Emmanuel Joel Aikins Abakah, Guglielmo Maria Caporale, and Luis A. Gil-Alana

Economic Policy Uncertainty: Persistence and Cross-Country Linkages

April 2020
ECONOMIC POLICY UNCERTAINTY: PERSISTENCE AND CROSS-COUNTRY LINKAGES

Emmanuel Joel Aikins Abakah
The University of Adelaide Business School, Australia

Guglielmo Maria Caporale
Brunel University London, UK

Luis A. Gil-Alana
University of Navarra and University Francisco de Vitoria, Spain

April 2020

Abstract

This paper provides new evidence on the stochastic behaviour of the EPU (Economic Policy Uncertainty (EPU) index constructed by Baker et al. (2016) in six of the biggest economies (Canada, France, Japan, US, Ireland, and Sweden) over the period from January 1985 to October 2019. In particular, it uses fractional integration methods to shed light on its degree of persistence, and also carries out appropriate break tests. Further, the possible co-movement of this index between countries is examined applying a fractional cointegration method which tests for the possible existence of a long-run equilibrium relationship linking the individual indices. EPU is found to be in most cases a non-stationary, mean-reverting series which is characterised by long memory. Several breaks are also detected in each country. Finally, there is very little evidence of cross-country linkages.

JEL Classification: C15; C32; C51; C52; E60

Keywords: economic policy uncertainty; persistence; long memory; fractional integration; fractional cointegration

Corresponding author: Professor Guglielmo Maria Caporale, Department of Economics and Finance, Brunel University, London, UB8 3PH, UK. Tel.: +44 (0)1895 266713. Fax: +44 (0)1895 269770. Email: Guglielmo-Maria.Caporale@brunel.ac.uk

* Prof. Luis A. Gil-Alana gratefully acknowledges financial support from the MINEIC-AEI-FEDER ECO2017-85503-R project from ‘Ministerio de Economía, Industria y Competitividad’ (MINEIC), ‘Agencia Estatal de Investigación’ (AEI) Spain and ‘Fondo Europeo de Desarrollo Regional’ (FEDER). He also acknowledges support from an internal Project of the Universidad Francisco de Vitoria.
1. Introduction

Economic activity and the behaviour of economic agents at the household and firm level are greatly influenced by uncertainty (Bernanke, 1983; Carroll, 1997; Bansal & Yaron, 2004; McDonald & Siegel, 1986; Dixit & Pindyck, 1994; Bloom, Bond, & Van Reenen 2001; Dixit, 1989). In particular, in recent years the role played by economic policy uncertainty (EPU thereafter) in driving macroeconomic fluctuations has been one of the most intensely discussed issues among academics, policy-makers and practitioners. In his well-known study, Bloom (2009) estimated a time-varying model using firm-level data and concluded that higher uncertainty can generate sharp recessions, and subsequent swift rebounds, in both output and employment, owing to the ‘wait and see’ attitude of firms making investment and hiring decisions subject to uncertainty.

Other studies provide mixed evidence on the impact of EPU on economic activity. For example, Baker et al. (2016), using a structural VAR model, showed that it causes statistically significant declines in employment, investment and industrial production both in the US economy and in an international setting. Gulen and Ion (2016) and Kang et al. (2014) (in the case of the US) and Rodrik and Fernandez (1991) (for the developing countries) found that uncertainty causes capital investment and productivity to plummet. Leduc and Liu (2016) reported that an uncertainty shock increases unemployment and at the same time lowers inflation. Pastor and Veronesi (2012) showed that higher policy uncertainty is associated with lower stock prices, higher volatility and higher correlations among stock returns. Ko and Lee (2015) found that an increase in EPU reduces stock prices. Sahinoz and Cosar (2018) concluded that EPU has an adverse effect on economic growth and investment.

Although there exists a comprehensive literature on the impact of EPU on the economy, various key issues are yet to be analysed – for instance, the stochastic...
properties of EPU (for example, its degree of persistence), spillovers across countries and structural breaks; in particular, examining EPU cross-country linkages could provide useful insights to both investors focusing on higher frequencies or short-term movement and hedgers and arbitragers who are mainly interested in lower frequencies or long-term co-movement. The present study addresses these issues by carrying out a comprehensive analysis of EPU over the period January 1985 to October 2019 for six countries (Canada, France, Japan, US, Ireland, and Sweden); specifically, fractional integration and cointegration techniques are applied, respectively, to investigate the stochastic properties of and the bilateral linkages between the series of interest, and break tests are also carried out.

The layout of the paper is the following. Section 2 provides a brief review of the relevant literature. Section 3 outlines the empirical methodology. Section 4 describes the data and presents the empirical results. Section 5 provides some concluding remarks.

2. Literature Review

Economic policy uncertainty (EPU) is defined as the agents’ inability to predict future economic policies as well as the consequences of policies that have already been adopted by the government. Agents often face uncertainty about the timing, content and potential effect of policy decisions. Quantifying policy uncertainty is very difficult because of its unobservable nature. Baker et al. (2016) constructed an index for EPU based on newspaper coverage frequency, the underlying idea being that a higher number of news articles about EPU reflects a higher level of uncertainty faced by agents. Subsequent papers have followed a similar approach for developing EPU indices for other countries (Arbatli et al. 2017; Cerda, Silva, and Valente 2016; Zalla 2017;
Other studies have examined the impact of the EPU index constructed as in Baker et al. (2014 and 2016) on various economic variables. Using firm-level data, Gulen and Ion (2016) found that EPU can explain up to 32% of the drop in corporate investment over the 2007-2009 time period. Pastor and Veronesi (2012, 2013) developed a model in which agents learn through a Bayesian updating process about the effects of policies endogenously chosen by governments; they also showed that higher EPU is associated with higher volatility of US equities and higher correlations between them. Gourinchas and Parker (2002) and Guiso et al. (2013) showed the importance of life-cycle income uncertainty on pre-cautionary savings. Brogaard and Detzel (2015) found that increases in EPU lower equity prices by raising the discount rate on future cash flows and by affecting the risk premium. Shoag and Veuger (2016) showed that the cross-sectional variation in uncertainty can explain a significant percentage of unemployment fluctuations during the Great Recession.

As for the effects of specific types of uncertainty, Baker et al. (2016) found that tax policy uncertainty is the largest source of policy uncertainty in the US. Kydland and Zarazaga (2016) showed that uncertainty about fiscal policy (and, more specifically, tax policy) accounts for the weaker than expected recovery of the US economy after the 2007-2008 crisis. Sinha (2016) reported that an increase in interest rate uncertainty leads to lower output, while Husted et al. (2018) found that higher monetary policy uncertainty in the US increases interest rates and yield spreads and lowers output and inflation. Aghion et al. (2009) provided evidence that real exchange rate volatility can affect output growth significantly, while Aguiar (2005) found that, after the Mexican Peso devaluation, the balance sheet effect outweighed the potential benefits for exports.
Finally, Kane (2000) provided evidence about the connection between capital outflows, banking insolvency and silent runs during the Asian crisis.

