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Commonality in Tail Risk Premia around the World*

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<Abstract>

This study examines tail risk premia for 44 countries from 1990 to 2015 and provides evidence on the existence of common and systematic components in the variation of tail risk premia across countries. Specifically, we found that individual countries' tail risk premia significantly comove with U.S., regional, and global tail risk premia. The first five principal components explain all variation in the premia, with the first principal component alone explaining over 30% of the variation. The comovement, or commonality, is stronger for developed market countries and more open countries. We also provide evidence that premia are affected by the U.S. economic environment and global stock market volatility, leading to a common variation in tail risk premia around the world.

Keywords: Tail Risk; Tail Risk Premium; Commonality; Comovement; International Stock Market

JEL Classification: G12, G14, G15,

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꼬리 위험프리미엄의 동조화 현상에 대한 연구: 전세계 주식시장을 중심으로*

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< 요 약 >

본 연구는 1990년부터 2015년까지 44개국의 꼬리 위험프리미엄에 대해서 분석한 연구이다. 분석결과 국가 간 꼬리 위험프리미엄의 변동에 공통적이고 체계적인 요소가 존재한다는 증거를 제시하였다. 특히, 개별 국가의 꼬리 위험프리미엄이 미국, 대륙 지역별 그리고 글로벌 꼬리 위험프리미엄과 유의미한 상관관계를 보인다는 사실을 발견하였다. 또한 본 연구에서는 주성분분석을 진행하였는데 주성분분석결과 처음 다섯 개의 주성분이 프리미엄의 모든 변동성을 설명하고 있으면 첫 번째 주성분만으로도 변동성의 30%이상을 설명한다는 결과를 제시하였다. 이러한 동조화 현상은 선진국 및 자본시장을 대외에 개방하는 국가일수록 더 강하게 나타났다. 또한 꼬리 위험프리미엄은 미국 경제 환경과 글로벌 주식 시장 변동성의 영향을 받아 전 세계적으로 꼬리 위험프리미엄이 공통적으로 변한다는 증거를 제시하였다.

핵심 단어: 꼬리위험, 꼬리위험 프리미엄, 공통성, 동조화 현상, 글로벌주식시장

JEL 분류기호: *G12, G14, G15*

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1. Introduction

Anecdotal evidence suggests that stock market crashes, or tail event occurrences, are typically a worldwide phenomenon and not restricted to a single country. The financial crisis from the burst of Dotcom bubble in the U.S. in the early 2000s and the crisis triggered by the meltdown of U.S. housing markets in the late 2000s are clear examples of these occurrences. Since these events originated in a single country, they have material impacts on international stock markets. More recently, we observed how the financial crisis that began in Greece spilled over to Eurozone countries, then 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 within a single country can spill over to many other countries (Summers, 2000; Bae, Karolyi, and Stulz, 2003; Brooks and Negro, 2004; Forbes, 2004; Boyer, Kumagai, and Yuan, 2006). Given the global impact of these tail events, the risks associated with them are difficult to diversify away even in the global stock market setting. Thus, bearing such risks should be rewarded through adequate changes in asset prices. No arbitrage principle implies that the 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 premia around the world.

A large body of research papers examines the tail risk spillover within financial systems. Chiu et al. (2015) show the presence of tail risk spillovers between the financial and real sectors. Xu et al. (2020) investigate the dependence of tail risk spillovers among 23 cryptocurrencies. Wen et al. (2019) focus on the risk spillover effect between oil and stock markets. None of these papers investigates the effect on the expected return of the tail risk as a characteristic, which is different from the effect of tail risk (tail beta). The pricing of tail risk in a global setting is studied by Lee and Yang (2022), Long et al. (2019). These papers investigate the pricing of tail risk in international markets. Long et al. (2019) find a negative relationship between expected stock return and tail risk beta, with this effect being more pronounced in developed market. It is important to note that, in contrast to first- and second-moment risk measures, tail risk captures information regarding the extreme event that directly affects individual stock (Bali, Cakici, and Whitelaw, 2014). In addition, Ang et al. (2006, 2009) and Bali et al. (2011) show that downside or tail risk plays an important role in determining expected returns. Given the importance of tail risk, a natural question arises as to whether the tail risk premium comoves across different countries. This paper addresses this gap by investigating the commonality in tail risk across countries – a topic that has received relatively less attention in the existing literature.

