Economic Policy Uncertainty and the Volatility in the Foreign Exchange Markets : An Analysis the Autoregressive Distributed Lag and Error Correction Models

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Abstract:

This study applies the autoregressive distributed lag and error correction models to analyse the dynamic relationship between economic policy uncertainty and volatility in the foreign exchange market for six major currencies vis-à-vis the US dollar. Empirical analysis finds that domestic economic policy uncertainty has non-negligible effects on the volatility of the Australian and Canadian dollars, but not the other currencies. The short and long-run multipliers also show differences in the adjustment process toward equilibrium between the currencies.

Keywords

economic policy uncertainty, foreign exchange rate, volatility, autoregressive-distributed lag model, error correction model

1. Introduction

In recent years, there is a resurgence of interest in the relationship between economic policy uncertainty and volatility in the foreign exchange market. In 2016, for example, Brexit and the US presidential election gave jitters to the foreign exchange market. Given that the United Kingdom was the first member country that decided to leave the European Union (EU), the British pound dropped to new three-decade low with market participants speculating on how the exit from the EU would be processed. After Donald Trump unexpectedly won the presidential election in the United States, the British pound, the Euro, the Japanese yen and some emerging currencies plunged while the US dollar soared. These political events created uncertainty in the market, making foreign exchange rates highly volatile for months.

Since the breakdown of the Bretton Woods system in the early 1970s, the ups and downs of foreign exchange rates have increased risks associated with international transactions and raised concerns among market participants and policy makers. Risk-averse investors are willing to pay for costly financial derivatives to hedge exchange rate risk while risk-loving investors see high volatility in the foreign exchange market as a source of profits. Most of exporters and importers do not have risk appetites to take either long or short positions in foreign currencies. Policy makers are concerned about the potential impacts of volatile foreign exchange rates on domestic economies.

In the literature, econometric studies have tried to identify the macroeconomic determinants of exchange rate volatility. There is, however, no consensus among economists and practitioners about what makes foreign exchange rates more volatile. This is partly because different studies apply different theoretical models to investigate the sources of the volatility. Monetary models, for example, focus on monetary variables, such as monetary aggregates and inflation, while other theories use non-monetary factors, such as output, international trade and commodity prices, for explanatory variables (Bayoumi and Eichengreen (1998), Devereux and Lane (2003), Grydaki and Fontas (2009), Morana (2009)). There are also studies that synthesize a variety of theoretical models and take eclectic approaches (Chipili (2012), Jabeen and Khan (2014)). Some studies, however, find no linkage between macroeconomic fundamentals and exchange rate volatility, and emphasize the role of non-macroeconomic factors, such as news, in the determination of exchange rate volatility (Andersen and Bollerslev (1997) and Flood and Rose (1995)).

Economic policy uncertainty is one of potential variables that can influence volatility in the foreign exchange market. In econometric modelling of exchange rates, it is generally assumed that exchange rates reflect relative conditions between two countries. Differences in interest rate, price level, inflation, money, output, productivity, portfolio balance and some other risk factors are often included as explanatory variables in econometric models. More importantly, exchange rates are largely influenced by expectations on whether these economic variables will converge or diverge in the short and long runs. In a similar vein, it is highly plausible that a difference in economic policy uncertainty between countries also affects exchange rates since risk-averse investors consider economic policy uncertainty as an additional risk factor. However, there have not been many studies that quantify the effects of economic policy uncertainty on exchange rates. Only recently, Balcilar et al. (2016) and Krol (2014) empirically investigate whether economic policy uncertainty has an impact on exchange rates. These studies find non-negligible effects of economic policy uncertainty on exchange rate volatility. Balcilar et al. (2016) find that economic policy uncertainty Granger-causes exchange rate volatilities, but not returns. Krol (2014) shows that economic policy uncertainty increases the volatility of exchanges rate for industrial and emerging economies. Martin and Urrea (2007) develop a general equilibrium model based on Lucas (1982) and provide empirical evidence suggesting that economic policy uncertainty determines risk premium in the foreign exchange market more than fundamental macroeconomic uncertainty.

The degree of economic policy uncertainty is, however, difficult to quantify in an objective way since it relates to expectations that market participants form about what polities governments will or will not take in the future. Recent empirical studies apply text search methods to yield a less subjective proxy variable for economic policy uncertainty. Alexoupoulos and Cohen (2015), Boudoukh et al. (2013), Gentzkow and Shapiro (2010), and Hoberg and Phillips (2010) utilize information from newspaper archives, supplemented with other public sources. Baker et al. (2013, 2016) develop the index of economic policy uncertainty, called the EPU index, based on newspaper coverage frequency for major countries as well as global and regional indexes. Many empirical studeis recently use the EPU index to measure economic policy uncertainty. Although the EPU index is not completely bias-free, it is highly correlated with major political events and other quantitative uncertainty measures, such as stock volatility indexes (Baker et al. (2016)). Balcilar et al. (2016) and Krol (2014) estimate the effects of economic policy uncertainty in the foreign exchange market, using the EPU index as a proxy variable for economic policy uncertainty.

