ON ECONOMIC UNCERTAINTY, STOCK MARKET PREDICTABILITY AND NONLINEAR SPILLOVER EFFECTS

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ABSTRACT

This paper uses a *k*-th order nonparametric Granger causality test to analyze whether firm-level, economic policy and macroeconomic uncertainty indicators predict movements in real stock returns and their volatility. Linear Granger causality tests show that whilst economic policy and macroeconomic uncertainty indices can predict stock returns, firm-level uncertainty measures possess no predictability. However, given the existence of structural breaks and inherent nonlinearities in the series, we employ a nonparametric causality methodology, since the linear model is misspecified and the results emanating from it cannot be considered reliable. The nonparametric test reveals that, in fact, there is in general no predictability from the various measures of uncertainties, i.e., firm-level, macroeconomic, and economic policy uncertainty, for real stock returns. In turn, the predictability is concentrated in the volatility of real stock returns, except under the case of firm-level uncertainty. Thus, our results not only emphasize the role of economic and firm-level uncertainty measures in predicting volatility of stock returns, but also presage against using linear models which are likely to suffer from misspecification in the presence of parameter instability and nonlinear spillover effects.

JEL Codes: C32, C58, G10, G17
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1. INTRODUCTION

Predicting stock market returns and volatility is of utmost importance to policy makers and portfolio managers when reflecting on future corporate health and investment prospects (Poon and Granger, 2003; Rapach and Zhou, 2013). Asset returns are functions of the state variables of the real economy, and the real economy itself displays significant fluctuations. Beyond standard theoretical or empirical justifications of such fluctuations based on productivity and/or policy shocks, a recent strand of literature relates the impact of various forms of firm-level, macro-

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financial and policy-generated uncertainty to movements in output, inflation, investment, employment and interest rates (Bloom, 2009; Jones and Olson, 2013; Jurado *et al.*, 2015), which in turn are expected to affect the mean and volatility fluctuations of stock returns. Empirical evidence along this line of reasoning - yet only for stock returns - can be found in the works of Antonakakis *et al.* (2013), Kang and Ratti (2013), Gupta *et al.* (2014), Chang *et al*. (2015) and Jurado *et al*. (2015).

In light of the recent evidence, we investigate whether news-based measures of economic policy uncertainty (EPU) (Baker *et al.*, 2015), firm-level and macro-financial uncertainty indices (Jurado *et al.*, 2015), could comprise reliable predictors of S&P500-based real stock returns and volatility. For our purpose, we use the recently developed nonparametric causality test by Nishiyama *et al*. (2011), which is applied to monthly and quarterly datasets that span very long periods, i.e., 1900:1-2014:2 for EPU, 1960:7-2011:12 for macroeconomic and financial uncertainty, and 1970:1-2011:2 for the firm-level uncertainty index respectively. As opposed to the results reported in recent works, this is the first study to our knowledge that compares alternative measures of uncertainties in predicting not only stock returns, but also their volatility fluctuations. Furthermore, given the use of Nishiyama *et al.* (2011) nonparametric approach, we provide evidence in favor of possible misspecification in linear models as reported in the existing studies thus far, due to structural breaks and nonlinearity. The rest of the paper is organized as follows: Section 2 presents the methodology, while Section 3 discusses the data and results. Finally, Section 4 concludes.

2. METHODOLOGY

We briefly describe the methodology proposed by Nishiyama *et al.* (2011), with the test restricted to the case when the examined series follow a stationary nonlinear autoregressive process of order one under the null. Nishiyama *et al.* (2011) motivated the high-order causality by using the following nonlinear dependence between series

$$x_t = g(x_{t-1}) + \sigma(y_{t-1})\epsilon_t \qquad (1)$$

where $\{x_t\}$ and $\{y_t\}$ are stationary time series and $g(.)$ and $\sigma(.)$ are unknown functions which satisfy certain conditions for stationary. In general, y_{t-1} has information in predicting x_t^K for a given integer *K*. Consequently, the null hypothesis of non-causality in the K^{th} moment is given by