3. Methodology

Granger (1980) showed that many economic aggregates display estimated spectrums with a large value at the zero frequency, which suggests that first differences of these series should be taken. However, once they are first differenced, the estimated spectrum shows values close to zero at the smallest (zero) frequency, which implies over-differentiation. This observation led to the development of fractional integration or I(d) models with $0 < d < 1$.

These processes became popular in the econometrics literature in the late 1990s. Nelson and Plosser (1982) had examined fourteen macroeconomics series and found that models with unit roots or stochastic trends were more appropriate than deterministic ones; however, using an extended sample, Gil-Alana and Robinson (1997) concluded that all of them except one displayed orders of integration in the interval $(0, 1)$ that are significantly different from 1. Since then, I(d) models have been widely employed in the literature (see, e.g., Banerjee and Urga, 2005; Mayoral, 2006; Gil-Alana and Moreno, 2012; Abbritti et al., 2016; Baillie et al., 2019; etc.).

Fractional cointegration is a natural extension of fractional integration to the multivariate case. Cointegration was first introduced in the seminal paper by Engle and Granger (1987), who argued that two or more series are cointegrated if they are non-stationary and integrated of order d, i.e., I(d), but there exists at least one linear combination of them which is integrated of order $d - b$, with $b > 0$. Although this definition held for any real values d and b, all the empirical applications based on this approach assumed integer degrees of differentiation, namely $d = b = 1$. Subsequently,
Johansen (1988, 1991, 1995) introduced the LR and trace test statistics for cointegration in a multivariate framework. The extension to the fractional case was first implemented by Cheung and Lai (1993) and Gil-Alana (2003) having been introduced in a series of papers by Marinucci and Robinson (2001), Robinson and Yajima (2002), Robinson and Hualde (2003), Hualde and Robinson (2007), etc. Later on, Johansen and Nielsen (2010, 2012) extended the CVAR model (Johansen, 1991; Johansen and Juselius, 1994) to the fractional case (fractional CVAR, FVAR model).

4. Data and Empirical Results

The data for the EPU index constructed by Baker et al. (2016) have been downloaded from the website www.policyuncertainty.com for the period of January 1985 to October 2019 for the six countries with the longest data span (Canada, France, Japan, USA, Ireland, and Sweden). This index has already been used by several researchers (for example, He and Niu 2018, and Ko and Lee 2015) because, as argued by Istitiak and Serletis (2018), it has four advantages over other uncertainty measures: (i) it incorporates past movements in policy-related economic uncertainty, (ii) it is available for all the big economies (see www.policyuncertainty.com), (iii) it reflects the true nature of uncertainty for the whole economy, and (iv) it explains the cross-sectional patterns in some economic variables.

As a first step, we carry out the univariate analysis using the following model:

$$y_t = \alpha + \beta t + x_t, \quad (1-L)^d x_t = u_t, \quad t = 1, 2, ..., \quad (1)$$

where $y_t$ stands for the observed time series (in logs); $\alpha$ and $\beta$ are the coefficients on the intercept and the linear time trend; $d$ is a real value and $u_t$ is assumed to be $I(0)$. We report the estimated values of $d$ from three different specifications: i) when $\alpha$ and $\beta$ are assumed to be 0, i.e. no deterministic terms are included in the regression model (1), ii)
with $\beta = 0$, that is, allowing for an intercept, and iii) estimating $\alpha$ and $\beta$ from the data and therefore allowing for both an intercept and a linear time trend. Further, the disturbance term $u_t$ is assumed to follow a white noise process (in Tables 1 and 2) or, alternatively, to be autocorrelated (in Tables 3 and 4) as in the non-parametric spectral approach proposed by Bloomfield (1973).

### Table 1: Estimated values of $d$ under the assumption of white noise errors

| Country | No terms | An intercept | An Intercept and a Linear Time Trend |
|---------|----------|--------------|-------------------------------------|
| CANADA  | 0.81 (0.76, 0.89) | 0.60 (0.53, 0.68) | **0.59** (0.53, 0.68) |
| FRANCE  | 0.71 (0.66, 0.77) | 0.49 (0.45, 0.54) | **0.47** (0.42, 0.53) |
| IRELAND | 0.53 (0.48, 0.58) | 0.37 (0.33, 0.42) | **0.33** (0.29, 0.39) |
| JAPAN   | 0.91 (0.85, 0.99) | **0.65** (0.58, 0.75) | 0.66 (0.58, 0.75) |
| SWEDEN  | 0.89 (0.83, 0.95) | **0.46** (0.41, 0.53) | 0.46 (0.41, 0.53) |
| US      | 0.82 (0.76, 0.88) | **0.54** (0.47, 0.64) | 0.54 (0.46, 0.63) |

Notes: In bold the estimates from the specification selected on the basis of the statistical significance of the deterministic terms for each country. In parenthesis, the 95% confidence band for the values of $d$.

### Table 2: Estimated coefficients of the parameters of the selected models in Table 1

| Country | No terms | An intercept | An Intercept and a Linear Time Trend |
|---------|----------|--------------|-------------------------------------|
| CANADA  | 0.59 (0.53, 0.68) | 4.2115 (18.93) | 0.0035 (2.25) |
| FRANCE  | 0.47 (0.42, 0.53) | 4.2007 (20.60) | 0.0033 (3.20) |
| IRELAND | 0.33 (0.29, 0.39) | 4.1979 (31.81) | 0.0018 (3.31) |
| JAPAN   | 0.65 (0.58, 0.75) | 4.3388 (30.16) | --- |
| SWEDEN  | 0.46 (0.41, 0.53) | 4.6346 (65.08) | --- |
| US      | 0.54 (0.47, 0.64) | 4.6219 (29.54) | --- |

Notes: In parenthesis, in the second column, the 95% confidence band for the values of $d$; in column 3 and 4, the corresponding t-values.

It can be seen in Table 1 that in the cases of Canada, France and Ireland a time trend is required, its coefficient being positive and significant, while an intercept is
sufficient in the remaining three cases, namely Japan, Sweden and US (see Table 2). All estimated values of d are between 0 and 1 (specifically, they range between 0.23 (Ireland) and 0.65 (Japan)) and their confidence intervals exclude the case of d = 1; this implies that the series, though exhibiting long memory, are mean-reverting, with shocks having transitory effects. When allowing for autocorrelation in the residuals (in Tables 3 and 4) the time trend coefficient is significant in the cases of Canada, France and US, again with a positive coefficient, and the estimates of d are once more in the interval (0, 1), ranging from 0.40 (US) to 0.56 (France), which again implies long memory and mean-reverting behaviour.