This study investigates whether a change in the EPU index has an impact on the volatility of exchange rates and, if so, how long it takes for the impact to dissipate in the foreign exchange market. We apply the autoregressive distributed lag (ADL) model and the error correction model (ECM) to the foreign exchange rates of six major currencies vis-à-vis the US dollar in order to analyse the dynamic relationship between the EPU index and the volatility. The ADL model is a simple but flexible model relating a dependent variable to its past values and an independent variable. The model allows us to calculate the short and long-run multipliers of the dependent variable. The ADL model is also represented as the ECM, which shows how quickly the disequilibrium is corrected and the system reverts to the equilibrium.

As tested later in this paper, the exchange rate volatilities and the EPU indexes both are stationary. The ECM has been widely applied to non-stationary but cointegrated variables in econometrics since the seminal paper by Engle and Granger (1987) showed that a cointegrating relationship has an alternative representation as an ECM. It, however, has been debated whether the ECM is suitable for stationary time series as well. Keele and De Boef (2004) derive the ECM from the ADL model, justifying the use of the ECM for stationary variables. They interpret the equilibrium, or long-run, relationship between stationary variables in the ECM as the relationship between long-memoried variables. In this paper, we estimate the ADL model and compute the implied parametric values of the ECM under the assumption that the volatility series and the EPU indexes are long-memoried.

The rest of the paper is organized as follows. The next section describes the models used in the analysis. We derive the ECM and its parameters from the ADL model. The third section presents the data and the volatility measures used in the analysis. In this study, we estimate the volatility of foreign exchange rates from the generalized autoregressive conditional heteroskedasticity (GARCH) model. Unit root tests are also performed on the estimated volatilities and the EPU indexes, rejecting all the null hypotheses of unit roots. The fourth section shows empirical results from the estimation of the ADL model. We also compute the short and long-run multipliers as well as the speed of adjustment in the ECM. The last section summarizes the results and concludes.

2. The Autoregressive Distributed Lag and Error Correction Models

Economic variables are often non-stationary but cointegrated. To study cointegrating relationships and short-run error correction mechanism, the ECM is widely applied to cointegrated time series. Engle and Granger (1987) shows that cointegrated variables have an error correction representation, and the linkage between cointegration and the ECM dates back to their study.

As seen later in Section 3.3, however, the volatility measures in the foreign exchange market and the EPU indexes are stationary. It has been discussed whether the ECM can be applied to a set of stationary variables, particularly in political science, where many time series are known to be stationary. Some studies, such as Beck (1991), Keele and De Boef (2004) and Williams (1992), apply the ECM to stationary time series under the assumption that variables in the systems are stationary but long-memoried. Keele and De Boef (2004), for example, study the dynamic process of public support for the Supreme Court in the United States, assuming that any change in general feelings about government have both immediate and persistent effects. They estimate an ECM with congressional approval as a proxy variable for general feelings about government and find its short and long-term effects are both statistically significant.

Similarly, it is not unreasonable to assume that the volatility and economic policy uncertainty have a long memory. Economic policy uncertainty essentially relates to expectations on how political events will unfold in the future. The Brexit, for example, reflects the underlying socio-economic characteristics of the UK economy, which are expected to remain relatively unchanged for years and, it is natural to assume that economic policy uncertainty after the referendum in the United Kingdom can have long-lasting effects on the foreign exchange market.

Following Bannerjee (1993), Davidson and MacKinnon (1993), Verbeek (2000), Keele and De Boef (2004) derive the ECM from the ADL model. The ADL model describes the dynamic relationship between variables in the form of

$$Y_t = \alpha_0 + \sum\nolimits_{i=1}^{p} \alpha_i Y_{t-i} + \sum\nolimits_{j=1}^{q} \beta_j X_{t-j} + \varepsilon_t \quad (1)$$

where α's and β's are time-invariant coefficients, and ε_t is an random error at time t. The ADL model is generally denoted as ADL (p, q), where p and q refer to the number of lags of Y and X on the right-hand side. The current value of Y depends on p lags of its own and the current value and q lags of X (plus the random error).

In this study, we model the dynamic relationship between the EPU index and the exchange rate volatility as ADL (1, 1):

$$Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \beta_0 X_t + \beta_1 X_{t-1} + \varepsilon_t \qquad (2)$$

where Y_t is the volatility measure of an exchange rate, X_t is the EPU index (or a vector of the EPU indexes) at time t.

The short-run multipliers of the EPU index on the exchange rate volatility are calculated by successive substitution from (2):

$$\begin{aligned} &\partial Y_t / \partial X_t = \beta_0 \\ &\partial Y_{t+1} / \partial X_t = \beta_1 + \alpha_1 \beta_0 \\ &\partial Y_{t+2} / \partial X_t = \alpha_1 \beta_1 + \alpha_1^2 \beta_0 \qquad (3) \\ &\qquad \cdots \\ &\partial Y_{t+i} / \partial X_t = \alpha_1^i (\beta_1 / \alpha_1 + \beta_0) \end{aligned}$$

These partial derivatives measure the impact of a transitory change in the EPU index on exchange rate volatility. The coefficients β_0 and β_1 represent the immediate impacts of X on Y. The error correction parameter α measures how persistent impacts are in the adjustment mechanism.

