Commonality in Tail Risk Premia around the World

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December, 2020

Abstract

We examine the tail risk premia for 44 countries from 1990 to 2015 and provide evidence on the existence of common and systematic components in the variation of tail risk premia across countries. Specifically, tail risk premium of a country significantly comoves with the U.S., regional, and global tail risk premia. The first five principal components explain all variations in the premia with the first principal component alone explaining more than 30% of the variation. The comovement, or commonality, is stronger for developed market countries and the more open countries. We also provide evidence that the premium is affected by the U.S. economic environment and the global stock market volatility, leading to a common variation of tail risk premia around the world.

JEL classification:
Keywords: tail risk, tail risk premium, commonality, comovement, international stock market

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I. Introduction

Anecdotal evidence suggests that stock market crash, or occurrence of tail events, is typically a worldwide phenomenon, which is not restricted to a single country. The financial crisis from the burst of Dotcom bubble in the U.S. in early 2000s or the crisis triggered by the meltdown of U.S. housing markets in the late 2000s are good such examples since these events, though originated in a single country, have material impact on international stock markets. More recently, we observe that the financial crisis started in Greece spills over to Eurozone countries, further to European countries, and subsequently to countries worldwide. Academic literature on the contagion of financial crisis also shows that, along with the development of financial globalization among countries, financial crisis in a single country can be spilled over to many other countries (Summers, 2000; Bae, Karolyi, and Stulz, 2003; Brooks and Negro, 2004; Forbes, 2004; Boyer, Kumagai, and Yuan, 2006). To a degree to which tail events have such global aspect, the risk aligned with the tail event is difficult to diversify away even in a global stock market setting. Then, bearing such risk therefore should be rewarded through adequate changes in asset prices. No arbitrage principle implies that required rate of return should be adjusted in a way that is systematic across countries, not specific to a subset of countries, suggesting the existence of commonality in the premia around the world. We examine in this paper the common variation, or commonality, in the price of tail risk across countries based on 23,065 stocks from 44 countries from 1990 to 2015. We also investigate cross-country differences in the commonality as well as economic sources that drive the common variation in the premium. To the best of our knowledge, this is the first paper dealing with this issue.

We estimate tail risk of a country following Kelly and Jiang (2014) and first test whether bearing tail risk is properly rewarded in the form of stock returns in global financial markets. We find global evidence that stocks whose returns are more sensitive to a tail risk of a country are traded, on average, at a discount since investors request higher rate of return to hold such stocks. Given evidence of this unconditional pricing of tail risk, next we examine whether the price of tail risk of a country has systematic components which are common across countries. The regression analyses show that tail risk premium of a country tends to comove with the regional and global aggregates of tail risk premia, supporting the existence of global commonality. This result is robust to the inclusion of global as well as regional factors. Reflecting the dominant influence of U.S. stock market in global stock markets, the commonality is also found with respect to the tail risk premium of U.S. stock market. Principal component analysis to extract common and systematic component in the premia across countries shows that the first five principal components explain all variation of tail risk premia across countries, with the first principal component alone explaining more than 30% of the variation.

We investigate in the subsequent analyses the potential driving forces of common variation of tail risk premia, especially focusing on economic uncertainty. We use various proxies for economic uncertainty such as implied volatility of S&P 500 index futures (VIX), , default premium and term premium in the U.S as well as global stock market volatility. Our regression shows that US economic situation and the global market volatility are significantly related to the changes in the premium for tail risk across countries, driving comovement in the tail risk premia. The result implies that correlated reaction to decline in economic situation of the U.S. and the global market raises required rate of return for holding stocks with high tail risk worldwide, leading to a common variation of tail risk premia around the world. That is, the pricing of tail risk is driven by systematic variation of tail risk premium so that arbitrage opportunity from price discrepancy can be washed away.

Our paper contributes first to the literature on tail risk. Tail risk is shown to be priced (Bollerslev and Todorov, 2011; Kelly and Jiang, 2014; Bali *et al*., 2014; Chabi-yo, Ruenzi, and Weigert, 2015) and the time variation of its premium is shown to be related to return predictability (Bollerslev, Todorov, and Xu, 2015). However, these papers exclusively focus on the U.S. market and the issue has yet been dealt with for international stock markets. The only exception is Lee and Yang (2018), who show that the development of financial globalization has increased tail risk worldwide by increasing the possibility of tail risk spillovers across countries. In the paper, the hybrid tail risk of Bali *et al*. (2014) is shown to be priced globally. Our paper is the first, together with Lee and Yang (2018), which show the unconditional pricing of tail risks around the world. Second, this is the first paper that shows the existence of commonality in tail risk premia across countries. International stock markets are shown to be correlated across countries (Roll, 1992; Bekaert, Hodrick, and Zhang, 2009; Dutt and Mihov, 2013) and the correlation is stronger when volatility is high (Longin and Solnik, 1995). Recently, illiquidity premia is shown to have commonality across countries (Amihud *et al*., 2015). We add to the literature by showing that commonality is also present in tail risk premia across countries. Third, we emphasize the role of global economic undertainty in the variation of tail risk premium. Bollerslev and Todorov (2011) build Investor Fear index by exploiting the jump tail behavior and show that the compensation for, or the price of, fears of crash events varies over time in the U.S. Bollerslev, Todorov and Xu (2015) show that the variation in the tail risk premia is linked to return predictability, highlighting the role of market fears in predicting returns. While these papers link fears to tail risk, we provide new insight on the role of economic uncertainty in the common variation of tail risk premia around the world.

II. Tail risk and tail risk premium

In this section, we describe our sample stocks and explain how we estimate tail risks and tail risk premium for each country.

II.1 Data and Sample

Our sample period is from 1990 to 2015 and we have 44 countries including 18 emerging markets (Argentina, Brazil, Chile, China, Hungary, India, Indonesia, Malaysia, Mexico, Pakistan, Peru, Philippines, Poland, Russia, South Africa, Sri Lanka, Thailand, and Turkey) and 26 developed markets (Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hong Kong, Ireland, Israel, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Singapore, South Korea, Spain, Sweden, Switzerland, Taiwan, U.K., and the U.S.). Developed and emerging market classification is based on World Bank. For U.S. stocks, we obtain daily stock return data from the Center for Research and Security Prices (CRSP). To avoid survivorship bias, if stocks are delisted during the sample period we use delisting returns as stock returns, if available. For stocks from other countries, we obtain the data from Datastream. We use a daily total return index (RI) to calculate the return for non-U.S. stocks. Following Lee (2011) and Karolyi, Lee, and van Dijk (2012), we restrict the sample stocks to those listed on the major exchanges. Most sample countries have a single major exchange except for Canada (Toronto and TSX Venture), China (Shanghai and Shenzen), India (National India and BSE Ltd.), Japan (Tokyo and Jasdaq), , Russia (MICEX SE and Russian Trading Sys), South Korea (KOSPI and Kosdaq), Spain (Madrid and Madrid-SIBE), Taiwan (Taiwan and Taiwan OTC), and U.S. (NYSE, AMEX, and Nasdaq).

Following Griffin, Kelly, and Nardari (2010) and Lee (2011), we eliminate non-common shares by examining the name of stocks[1]. To construct reliable daily sample, we use the following several filters from Ince and Porter (2006) and Lee (2011). We set daily return as missing if total return index is less than 0.01; if daily return of greater than 100% is reversed the following day; or if daily return is greater than 200%. We also set a daily trading volume to missing if dollar volume on that day is less than USD100. We build monthly sample based on the daily sample. We eliminate the stock-month observations if the number of non-missing return days is less than 10 days or the number of days with zero return or no price change is greater than 80% of total trading days in a given month. Similar to daily return screening, we set monthly return, which is computed based on end-month daily RI, to missing if monthly return of 150% is reversed the following day or if monthly return is above 300%. After implementing all these screens, our sample includes 23,065 stocks from 44 countries.

