The U.S. Dollar Safety Premium

Matteo Maggiori*

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Abstract

I show that the US dollar earns a safety premium versus a basket of foreign currencies and that this premium is particularly high in times of global financial stress. These findings support the view that the dollar acts as the reserve currency for the international monetary system and that it is a natural safe haven in times of crisis, when a global flight to quality toward the reserve currency takes place. During such episodes, investors are willing to earn negative expected returns as compensation for holding safe dollars. I estimate the time varying dollar safety premium by using instrumental variable techniques to condition information down.

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*New York University, Stern School of Business. matteo.maggiori@stern.nyu.edu. I would like to thank the members of my PhD committee for advice well beyond their duties: Nicolae Gârleanu, Pierre-Olivier Gourinchas, Martin Lettau, Maurice Obstfeld, and Andrew Rose. I would also like to thank: Hélène Rey, Hanno Lustig, Anna Pavlova, Adrien Verdelhan, Andreas Stathopoulos, Nicolas Coeurdacier, Yesol Huh, Hayne Leland, Jerry Tsai and seminar participants at the AFA meeting, UNC Junior Faculty Roundtable, Joint Berkeley-Stanford PhD Seminar, LBS PhD Transatlantic Conference, and UC Berkeley. I gratefully acknowledge the financial support of the White Foundation and the UC Berkeley Institute for Business and Economics Research.

The international monetary system has long been characterized by the existence of a reserve currency: first it was gold, then the British pound sterling, and most recently the United States dollar. Conventional wisdom is that the reserve currency plays a special role in the international monetary system by acting as a safe asset during periods of rare, but intense, crisis. During such episodes a global flight to quality takes place: investors look for safe assets in international financial markets, concentrating their demand on short-term liabilities denominated in the reserve currency. The reserve currency should therefore, on average, earn a safety premium: the compensation that investors require to short this currency and invest in a basket of foreign currencies. This premium should vary over time and, in particular, be highest in times of global financial stress.

I document that this is exactly the role played by the US dollar during the modern floating exchange rate period (1973-2010). Figures 12-13 plot my estimates of the dollar safety premium. Periods of crisis are highlighted. The dollar safety premium is on average 1% on an annual basis. It increased to as much as 52% following the collapse of Lehman Brothers in October 2008.

The recent global financial crisis has been a painful reminder of the economic logic behind my results. The preceding period had been characterized by buoyant financial markets, low risk premia and an expanding world economy. The dollar had been on a depreciating trend since 2002 and the US was a large external debtor. During the crisis, and especially at the time of the Lehman Brothers default, the dollar experienced a knee-jerk appreciation. At the time, market commentary emphasized the global search for safe assets, which culminated in extraordinary demand for short-term US liabilities. Surprisingly this happened despite the US being a substantial international debtor with a worsening fiscal position and the US economy being among the worst hit by the global crisis. After June 2009, as the most acute phase of the crisis faded and markets began to stabilize, the dollar started to depreciate. In the words of the US Secretary of the Treasury, Timothy F. Geithner:[1]

> *"Over the last two and a half years, you have seen a period when the world was most concerned about the potential risk of global depression, was most concerned about the possibility of systemic collapse; you saw the world seek the safety of the risk-free asset of the United States. The dollar generally rose over that period of time, and as the world has become progressively more confident some of those safe-haven flows have been reversed."*

These facts can be interpreted in terms of the dollar safety premium. When a shock,

[1] CNBC interview on November 11, 2010.

such as the Lehman Brothers collapse, hits the economy, the dollar safety premium increases on impact as investors demand more dollars. This causes a dollar appreciation on impact to the point of overshooting:[2] to generate a high safety premium the dollar appreciates to such an extent that it is expected to depreciate in the future. The expected negative return from holding dollars is the compensation for its safety. As the shock fades, investor demand for the dollar decreases, thus triggering a dollar depreciation and a reduction in the dollar safety premium.

To estimate the dollar safety premium I first formalize the exchange rate dynamics in terms of risk premia (Section I). The theory section of this paper is intentionally minimalist so that the identification in the data is not strictly model dependent and its implications encompass a larger set of theoretical structural models. To estimate the dollar returns I employ a novel dataset of currency returns and a new measure of financially weighted exchange rates. I estimate the time varying dollar safety premium by employing techniques on information conditioning and instrumental variables developed in the empirical asset pricing literature (Campbell (1987), Harvey (1989), Duffee (2005)).

Despite conventional wisdom on the role of the reserve currency during crises being widely discussed in the financial press[3] and the clear importance of the subject for the global economy, relatively little academic literature has been devoted to the topic. The importance of the reserve currency during times of crisis was first noted by Bagehot (1873) in his treatise on London money markets. Triffin (1960) emphasized the possibility that the key country, which runs large deficits in its aim to supply currency to the rest of the world, could fall victim to a run on its currency in times of global stress.

In the context of more recent studies, this paper contributes to the literature on the role of the dollar in the international monetary system. This literature has investigated whether dollar denominated assets offer lower returns than comparable foreign currency assets, and whether this return differential is predictable. Gourinchas and Rey (2007a,b) find a positive and predictable return differential and call it the US "exorbitant privilege". Curcuru, Dvorak, and Warnock (2008, 2009), and Lane and Milesi-Ferretti (2009) show that systematic bias in revisions to the US balance of payments data leads to an overestimation of the return differential. More recently, Forbes (2010), Habib (2010) and revised estimates from Gourinchas and Rey (Gourinchas, Govillot, and Rey (2010)) find a positive return differential.

[2]This effect is reminiscent of the famous Dornbusch overshooting (Dornbusch (1976)). However, the effect here is caused by changes in the risk premium that are absent from the Dornbusch model. Risk premium effects to the level of the exchange rate were introduced by Obstfeld and Rogoff (1998).

[3]For a recent example from the Financial Times: "traders have long been using the US dollar as a proxy for risk appetite: its decline a signal that markets were relaxed about global economic growth, and its rise a gauge of haven flows as sentiment deteriorated" (article by Jamie Chisholm on October 11, 2010).

The main difficulty in accurately estimating returns for long time spans is the coarse detail that national statistics provide on the nature of assets held across borders. Even within asset categories such as equity, foreign direct investment (FDI), and bonds, there exists substantial cross-sectional heterogeneity that could swamp any international asset return differential.

By focusing on the US currency return (i.e. the return differential between US and rest of the world (RoW) risk-free bonds). With a simple theoretical decomposition, I show that this return is a direct component of the return differential of any other asset class (equities, FDI, corporate bonds). The advantage of focusing on the currency return is that I can use assets that are comparable across countries and for which returns are accurately measured. Clearly this return differential does not strictly imply a return differential for the US external position; that will depend on the exact composition of the assets held in the US external account. However, should there be a return differential between comparable US and RoW assets, then it should exist irrespective of whether the assets are actually held in the US external account or not.

I estimate the *conditional* dollar safety premium instead of focusing on unconditional returns, as is done in the literature discussed above. In fact, I show that the unconditional dollar safety premium, while positive, is not statistically significant. This is not surprising given the low mean returns and the volatility of exchange rates. Nor is it uncommon: it is a feature shared by many other risk premia in finance, including the equity risk premium. However, the hypothesis that the dollar acts as a key currency for the global financial system has the conditional implication that its safety premium should increase during times of global financial stress. Testing this conditional statement, I provide significant statistical evidence in favor of a positive dollar safety premium, particularly in times of crisis.

Authors have advanced a variety of possible explanations for the return differential: the superior ability of the US to time its investments compared to the RoW (Curcuru et al. (2009)), US exorbitant privileges (Gourinchas and Rey (2007a)), and the superior financial development of the US (Caballero, Farhi, and Gourinchas (2008), Mendoza, Quadrini, and Ríos Rull (2009), Forbes (2010), Maggiori (2011)). In this paper I suggest a simple risk based rationalization of the return differential. A portfolio that is short dollars and long a basket of foreign currencies earns an average positive return to compensate for the risk of negative returns in times of crisis, when the dollar appreciates due to the global flight to quality toward the reserve currency. Such a portfolio is risky, because it has a negative payoff in the bad states of the world. Time variation in this risk premium generates predictable movements in dollar returns.

This paper is also related to the literature on the failure of the Uncovered Interest Parity (UIP) condition and the carry trade. Fama (1984) documents systematic deviations from the UIP condition, stating that the exchange rate movement should offset the interest rate differential, so that returns from currency speculation are zero. Among a vast empirical literature, important recent contributions are Lustig and Verdelhan (2007),[4] Burnside, Eichenbaum, Kleshchelski, and Rebelo (2011) and Lustig et al. (2010, 2011), who estimate asset pricing models of currency returns with systematic deviations from UIP. The dollar safety premium estimated in this paper is also a deviation from UIP. The focus of this paper, however, is different from the UIP or carry trade literature: I am interested in the time series properties of the dollar safety premium, while this literature is mainly focused on the cross section of currency returns. I estimate a conditional asset pricing model, while the papers above focus on unconditional moments.[5] Within the UIP literature the most closely related papers are Cumby (1988), who estimates conditional covariances of bilateral currency returns with US consumption, and Lustig, Roussanov, and Verdhelan (2010), who estimate a countercyclical dollar risk premium using the average forward rate on a basket of foreign currencies and US industrial production growth.

I Theory

Consider a two country world: US and RoW. By simple no-arbitrage asset pricing, there exist two stochastic discount factors (SDF), one for each country, such that

$$1 = E_t[\Lambda_{t+1} R_{t+1}]; \qquad 1 = E_t[\Lambda^*_{t+1} R^*_{t+1}],$$

where Λ_{t+1} is the US SDF, and R_{t+1} is any US asset return. RoW variables are denoted by $*$. The exchange rate is defined as the US price of RoW currency and denoted $\mathcal{E}_t$ (a decrease in the exchange rate is a US dollar appreciation).

Proposition 1. *Assume no arbitrage and that all assets are traded internationally, then there exist two SDFs such that*

$$\Lambda_{t+1} = \Lambda^*_{t+1} \frac{\mathcal{E}_t}{\mathcal{E}_{t+1}}. \tag{1}$$

[4]See also Burnside (2011) and Lustig and Verdelhan (2011).

[5]Papers on the cross sections of currency returns most commonly sort currencies into portfolios based on the level of their interest rates. This sorting is close to a model where the only conditioning information is the interest rate.

Furthermore, the SDFs

$$M_{t+1} \equiv proj(\Lambda_{t+1}|A); \qquad M^*_{t+1} \equiv proj(\Lambda^*_{t+1}|A^*), \tag{2}$$

where $A^* = A\mathcal{E}_{t+1}$ is the space of internationally traded assets, always satisfy the above relationship.

A simple proof is relegated to Appendix A. The economic logic behind the proposition is provided by Backus, Foresi, and Telmer (2001) and Brandt, Cochrane, and Santa-Clara (2006). US and RoW agents agree on the prices of all assets that they can trade. Under complete markets, the span of assets covers the entire state space so that agents agree on all possible prices. Under this condition, the SDF of each country is unique and obeys the relationship in equation (1). However, if markets are not complete agents need only agree on the prices of assets that can actually be traded. For each country there exists an infinite set of valid SDFs. Equation (1) does not need to hold between any two arbitrary SDFs. However, two special SDFs continue to satisfy equation (1): the SDFs that lie in each country's payoff space. I work with these SDFs for the rest of the paper.[6]

In this setting it is possible to derive an intuitive decomposition of the expected excess return of investing in a RoW asset by shorting a US asset.

Proposition 2. *Assume that asset returns, SDFs and the exchange rate are jointly log-normally distributed. Then the expected excess return in dollars of the RoW asset over the US asset is*

$$\begin{aligned} &E_t[r^*_{t+1} + \Delta e_{t+1} - r_{t+1}] + \frac{1}{2}Var_t(r^*_{t+1} + \Delta e_{t+1}) - \frac{1}{2}Var_t(r_{t+1}) = \\ &\underbrace{-Cov_t(m^*_{t+1}, r^*_{t+1}) + Cov_t(m_{t+1}, r_{t+1})}_{domestic\ risk}\underbrace{+Cov_t(r^*_{t+1}, \Delta e_{t+1}) - Cov_t(m_{t+1}, \Delta e_{t+1})}_{exchange\ rate\ risk}. \end{aligned} \tag{3}$$

The simple derivation is in Appendix A. Lower cases denote natural logarithms. The LHS is the expected excess log return plus Jensen's inequality terms due to the use of logarithms. The RHS shows that the risk premium can be decomposed into four components:

- $-Cov_t(m^*_{t+1}, r^*_{t+1})$: RoW asset risk premium over the RoW risk-free rate, expressed in RoW currency;

[6]Working with these specific SDFs has the advantage of not having to assume complete markets. The drawback is that all subsequent derivations are valid up to the orthogonal elements to each SDF and their products being sufficiently small. This is routinely assumed to be the case in empirical finance work. An alternative setup discussed by Brandt, Cochrane, and Santa-Clara (2006) and Lustig et al. (2007,08,10) is to assume complete markets, so that the SDFs are unique, but also to assume the existence of frictions on the goods market.