In the long-run equilibrium, $Y_t = Y_{t-1} = Y^*$, $X_t = X_{t-1} = X^*$, which implies

$$Y^* = \frac{\alpha_0}{1-\alpha_1} + \frac{\beta_0 + \beta_1}{1-\alpha_1} X^* \qquad (4)$$

Thus, the long-run multiplier is

$$\partial Y^* / \partial X^* = (\beta_1 + \beta_2) / (1 - \alpha_0) \qquad (5)$$

This measures the impact of a permanent change in the EPU index on the volatility of an exchange rate.

The ADL (1, 1) model has an alternative representation as the ECM:

$$\Delta Y_t = \beta_0 \Delta X_t - (1 - \alpha_1) \left(Y_{t-1} - \frac{\alpha_0}{1-\alpha_1} + \frac{\beta_0 + \beta_1}{1-\alpha_1} X_{t-1} \right) + \varepsilon_t \qquad (6)$$

where $\Delta Y_t = Y_t - Y_{t-1}$ and $\Delta X_t = X_t - X_{t-1}$. The error term $\left(Y_{t-1} - \frac{\alpha_0}{1-\alpha_1} + \frac{\beta_0 + \beta_1}{1-\alpha_1} X_{t-1} \right)$ represents a deviation from the long-run equilibrium at the previous period. The coefficient $(1 - \alpha_1)$ measures the speed of adjustment to the equilibrium.

In what follows, we estimate the ADL (1, 1) model (2) by the ordinary least squares (OLS) and infer the implied value of the speed of adjustment $(1 - \alpha_1)$ in the ECM (6).

3. Data, Volatility Measure and Unite Root Tests

3.1 Data

In this study, we examine the impact of the EPU index on the foreign exchange rates of six major currencies – the Australian dollar, the Canadian dollar, the Euro, the Japanese yen, the Korean won and the British pound –

to the US dollar. The exchange rates are sourced from the FRED database of the Federal Reserve Bank of St. Louis. The series are the monthly averages of daily noon rates in New York City for cable transfers payable in the currencies. The sample period ranges from January 1999, when the Euro made its debut, to April 2016.

For economic policy uncertainty, we use the news-based EPU index of Baker et al. (2013, 2016), who develop global, regional and national monthly indexes. The indexes are based on the relative frequency of key words that appear in newspapers. For the United States, the index reflects how many articles contain the triple of key words – (1) "economic" or "economy", (2) "uncertain" or "uncertainty", and (3) one or more of "deficit", "Federal Reserve", "legislation", "regulation" or "White House" – in ten leading newspapers, and is standardized over time. For the other countries, the indexes are constructed from the frequency count of articles containing the equivalents of the three key words in sevreal largest newspapers published in the counntries. For the Euro area, the French, German and Italian indexes are used as a vector of the explanatory variables X_t. The global index, which is aggregated from the national EPU indexes, is also used in an alternative specification of the ADL model (For more on the methodology of constructing the EPU indexes, see Baker et al. (2013, 2016)).

3.2 Volatility Measure

In predicting exchange rate volatility, conditional variance models are widely used. In particular, the GARCH (1, 1) model of Bollerslev (1986) and Taylor (1986) is often applied to time series because it can flexibly model the dynamic characteristics of exchange rates despite its simplicity. This paper estimates the volatility of an exchange rate as a predicted value from the GARCH (1, 1):

$$\begin{aligned} Z_t &= \theta_0 + \theta_1 Z_{t-1} + \epsilon_t + \theta_2 \epsilon_{t-1} \\ \epsilon_t &= \nu_t \sigma_t \\ \sigma_t^2 &= \vartheta_0 + \vartheta_1 \sigma_{t-1}^2 + \vartheta_2 \epsilon_{t-1}^2 \end{aligned} \tag{7}$$

where Z_t is an exchange rate at time t, and θ's, andϑ's are time-invariant coefficients. The first equation is the mean equation modeled as the first-order autoregressive moving average, or ARMA (1, 1), model; the mean of an exchange rate depends on its previous value and the error term ϵ_t that follows the first-order moving average process. As seen in the second equation, the error term ϵ_t is assumed to be heteroskedastic over time; σ_t is the conditional standard deviation of ϵ_t, and ν_t is an independent and identically distributed random error. The third equation describes the GARCH (1, 1) process in which the conditional variance σ_t^2 is a weighted function of the fitted value σ_{t-1}^2 and the realized volatility ϵ_{t-1}^2 at the previous period. The unconditional variance, or the long-term volatility, is given by $\frac{\vartheta_0}{1-\vartheta_1-\vartheta_2}(\vartheta_1+\vartheta_2<1)$.

Under the normality assumption for the error term ϵ_t, the parameters of the model can be estimated by maximizing the log-likelihood function:

$$\begin{aligned} L = &-\frac{T}{2}\log(2\pi) - \frac{1}{2}\textstyle\sum_{t=1}^{T}(\sigma_t^2) \\ &-\frac{1}{2}\frac{\sum_{t=1}^{T}(Y_t - \theta_0 - \theta_1 Z_{t-1} - \theta_2 \epsilon_{t-1})}{\sigma_t^2} \end{aligned} \tag{8}$$

where T is the sample size. Table 1 presents the estimates and standard errors of the GARCH (1, 1) model. We also perform Ljung-Box-Pierce Q tests on the residuals to verify that there is no autocorrelation up to 1, 5 and 9 lags.

