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The effect of economic policy uncertainty on the long-term correlation between U.S. stock and bond markets☆

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ABSTRACT

We investigate the time-varying long-term correlation of U.S. stock and bond markets, as influenced by an economic policy uncertainty (EPU) index based on the modified DCC-MIDAS model. Considering the structural breakpoints of the 1997 Asian financial crisis and the 2008 financial crisis, we extend the model by incorporating dummy variables to adjust the long-term correlation during different periods. The empirical results show that the modified model is more efficient than the baseline model. Moreover, consistent with the flight-to-quality phenomenon, we further find that EPU has a significant negative influence on long-term stock-bond correlation.

1. Introduction

Stocks and bonds are two main types of asset allocation. The time-varying relationship between them has received considerable attention, and there have been many attempts to understand their co-movement during the past few years (Kim et al., 2006; Connolly et al., 2005; Aslanidis and Christiansen, 2014; Chen et al., 2014). Moreover, investors' portfolio optimization, risk management, and hedging choices may be vastly improved by taking the long-term relationship between two main asset classes into consideration (De Goeij and Marquering, 2004; Baele et al., 2010; Perego and Vermeulen, 2016). Recently, (Asgharian et al., 2015) have shown that stocks and bonds are likely connected because investors expect that the future cash flows and discount rates of both returns will be influenced by common economic factors. It is generally known that the United States is of great importance in its international influence and financial market size. Therefore, understanding the driving factors behind the long-term stock-bond correlation in the United States is crucial to formulating and implementing investment strategies. In this paper, we explore two interesting but rarely researched issues: whether the economic policy uncertainty (EPU) index has an impact on long-term stock-bond correlation and how the time-varying relationship reacts to financial crises.

Recently, the impact of policy risk on the market is growing and economic policy decisions influence economic activity. Uncertainty pertaining to economic policy decisions, regardless of its origin (whether from fiscal or monetary policy decisions), will discourage investor confidence and firms from investing, and thus, have a profound impact on the stock and bond markets. Many prior studies emphasize the importance of uncertainty in economic policy (Colombo, 2013; Antonakakis et al., 2013; Dakhlaoui and Aloui, 2016). (Baker et al., 2016) constructed an EPU index to measure the uncertainty related to monetary, fiscal and other relevant policies, and the study showed that the EPU index influences the intensity of the business cycle and investment. It has been widely recognized that EPU has a significant impact on the stock market (Dakhlaoui and Aloui, 2016; Arouri et al., 2016) and bond market (Wisniewski and Lambe, 2015). However, there is very little research investigating the role of EPU on the long-term correlation between stock and bond markets.

In this paper, we examine how EPU drives time-varying stock-bond correlations based on different effects on stock and bond returns. Specifically, we extend the DCC-MIDAS model proposed by (Colacito et al., 2011) to allow long-term correlation driven by EPU and incorporate dummy variables to adjust the correlation during different periods. By adding (Bai and Perron, 2003) test, we detect the multiple structural breakpoints during the time-varying correlation. Considering the structural breakpoints of the 1997 Asian financial crisis and the 2008 financial crisis, we divide the sample period into

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three sub-sample periods to test whether or not a certain financial crisis impacts long-term stock-bond correlations. The model can combine daily stock and bond returns with the monthly EPU index and take financial market turmoil into account. The results show that innovations in the EPU index have a significant negative impact on long-term stock-bond correlations, explaining the existence of the flight-to-quality phenomenon (Kim et al., 2006; Baele et al., 2010; Dua and Tuteja, 2016; Perego and Vermeulen, 2016). Moreover, the long-term co-movement of stock and bond returns is negative during periods of market turmoil.

This article contributes to the existing literature in several ways. Firstly, we explore the link between economic policy uncertainty and the long-term stock-bond correlation using the DCC-MIDAS model. By investigating the long-term co-movement and relating it to economic policy uncertainty, we provide new empirical evidence that EPU has a significant negative influence on long-term stock-bond correlation. Second, considering structural breaks, we apply the well-known BP test to identify the breakpoints and extend the DCC-MIDAS model, which combines the DCC specification (Engle, 2002) and the GARCH-MIDAS framework (Engle et al., 2013), and create a new model by incorporating dummy variables to explore the time-varying relationship in different periods. Identifying the structural changes caused by financial crises during the long-term relationship, we find that the modified model fits more accurately. Finally, another key contribution of this study is that it provides an alternative mechanism that could potentially explain the correlation between the U.S. stock and bond markets, based on capital movements induced by the flight-to-quality phenomenon. As investors substitute safe assets for riskier assets, bond and stock market returns become negatively correlated.