- $-Cov_t(m_{t+1}, r_{t+1})$: US asset risk premium over the US risk-free rate, expressed in dollars;
- $Cov_t(r^*_{t+1}, \Delta e_{t+1})$: RoW asset is riskier for US investors if it pays higher when the dollar depreciates; and
- $-Cov_t(m_{t+1}, \Delta e_{t+1})$: dollar currency safety premium.

Intuitively consider the case of RoW and US equities. A US investor who buys RoW equities by selling US equities will earn the RoW equity premium, pay the US equity premium, and earn/pay a compensation for foreign exchange risk.

The first two terms on the RHS of equation (3) are typical of closed economy analysis. Flight to quality, in that setting, is manifested as the increase in the risk premium of riskier assets (say, equities) in times of economic stress. The last two terms add the international dimension to the analysis of flight to quality: the exchange rate. In this light, global flight to quality toward the dollar is manifested as an increase in the risk premium of investing in RoW currency by funding in dollars in times of economic stress.

The last term on the RHS of equation (3) is identified to be the dollar safety premium ($\$SP_t$) by observing that in the case of the US and RoW risk-free rate, equation (3) reduces to

$$\$SP_t \equiv r^*_{f,t+1} + E_t[\Delta e_{t+1}] - r_{f,t+1} + \frac{1}{2}Var_t(\Delta e_{t+1}) = -Cov_t(m_{t+1}, \Delta e_{t+1}). \tag{4}$$

The dollar safety premium is positive if the dollar appreciates when the SDF increases. Logically, the dollar is safe if it appreciates in times of economic stress. Those times are characterized by high marginal utility growth, and therefore a high SDF. The safety premium is closely related to the deviation from uncovered interest parity (UIP). The UIP condition can be stated in logs as $E_t[r^*_{f,t+1} + \Delta e_{t+1} - r_{f,t+1}] = 0$. Therefore, up to the Jensen's inequality term $\frac{1}{2}Var_t(\Delta e_{t+1})$ the currency risk premium is the deviation from UIP.

The last step to make the above equations operational is to specify the functional form of the SDFs in equation (2). $M_{t+1} = A_t - B_t R^w_{t+1}$ $(A > 0,\ B > 0)$ is the unique US SDF lying in the payoff space: it consists of a long position in the US risk-free rate $(A_t/R_{f,t+1})$ and a short position in the world equity portfolio expressed in dollars (B_t). If one identifies the world equity portfolio to be the market portfolio, the above SDF yields the CAPM. By substituting the log approximation $m_{t+1} = a_t - b_t r^w_{t+1}$ to M_{t+1} in equation (4), the dollar safety premium reduces to

$$\$SP_t = -Cov_t(m_{t+1}, \Delta e_{t+1}) = b_t Cov_t(r^w_{t+1}, \Delta e_{t+1}). \tag{5}$$

There are two possible sources of time variation of the risk premium: time varying price of risk (b_t), and time varying quantity of risk (covariance). Furthermore, the two variations could amplify each other (synchronous) or smooth each other (asynchronous). The challenge is that the conditional covariance is not observable and needs to be estimated.

II Data

I build indices for the dollar currency return versus a basket of foreign currencies (the RoW currency), as well as comparable indices for stock market returns at monthly frequency for the period from January 1970 to March 2010.

I use the Morgan Stanley Capital International (MSCI) Barra indices to measure stock market returns. These indices are weighted by the equity market capitalization of each component country. The MSCI-Barra indices are widely used both in the financial industry and in academia (Fama and French (1998)) to measure international stock returns. They are particularly suited to this paper because they only include stocks that can actually be traded by foreigners and are adjusted to make returns comparable across countries' different accounting and legal systems. I use a World index that includes 23 developed and 22 emerging countries, and a Developed index that only includes the developed countries.[7] The two indices are identical for the period 1970-1987 as the emerging countries are assigned a zero weight, and progressively differ for the period 1988-2010 as the emerging countries' market capitalization increases. Figure 1 plots the two total return[8] equity indices.

For both the Developed and World indices I build US dollar spot exchange rate indices, shown in Figure 2. These are market capitalization[9] weighted exchange rate indices. For example, the dollar exchange rate corresponding to the World index measures the value of the dollar versus a basket of currencies, where the weight of each bilateral exchange rate[10] corresponds to the weight of the country in the equity World index excluding the United States.

[7]The "Developed index" corresponds to the MSCI Barra World index. The "World index" is built by using the MSCI Barra World index for the period 1970-1987 and the MSCI Barra All Country World index for the period 1988-2010. All indices are available on the MSCI Barra website and from Datastream.

[8]These indices include dividend payouts.

[9]The capitalization here refers to the equity market, which is particularly suited to this papers as it makes equity and currency returns comparable. In general, it would be desirable to have a foreign exchange market capitalization weighted exchange rate, where the weight of each currency corresponds to its share of transactions in the foreign exchange market. Unfortunately, the foreign exchange market is over-the-counter and, therefore, the necessary data is not readily available.

[10]The data for bilateral spot exchange rates is from MSCI-Barra and is available from Datastream. MSCI-Barra collects the data from Reuters' multi contributors pages and WM-Reuters exchange rate service.

Financially weighted exchange rates are a notable improvement over the trade weighted or equally weighted exchange rates more commonly used in the literature to analyze broad movements in currency values. Lane and Shambaugh (2010) show that trade weighted indices are insufficient to understand the financial impact of currency movements and argue for financial exchange rates. They build financial exchange rates for each country based on the currency composition of its foreign assets and liabilities. Their exchange rates, although similar in spirit, differ from those employed here. To the best of my knowledge, I am the first to use market capitalization based exchange rates.

To measure the dollar currency returns I first build estimates of the bilateral interest rate differential between each country in the sample and the US, then weight each of these differentials using the same MSCI-Barra weights as above. One would hope that such data for the modern floating period 1973-2010 would be readily available and commonly shared among papers in the literature. Surprisingly this is not the case. I detail the methods used to build bilateral interest rate differentials in a separate note, "Note on New Estimates of Currency Returns". The resulting dataset is more extensive both in terms of the currencies (53) and the time span (1970-2010) covered. Figure 3 shows the time series of the interest rate differential indices for the World and the Developed indices.

The use of World and Developed countries weighted indices for both equity and currency returns minimizes concerns about sovereign credit risk and investors' access to these assets for trading purposes. In particular, Emerging Markets have relatively little weight in the World index until recent years, and all the results in this paper are robust to focusing only on the more financially developed countries included in the Developed index.

III Empirical Identification

To estimate the dollar safety premium in equation (5), I employ the instrumental variable approach pioneered by Campbell (1987) and Harvey (1989). I follow most closely the approach in Duffee (2005), who estimates the conditional covariance between US consumption and US stock returns.

To lighten the notation I suppress the superscript w from the equity returns. The covariance in equation (5) can be expressed as

$$r_{t+1} = E_t[r_{t+1}] + \eta^r_{t+1}; \qquad \Delta e_{t+1} = E_t[\Delta e_{t+1}] + \eta^e_{t+1}; \tag{6}$$

$$Cov_t(r_{t+1}, \Delta e_{t+1}) \quad = \quad E_t[\eta^r_{t+1}\eta^e_{t+1}]. \tag{7}$$

This leads to a three stage procedure. The zero stage regressions are classic predictive regressions of the type run by Campbell and Shiller (1988), and Fama (1984):

$$r_{t+1} = \alpha_r Y_t^r + \epsilon_{t+1}^r; \tag{8}$$

$$\Delta e_{t+1} = \alpha_e Y_t^e + \epsilon_{t+1}^e. \tag{9}$$

where (Y_t^r, Y_t^e) are vectors of predictive variables, such as the dividend-price ratio and the interest rate differential. These regressions are dubbed zero stage regressions to distinguish them from the first and second stage regressions typical of the GMM-IV setup that follows. The role of the zero stage is to extract the predictable element (the time t expectation) in equation (6) from stock returns and exchange rate changes.

Denote the product of the residuals in equations (8-9) as $\widetilde{Cov}(r_{t+1}, \Delta e_{t+1}) \equiv \hat{\epsilon}_{t+1}^r \hat{\epsilon}_{t+1}^e$. The tilde is to stress that this is an ex-post estimate of the covariance and a time $t+1$ object. The first stage regression projects this ex-post covariance on a set of instruments Z_t to obtain an estimate of the time t conditional covariance:

$$\widetilde{Cov}(r_{t+1}, \Delta e_{t+1}) = \alpha_z Z_t + \xi_{t+1}; \tag{10}$$

$$\widehat{Cov}(r_{t+1}, \Delta e_{t+1}) = \hat{\alpha}_z Z_t. \tag{11}$$

The choice of instruments is detailed in Section A . The conditional covariance (equation (11)) is the estimate of the unobservable conditional covariance in equation (7).

The second stage regression estimates the model in equation (5) with instrumental variables:

$$r_{f,t+1}^* + \Delta e_{t+1} - r_{f,t+1} + \frac{1}{2}\widetilde{Var}(\Delta e_{t+1}) = d_0 + [d_1 + d_2 b_t]\widetilde{Cov}(r_{t+1}, \Delta e_{t+1}) + \omega_{t+1}, \tag{12}$$

where $\widetilde{Var}(\Delta e_{t+1}) \equiv (\hat{\epsilon}_{t+1}^e)^2$ is the ex-post estimate of the variance of the exchange rate, and b_t some observable proxy for the price of risk. This setup is quite flexible. For $d_2 = 0$, the only source of time variation in the dollar safety premium is the time variation of the covariance. For $d_2 \neq 0$ a time varying price of risk also contributes to the time variation of the dollar safety premium.

I estimate the first stage regression using OLS and allow for both heteroskedasticity and serial correlation by using the Newey-West variance covariance matrix. To test the hypothesis of time variation in the conditional covariance I use the asymptotically valid χ^2 test that all coefficients, except the constant, are jointly zero. However, I also report

the F test because of its prominent role in instrumental variable analysis.[11] The zero and second stage regressions are estimated jointly using GMM. This allows the second stage standard errors to not only incorporate uncertainty deriving from the first stage estimation (as it is standard in IV settings), but also the uncertainty deriving from the zero stage estimation. The details of the GMM estimation are discussed in Appendix B.

A Choice of Instruments

My choice of predictors in (Y_t^r, Y_t^e) follows an established literature started by Campbell and Shiller (1988) and Fama (1984) in using, respectively, the dividend-price ratio and the interest rate differential. I also include one lag of returns and exchange rate changes to account for possible serial correlation.[12] The sets of regressors are

$$Y_t^r = [1, dp_t, r_t]; \qquad Y_t^e = [1, r^*_{f,t+1} - r_{f,t+1}, \Delta e_t].$$

The set of variables to be used as instruments (Z_t) in the first stage regression can potentially contain any variable that is known at time t. Cochrane (2005), however, cautions against the use of instruments that lack a theoretical underpinning in order to avoid spurious correlations. In the setting of this paper, theory suggests that the conditional covariance should increase during times of economic stress, when risk premia are high. Correspondingly, I include instruments that have been shown to pick up increases in the risk premia in times of stress. I include the dividend-price ratio. Cochrane (2008) shows that, given the inability of the dividend-price ratio to predict future dividends, its time variation is caused by time-varying risk premia. I include one lag of stock returns and exchange rate changes since large (negative) movements are associated with increases in variance and risk premia. For similar reasons I also include lagged variances of stock returns and exchange rate changes. Menkhoff, Sarno, Schmeling, and Schrimpf (2011) show that the lagged volatility of exchange rates is a predictor of currency risk premia. Finally, I include lagged covariances to account for potential serial correlation.

To summarize, the benchmark set of instruments is

$$Z_t = [1, dp_t, r_t, \Delta e_t, var_t^{'r}, var_t^{'e}, cov_t'].$$

To avoid estimated regressors bias, I follow Duffee (2005) in employing close proxies to

[11] The χ^2 and F test are asymptotically equivalent. In small samples the F test has wider confidence intervals. However, in this paper the sample length and the number of restrictions are such that the rejection regions are approximately identical for the two tests.

[12] I experimented with further lags. Lags beyond the first are mostly not statistically significant and do not alter the results.

the lagged variances and covariances that do not need to be estimated in the zero order regression. These proxies match the time series properties of the estimated series closely. To limit the number of explanatory variables I use 2-month sums for the volatilities. Since the correlogram of the estimated covariances suggests autocorrelations up to the third lag, I use 3-month cross products for the covariance.

$$var_t^{'r} \equiv \sum_{i=0}^{1}(r_{t-i} - \bar{r})^2; \qquad var_t^{'e} \equiv \sum_{i=0}^{1}(\Delta e_{t-i} - \bar{\Delta e})^2;$$
$$cov_t' \equiv \sum_{i=0}^{2}(r_{t-i} - \bar{r})(\Delta e_{t-i} - \bar{\Delta e}),$$

where barred variables are sample averages.

In an extension of the instrument set, I also include the interest rate differential because the covariance is closely related to the deviation from UIP.

The set of instruments employs only variables that closely match the stock and exchange rate indices used in the RHS of equation (10). In the robustness checks I extend the set of instruments to variables that, while not directly related to the indices employed here, have also been shown to predict stock returns and exchange rates.