Figures 1 plot the predicted values of the volatility σ_t and the EPU indexes from February 1999 to April 2016 for the six currencies. The US and global EPU indexes are

Table 1: The ARMA (1, 1) -GARCH (1, 1) Model

	Australian Dollar		Canadian Dollar		Euro	
	estimate	standard error	estimate	standard error	estimate	standarderror
θ0	0.001	0.003	0.000	0.002	0.001	0.002
θ1	−0.059	0.216	−0.010	0.172	0.149	0.194
θ2	0.438	0.191	0.424	0.153	0.159	0.200
ϑ0	0.000	0.000	0.000	0.000	0.000	0.000
ϑ1	0.688	0.240	0.603	0.119	0.749	0.191
ϑ2	0.133	0.076	0.347	0.130	0.057	0.046
Q(1)	0.053		0.045		0.003	
Q(5)	0.492		2.743		1.213	
Q(9)	1.376		3.925		4.603	

	Japanese Yen		Korean Won		British Pound	
	estimate	standard error	estimate	standard error	estimate	standarderror
θ0	0.000	0.001	−0.002	0.002	−0.001	0.002
θ1	0.510	0.158	−0.188	0.169	−0.025	0.359
θ2	−0.278	0.173	0.571	0.144	0.220	0.345
ϑ0	0.000	0.000	0.000	0.000	0.000	0.000
ϑ1	0.437	0.445	0.584	0.111	0.148	0.288
ϑ2	0.068	0.098	0.241	0.082	0.249	0.117
Q(1)	0.023		0.159		0.352	
Q(5)	5.906		0.620		2.033	
Q(9)	9.487		2.140		4.141	

also plotted. Table 2 reports descriptive statistics for the predicted volatilities and the EPU indexes.

3.3 Unit Root Tests

Dickey and Fuller (1979) develop a statistical test for unit roots. We carry out the augmented Dickey-Fuller (ADF) test on the volatilities and the EPU indexes. For a variable W_t, the ADF test is based on the auxiliary regression:

$$\Delta W_t = \varphi_0 + \varphi_1 t + \varphi_2 W_t + \sum\nolimits_{j=1}^{l} \phi_j \Delta W_{t-j} + v_t \qquad (9)$$

where t is a deterministic time trend, ν_t is an error term, and φ's and ϕ's are all fixed coefficients. The lagged values of ΔW_{t-j} are included to correct autocorrelation in ν_t. The lag length l is determined by information criterions, such as the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) (Akaike (1973) and Schwarz (1978)). The regression (8) includes the time trend t and the drift term φ_0 not to reduce the power of the test if they are statistically significant.