**Table 3: Estimated values of d under the assumption of autocorrelated errors**

| Country | No terms | An intercept | An Intercept and a Linear Time Trend |
|---------|----------|--------------|--------------------------------------|
| CANADA  | 0.84 (0.76, 0.95) | 0.56 (0.47, 0.67) | **0.54** (0.45, 0.66) |
| FRANCE  | 0.83 (0.74, 0.96) | 0.57 (0.50, 0.66) | **0.56** (0.47, 0.65) |
| IRELAND | 0.78 (0.69, 0.89) | **0.42** (0.34, 0.50) | 0.38 (0.30, 0.49) |
| JAPAN   | 0.85 (0.77, 0.97) | **0.53** (0.43, 0.66) | 0.53 (0.43, 0.66) |
| SWEDEN  | 0.94 (0.86, 1.07) | **0.45** (0.38, 0.53) | 0.45 (0.37, 0.52) |
| US      | 0.84 (0.76, 0.94) | 0.42 (0.33, 0.52) | **0.40** (0.31, 0.53) |

Notes: In bold the estimates from the specification selected on the basis of the statistical significance of the deterministic terms for each country. In parenthesis, the 95% confidence band for the values of d.

**Table 4: Estimated coefficients of the parameters of the selected models in Table 3**

| Country | No terms | An intercept | An Intercept and a Linear Time Trend |
|---------|----------|--------------|--------------------------------------|
| CANADA  | 0.54 (0.45, 0.66) | 4.2027 (20.61) | 0.0034 (2.80) |
| FRANCE  | 0.56 (0.47, 0.65) | 4.2241 (17.04) | 0.0033 (2.11) |
| IRELAND | 0.42 (0.34, 0.50) | 4.5514 (21.91) | --- |
| JAPAN   | 0.53 (0.43, 0.66) | 4.4031 (39.87) | --- |
| SWEDEN  | 0.45 (0.38, 0.53) | 4.6328 (67.50) | --- |
Next, we test for structural breaks, since high levels of persistence could be the consequence of breaks which have not been taken into account (Diebold and Inoue, 2001; Granger and Hyung, 2004; etc.); specifically, we carry out the Bai and Perron (2003) and Gil-Alana (2008) tests, the latter being an extension of the former to the fractional case. The detected breaks are the same in both cases (see Table 5).

| Country | N. of breaks | Break dates               |
|---------|--------------|---------------------------|
| CANADA  | 3            | 2003m7; 2008m9; 2014m11   |
| FRANCE  | 4            | 1997m2; 2002m3; 2007m8; 2012m9 |
| IRELAND | 3            | 1994m10; 2001m11; 2007m10 |
| JAPAN   | 5            | 1992m4; 1997m8; 2003m7; 2008m6; 2013m5 |
| SWEDEN  | 3            | 1998m11; 2003m10; 2010m5  |
| US      | 4            | 1993m9; 1998m8; 2003m10; 2008m9 |

Table 6 displays the estimated values of d for each subsample and each series under the assumption of autocorrelated errors (similar results, not reported for brevity’s sake, were obtained in the case of white noise disturbances). In most cases they are significantly positive, which indicates the presence of long memory. Evidence of short memory, i.e., d = 0, is only found in the last subsample for Canada and the last three subsamples for Ireland.
| Country | No terms | An intercept | An Intercept and a Linear Time Trend |
|---------|----------|--------------|-------------------------------------|
| LCAN    | 1987M1 - 2003M6 | 0.79 (0.71, 0.89) | **0.54 (0.45, 0.67)** | 0.55 (0.45, 0.67) |
|         | 2003M7 - 2008M8 | 0.98 (0.81, 1.23) | **0.45 (0.27, 0.75)** | 0.45 (0.26, 0.76) |
|         | 2008M9 - 2014M10 | 0.88 (0.72, 1.10) | **0.69 (0.53, 0.89)** | 0.70 (0.56, 0.89) |
|         | 20014M11 - 2019M10 | 0.90 (0.74, 1.12) | 0.39 (0.28, 0.56) | **0.21 (0.00, 0.50)** |
|         | 1987M1 - 1997M1 | 0.80 (0.70, 0.93) | **0.34 (0.24, 0.48)** | 0.34 (0.23, 0.48) |
|         | 1997M2 - 2002M2 | 0.74 (0.60, 0.94) | **0.36 (0.25, 0.51)** | 0.36 (0.25, 0.51) |
|         | 2002M3 - 2007M7 | 0.81 (0.67, 0.99) | 0.38 (0.24, 0.62) | **0.32 (0.12, 0.61)** |
|         | 2007M8 - 2012M8 | 0.88 (0.69, 1.17) | 0.39 (0.28, 0.55) | **0.24 (0.05, 0.48)** |
|         | 2012M9 – 2019M10 | 0.90 (0.77, 1.09) | **0.42 (0.29, 0.61)** | 0.42 (0.27, 0.61) |
|         | 1987M1 - 1994M9 | 0.64 (0.50, 0.81) | **0.14 (0.03, 0.30)** | 0.09 (-0.05, 0.28) |
|         | 1994M10 - 2001M10 | 0.61 (0.46, 0.79) | **-0.07 (-0.20, 0.12)** | -0.09 (-0.23, 0.11) |
|         | 2001M11 - 2007M9 | 0.68 (0.54, 0.85) | 0.10 (0.01, 0.23) | **-0.06 (-0.19, 0.12)** |
|         | 20007M10 - 2019M10 | 0.69 (0.61, 0.79) | **0.08 (-0.02, 0.22)** | 0.07 (-0.04, 0.21) |
|         | 1987M1 - 1992M3 | 0.98 (0.80, 1.23) | **0.55 (0.34, 0.93)** | 0.54 (0.31, 0.94) |
|         | 1992M4 - 1997M7 | 0.96 (0.80, 1.24) | **0.48 (0.28, 0.74)** | 0.48 (0.28, 0.74) |
|         | 1997M8 - 2003M6 | 0.94 (0.81, 1.13) | **0.72 (0.55, 0.98)** | 0.72 (0.53, 0.98) |
|         | 2003M7 - 2008M5 | 0.94 (0.77, 1.19) | **0.45 (0.34, 0.62)** | 0.43 (0.31, 0.61) |
|         | 2008M6 – 2013M4 | 0.93 (0.77, 1.16) | **0.41 (0.16, 0.78)** | 0.40 (0.15, 0.78) |
|         | 2013M5 – 2019M10 | 0.91 (0.77, 1.12) | **0.71 (0.53, 1.00)** | 0.71 (0.52, 1.00) |
|         | 1987M1 - 1998M10 | 0.90 (0.81, 1.02) | **0.34 (0.24, 0.49)** | 0.35 (0.25, 0.49) |
|         | 1998M11 - 2003M9 | 0.91 (0.75, 1.14) | **0.49 (0.34, 0.80)** | 0.52 (0.36, 0.80) |
|         | 2003M10 - 2010M5 | 0.94 (0.79, 1.13) | **0.39 (0.25, 0.60)** | 0.36 (0.17, 0.59) |
|         | 2010M6 - 2019M10 | 0.89 (0.75, 1.09) | **0.19 (0.04, 0.41)** | 0.15 (-0.05, 0.40) |
|         | 1987M1 - 1993M8 | 0.87 (0.74, 1.06) | **0.45 (0.24, 0.75)** | 0.44 (0.23, 0.74) |
|         | 1993M9 - 1998M7 | 0.96 (0.79, 1.26) | **0.30 (0.09, 0.66)** | 0.30 (0.06, 0.66) |
|         | 1998M8 - 2003M9 | 0.93 (0.71, 1.22) | **0.72 (0.52, 1.02)** | 0.72 (0.50, 1.02) |
|         | 2003M10 - 2008M8 | 0.86 (0.72, 1.07) | **0.48 (0.33, 0.69)** | 0.47 (0.32, 0.69) |
|         | 2008M9 - 2019M10 | 0.85 (0.75, 0.99) | **0.44 (0.33, 0.62)** | 0.45 (0.33, 0.64) |

Notes: In bold the estimates from the specification selected on the basis of the statistical significance of the deterministic terms for each country. In parenthesis, the 95% confidence band for the values of d.
Next, we examine the possible existence of a long-run equilibrium relationship between the series of interest by carrying out fractional cointegration tests. This requires establishing in the first instance whether the individual series have the same degree of integration.