II.2 Tail risk and its premium

We employ the tail risk measure proposed by Kelly and Jiang (2014). They propose a new measure of time-varying tail risk obtained by a panel estimation approach, which is designed to overcome

[1] We drop stocks with names including "REIT", "REAL EST", "ADR", "GDR", "PF", "PREF", or "PRF" as these terms may represent REITs, ADRs, GDRs, or preferred stocks. We drop stocks with names including "DUPLICATE", "DUPL", "WARRANT", "WTS", "DEBENTURE", "RLST", "ADS", "RESPT", "UNIT" (except for United Airline, etc), "TST", "TRUST", "INCOME FD", "INCOME FUND", "UTS", "RST", "CAP.SHS", "INV", 'INV TRU.S.T", "HDG", 'UNIT TST", "UNIT TRU.S.T", "BOND FUND", "SBVTG", "VTG.SAS", "GW.FD", "RTN.INC", "VCT", "ORTF", "HI.YIELD", 'YIELD", "YLD", "PARTNER", "HIGH INCOME", "INC.&GROWTH", and "INC.&GW" because these words describe some special features in shares. Following Griffin *et al*. (2010), we apply industry selection criteria and exclude financial firms using the Datastream industry code of "ITSPL", "ITPEQ", "INVNK", "ITINT", "UNITS", "RLDEV", "CURFD", "COMUT", "INSPF", "OFFSH", "INVTO", "PRPUT", "OEINC", "ITVCT", "EXTRF", "RITIO", "RITRT", "RITRS", "RITDV", "RITSP" , "RITMG", "RITHL", "ITHSI", "RLSRV", "MUTFS", "PENSF", "HEDGE", "MMFDS", and "ITSPL". For the U.S., we use the CRSP share code of 10 and 11 to extract common shares.

the econometric problem arising from infrequent nature of extreme events. When the probability of crash follows a "power law," it can be modeled as:

$$Prob\left(r_{j,i,t+1} < r_j^* | r_{j,i,t+1} < u_{j,t} \ and \ \Phi_t\right) = \left(\frac{r_j^*}{u_{j,t}}\right)^{-\left(\frac{a_{j,i}}{TR_{j,t}}\right)}, \qquad (1)$$

with the restriction for the lower tail threshold, $u_{j,t}$, to be $r_j^* < u_{j,t} < 0$. In the equation, $r_{j,i,t+1}$ is a return of stock *i* in country *j* at time *t*+1 and Φ_t is an information set at time *t*. The probability will be governed by two parameters, of which one is stock-specific ($a_{j,i}$) and the other is common across stocks in a given country *j* ($TR_{j,t}$). By focusing on the common aspect of tail risks in the cross-section of stocks at time *t*, Kelly and Jiang (2014) propose that the tail risk, $TR_{j,t}$, be estimated in a panel data framework though the crash events are infrequent.

To estimate the tail risk for each country, we first calculate the 5th percentile ($u_{j,t}$) of daily stock returns from pooled cross-section in month *t* for country *j*. Then, given the lower threshold of $u_{j,t}$, we estimate the tail risk by Eq. (2) by applying Hill's (1975) power law estimator to all stocks in month *t*, following Kelly and Jiang (2014).

$$TR_{j,t} = \frac{1}{N_{j,t}} \sum_{n=1}^{N_{j,t}} ln\left(\frac{r_{j,n,t} | r_{j,n,t} < u_{j,t}}{u_{j,t}}\right) \qquad (2)$$

The numerator in the parenthesis in Eq. (2) is the daily return, which falls below the threshold level of $u_{j,t}$. $N_{j,t}$ is the number of stock-day observations in country *j* in month *t*, in which the daily return is lower than the threshold. Given the estimated tail risk on month *t*, we estimate tail risk beta in the regression of stock return on tail risk of a country using the most recent 60 months of data (stocks are required to have at least 24 months of data in this window):

$$r_{j,i,t+1} = \alpha_{j,i} + \beta_{j,i} TR_{j,t} + \varepsilon_{j,i,t} \quad (3)$$

Stocks with high value of tail risk beta on month *t*, $\beta_{j,i}$, are more sensitive to tail risk and thus should be compensated more for the tail risk. Therefore, we expect stocks with high tail risk beta to have higher future return than stocks with low beta. For each country, we sort stocks into five portfolios based on the average of estimated loadings on tail risk of *t*-3 to *t*-1 and calculate both equal- and value-weighted average of stock returns for each portfolio for month *t*+1, *t*+2, and *t*+3, skipping month *t* to avoid short-term return reversal. The tail risk premium is then defined as the return difference between the top and the bottom quintile tail beta portfolios.

[INSERT TABLE 1 HERE]

Table 1 displays the return, volatility, estimated tail risk and the tail risk premium for each country, separately for developed (panel A) and emerging markets (panel B). Ret (%) and Volatility (%) are averages of cross-sectional average in a given country of monthly U.S. dollar stock return and of standard deviation of daily stock returns in a given month, respectively. Tail risk, estimated by Eq. (2), is averaged over the sample period for each country. Tail risk premium is an average of returns for months of *t*+1, *t*+2, and *t*+3 after portfolio formation based on average tail risk beta of *t*-1 to *t*-3 of equal- (EW) or value-weighted (VW) portfolio that longs stocks with high tail risk beta stocks and shorts stocks with low tail risk beta.

For many of the sample countries, the sample starts from early 1990s. Ireland has the shortest sample period, starting from 2002. Reflecting the high-risk and high-return feature of emerging market countries, the average return (volatility) is 1.00% (2.94%) for developed market, while it is 1.84% (3.15%) for emerging market countries. Tail risk is smallest in Taiwan and China and largest in Peru. The average tail risk is similar across emerging (0.40) and developed (0.41) market countries. Tail risk premium is mostly positive in our sample.

Based on the estimated tail risk beta or the sensitivity of stock return on a tail risk, we sort stocks into five equal- (EW) or value-weighted (VW) portfolios for each country. Tail risk premium (*TailPrem*) is defined as the difference in US dollar returns between the highest tail risk beta portfolio and the lowest tail risk beta portfolio. The table reports the tail risk premium and the risk adjusted premium (*Alpha*). *Alpha* is obtained by the estimated intercept in the regression of tail risk premium on global as well as regional factors in Eq. (4).

$$TailPrem_{j,t} = \alpha_j + \beta_{1,j} MKT_t^G + \beta_{2,j} SMB_t^G + \beta_{3,j} HML_t^G + \gamma_{1,j} MKT_t^{R\_orth} + \gamma_{2,j} SMB_t^{R\_orth} + \gamma_{3,j} HML_t^{R\_orth} + \varepsilon_{j,t} \quad (4)$$

MKT^G is MSCI world market return in excess of U.S. T-Bill rate. Following Amihud *et al*. (2015), we construct global factors of SMB^G and HML^G as an average of *SMB* and *HML*, respectively, across sample countries, weighted by the previous year-end market capitalization (in USD) of a country. *SMB* (HML) is a return of a portfolio formed on size (book-to-market ratio) as in Fama and French (1993) [2]. The factors with superscript of *R_orth* denote that the regional factors are orthogonalized against each global counterpart (Jorion and Schwartz, 1986; Lee, 2011). To form regional factors, we divide the sample countries into three regions, Asia-Pacific (Australia, China, Hong Kong, India, Indonesia, Japan, Malaysia, New Zealand, Pakistan, Philippines, South Korea, Singapore, Sri Lanka, Taiwan, and Thailand), America (Argentina, Brazil, Canada, Chile, Mexico,

[2] For the U.S., we obtain SMB, HML, and MKT from Kenneth R. French's Data Library.

Peru, and the U.S.), and Europe (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Netherlands, Norway, Poland, Portugal, Russia, South Africa, Spain, Sweden, Switzerland, Turkey, and the U.K.). Regional factors are formed based on the average of country factors across countries in the region. We use global and regional factors, but not country factors in the regressions, since country factors are mostly explained by regional factors and we can reduce the number of factors in the regression by using regional factors rather than country factors (Amihud *et al*., 2015; Brooks and Negro, 2005; Bekaert, Hodrick, and Zhang, 2009; Ang, Hodrick, Xing, and Zhang, 2009).

The unconditional average of the tail risk premium based on equally-weighted (value-weighted) portfolios is positive for 35 (26) countries and significant as well for 8 (8) countries. This result shows that the tail risk indeed matters in asset pricing for many countries around the world. The more intriguing feature of tail risk premium is, however, on its time varying pattern in relation to changes in economic environment, rather than on its unconditional characteristic. For example, investors may be less willing to pay premium for bearing tail risk or even ignore the tail risk when the tail event is highly unlikely to occur, i.e., when the economy is good. On the contrary, investors will be more likely to pay premium of tail risk when the economy is weak. We will investigate this issue in the later part of this paper.

III. Common variation of tail risk premia across countries

We examine whether there are common and systematic patterns in the variation of tail risk premia around the world. In doing so, we use both regression analysis and principal component analysis in this section.

III.1 Comovement with global and regional tail risk premia

As a first step, we examine the time-series plot of the premium by regions. Figure 1 shows the plots.

[INSERT FIGURE 1 HERE]

We first see that there is substantial time variation in the tail risk premium around the world, regardless of the weighting scheme. The premium is large and highly volatile especially around crash events such as the meltdown of LTCM (1998), the Subprime Mortgage Crisis, and the Eurozone crisis in early 2010s. In panels B and C, we observe the similar or *common* pattern in the time variation of tail risk premium for the subsets of sample countries. For example, the peaks in the late 1990s and the early and late 2000s are conspicuous for developed countries, emerging market countries and the U.S. This similarity in the time variation in different subsets of sample countries implies the existence of common and systematic patterns, or the *commonality*, in the variation of tail risk premia worldwide. Therefore, it is natural to examine the pattern more rigorously and to subsequently ask an important research question about the driving force of such common variations in the premia.

