UNIVERSIDADE
BEIRA INTERIOR

The effect of the Economic Policy Uncertainty on the development of the North American index and the Spillover effect in Canada and Japan

Versão final após defesa

Luís Carlos Carlota Ramos

Dissertação para obtenção do Grau de Mestre em
ECONOMIA
(2º ciclo de estudos)

Orientador: Prof. Doutor Vitor Manuel Ferreira Moutinho
Co-orientadora: Prof. Doutora Zélia Maria da Silva Serrasqueiro Teixeira

julho de 2023

Declaração de Integridade

Eu, Luís Carlos Carlota Ramos, que abaixo assino, estudante com o número de inscrição 11359 de Economia da Faculdade de Ciências Sociais e Humanas, declaro ter desenvolvido o presente trabalho e elaborado o presente texto em total consonância com o **Código de Integridades da Universidade da Beira Interior**.

Mais concretamente afirmo não ter incorrido em qualquer das variedades de Fraude Académica, e que aqui declaro conhecer, que em particular atendi à exigida referenciação de frases, extratos, imagens e outras formas de trabalho intelectual, e assumindo assim na íntegra as responsabilidades da autoria.

Universidade da Beira Interior, Covilhã 11/08/2022

Luís Ramos

(assinatura conforme Cartão de Cidadão ou preferencialmente
assinatura digital no documento original se naquele mesmo formato)

Dedicatória

Sei que estás por perto.... Obrigado

Agradecimentos

Primeiro agradecer ao meu orientador e amigo Professor Doutor Victor Moutinho que sempre me indicou o melhor caminho a seguir neste percurso. Agradecer também à professora Zélia Serrasqueiro por todo o apoio neste processo. Sem a vossa ajuda este trabalho não teria o mesmo brio.

Agradeço ao meu pai e ao meu avô Luís por todos os ensinamentos não só neste capítulo como em todos os outros. Agradeço também à minha avó Natália, Madrinha, ao meu padrinho "emprestado" e à Telma por terem dado o seu contributo nesta etapa. À Mariana, Filipa e ao Enzo por me terem dado sempre um sorriso quando parecia difícil.

Por fim, obrigado a ti, Ana, pela tua presença e dedicação.

Espero que vejam esta dissertação como um reflexo de tudo o que são para mim e a sintam também um bocadinho como vossa.

Resumo Alargado

A presente dissertação pretende estudar o efeito do índice de incerteza política económica (EPU) no comportamento do índice bolsista. Tendo em conta os dados disponíveis optou-se por estudar o efeito que o EPU tem no desenvolvimento do S&P500, índice bolsista norte americano, e o efeito contágio em países que mantinham alguma relação, seja económica ou geográfica como é o caso do Japão e do Canadá.

Existe uma vasta literatura sobre o efeito do EPU nas diversas economias e índices bolsistas. Predominam diversos trabalhos, cujas evidências empíricas mostram a influencia estatística e significativa que o EPU desempenha em diversos países, contudo, ainda é escassos os estudos que relacionem o EPU desagregado em diversas áreas/domínios da economia tendo também em consideração o efeito contágio de um dado país para outros países com quem tenham relações geo -políticas e económicas.

Identificada este gap na revisão de literatura realizada, apresentamos duas questões fulcrais nesta investigação, nomeadamente:

(i) Quais as componentes do EPU que mais influenciam o desenvolvimento do índice S&P500?
(ii) Existência de um efeito contágio do EPU agregado e desagregado dos Estados Unidos com os índices bolsitas Canadiano e Japonês?

Face à disponibilidade e limitação de dados disponíveis para a métrica do EPU, consideramos dados mensais desde 1987 até 2022 Para além do EPU agregado e desagregado utilizámos outras variáveis de controlo como o Índice de Preços Consumidor e o Índice de Produção Industrial para explicar o comportamento das Taxas de retorno dos índices de mercado bolsista.

Através do método de causalidade denominado time-varying LA-VAR Granger causality test, avaliamos que as políticas fiscais e monetárias são as que apresentam maior efeito de causalidade á Granger com variação no tempo de analise considerado, no que diz respeito ao índice S&P 500 escolhido. Numa outra abordagem econométrica. Através da regressão Markov-Switching, os nossos resultados apresentam significância para postularmos que existe uma relação de contágio entre o índice S&P500, o índice Nikeei225 e o índice TSX

Os resultados dos modelos ARCH e GARCH mostram-nos numa primeira fase que o EPU dos Estados Unidos não se mostrou estatisticamente significante enquanto o EPU do Japão apresenta evidencia significativa na influencia sobre o comportamento do índice de bolsa TSX. Contudo, os resultados dos modelos GARCH não mostraram evidencia estatística desta mesma relação.