Table 7: Estimates of $d$ on the parent series using Robinson (1994)

| Series    | No autocorrelation | With autocorrelation |
|-----------|---------------------|----------------------|
| CANADA    | 0.59 (0.53, 0.68)   | 0.54 (0.45, 0.66)   |
| FRANCE    | 0.47 (0.42, 0.53)   | 0.56 (0.47, 0.65)   |
| IRELAND   | 0.33 (0.29, 0.39)   | 0.42 (0.34, 0.50)   |
| JAPAN     | 0.65 (0.58, 0.75)   | 0.53 (0.43, 0.66)   |
| SWEDEN    | 0.46 (0.41, 0.53)   | 0.45 (0.38, 0.53)   |
| US        | 0.54 (0.47, 0.64)   | 0.40 (0.31, 0.53)   |

Notes: In parenthesis, the 95% confidence band for the values of $d$.

Table 7 summarises the estimated values of $d$ for each series using Robinson’s (1994) parametric approach. Table 8 shows instead the estimates obtained applying a semi-parametric method which does not require any assumption about the I(0) error term; in particular, we use a “local” Whittle approach with the frequencies degenerating to zero as in Robinson (1995); this has the advantage of being simple and requiring a single bandwidth parameter, whilst more recent methods (see, e.g., Velasco, 1999, Phillips and Shimotsu, 2005, Abadir et al., 2007) require additional ones, with the estimates of $d$ generally being very sensitive to those. It can be seen that the semi-parametric estimates are much higher than the parametric ones, in all cases exceeding 0.5, which implies non-stationary behaviour.


Table 8: Estimates of d using a semi-parametric approach

| Series / m | 11 ≈ T^{0.4} | 18 ≈ T^{0.5}⁻¹ | 19 ≈ T^{0.5} | 20 ≈ T^{0.5}⁺¹ | 36 ≈ T^{0.6} |
|------------|---------------|-----------------|-------------|----------------|-----------|
| CANADA     | 0.692         | 0.706           | 0.714       | 0.731          | 0.600     |
| FRANCE     | 0.756         | 0.722           | 0.731       | 0.739          | 0.634     |
| IRELAND    | 0.891         | 0.746           | 0.758       | 0.796          | 0.509     |
| JAPAN      | 0.560         | 0.521           | 0.564       | 0.618          | 0.849     |
| SWEDEN     | 0.843         | 0.748           | 0.749       | 0.723          | 0.570     |
| US         | 0.535         | 0.640           | 0.693       | 0.735          | 0.470     |

Next we test for the homogeneity in the orders of integration across countries by employing the Robinson and Yajima’s (2002) approach. The results are displayed in Table 9: the null of equal orders of integration cannot be rejected in any case. The same conclusion is reached using Hualde’s (2003) approach (these results are not reported to save space).

Table 9: Robinson and Yajima’s (2002) tests for homogeneity in the integration order

|           | FRANCE | IRELAND | JAPAN | SWEDEN | US  |
|-----------|--------|---------|-------|--------|-----|
| CANADA    | -0.170 | -0.440  | 1.499 | -0.350 | 0.209|
| FRANCE    | ---    | -0.270  | 1.669 | -0.180 | 0.379|
| IRELAND   | ---    | ---     | 1.940 | 0.090  | 0.649|
| JAPAN     | ---    | ---     | ---   | -1.850 | -1.293|
| SWEDEN    | ---    | ---     | ---   | ---    | 0.559|
| US        | ---    | ---     | ---   | ---    | ---  |

To test for cointegration we use first Engle and Granger (1987)’s approach; this involves testing the order of integration of the estimated residuals from the OLS regression of one variable against another (see Gil-Alana, 2003). The estimated values of d for the three model specifications are reported in Tables 10 and 11 for the two cases of white noise and autocorrelated errors respectively, and provide very little evidence of
a lower degree of integration compared to the individual series. The values in bold are those corresponding in each case to our preferred specification (which is selected on the basis of the statistical significance of the other coefficients) and are also reported in Table 12.

Table 10: Fractional cointegration using Engle and Granger (1987) (Gil-Alana, 2003) under the assumption of white noise errors

| Country   | No terms         | An intercept       | An Intercept and a Linear Time Trend |
|-----------|------------------|--------------------|-------------------------------------|
| LCAN / LFRA | 0.41 (0.35, 0.47) | **0.41 (0.35, 0.47)** | 0.41 (0.35, 0.47)                   |
| LCAN / LIRE | 0.40 (0.35, 0.46) | 0.40 (0.35, 0.46)   | **0.39 (0.34, 0.46)**               |
| LCAN / LJAP | 0.53 (0.48, 0.60) | 0.53 (0.48, 0.60)   | **0.52 (0.47, 0.60)**               |
| LCAN / LSWE | 0.52 (0.46, 0.59) | 0.50 (0.45, 0.57)   | **0.48 (0.41, 0.56)**               |
| LCAN / LUS  | 0.40 (0.36, 0.45) | 0.39 (0.35, 0.45)   | **0.38 (0.34, 0.44)**               |
| LFRA / LIRE | 0.33 (0.28, 0.38) | 0.32 (0.28, 0.37)   | **0.28 (0.24, 0.34)**               |
| LFRA / LJAP | 0.49 (0.43, 0.54) | 0.48 (0.44, 0.53)   | **0.47 (0.42, 0.52)**               |
| LFRA / LSWE | 0.49 (0.45, 0.55) | 0.48 (0.44, 0.53)   | **0.45 (0.40, 0.52)**               |
| LFRA / LUS  | 0.44 (0.40, 0.49) | 0.43 (0.34, 0.49)   | **0.42 (0.37, 0.48)**               |
| LIRE / LJAP | 0.26 (0.22, 0.30) | 0.26 (0.22, 0.30)   | **0.23 (0.19, 0.28)**               |
| LIRE / LSWE | 0.26 (0.22, 0.31) | 0.26 (0.22, 0.31)   | **0.21 (0.17, 0.26)**               |
| LIRE / LUS  | 0.18 (0.14, 0.23) | 0.18 (0.14, 0.23)   | **0.15 (0.08, 0.21)**               |
| LJAP / LSWE | 0.65 (0.58, 0.74) | **0.65 (0.57, 0.74)** | 0.65 (0.57, 0.74)                   |
| LJAP / LUS  | 0.54 (0.47, 0.61) | **0.53 (0.47, 0.61)** | 0.53 (0.47, 0.61)                   |
| LSWE / LUS  | 0.44 (0.39, 0.51) | **0.44 (0.39, 0.50)** | 0.43 (0.38, 0.49)                   |

Notes: In bold the estimates selected on the basis of the statistical significance of the deterministic terms for each pair of countries. In parenthesis, the 95% confidence band for the values of d.