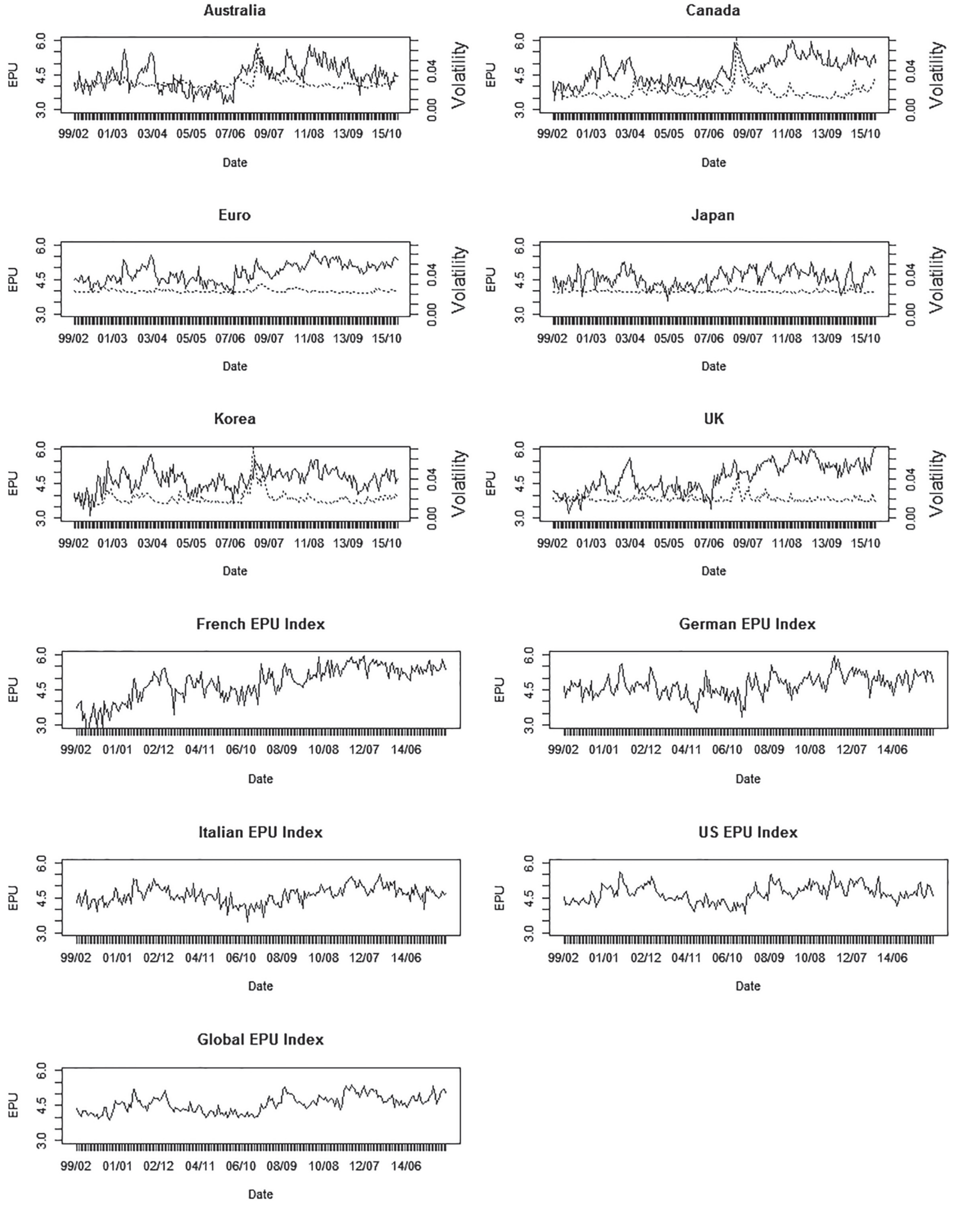
The null and alternative hypotheses are

$$\begin{aligned} H_0 &: \varphi_2 = 0 \\ H_1 &: \varphi_2 \neq 0 \end{aligned} \qquad (10)$$

The null hypothesis is that the variable has a unit root and is non-stationary. The alternative hypothesis implies that the variable does not have a unit root and is stationary. If the null hypothesis is rejected for the level of the variable, the test is performed on the first difference $\Delta W_t = W_t - W_{t-1}$.

Table 3 presents the results from the ADF tests on the volatilities and the EPU indexes.

Figure 1: The EPU Indexes and the Predicted Volatilities



Australia

Canada

Euro

Japan

Korea

UK

French EPU Index

German EPU Index

Italian EPU Index

US EPU Index

Global EPU Index

The lag length l is selected by the AIC. The p-values of the ADF statistics, the time trend, and the drift term are also reported in the table. The results show that the null hypotheses are all rejected, which implies that the volatilities and the EPU indexes are all stationary. The BIC yields the same results.

4. Empirical Results

Using the volatility measure predicted by the GARCH (1, 1) as a dependent variable, we estimate the ADL (1, 1) model by the ordinary least squares (OLS). Table 4 presents the estimates and standard errors of four different specifications of ADL (1, 1) for the five

Table 2: Descriptive Statistics

	Volatility			
	mean	standard error	minimum	maximum
Australia	0.027	0.005	0.022	0.027
Canada	0.018	0.007	0.011	0.023
France	NA	NA	NA	NA
Germany	NA	NA	NA	NA
Italy	NA	NA	NA	NA
Japan	0.023	0.001	0.021	0.023
Korea	0.020	0.007	0.014	0.022
UK	0.020	0.004	0.017	0.020
US	NA	NA	NA	NA
Euro	0.023	0.002	0.021	0.023
Global	NA	NA	NA	NA

	EPU Index			
	mean	standard error	minimum	maximum
Australia	4.435	0.558	3.245	4.645
Canada	4.682	0.561	3.404	4.213
France	4.791	0.709	2.424	4.420
Germany	4.711	0.444	3.348	4.883
Italy	4.616	0.354	3.465	4.807
Japan	4.550	0.353	3.558	4.627
Korea	4.677	0.456	3.120	4.147
UK	4.780	0.644	3.232	4.182
US	4.663	0.320	4.047	4.411
Euro	NA	NA	NA	NA
Global	4.576	0.356	3.893	4.591

Table 3: The Augmented Dickey-Fuller Unit Root Tests

		Volatility					
		time trend		drift		none	
		t	p-value	t	p-value	t	p-value
Australia	ϕ0	4.370	0.000	4.613	0.000		
	ϕ1	−0.338	0.736				
	ϕ2	−4.663	0.000	−4.662	0.000	−0.398	0.691
Canada	ϕ0	2.973	0.003	3.860	0.000		
	ϕ1	0.540	0.590				
	ϕ2	−4.061	0.000	−4.039	0.000	−0.234	0.815
Euro	ϕ0	3.933	0.000	3.925	0.000		
	ϕ1	−0.514	0.608				
	ϕ2	−3.958	0.000	−3.934	0.000	−0.236	0.814
Japan	ϕ0	6.571	0.000	6.601	0.000		
	ϕ1	−0.184	0.855				
	ϕ2	−6.594	0.000	−6.609	0.000	−0.317	0.752

Korea	$\phi0$	3.579	0.000	4.005	0.000		
	$\phi1$	0.031	0.975				
	$\phi2$	-4.100	0.000	-4.113	0.000	-0.763	0.446
UK	$\phi0$	3.576	0.000	3.586	0.000		
	$\phi1$	-0.444	0.658				
	$\phi2$	-3.618	0.000	-3.607	0.000	-0.382	0.703