Regista-se ainda, que os nossos resultados mostram que existe efetivamente um efeito entre o EPU e as taxas de retorno dos índices sejam agregado ou desagregado. O efeito contágio também é provado quando percebemos que existem componentes do EPU desagregado que impactam nas taxas de retorno dos outros países considerados no estudo.

Em termos conclusivos de âmbito geral, diremos que este estudo de investigação evidência a importância do facto de que as decisões de política económica devam ser tomadas a partir da relação de métricas que avaliam o impacte de politica monetária, fiscal, de regulação financeira, entre outras, sobre o retorno dos mercados bolsistas. Esta premissa conclusiva, é corroborada na literatura, dado a existência do consenso de que, o comportamento e volatilidade destes mesmos mercados financeiros inferem sobre a “saúde económica e financeira” duma economia.

Palavras-chave

Bolsa de valores; EPU; EUA; Japão; Canada; Markov-Switching; Correlação dePearson; S&O500; NIKKEI 225; TSX

Abstract

This dissertation aims to study the effect of the political uncertainty index on the stock market index behavior. Considering the available data, it was decided to study the effect that the EPU has on the development of the S&P500, the North American stock market index, and the contagion effect in countries that had some relation, either economic or geographic, such as Japan and Canada.

To this end, the dissertation was divided into two parts. In the first part we analyze the influence of the EPU only in the United States, and in the second part we expand the study to the other countries already mentioned.

Through the time-varying LA-VAR Granger causality test we realize that fiscal and monetary policies are the ones that present greater causality with respect to the chosen North American index. The second part brings us similar results in agreement with the existing literature. Through Markov-Switching regression we prove that there is a contagion relation between the chosen North American nominees and the development of the chosen indexes for those countries.

The results of the ARCH and GARCH models show us in a first step that the EPU of the United States was not statistically significant while the EPU of Japan was shown to influence the behavior of the TSX exchange. The GARCH models showed no statistical evidence of this relationship.

Overall, this paper shows us the importance of the ability of political and economic decisions to be as clear as possible to avoid the opposite of desirable economic outcomes.

Keywords

Stock exchange; EPU; USA; Japan; Canada; Markov-Switching; Pearson Correlation; S&O500; NIKKEI 225; TSX

Index

Figures' List

Table's list

Lista de Acrónimos

EPU	Economic Policy Uncertainty Index
EUA	United States Of America
IPC	Consumer price Index

1.Introducction

The unpredictability of the stock market and its connection with economic variables have received special attention from researchers. Recent financial crises have led policy makers and central banks to be more concerned about mitigating the risk of contagion between economies (Plachý & Rašovec, 2015).

Over the past few years, the evolution of financial markets has been remarkable worldwide, not only in terms of stock exchanges and over-the-counter markets, but also in terms of the number of participants. This development is largely related to the increase in globalization, which has fostered the interrelationship between markets, as well as the behavioral change of investors and potential investors, who increasingly assume the importance of these markets for the development of countries, many seeing in this medium the answer to increasing their annual profitability. Thus, capital markets are characterized by transactions in securities, products and financial instruments, proving to be essential to promote an efficient allocation of capital by channeling the savings of economic agents with surplus funds to economic agents that lack these funds.

It should be noted that financial crises, both the global crisis and the sovereign crisis, according to the study by Gabriel and Manso (2015), result from the systematic risk inherent in the financial system, namely regarding the risk and profitability transmission channels adopted by investors, which strongly impact the exposure of markets to external shocks by increasing their vulnerability.

Capital appreciation or earning dividends are two ways for an investor to obtain financial returns when investing in financial markets. This financial return has some variables, with the operating results of companies or the development of the country having an influence. That said, the investor faces the unsystematic risk that belongs to each company and the systematic risk that belongs to the market.

The political uncertainty index is an index that measures the degree of uncertainty regarding government policies and political prospects of a country. This index is used by both investors and researchers to predict the behaviour of the stock market. For the United States, the country focused on in this article, the political uncertainty index was constructed based on three components.