$$H_0: E(x_t^K | x_{t-1}, \dots, x_1, y_{t-1}, \dots, y_1) = E(x_t^K | x_{t-1}, \dots, x_1)\ w.p.1. \qquad (2)$$

where $w.p.1$ abbreviates to "with probability one". Formally, we say that y_t does not cause x_t up to the K^{th} moment if

$$H_0: E(x_t^K | x_{t-1}, \dots, x_1, y_{t-1}, \dots, y_1) = E(x_t^K | x_{t-1}, \dots, x_1)\ w.p.1. \quad \text{for all } k = 1, \dots, K \qquad (3)$$

For $K = 1$, this definition reduces to non-causality in mean. Nishiyama *et al.* (2011) note that, it is easy to construct the test statistic $\hat{S}_t^{(k)}$ for each $k = 1, \dots, K$. We implement the test for $k = 1$ to test for causality in the 1st moment (non-causality in mean), and for $k = 2$ in the 2nd moment (non-causality in variance).

3. EMPIRICAL ANALYSIS

We analyse three types of uncertainty measures: firstly, a monthly news-based index called economic policy uncertainty (EPU) developed by Baker *et al.* (2015) for the period 1900:1-2104:2; secondly, the macroeconomic uncertainty measure developed by Jurado *et al.* (2015), which is based on a large number of monthly macroeconomic (132) and financial (147) variables for the period 1960:7-2011:12, and; thirdly, a quarterly firm-level measure of uncertainty that spans 1970:1-2011:2 and comprises 155 firm-level observations on change in pre-tax profit growth normalized by two-period moving average of sales. The latter measure was also introduced by Jurado *et al.* (2015).

In particular, the EPU index is constructed of month-by-month searches of newspaper articles related to economic and policy uncertainty[1]. The macroeconomic and firm-level measures include econometric estimates of time-varying macroeconomic and firm-level uncertainty indices at various horizons (one to twelve for the former and one to six for the latter), defined as the common volatility in the unforecastable component of a large number of economic, financial and firm-level indicators (Jurado *et al.*, 2015)[2]. We take natural logarithms of those measures. Next, we use prices of the S&P500 and the consumer price index (CPI) to deflate the nominal S&P500 series and yield real values of the index, covering the period 1899:12-2014:2 (monthly frequency)[3]. The real returns are computed as first differences of the natural logarithms of the real stock prices multiplied by 100. In order to estimate the quarterly real stock returns used in the firm-level uncertainty measure, we take the 3-month averages of the monthly real stock prices. As our causality methodology requires stationarity, we conducted unit root tests. The analysis reveals that the various uncertainty indices and the real stock returns are stationary.[4]

For the sake of comparability and completeness, we start our investigation with standard linear Granger causality tests. To keep our analysis in line with Nishiyama *et al.* (2011) we use a linear VAR(1) model specification. As can be seen from Table 1, the null that firm-level uncertainty for various horizons does not cause real stock returns cannot be rejected even at the 10% level over the period 1970:1-2011:2. In case of EPU, for the entire period 1900:1-2014:2, the null of no-Granger causality is rejected at the 10% level of significance. However, no evidence of directional predictability is found when the analysis is repeated over 1960:7-2011:12.[5] Instead, the macro-financial uncertainty at various horizons within 1960:7-2011:12 shows strong evidence of predictability for the real stock returns at the 5% significance level.

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[1] Data and further details are available at: http://www.policyuncertainty.com/us_historical.html.

[2] Further details on the data included in the supplementary material of Jurado *et al.* (2015) are downloadable from: http://www.econ.nyu.edu/user/ludvigsons/.

[3] The data can be downloaded from the Global Financial Database

[4] Complete details of the unit root tests are available upon request from the authors.

[5] An updated version of the EPU index covering the period 1985:1-2014:12 is available from: http://www.policyuncertainty.com/us_monthly.html. However, again no evidence of causality was detected when we applied the Granger causality test to this data set. The results are available upon request.