Given the perceived existence of commonality in the tail risk premium in Figure 1, we now turn to more rigorous framework to support this finding. We regress the tail risk premium of a given country *j* on global, regional, and U.S. tail risk premia as well as on the global and regional factors to adjust the premium for known risks (Eq. (5)).

$$TailPrem_{j,t} = \alpha_j + \lambda_{1,j}TailPrem_t^G + \lambda_{2,j}TailPrem_t^R + \lambda_{3,j}TailPrem_t^{US}$$

$$+\beta_{1,j}MKT_t^G + \beta_{2,j}SMB_t^G + \beta_{3,j}HML_t^G$$

$$+\gamma_{1,j}MKT_t^{R\_orth} + \gamma_{2,j}SMB_t^{R\_orth} + \gamma_{3,j}HML_t^{R\_orth} + \varepsilon_{j,t} \qquad (5)$$

The superscript *G*, *R*, and *US* denote that the variables are formed based on stocks from all sample countries, given regions (developed or emerging), and the U.S., respectively. $TailPrem^G$ ($TailPrem^R$) is a tail risk premium averaged across all sample countries (developed market countries or emerging market countries), excluding the premium of country *j*.

[INSERT TABLE 2 HERE]

Table 2 shows the results of the regression. The coefficients of $TailPrem^G$ and $TailPrem^R$ are positive and highly significant for both equally-weighted and value-weighted cases and for all sample countries as well as for developed and emerging market countries. Furthermore, we see that the coefficient on $TailPrem^{US}$ is always positive and significant in some cases. The R^2 of the regressions is high enough ranging from 72.8% to 85.7%. The results imply that the tail risk premium at the country level contains systematic components, which co-varies with the global, regional, and the U.S. tail risk premium, supporting the existence of commonality in tail risk premium around the world.

In Table 2, the comovement with global market tail risk premium, $TailPrem^G$, is stronger in developed countries than in emerging market countries. On the contrary, the comovement with regional market tail risk premium, $TailPrem^R$, is stronger in emerging market than in developed market. It may be possible that the smaller degree of financial market openness in emerging market than in developed market may play some role here. Hence, we further examine the existence of commonality in relation to the openness of financial market.

In doing so, we augment the regressions in Eq. (5) by adding interaction terms of global, regional and US tail risk premia with the dummy variable, *Open*, which measures the openness of financial markets. The variable is obtained from FactSet which provides the percentage of foreigner ownership for each stock each country quarterly (our data periods is from 2000 to 2013). Open equals 1 is country *j*'s foreign ownership is higher than average of all countries foreign ownership in our sample in a given year and zero otherwise.

[INSERT TABLE 3 HERE]

Table 3 shows the results of the regressions. The coefficient of $TailPrem^G$, $TailPrem^R$, and $TailPrem^{US}$ are positive and significant, reflecting the existence of commonality in tail risk premium. Moreover, the interaction of $TailPrem^G$ with *Open* is significant and positive, supporting our expectation that the commonality with respect to $TailPrem^G$ is stronger for countries that are more open. Interaction of *Open* with other tail risk premia such as $TailPrem^R$ and $TailPrem^{US}$ is, however, not significant or negative. The negative and significant interaction terms with regional- and US-related commonality imply that what is important is the commonality with respect to global, not regional nor US, tail risk premium for open countries.

III.2 Principal component analysis

In a further empirical exercise for the commonality in tail risk premia, we perform the principal component analysis in this section. The principal component analysis is an econometric methodology, which is popular to extract common and systematic components across multiple variables of interest. For example, Hasbrouck and Seppi (2001) show the existence of commonality in liquidity by the principal component analysis. Korajczyk and Sadka (2008) show that the common components extracted by the principal component analysis across different measures of stock illiquidity significantly contribute to the pricing of illiquidity. Kim and Lee (2014) test the liquidity-adjusted capital asset pricing model of Acharya and Pedersen (2005) using the principal components across multiple illiquidity measures. Baker, Wurgler, and Yuan (2012) build global sentiment indicator by the first principal component extracted from local investor sentiment indices from six countries.

Since we have an unbalanced panel of tail risk premia across countries, it is important to properly handle missing observations in performing the principal component analysis. Stock and Watson (2002) develop the expectation and maximization (EM) algorithm, which helps us cope with this issue. The details of the principal component analysis embedded with the EM algorithm are as follows. We initially fill the missing observations using the unconditional mean of non-missing tail risk premia across countries in a given month. Based on this new balanced panel, we extract first N principal components (PC) of the premia across countries. The number of PCs, N, is chosen at the level, above which the proportion of variation of the premium explained by the PCs becomes larger than 50%. Subsequently, we regress the tail risk premium on these N PCs. Then, we project the missing observation by combining the estimated coefficients with the non-missing PCs. We repeat the procedure until the PC estimates converge to those in the previous iteration. Convergence is measured by the sum of the squared prediction errors.

[INSERT FIGURE 2 HERE]

Figure 2 shows the eigenvalue of the first five principal components for tail risk premia across countries in separate panels for equally-weighted and value-weighted premia. We see that the first five PCs fully explain the total variation of tail risk premia across countries, while the first PC explains more than 30% of total variation. The eigenvalue for the second PC is much lower than the first PC, but is still around 20%. The results are similar for both EW and VW cases. The principal component analysis exercise also supports the earlier finding of the existence of commonality in tail risk premia across countries.

IV. What drives common variation in tail risk premia around the world?

In this section, we examine the source of commonality in the tail risk premia across countries. It is quite plausible that the degree of commonality may vary across countries. Therefore, we first examine the cross-country variation in the commonality in the tail risk premium. In doing so, we compute the correlation of tail risk premium for each country with the first principal component obtained in the previous section.

[INSERT FIGURE 3 HERE]

The degree of commonality is, indeed, greatly different across countries. Developed countries seem to have higher correlation, while emerging market countries generally have lower correlation. This is consistent with the findings in Table 2. In both panels, the U.S., UK, France, Denmark and Russia are the countries with the highest correlation with the first PC of tail risk premia, hence with the largest degree of commonality. Among these countries, we specifically focus on the U.S., whose dominant role in the global financial markets has been emphasized much until recently. We posit the possibility that some forces that are significantly related to the U.S. economic situation drive the time-variation of tail risk premium across countries worldwide. We examine this possibility in the next section.

IV.1 Commonality in tail risk premium and the U.S. economic environment

It is well known that the U.S. stock market is the world's largest one,[3] and that the crash events in the US such as the meltdown of LTCM or the Subprime mortgage crisis had significant impact on global economy. Lee (2011) shows that the U.S. market liquidity has substantial impact on the asset pricing in international financial market. Moreover, our regression analysis in Table 3 shows that the tail risk premium by each country is significantly and positively related to the US tail risk premium. Therefore, in this section, we test whether U.S. economic environment has an impact on the variation of tail risk premium around the world.

Investors request higher compensation in economic downturns for bearing tail risks since stocks with high tail risk are more likely to plunge in such period, resulting in negative relation between tail risk premium and economic environment. To a degree to which U.S. economic environment has a global impact[4], such negative relation will be observed in many countries, leading to commonality in tail risk premium around the world. We use the volatility index based on S&P 500 stock index options from Chicago Board Options Exchange (*US VIX*), yield difference between Moody's seasoned BAA-rated corporate bonds and AAA-rated corporate bond with maturities 20 years (*Default premium*), and yield difference between 10-year Treasury and 3-

[3] For example, the U.S. listed stocks takes more than 42% of global stock market in terms of market capitalization in 2016 (World Bank).

[4] For example, Baker, Wurgler, and Yuan (2012) show that market sentiment is correlated across countries through capital flows.

month Treasury (*Term spread*) as proxies for U.S. economic environment. We obtain the last two variables from Federal Reserve Economic Data. We run the following regressions for each country.

$$TailPrem_{j,t} = \alpha_j + \beta_{1,j} Char_{t-1} + Factors + \varepsilon_{j,t}$$

$$TailPrem_{j,t} = \alpha_j + \beta_{1,j} Char_{t-1}^{High} + \beta_{2,j} Char_{t-1}^{Low} + Factors + \varepsilon_{j,t} \qquad (6)$$

Char is a proxy of U.S. economic environment specified above. $Char^{High}$ ($Char^{Low}$) equals to *Char* if *Char* is above (below) the mean and zero otherwise. *Factors* include MKT^{G}, SMB^{G}, HML^{G}, MKT^{R_orth}, SMB^{R_orth}, and HML^{R_orth}. Table 4 reports the coefficients and *t*-values averaged across all sample countries (panel A), developed markets excluding the U.S. (panel B) and emerging market countries (panel C). The result for the U.S. is in panel D.