Specifically, we examine 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 these commonalities as well as the economic sources that drive common premia variation. We estimate the tail risk of each country following Kelly and Jiang (2014). First, we test whether bearing a 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 a higher rate of return to hold such stocks. Given the evidence of this unconditional pricing of tail risk, we then 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 the U.S. stock market on global stock markets, this commonality is also found with respect to the tail risk premium of U.S. stock market. A principal component analysis to extract common and systematic components in premia across countries shows that the first five principal components explain all variation of tail risk premia across countries. Moreover, the first principal component alone explains over 30% of the variation.

In our subsequent analyses, we also investigate 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 the U.S. 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 reactions to decline in economic situation of the U.S. and the global market raise the 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 to be 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 Bail *et al.* (2014), the hybrid tail risk 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 expand the existing literature by showing that commonality is also present in tail risk premia across countries. Third, we emphasize the role of global economic uncertainty 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.

2. 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.

2.1 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 the World Bank. For U.S. stocks, we obtained 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 obtained data from Datastream. We use a daily total return index (RI) to calculate the returns for non-U.S. stocks. Following Lee (2011) and Karolyi, Lee, and van Dijk (2012), we restricted our 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 the U.S. (NYSE, AMEX, and Nasdaq).

Following Griffin, Kelly, and Nardari (2010) and Lee (2011), we eliminate non-common shares by examining stock names.) To construct a reliable daily sample, we use the following several filters from Ince and Porter (2006) and Lee (2011). We set the daily return as missing if the total return index is less than 0.01; if the daily return of greater than 100% is reversed the following day; or if the daily return is greater than 200%. We also set daily trading volume to missing if the dollar volume on that day is less than USD100. We then build monthly sample based on the daily sample. We eliminate 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 a 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.

2.2 Tail Risk and its Premium

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

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

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 second is common across stocks in a given country j ($TR_{j,t}$). By focusing on the common aspects of tail risk in the cross-section of stocks at time t, Kelly and Jiang (2014) propose that tail risk, $TR_{j,t}$, be estimated in a panel data framework though the crash events are infrequent.

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

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

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 for month t, we estimate the tail risk beta in the stock return regression on a country's tail risk using the most recent 60 months of data (stocks are required to have at least 24 months of data in this window):

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

Stocks with a high value of tail risk beta for 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 months 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.

<Table 1> displays the return, volatility, estimated tail risk, and tail risk premium for each country. Panel A displays these values for developed markets, while panel B does so for emerging markets. Ret (%) and Volatility (%) are averages of the cross-sectional average in a given country of monthly U.S. dollar stock returns and of the 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

<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 the cross-sectional average in a given country of monthly U.S. dollar stock returns and of the 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 in month t using the coefficient of tail risk in the regression of stock returns on tail risk over months $t-60$ to $t-1$. We sort stocks into five equal-(EW) or value-weighted (VW) portfolios for 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 premia on global and regional Fama-French factors, as in Eq. (4). The asterisks *, **, 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

<Table 1> Summary Statistics(Continued)

Country	Start year	N of firms	Ret (%)	Volatility (%)	Tail risk	TailPrem		Alpha	
						EW	VW	EW	VW
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

premium is an average of returns for months of t+1, t+2, and t+3 after portfolio formation based on the average tail risk beta of t-1 to t-3 of an 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 begins in the early 1990s. Ireland has the shortest sample period, starting in 2002. Reflecting the high-risk and high-return features 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 the 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 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 U.S. dollar returns between the highest tail risk beta portfolio and the lowest tail risk beta portfolio. The last two columns of <Table 1> repot tail risk premium and risk adjusted premium (*Alpha*). *Alpha* is obtained by an estimated intercept in the regression of tail risk premium based on global and regional factors, as in Eq. (4) shows.