TABLE 1: LINEAR GRANGER-CAUSALITY TEST

Null Hypothesis	$\chi^2(1)$-stat	*p*-value
f01 ≠> rsr	0.0597	0.8073
f02 ≠> rsr	0.0540	0.8166
f03 ≠> rsr	0.0697	0.7921
f04 ≠> rsr	0.0806	0.7768
f05 ≠> rsr	0.0846	0.7715
u06 ≠> rsr	0.0830	0.7736
EPU ≠> rsr, (1900:1-2014:2)	3.2444	0.0719
EPU ≠> rsr, (1960:7-2011:12)	1.5374	0.2155
u01 ≠> rsr	4.9493	0.0265
u02 ≠> rsr	5.2978	0.0217
u03 ≠> rsr	5.4178	0.0203
u04 ≠> rsr	5.2798	0.0219
u05 ≠> rsr	5.1642	0.0234
u06 ≠> rsr	5.0476	0.0250
u07 ≠> rsr	4.9329	0.0267
u08 ≠> rsr	4.8088	0.0287
u09 ≠> rsr	4.6855	0.0308
u10 ≠> rsr	4.5657	0.0330
u11 ≠> rsr	4.4475	0.0354
u12 ≠> rsr	4.3292	0.0379

Note: rsr: real stock returns; *f01,…, f06*: quarterly firm-level uncertainty for one-to six-steps-ahead; *EPU*: monthly economic policy uncertainty; *u01,…, u12*: monthly macroeconomic uncertainty for one to twelve-steps-ahead; *≠>:* stands for "*does not Grange cause*".

However, the use of financial data spanning long time periods implies non-robustness for the linear Granger causality results due to nonlinearity and structural breaks in the examined variables. The Brock *et al.* (1996, BDS) test is applied to the residuals of an AR(1) model fitted to real stock returns and volatility, as well as, to the real stock returns and volatility equations of the VAR(1) models depicting the relationship between returns and volatility and their relationships with the various uncertainty indices. As can be seen from Table 2, the BDS test rejected the null hypothesis of independent and identically distributed (*iid*) residuals at standard levels of significance across various dimensions. Hence, the results provide strong evidence of nonlinearity in the data.

In addition, we we applied the Bai and Perron (2003) test of multiple structural breaks, and parameter instability was consistently observed, with detection of structural breaks in all cases considered for the real stock returns and volatility, and their relationships with the various measures of uncertainty for both the quarterly and monthly data sets. Though the break dates observed for the real stock returns and volatility does not exactly match, they are, in general, quite close to one another, across the specific forms of uncertainties considered. The break dates under macroeconomic uncertainty are more frequent than under firm uncertainty. The dates of breaks under firm-level uncertainty for the stock returns is primarily clustered around the oil shock, while for volatility, it is more around the mid- to late 1980s, which coincides with the date of financial liberalization in the U.S. economy. As far as the macroeconomic uncertainties are concerned, the dates are quite well-spread covering the period of the oil shocks, the disinflationary episode in the US, financial liberalization, the NASDAQ crash and of course the "Great Recession" and the recent global financial crisis. Under the long-span EPU scenario (1900:1-2014:02), the break dates for real stock returns and volatility are primarily during the "Great Depression". For the short-span EPU case (1960:07-2011:12), the break dates are similar to those obtained under the macroeconomic uncertainty indices. More importantly, our results from the multiple structural break test, provides strong evidence of regime changes in the data. So, putting together, the BDS test and the Bai and Perron (2003) test suggests the need to incorporate nonlinearity and regime changes in our Granger causality test. In other words, the results from the standard linear Granger causality test are completely unreliable, and we need to resort to a nonlinear (nonparametric) test, to which we turn to next.

Given the presence of structural breaks and nonlinearity, we implement the nonparametric causality test of Nishiyama *et al.* (2011) to investigate the existence of predictability for stock returns and their volatility. The results are reported in Table 4. Just like the linear case, firm-level uncertainty fails to Granger cause returns, as well as, volatility at 5% significance level. As far as the EPU is concerned, the null of no-causality in returns is rejected for the full-sample, but not the sub-sample period of 1960:7-2011:12- similar to what was observed under the linear tests. However, for both the full-sample and the sub-sample, EPU causes real stock returns volatility significantly at the 5% level of significance.[6] Interestingly, unlikeresults produced by the linear

[6] However, no evidence of causality was detected either for returns or volatility, when we applied the nonparametric causality test to data covering the period 1985:1-2014:12.