Table 11: Fractional cointegration using Engle and Granger (1987) (Gil-Alana, 2003) under the assumption of autocorrelated errors

| Country   | No terms | An intercept | An Intercept and a Linear Time Trend |
|-----------|----------|--------------|-------------------------------------|
| LCAN / LFRA |         |              |                                     |
| LCAN / LIRE |         |              |                                     |
| LCAN / LJAP |         |              |                                     |
| LCAN / LSWE |         |              |                                     |
| LCAN / LUS  |         |              |                                     |
| LFRA / LIRE |         |              |                                     |
| LFRA / LJAP |         |              |                                     |
| LFRA / LSWE |         |              |                                     |
| LFRA / LUS  |         |              |                                     |
| LIRE / LJAP |         |              |                                     |
| LIRE / LSWE |         |              |                                     |
| LIRE / LUS  |         |              |                                     |
| LJAP / LSWE |         |              |                                     |
| LJAP / LUS  |         |              |                                     |
| LSWE / LUS  |         |              |                                     |
| Country     | No autocorrelation | With autocorrelation |
|-------------|---------------------|----------------------|
| LCAN / LFRA | 0.41 (0.35, 0.47)   | 0.49 (0.38, 0.63)    |
| LCAN / LIRE | 0.39 (0.34, 0.46)   | 0.45 (0.35, 0.57)    |
| LCAN / LJAP | 0.52 (0.47, 0.60)   | 0.54 (0.45, 0.66)    |
| LCAN / LSWE | 0.48 (0.41, 0.56)   | 0.41 (0.32, 0.54)    |
| LCAN / LUS  | 0.38 (0.34, 0.44)   | 0.45 (0.39, 0.54)    |
| LFRA / LIRE | 0.47 (0.24, 0.34)   | 0.38 (0.30, 0.48)    |
| LFRA / LJAP | 0.47 (0.42, 0.52)   | 0.62 (0.53, 0.70)    |
| LFRA / LSWE | 0.45 (0.40, 0.52)   | 0.51 (0.43, 0.61)    |
| LFRA / LUS  | 0.42 (0.37, 0.48)   | 0.49 (0.43, 0.59)    |
| LIRE / LJAP | 0.23 (0.19, 0.28)   | 0.40 (0.34, 0.48)    |
| LIRE / LSWE | 0.21 (0.17, 0.26)   | 0.35 (0.26, 0.46)    |
| LIRE / LUS  | 0.15 (0.08, 0.21)   | 0.21 (0.13, 0.32)    |

Notes: In bold the estimates from the specification selected on the basis of the statistical significance of the deterministic terms for each pair of countries. In parenthesis, the 95% confidence band for the values of d.
Next, we test the null hypothesis of no cointegration versus the alternative of fractional cointegration by carrying out the Hausman test proposed by Marinucci and Robinson (2001), who tested that

\[ H_{1s} = 8s(\hat{d}_s - \hat{d}_j)^2 \rightarrow_d \chi^2_1 \quad \text{as} \quad \frac{1}{s} + \frac{s}{T} \rightarrow 0 \quad (5) \]

where \( i = x, y; \ s < [T/2] \) is another bandwidth parameter similar to \( m \) above, and \( \hat{d}_s \) is a restricted estimate of \( d \) obtained from the bivariate representation of the two series under the assumption that \( d_x = d_y \). More precisely:

\[
\hat{d}_s = \frac{\sum_{j=1}^{s} 1/2 T \hat{\Omega}^{-1} Y_j v_j}{2 1/2 T \hat{\Omega}^{-1} \sum_{j=1}^{s} v_j^2}
\]

where \( Y_j = [\log I_{xx}(\lambda_j), \log I_{yy}(\lambda_j)]^T \) and \( v_j = \log j - \frac{1}{s} \sum_{j=1}^{s} \log j \), and \( \hat{\Omega} \) is a consistent estimate of the limiting variance matrix of \( 2s^{1/2}(\hat{d} - d) \).

The estimates of \( d^* \) from the joint representation of the two series for a range of bandwidth parameters from 10 to 15 are reported in Table 13; they are required for the Hausman test in a semi-parametric context.

| Series / m | 11 ≈ T^{0.4} | 18 ≈ T^{0.5-1} | 19 ≈ T^{0.5} | 20 ≈ T^{0.5+1} | 36 ≈ T^{0.6} |
|------------|---------------|----------------|--------------|----------------|-------------|
| LCAN / LFRA | 0.811         | 0.595          | 0.586        | 0.599          | 0.498       |

Notes: In parenthesis, the 95% confidence band for the values of \( d \).
Tables 14 and 15 display the Hausman test results for testing the null of no cointegration against the alternative of cointegration. Specifically, Table 14 presents the results based on Robinson’s (1994) parametric approach, and Table 15 those obtained using the “local” Whittle semi-parametric approach. In the former case the only evidence of cointegration is obtained for Canada versus US for two of the bandwidth parameters, and for Ireland versus US for all bandwidths. In the latter case there is some evidence of cointegration only for the cases of France/Ireland, Ireland/US, Japan/Sweden and Japan/US.

**Table 14: Testing fractional cointegration with Robinson and Marinucci (2001) using the parametric approach of Robinson (1994)**

| series / m | No autocorrelation | With autocorrelation |
|------------|---------------------|----------------------|
|            | 18≈T^{0.5}−1       | 20≈T^{0.5}+1        | 18≈T^{0.5}−1 | 19 ≈ T^{0.5} | 20≈T^{0.5}+1 |
| LCAN /     | H_{10}: 4.66        | H_{10}: 4.92         | H_{10}: 5.18 | H_{10}: 0.36 | H_{10}: 0.38 |
| LIRE /     |                     |                      |             |              |               |
| LJAP /     |                     |                      |             |              |               |
| LSWE / LUS |                     |                      |             |              |               |
Table 15: Testing fractional cointegration with Robinson and Marinucci (2001) using the semiparametric Whittle approach

