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Re-examination of risk-return dynamics in international equity markets and the role of policy uncertainty, geopolitical risk and VIX: Evidence using Markov-switching copulas

Emmanuel Joel Aikins Abakah [a], Aviral Kumar Tiwari [b], Imhotep Paul Alagidede [c,d], Luis Alberiko Gil-Alana [e,*]

[a] University of Cape Coast School of Economics, Cape Coast, Ghana
[b] Rajagiri Business School, Rajagiri Valley Campus, Kochi, India
[c] University of the Witwatersrand, Johannesburg, South Africa
[d] SDD-UBIDS, WA, Ghana
[e] University of Navarra and University Francisco de Vitoria, Spain

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ABSTRACT

This study re-examines the empirical relationship between risk and return from 1994m12 to 2020m08 in fifteen international equity markets employing the novel time-varying Markov switching copula models. We provide first-time insightful evidence of time-varying Markov tail dependence structure and dynamics between risk and return in international equity markets. Results show that the dependence structure is positive for USA, UK, Germany, Italy, Brazil, Australia, Taiwan, Canada, Mexico, Japan, France and South Africa and negative for Singapore, India, Japan and China. Finally, we document the effects of policy uncertainty, geopolitical risk and VIX conditional on different markets states.

1. Introduction

According to Leon-Valle et al. (2005) and Chen (2015), the risk-return trade-off relation regarded as a long-standing phenomenon in investment analysis is the foundation of modern financial economics. On the other hand, Ghysels et al. (2005) assert that the risk-return relation which postulates that expected excess return is related positively to the conditional variance is the first fundamental law of finance. Interestingly, even though the risk-return relation has emerged as one of the most debated themes in financial economics, evidence from the empirical literature that focuses on index returns is inconclusive. Campbell (1987), Whitelaw (1994), Brandt and Wang (2010), Chen (2015) document a negative relationship, while studies by Ghysels et al. (2005), Guo and Whitelaw (2006) and Lundblad (2007), find a positive trade-off between risk and return. Several studies have also estimated the empirical trade-off between risk and return using specific markets. Studies such as Glosten et al. (1993), French et al. (1987), Baillie and De Gennaro (1990), Nelson (1991), Bekaert and Wu (2000), Lanne and Saikkonen (2003) all focused on the US markets with mixed results. Other studies such as Theodossiou and Lee (1995), Paudyal and Saldanha (1997), Xing and Howe (2003), Li et al. (2005), Bali

* Corresponding author.
E-mail addresses: Imhotep.alagidede@wits.ac.za (I.P. Alagidede), alana@unav.es (L.A. Gil-Alana).

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and Peng (2006) and Salvador et al. (2014) also focused markets including UK, Australia, France, Italy, Japan, Germany, Canada and Belgium with mixed findings. Likewise, emerging stock markets in Europe, Asia and Latin America have also received some attention from the research community (Chui and Wei, 1998; Chiang and Doong, 2001; Tabak and Guerra, 2002; Kovacic, 2008). Concerning stock markets of emerging economies, we find scant studies focusing on the risk-return relationship with most studies focusing on the Johannesburg stock exchange (Suliman, 2012; Mandimika and Chinzara, 2012; Darrat et al., 2012; Tah, 2013).

Majority of earlier studies in this area employed both multivariate and linear GARCH models to examine the risk return relationship (Brandt and Kang, 2004; Ghysels et al., 2005; Pastor et al., 2008; Guo and Whitelaw, 2006; Rapach et al., 2013). However, due to the shortcomings of linear and correlational methodologies and modified versions of GARCH approaches which are often used to model the risk-return trade-off, this study adopts the Markov-switching time-varying copula model (Boubaker and Sghaier, 2016; Tiwari et al., 2021; Abakah et al., 2021) to re-examine the risk-return relationship trade-off in international equity markets.

To the best of our knowledge, this is the first paper to re-examine the risk-return relationship trade-off using variant forms of copulas. The strength of the selected switching Markov time-varying copulas is due to their ability to establish the dependency structures for wavelet decomposed series, accounting for potential different market states. For this estimation technique, the ad hoc determination of change point in the dependence measures is not required. The Markov-switching copulas allow the copula parameter to change, contingent on the condition of the unobserved Markov switching chain analogous transition probabilities (Hamilton and Susmel, 1994). This method aids in assessing the time-varying interdependence structures between expected return and conditional volatility. The examination of the risk-return relationship contributes to the literature in a range of settings, concerning issues such as portfolio diversification across international markets, volatility and investment management, since the findings will aid in global hedging and portfolio formulation strategies.