$$\begin{aligned} TailPrem_{j,t} &= \alpha_j + \beta_{1,j} MKT_t^G + \beta_{2,j} SMB_t^G + \beta_{3,j} HML_t^G \\ &\quad + \gamma_{1,j} MKT_t^{R\_orth} + \gamma_{2,j} SMB_t^{R\_orth} + \gamma_{3,j} HML_t^{R\_orth} + \varepsilon_{j,t} \end{aligned} \tag{4}$$

MKT^G is MSCI world market returns in excess of the 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).[1] 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, 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,

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

Switzerland, Turkey, and the U.K.). Regional factors are formed based on the average of country factors across countries in region. In our regressions, we utilize global and regional factors, but not country factors, 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 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 characteristics. For example, investors may be less willing to pay the premium for bearing tail risk or even ignore tail risk when the tail event is highly unlikely to occur; i.e., when the economy is good. In contrast, investors will be more likely to pay premium of tail risk when the economy is weak. We will further investigate this issue in a later section of this paper.

3. 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.

3.1 Comovement with Global and Regional Tail Risk Premia

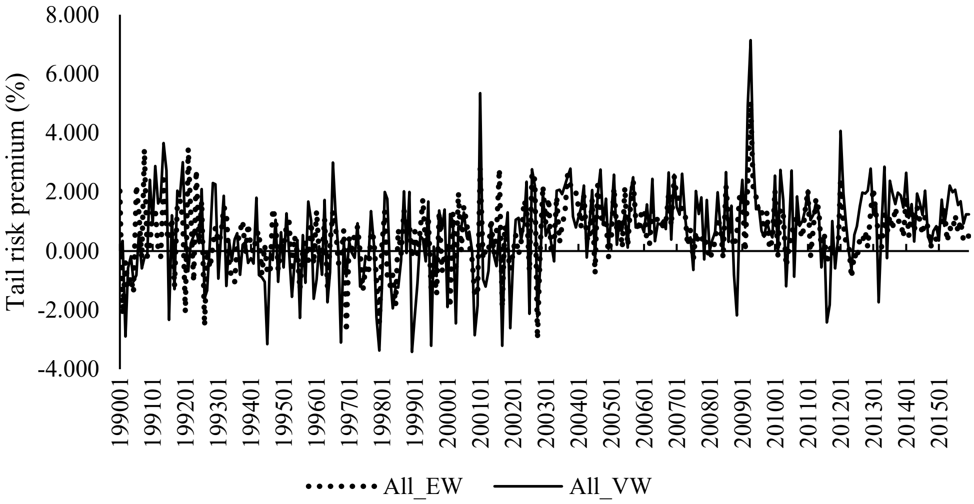
First, we examine the time-series plot of premia by region. <Figure 1> shows the plots.

We can observe that there is substantial time variation in tail risk premia around the world, regardless of weighting scheme. Premia are large and highly volatile especially around crash events; e.g., such as the meltdown of LTCM (1998), the Subprime Mortgage Crisis, and the Eurozone crisis in the early 2010s. In panels B and C, we can observe a similar or *common* pattern in the time variation of tail risk prema 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 *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.