The remainder of the article is organized as follows. First, in Section 2, we introduce the related literature. Then we focus on data and methodology in Section 3. Section 4 discusses the empirical findings and conducts further analysis. We conclude in Section 5.

2. Literature review

This paper studies the co-movement between the stock market and government bond market and attempts to explain the effect of economic policy uncertainty (EPU) on the long-term correlation. There is a strand of literature that investigates the co-movement of stock and bond returns.

Over the past few years, the nature of co-movements between stock and bond markets has received considerable attention. There have been many attempts to comprehend their fundamental relationship. The existing related research generally reaches an agreement on how stock and bond returns co-move over time. Early study represented by (Campbell and Ammer, 1993) implicitly assume that the stock-bond correlation is time invariant and the observed levels cannot be justified by economic fundamentals. More recently, several studies have shown that the co-movement between stock and bond returns exhibits considerable time variation (Asgharian et al., 2015; Andersson et al., 2008; Perego and Vermeulen, 2016; Li et al., 2015). (De Goeij and Marquering, 2004) argue that co-variances between stock and bond returns tend to be relatively low after bad news in the stock market and good news in the bond market. (Andersson et al., 2008) show that stock and bond prices move in the same direction during periods of high inflation expectations, while epochs of negative stock-bond return correlation seem to coincide with subdued inflation expectations. (Li et al., 2015) find that innovations in the policy uncertainty index impact negatively and asymmetrically on stock-bond correlations. Long-term correlation tends to be small and negative during economic downturns, supporting the flight-to-quality phenomenon.

The underlying factors of the long-term time-varying correlation between stock and bond returns are controversial. A few variables that may affect the stock-bond correlation are macro-finance factors, since we expect future cash flows and discount rates to be influenced by the same macro-finance factors. (Andersson et al., 2008) investigate the influence of inflation and expected stock market uncertainty on the time-varying stock-bond correlation, and they find that expected inflation is positively related to time-varying co-movement, while expected stock market uncertainty, as measured by implied volatility, is negatively related to it. (Asgharian et al., 2015) use the DCC-MIDAS model to examine the impact of macro-finance factors on the correlation between stock and bond returns and find that macro-finance factors are good at forecasting long-term correlation. In contrast, (Baele et al., 2010) find that macroeconomic fundamentals contribute little to explaining stock and bond return correlations but that other factors, especially liquidity proxies, play a more important role. (Aslanidis and Christiansen, 2014) provide new evidence that macroeconomic factors have only a little explanatory power when the correlation is largely positive. However, when the stock-bond correlation is largely negative, these factors are the most useful explanatory variables.

(Baker et al., 2016) propose the EPU index to measure the uncertainty in monetary, fiscal, and other relevant policies. Recently, the focus on the effect of EPU on the stock and bond markets is increasing (Brogaard and Detzel, 2015; Wisniewski and Lambe, 2015; Arouri et al., 2016). (Antonakakis et al., 2013) present the following rationale for the correlation between EPU and stock market returns. Uncertain economic policies significantly influence expected cash flows and discount rates. High levels of policy uncertainty can also cause households and businesses to hold back on spending, investment, and hiring. Therefore, uncertainty induced by economic policy has a profound influence on the overall financial market and the national economy.

Our paper is related to but different from the above studies. To begin with, we incorporate the economic policy uncertainty index into an appropriately modified long-term correlation component and take structural break points into consideration. Specifically, we investigate what effects EPU may have on long-term stock-bond correlations by using DCC-MIDAS (Colacito et al., 2011). To adjust the correlation that cannot be explained by EPU around the recession periods, dummy variables are added to extend the baseline model. The empirical results show that the modified model is more efficient.

3. Data and methodology

In this study, we combine daily U.S. stock and bond market returns with the monthly U.S. economic policy uncertainty index. Stock and bond market returns in the U.S. are calculated using the S & P 500 index and the 10-year government bond price index from the Bloomberg database. We take logarithm prices to calculate the returns. To measure the uncertainty of economic policy, we use the EPU index constructed by (Baker et al., 2016)[1] The sample starts on 3 January 1985 and ends on 27 May 2016, with a total of 7511 observations.