IV Empirical Results: the US Dollar Safety Premium

A The Average Safety Premium

I find that the average US dollar safety premium is 1% on an annual basis. Table 1 provides the sample averages of both the total premium and its subcomponents. The safety premium is similar for both the World and Developed indices. The largest monthly gains (10%) occurred in February 1973, when the Bretton Woods system broke down. The largest monthly losses occurred in November 1978 and in October 2008. The November 1978 dollar appreciation was the result of large scale US intervention[13] in the currency market to support the value of the dollar against the backdrop of the second oil shock. The October 2008 dollar appreciation during the Lehman Brother crisis has already been

[13]The US government approved the build-up of 30 billion dollars in foreign currency reserves to intervene in the currency market in support of the dollar. The US Treasury issued foreign currency-denominated securities, which would become known as the "Carter bonds", in the Swiss and German capital markets in order to acquire foreign currencies needed for sale in the market. The US also drew its reserve position in the IMF.

discussed in the introduction.

The safety premium is not statistically significant. This is not surprising. Economically it is just a symptom of low Sharpe ratios (low mean returns compared to their standard deviation) and relatively short time spans. With an annualized mean of 1% and volatility of 8%, and using the standard formula $\sigma/\sqrt{T}$, it would take $T \geq 64$ years to detect statistical significance! This feature is shared by many risk premia in finance.[14] For example the US equity premium[15] for the same period is also not statistically significant, with a t-statistic of only 1.04.

Figures 4-5 show that the mean US dollar safety premium is fairly volatile across different choices of samples, but remains positive throughout. Figure 4 plots the mean safety premium for a rolling window with a fixed end in March 2010 (i.e. start-year to March 2010). The highest safety premium (2% and above) is achieved when the sample starts in the years 1983-1986.

A safety premium around 2% is comparable with the results in Lustig et al. (2010) and Menkhoff et al. (2011), whose sample starts in 1983. Since these papers use an equally weighted basket of currencies versus the dollar, in this section I also report results for an equally weighted index. Figure 5 plots the mean safety premium for a reverse rolling window with a fixed start in March 1970 (i.e. March 1970 to end-year). The recent crisis decreases the mean premium by about 0.2%, but does not alter the overall results.

B Predictability of Currency and Equity Returns: Zero Stage Regressions

While the dataset covers the period from 1970 to 2010, in the benchmark econometric estimation I start the sample in January 1975 in order to eliminate possible concerns about the inclusion of the pre-floating exchange rate period or the period immediately following the break-down of the Bretton Woods system (December-March 1973).

Table 2 contains the results of the zero stage regressions. It re-establishes what are by now classic results from previous studies using the new dataset. The regression in equation (8) confirms not only the failure of the UIP condition, a coefficient different from -1, but also the carry trade phenomenon, a positive coefficient. The deviation from UIP is stronger for the Developed index than the World one, both in terms of point estimate and statistical significance. This is due to the inclusion in the World index of emerging market currencies, which have smaller deviations from UIP (Bansal and

[14] It leads Cochrane (2005) to conclude that "this is a pervasive, simple, but surprisingly underappreciated problem in empirical asset pricing".

[15] Computed using the MSCI-Barra US equity Index and the 1-month US Libor rate.

Dahlquist (2000)).[16] The regression in equation (9) confirms the predictability of stock returns from the dividend-price ratio.[17]

Figures 6-7 plot the ex post estimate of the covariance $\widetilde{Cov}(r_{t+1}, \Delta e_{t+1})$ obtained as the product of the residuals of zero order regressions.

C Time Varying Conditional Covariances: First Stage Regressions

The first stage regression results in Table 3 show that the covariance is time varying and predictable. The covariance predictability is robust to the choice of a subset of instruments or to the addition of the interest rate differential, with the χ^2 statistic rejected at the 1% level in all cases. The most substantial drop in predictability occurs when the lagged volatilities are excluded from the instrument set. The inclusion of the interest rate differential in the set of instruments does not help to predict the covariance.

Furthermore, Panel B details that in a univariate regression where the interest rate differential is the only instrument it has a negative coefficient. Theory actually predicts a positive coefficient, as a high interest rate differential with the RoW should make the dollar safer, thus increasing the covariance. In analogous univariate regressions for the other instruments, I confirm that their relationship with the covariance has the sign predicted by theory. While full results from univariate regressions are omitted in the interest of space, the sign predictions and results are summarized in Table 4.

Kleibergen (2002) suggests that F statistics above 10 minimize concerns of weak instruments. For this reason, while the χ^2 test is the asymptotically efficient one, I also report the F test. The F statistics of the first stage regressions with the full set of instruments are above 10 and provide support for a strong identification.[18]

Figures 8-9 plot the conditional covariance estimated using the full set of instruments. Periods of crisis are highlighted. The covariance has a substantial degree of time variation and spikes in times of crisis. The global financial crisis of 2007-09, and in particular the October 2008 Lehman default, is by far the most dramatic event in my sample, as

[16] A separate UIP regression that uses an emerging market exchange rate index, not reported here, confirms this result.

[17] In unreported robustness checks I varied the set of forecasting variables included in each of the zero stage regressions. The results of the paper are robust to these variations. The results are also robust to including only a constant in the zero stage regressions, so that the sample average is used to form the expectations.

[18] While Kleibergen (2002) has been a seminal contribution to the analysis of IV under weak instruments, the set-up considered in this paper is more complex than standard IV analysis because of the presence of zero stage regressions (noted by Duffee (2005)). The full description of the properties of more general GMM settings under weak instruments is a work in progress in the econometrics literature.

would be expected. Large increases in the covariance also occur during previous periods of crisis or financial stress, such as the collapse of LTCM and the Russian default in August-September 1998, the Worldcom and Enron scandals of the summer of 2002, the terrorist attacks on Septermber 11, the first Gulf war, the stock market crash of 1987, and the second OPEC oil shock of November 1978, to cite a few. A complete list of these events is included in Table 6.

One datapoint that needs further attention is the stock market crash of 1987. The econometric procedure estimates an increase in the conditional covariance in November after the October crash, while Figures 6-7 show that on impact (in October 1987) the ex-post covariance is negative. This could simply be due to the difference between the ex-ante covariance and its ex-post realization: the agents' ex-ante expectations about the risk premium need not be exact period by period. A less favorable interpretation is that while the model does well, on average, in predicting the covariance, it does not fit the 1987 episode correctly. This is a valid concern, and it is not econometrically possible to distinguish between the two. However, I want to stress that the χ^2 tests are automatically penalized for this large residual.

There are three notable periods of lower covariance. The covariance trends down during the early part of the 1990s in conjunction with the "great moderation" and the associated decrease in risk premia (Lettau, Ludvigson, and Wachter (2008)). The lowest covariance is achieved during the Dotcom boom market of 1999. The "calm before the storm" of the boom years 2003-07 is noticeable in a decrease of the volatility of the covariance.

While the list of crises examined mostly includes obvious episodes, there is a valid concern of overfitting the story by only looking for crises that are evidenced in the graph. To alleviate this concern, I note that all episodes considered here, with the exception of the Latin America debt crisis of the early 1980s and the Dotcom bust of April 2001, match those identified by Bloom's (2009) research on volatility shocks.

Figures 10-11 show the 95% confidence interval around the estimated conditional covariance. The covariance is mostly positive and, in particular, is statistically above zero during episodes of crisis. The mean covariance is 3.58×10^{-4} for the World index and 3.49×10^{-4} for the Developed index, and statistically significant at the 1% level in both cases.[19]

[19]These refer to the t-tests for the intercept in the first stage regressions where all other regressors have been de-meaned.

D Time Varying US Dollar Safety Premium: Second Stage Regressions

Table 5 reports the estimates of equation (12) under the assumption that the covariance is the only source of time variation in the dollar safety premium (i.e. $d_2 = 0$). The covariance has a statically significant and positive association with ex post dollar returns. This confirms not only that the covariance is related to the dollar safety premium, but also that increases in the covariance *are* increases in the dollar safety premium. Under the full set of instruments, the estimated price of risk (d_1) is around 12 and statistically significant at the 1% level for both the Developed and the World indices. This estimate, while not directly comparable, is close to the "plausibility range" of 5-10 for prices of risk from theoretical models. It is much lower than the prices of risk estimated by standard consumption models, but this is not entirely surprising since I am using market returns in the discount factors rather than the far less volatile consumption measures.

Table 5 also shows that the estimated constant d_0 is not statistically significant. Since the constant could have picked up any approximation error due to imposing a log-linear model to the data, this alleviates concerns that the model is misspecified.

Figures 12-13 plot the estimated dollar safety premium. The premium varies substantially over time, from lows of -2% during the boom years of 2003-07 to highs of 52% and 48% for the World and Developed indices, respectively, during October 2008. The premium is at approximately 10% during many of the crisis episodes considered here. During these episodes investors are willing to forgo substantial expected returns in order to benefit from the safety of the dollar. This is the price evidence of a global flight to quality toward the dollar.

By exploring the results for subsets of the instruments it becomes clear that a strong driver of the results are the lagged volatilities. Once they are excluded from the instrument set the first stage predictability drops substantially (Table 3) and the second stage regression loses significance (Table 5). This suggests that volatility or uncertainty shocks play a large role in the global flight to quality toward the dollar. In fact, as noted in the previous section, almost all of the spikes in the dollar safety premium correspond to the uncertainty shocks in Bloom (2009). This opens possible new directions for future theoretical work on the topic. The exclusion of lagged equity returns and exchange rate changes also deteriorates the second stage regressions, but there is no corresponding deterioration in the first stage predictability. The results are robust, but overall weakened, by the inclusion of the interest rate differential or the exclusion of lagged covariances and the dp ratio from the instrument set.

In the benchmark estimates, I started the sample in January 1975 in order to exclude

the early period of adjustment to floating exchange rates (1973-1975). By including this earlier period, Figures 14-15 interestingly highlight two more time periods (see Table 6): the first OPEC crisis and the Arab-Israeli War in December 1973, and the Franklin National debacle of September-October 1974.

The above results provide evidence that the conditional CAPM can explain the time series behavior of the US dollar returns versus a basket of foreign currencies. Lettau, Maggiori, and Weber (2011) find that by allowing variation in both the price of risk and the covariances in good and bad times CAPM can also price the cross-section of currency returns. In both the time series and the cross-section it is crucial for the empirical performance of CAPM to correctly account for the time variation in expected returns present in the data.

V Conclusion

I have shown that the US dollar earns a safety premium versus a basket of foreign currencies and that this premium is particularly high in times of crisis. These findings support the view that the US dollar acts as reserve currency in the international monetary system and that it is a natural safe haven during crises, when a global flight to quality toward the reserve currency takes place.

These findings open new avenues for research to explore what constitutes a reserve currency and the drivers behind its role in the monetary system. They suggest the need to incorporate currency risk premia in the study of global imbalances and external adjustment models more generally.

The dollar safety premium shown here is a primitive of the valuation channel of external adjustment pioneered by Obstfeld and Rogoff (1995) and analyzed by the subsequent literature.[20] In this light, note that the risk premium view of the role of the reserve currency stresses that US investors earn a premium on their currency investments abroad as a compensation for risk: the risk of large negative payoffs due to an appreciating dollar precisely in times of crisis. It would be incorrect to infer that the dollar, or US investors, earn a free lunch. While the dollar safety premium might facilitate the US external deficit adjustment and my results suggest a "run to" the dollar at times of crisis, a serious consideration of the inherent riskiness prevents us from simply brushing off Triffin's concerns that eventually larger US deficits could lead to an inversion of the dollar safety premium and a "run from" the dollar during a crisis.

[20] Obstfeld and Rogoff (2005), Gourinchas and Rey (2007b), Mendoza et al. (2009), Pavlova and Rigobon (2008, 2010).

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Appendix A: Proofs

Proposition 1. Let Λ_{t+1} denote a US SDF. Now consider the stochastic process $\Lambda_{t+1}\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t}$ and an arbitrary traded asset return in RoW currency R^*_{t+1}; one has

$$1 = E_t[\Lambda_{t+1}\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t}R^*_{t+1}].$$

It follows that $\Lambda_{t+1}\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t}$ is a RoW SDF. Denote this RoW SDF by Λ^*_{t+1}.

Consider the orthogonal projections of the US and RoW SDFs above on the space of traded assets A and A^*, given respectively by $M_{t+1} = proj(\Lambda_{t+1}|A)$ and $M^*_{t+1} \equiv proj(\Lambda^*_{t+1}|A^*)$. Recall that such projections are also SDF and are unique (see Cochrane (2005, page 64)). Given that M_{t+1} is a SDF and lies in A, then $M_{t+1}\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t}$ is also a SDF and lies in A^*. Then

$$M^*_{t+1} = M_{t+1}\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t}.$$

Proposition 2. Let R_{t+1} and R^*_{t+1} denote two arbitrary traded asset returns denominated in US dollars and RoW currency, respectively. Consider the excess return

$$0 = E_t[M_{t+1}(R^*_{t+1}\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} - R_{t+1})].$$

Since all variables are jointly log-normally distributed taking the expectation and then taking logarithms leads to

$$\begin{aligned}&E_t[r^*_{t+1} + \Delta e_{t+1} - r_{t+1}] + \frac{1}{2}Var_t(r^*_{t+1} + \Delta e_{t+1}) - \frac{1}{2}Var_t(r_{t+1}) = \\ &-Cov_t(m_{t+1}, r^*_{t+1}) + Cov_t(m_{t+1}, r_{t+1}) - Cov_t(m_{t+1}, \Delta e_{t+1}).\end{aligned}$$

The equation in the text follows from the substitution $m^*_{t+1} = m_{t+1} + \Delta e_{t+1}$.

