United States are excluded from the sample (columns 2 and 6). Robust standard errors are reported in parentheses. The asterisks ***, ** and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

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A Details on the VAR: specfication and estimation

The VAR model includes seven variables, namely the interest rate on the one-year Treasury bill, the log of the Consumer Price Index, the log of the S&P500 index, the log of the US dollar index, the yield of an US dollar High-Yield Corporate Bonds index, the log price of oil and the VIX.[26] Collecting these variables in the vector y_t, the structural representation of the model, which allows for contemporaneous interaction of the variables, is the following:

$$A_0 y_t = A_1 y_{t-1} + A_2 y_{t-2} + ... + A_p y_{t-p} + c + e_t \qquad e_t \sim i.i.d.\ N(0, I),$$

where A_0 is an $n \times n$ matrix of contemporaneous interactions, the p matrices A_j, $j = 1, 2, ..., p$ of dimension $n \times n$ collect the autoregressive coefficients, e_t is a n dimensional vector of structural shocks and c is an intercept term. The model can be written in compact form:

$$A_0 y_t = A_+ x_t + e_t \qquad e_t \sim i.i.d.\ N(0, I),$$

where $A_+ = [A_1, A_2, ..., A_p, c]$ and $x_t = [y'_{t-1}, y'_{t-2}, ..., y'_{t-p}, 1]'$. Pre-multiplying both sides by A_0^{-1} the model can be cast in its reduced form:

$$y_t = \Phi_+ x_t + u_t \qquad u_t \sim i.i.d.\ N(0, \Sigma),$$

where $\Phi_+ = {A_0}^{-1} A_+$ and $\Sigma = (A_0' A_0)^{-1}$. The relationship between reduced form and structural shocks is given by the set of equations:

$$u_t = A_0^{-1} e_t = B e_t. \tag{4}$$

where the matrix B, the structural impact matrix, is the key element of interest. Structural identification consists of estimation of the columns of B starting from the reduced form coefficients Φ_+ and Σ. Together with the reduced form parameters Φ_+ and Σ, the matrix B allows us to compute structural shocks via equations (4), as well as other quantities of interest, namely Impulse Response Functions (IRFs) and forecast error variance decomposition (FEVDs).

[26] One-year T-Bill rates and the US dollar index are from the Board of Governors of the Federal Reserve System. The Consumer Price Index is from the U.S. Bureau of Labor Statistics. The S&P500 index is from Bloomberg. The yield on US dollar High-Yield Corporate Bonds is the ICE Bank of America Merrill Lynch US Corporate & High Yield Index. The oil price is the US dollar Brent benchmark from the U.S. Energy Information Administration. The VIX is from the Chicago Board Options Exchange.

Identification of the structural shocks in VARs is conceptually similar to the estimation of *causal* effects in linear regressions. Indeed, a growing literature suggests the use of instrumental variables techniques to measure the causal effects of shocks on macroeconomic variables; see Stock and Watson (2018) for a survey. In this paper we use an eclectic approach, and combine this method with two other popular identification strategies proposed in the literature. The first is the method of sign restrictions, which imposes inequality constraints on impulse response functions consistently with economic beliefs about the effects of a given shock (Rubio-Ramirez et al., 2016). The latter is the "narrative" restrictions approach developed by Antolin-Diaz and Rubio-Ramirez (2016). This consists of retaining, out of a large number of candidate structural shocks, only those that are consistent with a priori beliefs about the structural drivers of macroeconomic variables *in some particular episodes*. For instance, it is natural to think of the onset of the financial crisis in September 2008 as being mainly caused by a financial shock. Such a belief can be used to discipline the estimation of structural shocks, making identification more plausible.[27]

[27]Technical details on how to combine these approaches are discussed in Cesa Bianchi and Sokol (2017), Braun and Brüggemann (2017) and Arias et al. (2018). Estimation is performed via the Bayesian framework of Caldara and Herbst (2019) using standard hyperparameters for the priors.

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