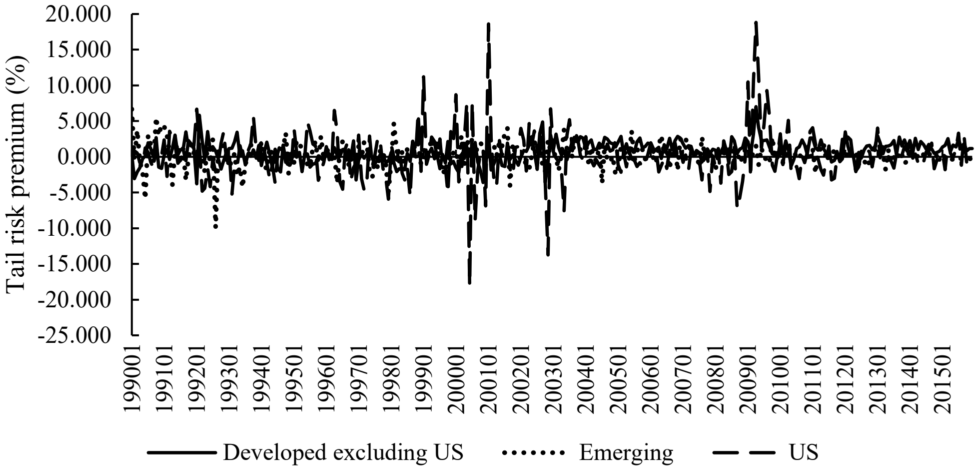
<Figure 1> Variation of Stail Risk Premia

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 following 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 in month t from the coefficient of tail risk in the regression of stock returns on tail risk over months 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 risk 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

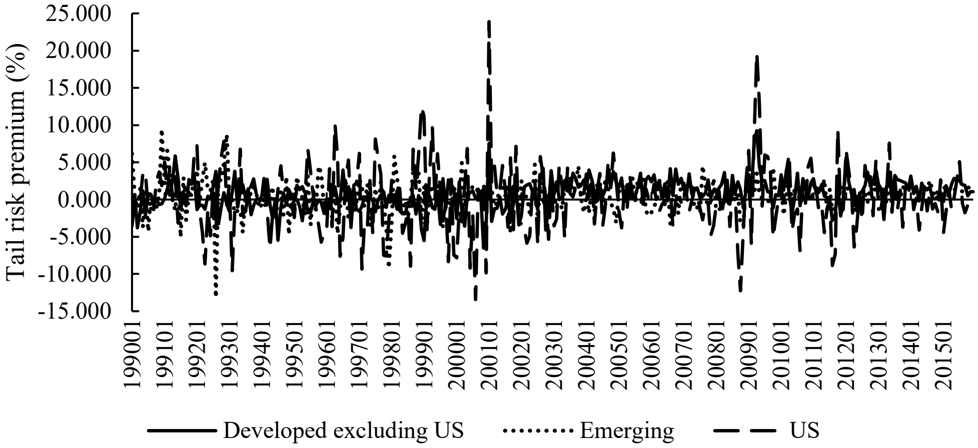


Panel B: Tail risk premia based on equally-weighted portfolios by region



<Figure 1> Variation of Stail Risk Premia (Continued)

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



Given the perceived existence of commonality in tail risk premia in <Figure 1>, we now turn to a 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 in order to adjust the premium for known risks (Eq. (5)).

$$
\begin{aligned}
TailPrem_{j,t} = {} & \alpha_j + \lambda_{1,j} TailPrem_t^G + \lambda_{2,j} TailPrem_t^R + \lambda_{3,j} TailPrem_t^{US} \\
& + \beta_{1,j} MKT_t^G + \beta_{2,j} SMB_t^G + \beta_{3,j} HML_t^G \\
& + \gamma_{1,j} MKT_t^{R\_orth} + \gamma_{2,j} SMB_t^{R\_orth} + \gamma_{3,j} HML_t^{R\_orth} + \varepsilon_{j,t}
\end{aligned} \tag{5}
$$

The superscripts *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*.

<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%. These results imply that tail risk premia at the country level contains systematic components, which co-varies with global, regional, and U.S. tail risk premia, supporting the existence of commonality in tail risk premia around the world.

<Table 2> Commonality in Tail Risk Premia

The table shows the results of the regression of tail risk premia on tail risk premia of global, regional, and U.S. markets. We first estimate monthly tail risk following 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 in month *t* from the coefficient of tail risk in the regression of stock returns on tail risk over months *t*-60 to *t*-1. We sort stocks into five equal-(EW) or value-weighted (VW) portfolios for 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.