Fig. 1 depicts the monthly evolution of the EPU index. Obviously, EPU captures turbulent economic events, such as the American financial crisis from 2007 to 2009 and the European debt crisis in 2011. The American financial crisis in 2007–2009 exerted a profound influence on the economy, such as the crash of international trade flows (Chor and Manova, 2012). (Steelman and Weinberg, 2015) discussed public policy responses during this crisis. As seen in Fig. 1, the EPU index reached a peak around 2008. In addition, some important member states of the Eurozone were unable to repay their government debt or bail out over-indebted banks, which resulted in sovereign credit risk and redenomination risk in the Eurozone in 2011. (Basse, 2014) and (Sibbertsen et al., 2014) analyzed the structural breaks in the long-term relationship between government bond yields in several Eurozone member states caused by this debt crisis, and the results implicated

[1] EPU data are available on www.policyuncertainty.com

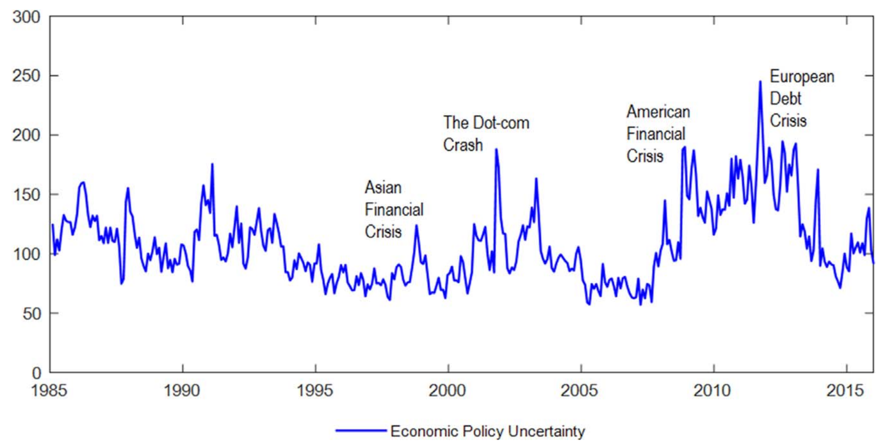

Fig. 1. Economic policy uncertainty.

that sovereign credit risk increased. Policymakers took actions to cope with such increased risk. From Fig. 1, we can see that the EPU index reached another peak around 2011.

We begin with the univariate GARCH-MIDAS framework of (Engle et al., 2013) to model stock and bond market returns. We then apply the DCC-MIDAS model (Colacito et al., 2011) based on the standardized residuals calculated in the first step to investigate the long-term correlation between stock and bond markets.

Consider a bivariate vector of returns $\mathbf{r_t} = [r_{stock,t}, r_{bond,t}]'$ on day t, and $r_{i,t}$ (i denotes stock and bond markets, respectively) follows the process:

$$r_{i,t} = \mu_i + \sqrt{m_{i,\tau} \cdot g_{i,t}}\,\xi_{i,t} \tag{1}$$

where $\xi_{i,t}|\Omega_{t-1} \sim N(0, 1)$ with Ω_{t-1} is the information setup to day $t-1$, $g_{i,t}$ is the short-term variance component and $m_{i,\tau}$ is the long-term component. Specially, the short-run variance component $g_{i,t}$ changes at the daily frequency t and follows a GARCH(1,1) model, while the long-run variance component $m_{i,\tau}$ is held fixed at the monthly frequency τ. The GARCH(1,1) model for short-run variance is specified as follows:

$$g_{i,t} = (1 - \alpha_i - \beta_i) + \alpha_i \frac{(r_{i-1,t} - \mu)^2}{m_{i,\tau}} + \beta_i g_{i-1,t} \tag{2}$$

with $\alpha_i > 0$ and $\beta_i > 0$, $\alpha_i + \beta_i < 1$. The long-run component $m_{i,\tau}$ is modeled as a slowly varying function of the lagged EPU using the MIDAS specification

$$\log(m_{i,\tau}) = m_v^i + \theta_v^i \sum_{k=1}^{K_v^i} \varphi_k(w_v^i) EPU_{\tau-k} \tag{3}$$