Appendix B: GMM Estimation Details

The zero and second stage regressions are estimated jointly with GMM. The set of moments is

$$g_T(\beta) = \frac{1}{T} \begin{bmatrix} Y^{r'}\eta^r \\ Y^{e'}\eta^e \\ Z'\omega \end{bmatrix}.$$

The estimation of $\hat{\beta}$ follows by solving $a_T g_T(\beta) = 0$, where a_T takes the form

$$a_T = -\frac{1}{T} \begin{bmatrix} I_2 & 0 & 0 \\ 0 & I_2 & 0 \\ 0 & 0 & X^{rp'}ZW \end{bmatrix},$$

where I_2 is the 2×2 identity matrix and $X^{rp} = [1 \quad \widetilde{Cov}(r_{t+1}, \Delta e_{t+1}) \quad b*\widetilde{Cov}(r_{t+1}, \Delta e_{t+1})]$ is the set of regressors for the second stage regression. The constant price of risk case omits the last regressor.

In the first stage of GMM the matrix W is set to $(Z'Z)^{-1}$ so that the estimator for the last two/three parameters is identical to the IV 2SLS estimator. In subsequent iterations of GMM "efficiency" is achieved by setting W equal to the inverse of the bottom right 2×2 or 3×3 (again depending on the choice of model) block of the estimated spectral density matrix of the moments. I estimate the spectral density matrix by Newey-West with lag length set to the square root of the sample size. This produces IV estimators corrected for heteroskedasticity and serial correlation. I keep iterating the GMM procedure until the GMM results stabilize. While there is no fix point theorem to guarantee GMM convergence, my results completely stabilize after 8 to 10 iterations.[21]

[21] For an application of iterative GMM see, for example, Cochrane (1996). Ferson and Foerster (1994) find that iterative GMM has better finite sample properties in conditional asset pricing models than two stage GMM.

Table 1: US Dollar Mean Safety Premium

	World	*Developed*	*Equally Wght*
Mean	0.98%	0.99%	1.18%
Stand. Dev	8.06%	8.26%	7.16%
Max	10.34%	10.33%	10.21%
Max Date	Feb-73	Feb-73	Feb-73
Min	-9.15%	-9.16%	-8.36%
Min Date	Nov-78	Nov-78	Oct-08
Subcomponents			
$\overline{\Delta e}$	0.72%	1.12%	-2.20%
$\overline{r_f^* - r_f}$	-0.05%	-0.45%	3.13%

Statistics are for monthly currency returns from January 1970 to March 2010. The mean and standard deviations are annualized, while the Max and Min realizations are on a monthly basis. The Max and Min date refer to the month when the highest and lowest returns occurred, respectively. The subcomponents $\overline{\Delta e}$, *and* $\overline{r_f^* - r_f}$ *are the mean log exchange rate change and interest rate differential for each index.*

Table 2: Zero Stage Regressions: Equity Returns and Exchange Rate Changes

	World	*Developed*
Equity Returns	r_{t+1}	r_{t+1}
const.	0.0463	0.0448
	[2.41]	[2.34]
dp_t	0.0106	0.0102
	[2.03]	[1.95]
r_t	0.1259	0.1227
	[1.68]	[1.67]
R^2	0.0238	0.0228
Exchange Rate Changes	Δe_{t+1}	Δe_{t+1}
const.	0.0004	0.0013
	[0.29]	[1.01]
$r^*_{f,t+1} - r_{f,t+1}$	0.1072	0.1330
	[1.96]	[2.22]
Δe_t	0.0526	0.0415
	[0.99]	[0.81]
R^2	0.0133	0.0169

Top panel: regression of the one month return of the equity index on a constant, the logarithm of the dividend-price ratio for the equity index and the lagged equity index return (see equation (8)). The explanatory variables are lagged one month. The regression results are provided for both the World and Developed equity indices. Bottom panel: regression of the one month logarithmic exchange rate change for the currency index on a constant, the interest rate differential for the currency index and the lagged logarithmic exchange rate change for the currency index (see equation (9)). The explanatory variables are lagged one month. The regression results are provided for both the World and Developed currency indices. The regressions are for the period January 1975-March 2010: 423 observations. The estimates are OLS and the standard errors are Newey-West with 4 lags. The t-statistic is reported in square brackets.

Table 3: First Stage Regressions

Panel A: Exploring covariance predictability						
	World			*Developed*		
Instruments	$F-Stat$	χ^2-Stat	$\chi^2\ p-val$	$F-Stat$	χ^2-Stat	$\chi^2\ p-val$
All	15.76	94.56	(0.0000)	15.38	92.29	(0.0000)
ex dp ratio	14.03	70.16	(0.0000)	13.18	65.88	(0.0000)
ex covariance	17.10	85.52	(0.0000)	15.65	78.27	(0.0000)
ex volatilities	5.12	20.46	(0.0004)	4.11	16.42	(0.0025)
ex return & exch. rate chg.	19.70	78.78	(0.0000)	19.15	76.61	(0.0000)
cum int. diff.	14.12	98.85	(0.0000)	13.49	94.44	(0.0000)
Panel B: Details						
	World			*Developed*		
	$Coeff.\times 10^4$	χ^2-Stat	$\chi^2\ p-val$	$Coeff.\times 10^4$	χ^2-Stat	$\chi^2\ p-val$
int. diff.	-0.60	1.20	(0.2725)	-0.44	0.45	(0.5021)
	-[1.10]			-[0.67]		

Panel A: regression of the cross product of residuals from the zero stage regressions for the currency and equity indices on the set of instruments (see equation (10)). The set of instruments (All) includes: a constant, the dividend-price ratio for the equity index, the one month lagged return for the equity index, the lagged one-month return for the equity index, the lagged one-month exchange rate change for the currency index, the lagged two-month variances for the equity and currency indices, and the lagged three-month covariance of the equity and currency indices. Robustness checks are performed by excluding subsets of the instruments. For example, the "ex dp ratio" line reports the regression results for the set of instruments excluding the equity index dividend-price ratio. The "cum int. diff." line reports the regression results adding to the set of instruments the interest rate differential for the currency index. The F-statistic and the Wald χ^2 statistic are reported for the null hypothesis that all coefficients, except the constant, are jointly zero. The p-value for the Wald χ^2 test is reported in parenthesis. Panel B: regression of the cross product of residuals from the zero stage regressions for the currency and equity indices on a constant and the interest rate differential for the currency index. The point estimate for the coefficient on the interest rate differential and the corresponding t-statistic, in square brackets, are reported in addition to the Wald χ^2 statistic and corresponding p-value as described above. The regressions are for the World and Developed equity and currency indices for the period April 1975-March 2010: 420 observations. The estimates are OLS and the standard errors are Newey-West with lag set at the square root of the sample length (20 month).

Table 4: Instruments Theoretical Sign Predictions

Instrument	*Definition*	*Predicted Sign(α_z)*	$\hat{\alpha}_z$
dp_t	dividend price ratio	+	+
$var_t^{'r}$	lagged equity return volatility	+	+
$var_t^{'e}$	lagged exchange rate volatility	+	+
$r^*_{f,t+1} - r_{f,t+1}$	interest rate differential	+	-
r_t	lagged equity return	-	-
Δe_t	lagged exchange rate change	-	-
Cov'_t	lagged covariance	+/-	+

The table reports the set of instruments used in the first stage regressions. The column "Predicted Sign (α_z)" reports the sign that theoretical reasoning predicts for each instrument in the first stage regression. The theoretical reasoning underlying each sign prediction is discussed in Section IV.C. The column "$\hat{\alpha}_z$" reports the estimated sign of each instrument in a first stage regression using the entire set of instruments, including the interest rate differential. The estimated signs are identical for the World and Developed indices.

Table 5: Second Stage Regressions

	World		*Developed*	
	d_0	d_1	d_0	d_1
All	-0.0028	12.0672	-0.0031	12.4887
	-[1.45]	[3.19]	-[1.51]	[3.17]
ex dp ratio	-0.0042	16.3391	-0.0041	15.4557
	-[1.59]	[2.55]	-[1.55]	[2.46]
ex covariance	-0.0031	13.1771	-0.0035	13.7937
	-[1.56]	[3.16]	-[1.64]	[3.14]
ex volatilities	-0.0005	3.6559	-0.0006	3.8685
	-[0.22]	[0.82]	-[0.27]	[0.79]
ex return & exch. rate chg.	-0.0009	4.6295	-0.0012	5.6272
	-[0.44]	[1.07]	-[0.54]	[1.21]
cum int. diff.	0.0001	10.2047	0.0006	9.4118
	[0.03]	[2.54]	[0.34]	[2.28]

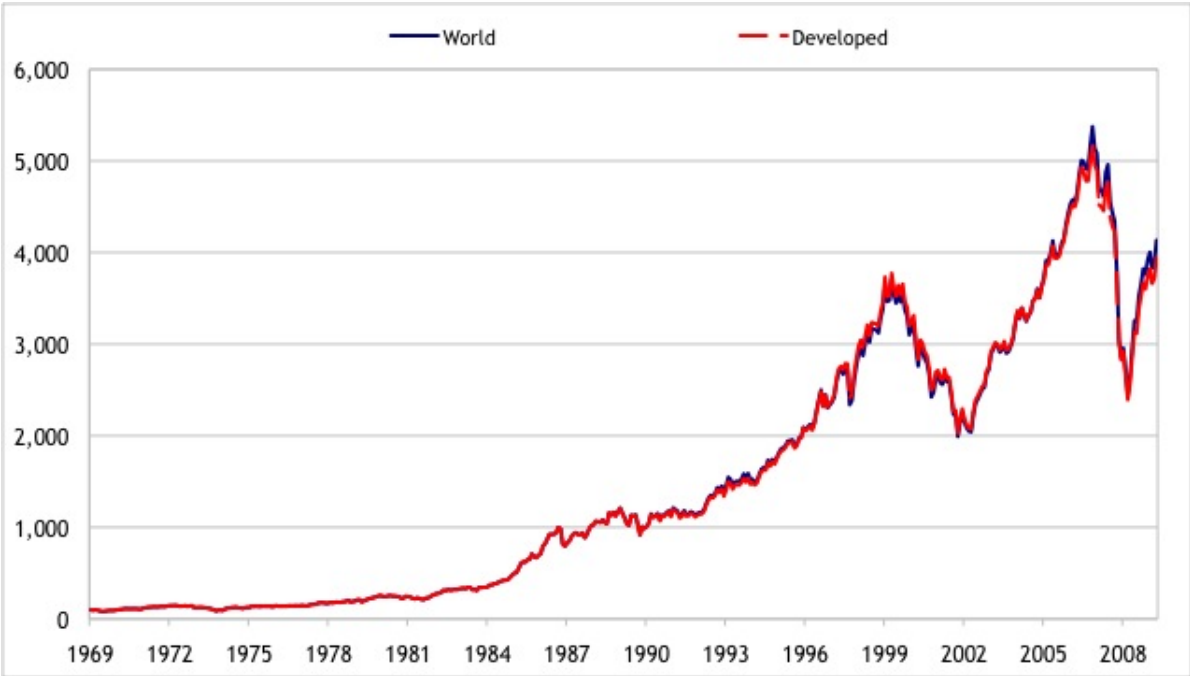
Results for the second stage regressions for the case of no time variation in the price of risk. The LHS variable is the US dollar safety premium: the monthly logarithmic return of investing in the currency index while funding in US dollars plus the Jensen's inequality term. The RHS regressors are a constant and the estimated, in the first stage, conditional covariance between the equity and currency indices returns. See equation (12) for details. Robustness checks are performed by varying the set of instruments included in the first stage regressions and, therefore, the resulting estimated covariance that is used as a regressor in the second stage regression reported here. The set of instruments (All) includes: a constant, the dividend-price ratio for the equity index, the lagged one-month return for the equity index, the lagged one-month exchange rate change for the currency index, the lagged two-month variances for the equity and currency indices, and the lagged three-month covariance of the equity and currency indices. The "ex dp ratio" line, for example, reports the regression results for the set of instruments excluding the equity index dividend-price ratio. The "cum int. diff." line reports the regression results, adding to the set of instruments the interest rate differential for the currency index. The standard errors are computed using GMM to jointly estimate the zero, and second stage regressions. The standard errors are based on the Newey-West estimate of the spectral density matrix in GMM, with lag set to the square root of the sample size (20 lags here), and are corrected for the uncertainty deriving from using estimated regressors from the zero and first stage. See Appendix B for details of the estimation.