[INSERT TABLE 4 HERE]

The table shows that the tail risk premium around the world is indeed significantly affected by the US economic situation. In panel A, we see that default premium and term spread are significantly and positively related to tail risk premium, supporting the negative relation between the premium and the strength of the U.S. economy. US VIX is not significant but positive. When US VIX is broken down to high and low VIX, we see that they both are significant and positive. The nonlinear relation is also found. The impact of term spread on tail risk premium comes only from the increase in term premium. We see similar patterns for developed countries in panel B. The impact of the US economy is significant only through VIX in emerging markets (panel C). The results in this table show that the impact of U.S. economic environment is widely recognized worldwide in both developed and emerging market countries. Overall, we find that the U.S. economic condition is a source of commonality in tail risk premium.

IV.2 Commonality in tail risk premium and the global stock market volatility

We now turn to the impact of global economic environment on the tail risk premium. We use global market volatility as a proxy for global economic uncertainty. The periods of high global market volatility generally coincide with the periods of elevated uncertainty, during which the price of risk is disproportionately high (French, Schwert, and Stambaugh, 1987; Campbell and Hentschel, 1992; Baker, Wurgler, and Yuan, 2012). Longin and Solnik (1995) provide global evidenced that stock market correlation increases in periods of high volatility. Therefore, we expect positive relation between tail risk premium and market volatility. To a degree to which the responses of tail risk premium to global stock market volatility are correlated across countries, the strong commonality in the tail risk premia around the world will be observed.

We run the regressions in Eq. (6) by country with *Char* replaced with global stock market volatility (*GMKVOL*). *GMKVOL* is global market volatility, which is an average across countries of an equal-weight average of standard deviation of daily stock returns in a given country and month. Table 5 shows the results.

[INSERT TABLE 5 HERE]

Panel A shows that global stock market volatility is significantly and positively related to the tail risk premium. The relation is preserved whether the global market volatility is high or low. This is also shown for developed market countries in panel B. In panel C, tail risk premia from emerging market countries are also positively and significantly related to global market volatility. In the U.S., the nonlinear pattern is more explicit in that the premium is affected only when the global market volatility is high. Overall, we see that global uncertaintly, proxied by global market volatility has significant impact on tail risk premium, driving the commonality in the premium around the world.

V. Conclusion

In this paper, we examine common patterns in the variation of tail risk premia across countries. Our sample covers 71,006 stocks from 44 countries and the sample period ranges from 1990 to 2015. Based on this large sample of stocks, we estimate tail risk of a country following Kelly and Jiang (2014). We first find evidence that the sensitivity of stock returns to a tail risk of a country is significantly priced worldwide. We further show that the tail risk premium of a country is significantly related with the U.S., regional, and global tail risk premia, evidence of which show the existence of commonality in tail risk premia across countries. The commonality is also supported by the principal component analysis, which shows that majority of variation in the premia across countries is explained by the first five principal components. The test to examine the cross-country differences in the commonality shows that the commonality is stronger for countries that are more open. To investigate the source of common time variation in the tail risk premia, we examine the relation between the premium and the U.S. economic environment and the global market volatility. We show that weakening of U.S. economy raises required rate of return for holding stocks with high tail risk worldwide, which in turn leads to a common variation of tail risk premia around the world.

Although we provide evidence on the existence and the driving force of common variation in the tail risk premia in this paper, we do not investigate the differences in the commonality across stocks in a country. Since our sample covers stocks as well as countries with various characteristics, cross-stock analyses combined with cross-country analyses may also provide a good opportunity to understand the commonality in tail risk. Building on this paper, it would be interesting to investigate this issue in the future studies.

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Table 1. Summary statistics

The table shows the summary statistics for our sample stocks separately for developed (panel A) and emerging markets (panel B). *Start year* denotes the first year in which firm-level data are available. *N of firms* is the total number of sample firms in a given country. *Ret (%)* and *Volatility (%)* are averages of cross-sectional average in a given country of monthly US dollar stock return and of standard deviation of daily stock returns in a given month, respectively. *Tail risk* is an average for each country of monthly tail risk of Kelly and Jiang (2014) (Eq. (2)), which is obtained using daily returns of all stocks in a country in a month. We estimate stock's tail risk beta on month *t* from the coefficient of tail risk in the regression of stock return on the tail risk over months from *t*-60 to *t*-1. We sort stocks into five equal- (EW) or value-weighted (VW) portfolios in each country based on the average tail risks in months *t*-3 to *t*-1 and calculate the return difference, *TailPrem* (%), between the high tail risk portfolio and low tail risk portfolio for months *t*+1, *t*+2, and *t*+3. The portfolio formation is repeated for every three months *Alpha* is an abnormal return (%) or an intercept in the regression of tail risk premium on global and regional Fama-French factors as in Eq. (4). The asterisks of *, **, and *** denote the significance at 10%, 5%, and 1% level, respectively. The standard error is Newey-West adjusted with a lag of three months.

Country	Start year	N of firms	Ret(%)	Volatility (%)	Tail risk	TailPrem		Alpha	
						EW	VW	EW	VW
Panel A: Developed Markets (26 countries)									
AUSTRALIA	1990	859	1.317	3.969	0.436	0.433*	0.120	0.724**	0.788**
AUSTRIA	1990	59	0.643	2.143	0.462	0.271	0.615	0.125	0.444
BELGIUM	1990	125	0.875	2.175	0.415	0.452	0.390	0.376	0.229
CANADA	1990	1,538	1.110	5.906	0.401	0.174	-0.095	0.621**	0.515
DENMARK	1990	119	1.009	2.371	0.466	0.313	0.200	0.559	0.442
FINLAND	1990	91	1.244	2.596	0.396	0.005	-0.396	-0.039	-0.312
FRANCE	1990	535	0.962	2.523	0.458	0.251	0.015	0.256	-0.002
GERMANY	1990	599	0.300	3.526	0.467	0.587**	0.274	0.337	0.261
GREECE	1990	200	1.143	3.335	0.314	-0.522	-1.165*	-0.602	-1.368**
HONG KONG	1990	742	1.664	3.325	0.368	0.179	-0.106	-0.172	-0.386
IRELAND	2002	35	1.162	3.414	0.494	1.476*	2.246*	1.363	2.177*
ISRAEL	1995	278	1.420	2.917	0.435	0.140	-0.426	0.113	-0.571
ITALY	1990	237	0.572	2.263	0.323	0.069	0.342	0.236	0.349
JAPAN	1990	2,723	0.568	2.689	0.346	0.116	-0.064	0.117	-0.065
NETHERLANDS	1990	145	0.797	2.347	0.438	-0.479*	-0.110	-0.597	-0.224
NEW ZEALAND	1992	95	1.205	2.382	0.489	-0.010	0.717**	-0.230	0.231
NORWAY	1990	133	1.025	3.197	0.393	0.000	0.168	0.178	0.418
PORTUGAL	1990	44	0.552	2.330	0.486	0.358	-0.431	0.206	-0.429
S.KOREA	1990	1,079	1.372	3.576	0.282	0.296	-0.006	-0.097	-0.068
SINGAPORE	1990	308	1.232	2.912	0.406	0.203	0.716**	0.166	0.972**
SPAIN	1992	139	0.744	2.264	0.338	0.319	0.771*	0.321	0.896**
SWEDEN	1990	331	0.944	3.294	0.441	-0.295	-0.135	-0.094	0.095
SWITZERLAND	1991	257	0.954	2.093	0.406	0.325	0.644**	0.345	0.531
TAIWAN	1993	961	0.753	2.614	0.267	0.270	-0.007	0.343	0.348
UK	1990	874	0.986	2.556	0.475	0.365*	-0.044	0.115	-0.262
US	1990	5,326	1.180	3.774	0.426	0.307	0.267	0.192	0.002
Panel B: Emerging Markets (18 countries)									
ARGENTINA	1995	51	1.621	2.824	0.316	0.015	0.489	0.101	0.357
BRAZIL	2001	130	2.039	3.268	0.411	0.888**	1.231**	1.025**	1.490**
CHILE	1991	69	1.812	2.037	0.414	1.058***	0.841**	0.947***	0.683**
CHINA	1994	1,190	2.725	2.981	0.267	0.028	-0.111	-0.134	-0.264
HUNGARY	1993	24	0.829	2.929	0.477	0.360	-0.340	0.223	-0.376
INDIA	1997	1,534	1.873	3.819	0.340	0.477	0.255	0.489	0.221
INDONESIA	1992	94	1.956	3.318	0.385	0.342	0.419	0.313	-0.079
MALAYSIA	1990	565	1.303	3.042	0.366	-0.016	-0.195	0.298	-0.216
MEXICO	1990	60	1.827	2.423	0.396	0.518	1.594	0.499	1.683**
PAKISTAN	1994	118	2.221	3.190	0.461	-0.240	-0.795	0.005	-0.417