The weighting scheme in the above specification is so-called Beta weights defined as:

$$\varphi_k(w_v^i) = \frac{(1 - \frac{k}{K_1})^{w_v^i - 1}}{\sum_{j=1}^{K_v} (1 - \frac{j}{K_v})^{w_v^i - 1}}, \forall\ k = 1, \ldots, K_v \tag{4}$$

The DCC-MIDAS model (Colacito et al., 2011) naturally extends the GARCH-MIDAS model to dynamic correlations. Similarly to (Conrad et al., 2014), we extend the specification by allowing the long-run correlation to depend directly on the lagged EPU. In this paper, the conditional correlation between stock and bond market returns is given as $R_t = diag(Q_t)^{-1/2} Q_t diag(Q_t)^{-1/2}$, where Q_t is the short-run correlation component. And we define $q_{ij,t}$ as the elements in Q_t:

$$q_{ij,t} = (1 - a - b)\overline{\rho}_{ij,\tau} + a\xi_{i,t-1}\xi_{j,t-1} + bq_{ij,t-1} \tag{5}$$

where $\xi_{i,t-1}$ and $\xi_{j,t-1}$ are the standardized residuals from the GARCH-MIDAS models and $\overline{\rho}_{ij,\tau}$ is a slowly moving long-run correlation defined by a Fisher-z transformation of the correlation coefficient as follows:

$$\overline{\rho}_{ij,\tau} = \frac{\exp(2z_{ij,\tau}) - 1}{\exp(2z_{ij,\tau}) + 1} \tag{6}$$

$\overline{\rho}_{ij,\tau}$ keeps locally constant during a long-term τ period, while $z_{ij,\tau}$ is directly dependent on the lagged EPU:

$$z_{ij,\tau} = m_c + \theta_c \sum_{k=1}^{K_c} \delta_k(w_c) EPU_{t-k} \tag{7}$$

The correlation ρ_t is obtained by the specification $\rho_t = \frac{q_{12,t}}{\sqrt{q_{11,t} q_{22,t}}}$, which is the correlation between the standardized residuals. The weighting scheme $\delta_k(w_c)$ is defined similarly to $\varphi_k(w_v^i)$, and the parameter θ_c denotes the effect of the EPU on the long-term correlation.

There have been many turbulent economic events during the past few years, so it is necessary to consider possible structural changes in the DCC-MIDAS model. It is clear that parameter m in Eq. (7) represents the correlation that cannot be explained by EPU. Therefore, we improve the model by adjusting dynamic changes of parameter m to avoid the deviation between long- and short-term correlations. Specifically, we incorporate dummy variables to adjust the structural changes of parameter m. The modified model is specified as:

$$z_{ij,\tau} = m_{c0} + \sum_{i=1}^{n} m_{ci} D_i + \theta_c \sum_{k=1}^{K_c} \delta_k(w_c) EPU_{\tau-k} \tag{8}$$

We divide the sample period into several sub-sample periods to test whether or not a certain financial crisis impacts long-term stock-bond correlations. The value of dummy variables D_i is 1 during sub-sample period i, and 0 otherwise. The coefficient m_{ci} is considered as an increment in the intercept m during sub-sample period i. To avoid the multiple-collinearity problem, during the first sub-sample period we set the value of m_{c1} as 0. So the intercept m varies across different sub-sample periods. In other words, the value of intercept m is m_{c0} during the first sub-sample period, $m_{c0} + m_{c2}$ during the second sub-sample period, and so on. By considering the structural changes in the relationship between the stock-bond correlation and the EPU index caused by financial crises, the modified model fits more accurately.

Since both the GARCH-MIDAS and DCC-MIDAS models require additional lags of the explanatory variables at the beginning of the sample, we include three MIDAS lag years in the filter, which means that $K_v = K_c = 36$. The three-year MIDAS lag is consistent with (Conrad et al., 2014).

4. Empirical results

In this section, we first apply the DCC-MIDAS model (Colacito et al., 2011) without exogenous variables to describe the long-term correlation of stock and bond returns. Subsequently, we extend the model by allowing long-term volatility and correlation to be affected by

Table 1
GARCH-MIDAS and DCC-MIDAS parameter estimates of realized correlation (RC).