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

The superscripts *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 the superscript *R_orth* denote that the regional factors are orthogonalized against global counterparts. *MKT* is MSCI world market returns in excess of the U.S. T-Bill rate. *SMB* and *HML* are size and book-to-market factors, respectively. The t-values are in italics, and standard errors are clustered by country and month. The ***, **, and * represent significance at the 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 premia. We first estimate monthly tail risk following 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 in month *t* from the coefficient of tail risk in the regression of stock returns on tail risk over months *t*-60 to *t*-1. We sort stocks into five equal-(EW) or value-weighted (VW) portfolios for each country based on the average tail risk 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 superscripts *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 the superscript *R_orth* denote that the regional factors are orthogonalized against global counterparts. *MKT* is MSCI world market return in excess of the U.S. T-Bill rate. *SMB* and *HML* are size and book-to-market factors, respectively. The *t*-values are in italics, and standard errors are clustered by country and year. The ***, **, and * represents significance at the 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*

〈Table 3〉 Source of Commonality(Continued)

	EW					VW				
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*	*1.35*	*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

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 markets than in developed markets. It is possible that emerging markets' smaller degree of financial market openness, as compared to that of developed markets, may play some role here. Thus, we further examine the existence of commonality in relation to the openness of financial market.

To do so, we augment the regressions in Eq. (5) by adding the interaction terms of global, regional, and U.S. 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 if country *j*'s foreign ownership is higher than the average of all countries' foreign ownership in our sample for a given year; otherwise, *Open* is zero.

<Table 3> shows the results of the regressions. The coefficients of $TailPrem^G$, $TailPrem^R$, and $TailPrem^{US}$ are positive and significant, reflecting the existence of commonality in tail risk premia. Moreover, the interaction of $TailPrem^G$ with *Open* is significant and positive, supporting our expectation that commonality with respect to $TailPrem^G$ is stronger for countries that are more open. The 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 U.S.-related commonality imply that commonality is most important in terms of global, rather than regional or U.S., tail risk premia for open countries.

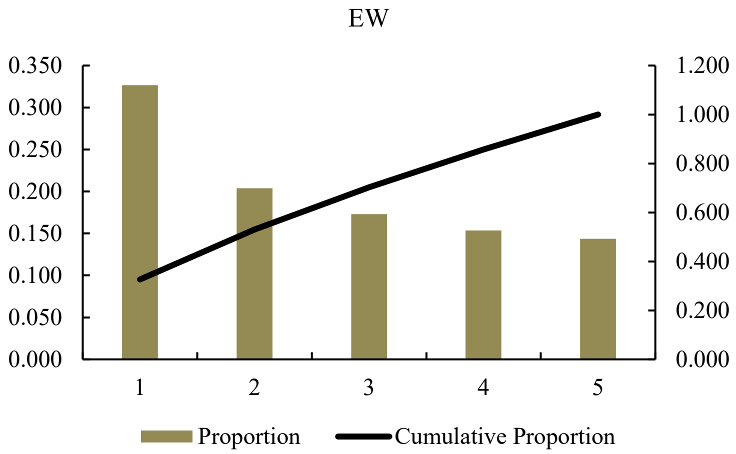
3.2 Principal Component Analysis

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 principal components across multiple illiquidity measures. Finally, Baker, Wurgler, and Yuan (2012) build global sentiment indicator by the first principal component extracted from local investor sentiment indices from six countries.