Our findings contribute to the literature in several ways; (i) our paper is a pioneering effort to explore the tail dependence dynamics between risk and return across international equity markets; (ii) it employs the novel Markov switching copula approach that permits a regime change in the copula parameter estimation in order to measure the time-varying dependency structure. The key benefit of this estimation technique is that the dependence structure does not involve an ad hoc determination of change points (da Silva Filho et al., 2012; Boubaker and Sghaier, 2016). We document several significant findings. First, we find a significant negative tail dependency between risk and return for the following equity markets: Singapore, India, Japan and China, and positive dependence dynamics for the USA, the UK, Germany, Italy, Brazil, Australia, Taiwan Canada, Mexico, Japan, France and South Africa. Second, we observe that the relationship is time varying Markov dependence for all markets examined. Third, from the dependence parameter plots we note that the dynamic dependence is intense irrespective of prevailing market conditions when we compared the variation during crisis periods and normal market conditions. Lastly, we provide evidence that policy uncertainty, geopolitical risk and equity market volatility (VIX) have negative effects on the risk-return relationship for all markets at lower, medium and higher quantile levels.

The remaining parts of the paper are outlined as follows. We present in Section 2 the methodology. Section 3 contains the data and summary statistics while Section 4 reports discussion of results. Section 4 documents the conclusion.

2. Empirical methodology

In this paper, we used various copula models including time invariant, time-variant and Markov switching techniques. Details are discussed in the supplementary file.

3. Data specification and summary statistics

We obtained daily price indices of fifteen international equity markets including Canada, the UK, the USA, Italy, France, Germany, Brazil, Mexico, Japan, China, Australia, Singapore, India, Taiwan and South Africa from Datastream from 30th December 1994 to 24th August 2020. Daily returns are in log form while volatility is measured as absolute returns (Antonakakis and Kizys (2015). The summary statistics of the underlying series are provided in Table 2S and Table 3S in the supplementary file.

4. Empirical discussion

4.1. Results from the marginal distribution

First, we use ARMA filtering process to explore the feature of price returns for each market and absolute returns to confirm that the residuals obtained are free from any autocorrelation effect. Next, we use an ARCH-LM test to examine the ARCH effects of the fitted series with results showing proof of heteroscedasticity across all series. We establish the optimal lag length in each of the univariate GARCH and fit specifications to the second moments. From Table 4S and Table 5S,[1] we present the estimated output of the ARMA-GARCH models for the return series and absolute returns of the fifteen equity markets under examination. Based on the Akaike Information Criterion (AIC) value, we select the best fit model. Using the Akaike Information Criterion (AIC), we note that the best fit model is ARMA (1, 0) - GARCH (1, 1) for all the returns and absolute returns of the fifteen international equity markets. After confirming the bit fit model through the marginal specifications, we move to the next step where we applied the empirical distribution

[1] Available in the supplementary file.

function (ecdf's) to convert the standardized i.i.d. residuals into identical margins. Next, we use the ARCH-LM test and the Ljung-Box test to conduct goodness of fit tests on the probability integral transform (PIT) residuals of the fundamental error terms for each of the ARMA-GARCH (p,q) procedures. From Panel-C of Table 4S and Table 5S, we document the absence of autocorrelation across all series which validates the suitability of the marginal models.

4.2. Results from copula estimation

We discuss the tail dependency structures between risk and return and depend on the log likelihood estimate to select the best copula fit estimated model.

First, the risk-return trade off tail dependence structures for all markets are estimated using the time-invariant copulas in Panel A of Table 1. We note that student–t copula is the best copula fit for modelling the risk-return trade-off for Canada, the UK, the USA, Italy, France, Germany, Brazil, Mexico, Japan, China, Singapore, India, Taiwan and South Africa. Student-*t* copula shows series' symmetric upper tail and lower tail dependence structures which confirms the co-movement during both good and good market states. The symmetric dependence in risk-return trade-off for these countries suggests that the variables are intertwined based on the Tau estimate which reveals marginal dependence between risk and return. For the case of Australia, we note that the Symmetrized Joe copula (SJC), which captures the dependence behaviour of the lower and upper tails, best captures the relationship. Overall, we find a positive tail dependence between risk and return for the markets under examination using time invariant copulas.

However, following the drawbacks of static copulas and the extent of volatility changes in equity markets, we perform additional analysis time-variant and time-variant Markov switching copulas to further test the sign and magnitude of the risk-return relationship trade off across the fifteen equity markets under examination.

In Panel-B and Panel-C of Table 1, we present results for the dependence between risk and return using time variant and time-varying Markov switching copulas. We note that for the case of Canada, Mexico, Japan and France, time varying Rotated Clayton copula is the best copula fit that accurately captures the risk-return trade-off for these equity markets, using the LL estimate with a significant negative dependence structure. Consequently, a look at the probabilities ρ and q for the dependence between risk and return for these four equity markets (Canada, Mexico, Japan and France) confirms that the dependence structure is Markov-switching time-varying. Focusing on the estimates ofβ[2] for each markets, we find they are significant, which further suggests that the relationships between risk and return for these markets are time-varying. Relying on the sign ofβ, we can confirm the nature of the dependency structure between risk and return for these markets.