		EPU					
		time trend		drift		none	
		t	p-value	t	p-value	t	p-value
Australia	$\phi0$	3.882	0.000	3.798	0.000		
	$\phi1$	1.121	0.264				
	$\phi2$	-3.977	0.000	-3.816	0.000	-0.079	0.937
Canada	$\phi0$	4.069	0.000	2.709	0.007		
	$\phi1$	2.454	0.015				
	$\phi2$	-4.062	0.000	-2.668	0.008	0.536	0.592
France	$\phi0$	3.269	0.001	2.506	0.013		
	$\phi1$	2.115	0.036				
	$\phi2$	-3.088	0.002	-2.383	0.018	0.862	0.390
Germany	$\phi0$	5.678	0.000	4.990	0.000		
	$\phi1$	2.714	0.007				
	$\phi2$	-5.761	0.000	-4.999	0.000	0.356	0.722
Italy	$\phi0$	3.254	0.001	3.170	0.002		
	$\phi1$	0.754	0.452				
	$\phi2$	-3.230	0.001	-3.161	0.002	0.204	0.839
Japan	$\phi0$	5.137	0.000	5.089	0.000		
	$\phi1$	0.907	0.365				
	$\phi2$	-5.164	0.000	-5.089	0.000	0.301	0.764
Korea	$\phi0$	5.569	0.000	5.560	0.000		
	$\phi1$	0.536	0.593				
	$\phi2$	-5.536	0.000	-5.552	0.000	0.183	0.855
UK	$\phi0$	3.918	0.000	2.610	0.010		
	$\phi1$	2.959	0.003				
	$\phi2$	-3.922	0.000	-2.523	0.012	1.214	0.226
US	$\phi0$	3.403	0.001	3.384	0.001		
	$\phi1$	0.000	0.000				
	$\phi2$	-3.390	0.001	-3.379	0.001	0.185	0.853
Global	$\phi0$	3.785	0.000	2.877	0.004		
	$\phi1$	1.911	0.057				
	$\phi2$	-3.768	0.000	-2.839	0.005	0.501	0.617

currencies excluding the Euro. The first three columns show the results with the national EPU and US indexes, either alone or in combination. In the last column, we extend the ADL model to include the Global EPU index as another explanatory variable. For the Euro, we estimate the ADL (1, 1) model with the French, German, Italian, US and Global EPU indexes all in combination. The estimated coefficients and their standard errors are reported in Table 5.

For each currency, the OLS estimates are similar across all the specifications. The coefficients of the lagged dependent variable α_1 are

Table 4: The ADL (1, 1) Model

		Australian Dollar							
		estimate	standard error	estimate	standard error	estimate	standard error	estimate	standard error
Lagged Dependent Variable	α0	0.002	0.002	0.001	0.003	0.001	0.003	0.002	0.003
	α1	0.807^{**}	0.041	0.803^{**}	0.042	0.807^{**}	0.042	0.805^{**}	0.043
National EPU	β0	0.002^{**}	0.001			0.002^{**}	0.001	0.002^{*}	0.001
	β1	-0.001^{**}	0.001			−0.001	0.001	−0.001	0.001
US EPU	β0			0.001	0.001	0.000	0.001	−0.001	0.001
	β1			0.000	0.001	0.001	0.001	0.002	0.001
Global EPU	β0							0.001	0.002
	β1							−0.002	0.002
adjusted R squared		0.157		0.164		0.161		0.176	
Box-Ljung Q Test		0.000		0.000		0.000		0.001	
p-value		0.989		0.993		0.989		0.977	

		Canadian Dollar							
		estimate	standard error	estimate	standard error	estimate	standard error	estimate	standard error
Lagged Dependent Variable	α0	0.002	0.003	−0.003	0.004	−0.003	0.004	−0.008	0.005
	α1	0.782^{**}	0.044	0.767^{**}	0.045	0.778^{**}	0.044	0.779^{**}	0.044
National EPU	β0	0.004^{**}	0.001			0.004^{**}	0.001	0.003^{**}	0.002
	β1	-0.003^{**}	0.001			-0.004^{**}	0.001	-0.005^{**}	0.001
US EPU	β0			0.001	0.001	−0.001	0.002	−0.002	0.002
	β1			0.001	0.001	0.003	0.002	0.002	0.002
Global EPU	β0							0.003	0.003
	β1							0.002	0.003
adjusted R squared		0.130		0.123		0.123		0.116	
Box-Ljung Q Test		0.001		0.000		0.002		0.002	
p-value		0.978		0.988		0.962		0.966	

		Japanese Yen							
		estimate	standard error	estimate	standard error	estimate	standard error	estimate	standard error
Lagged Dependent Variable	α0	0.010**	0.002	0.010**	0.002	0.010**	0.002	0.010**	0.002
	α1	0.469**	0.064	0.484**	0.062	0.476**	0.065	0.476**	0.065
National EPU	β0	0.000	0.000			0.000	0.000	0.000	0.000
	β1	0.000	0.000			0.000	0.000	0.000	0.000
US EPU	β0			0.000	0.000	0.000	0.000	0.000	0.000
	β1			0.000	0.000	0.000	0.000	0.000	0.000
Global EPU	β0							0.000	0.001
	β1							0.000	0.001
adjusted R squared		0.282		0.250		0.279		0.276	
Box-Ljung Q Test		0.054		0.044		0.046		0.048	
p-value		0.817		0.834		0.830		0.827	