Table 6: Episodes of Crisis

Event	Period
OPEC I, Arab-Israeli War	December 1973
Franklin National	September-October 1974
OPEC II, Fed currency Intervention	November 1978
Iran Hostage Crisis	November 1979
Silver Wednesday, US-Iran Military Intervention	March 1980
Latam defaults	Early 1980s*
1987 crash - Black Monday	October 1987
Gulf War I	September-October 1990
Asian Crisis	November 1997
Russian, LTCM default	August-September 1998
Dotcom Bust	April 2001*
9/11 terrorist attack	September 2001
Worldcom, Enron bankruptcy	July-September 2002
Credit Cruch, Lehman Default	Aug. 2007-Mar. 2009, Oct. 2008

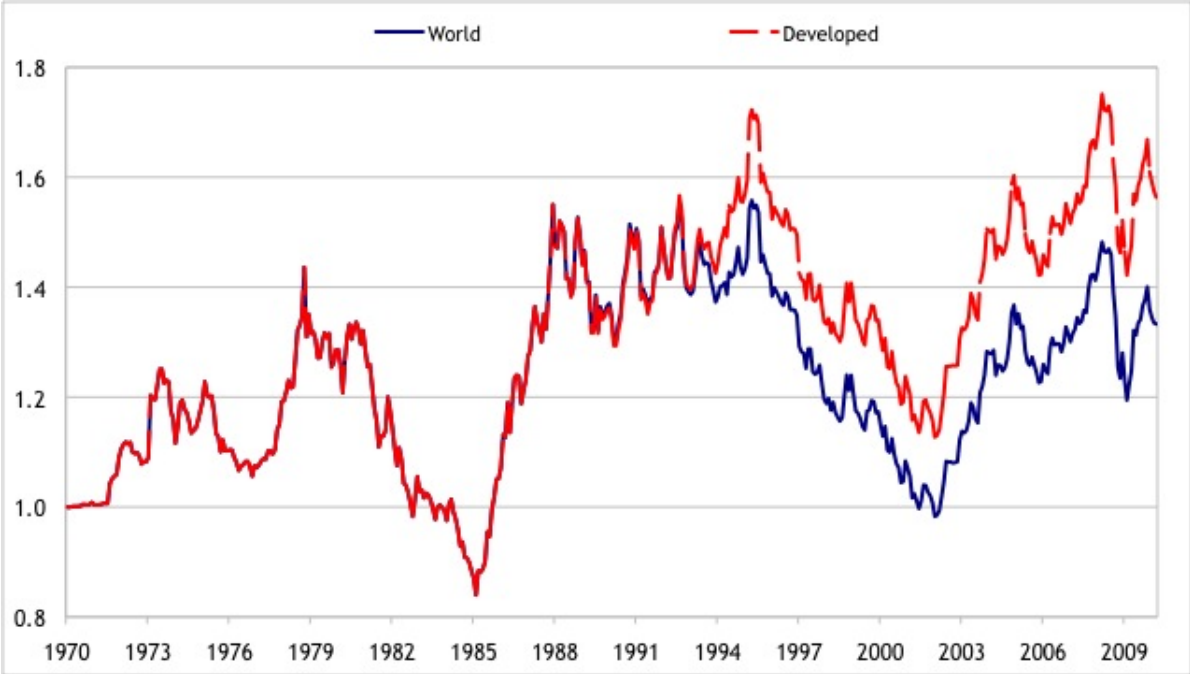
*All but episodes marked by * are from Bloom (2009). Bloom uses the US VXO implied volatility index, backdated using realized volatility, and selects the events as "those with stock-market volatility more than 1.65 standard deviations above the Hodrick Prescott detrended (filter multiplier set at 129,600) mean of the stock-market volatility series". The * episodes are added to the list of crises to account for two well known historical events absent from the list in Bloom (2009). I split the March 1980 event that Bloom completely attributed to the Iran hostage crisis into two: the November 1979 start of the crisis and the March 1980 US military intervention that also coincided with the panic following the cornering of the silver market by the Hunt brothers. Two events from Bloom's list are not present here. The October-August 1982 "Monetary policy turning point" has been replaced by the more general label of "Latam defaults" crises to highlight the protracted period of high volatility without necessarily singling out the monthly evolution of events. The "Gulf War II" event of March 2003 has been omitted since there was no evidence in my time series of a market reaction.*

Figure 1: Equity Total Return Indices: World and Developed



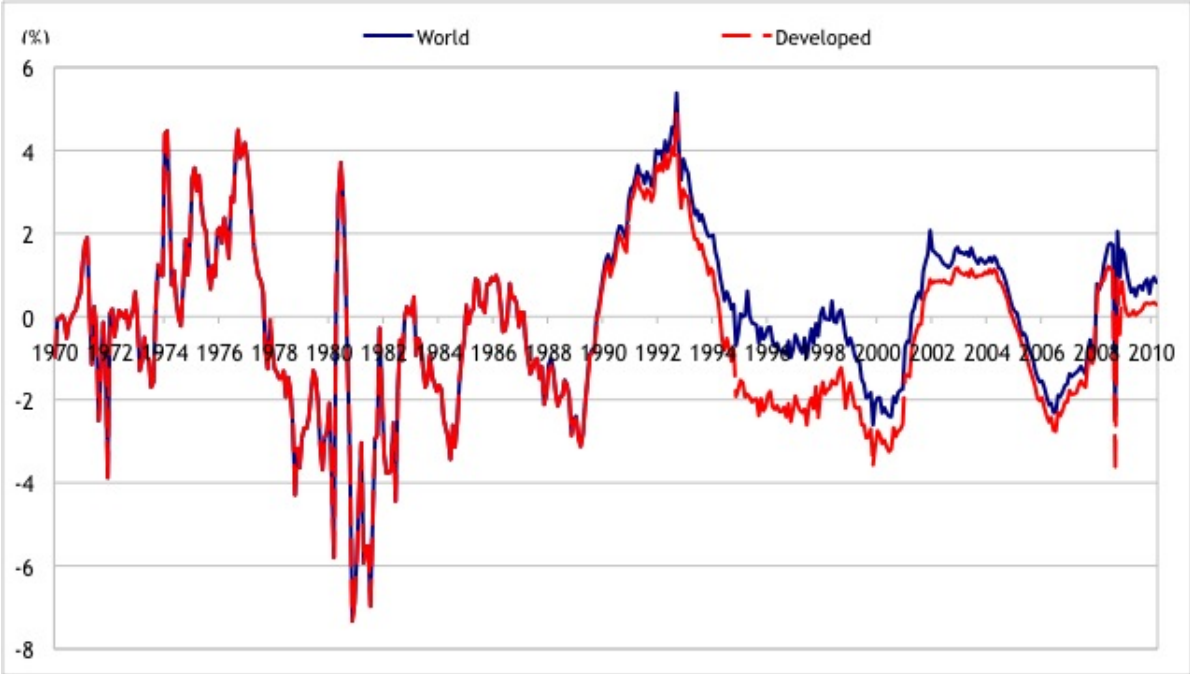
The indices are total return, capital gains plus dividends. The World index includes 23 developed and 22 emerging countries. The Developed index only includes the 23 developed countries. The indices are stock market capitalization weighted using the MSCI Barra weights. Both indices include the United States. The two indices are identical for the period 1970-1987 as the emerging countries are assigned a zero weight, and progressively differ for the period 1988-2010 as the emerging countries' market capitalization increases. The Developed index corresponds to the MSCI Barra World index. The World index is built by using the MSCI Barra World index for the period 1970-1987 and the MSCI Barra All Country World index for the period 1988-2010. The data are monthly Dec 1969-Mar 2010.

Figure 2: Exchange Rate Spot Indices: World and Developed



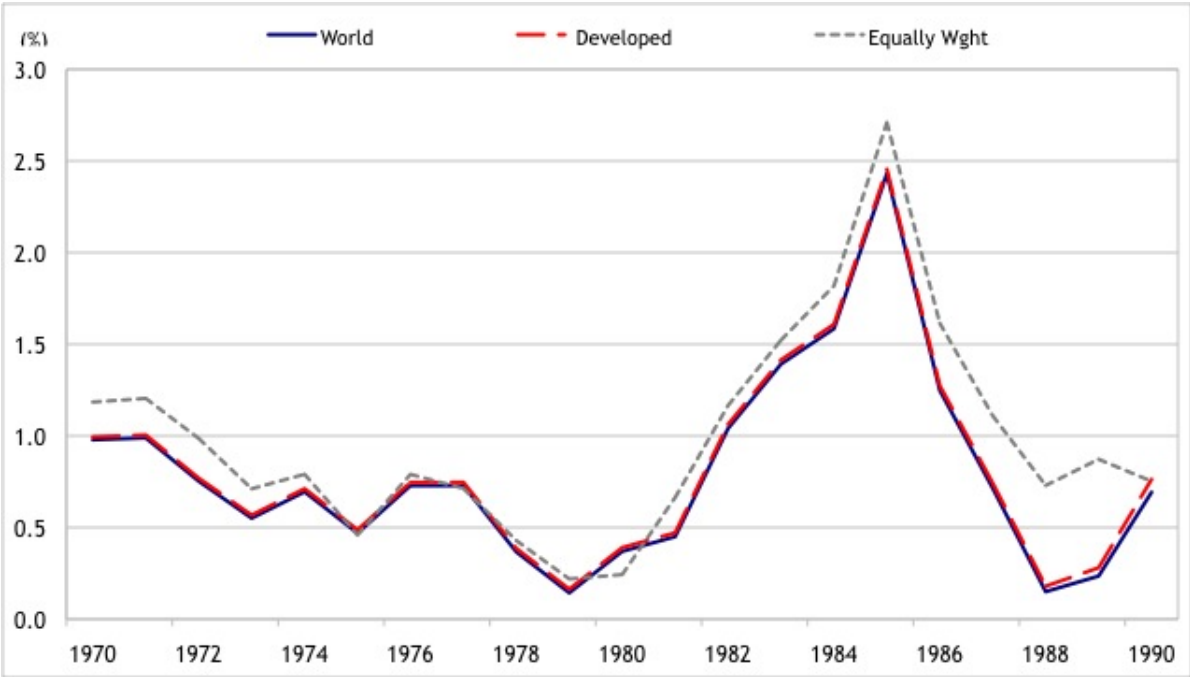
The US dollar spot exchange rate indices are market capitalization weighted indices. The World index includes 23 developed and 22 emerging countries. The Developed index only includes the 23 developed countries. The indices are stock market capitalization weighted using the MSCI Barra weights. The two indices are identical for the period 1970-1987 as the emerging countries are assigned a zero weight, and progressively differ for the period 1988-2010 as the emerging countries' market capitalization increases. The dollar exchange rate corresponding to the World (Developed) index measures the value of the dollar versus a basket of currencies, where the weight of each bilateral exchange rate corresponds to the weight of the country in the equity World (Developed) index excluding the United States. Bilateral spot exchange rates are from MSCI-Barra. The data are monthly Jan 1970-Mar 2010.

Figure 3: Interest Rate Differential Indices: World and Developed



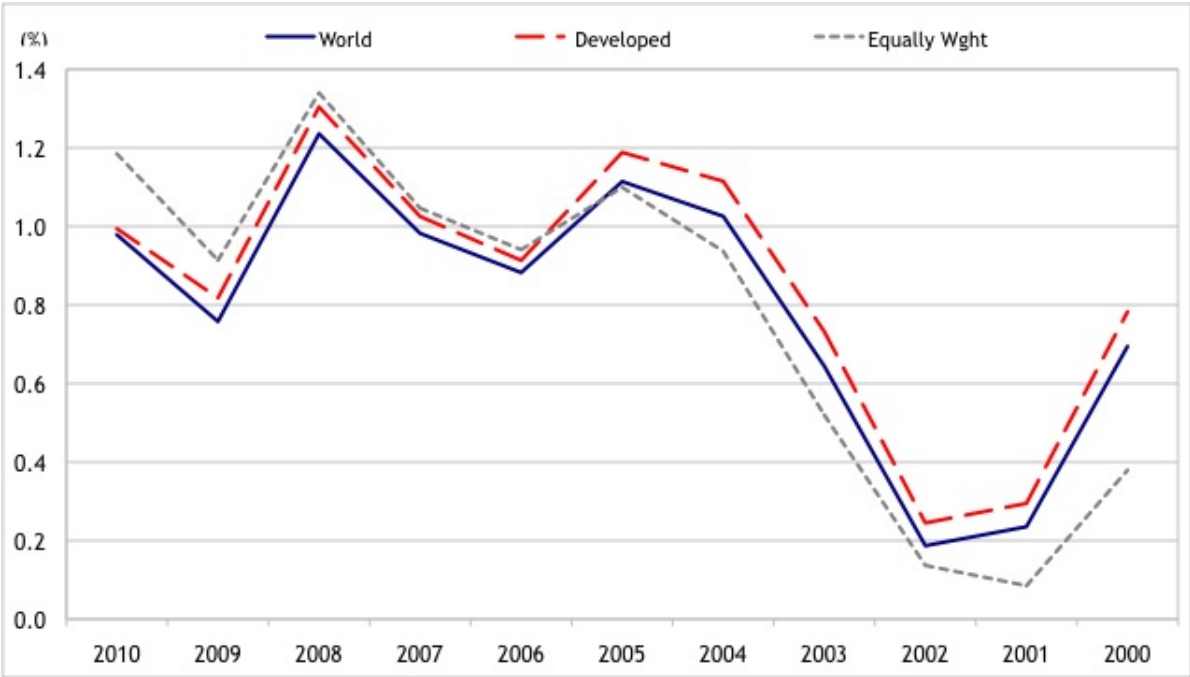
The interest rate differential indices between the Rest of the World and the US are market capitalization weighted indices. The World index includes 23 developed and 22 emerging countries. The Developed index only includes the 23 developed countries. The indices are stock market capitalization weighted using the MSCI Barra weights. The two indices are identical for the period 1970-1987 as the emerging countries are assigned a zero weight, and progressively differ for the period 1988-2010 as the emerging countries' market capitalization increases. The World (Developed) index measures the weighted interest rate differential between the US and the countries included in the index, where the weight of each bilateral interest rate differential corresponds to the weight of the country in the equity World (Developed) index excluding the United States. Bilateral interest rate differentials are from Maggiori (2010). The data are monthly Jan 1970-Mar 2010.