Table 2: BDS Test

Panel A: Real Stock Returns					
Quarterly Data: 1970:01 - 2011:02					
	Dimension				
Model	2	3	4	5	6
rsr	1.888*	2.853***	3.545***	3.708***	3.727***
f01	1.796*	2.820***	3.522***	3.729***	3.755***
f02	1.782*	2.803***	3.496***	3.698***	3.717***
f03	1.760*	2.793***	3.506***	3.722***	3.758***
f04	1.753*	2.790***	3.517***	3.726***	3.769***
f05	1.787*	2.827***	3.556***	3.771***	3.824***
f06	1.761*	2.794***	3.523***	3.738***	3.788***
Monthly Data: 1900:01 - 2014:02					
rsr	9.891***	11.626***	12.849***	13.769***	14.680***
lepu	10.044***	11.702***	12.885***	13.815***	14.722***
Monthly Data: 1960:07 - 2011:12					
rsr	3.681***	4.292***	5.046***	5.662***	6.443***
lepu	3.823***	4.235***	5.040***	5.643***	6.392***
u01	3.522***	4.214***	5.038***	5.697***	6.493***
u02	3.512***	4.196***	5.014***	5.663***	6.463***
u03	3.535***	4.245***	5.086***	5.753***	6.565***
u04	3.525***	4.233***	5.061***	5.733***	6.545***
u05	3.513***	4.216***	5.044***	5.723***	6.547***
u06	3.521***	4.224***	5.052***	5.728***	6.551***
u07	3.533***	4.236***	5.054***	5.725***	6.537***
u08	3.561***	4.247***	5.057***	5.715***	6.514***
u09	3.554***	4.241***	5.049***	5.699***	6.501***
u10	3.539***	4.222***	5.023***	5.673***	6.469***
u11	3.549***	4.229***	5.023***	5.665***	6.457***
u12	3.547***	4.223***	5.008***	5.652***	6.442***
Panel B: Real Stock Returns Volatility					
Quarterly Data: 1970:01 2011:02					
	Dimension				
Model	2	3	4	5	6
rsr^2	2.027**	2.989**	3.290***	3.689***	4.552***
u01	3.871***	5.868***	7.578***	10.366***	13.851***
u02	3.989***	6.288***	7.904***	10.681***	13.796***
u03	4.011***	6.326***	7.895***	10.730***	14.139***
u04	3.893***	6.012***	7.603***	10.386***	13.707***
u05	3.743***	5.728***	7.056***	9.342***	12.170***
u06	3.761***	5.673***	6.876***	9.103***	11.495***
Monthly Data: 1900:01 - 2014:02					

rsr^2	10.615***	11.309***	11.958***	12.260***	12.837***
lepu	11.018***	11.578***	11.956***	12.251***	12.816***
Monthly Data: 1960:07 - 2011:12					
rsr^2	3.174***	3.309***	3.661***	3.791***	4.038***
lepu	5.488***	5.166***	5.319***	5.329***	5.549***
u01	4.930***	5.992***	6.441***	6.596***	6.995***
u02	5.092***	6.157***	6.590***	6.758***	7.163***
u03	5.200***	6.260***	6.693***	6.870***	7.265***
u04	5.110***	6.168***	6.606***	6.779***	7.155***
u05	5.023***	6.082***	6.529***	6.706***	7.078***
u06	4.946***	5.990***	6.436***	6.616***	6.975***
u07	4.902***	5.932***	6.387***	6.571***	6.918***
u08	4.848***	5.863***	6.330***	6.523***	6.868***
u09	4.807***	5.817***	6.279***	6.471***	6.807***
u10	4.732***	5.743***	6.208***	6.402***	6.731***
u11	4.690***	5.685***	6.156***	6.357***	6.683***
u12	4.644***	5.609***	6.081***	6.284***	6.608***

Note: The entries indicate the BDS test based on the residuals of an AR(1) model of *rsr* or *rsr*^{2} and the residuals from the equation of *rsr* or *rsr*^{2} in a VAR(1) model with the various measures of uncertainties. ***, ** and * indicate rejection of the null of residuals being independent and identically distributed (*iid*) at 1%, 5% and 10% levels of significance respectively.