PERU	1994	37	2.367	2.812	0.553	-0.653	-0.440	-0.857	-0.802
PHILIPPINES	1990	106	1.616	3.502	0.408	0.618	0.307	0.399	-0.089
POLAND	1995	235	2.024	3.557	0.397	0.685	0.640	0.543	0.705
RUSSIA	2001	78	2.446	3.637	0.447	0.900	0.817	0.846	0.728
S.AFRICA	1992	229	1.097	3.209	0.527	0.277	0.519	0.381	0.642*
SRI LANKA	1992	96	1.939	3.443	0.398	-0.550	-0.473	-0.297	-0.042
THAILAND	1990	323	1.425	3.012	0.365	0.592	0.333	0.236	-0.033
TURKEY	1996	294	1.999	3.637	0.303	0.415	0.381	0.408**	0.070

Table 2. Commonality in tail risk premium

The table shows the results of the regression of tail risk premium of a country on the tail risk premium of global, regional, and U.S. markets. We first estimate monthly tail risk of Kelly and Jiang (2014) (Eq. (2)) for each country using daily returns of all stocks in a country in a month and subsequently estimate stock's tail risk beta on month *t* from the coefficient of tail risk in the regression of stock return on the tail risk over months from *t*-60 to *t*-1. We sort stocks into five equal-(EW) or value-weighted (VW) portfolios in each country based on the average tail risks in months *t*-3 to *t*-1 and calculate the return difference, *TailPrem* (%), between the high tail risk portfolio and low tail risk portfolio for months *t*+1, *t*+2, and *t*+3. The portfolio formation is repeated for every three months.

$$TailPrem_{j,t} = \alpha_j + \lambda_{1,j} TailPrem_t^G + \lambda_{2,j} TailPrem_t^R + \lambda_{3,j} TailPrem_t^{US}$$
$$+\beta_{1,j} MKT_t^G + \beta_{2,j} SMB_t^G + \beta_{3,j} HML_t^G + \gamma_{1,j} MKT_t^{R\_orth} + \gamma_{2,j} SMB_t^{R\_orth} + \gamma_{3,j} HML_t^{R\_orth} + \varepsilon_{j,t}$$

The superscript *G*, *R*, and *US* denote that the variables are aggregated over stocks from all sample countries, given regions (America, Europe, or Asia-Pacific), and the U.S., respectively, excluding those from country *j*. The factors with superscript of *R_orth* denote that the regional factors are orthogonalized against global counterparts. *MKT* is MSCI world market return in excess of U.S. T-Bill rate. *SMB* and *HML* are size and book-to-market factors, respectively. The *t*-values is in italic and standard errors are clustered by country and month. The ***, **, and * represents significance at 1%, 5%, and 10% level, respectively.

	All		Developed markets		Emerging markets	
	EW	VW	EW	VW	EW	VW
$TailPrem^G$	0.121***	0.067***	0.184***	0.092***	0.031	0.031
	3.34	*3.03*	*4.19*	*2.89*	*0.66*	*1.38*
$TailPrem^R$	0.855***	0.870***	0.771***	0.858***	0.959***	0.885***
	8.09	*13.79*	*4.49*	*8.06*	*57.29*	*16.09*
$TailPrem^{US}$	0.039**	0.021*	0.052	0.026*	0.028	0.016
	1.97	*1.86*	*1.64*	*1.94*	*1.53*	*1.33*
MKT^G	0.013**	0.025**	0.012	0.027*	0.015**	0.023
	2.05	*2.12*	*1.28*	*1.70*	*2.53*	*1.26*
SMB^G	0.023	0.068**	0.042	0.072	-0.005	0.068**
	1.07	*2.12*	*1.21*	*1.31*	*-0.20*	*2.44*
HML^G	0.028*	0.025	0.029	0.035	0.018	0.018
	1.95	*1.13*	*1.27*	*1.01*	*1.14*	*0.60*
MKT^{R_orth}	-0.001	0.003	-0.000	0.009	-0.004	-0.011
	-0.15	*0.34*	*-0.01*	*0.97*	*-0.50*	*-0.97*
SMB^{R_orth}	0.035**	0.034**	0.033*	0.034	0.030	0.037*
	2.48	*2.38*	*1.85*	*1.48*	*1.63*	*1.91*
HML^{R_orth}	0.036	0.046	0.046	0.061	0.033	0.014
	1.04	*1.15*	*1.00*	*1.13*	*0.89*	*0.43*
R^2 (%)	78.3%	78.0%	72.8%	77.2%	85.7%	79.1%
Country Dummy	YES	YES	YES	YES	YES	YES

Table 3. Source of commonality

This table shows the results of market openness and tail risk premium. We first estimate monthly tail risk of Kelly and Jiang (2014) (Eq. (2)) for each country using daily returns of all stocks in a country in a month and subsequently estimate stock's tail risk beta on month *t* from the coefficient of tail risk in the regression of stock return on the tail risk over months from *t*-60 to *t*-1. We sort stocks into five equal-(EW) or value-weighted (VW) portfolios in each country based on the average tail risks in months *t*-3 to *t*-1 and calculate the return difference, *TailPrem* (%), between the high tail risk portfolio and low tail risk portfolio for months *t*+1, *t*+2, and *t*+3. The portfolio formation is repeated for every three months.

$$TailPrem_{j,t} = \alpha_j + \lambda_{1,j}TailPrem_t^G + \lambda_{2,j}TailPrem_t^R + \lambda_{3,j}TailPrem_t^{US} + \lambda_{4,j}TailPrem_t^G \times Open_{j,t} + \lambda_{5,j}TailPrem_t^R \times Open_{j,t} + \lambda_{6,j}TailPrem_t^{US} \times Open_{j,t} + \lambda_{7,j}MKT_t^G \times Open_{j,t} + \lambda_{8,j}Open_{j,t} + \beta_{1,j}MKT_t^G + \beta_{2,j}SMB_t^G + \beta_{3,j}HML_t^G + \gamma_{1,j}MKT_t^{R\_orth} + \gamma_{2,j}SMB_t^{R\_orth} + \gamma_{3,j}HML_t^{R\_orth} + \varepsilon_{j,t}$$

The superscript *G*, *R*, and *US* denote that the variables are aggregated over stocks from all sample countries, given regions (America, Europe, or Asia-Pacific), and the U.S., respectively, excluding those from country *j*. The factors with superscript of *R_orth* denote that the regional factors are orthogonalized against global counterparts. *MKT* is MSCI world market return in excess of U.S. T-Bill rate. *SMB* and *HML* are size and book-to-market factors, respectively. The *t*-values is in italic and standard errors are clustered by country and year. The ***, **, and * represents significance at 1%, 5%, and 10% level, respectively.

	EW					VW				
$TailPrem^G$	0.113	0.214***	0.215***	0.104	0.145**	0.139**	0.265***	0.267***	0.134**	0.145**
	1.68	*3.36*	*3.19*	*1.59*	*2.20*	*2.03*	*3.48*	*3.44*	*1.96*	*2.02*
$TailPrem^R$	0.734***	0.952***	0.733***	0.953***	0.959***	0.794***	0.967***	0.794***	0.968***	0.970***
	4.38	*54.53*	*4.37*	*55.07*	*62.16*	*7.91*	*63.82*	*7.92*	*64.07*	*66.23*
$TailPrem^{US}$	0.113***	0.113***	0.072***	0.114***	0.046**	0.049***	0.046***	0.025	0.047***	0.012
	2.90	*3.33*	*2.75*	*3.31*	*2.52*	*3.04*	*2.63*	*1.19*	*2.59*	*0.53*
$TailPrem^G$*Open	0.193*			0.214**	0.140*	0.248**			0.258**	0.238**
	1.88			*1.98*	*1.88*	*2.32*			*2.34*	*2.33*
$TailPrem^R$*Open		-0.31		-0.31	-0.32		-0.26**		-0.26**	-0.26**
		-1.58		*-1.59*	*-1.61*		*-2.25*		*-2.25*	*-2.27*
$TailPrem^{US}$*Open			0.08		0.13			0.05		0.07
			1.36		*1.53*			*1.03*		*1.49*
MKT^G*Open	0.014	0.039	0.007	0.030	0.007	0.035	0.087**	0.038*	0.064*	0.037*
	1.32	*1.38*	*0.94*	*1.36*	*0.82*	*1.34*	*2.04*	*1.80*	*1.95*	*1.86*
Open	0.000	0.001	0.000	0.001	0.000	0.002	0.003*	0.003	0.002	0.002
	-0.16	*0.71*	*-0.07*	*0.35*	*0.11*	*1.10*	*1.89*	*1.46*	*1.36*	*1.27*
MKT^G	-0.003	-0.015	0.001	-0.010	0.002	0.005	-0.020	0.003	-0.008	0.006
	-0.18	*-0.77*	*0.08*	*-0.59*	*0.18*	*0.21*	*-0.79*	*0.15*	*-0.37*	*0.40*
SMB^G	0.009	0.009	0.008	0.010	0.009	0.153***	0.141***	0.151***	0.143***	0.143***
	0.23	*0.24*	*0.22*	*0.24*	*0.23*	*2.64*	*2.80*	*2.62*	*2.81*	*2.81*
HML^G	0.025	0.009	0.026	0.009	0.009	0.053	0.044	0.054	0.042	0.042
	1.15	*0.41*	*1.22*	*0.37*	*0.41*	*1.35*	*1.26*	*1.40*	*1.21*	*1.22*
MKT^{R_orth}	-0.003	0.002	-0.001	0.002	0.005	-0.011	0.000	-0.010	0.000	0.001