From Panel-C of Table 1, we find a positive dependence structure for the Canadian, Mexican and French equity markets, which means the risk and return relationship for these markets modelled accurately using time-varying Markov rotated clayton copula co-move in the same direction. However, we note a negative dependence structure for the return- risk relationship for Japan. This connotes that for Japanese equity markets, risk and return move in an opposite direction, thus investors could gain for holding a portfolio with such assets. Concerning the nature and magnitude of the dependence structure between risk and return the remaining markets under examination, we observe that for the case of the USA, the UK, Germany, Italy, Brazil, Australia, Singapore, India, China and South Africa, results from Table 1 Panel-C show that the time-variant Normal Markov switching copula is the best copula fit model for these markets. Subsequently, a look at the probabilities ρ and q for the dependence between risk and return for these markets shows that the dependence structure for each of these markets is Markov-switching time-varying.

Next, to examine the nature of the dependence structure, we focus on the estimates of$\beta$for each market. From the sign ofβ, the nature of the dependence structure is established. From Table 1 Panel-C, we find a negative relationship between risk and return for Singapore, India and China, while the dependence is positive for the USA, the UK, Germany, Italy, Brazil, Australia, and South Africa. The negative dependence structure between risk and return suggests that the variables move in opposite directions while the positive dependence suggests the risk and return move in the same direction. With regarding to Taiwanese equity markets, time varying Clayton Markov copula emerged to be the best fit model able to capture the risk return relationship with the risk return dependence structure being positive. Comparing our results with earlier studies, our findings of a positive dependence structure for the USA market is in consonance with the findings of Ghysels et al. (2005), Lanne and Saikkonen (2003), Guo and Whitelaw (2006) and Lundblad (2007) who documented a positive trade-off between risk and return for the USA market. For the South African markets, our findings differ from the few existing studies that documented a negative significant relationship between risk and return (e.g., Darrat et al., 2012). For the case of our findings regarding Europe's equity markets, these being the UK, Italy, France, Germany, we document findings similar to the conclusion of Salvador et al. (2014) who documented a positive relationship after relaxing the linear assumption. The findings on China which show a positive dependence time varying structure is not in agreement with the findings of Chen (2015) but in agreement with Chen (2013). In the case of Taiwan, Chiang and Doong (2001) documented findings similar to ours. Overall, our findings indicating that the risk-return relationship is time-varying Markov switching and not static or linear supports the school of thought that maintaining the linear assumption in the risk-return trade-off leads to insignificant estimation (Yang, 2011; Salvador et al., 2014; etc.).

In our quest to further validate our earlier findings, we conduct additional analysis using the time-varying dependence parameter plots for each market's risk and return trade-off in Figure 2S.[3] We observe that the dependence structure between risk and returns for all the markets examined varies with time both in bearish and moderate market conditions. In brief, the dependence structure varies

[2] In Table 1, the estimates for standard errors are not reported for simplicity purposes and would be made available upon request.

[3] Available in supplementary file

Table 1.
Estimation of the dependence-switching copula model for returns and volatility per country.