| Series / m | $11 \approx T^{0.4}$ | $18 \approx T^{0.5}$ - 1 | $19 \approx T^{0.5}$ | $20 \approx T^{0.5}$+1 | $36 \approx T^{0.6}$ |
|------------|---------------------|--------------------------|---------------------|---------------------|---------------------|
| LFRA       | $H_{10}: 0.51$      | $H_{20}: 0.54$            | $H_{20}: 0.57$      | $H_{20}: 0.70$      | $H_{20}: 0.74$      | $H_{20}: 0.78$      |
| LCAN /     | $H_{10}: 5.75$      | $H_{10}: 6.07$            | $H_{10}: 6.39$      | $H_{10}: 1.16$      | $H_{10}: 1.23$      | $H_{10}: 1.29$      |
| LIRE       | $H_{20}: 0.51$      | $H_{20}: 0.54$            | $H_{20}: 0.57$      | $H_{20}: 0.12$      | $H_{10}: 0.13$      | $H_{20}: 0.14$      |
| LCAN /     | $H_{10}: 0.70$      | $H_{10}: 0.74$            | $H_{10}: 0.78$      | $H_{10}: 0.00$      | $H_{10}: 0.01$      | $H_{10}: 0.00$      |
| LJAP       | $H_{20}: 2.43$      | $H_{20}: 2.56$            | $H_{20}: 2.70$      | $H_{20}: 0.01$      | $H_{20}: 0.01$      | $H_{20}: 0.01$      |
| LCAN /     | $H_{10}: 1.74$      | $H_{10}: 1.83$            | $H_{10}: 1.93$      | $H_{10}: 2.43$      | $H_{10}: 2.56$      | $H_{10}: 2.70$      |
| LSWE       | $H_{20}: 0.05$      | $H_{20}: 0.06$            | $H_{20}: 0.06$      | $H_{20}: 0.24$      | $H_{20}: 0.24$      | $H_{20}: 0.26$      |
| LCAN /     | $H_{10}: 6.35$      | $H_{10}: 6.70$            | $H_{10}: 7.05$      | $H_{10}: 1.16$      | $H_{10}: 1.23$      | $H_{10}: 1.29$      |
| LUS        | $H_{20}: 3.68$      | $H_{20}: 3.89$            | $H_{20}: 4.09$      | $H_{20}: 0.36$      | $H_{20}: 0.37$      | $H_{20}: 0.40$      |
| LFRA /     | $H_{10}: 5.19$      | $H_{10}: 5.48$            | $H_{10}: 5.77$      | $H_{10}: 4.66$      | $H_{10}: 4.92$      | $H_{10}: 5.18$      |
| LIRE       | $H_{20}: 0.36$      | $H_{20}: 0.38$            | $H_{20}: 0.40$      | $H_{20}: 0.23$      | $H_{20}: 0.24$      | $H_{20}: 0.26$      |
| LFRA /     | $H_{10}: 0.00$      | $H_{10}: 0.00$            | $H_{10}: 0.00$      | $H_{10}: 0.51$      | $H_{10}: 0.54$      | $H_{10}: 0.57$      |
| LJAP       | $H_{20}: 4.66$      | $H_{20}: 4.92$            | $H_{20}: 5.18$      | $H_{20}: 1.16$      | $H_{10}: 1.23$      | $H_{20}: 1.29$      |
| LFRA /     | $H_{10}: 0.05$      | $H_{10}: 0.06$            | $H_{10}: 0.06$      | $H_{10}: 0.36$      | $H_{10}: 0.38$      | $H_{10}: 0.40$      |
| LSWE       | $H_{20}: 0.01$      | $H_{20}: 0.01$            | $H_{20}: 0.01$      | $H_{20}: 0.51$      | $H_{20}: 0.54$      | $H_{20}: 0.57$      |
| LFRA /     | $H_{10}: 0.36$      | $H_{10}: 0.38$            | $H_{10}: 0.40$      | $H_{10}: 0.70$      | $H_{10}: 0.74$      | $H_{10}: 0.78$      |
| LUS        | $H_{20}: 2.07$      | $H_{20}: 2.18$            | $H_{20}: 2.30$      | $H_{20}: 1.16$      | $H_{20}: 1.23$      | $H_{20}: 1.29$      |
| LIRE       | $H_{10}: 1.44$      | $H_{10}: 1.52$            | $H_{10}: 1.60$      | $H_{10}: 0.05$      | $H_{10}: 0.06$      | $H_{10}: 0.06$      |
| LJAP       | $H_{20}: 25.9$      | $H_{20}: 26.8$            | $H_{20}: 28.2$      | $H_{20}: 2.43$      | $H_{20}: 2.56$      | $H_{20}: 2.70$      |
| LIRE       | $H_{10}: 2.07$      | $H_{10}: 2.18$            | $H_{10}: 2.30$      | $H_{10}: 0.70$      | $H_{10}: 0.74$      | $H_{10}: 0.78$      |
| LSWE       | $H_{20}: 2.07$      | $H_{20}: 2.18$            | $H_{20}: 2.30$      | $H_{20}: 0.70$      | $H_{10}: 0.74$      | $H_{10}: 0.78$      |
| LUS        | $H_{20}: 9.00$      | $H_{20}: 9.50$            | $H_{20}: 10.0$      | $H_{20}: 1.44$      | $H_{20}: 1.51$      | $H_{20}: 1.60$      |
| LIRE       | $H_{10}: 4.66$      | $H_{10}: 4.92$            | $H_{10}: 5.18$      | $H_{10}: 6.35$      | $H_{10}: 6.70$      | $H_{10}: 7.05$      |
| LUS        | $H_{20}: 21.9$      | $H_{20}: 23.1$            | $H_{20}: 24.3$      | $H_{20}: 5.19$      | $H_{20}: 5.48$      | $H_{20}: 5.77$      |
| LIRE       | $H_{10}: 0.00$      | $H_{10}: 0.00$            | $H_{10}: 0.00$      | $H_{10}: 0.05$      | $H_{10}: 0.06$      | $H_{10}: 0.06$      |
| LSWE       | $H_{20}: 5.19$      | $H_{20}: 5.48$            | $H_{20}: 5.77$      | $H_{20}: 1.44$      | $H_{20}: 1.52$      | $H_{20}: 1.60$      |
| LIRE       | $H_{10}: 2.07$      | $H_{10}: 2.18$            | $H_{10}: 2.30$      | $H_{10}: 0.01$      | $H_{10}: 0.01$      | $H_{10}: 0.01$      |
| LUS        | $H_{20}: 0.01$      | $H_{20}: 0.01$            | $H_{20}: 0.01$      | $H_{20}: 2.82$      | $H_{20}: 2.97$      | $H_{20}: 3.13$      |
| LSWE       | $H_{10}: 0.05$      | $H_{10}: 0.06$            | $H_{10}: 0.06$      | $H_{10}: 0.01$      | $H_{10}: 0.01$      | $H_{10}: 0.01$      |
| LUS        | $H_{20}: 1.44$      | $H_{20}: 1.52$            | $H_{20}: 1.60$      | $H_{20}: 0.51$      | $H_{20}: 0.54$      | $H_{20}: 0.57$      |