The first component is journalistic coverage of political uncertainty based on 10 major newspapers; the second component is based on reports from the Congressional Budget Office (CBO) that combine temporary forecasts of the Federal tax code; and the last component is based on surveys from the Federal Reserve Bank of Philadelphia.

Another important aspect of financial markets that we want to address is the issue of contagion and how economies behave given the ease of communication and access to information. This degree of access to communication has made financial markets increasingly global.

The contagion effect on economies is a concept that has been widely studied over time. According to Angela (2000) there is no defined and consensual concept in the scientific community, but it defines contagion in markets as similar behaviour in periods of crisis. From a statistical point of view, (Forbes & Rigobon, 2000), states that contagion cannot be defined only by the increase in correlation between two markets (Bekaert et al., 2005).

When there is greater risk in the market, investors tend to demand greater rewards because the risk of incurring losses is greater. A shortage of liquidity may lead these investors to deleverage their investments resulting in a rapid sale of assets.

The contagion effect can be dangerous at the economic level as it can lead to an amplification of economic problems, lower investor confidence, increase volatility in the financial markets and consequently negatively affect economic growth.

This article uses this disaggregated index for the United States of America. It is very common to observe in the existing literature the use of this aggregated index, but its use disaggregated by types of policies is rarely seen. Based on this gap in the literature, we intend to study the effect of disaggregated EPU in countries such as the United States, Japan and Canada.

To contextualize the behavior of the variables we present the following graphs.

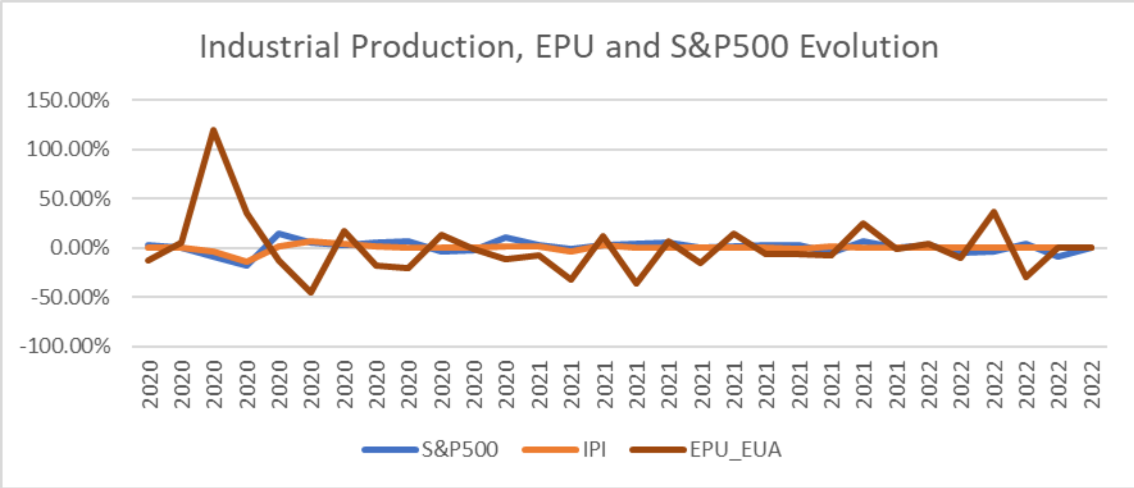


Figure 1- Industrial production, EPU and S&P500 evoluiton

The relationship between the industrial production index and the S&P500 Index is positive. When we observe positive variation rates for the S&P500 we verify that there was also a positive variation, but not so accentuated in the industrial production index. We can also see that there is an opposite behavior between the EPU and the stock market index, although it is not very pronounced.