Panel A

GARCH-MIDAS	μ	α	β	θ_v	ω_v	m_v
Stock	0.0576*** (0.0101)	0.1073*** (0.0258)	0.8689*** (0.0322)	0.0081** (0.0033)	1.3858** (0.5655)	−0.0382 (0.2147)
Bond	0.0284** (0.0129)	0.0463*** (0.0058)	0.9517*** (0.0060)	−0.0042 (0.0036)	2.4019*** (0.8400)	0.9508*** (0.3667)

Panel B

DCC-MIDAS	a	b	ω_c
	0.0698*** (0.0157)	0.8416*** (0.0630)	11.3008 (8.9158)

Note: Panel A reports the estimates of the GARCH-MIDAS coefficients for the considered assets. Panel B reports the estimates of the DCC-MIDAS parameters. The numbers in parentheses are standard errors. The sample covers from 3 Jan 1985 to 27 May 2016.
* Indicates significance at the 10% level.
*** Indicates significance at the 1% level.
** Indicates significance at the 5% level.

monthly EPU. According to the long-term correlation influenced by EPU, we incorporate dummy variables to investigate structural breaks. Using the modified model (shown in Eq. (8)), we can explore the role of EPU in the long-term correlation of stock and bond markets during different periods. For the robustness checks, we test the model by choosing diverse sub-samples. Furthermore, we apply different kinds of EPU, such as global EPU, into DCC-MIDAS-EPU and modified DCC-MIDAS-EPU model. The results are not fully displayed because of the space constraints.

4.1. DCC-MIDAS model

Without exogenous variables, we first examine the long-term correlation between stock and bond markets affected by realized correlation (RC). Table 1 shows the results from estimating the DCC-MIDAS model for stock and bond market returns. Obviously, θ is significant for the realized volatility (RV) and realized correlation (RC). The long- and short-term stock-bond correlations are plotted in Fig. 2. We notice that these two components clearly follow a similar trend, while the long-term correlation is much smoother.

It is clear that the long-term relationship stayed positive until December 1997 and then experienced an abrupt drop below zero from late 1997 to July 1999. The stock-bond relationship became positive again in the middle of 1999, then turned below zero in July 2000 and dropped sharply during 2002 and early 2003. From 2003 to 2006, the

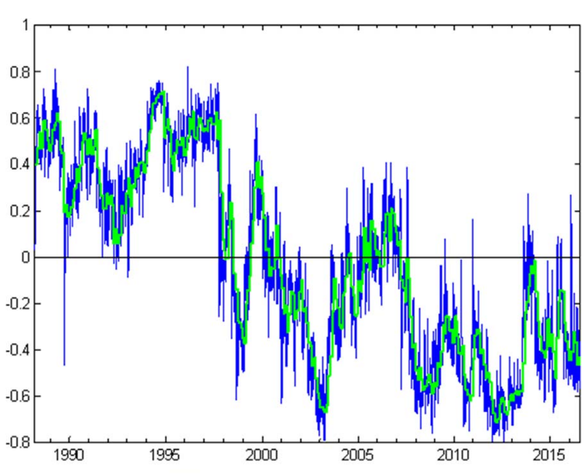

Fig. 2. Dynamic correlation and long-run component between the bond and stock markets affected by realized correlation.

long-term correlation gradually increased and started to hover in the positive position. However, the correlation fell back below zero after 2007 and has stayed consistently negative until now.

Furthermore, the figure implies an interesting cyclical pattern in the evolution of the long-term correlation. Around the recession periods of 1997–1998 and 2007–2009, the long-term correlation between stock and bond markets decreased sharply, while during the recovery phases of financial crises the correlation gradually increased. A key explanation is that the equity risk premium increased and the bond term premium decreased conversely during the financial crises (Andersson et al., 2008). The rationale may lead to the flight-to-quality phenomenon, as investors tend to substitute equity with relatively safe assets to spread risk during periods of financial turmoil.

4.2. DCC-MIDAS-EPU model

The preceding empirical results fundamentally exhibit the long-term correlation between stock and bond markets. Based on the framework, we extend the specification by allowing long-term volatility and correlation to be affected by the EPU index. The model combines daily stock and bond returns with the monthly EPU index and decomposes the total dynamic correlation into long- and short-term components.