	Canada	USA	UK	Germany	France	Italy	Brazil	Mexico
Panel A: Parameter Estimates for time-invariant copulas								
Normal Copula								
ρ	0.0182	0.0158	0.0006	0.0052	0.0081	−0.0105	−0.0043	0.0061
Log-like	−1.1095	−0.0008	0.0000	−0.0001	−0.2202	−0.3698	−0.0001	−0.0001
Clayton's copula								
α	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Log-like	0.1211	0.0001	0.0001	0.0001	0.1339	0.1407	0.0001	0.0001
Rotated Clayton copula								
α	0.3727	0.3756	0.3644	0.3679	0.3735	0.3412	0.3529	0.3805
Log-like	−292.17	−0.2922	−0.2910	−0.2962	−303.47	−266.07	−0.2774	−0.3149
Plackett copula								
δ	1.2523	1.2741	1.1183	1.1318	1.1386	1.0614	1.1005	1.1002
Log-like	−14.5018	−0.0168	−0.0036	−0.0044	−4.8422	−1.0215	−0.0026	−0.0026
Frank Copula								
δ	0.3826	0.4113	0.1899	0.2102	0.2210	0.1015	0.1622	0.1615
Log-like	−12.3031	−0.0142	−0.0030	−0.0037	−4.1206	−0.8700	−0.0022	−0.0022
Gumble Copula								
δ	1.1493	1.1509	1.1403	1.1419	1.1432	1.1308	1.1361	1.1450
Log-like	−240.116	−0.2396	−0.2373	−0.2450	−249.63	−216.72	−0.2272	−0.2566
Rotated Gumble Copula								
δ	1.1000	1.1000	1.1000	1.1000	1.1000	1.1000	1.1000	1.1000
Log-like	137.9048	0.1383	0.1590	0.1547	154.19	168.067	0.161	0.1580
Student's t copula								
ρ	0.0610	0.0661	0.0283	0.0326	0.0358	0.0119	0.0220	0.0239
υ	2.2005	2.1607	2.1297	2.1179	2.1621	2.1547	2.1104	2.1000
Log-like	−487.078	−0.5068	−0.5114	−0.5124	−498.67	−498.133	−0.5171	−0.5252
SJC Copula								
λ_U	0.2650	0.2682	0.2600	0.2615	0.0047	0.2441	0.2517	0.2692
λ_L	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Log-like	−342.089	−0.3454	−0.3425	−0.3510	−103.35	−310.279	−0.322	−0.3754
Panel B: Parameter Estimates of time-varying copulas								
TVP Normal copula								
ψ_o	0.09804	0.0139	0.0048	0.0220	0.0249	−0.0017	0.0205	0.0723
ψ_1	0.30830	−0.0083	0.0276	0.0772	0.0353	0.0380	0.2426	0.2335
ψ_2	−1.85164	1.0743	−0.5310	−0.5129	−0.5934	1.6298	−1.1329	−2.0002
Log-like	−9.2061	−0.0009	−0.0001	−0.0009	−0.3728	−5.3928	−0.0067	−0.0150
TVP Clayton copula								
ψ_o	0.00031	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
ψ_1	−3.09219	−3.1457	−2.8825	−2.8953	−2.7519	−2.7823	−3.0676	−3.1207
ψ_2	0.00000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Log-like	0.121	0.0001	0.0001	0.0001	0.1338	0.1406	0.0001	0.0001
TVP Rotated Clayton copula								
ψ_o	1.33605	0.7980	1.0371	0.9702	0.3533	0.4414	1.3597	1.3926
ψ_1	−0.60949	−0.2123	−0.8038	−0.3392	0.7351	0.6071	−0.7518	−0.5624
ψ_2	−1.48040	−0.3172	−0.3997	−0.7076	−0.0556	−0.1963	−1.4268	−1.6150
Log-like	−307.468	−0.2931	−0.2924	−0.3005	−307.27	−272.077	−0.2948	−0.3356
TVP Gamble copula								
Ω	1.84151	−0.3866	−0.4680	1.4012	0.9540	−0.7776	2.0308	1.8044
β	−1.02366	0.6638	0.7101	−0.8009	−0.4817	1.0346	−1.2498	−0.9821
α	−0.82614	0.0329	0.0970	−0.3246	−0.0741	−0.0935	−0.6857	−0.8532
Log-like	−248.35	−0.2396	−0.2382	−0.2463	−249.71	−219.571	−0.2344	−0.2673
TVP Rotated Gumble copula								
ω_U	0.02526	0.0193	0.0199	0.0250	0.0218	0.0000	0.0000	0.0000
α_U	−0.02525	−0.0193	−0.0199	−0.0250	−0.0218	0.0000	0.0000	0.0000
β_U	−0.00002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Log-like	0.0915	0.0001	0.0002	0.0001	0.1227	0.0041	0.0004	0.0011
TVP SJC copula								
ω_U	1.87455	−0.2433	0.7648	0.5397	−0.0167	−1.7713	1.9674	2.1984
α_U	−5.89733	−1.3019	−1.5749	−2.9547	−1.5372	−0.9270	−5.5611	−6.8785
β_U	−3.86038	−1.4079	−5.1080	−2.4611	−2.0387	3.7957	−4.8136	−3.4437
ω_L	−21.05855	−22.983	−21.086	−22.420	−20.989	−22.5732	−20.792	−21.1701
α_L	−0.03487	0.0000	0.0059	0.0042	−1.2575	−0.0446	−0.0039	−0.0172
β_L	−280.43	0.0000	0.0000	0.0000	−0.0039	−0.0001	0.0000	0.0000
Log-like	1.87455	−0.2675	−0.2636	−0.2736	−278.25	−237.717	−0.2615	−0.3110
Panel C: Parameter Estimates for time-varying Markov copula								
Time-varying Normal Markov copula								
$\omega_{c,}^{0}N$	−0.6536	**−0.6606**	**−0.7637**	**−0.9602**	−4.2378	**−0.8583**	**−0.9103**	−0.5245
	0.018022	**0.0030**	**0.0955**	**0.1694**	2.0945	**0.1723**	**0.1594**	0.0191

(*continued on next page*)

Table 1. (*continued*)