Figure 4: Mean US Dollar Safety Premium Rolling Window: Start Date to 2010



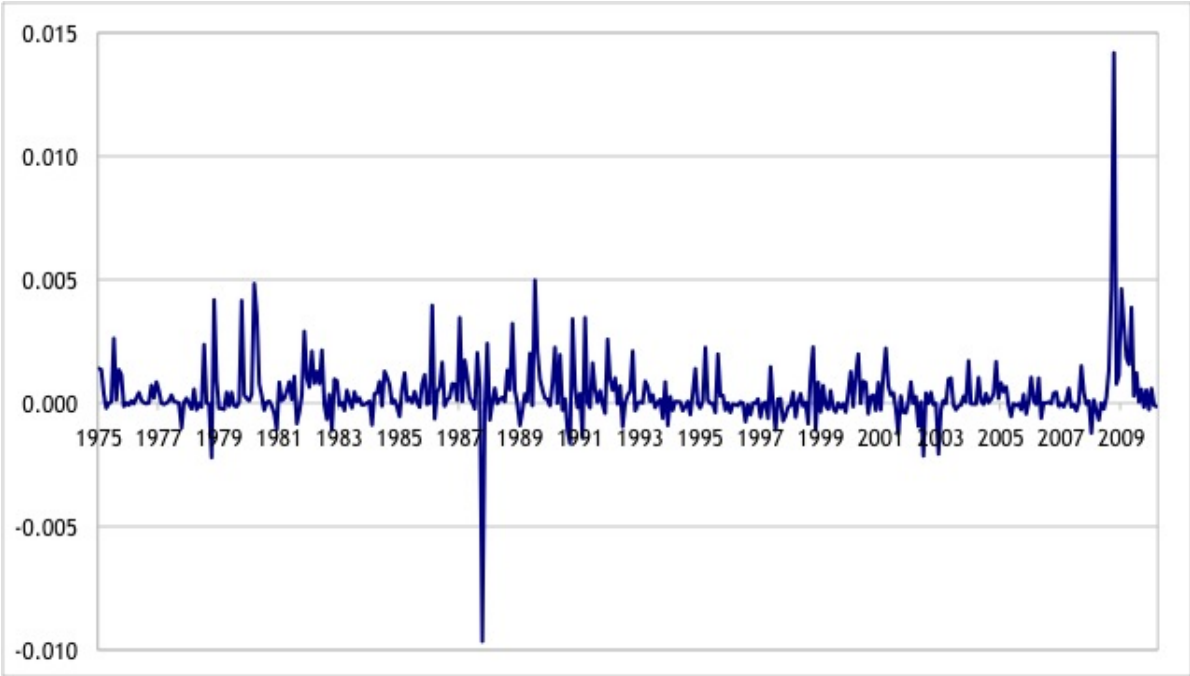
Plots the average US dollar safety premium for three indices: World, Developed, and Equally Weighted. The average is taken over a window with a rolling start date and a fixed end date in March 2010. Therefore, the datapoint for January 1970 is the average for the period Jan 1970-Mar 2010 and the datapoint for February 1970 is the average for the period Feb 1970-March 2010. The safety premium in each month is computed as the sum of the logarithmic interest rate differential, the logarithmic exchange rate change, and the Jensen's inequality term. The World index includes 23 developed and 22 emerging countries. The Developed index only includes the 23 developed countries. The indices are stock market capitalization weighted using the MSCI Barra weights. The two indices are identical for the period 1970-1987 as the emerging countries are assigned a zero weight, and progressively differ for the period 1988-2010 as the emerging countries' market capitalization increases. The Equally weighted index includes all the 55 countries in the World index and assigns equal weight to each country. The data are monthly Jan 1970-Mar 2010.

Figure 5: Mean US Dollar Safety Premium Reverse Rolling Window: 1970 to End Date



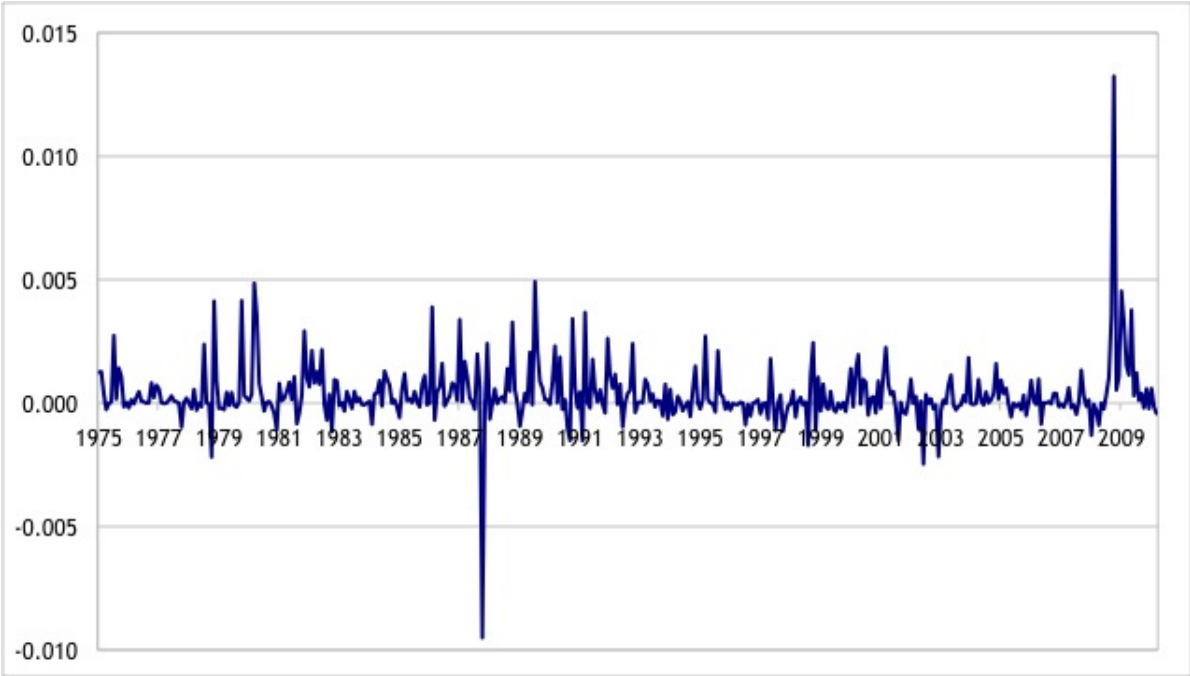
Plots the average US dollar safety premium for three indices: World, Developed, and Equally Weighted. The average is taken over a window with a fixed start date in January 1970 and a rolling end date. Therefore, the datapoint for March 2010 is the average for the period Jan 1970-Mar 2010 and the datapoint for February 2010 is the average for the period Feb 1970-Feb 2010. The safety premium in each month is computed as the sum of the logarithmic interest rate differential, the logarithmic exchange rate change and the Jensen's inequality term. The World index includes 23 developed and 22 emerging countries. The Developed index only includes the 23 developed countries. The indices are stock market capitalization weighted using the MSCI Barra weights. The two indices are identical for the period 1970-1987 as the emerging countries are assigned a zero weight, and progressively differ for the period 1988-2010 as the emerging countries' market capitalization increases. The Equally weighted index includes all the 55 countries in the World index and assigns equal weight to each country. The data are monthly Jan 1970-Mar 2010.

Figure 6: Ex Post Covariance $\widetilde{Cov}(r_{t+1}, \Delta e_{t+1})$: World Index



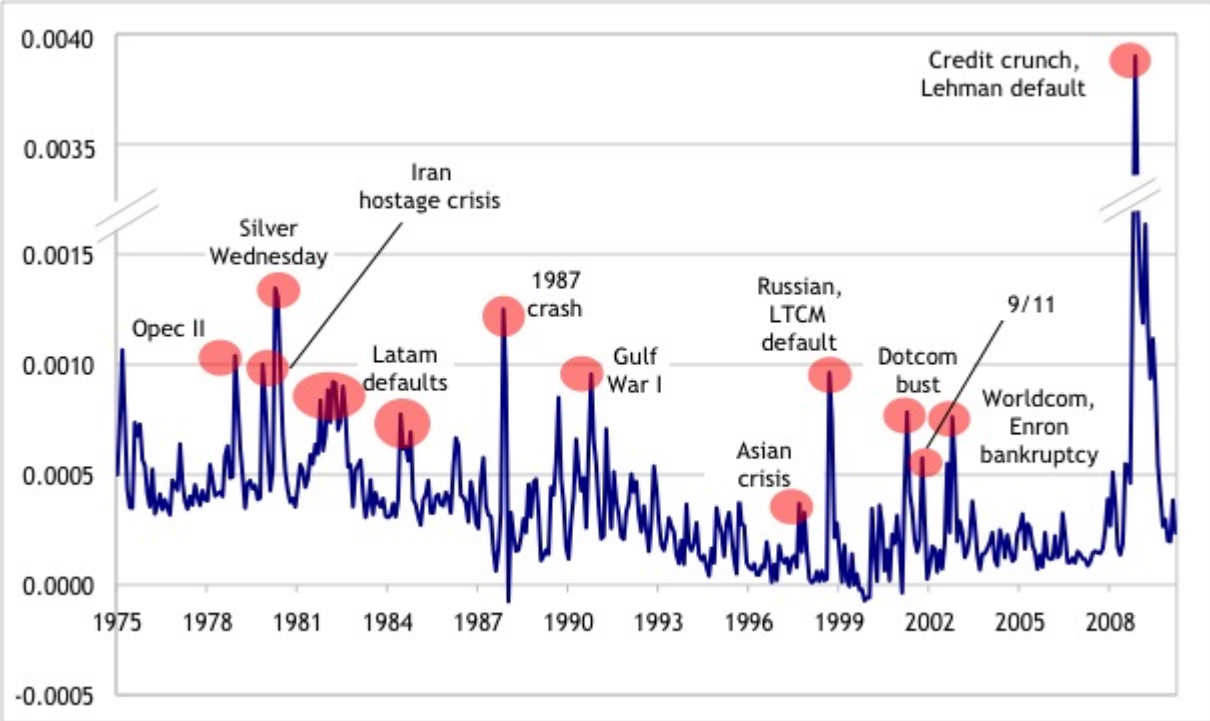
The ex post covariance is the product of the residuals of the zero stage regressions: $\widetilde{Cov}(r_{t+1}, \Delta e_{t+1}) \equiv \hat{\epsilon}^r_{t+1}\hat{\epsilon}^e_{t+1}$, *where* $\{\hat{\epsilon}^r_{t+1}, \hat{\epsilon}^e_{t+1}\}$ *are the residuals of the regressions in equations (8-9). The zero stage regressions point estimates are obtained by OLS. The resulting time series, the ex-post covariance, is monthly January 1975-March 2010: 423 observations. The World indices for equity and currency returns are used in the zero stage regression to estimate the residuals, and consequently the ex post covariance.*

Figure 7: Ex Post Covariance $\widetilde{Cov}(r_{t+1}, \Delta e_{t+1})$: Developed Index