	-0.21	*0.16*	*-0.07*	*0.14*	*0.38*	*-0.53*	*0.00*	*-0.49*	*-0.02*	*0.04*
SMB^{R_orth}	0.058**	0.049**	0.058**	0.049**	0.048**	0.065***	0.051**	0.065**	0.050**	0.049**
	2.37	*2.30*	*2.38*	*2.38*	*2.47*	*2.63*	*2.33*	*2.57*	*2.46*	*2.48*
HML^{R_orth}	0.095	0.084	0.090	0.086	0.081	0.127	0.112	0.121	0.116	0.113
	1.43	*1.29*	*1.42*	*1.33*	*1.34*	*1.42*	*1.26*	*1.37*	*1.32*	*1.32*
R^2 (%)	65.0%	67.1%	65.0%	67.2%	67.3%	66.6%	67.9%	66.5%	68.1%	68.1%
Country Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 4. Variation of tail risk premia and the U.S. economic environment

The table shows the results of the regression of tail risk premium on U.S. economic environment. We first estimate monthly tail risk of Kelly and Jiang (2014) (Eq. (2)) for each country using daily returns of all stocks in a country in a month and subsequently estimate stock's tail risk beta on month *t* from the coefficient of tail risk in the regression of stock return on the tail risk over months from *t*-60 to *t*-1. We sort stocks into five equal-(EW) or value-weighted (VW) portfolios in each country based on the average tail risks in months *t*-3 to *t*-1 and calculate the return difference, *TailPrem* (%), between the high tail risk portfolio and low tail risk portfolio for months *t*+1, *t*+2, and *t*+3. The portfolio formation is repeated for every three months. *Char* is a proxy for U.S. economic environment such as CBOE volatility index (*US VIX*), yield spread between BBB-rated corporate bonds and AAA-rated corporate bond (*Default premium*), and yield spread between 10-year Treasury and 3-month Treasury (*Term spread*). We run the following regressions for each country.

$$TailPrem_{j,t} = \alpha_j + \beta_{1,j} Char_{t-1} + Factors + \varepsilon_{j,t}$$

$$TailPrem_{j,t} = \alpha_j + \beta_{1,j} Char_{t-1}^{High} + \beta_{2,j} Char_{t-1}^{Low} + Factors + \varepsilon_{j,t}$$

$Char^{High}$ ($Char^{Low}$) equals to *Char* if *Char* is above (below) the mean and zero otherwise. *Factors* include MKT^G, SMB^G, HML^G, MKT^{R_orth}, SMB^{R_orth}, and HML^{R_orth}. The superscript *G* denotes that the variables are aggregated over stocks from all sample countries excluding those from country *j*. The factors with superscript of *R_orth* denote that the regional factors are orthogonalized against global counterparts. *MKT* is MSCI world market return in excess of U.S. T-Bill rate. *SMB* and *HML* are size and book-to-market factors, respectively. The table reports the coefficients and *t*-values for all sample countries (panel A), developed markets excluding the U.S. (panel B) and emerging market countries (panel C). The result for the U.S. is in panel D. The *t*-values is in italic and standard errors are clustered by country and month. For panel D, standard error is Newey-West adjusted with a lag of three months. The asterisks of ***, **, and * represents significance at 1%, 5%, and 10% level, respectively.

	Char = US VIX*100		Char = Default Premium		Char = Term Spread	
	(1)	(2)	(1)	(2)	(1)	(2)
Panel A: All Countries						
Char	0.033		0.009**		0.002**	
	1.65		*2.24*		*2.15*	
$Char^{High}$		0.055**		0.012**		0.001*
		1.97		*2.39*		*1.85*
$Char^{Low}$		0.085**		0.017**		0.000
		2.13		*2.32*		*-0.05*
MKT^G	0.111***	0.114***	0.095***	0.095***	0.084***	0.084***
	3.59	*3.70*	*3.91*	*4.01*	*3.33*	*3.34*
SMB^G	0.101**	0.096**	0.082**	0.079*	0.077*	0.076*
	2.54	*2.40*	*1.99*	*1.91*	*1.81*	*1.79*
HML^G	0.150***	0.156***	0.147***	0.147***	0.138***	0.135***
	3.61	*3.75*	*3.72*	*3.66*	*3.43*	*3.42*
MKT^{R_orth}	0.027	0.030	0.026	0.025	0.028	0.029
	1.41	*1.25*	*1.11*	*1.04*	*1.19*	*1.20*
SMB^{R_orth}	-0.000	-0.000	0.006	0.011	-0.003	-0.004
	-0.01	*-0.00*	*0.22*	*0.42*	*-0.11*	*-0.13*
HML^{R_orth}	0.040	0.036	0.027	0.025	0.052	0.053
	0.72	*0.66*	*0.52*	*0.49*	*0.78*	*0.80*
R^2(%)	1.3%	1.4%	1.5%	1.6%	1.2%	1.2%
Country Dummy	YES	YES	YES	YES	YES	YES
Panel B: Developed countries excluding US						
Char	0.026		0.010**		0.003***	
	0.97		*2.26*		*3.13*	
$Char^{High}$		0.048		0.014***		0.002***
		1.49		*2.64*		*2.84*
$Char^{Low}$		0.081*		0.022***		0.000
		1.78		*2.61*		*0.09*
MKT^G	0.098***	0.101***	0.090***	0.091***	0.077***	0.077***
	2.74	*2.83*	*3.13*	*3.21*	*2.74*	*2.74*
SMB^G	0.094*	0.089	0.077	0.072	0.064	0.062
	1.67	*1.57*	*1.33*	*1.24*	*1.12*	*1.08*
HML^G	0.150***	0.156***	0.152***	0.151***	0.142***	0.138***

	2.95	3.11	3.19	3.12	2.96	2.89
MKT^{R_orth}	0.019	0.023	0.019	0.017	0.018	0.019
	0.65	0.78	0.64	0.59	0.64	0.65
SMB^{R_orth}	-0.009	-0.008	0.001	0.009	-0.013	-0.013
	-0.24	-0.23	0.03	0.27	-0.35	-0.37
HML^{R_orth}	0.045	0.041	0.025	0.023	0.053	0.056
	0.71	0.65	0.43	0.41	0.71	0.75
R^2(%)	1.3%	1.4%	1.7%	1.9%	1.5%	1.5%
Country Dummy	YES	YES	YES	YES	YES	YES
Panel C: Emerging Market Countries						
Char	0.040**		0.006		0.000	
	2.35		1.58		0.01	
$Char^{High}$		0.057**		0.007		0.000
		2.30		1.39		0.00
$Char^{Low}$		0.082*		0.009		-0.000
		1.94		1.13		-0.04
MKT^{G}	0.117***	0.119***	0.092**	0.092**	0.086**	0.086**
	3.00	3.09	2.36	2.37	2.11	2.11
SMB^{G}	0.101**	0.097**	0.085*	0.084*	0.090	0.090
	2.08	1.99	1.69	1.68	1.60	1.60
HML^{G}	0.153***	0.158***	0.143***	0.143***	0.136***	0.135***
	3.01	3.01	2.77	2.77	2.71	2.74
MKT^{R_orth}	0.045	0.045	0.044	0.043	0.048	0.048
	1.05	1.05	1.05	1.02	1.17	1.17
SMB^{R_orth}	0.001	0.001	0.005	0.007	0.003	0.003
	0.02	0.02	0.10	0.14	0.06	0.06
HML^{R_orth}	0.042	0.038	0.039	0.037	0.059	0.059
	0.61	0.56	0.55	0.54	0.75	0.75
R^2(%)	1.2%	1.3%	1.2%	1.2%	1.0%	1.0%
Country Dummy	YES	YES	YES	YES	YES	YES
Panel D: U.S.						
Char	0.106**		0.024***		0.001	
	1.99		3.00		0.66	
$Char^{High}$		0.156**		0.026***		0.001
		2.32		2.74		0.29
$Char^{Low}$		0.228**		0.029**		-0.004
		2.29		2.09		-0.93
MKT^{G}	0.269***	0.272***	0.207***	0.206***	0.189***	0.189***
	4.06	4.10	4.15	4.11	4.17	4.13
SMB^{G}	0.211*	0.202	0.151	0.148	0.165	0.163
	1.67	1.62	1.23	1.22	1.28	1.27
HML^{G}	0.152	0.168*	0.137	0.138	0.105	0.097
	1.50	1.67	1.33	1.33	0.95	0.91
MKT^{R_orth}	0.224**	0.222**	0.212**	0.215**	0.175**	0.178**
	2.40	2.34	2.53	2.53	1.97	2.01
SMB^{R_orth}	0.127	0.147	0.159	0.165	0.156	0.162
	1.18	1.33	1.36	1.42	1.45	1.51
HML^{R_orth}	0.075	0.102	0.067	0.069	0.031	0.032
	0.42	0.55	0.39	0.39	0.16	0.17
R^2(%)	13.4%	14.7%	16.6%	16.7%	9.2%	9.7%