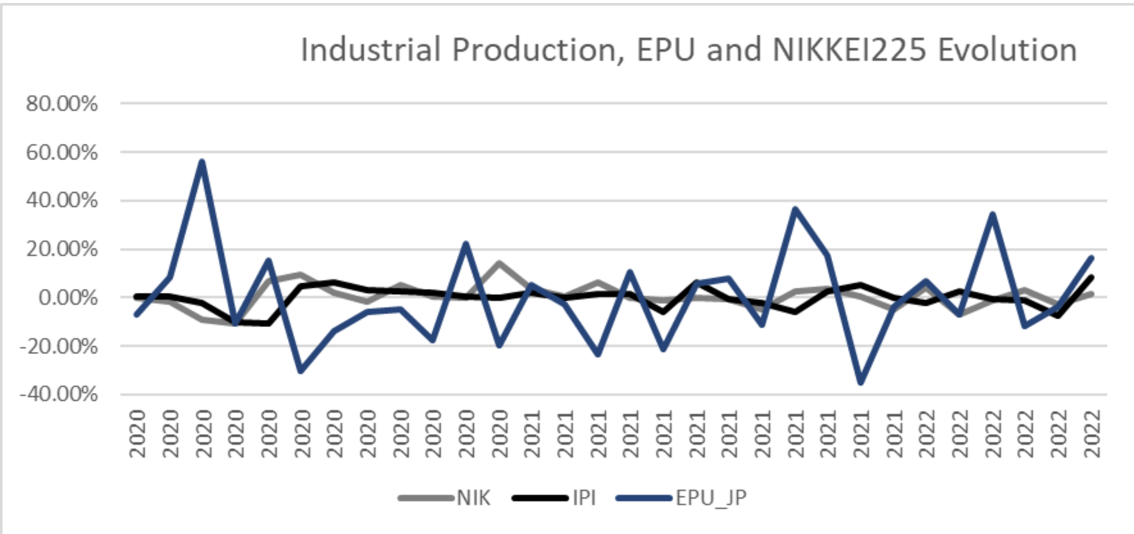


Figure 2-Industrial productiom, EPU and NIKKEI225 evolution

In Japan we see a similar behavior. However, it seems that there is not such a great relationship between the IPI and the NIKKEI225 since the falls of the IPI are not as significant as those of the stock market index.

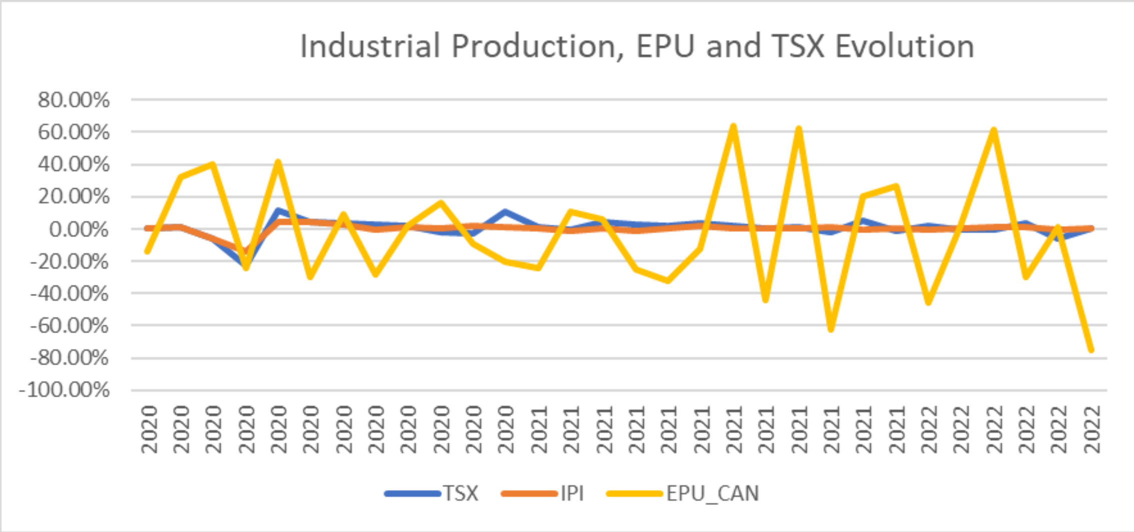


Figure 3- Industrial Production, EPU and TSX evolution

In Canada once again we can conclude that there is a relationship between the two variables presented. However, we can see that the IPI is much more stable than the TSX but show similar behavior over the horizontal period studied.

It is also important to relate the components of the EPU and the behavior of the Index. The time horizon of the data starts only in 2020 for a better perception.