TABLE 3: BAI AND PERRON (2003) MULTIPLE STRUCTURAL BREAK TEST

Panel A: Real Stock Returns	
Quarterly Data: 1970:01 - 2011:02	
Model	Break Dates
rsr	1974:4
f01	1974:4
f02	1974:3, 1976:3
f03	1974:3, 1976:3, 1995:1, 2005:1, 2009:2
f04	1974:4
f05	1974:4
f06	1974:4
Monthly Data: 1900:01 - 2014:02	
rsr	1933:07
lepu	1933:07
Monthly Data: 1960:07 - 2011:12	
rsr	1970:07, 1974:10, 1978:03, 2006:08, 2009:03
lepu	1974:10, 1982:08, 1995:01, 2002:11, 2009:03
u01	1974:10, 1980:02, 1982:08, 1987:02, 2009:03

u02	1974:10, 1980:02, 1982:08, 1987:02, 2009:03
u03	1974:10, 1980:02, 1982:08, 1987:02, 2009:03
u04	1974:10, 1980:02, 1982:08, 1987:02, 2009:03
u05	1974:10, 1982:08, 1991:04, 2001:03, 2009:03
u06	1974:10, 1982:08, 1991:04, 2001:03, 2009:03
u07	1974:10, 1982:08, 1991:04, 2001:03, 2009:03
u08	1974:10, 1982:08, 1991:04, 2001:03, 2009:03
u09	1974:10, 1982:08, 1991:07, 2001:03, 2009:03
u10	1974:10, 1982:08, 1991:07, 2000:10, 2009:03
u11	1974:10, 1982:08, 1991:07, 2000:10, 2009:03
u12	1974:10, 1982:08, 1991:07, 2000:10, 2009:03
Panel B: Real Stock Returns Volatility	
Quarterly Data: 1970:01 2011:02	
Model	Break Dates
rsr^2	1973:4, 1975:4
u01	1988:1
u02	1988:1
u03	1988:1
u04	1988:1
u05	1988:1
u06	1974:3, 1976:3
Monthly Data: 1900:01 - 2014:02	
rsr^2	1923:05, 1940:06
lepu	1923:05, 1940:06
Monthly Data: 1960:07 - 2011:12	
rsr^2	1972:05, 1974:11, 1985:09, 1988:03, 2008:09
lepu	1974:11, 1985:03, 1987:11, 2008:09
u01	1975:02, 1986:07, 2003:06, 2008:09
u02	1975:02, 1986:07, 2003:06, 2008:09
u03	1975:02, 1986:07, 2003:06, 2008:09
u04	1975:02, 1986:07, 2003:06, 2008:09
u05	1975:02, 1986:07, 2003:06, 2008:09
u06	1975:02, 1986:07, 2003:06, 2008:09
u07	1975:02, 1986:07, 2003:06, 2008:09
u08	1975:02, 1986:07, 2003:06, 2008:09

u09	1975:02, 1986:07, 2003:06, 2008:09
u10	1975:02, 1986:07, 2003:06, 2008:09
u11	1975:02, 1986:07, 2003:06, 2008:09
u12	1975:02, 1986:07, 2003:06, 2008:09

Note: See Notes to Table 3.

tests, macroeconomic uncertainty at any horizon is not found to Granger-cause real stock returns. . However, macroeconomic uncertainty at all horizons can strongly predict stock volatility.[7]

So overall, we can conclude the following: (i) The results from the linear Granger causality cannot be relied upon, as there is strong evidence of structural breaks and nonlinearity in the system, which in turn, makes the linear model misspecified; (ii) Given this misspecification in the linear Granger