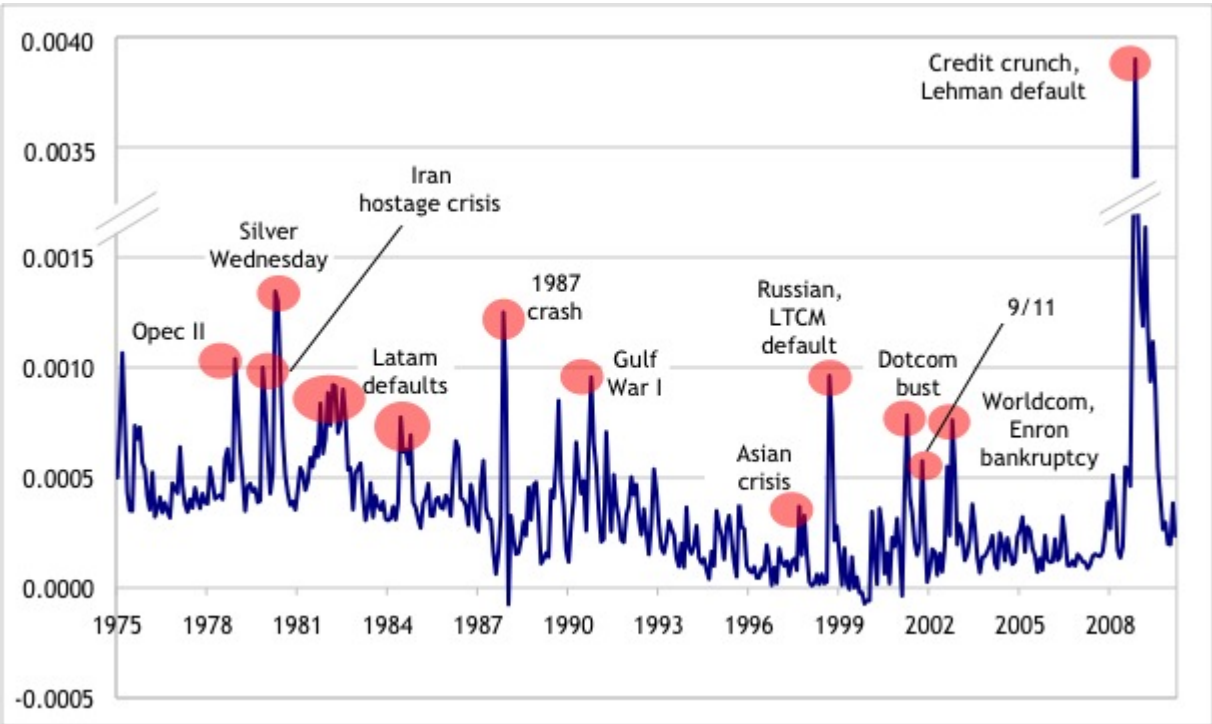
The ex post covariance is the product of the residuals of the zero stage regressions: $\widetilde{Cov}(r_{t+1}, \Delta e_{t+1}) \equiv \hat{\epsilon}^r_{t+1}\hat{\epsilon}^e_{t+1}$, *where* $\{\hat{\epsilon}^r_{t+1}, \hat{\epsilon}^e_{t+1}\}$ *are the residuals of the regressions in equations (8-9). The zero stage regressions point estimates are obtained by OLS. The resulting time series, the ex-post covariance, is monthly January 1975-March 2010: 423 observations. The Developed indices for equity and currency returns are used in the zero stage regression to estimate the residuals, and consequently the ex post covariance.*

Figure 8: Conditional Covariance $\widehat{Cov}(r_{t+1}, \Delta e_{t+1})$: World Index



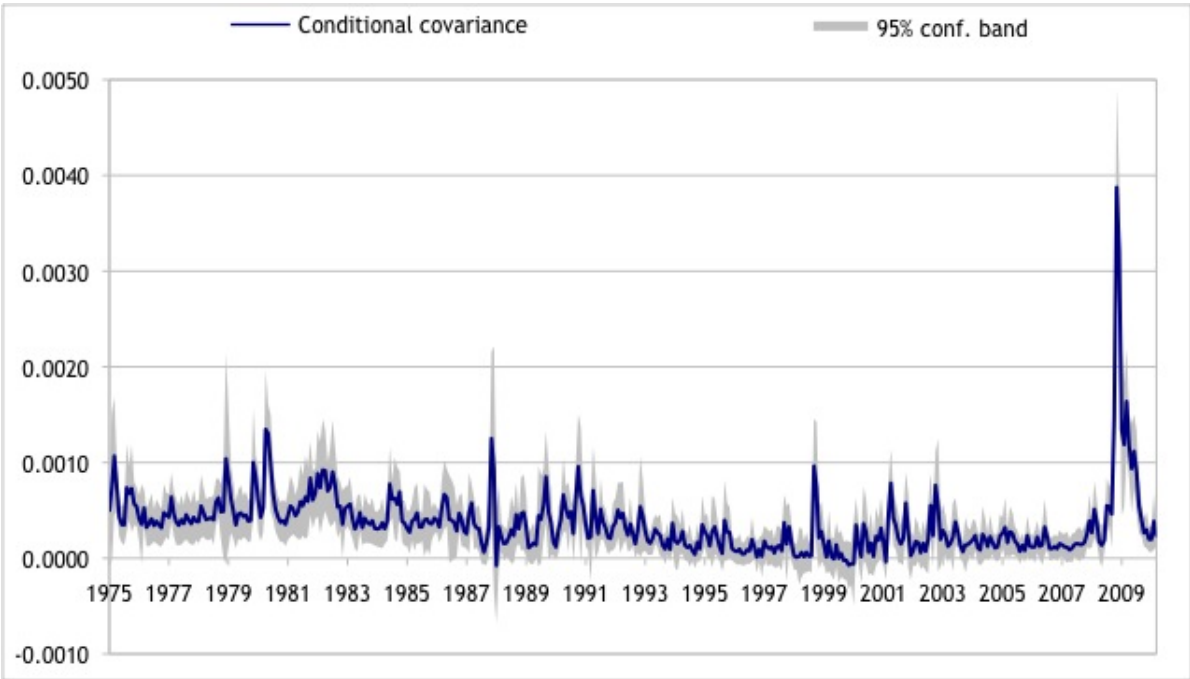
The conditional covariance is the fitted value of the first stage regression in equation (10). The first stage regresses the ex post covariance obtained from the zero stage regressions on a set of instruments. The set of instruments includes: a constant, the dividend-price ratio for the equity index, the lagged one-month return for the equity index, the lagged one-month exchange rate change for the currency index, the lagged two-month variances for the equity and currency indices, and the lagged three-month covariance of the equity and currency indices. The regression uses the OLS estimator for the World equity and currency indices for the period April 1975-March 2010: 420 observations.

Figure 9: Conditional Covariance $\widehat{Cov}(r_{t+1}, \Delta e_{t+1})$: Developed Index



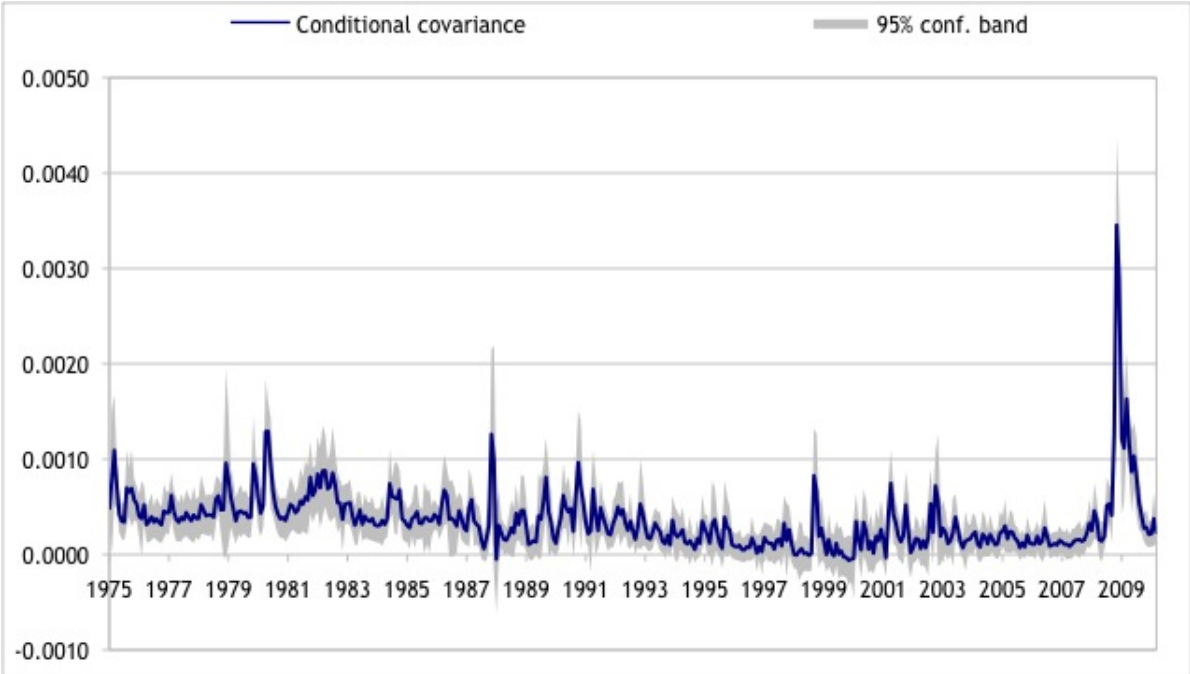
The conditional covariance is the fitted value of the first stage regression in equation (10). The first stage regresses the ex post covariance obtained from the zero stage regressions on a set of instruments. The set of instruments includes: a constant, the dividend-price ratio for the equity index, the lagged one-month return for the equity index, the lagged one-month exchange rate change for the currency index, the lagged two-month variances for the equity and currency indices, and the lagged three-month covariance of the equity and currency indices. The regression uses the OLS estimator for the Developed equity and currency indices for the period April 1975-March 2010: 420 observations.

Figure 10: 95% Confidence Band for Conditional Covariance: World Index



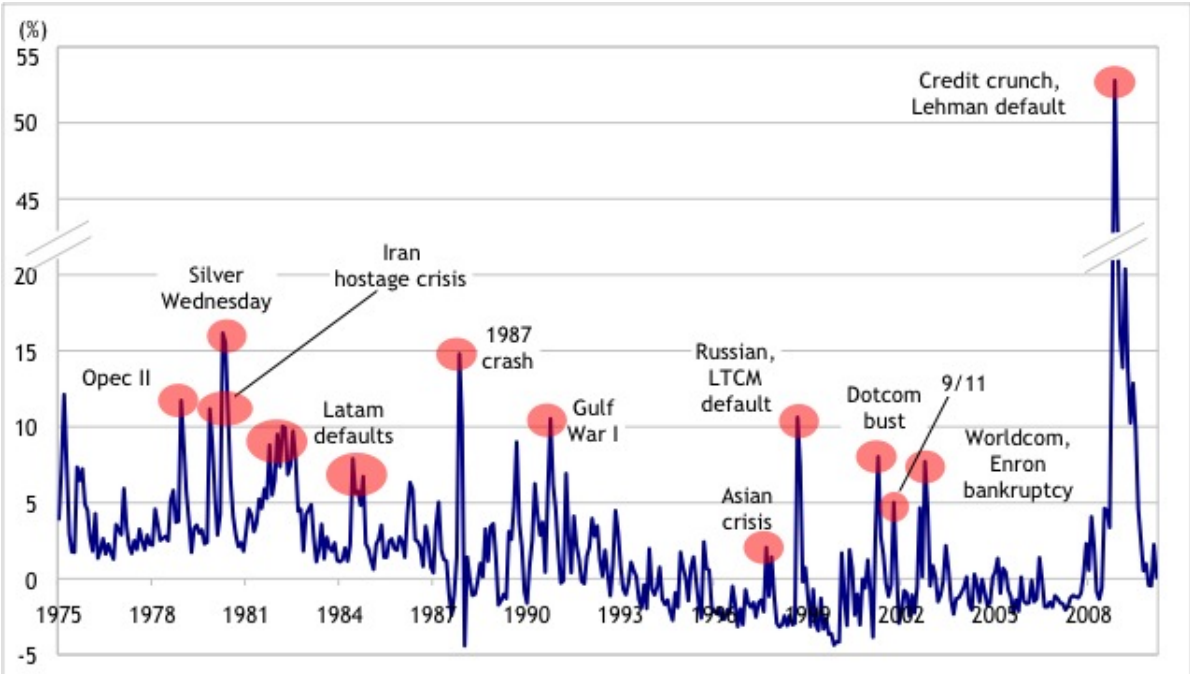
The conditional covariance is the fitted value of the first stage regression in equation (10). The first stage regresses the ex post covariance obtained from the zero stage regressions on a set of instruments. The set of instruments includes: a constant, the dividend-price ratio for the equity index, the lagged one-month return for the equity index, the lagged one-month exchange rate change for the currency index, the lagged two-month variances for the equity and currency indices, and the lagged three-month covariance of the equity and currency indices. The regression uses the OLS estimator for the World equity and currency indices for the period April 1975-March 2010: 420 observations. The confidence band for the estimate is based on the two sided 95% t-statistic with Newey-West estimates of the standard errors. The Newey-West lag length is set at the square root of the sample length (20 month).