$\chi^2(5\%) = 3.84$, * indicates rejection of the null hypothesis of no cointegration at the 5% level.
LIRE / LJAP  
H₁₀: 0.03  H₁₀: 1.71  H₂₀: 6.76  H₂₀: 2.78  H₁₀: 0.04
LIRE / LFRA  
H₁₀: 0.89  H₁₀: 0.03  H₂₀: 4.65  H₂₀: 3.74  H₂₀: 42.91
LIRE / LUS  
H₁₀: 1.52  H₂₀: 0.94  H₂₀: 9.76  H₂₀: 4.28
LJAP / LFRA  
H₁₀: 0.01  H₁₀: 0.24  H₂₀: 0.56  H₂₀: 0.52  H₂₀: 0.41
LJAP / LJAP  
H₁₀: 5.63  H₁₀: 1.64  H₁₀: 6.76  H₁₀: 2.78  H₁₀: 0.04
LJAP / LSWE  
H₁₀: 1.59  H₁₀: 2.85  H₂₀: 4.51  H₁₀: 41.15
LUS / LSWE  
H₁₀: 3.88  H₁₀: 0.01  H₁₀: 0.02  H₁₀: 0.05  H₁₀: 0.06
LUS / LUS  
H₂₀: 0.84  H₂₀: 1.35  H₂₀: 0.72  H₂₀: 0.05  H₂₀: 4.42

χ²₁ (5%) = 3.84. * indicates rejection of the null hypothesis of no cointegration at the 5% level.

5. Conclusions

It is well known that uncertainty in its various forms affects the behaviour of economic agents (consumers and/or firms). One specific type of uncertainty whose role has been analysed extensively in recent years is EPU. Most studies have used the index constructed by Baker et al. (2016), whose advantages are apparent, and investigated its impact on the economy as a whole and the financial sector in particular. However, its statistical properties and possible cross-country linkages have not been considered.

The present paper aims to fill this gap by providing new evidence on the stochastic behaviour of EPU in six of the biggest economies for which long runs of data are available (Canada, France, Japan, US, Ireland, and Sweden); in particular, it uses fractional integration methods to shed light on its degree of persistence, and also carries out appropriate break tests. Further, the possible co-movement of this index between
countries is examined by applying a fractional cointegration method which tests for the possible existence of a long-run equilibrium relationship linking the individual indices.

The main results can be summarised as follows. EPU is found to be in most cases a non-stationary, mean-reverting series which is characterised by long memory. Several breaks are also detected in each country. Further, there is very little evidence of cross-country linkages. These findings should be taken into account by academics, policy makers and practitioners when building models aimed at evaluating the impact of EPU on the economy, designing policy measures and developing investment strategies. Future work will address other issues such as the presence of cyclical patterns in EPU and also apply alternative methods such as Johansen’s (2012) FCVAR approach to investigate further dynamic linkages across countries.
References

Abadir, K.M., W. Distaso and L. Giraitis (2007), Nonstationarity-extended local Whittle estimation, *Journal of Econometrics* 141, 1353-1384.

Abbritti, M., L. Gil-Alana, Y. Lovcha, and A. Moreno. 2016. “Term Structure Persistence”, Journal of Financial Econometrics 14, (2), 331–52.

Aghion, P. P. Bacchetta, R. Rancière, and K. Rogoff, "Exchange rate volatility and productivity growth: The role of financial development," Journal of Monetary Economics, 56 (2009), 494-513.

Aguiar, M., "Investment, devaluation, and foreign currency exposure: The case of Mexico," Journal of Development Economics, 78 (2005), 95-113.

Arbatli, E. C., S. J. Davis, A. Ito, N. Miake, and I. Saito. 2017. “Policy Uncertainty in Japan.” IMF Working Paper No. 17/128. doi:10.5089/9781484300671.001

Bai, J., & Perron, P. (2003). Computation and analysis of multiple structural change models. *Journal of applied econometrics*, 18(1), 1-22.

Baijlie, R.T., F. Calonaci, D. Cho and S. Rho, (2019), Long Memory, Realized Volatility and Heterogeneous Autoregressive Models, Journal of Time Series Analysis 40, 4, 609-628.

Banerjee, A., Urga, G. (2005). Modelling structural breaks, long memory and stock market volatility: an overview. Journal of Econometrics 129 (1-2), 1-34.

Baker, Scott R., Nicholas Bloom, and Steven J. Davis, (2016), "Measuring Economic Policy Uncertainty," The Quarterly Journal of Economics, 131, 1593-1636.

Baker, S. R., Bloom, N., Canes-Wrone, B., Davis, S. J., & Rodden, J. (2014). Why has US policy uncertainty risen since 1960?. *American Economic Review*, 104(5), 56-60.

Bansal, R., & Yaron, A. (2004). Risks for the long run: A potential resolution of asset pricing puzzles. *The Journal of Finance*, 59(4), 1481-1509.

Bernanke, B. S. (1983). Irreversibility, uncertainty, and cyclical investment. *The Quarterly Journal of Economics*, 98(1), 85-106

Bhagat, S., P. Ghosh, and S. Rangan. 2013. “Economic Policy Uncertainty and Economic Growth in India.” Research Paper No. 407, Indian Institute of Management (IIM), Bangalore, India. http://dx.doi.org/10.2139/ssrn.2246882.

Bloom, N. (2009). The impact of uncertainty shocks. *econometrica*, 77(3), 623-685.

Bloom, N., Bond, S. R., & Van Reenen, J. (2001). The dynamics of investment under uncertainty. No W01/05, *IFS Working Papers* from *Institute for Fiscal Studies*

Bloomfield, P. (1973). An exponential model in the spectrum of a scalar time series,
Biometrika, 60, 217-226.

Brogaard, J., and A. Detzel, 2015, "The Asset-Pricing Implications of Government Economic Policy Uncertainty," Management Science, 61(2015), 3-18.

Carroll, C. D. (1997). Buffer-stock saving and the life cycle/permanent income hypothesis. The Quarterly Journal of Economics, 112(1), 1-55.

Cerda, R., A. Silva, and J. T. Valente. 2016. “Economic Uncertainty Impact in a Small Open Economy: The Case of Chile.” Applied Economics. Published online 07 December 2017. https://doi.org/10.1080/00036846.2017.1412076.

Cheung, Y.W. and K.S. Lai, (1993), A fractional cointegration analysis of purchasing power parity, Journal of Business and Economic Statistics 11, 103-112.

Dahlhaus, R., (1989). Efficient parameter estimation for self-similar process. Annals of Statistics. 17, 1749-1766.

Diebold, F. X., & Inoue, A. (2001). Long memory and regime switching. Journal of Econometrics, 105(1), 131-159.

Dixit, R. K., & Pindyck, R. S. (1994). Investment under uncertainty. Princeton University Press.

Dixit, A. (1989). Entry and exit decisions under uncertainty. Journal of political Economy, 97(3), 620-638.

Engle, R.F. and C.W.J. Granger (1987) Co-Integration and Error Correction: Representation, Estimation, and Testing, Econometrica 55, 2, 251-276. DOI: 10.2307/1913236.