We subsequently estimate the DCC-MIDAS-EPU parameters by incorporating monthly EPU into the long-term volatility and correlation component. Table 2 presents the DCC-MIDAS estimation results of dynamic correlation influenced by EPU. Panel A of Table 2 presents the bivariate estimation results for the GARCH-MIDAS-EPU model of stock and bond returns, respectively. Then, we discuss the estimated θ parameters individually for these markets. The sign of θ indicates the response of long-term volatility to EPU shocks. The coefficient for θ is positive and significant at the 1% level for the bond returns, indicating that EPU has a significant positive influence on long-term bond-market volatility. Our findings confirm the positive relationship between market uncertainty and bond-market volatility proposed by (Asgharian et al., 2015). However, the estimated coefficient θ for the stock market is insignificantly negative, which means that the effect of EPU on long-term stock volatility is rather ambiguous.[2] The DCC estimation results are shown in Panel B of Table 2. The estimated parameter θ reflects how stock-bond correlation responds to EPU shocks, and θ is negative and statistically significant only at the 10% level.

[2] Different types of stocks respond differently to the policy uncertainty and the impacts cancel each other out. In contrast, the reactions of different bond varieties to policy uncertainty are relatively stable in the United States.

Table 2
GARCH-MIDAS-EPU and DCC-MIDAS-EPU parameter estimations.

Panel A						
GARCH-MIDAS	μ	α	β	θ_v	ω_v	m_v
Stock	0.0516*** (0.0099)	0.0799*** (0.0132)	0.9083*** (0.0144)	−0.1822 (0.4136)	30.1825* (17.0335)	0.3267 (0.6302)
Bond	0.0274*** (0.0128)	0.0351*** (0.0060)	0.9617*** (0.0067)	0.4991*** (0.1832)	16.0210 (12.3318)	−0.1896 (0.3911)
Panel B DCC-MIDAS	a	b	θ_c	ω_c	m_c	
	0.0439*** (0.0061)	0.9508*** (0.0095)	−0.2290* (0.0691)	21.8770 (0.0925)	−0.1251 (2.1384)	

Note: Panel A reports the estimates of the GARCH-MIDAS-EPU coefficients for the considered assets. Panel B reports the estimates of the DCC-MIDAS-EPU parameters. The numbers in parentheses are standard errors. The sample covers from 3 Jan 1985 to 27 May 2016.
** Indicates significance at the 5% level.
*** Indicates significance at the 1% level.
* Indicates significance at the 10% level.

As a further illustration, we depict the estimated stock-bond correlation in Fig. 3. We notice that deviations between the long-term and short-term components of the stock-bond correlation fluctuate during different periods. As seen in Fig. 3, the long-term correlation is below the short-term trend line before 1997, but it is significantly above the short-term correlation after 2007. A key explanation is that there are structural break points approximately 1997 and 2009, which cause the goodness of fit of the DCC-MIDAS-EPU model to be poor. Compared with the long-term correlation driven by realized correlation (RC), we find that the EPU index is not the only factor that drives the changes in correlation, which motivate us to improve the model.

4.3. Modified model

The sample period covers a few economic crises, which resulted in downturns in stock market returns and had a significant impact on the demand for bonds. These economic crises may cause structural changes in the trend of long-term stock-bond correlation. From Fig. 3, we note that long- and short-term components of the stock-bond correlation are not fitted. Thus, it is assumed that the stock–bond correlation may experience dramatic changes in recent years. We use the well-known (Bai and Perron, 2003) test to detect multiple structural breakpoints in the stock–bond correlation. First, we estimate the following model for the long-run correlation:

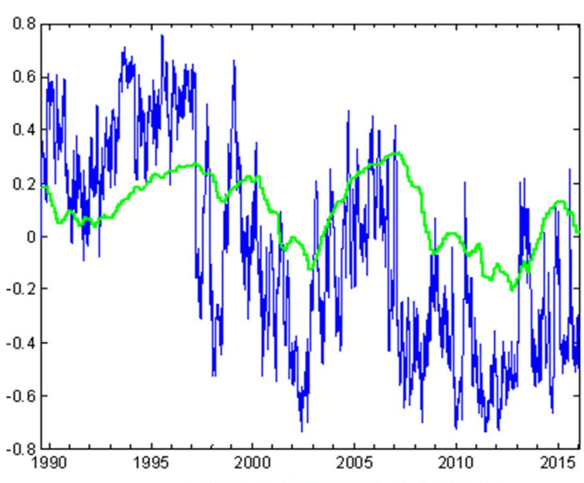

Fig. 3. Dynamic correlation and long-run component between the bond and stock markets affected by EPU.