	Canada	USA	UK	Germany	France	Italy	Brazil	Mexico
$\omega_{c,}^{1}N$								
$\beta_{c,}N$	2.132445	**2.1778**	**1.9616**	**1.7886**	−2.4442	**1.7605**	**1.8021**	2.1178
$\alpha_{c,}N$	−0.07908	**−0.0692**	**−0.1396**	**−0.1056**	−0.4056	**−0.0738**	**−0.0804**	−0.0363
ρ	−4.69045	**−0.2665**	**−0.1654**	**−0.3335**	−0.2137	**−0.1184**	**−3.6826**	−3.8028
q	5.690449	**1.2665**	**1.1654**	**1.3335**	1.2137	**1.1184**	**4.6826**	4.8028
Log-like	−480.97	**−0.4661**	**−0.4481**	**−0.4409**	−415.52	**−416.785**	**−0.4873**	−0.4689
Time-varying Clayton Markov copulas								
$\omega_{c,}^{0}C$	0.09679	0.0075	−0.0001	−0.0155	0.0598	0.0449	0.0300	0.0160
$\omega_{c,}^{1}C$	−1.90475	−1.8881	−0.0001	−1.7498	−1.8323	−1.8733	−1.8919	−1.9169
$\beta_{c,}C$	−0.12254	−0.1318	1.4340	−0.1443	−0.1314	−0.1300	−0.1295	−0.1307
$\alpha_{c,}C$	−0.31638	−0.0268	0.0000	0.0599	−0.1815	−0.1267	−0.0996	0.0157
ρ	0.343953	0.3136	0.5000	0.3948	0.0130	−0.1193	−0.0308	−0.1452
q	0.656047	0.6864	0.5000	0.6052	0.9870	1.1193	1.0308	1.1452
Log-like	10.3288	0.0053	0.0001	0.0044	−0.4505	−3.3739	−0.001	−0.0020
Time-varying Rotated Clayton Markov copulas								
$\omega_{c,}^{0}RC$	**−0.10096**	0.3028	0.4318	0.0745	**0.1024**	0.2403	0.0323	**−0.1119**
$\omega_{c,}^{1}RC$	**−1.57517**	−0.4825	−0.3796	−1.5011	**−1.4388**	−1.2960	−1.5118	**−1.6743**
$\beta_{c,}RC$	**0.378163**	−0.2883	−0.2806	0.4761	**0.4419**	0.4980	0.4768	**0.4432**
$\alpha_{c,}RC$	**0.278933**	−0.7844	−1.0663	−0.1984	**−0.2848**	−0.6295	−0.0829	**0.2876**
ρ	**0.695285**	0.4661	0.3881	0.4582	**0.4638**	0.5060	0.6302	**0.5480**
q	**0.304715**	0.5339	0.6119	0.5418	**0.5362**	0.4940	0.3698	**0.4520**
Log-like	**−451.555**	−0.4571	−0.4437	−0.4328	**−438.45**	−383.819	−0.4228	**−0.4757**
Time-varying Gumbel Markov copulas								
$\omega_{c,}^{0}G$	−0.00466	−0.7002	−0.4318	−0.0934	−0.1515	−0.6676	−0.2388	−0.0363
$\omega_{c,}^{1}G$	−0.5244	−1.4746	−1.1331	−0.6015	−0.8018	−1.4094	−1.0405	−0.5495
$\beta_{c,}G$	0.432602	0.2477	0.3161	0.4151	0.3405	0.2393	0.2449	0.4110
$\alpha_{c,}G$	0.303355	2.8013	1.7924	0.5382	1.0603	2.4857	1.6605	0.4585