Table 5. Variation of tail risk premia and global stock market volatility

The table shows the results of the regression of tail risk premium on the global stock market volatility. We first estimate monthly tail risk of Kelly and Jiang (2014) (Eq. (2)) for each country using daily returns of all stocks in a country in a month and subsequently estimate stock's tail risk beta on month *t* from the coefficient of tail risk in the regression of stock return on the tail risk over months from *t*-60 to *t*-1. We sort stocks into five equal-(EW) or value-weighted (VW) portfolios in each country based on the average tail risks in months *t*-3 to *t*-1 and calculate the return difference, *TailPrem* (%), between the high tail risk portfolio and low tail risk portfolio for months *t*+1, *t*+2, and *t*+3. The portfolio formation is repeated for every three months. *GMKVOL* is global market volatility, which is an average across countries of an equal-weight average of standard deviation of daily stock returns in a given country and month. We run the following regressions for each country.

$$TailPrem_{j,t} = \alpha_j + \beta_{1,j} GMKVOL_{t-1} + Factors + \varepsilon_{j,t}$$

$$TailPrem_{j,t} = \alpha_j + \beta_{1,j} GMKVOL_{t-1}^{High} + \beta_{2,j} GMKVOL_{t-1}^{Low} + Factors + \varepsilon_{j,t}$$

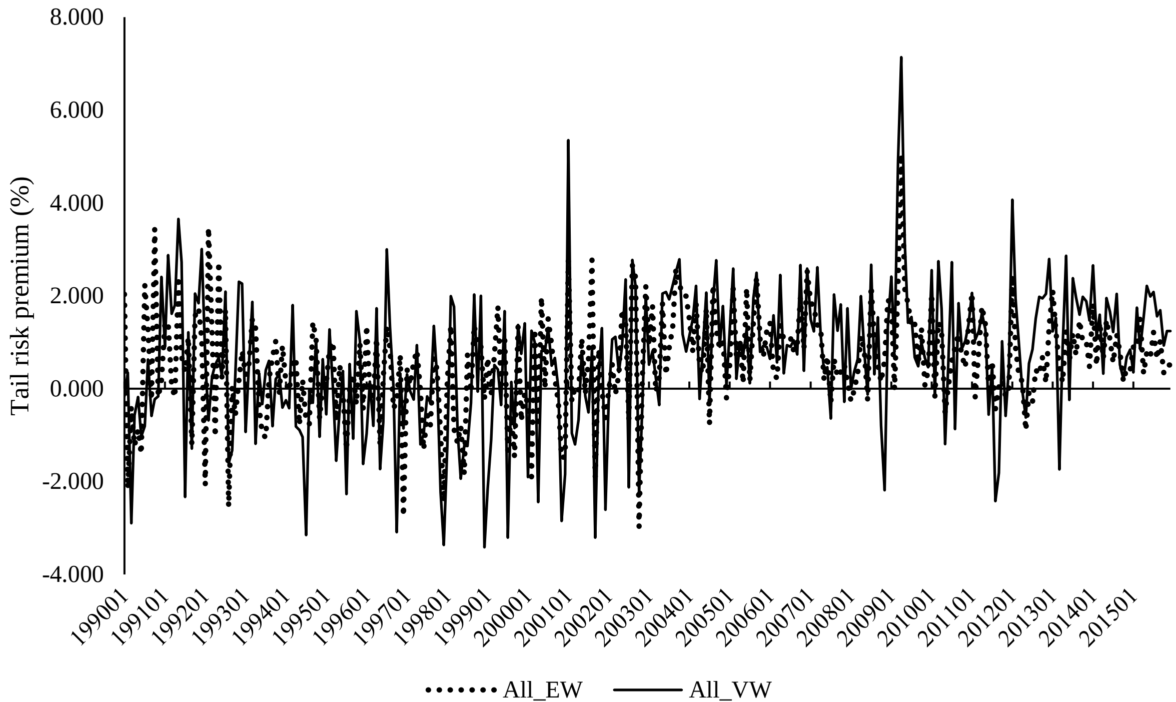
$GMKVOL^{High}$ ($GMKVOL^{Low}$) equals to *GMKVOL* if *GMKVOL* is above (below) the mean and zero otherwise. *Factors* include MKT^G, SMB^G, HML^G, MKT^{R_orth}, SMB^{R_orth}, and HML^{R_orth}. The superscript *G* denotes that the variables are aggregated over stocks from all sample countries excluding those from country *j*. The factors with superscript of *R_orth* denote that the regional factors are orthogonalized against global counterparts. *MKT* is MSCI world market return in excess of U.S. T-Bill rate. *SMB* and *HML* are size and book-to-market factors, respectively. The table reports the coefficients and *t*-values for all sample countries (panel A), developed markets excluding the U.S. (panel B) and emerging market countries (panel C). The result for the U.S. is in panel D. The *t*-values is in italic and standard errors are clustered by country and month. For panel D, standard error is Newey-West adjusted with a lag of three months. The asterisks of ***, **, and * represents significance at 1%, 5%, and 10% level, respectively.

	Panel A: All countries			Panel B: Developed markets excluding US			Panel C: Emerging markets			Panel D: US		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
GMKVOL	0.413*			0.301			0.518**			1.219**		
	1.89			*1.21*			*2.19*			*2.17*		
$GMKVOL^{High}$		0.614**			0.601*			0.582			1.208*	
		2.18			*1.83*			*1.57*			*1.82*	
$GMKVOL^{Low}$		0.742**			0.792*			0.623			1.202	
		2.10			*1.87*			*1.26*			*1.56*	
MKT^G	0.103***	0.102***	0.105***	0.091***	0.090***	0.092***	0.108***	0.108***	0.112***	0.240***	0.240***	0.242***
	3.80	*3.82*	*3.86*	*2.85*	*2.85*	*2.89*	*2.90*	*2.89*	*2.97*	*4.28*	*4.28*	*4.42*
SMB^G	0.105***	0.103***	0.110***	0.096*	0.093*	0.099*	0.108**	0.108**	0.116**	0.219	0.219	0.224*
	2.65	*2.62*	*2.80*	*1.71*	*1.68*	*1.80*	*2.16*	*2.13*	*2.22*	*1.63*	*1.64*	*1.66*
HML^G	0.146***	0.150***	0.152***	0.146***	0.152***	0.153***	0.150***	0.151***	0.153***	0.130	0.130	0.135
	3.58	*3.74*	*3.74*	*2.92*	*3.13*	*3.14*	*2.97*	*2.93*	*2.92*	*1.22*	*1.23*	*1.22*
MKT^{R_orth}	0.031	0.030	0.032	0.022	0.021	0.023	0.050	0.049	0.049	0.209**	0.209**	0.205**
	1.32	*1.27*	*1.35*	*0.75*	*0.70*	*0.79*	*1.21*	*1.21*	*1.20*	*2.34*	*2.32*	*2.35*
SMB^{R_orth}	0.005	0.005	0.006	-0.004	-0.005	-0.003	0.006	0.006	0.004	0.112	0.111	0.116
	0.19	*0.17*	*0.19*	*-0.11*	*-0.15*	*-0.09*	*0.12*	*0.12*	*0.09*	*1.02*	*0.99*	*1.07*
HML^{R_orth}	0.039	0.038	0.036	0.045	0.046	0.044	0.037	0.037	0.035	0.070	0.070	0.072
	0.67	*0.67*	*0.64*	*0.68*	*0.69*	*0.66*	*0.56*	*0.55*	*0.54*	*0.38*	*0.38*	*0.40*
R^2(%)	1.3%	1.3%	1.3%	1.3%	1.4%	1.3%	1.2%	1.2%	1.3%	12.6%	12.6%	12.7%
Country Dummy	YES	YES	YES	YES	YES	YES	YES	YES	YES	N/A	N/A	N/A

Figure 1. Variation of tail risk premium

The figure shows the time-series plot of tail risk premium (in %), which is an average of premium of all sample countries (panel A) and that of stocks from the subset of countries. We first estimate monthly tail risk of Kelly and Jiang (2014) (Eq. (2)) for each country using daily returns of all stocks in a country in a month and subsequently estimate stock's tail risk on month *t* from the coefficient of tail risk in the regression of stock return on the tail risk over months from *t*-60 to *t*-1. We sort stocks into five equal-(EW) or value-weighted (VW) portfolios in each country based on the average tail risks in months *t*-3 to *t*-1 and calculate the return difference, *TailPrem* (%), between the high tail risk portfolio and low tail risk portfolio for months *t*+1, *t*+2, and *t*+3. The portfolio formation is repeated for every three months.