TABLE 4: NONLINEAR CAUSALITY TEST

Null hypothesis	Test Statistics	
	$\hat{S}_T^{(1)}$	$\hat{S}_T^{(2)}$
f01 ≠> *rsr*	2.3648	8.6247
f02 ≠> *rsr*	2.1279	7.2972
f03 ≠> *rsr*	2.4631	7.4666
f04 ≠> *rsr*	2.6775	7.6270
f05 ≠> *rsr*	2.8038	7.6890
f06 ≠> *rsr*	2.8614	7.7450
EPU ≠> *rsr*, (1900:1-2014:2)	34.4882	21.9154
EPU ≠> *rsr*, (1960:7-2011:12)	4.0798	15.5397
u01 ≠> *rsr*	6.2007	19.9300
u02 ≠> *rsr*	6.1143	20.7080
u03 ≠> *rsr*	5.5775	20.3862
u04 ≠> *rsr*	4.9257	20.3306
u05 ≠> *rsr*	4.4348	20.0507
u06 ≠> *rsr*	4.0573	19.7002
u07 ≠> *rsr*	3.7765	19.3430
u08 ≠> *rsr*	3.5756	19.0065
u09 ≠> *rsr*	3.4417	18.6931
u10 ≠> *rsr*	3.3749	18.4179
u11 ≠> *rsr*	3.3704	18.1919
u12 ≠> *rsr*	3.4168	18.0171

Note: Same as in Table 1. Additionally, $\hat{S}_T^{(1)}$: Test statistic for causality in-mean; $\hat{S}_T^{(2)}$: Test statistic for causality in-variance. The 5% critical value for both test statistics is 14.3800.

causality tests, we need to rely on the robust nonparametric causality approach. The results from the

[7] [7] Similarly, an updated macroeconomic uncertainty index for 1960:7-2014:12 with 1-, 3- and 12-step ahead horizons is also available from: http://www.econ.nyu.edu/user/ludvigsons/. The standard Granger causality test at the 5% level of significance revealed again strong predictability for real stock returns, but the nonparametric test only picked up predictability in the volatility of real stock returns, with these results being consistent with those reported in Tables 1 and 4. The details are available upon request from the authors.

Nishiyama *et al.*, (20111) suggests that, while firm-level uncertainty cannot predict stock returns or volatility, EPU and macroeconomic uncertainty primarily predicts real stock returns volatility, but not returns, with the exception of the EPU over the full-sample, which in turn, causes both returns and volatility.

4. CONCLUSIONS

Predicting stock market returns and volatility is of paramount importance to policy-makers and portfolio managers. Theoretically, asset returns are functions of the state variables of the real economy. In this vein, a rich literature exists that relates micro- and macro-economic, financial and policy uncertainty indicators to stock returns. Beyond the current literature, this paper analyzes whether alternative uncertainty measures can predict stock returns and their volatility using a *k*-th order nonparametric test of Granger causality. The results based on the linear Granger causality tests, show that only economic policy and macroeconomic uncertainty indicators can predict real stock returns, but not firm-level uncertainty. However, we also depict evidence of nonlinearity and regime changes, which in turn, makes the results from the linear model completely reliable. Given this, when we use the nonlinear causality testing, we find that now in addition to firm-level uncertainty which does not cause real real stock returns, various measures of macroeconomic uncertainty and the EPU over a shorter-sub-sample (1960:07-2011:12) too fails to predict real stock returns – a result in complete contrast to the linear Granger causality test. However, just like the linear causality test, the long-sample based EPU (1900:01-2014:02) does cause real stock returns. The robust nonparametric test, however, indicates that barring the firm-level uncertainty, the macroeconomic uncertainties at various horizons, along with the short and long-period EPUs have strong predictive content for volatility of real stock returns. Consequently, our work aside from highlighting the role of uncertainty measurement in predicting financial market volatility also presages against using linear modeling, which is likely to suffer from misspecification in the presence of parameter instability and nonlinear spillover effects.

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