ρ	0.729618	0.2606	0.2498	3.1329	0.1241	0.2046	−4.5922	0.8756
q	0.270382	0.7394	0.7502	−2.1329	0.8759	0.7954	5.5922	0.1244
Log-like	−305.964	−0.3116	−0.3034	−0.2941	−297.56	−257.273	−0.2863	−0.3277
Time-varying Rotated Gumbel Markov copulas								
$\omega_{c,}^{0}RG$	−1.16E-05	−2.0047	−3.1664	3.0684	0.0000	0.0000	0.0000	0.0000
$\omega_{c,}^{1}RG$	−1.16E-05	−2.0047	−3.1664	3.0686	0.0000	0.0000	0.0000	0.0000
$\beta_{c,}RG$	1.16E-05	2.0043	3.1586	−3.0782	0.0000	0.0000	0.0000	0.0000
$\alpha_{c,}RG$	1.22E-08	0.0006	0.0246	0.0267	0.0000	0.0000	0.0000	0.0000
ρ	0.5	0.5000	0.5005	0.5157	0.5000	0.5000	0.5000	0.5000
q	0.5	0.5000	0.4995	0.4843	0.5000	0.5000	0.5000	0.5000
Log-like	0.0915	0.0001	0.0001	−0.0001	0.1227	0.0041	0.0004	0.0011
Time-varying SJC Markov copulas								
$\omega_{c,}^{0}U$	1.674614	−2.1304	0.7916	1.6153	1.6344	−1.2669	6.2618	−7.6189
$\omega_{c,}^{1}U$	−5.64178	−22.387	−0.0578	0.6747	0.8351	−11.1270	0.2688	−3.4438
$\beta_{c,}U$	−17.85	−10.720	0.7648	−0.9087	−0.9295	−1.7709	1.5561	2.1984
$\alpha_{c,}U$	−15.3041	−22.577	−20.604	−12.908	−12.940	−21.2017	−12.993	−13.3219
ρ	−1.9207	3.9404	−5.1079	0.4469	0.4745	3.7948	−5.0091	−3.4431
q	16.58504	−1.3234	−8.4643	−2.8021	−2.7045	−8.1574	−2.7159	22.0586
Log-like	−1.5921	−0.3577	−1.5747	−0.2689	−274.97	−237.829	−0.2649	−0.3110
	Japan	**Australia**	**Singapore**	**India**	**China**	**Taiwan**	**South Africa**	
Panel A: Parameter Estimates for time-invariant copulas								
Normal Copula								
ρ	−0.0109	0.0047	−0.0060	0.0063	−0.0077	0.0024	−0.0015	
Log-like	−0.0004	−0.0001	−0.1200	−0.0001	−0.0002	0.0000	0.0000	
Clayton's copula								
α	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	
Log-like	0.0002	0.0001	0.1397	0.0001	0.0001	0.0001	0.0001	
Rotated Clayton copula								
α	0.3592	0.3732	0.3457	0.3732	0.3655	0.3855	0.3606	
Log-like	−0.2947	−0.2965	−275.916	−0.3047	−0.3057	−0.3227	−0.287	
Plackett copula								
δ	1.0073	1.1676	1.0388	1.1186	0.9996	1.0761	1.1061	
Log-like	0.0000	−0.0069	−0.4199	−0.0036	0.0000	−0.0015	−0.0029	
Frank Copula								