		Korean Won							
		estimate	standard error	estimate	standard error	estimate	standard error	estimate	standard error
Lagged Dependent Variable	α0	0.002	0.003	0.004	0.004	0.004	0.004	0.004	0.004
	α1	0.814**	0.042	0.823**	0.043	0.820**	0.043	0.825**	0.043
National EPU	β0	0.000	0.001			0.001	0.001	0.001	0.001
	β1	0.000	0.001			0.000	0.001	0.000	0.001
US EPU	β0			0.000	0.001	−0.001	0.001	0.000	0.002
	β1			0.000	0.001	0.000	0.001	−0.001	0.002
Global EPU	β0							−0.003	0.003
	β1							0.003	0.003
adjusted R squared		0.164		0.181		0.182		0.177	
Box-Ljung Q Test		0.003		0.002		0.003		0.002	
p-value		0.956		0.961		0.959		0.966	

		British Pound							
		estimate	standard error	estimate	standard error	estimate	standard error	estimate	standard error
Lagged Dependent Variable	α0	0.010**	0.002	0.008*	0.003	0.008*	0.003	0.009*	0.004
	α1	0.428**	0.064	0.421**	0.065	0.428**	0.065	0.428**	0.065
National EPU	β0	0.001	0.001			0.001	0.001	0.001	0.001
	β1	−0.001	0.001			−0.001	0.001	−0.001	0.001
US EPU	β0			0.000	0.001	−0.001	0.001	−0.001	0.002
	β1			0.001	0.001	0.001	0.001	0.002	0.002
Global EPU	β0							0.001	0.002
	β1							−0.001	0.002
adjusted R squared			0.285		0.299		0.301		0.295
Box-Ljung Q Test			0.046		0.056		0.055		0.049
p-value			0.829		0.813		0.814		0.825

Note:
$^{*}p < 0.05$
$^{**}p < 0.01$

quantitatively large and statistically significant at the 1% level for all the foreign exchange rates. The implied values of the speed of adjustment $(1-\alpha_1)$ are reported in Table 6. The values vary from 0.186 for the Korean won to 0.572 for the British Pound. For the Australian dollar, the Canadian Dollar and the Korean won, approximately 20 percent of the disequilibrium is corrected after one month and the half-life of the shock is about four months. For the Japanese yen and the British pound, the speed of adjustment toward the equilibrium is higher; about half of the disequilibrium is adjusted within a month.

For each currency, the estimated coefficients of the present and lagged values of the EPU indexes are similar across the specifications. Most of the coefficients are statistically insignificant; only the present and lagged values of the Australian and Canadian national EPU indexes are statistically significant at the 1% level. For these two currencies, the error correction coefficient α_1 and the coefficients of the national EPU index β_0 and β_1 are statistically significant, which indicate that there is a long-memoried relationship between the volatility and the EPU index. The omission of the US and global EPU indexes has essentially no effect on the results. For these two currencies, Figures 2 and 3 plot the short-term multipliers as percentage of the mean, or

$$\frac{\partial \hat{Y}_{t+i}}{\partial X_t} \times \hat{\sigma}_X / \bar{Y} \qquad (11)$$

where $\hat{Y}_{t+i}$ is the predicted value of the volatility, $\hat{\sigma}_X$ is the sample standard deviation of the EPU index, and $\bar{Y}$ is the sample mean of the volatility. The short-run multipliers are calculated from the parametric values of the ADL model in the first columns of Table 4. assuming that the national EPU index temporarily rises by one standard deviation at time t. The shock decays very slowly for the Australian dollar while the effect of the national EPU index becomes negligibly small af-

Table 5: The ADL (1,1) Model for the Euro

	Euro		
		estimate	standard error
Lagged Dependent Variable	$\alpha 0$	0.004^{**}	0.001
	$\alpha 1$	0.785^{**}	0.044
French EPU	$\beta 0$	0.000	0.000
	$\beta 1$	0.000	0.000
German EPU	$\beta 0$	0.000	0.000
	$\beta 1$	0.000	0.000
Italian EPU	$\beta 0$	0.000	0.000
	$\beta 1$	0.000	0.000
US EPU	$\beta 0$	0.000	0.000
	$\beta 1$	0.001	0.000
Global EPU	$\beta 0$	0.001	0.001
	$\beta 1$	0.000	0.001
adjusted R squared		0.209	
Box-Ljung Q Test		0.0913	
p-value		0.8265	

Table 6: The Speed of Adjustment in the ECM

Australia	Canada	Euro	Japan	Korea	UK
0.193	0.218	0.518	0.531	0.186	0.572

ter one month for the Canadian dollar. Table 7 reports the long-term multipliers of the national EPU index. The volatility rises by 30-40% if the national EPU index permanently rises by one standard deviation.