Fernandez, R., & Rodrik, D. (1991). Resistance to reform: Status quo bias in the presence of individual-specific uncertainty. The American Economic Review, 1146-1155.

Gil-Alana, L.A. (2003), Testing of Fractional Cointegration in Macroeconomic Time Series, Oxford Bulletin of Economics and Statistics 65, 4, 517-529. https://doi.org/10.1111/1468-0084.t01-1-00048.

Gil-Alana, L. A. (2008). Fractional integration and structural breaks at unknown periods of time. Journal of Time Series Analysis, 29(1), 163-185.

Gil-Alana, L.A. and A. Moreno, (2012), Uncovering the US term premium: An alternative route, Journal of Banking and Finance 36, 4, 1181-1193.

Gil-Alana, L.A. and P.M. Robinson, 1997, Testing of unit roots and other nonstationary hypotheses in macroeconomic time series. Journal of Econometrics 80, 241-268.

Gourinchas, P.-O. and J.A. Parker, "Consumption Over the Life Cycle," Econometrica, 70 (2002), 47-89.
Granger, C. W., & Hyung, N. (2004). Occasional structural breaks and long memory With an application to the S&P 500 absolute stock returns. *Journal of Empirical Finance* 11(3), 399-421.

Granger, C. W. (1980). Testing for causality: a personal viewpoint. *Journal of Economic Dynamics and control*, 2, 329-352.

Gulen, H., & Ion, M. (2016). Policy uncertainty and corporate investment. *The Review of Financial Studies*, 29(3), 523-564.

Guiso, L., Jappelli, T., & Padula, M. (2013). Pension wealth uncertainty. *Journal of Risk and Insurance*, 80(4), 1057-1085.

He, Z., & Niu, J. (2018). The effect of economic policy uncertainty on bank valuations. *Applied economics letters*, 25(5), 345-347.

Hlatshwayo, S., and M. Saxegaard. 2016. “The Consequences of Policy Uncertainty: Disconnects and Dilutions in the South African Real Effective Exchange Rate-Export Relationship.” IMF Working Paper No. 16/113. doi:10.5089/9781484383490.001.

Hualde, J., (2013). A simple test for the equality of integration orders, Economics Letters 119, 233-237.

Husted, L., J. Rogers, and B. Sun (2018), "Uncertainty, Currency Excess Returns, and Risk Reversals", Journal of International Money and Finance 88, 228-241.

Istia, K., & Serletis, A. (2018). Economic policy uncertainty and real output: evidence from the G7 countries. *Applied Economics*, 50(39), 4222-4233.

Johansen, S., 1988, “Statistical Analysis of Cointegration Vectors,” Journal of Economic Dynamics and Control, Vol. 12, No. 2–3, pp. 231–254.

Johansen, S., 1991, “Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models,” Econometrica, Vol. 59, No. 6, pp. 1551–1580.

Johansen, S., 1995, Likelihood-Based Inference in Cointegrated Vector Autoregressive Models (New York: Oxford University Press).

Johansen, S. and K. Juselius (1994). Identification of the long-run and short-run structure: an application of the ISLM model. Journal of Econometrics 63: 7–36.

Johansen, S. and M.Ø. Nielsen (2010), Likelihood inference for a nonstationary fractional autoregressive model, *Journal of Econometrics* 158, 51-66.

Johansen, S. and M.Ø. Nielsen (2012), Likelihood inference for a Fractionally Cointegrated Vector Autoregressive Model, *Econometrica* 80(6), 2667-2732.

Kane, E.J., (2000), "Capital movements, banking insolvency, and silent runs in the Asian financial crisis," Pacific-Basin Finance Journal, 8, 153-175.
Kang, W., Lee, K., & Ratti, R. A. (2014). Economic policy uncertainty and firm-level investment. *Journal of Macroeconomics, 39*, 42-53.

Kroese, L., S. Kok, and J. Parlevliet. 2015. “Beleidsonzekerheid in Nederland.” *Economisch Statistische Berichten* 4715: 464-467.

Ko, J. H., & Lee, C. M. (2015). International economic policy uncertainty and stock prices: Wavelet approach. *Economics Letters, 134*, 118-122.

Kydland, F.E., and C.E.J.M. Zarazaga, (2016). "Fiscal sentiment and the weak recovery from the Great Recession: A quantitative exploration," *Journal of Monetary Economics, 79*, 109-125.

Leduc, S., & Liu, Z. (2016). Uncertainty shocks are aggregate demand shocks. *Journal of Monetary Economics, 82*, 20-35.

Marinucci, D. and Robinson, P.M. 2001, ‘Semiparametric fractional cointegration analysis’, *Journal of Econometrics*, vol.105, pp.225-247.

Mayoral, L., 2006, Further evidence on the statistical properties of real GNP, *Oxford Bulletin of Economics and Statistics* 68, 901-920.

McDonald, R., & Siegel, D. (1986). The value of waiting to invest. *The Quarterly Journal of Economics, 101*(4), 707-727.

Pastor, L., & Veronesi, P. (2012). Uncertainty about government policy and stock prices. *The Journal of Finance, 67*(4), 1219-1264

Pastor, L. and P. Veronesi. 2013. "Political uncertainty and risk premia."*Journal of Financial Economics* 110 (3): 520-545.

Nelson, C. and C. Plosser (1982), Trends and random walks in macroeconomic time series: Some evidence and implications, *Journal of Monetary Economics* 10, 2, 139-162.

Phillips, P.C. and Shimotsu, K., 2005, Exact local Whittle estimation of fractional integration. *Annals of Statistics*33, 1890-1933.

Robinson, P.M. (1994) Efficient tests of nonstationary hypotheses, *Journal of the American Statistical Association* 89, 1420-1437.

Robinson, P.M. and Y. Yajima (2002) Determination of cointegrating rank in fractional systems, *Journal of Econometrics* 106, 217-241.

Robinson, P. M. (1995). Gaussian semiparametric estimation of long range dependence. *The Annals of Statistics, 23*(5), 1630-1661.
Robinson, P. M., & Yajima, Y. (2002). Determination of cointegrating rank in fractional systems. *Journal of Econometrics, 106*(2), 217-241.

Robinson, P. M., & Hualde, J. (2003). Cointegration in fractional systems with unknown integration orders. *Econometrica, 71*(6), 1727-1766.

Sahinoz, S., & E. Cosar, E. (2018). Economic policy uncertainty and economic activity in Turkey. *Applied Economics Letters, 25*(21), 1517-1520.

Shoag, D. and S. Veuger (2016). “Uncertainty and the Geography of the Great Recession”, Journal of Monetary Economics 84, 84-93.

Sinha, A. (2016). Monetary policy uncertainty and investor expectations. *Journal of Macroeconomics, 47*, 188-199.

Velasco, C. (1999), Gaussian semiparametric estimation of nonstationary time series, *Journal of Time Series Analysis* 20, 87-127.

Zalla, R. 2017. “Economic Policy Uncertainty in Ireland.” Atlantic Economic Journal 45: 269–271. doi:10.1007/ s11293-017-9536-8.