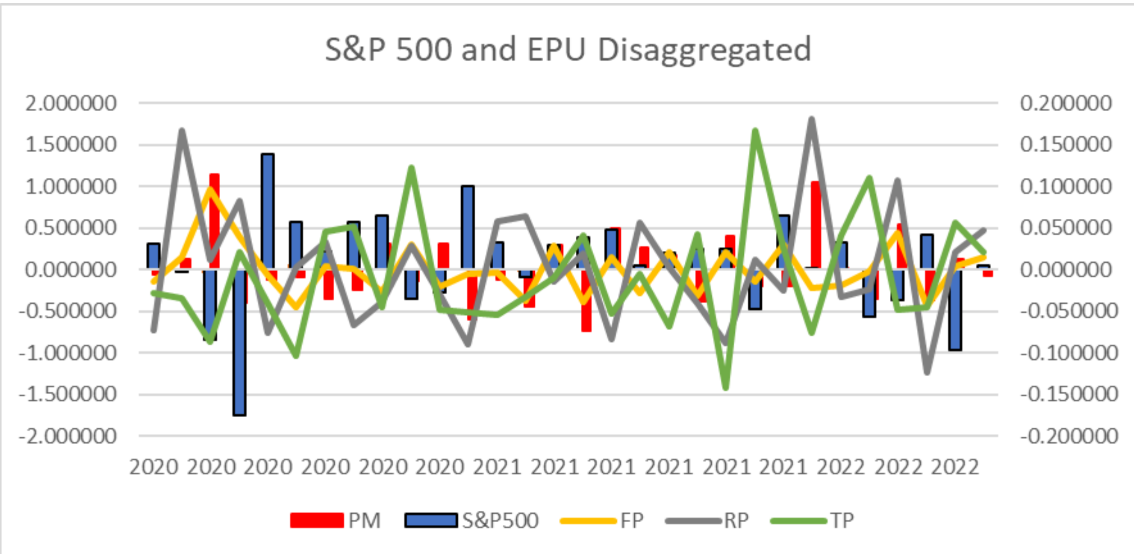


Figure 4- S&P500 and EPU Disaggregated

The chart shows us that the political components of trade and fiscal policies follow the behavior of the index over most of the time horizon. On the other hand, monetary policy appears to be inverse to the index.

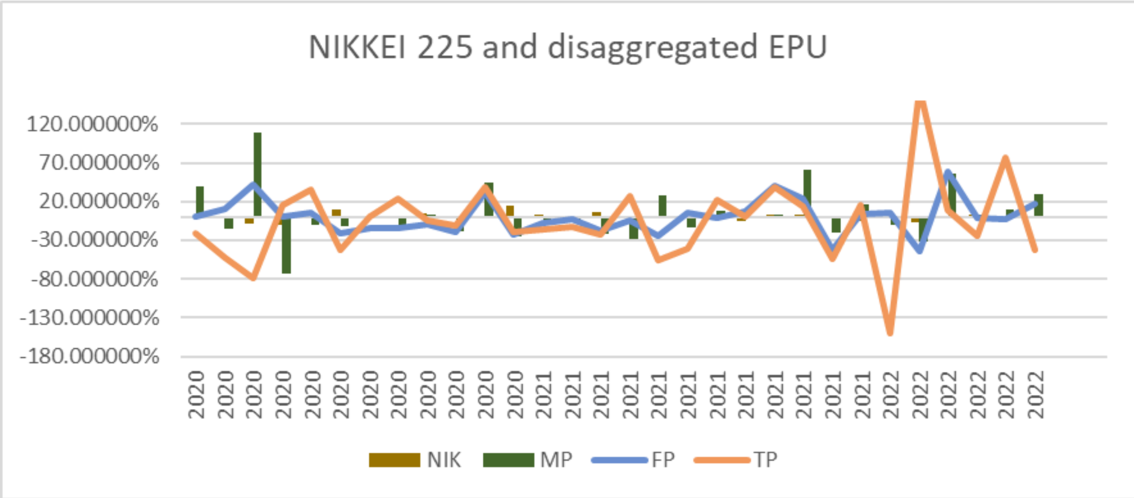


Figure 5- NIKKEI225 and disaggregated EPU

The chart for Japan shows more pronounced variations, but still with results identical to the US. We notice that the uncertainty about the trade policies present a behavior identical to that of the index. The fiscal policies in this case do not seem to have the same effect that we see in the US.

These graphs lead us to raise two questions of this research. A) Is uncertainty about economic policies a contributing factor to the performance of the S&P500 index? B) To what extent is there a contagion effect between the uncertainty about the economic policies of a country in the behavior of the stock market index in Canada and Japan?