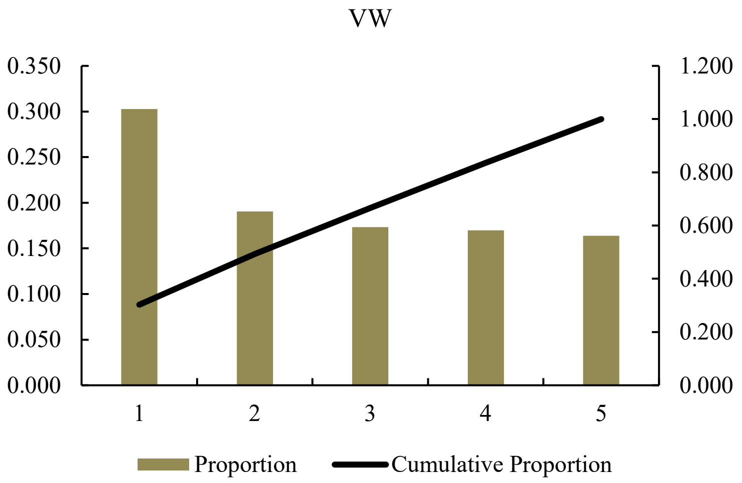
〈Figure 2〉 Principle components of tail risk premia across countries

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 following 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 in month t from the coefficient of tail risk in the regression of stock returns on tail risk over months 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. The bar graph denotes the proportion of each PC (left axis), while the line graph represents the cumulative proportion (right axis).

Panel A: Tail risk premia from equally-weighted portfolios



Panel B: Tail risk premia from value-weighted portfolios



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 observations 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.

<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 the total variation. The eigenvalue for the second PC is much lower than for the first PC, but it 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.

4. What Drives Common Variation in Tail Risk Premia around the World?

In this section, we examine the source of commonality in 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 commonality in tail risk premia. In doing so, we compute the correlation of tail risk premia for each country with the first principal component obtained in the previous section.

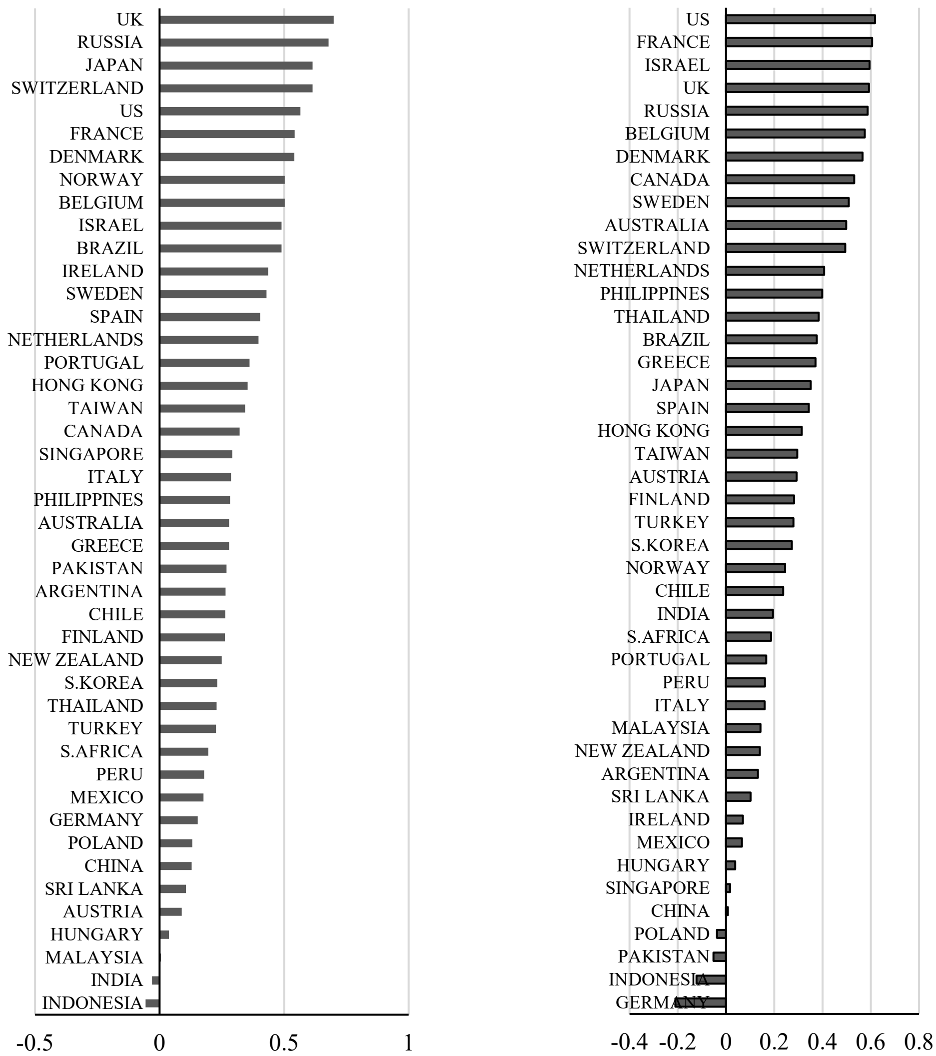
The degree of commonality is, indeed, significantly different across countries. Developed countries seem to have a higher correlation, while emerging market countries generally have lower correlation. This is consistent with the findings in <Table 2>. In both panels, the U.S., the U.K., France, Denmark, 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.,