$$Cor_T = \mu_l + \mu_T \tag{9}$$

where μ_l, for $l = 1, \ldots, m + 1$, are regime-dependent levels of long-run correlations within break dates $T = (T_1, \ldots, T_m)$, and m is the optimal number of breakpoints. We estimate the between-break levels and the break dates by minimizing the sum of squared residuals $\sum_{l=1}^{m+1}\sum_{T=T_{l-1}+1}^{T_l}[Cor_T - \mu_l]^2$. Finally, we obtain the optimal number of breakpoints m, using the sequential method as (Bai and Perron, 2003) and (Baele and Londono, 2013). The idea behind this method is to sequentially identify the statistical relevance of including an additional breakpoint. We assess this relevance by comparing the minimal value of the sum of squared residuals over all segments, including the additional breakpoints.

We present the results of the structural break test in Table 3, which shows that structural breakpoints occur around 1997 and 2007, both of which are periods of financial crises. The Asian financial crisis in 1997 caused panic selling of securities and the global economy experienced a sharp downturn during the 2008 financial crisis. In addition, (Perego and Vermeulen, 2016) find that the breaks coincide with the beginnings of financial crises, supporting our conjecture.

Therefore, we extend the model by adjusting dynamic changes of parameter m to measure the impact of the EPU index during different periods. Specifically, considering the structural breaks of 1997 and 2007, we incorporate dummy variables to adjust the structural changes of parameter m. This corresponds to Eq. (8), where:

Table 3
Structural breakpoints for long-term stock-bond correlation.

	Correlation	Correlation
Number of break points	2	3
Break point1	01/1997	01/1997
Break point2	12/2007	04/2001
Break point3	–	01/2008
F-statistic	10.14**	3.62
Scaled F-statistic	10.14**	3.62
Weighted F-statistic	12.05**	5.21

Note: This table reports the number of the structural breakpoints and the break dates for long-run stock-bond correlation. The table shows that the F-statistic, Scaled F-statistic and Weighted F-statistic of break points exceed their critical value，which is 7.22, so that we reject the null of no breaks in the 95% confidence interval. However, when the number of break points equals three, the F-statistic, Scaled F-statistic and Weighted F-statistic of break points are less than their critical value. In addition, the UDmax and WDmax statistics value 217.25 and 466.74, both indicate the presence of structural breakpoints in the 95% confidence interval. As such, in the 95% confidence interval, the break dates for long-run stock-bond correlation are around 1997 and 2007.

Table 4
Modified DCC-MIDAS parameter estimate of economic policy uncertainty (EPU).

DCC-MIDAS	a	b	θ_c	ω_c	m_{c0}	m_{c2}	m_{c3}
	0.0446***	0.9254***	−0.2818**	3.5641	0.7809***	−0.6325***	−0.8250***
	(0.0010)	(0.0231)	(0.1358)	(7.1932)	(0.1788)	(0.0895)	(0.0922)

Note: This panel reports the estimates of the modified DCC-MIDAS-EPU parameters. The numbers in parentheses are standard errors. As mentioned in the methodology section, Coefficient m_{ci} is considered as increment in the intercept m during sub-sample period i. To avoid multiple-collinearity problem, during the first sub-sample period, we set the value of m_{c1} as 0. So the intercept m varies across different sub-sample periods. The sample covers from 3 Jan 1985 to 27 May 2016.
* Indicates significance at the 10% level.
*** Indicates significance at the 1% level.
** Indicates significance at the 5% level.

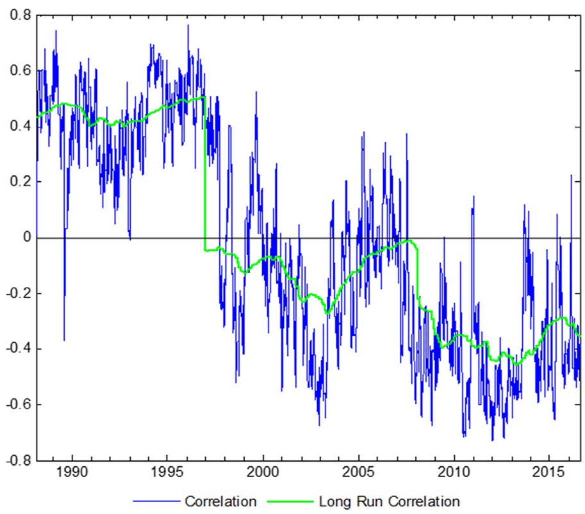

Fig. 4. Dynamic correlation and long-run component between the bond and stock markets affected by EPU.