(*continued on next page*)

Table 1. (*continued*)

	Canada	USA	UK	Germany	France	Italy	Brazil	Mexico
δ	0.0124	0.2632	0.0651	0.1900	0.0002	0.1242	0.1713	
Log-like	0.0000	−0.0058	−0.3594	−0.0030	0.0000	−0.0013	−0.0025	
Gumble Copula								
δ	1.1337	1.1456	1.1313	1.1426	1.1356	1.1447	1.1388	
Log-like	−0.2362	−0.2393	−228.247	−0.2523	−0.2531	−0.2615	−0.2322	
Rotated Gumble Copula								
δ	1.1000	1.1000	1.1000	1.1000	1.1000	1.1000	1.1000	
Log-like	0.1764	0.1534	167.5649	0.1555	0.1723	0.1645	0.1608	
Student's t copula								
ρ	−0.0002	0.0415	0.0059	0.0262	−0.0041	0.0200	0.0241	
υ	2.1302	2.1222	2.1771	2.1002	2.1000	2.1000	2.1299	
Log-like	−0.5071	0.1534	−486.804	−0.5259	−0.5589	−0.5306	−0.5093	
SJC Copula								
λ_U	0.2559	0.2663	0.2457	0.0042	0.2601	0.2734	0.2580	
λ_L	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
Log-like	−0.3378	−0.5163	−322.539	−0.1020	−0.3660	−0.3815	−0.3394	
Panel B: Parameter Estimates of time-varying copulas								
TVP Normal copula								
ψ_o	−0.0482	0.0425	0.0410	0.0739	−0.0022	0.0415	0.0329	
ψ_1	−0.1827	0.2755	0.5280	0.4602	0.6305	0.3471	0.3229	
ψ_2	−0.8278	−0.4927	−1.4962	−1.2024	−1.7836	−1.8318	−1.7903	
Log-like	−0.0038	−0.012	−30.1386	−0.0227	−0.0427	−0.0098	−0.0092	
TVP Clayton copula								
ψ_o	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0003	
ψ_1	−2.9711	−3.4416	−3.0009	−3.3750	−3.1227	−3.5370	−3.3984	
ψ_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
Log-like	0.0002	0.0001	0.1396	0.0001	0.0001	0.0001	0.0001	
TVP Rotated Clayton copula								
ψ_o	0.3431	1.1981	1.5094	1.3473	1.4465	1.3738	1.2657	
ψ_1	0.7465	−0.3356	−0.4178	−0.3644	−0.7057	−0.7153	−0.7157	
ψ_2	−0.0363	−1.3750	−2.2680	−1.7663	−1.7135	−1.3954	−1.2032	
Log-like	−0.2958	−0.3118	−319.734	−0.3324	−0.3335	−0.3361	−0.2961	
TVP Gamble copula								
Ω	1.4252	1.2744	1.5917	1.4316	2.0476	1.9748	1.9264	
β	−1.0355	−0.5782	−0.6834	−0.6436	−1.1457	−1.1730	−1.1666	
α	0.3399	−0.6839	−1.3257	−0.9279	−1.0965	−0.7322	−0.6612	
Log-like	−0.2374	−0.2459	−254.416	−0.2658	−0.2738	−0.2682	−0.2373	
TVP Rotated Gumble copula								
ω_U	0.0000	0.0000	2.4371	0.0313	0.0354	0.0290	0.0254	
α_U	0.0000	0.0000	−2.4354	−0.0313	−0.0354	−0.0290	−0.0254	
β_U	0.0000	0.0000	−0.0036	0.0000	0.0000	0.0000	0.0000	
Log-like	0.0001	0.0002	0.0543	0.0001	0.0001	0.0002	0.0001	
TVP SJC copula								
ω_U	−0.5360	1.5867	2.3576	1.8722	2.2733	1.6085	1.7911	
α_U	1.4766	−5.8207	−8.5795	−7.0582	−6.8607	−5.0530	−5.2491	
β_U	−4.2342	−2.7755	−2.7695	−2.3139	−4.1911	−3.4073	−4.5593	
ω_L	−22.1875	−20.5654	−21.6527	−20.9279	−22.0245	−21.163	−21.1645	
α_L	−1.4462	−0.0002	−0.0024	−1.3781	−0.0126	−0.0077	−0.0081	
β_L	−0.0053	0.0000	0.0000	−0.0047	0.0000	0.0000	0.0000	
Log-like	−0.263	−0.2823	−281.612	−0.3039	−0.3024	−0.0002	−0.2657	
Panel C: Parameter Estimates for time-varying Markov copula								
Time-varying Normal Markov copula								
$\omega_{c,}^{0}N$	−1.9495	**−0.5280**	**−4.1634**	**−3.9100**	**−3.5830**	0.0000	**−0.5131**	
$\omega_{c,}^{1}N$	2.8444	**−0.0084**	**1.9132**	**1.9140**	**2.2039**	0.0000	**0.0084**	
$\beta_{c,}N$	−1.8763	**2.1829**	**−2.3757**	**−2.0135**	**−2.4062**	0.0000	**2.1421**	
$\alpha_{c,}N$	−0.1852	**−0.0394**	**0.3170**	**0.6029**	**0.5431**	0.0000	**−0.0531**	
ρ	0.6711	**−0.5206**	**−7.1291**	**−0.3952**	**−0.6288**	0.0000	**−0.4173**	
q	0.3289	**1.5206**	**8.1291**	**1.3952**	**1.6288**	0.0000	**1.4173**	
Log-like	−0.3803	**−0.4519**	**−458.129**	**−0.4811**	**−0.5093**	−0.3098	**−0.4415**	
Time-varying Clayton Markov copulas								
$\omega_{c,}^{0}C$	−0.0001	0.0358	−0.0353	0.0181	−0.0001	**−0.4926**	0.1004	
$\omega_{c,}^{1}C$	−0.0001	−1.3502	−1.9686	−1.7750	−0.0001	**0.0233**	−1.8053	
$\beta_{c,}C$	1.3732	−0.1801	−0.1265	−0.1395	1.4329	**2.1010**	−0.1295	
$\alpha_{c,}C$	0.0000	−0.0971	−0.0197	−0.0462	0.0000	**−0.0236**	−0.3052	
ρ	0.5000	−0.0370	−0.2133	0.0740	0.5000	**−1.1208**	0.3479	
q	0.5000	1.0370	1.2133	0.9260	0.5000	**2.1208**	0.6521	
Log-like	0.0002	−0.0004	−1.5395	0.0047	0.0001	**−0.4443**	0.0092	

(*continued on next page*)

Table 1. (*continued*)