<Figure 3> Correlation of Tail Risk Premium of Each Country with the First Principal Component

This figure shows the correlation of tail risk premium of each country with the first principal component, extracted by the principal component analysis for tail risk premia across countries. We first estimate monthly tail risk following 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 in month t from the coefficient of tail risk in the regression of stock returns on tail risk over months $t-60$ 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



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 U.S. economic situation drive the time-variation of tail risk premia across countries worldwide. We examine this possibility in the next section.

4.1 Commonality in Tail Risk Premia and the U.S. Economic Environment

It is well known that the U.S. stock market is the world's largest,[2] and that crash

2) For example, the U.S. listed stocks accounted for over 42% of the global stock market in 2016 in terms of market capitalization (World Bank).

events in the U.S.—such as the LTCM meltdown and the subprime mortgage crisis—have a significant impact on the global economy. Lee (2011) shows that U.S. market liquidity has a substantial impact on asset pricing in the international financial market. Moreover, our regression analysis presented in <Table 3> shows that the tail risk premium by each country is significantly and positively related to the U.S. tail risk premium. Therefore, in this section, we test whether the U.S. economic environment has an impact on the variation of tail risk premium around the world.

Investors request higher levels of compensation in economic downturns for bearing tail risks because stocks with high tail risks are more likely to plunge during such period, resulting in a negative relationship between tail risk premia and the economic environment. To a degree to which the U.S. economic environment has a global impact,[3] such a negative relationship will be observed in many countries, leading to commonality in tail risk premia around the world. We use the volatility index based on S&P 500 stock index options from the Chicago Board Options Exchange (*US VIX*), yielded the differences between Moody's seasoned BAA-rated corporate bonds and AAA-rated corporate bonds with 20-year maturities (*Default premium*) as well as between 10-year Treasury and 3-month Treasury bonds (*Term spread*) as proxies for the U.S. economic environment. We obtain the last two variables from the Federal Reserve Economic Data. We run the following regressions for each country.

$$\begin{aligned} TailPrem_{j,t} &= \alpha_j + \beta_{1,j} Char_{t-1} + Factors + \varepsilon_{j,t} \\ TailPrem_{j,t} &= \alpha_j + \beta_{1,j} Char_{t-1}^{High} + \beta_{2,j} Char_{t-1}^{Low} + Factors + \varepsilon_{j,t} \end{aligned} \tag{6}$$

Char is a proxy for the 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

<Table 4> Variation of Tail Risk Premia and the U.S. Economic Environment

The table shows the results of the regression of tail risk premia on the U.S. economic environment. We first estimate monthly tail risk following 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 in month *t* from the coefficient of tail risk in the regression of stock returns on tail risk over months *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 risk 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 the CBOE volatility index (*US VIX*)), yield spread between BBB-rated corporate bonds and AAA-rated

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

corporate bonds (*Default premium*), and yield spread between 10-year Treasury and 3-month Treasury bonds (*Term spread*). We run the following regressions for each country.