Panel A: All countries



Panel B: Tail risk premium based on equally-weighted portfolios by region

Panel C: Tail risk premium based on value-weighted portfolios by region

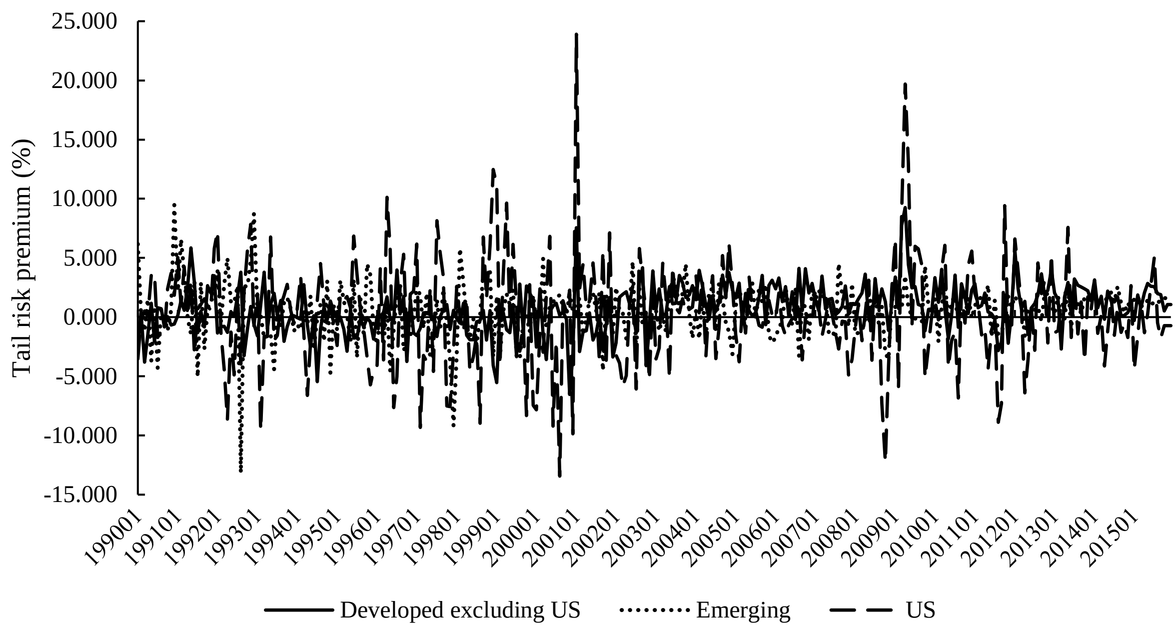
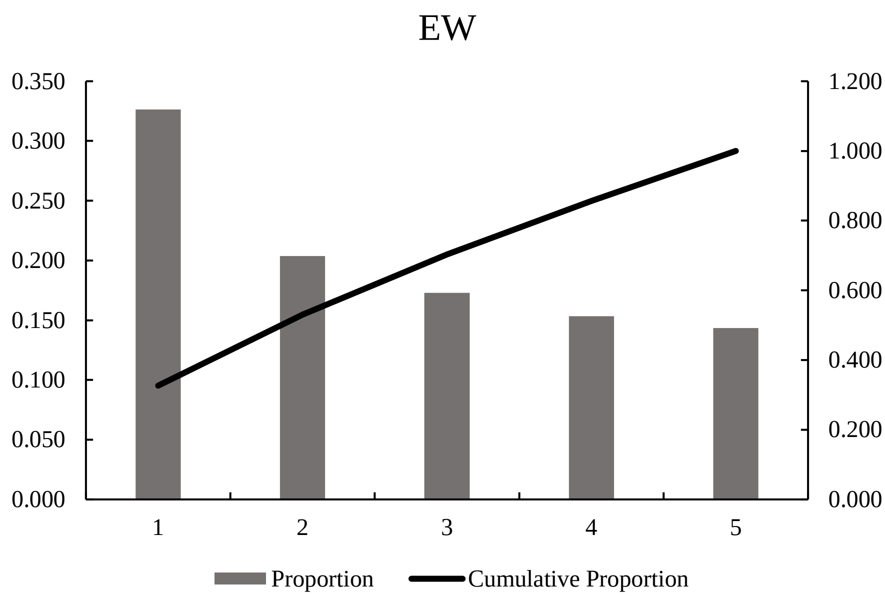


Figure 2. Principle components of tail risk premia across countries
Panels A and B show the plots of eigenvalue proportions of the first five principal components (PC) for tail risk premia across countries when the premia is obtained from equal-weighted (EW) and value-weighted (VW) portfolios, respectively. We first estimate monthly tail risk of Kelly and Jiang (2014) (Eq. (2)) for each country using daily returns of all stocks in a country in a month and subsequently estimate stock's tail risk on month *t* from the coefficient of tail risk in the regression of stock return on the tail risk over months from *t*-60 to *t*-1. We sort stocks into five equal-(EW) or value-weighted (VW) portfolios in each country based on the average tail risks in months *t*-3 to *t*-1 and calculate the return difference, *TailPrem* (%), between the high tail risk portfolio and low tailrisk portfolio for months *t*+1, *t*+2, and *t*+3. The portfolio formation is repeated for every three months. Bar graph denotes the proportion of each PC (left axis), and the line graph the cumulative proportion (right axis).

Panel A: Tail risk premium from equally-weighted portfolios



Panel B: Tail risk premium from value-weighted portfolios

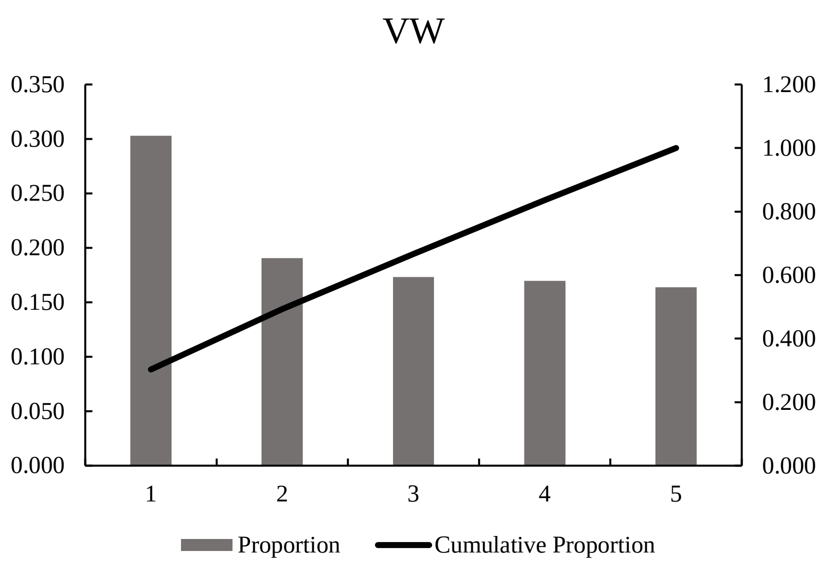


Figure 3. Correlation of tail risk premium of each country with the first principal component

The figure shows the correlation of tail risk premium of each country with the first principal component, extracted by the principal component analysis for the tail risk premia across countries. We first estimate monthly tail risk of Kelly and Jiang (2014) (Eq. (2)) for each country using daily returns of all stocks in a country in a month and subsequently estimate stock's tail risk on month *t* from the coefficient of tail risk in the regression of stock return on the tail risk over months from *t*-60 to *t*-1. We sort stocks into five equal-(EW) or value-weighted (VW) portfolios in each country based on the average tail risks in months *t*-3 to *t*-1 and calculate the return difference, *TailPrem* (%), between the high tail risk portfolio and low tail risk portfolio for months *t*+1, *t*+2, and *t*+3. The portfolio formation is repeated for every three months.

Panel A: Tail risk premia from EW portfolios

Panel B: Tail risk premia from VW portfolios