Figure 11: 95% Confidence Band for Conditional Covariance: Developed Index



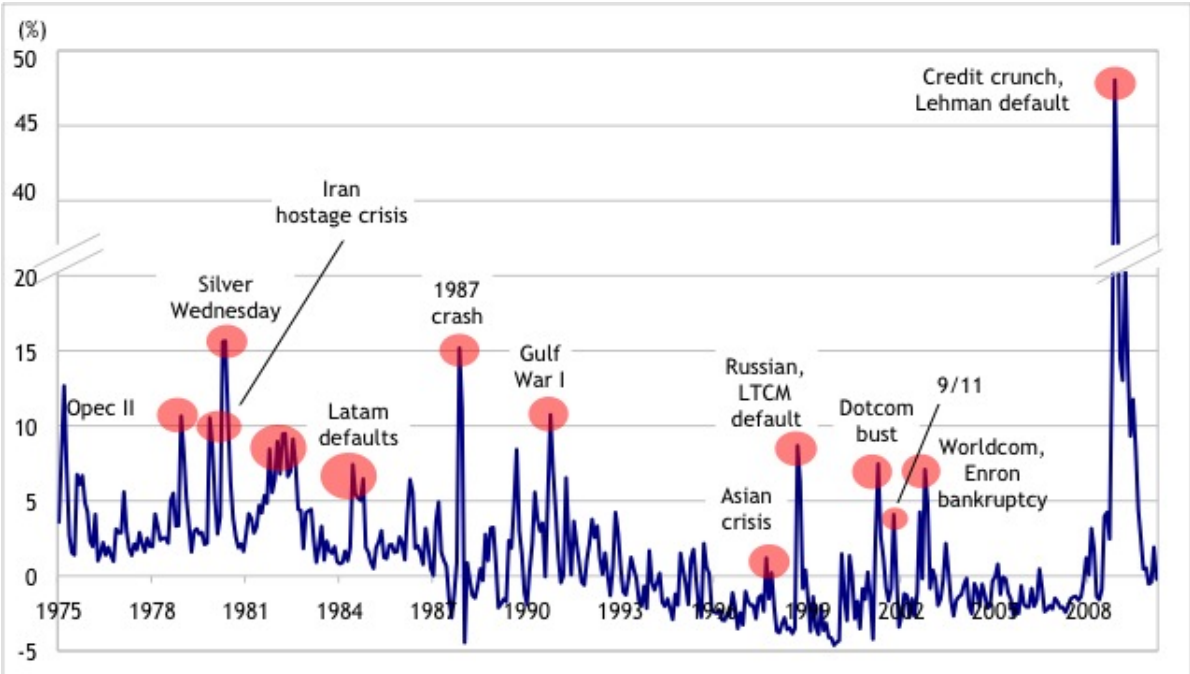
The conditional covariance is the fitted value of the first stage regression in equation (10). The first stage regresses the ex post covariance obtained from the zero stage regressions on a set of instruments. The set of instruments includes: a constant, the dividend-price ratio for the equity index, the lagged one-month return for the equity index, the lagged one-month exchange rate change for the currency index, the lagged two-month variances for the equity and currency indices, and the lagged three-month covariance of the equity and currency indices. The regression uses the OLS estimator for the Developed equity and currency indices for the period April 1975-March 2010: 420 observations. The confidence band for the estimate is based on the two sided 95% t-statistic with Newey-West estimates of the standard errors. The Newey-West lag length is set at the square root of the sample length (20 month).

Figure 12: US Dollar Safety Premium($\$SP_t$): World Index April 1975 - March 2010



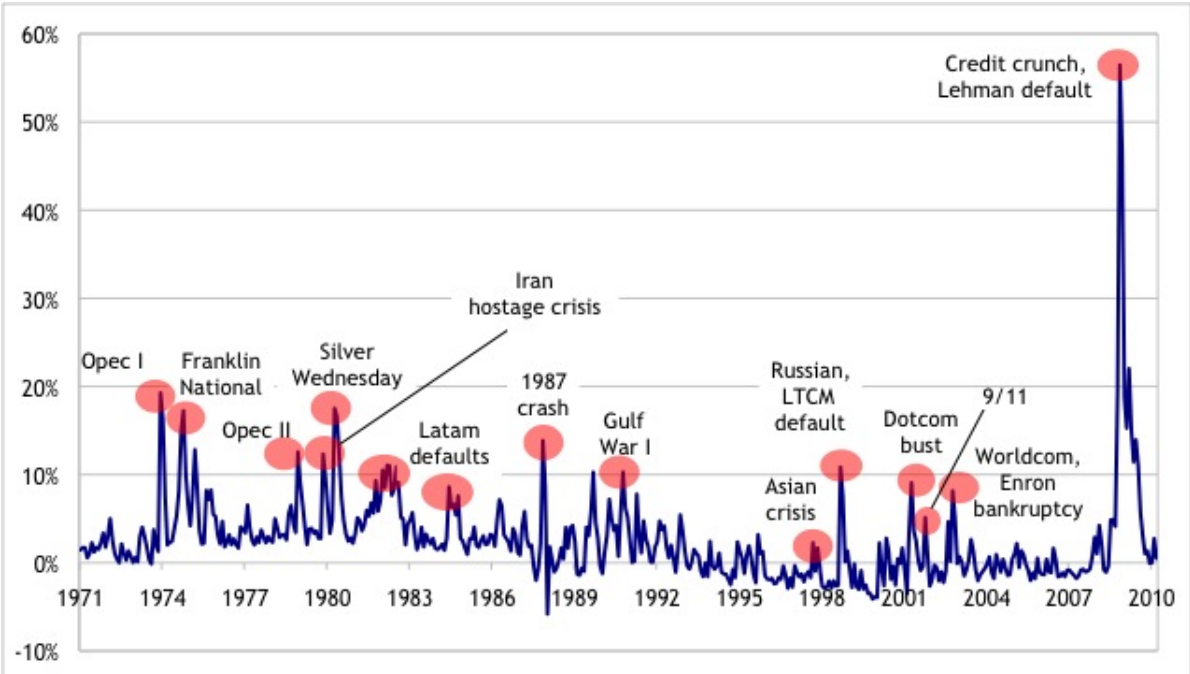
The US dollar safety premium is the fitted value of the second stage regression in equation (12) for the case of no time variation in the price of risk. The LHS variable is the US dollar safety premium: the monthly logarithmic return of investing in the currency index while funding in US dollars plus the Jensen's inequality term. The RHS regressors are a constant and the estimated, in the first stage, conditional covariance between the equity and currency indices returns. The set of instruments for the first stage regression includes: a constant, the dividend-price ratio for the equity index, the lagged one-month return for the equity index, the lagged one-month exchange rate change for the currency index, the lagged two-month variances for the equity and currency indices, and the lagged three-month covariance of the equity and currency indices. The estimates are obtained by iterated GMM and details are in Appendix B. The standard errors are computed using GMM to jointly estimate the zero, and second stage regressions. The standard errors are based on the Newey-West estimate of the spectral density matrix in GMM, with lag set to the square root of the sample size (20 lags here), and are corrected for the uncertainty deriving from using estimated regressors from the zero and first stage. The estimated spectral density matrix is used as the weighting matrix in iterations of GMM. The estimates employ the World equity and currency indices for the period April 1975-March 2010: 420 observations.

Figure 13: US Dollar Safety Premium($\$SP_t$): Developed Index April 1975 - March 2010



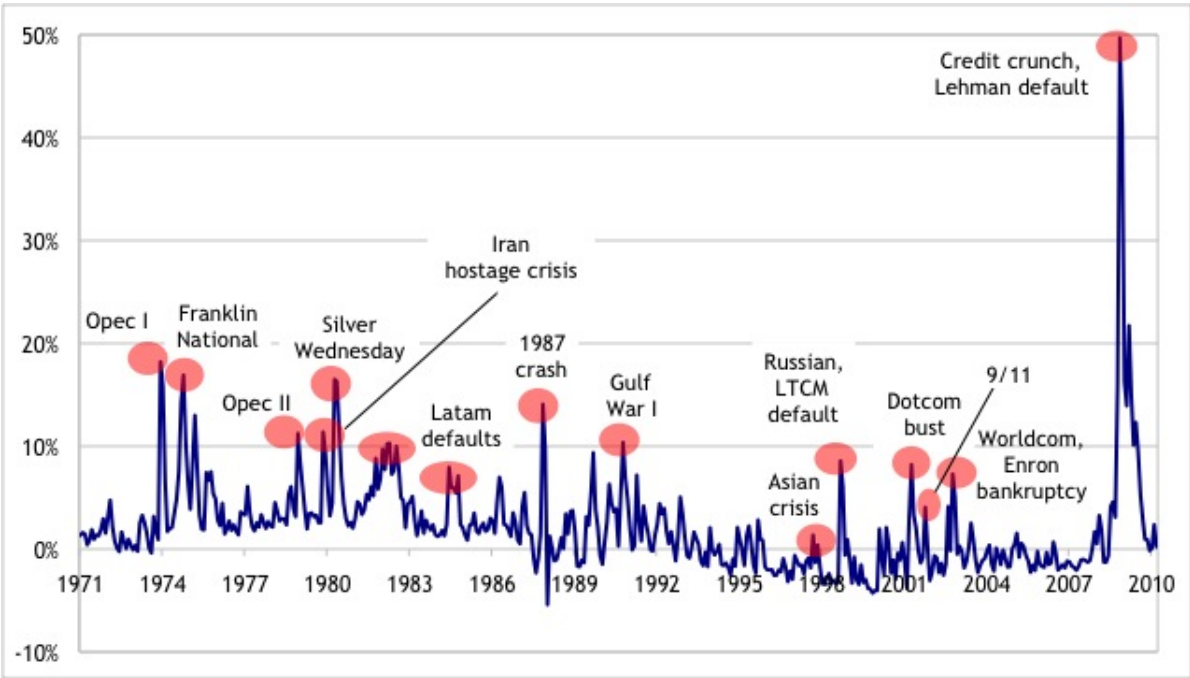
The US dollar safety premium is the fitted value of the second stage regression in equation (12) for the case of no time variation in the price of risk. The LHS variable is the US dollar safety premium: the monthly logarithmic return of investing in the currency index while funding in US dollars plus the Jensen's inequality term. The RHS regressors are a constant and the estimated, in the first stage, conditional covariance between the equity and currency indices returns. The set of instruments for the first stage regression includes: a constant, the dividend-price ratio for the equity index, the lagged one-month return for the equity index, the lagged one-month exchange rate change for the currency index, the lagged two-month variances for the equity and currency indices, and the lagged three-month covariance of the equity and currency indices. The estimates are obtained by iterated GMM and details are in Appendix B. The standard errors are computed using GMM to jointly estimate the zero, and second stage regressions. The standard errors are based on the Newey-West estimate of the spectral density matrix in GMM, with lag set to the square root of the sample size (20 lags here), and are corrected for the uncertainty deriving from using estimated regressors from the zero and first stage. The estimated spectral density matrix is used as the weighting matrix in iterations of GMM. The estimates employ the Developed equity and currency indices for the period April 1975-March 2010: 420 observations.

Figure 14: US Dollar Safety Premium($\$SP_t$): World Index January 1971 - March 2010



The US dollar safety premium is the fitted value of the second stage regression in equation (12) for the case of no time variation in the price of risk. The LHS variable is the US dollar safety premium: the monthly logarithmic return of investing in the currency index while funding in US dollars plus the Jensen's inequality term. The RHS regressors are a constant and the estimated, in the first stage, conditional covariance between the equity and currency indices returns. The set of instruments for the first stage regression includes: a constant, the dividend-price ratio for the equity index, the lagged one-month return for the equity index, the lagged one-month exchange rate change for the currency index, the lagged two-month variances for the equity and currency indices, and the lagged three-month covariance of the equity and currency indices. The estimates are obtained by iterated GMM and details are in Appendix B. The standard errors are computed using GMM to jointly estimate the zero, and second stage regressions. The standard errors are based on the Newey-West estimate of the spectral density matrix in GMM, with lag set to the square root of the sample size (20 lags here), and are corrected for the uncertainty deriving from using estimated regressors from the zero and first stage. The estimated spectral density matrix is used as the weighting matrix in iterations of GMM. The estimates employ the World equity and currency indices for the period January 1971-March 2010: 471 observations.

Figure 15: US Dollar Safety Premium($\$SP_t$): Developed Index January 1971 - March 2010



The US dollar safety premium is the fitted value of the second stage regression in equation (12) for the case of no time variation in the price of risk. The LHS variable is the US dollar safety premium: the monthly logarithmic return of investing in the currency index while funding in US dollars plus the Jensen's inequality term. The RHS regressors are a constant and the estimated, in the first stage, conditional covariance between the equity and currency indices returns. The set of instruments for the first stage regression includes: a constant, the dividend-price ratio for the equity index, the lagged one-month return for the equity index, the lagged one-month exchange rate change for the currency index, the lagged two-month variances for the equity and currency indices, and the lagged three-month covariance of the equity and currency indices. The estimates are obtained by iterated GMM and details are in Appendix B. The standard errors are computed using GMM to jointly estimate the zero, and second stage regressions. The standard errors are based on the Newey-West estimate of the spectral density matrix in GMM, with lag set to the square root of the sample size (20 lags here), and are corrected for the uncertainty deriving from using estimated regressors from the zero and first stage. The estimated spectral density matrix is used as the weighting matrix in iterations of GMM. The estimates employ the Developed equity and currency indices for the period January 1971-March 2010: 471 observations.