	Canada	USA	UK	Germany	France	Italy	Brazil	Mexico
Time-varying Rotated Clayton Markov copulas								
$\omega^0_{c,}RC$	**−1.0551**	2.2964	−0.1690	−0.0368	−0.1872	0.0210	−0.0637	
$\omega^1_{c,}RC$	**−2.2651**	1.0469	−1.5685	−1.4618	−1.7482	−1.8729	−1.5718	
$\beta_{c,}RC$	**−0.0096**	−0.1318	0.2989	0.3275	0.4009	−0.1317	0.4452	
$\alpha_{c,}RC$	**5.0079**	−4.6967	0.4191	0.0961	0.5306	−0.0665	0.1796	
ρ	**0.5321**	1.7743	0.3893	0.5279	0.4171	−0.0655	0.6054	
q	**0.4679**	−0.7743	0.6107	0.4721	0.5829	1.0655	0.3946	
Log-like	**−0.4076**	−0.4331	−438.552	−0.4634	−0.4895	0.0013	−0.4276	
Time-varying Gumbel Markov copulas								
$\omega^0_{c,}G$	−0.3326	−0.0644	1.7191	−0.0781	0.0921	−0.0370	−0.1392	
$\omega^1_{c,}G$	−0.0229	−0.7094	0.6665	−0.5615	−0.4300	−1.4253	−0.6186	
$\beta_{c,}G$	0.3627	0.3807	−0.4459	0.4308	0.4801	0.3045	0.4937	
$\alpha_{c,}G$	0.6641	0.6568	−0.4333	0.4701	−0.2693	0.0988	0.3304	
ρ	0.3324	1.1475	0.7899	0.6052	0.7427	0.6263	0.7770	
q	0.6676	−0.1475	0.2101	0.3948	0.2573	0.3737	0.2230	
Log-like	−0.2461	−0.2893	−300.361	−0.3151	−0.3384	−0.4742	−0.2833	
Time-varying Rotated Gumbel Markov copulas								
$\omega^0_{c,}RG$	0.0000	0.0000	2.4373	0.1082	−0.0001	−0.0700	−0.0001	
$\omega^1_{c,}RG$	0.0000	0.0000	2.4373	−0.4656	−0.0001	−0.6133	−0.0001	
$\beta_{c,}RG$	0.0000	0.0000	−2.4356	0.4210	0.0001	0.4260	0.0001	
$\alpha_{c,}RG$	0.0000	0.0000	−0.0036	0.1441	0.0000	0.4367	0.0000	
ρ	0.5000	0.5000	0.5000	0.7381	0.5000	0.7587	0.5000	
q	0.5000	0.5000	0.5000	0.2619	0.5000	0.2413	0.5000	
Log-like	0.0001	0.0002	0.0543	−0.0011	0.0001	−0.3136	0.0001	
Time-varying SJC Markov copulas								
$\omega^0_{c,}U$	−2.6792	1.2584	3.3177	4.6589	3.5678	−16.413	1.5196	
$\omega^1_{c,}U$	2.9187	−21.4398	−21.6711	−7.1862	−20.4121	−20.286	0.8519	
$\beta_{c,}U$	−0.5376	−10.4803	−8.9230	1.8724	−13.1781	2.0278	−0.9387	
$\alpha_{c,}U$	−21.4643	−22.7914	−10.8914	−13.1554	−23.5039	−11.219	−12.9102	
ρ	−4.2394	−2.1978	−2.8043	−2.3133	−3.5936	−2.8889	0.4770	
q	−7.8223	10.1988	11.4050	−0.7907	−10.0504	−3.3221	−2.7521	
Log-like	−0.263	−0.3492	−348.791	−0.3040	−0.3935	−0.381	−0.2627	

Time-varying T Markov copulas. Convergence was not achieved in any of the models; hence results are not presented.
Notes: This table reports the ML estimates for the different static and dynamic bivariate copula models per country. The minimum loglikelihood value (value on bold) indicates the best copula fit.

for both low and high dependency regimes with the dependency seen to be either negative or positive in both regimes

4.3. The effects of policy uncertainty, geopolitical risk and VIX on the dependence structure between risk and return

A strand of the literature also argues that macroeconomic factors affect measurement of the risk-return relation and as such should be accounted for in estimating the risk return nexus (De Long et al., 1990; Baker and Wurgler, 2006).Hence, we examine the effects of economic policy uncertainty, geopolitical risk and equity market volatility on the relationship between risk and return. Using quantile regression (QR), we find that policy uncertainty, geopolitical risk and VIX have a negative influence on the risk-return dynamics, which is not surprising since prior studies document the effects of these variables on varied asset classes. The results suggest these factors can divert diversification benefits during extreme and normal markets conditions as shown in Table 6S in the supplementary file.

5. Conclusion

This paper provides first time empirical evidence on the dependence structure between the risk-return trade-off in fifteen international equity markets using Markov switching copulas. First, we find a negative tail dependence between risk and return for Singapore, India, Japan and China, and a negative dependence dynamic for USA, the UK, Germany, Italy, Brazil, Australia, Taiwan Canada, Mexico, Japan, France and South Africa equity markets. Lastly, we provide evidence that policy uncertainty, geopolitical risk and equity market volatility (VIX) have negative effects on the risk-return relationship conditional on different markets.

Our findings have several implications. Our findings stress the perils of the linearity assumption when analysing the relationship between risk and return. This connotes that earlier studies the employed linear models fail to capture the global behaviour between risk and return in international equity markets. Hence, it is essential that any analysis of the relationship between risk and return takes into account the time varying properties of the series. From the policy perspective, policy makers' understanding and knowledge of whether a strong dependence structure exists between risk and return can help them program specific policies that can help mitigate the long and short term impacts of fluctuations on the risk-return trade-off.

Declaration of Competing Interest

There is no conflict of interest with the publication of the present manuscript.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.frl.2021.102535.

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