5. Summary and Concluding Remarks

This study has applied the ADL model to analyze the dynamic relationship between the EPU index and the volatility in the foreign exchange market for the six major currencies vis-à-vis the US dollar. Under the assumption that the EPU index and the volatility can have a long memory, we have also derived the implied parametric value of the ECM to measure how quickly the disequilibrium is corrected. The empirical analysis shows that the adjustment toward the equilibrium is not instantaneous for all the foreign exchange rates. The estimated effects of economic policy uncertainty, however, vary across the currencies. The national EPU indexes of Australia and Canada have non-negligible effects on the volatility of their exchange rates while none of the other indexes have essentially any impact on the volatility in the foreign exchange market.

One can speculate on economic reasons why there are differences in the effects of economic policy uncertainty on foreign exchange volatility across the currencies. The efficient market hypothesis (EMH) suggests that asset prices, including foreign currencies, should reflect all available information instantaneously in informationally efficient markets and any information is not expected to have persistent effects on volatility. For the British pound, the Euro, the Japanese Yen and the Korean won, the findings from the ADL models are consistent with the EMH. For the Australian dollar

Figure 2: The Short-Run Multiplier for the Australian Dollar

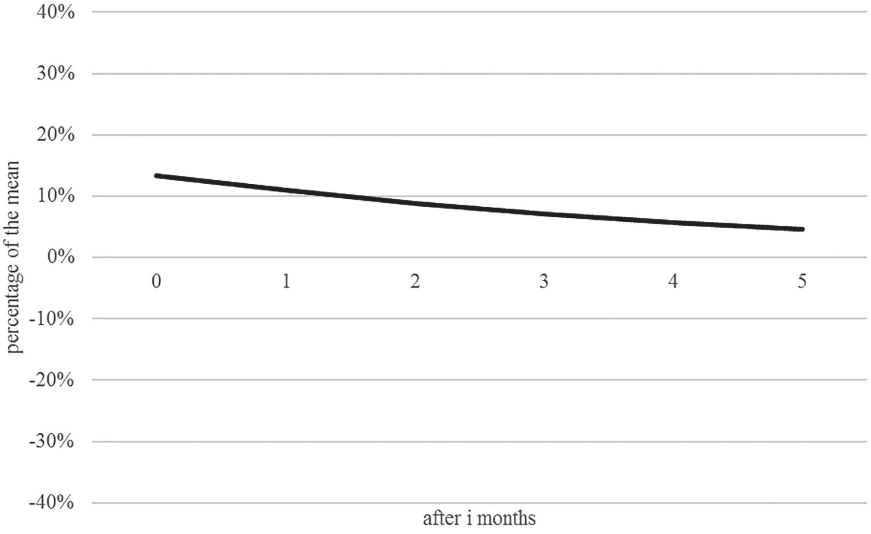


Figure 3: The Short-Run Multipliers for the Canadian Dollar

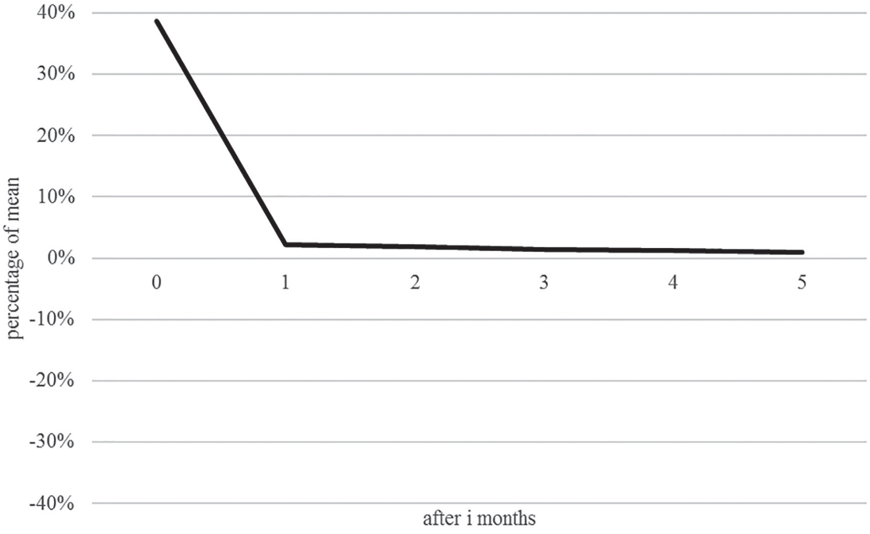


Table 7: The Long-Run Multiplier

Australia	Canada
34.573%	44.360%

and the Canadian dollar, on the other hand, the empirical results above indicate that the foreign exchange markets can be informationally inefficient. Ross (1989) interprets volatility in the financial markets as a measure of information flow. In the literature of empirical finance, there are studies finding that information does not spread instantaneously throughout the markets, but flows slowly from large to small institutions (Conard et al. (1991) and Hamao et al. (1990)). If information disseminates relatively slowly in the Australian and Canadian exchange rate markets, the estimates of the EPU index on the volatility should reflect differences in the speed of information flow between the markets.

In concluding, the limitations of this study should be borne in mind. In this study, the EPU index has been used as a proxy variable for policy uncertainty. The index is, however, not a direct measure of policy uncertainty. In particular, some of the EPU indexes are still the "beta" nature, drawing only upon the coverage of only a few newspapers. Thus, it cannot be denied that the index is a weak proxy measuring other risk factors. These limitations should be overcome through methodological improvements in further studies.

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