This paper is structured as follows. Section 2 is the literature review, where different approaches to the analysis of the relationships between financial markets, macroeconomic variables and disaggregated EPU metrics are described, and the respective empirical evidence is presented. Section 3 contains the presentation of the data and the methodological procedures applied in the study and the alignment of the general objectives defined in this research. Section 4 presents the statistical tests for stationarity and time-varying causality of the economic and financial series considered in the first objective of this study. In a second step, econometric techniques for the analysis of interdependencies, volatility and contagion between the American, Japanese, and Canadian capital markets are also considered in this study. The results are presented and analyzed, followed by a discussion of the results obtained per se and also in the context of a comparative approach with results and evidence obtained in other studies with similar and related objectives. Finally, section 5 presents the conclusions of the study and possible policy implications.

2.Literature Review

The key factor in an investor's decision making is to understand the risk that is inherent to their movement in the market. Given this fact, through the economic uncertainty index created by Baker et al. (2016) it is possible to measure the degree of uncertainty that economic agents have in the face of political decisions (Chiang, 2022).

The relationship between political uncertainty and financial markets has been the subject of study by many researchers in recent years. Political uncertainty can lead cautious investors to delay or alter their investment plans to avoid exposing themselves to excessive risk.Economic theory confirms that institutional and macroeconomic determinants are main drivers of the stock market (Ghani et al., 2022).

The EPU, according to Liu e Zhang (2015) can contain information about market volatility and that including it in forecasting models can increase their predictive ability (Liu & Zhang, 2015). Chiang (2019) showed that higher political uncertainty leads to higher stock market volatility as investors demand higher premiums for when they incur higher risk investments (Chiang, 2019).

The literature also portrays that the negative effect of political uncertainty can also impact macroeconomic indicators in a negative way (Rehman et al., 2019).

Bai et al., (2019) shows that the 6 largest economies in the world exhibit economic interconnectedness. The results show that the US is the main transmitter of risk with the UK and China being the main receivers.

Dai et al., (2021) studied the effect of EPU on the downside risk of the US stock market. The results showed that there is a correlation between an increase in EPU and an increase in stock market crash risk. This relationship is more pronounced when analysing the Covid-19 pandemic crisis period.

Gong et al., (2022) shows that EPU is significantly and negatively linked to stock market returns and affects both developed and emerging markets.

There are several extensions of the use of the EPU, such as measuring the impact that the EPU of the United States of America had on Japan (Chang, 2022) which shows evidence of an asymmetric impact on the U.S. market without the inverse relationship holding; or measuring the impact of the EPU by industries in the same country as is the case in the work of Jeon (2018) who measures the impact of the EPU on the real estate market in South Korea (Jeon, 2018).

Jeon (2018) who concludes that EPU of these four countries (Korea, Japan, Hong Kong, and China) has a significant negative effect on housing purchase price index, housing rental price index.

Ma et al. (2019) conducts a similar study for the Chinese market and realize that monetary and exchange rate policies cause uncertainty in the stock market negatively impacting market behaviour (Ma et al., 2019).

The relationships between the EPU between countries is also addressed by Nong (2021) who makes a link between the US and China market. The main conclusions refer to the higher probability of monetary policy causing uncertainty in the Chinese market and fiscal policy causing uncertainty in the North American market (Nong, 2021).

In 2022, Zeng et all., (2022) conduct a study for the US analyzing 11 subcategories of the economic and social EPU and conclude that they impact the behavior of the S&P500 Index (Zeng et al., 2022).

Baker Et al. (2016) showed that investor sentiment influences the volatility of financial asset prices and can even lead to excessive fluctuations. The authors argue that this sentiment can be influenced by local and global factors, and that there is also a contagion effect (Baker et al., 2016).

Using the univariate and bivariate predictive regression model, Xu et al. (2021) confirmed that the monthly EPU index, constructed by Davis, Liu, and Sheng (2019) for China, can significantly and negatively impact the returns of the following month's stocks, proving that there is better predictability regarding index returns. By comparing the predictive effect of the EPU index before and during special events with sharply increased uncertainty, they discovered that the predictive power of the EPU quickly diminishes when a sharply increased uncertainty event occurs (Xu et al., 2021).

The EPU was also used in four countries/regions such as China, Japan, Europe, and the United States, to study the risk of investment contagion in the global market. 22 markets worldwide were analyzed to understand which EPU had the most significant influence on them. Through dynamic correlation, it was observed that China was the country that spread the contagion risk with the highest amplitude, and its effect was Superior to that of the United States of America. The Japanese EPU only influenced emerging markets, and Europe was not influenced by the risk of contagion in the global market. The author attributed these results to the extreme trade dependency between some countries, as the performance of international companies was also influenced by their political context (Tsai, 2017).