$$D_1 = \begin{cases} 1, & t \le 1\ Jan\ 1997 \\ 0, & otherwise \end{cases}$$

$$D_2 = \begin{cases} 1, & 1\ Jan\ 1997\ < t \le 31\ Dec\ 2007 \\ 0, & otherwise \end{cases}$$

$$D_3 = \begin{cases} 1, & t > 31\ Dec\ 2007 \\ 0, & otherwise \end{cases}$$

Table 4 presents the estimation results for the modified model of Eq. (8). The sum of α and β is appreciably less than 1, indicating that in all specifications the short-term correlation component is mean-reverting to the long-term trend. The estimated parameter θ reflects the direction and magnitude of how the stock-bond correlation responds to EPU shocks. In line with our intuition, we note a negative and significant θ, which means EPU has a significantly negative impact on long-term stock-bond correlation. Coefficient m_{ci} is considered as an increment in the intercept m during sub-sample period i. To avoid the multiple-collinearity problem, during the first sub-sample period we set the value of m_{c1} as 0. Table 4 shows all m_{ci} are significant at the 1% level for different periods, which means the structural breaks of 1997 and 2007 are meaningful.

Fig. 4 plots the estimated correlation using the modified model. Considering the dynamic change of m parameter, the long- and short-term components follow a similar trend, which indicates that the modified model is more efficient than the primary DCC-MIDAS-EPU model. The estimation results not only confirm the findings of (Connolly et al., 2005) and (Li et al., 2015) but also identify the impact of financial crises on long-term stock-bond correlations. The model combines daily stock and bond returns with the monthly EPU index and considers financial market turmoil. We find that higher EPU implies greater economic policy volatility and this increase in uncertainty deteriorates the economic environment. Investors, being risk averse, tend to sell in the relatively riskier stock market and buy in the relatively safer bond market, leading to a decline in the correlations. This is also consistent with the flight-to-quality phenomenon because when stock-market returns fall, investors tend to flock and bid up the price of government bonds; the inverse relationship with yields causes a subsequent fall in bond returns.

5. Conclusion

In this paper, we scrutinize how economic policy uncertainty influences the long-term stock-bond correlation based on the DCC-MIDAS model proposed by (Colacito et al., 2011). For the sake of possible structural breaks in the long-run stock-bond correlation, we extend the model by incorporating dummy variables to adjust the structural changes of parameter m.

We consider the structural changes of the 1997 Asian financial crisis and the 2008 financial crisis in our model and find that the economic policy uncertainty index has a significant negative impact on long-term stock-bond correlations, which is consistent with (Connolly et al., 2005) and (Li et al., 2015). When economic policies are more uncertain, the demand for bonds increases and demand for stock decreases, resulting in a decline in correlations. Precisely, investors' effective risk aversion increases during volatile times. Thus, there is a "flight-to-quality effect," in that investors tend to substitute safe assets for risky assets and bond and stock market returns become negatively correlated. Considering that stocks and bonds are two major asset classes for investors, a lower stock-bond correlation indicates better diversification opportunities. Compared to models in existing studies, our model is more practical and the results are more credible.

The findings of this paper are especially helpful for policy makers, portfolio managers and individual investors. The long-term equilibrium relationship between the bond and stock markets and economic policy fluctuations can be crucial for policymakers in terms of understanding the transmission mechanisms of their decisions and adopting relevant policies. Our findings also greatly improve the efficiency of asset allocation for portfolio managers and investors. The results suggest implications for long-term investors who want to invest part of their wealth in stock and bond markets.

The study has directly identified the effect of economic policy uncertainty index on long-term stock-bond correlation. Moreover, future research can explore the forecasting ability of the EPU index to the correlation. In addition, in future studies, we can also investigate the performance of statistical arbitrage and cross-hedging strategies between these two markets, which will help in evaluating the role of bonds as a potential tool for hedging or providing safe haven in the U.S. stock market.

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