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

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

$Char^{High}$ ($Char^{Low}$) is equal 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 the 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 are in italics, and standard errors are clustered by country and month. For panel D, the standard error is Newey-West adjusted with a lag of three months. The asterisks ***, **, and * represent significance at the 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

<Table 4> Variation of Tail Risk Premia and the U.S. Economic Environment(Continued)

Panel B: Developed countries excluding U.S.						
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

<Table 4> Variation of Tail Risk Premia and the U.S. Economic Environment(Continued)

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%

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 results for the U.S. is in Panel D.

<Table 4> shows that tail risk premia around the world are indeed significantly affected by the U.S. economic situation. In panel A, we see that the default premium and term spread are significantly and positively related to tail risk premia, supporting the negative relationship 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 can see that both values are significant and positive. A nonlinear relation is also found. The impact of term spread on the tail risk premium arises only from an increase in the 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 premia.

4.2 Commonality in Tail Risk Premia and Global Stock Market Volatility

We now turn to the impact of the global economic environment on tail risk premia. We use global market volatility as a proxy for global economic uncertainty. The periods

<Table 5> Variation of Tail Risk Premia and Global Stock Market Volatility

The table shows the results of the regression of tail risk premia on global stock market volatility. We first estimate monthly tail risk following 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 in month t from the coefficient of tail risk in the regression of stock returns on tail risk over months 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 the standard deviation of daily stock returns in a given country and month. We run the following regressions for each country.

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

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

$GMKVOL^{High}$ ($GMKVOL^{Low}$) is equal 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 the superscript of *R_orth* denote that the regional factors are orthogonalized against global counterparts. *MKT* is MSCI world market returns in excess of the 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 are in italics, and standard errors are clustered by country and month. For panel D, the standard error is Newey-West adjusted with a lag of three months. The asterisks ***, **, and * represent significance at the 1%, 5%, and 10% level, respectively.

	Panel A: All countries			Panel B: Developed markets excluding U.S.			Panel C: Emerging markets			Panel D: U.S.		
	(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*	*3.15*	*3.14*	*2.97*	*2.93*	*2.92*	*1.22*	*1.25*	*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

of high global market volatility generally coincide with 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 evidence that stock market correlation increases in periods of high volatility. Therefore, we expect a positive relationship between tail risk premia and market volatility. To the degree to which the responses of tail risk premia to global stock market volatility are correlated across countries, stronger commonality in 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 the standard deviation of daily stock returns in a given country and month. <Table 5> shows the regression results.

Panel A shows that global stock market volatility is significantly and positively related to tail risk premia. The relationship is preserved whether 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 global market volatility is high. Overall, we see that global uncertaintly, proxied by global market volatility, has a significant impact on tail risk premia, driving commonality in premia around the world.

5. 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 the tail risk of a country following Kelly and Jiang (2014). We first find evidence that sensitivity of stock returns to a tail risk of a country is significantly priced worldwide. We further show that the tail risk premia are significantly related to the U.S., regional, and global tail risk premia; this evidence supports the existence of commonality in tail risk premia across countries. The commonality is also supported by principal component analysis, which shows that the majority of variation in premia across countries is explained by the first five principal components. The test to examine the cross-country differences in commonality shows that commonality is stronger for countries that are more open. To investigate the source of common time variation in tail risk premia, we examine the relationship between premia and the U.S. economic environment and global market volatility. We show that weakening of the U.S. economy raises the required rate of return for holding stocks with high tail risk worldwide, which in turn leads to common variation of tail risk premia around the world.

Although we provide evidence on the existence and driving force of common variation in tail risk premia in this paper, we do not investigate the differences in 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 future studies.

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