The industrial production index measures the evolution of productive activity in each geographical location, usually a country. Given its definition, this variable is expected to have a positive and significant impact when included in a model. In other study, Al-Rimawi & Kaddumi, (2021). come to the same conclusion, the industrial production index has a positive and significant impact on the development of Jordan country's index.

As suggested by (Ji et al., 2020), any negative shock affecting one of the domestic capital markets will quickly affect other equity markets and therefore increase global systemic risk. These authors found evidence of positive, negative and asymmetric effects in the risk spillover effect between the US and the remaining six G7 countries.

Research by Sharif, Aloui and Yarovaya (2020) further considered that 15 countries faced two simultaneous crises, the COVID-19 crisis, and the oil crisis, with "for the US economy oil remains the main source of systematic risk, while a spread of COVID-19 increases the uncertainty due to the unpredictable severity of the response to the pandemic" (see Sharif, Aloui and Yarovaya, 2020, pp.6). In turn, BenSaida and Litimi (2020) who using a regular copula vine found manifestations of contagion to the stock markets of the countries that make up the G10.

The dependence between oil prices and stock markets, as well as the spillover effect of crude oil price risk to the stock market, are well demonstrated, in the studies by X. Li & Wei, (2018), S. Li et al., (2022), Cui et al., (2021), among others. The results of these studies converge on the following evidence: (i) the recent financial crisis increases the dependencies between the crude oil market and China's stock market, (ii) the risk spillover effects from the oil price to China's stock market exhibit strong asymmetric characteristics, with larger downside risk effects in the long run.

In Azimli's study, (2022), this author indicates that political and economic uncertainty has a significant negative impact on firms' investment in countries such as the Czech Republic, Hungary, Poland, Russia, and Turkey. If destabilizing events occur in a given frontier market, such as a political crisis, economic problems and financial shocks can trigger a liquidity crisis in these markets, affecting other parts of the financial system.

In Jordan, Mohammed Ali, Al-Rimawie Thair and Adnan Kaddumi come to the same conclusion, the industrial production index has a positive and significant impact on the development of that country's index (Al-Rimawi & Kaddumi, 2021).

The ARMA (1,1) methodology and the GARCH (1,1) model were used to extract shocks in the EPU series of the United States and to examine how Chinese stock returns respond to these shocks. Overall, the authors concluded that changes in the US EPU explain both positively and negatively the returns of Chinese stocks with a one-week lag, and lower-value stocks tend to be more sensitive to these movements, as well as technology and agricultural company stocks. Generally, stocks that fall the most are those with higher returns, lower market capitalization, and lower operating profits. For this reason, investors who hold these types of stocks typically demand premiums for keeping them in their portfolios (Hu et al., 2018).

All these articles show that the index of political uncertainty negatively impacts stock markets and emphasize the importance of managing its development. This index is also of particular importance because understanding its behaviour can help implement more efficient and effective measures and strategies for the development of a country's stock market.

One of the criticisms made in this type of work is the use of GARCH models since they fail to detect shocks that are not revealed in the time series pattern of the data (Chiang, 2022). Therefore, the use of Time Varying Causality seems adequate to capture these effects.

3. Data and Methodology

3.1. Data

As already mentioned, the dissertation will be divided into two main questions. To study the effects of disaggregated EPU in the United States of America we choose as dependent variable the rate of return on the SP500 (RI) exchange in the United States of America, using the www.investing.pt website as a source. The independent variables are the monetary policy intensity index (RM), the economic regulation variation index (RFR) and the variation index on fiscal policies (RF). All three of these variables were taken from the website www.policyuncertainty.com. We also used the industrial production index (RPI) taken from the "Federal Reserve economic data" and from https://www.policyuncertainty.com/ . The studied time horizon starts in January 1987 and ends in August 2022 with monthly frequency.

To answer the second question asked we added other variables to the model. The model starts in January 1987 and ends in June 2022 with a monthly data frequency. For this study the following variables were used for the United States of America, Canada, and Japan: industrial production index (IPI), economic policy uncertainty index (EPU).
For the United States we also used the S&P500 index return rate (SP_EUA), the monetary policy uncertainty index (PM_EUA), the fiscal policy uncertainty index (FP_EUA), the financial regulation uncertainty index (FR_EUA) and the trade policy uncertainty index (TP_EUA). For Japan the rate of return of the Nikkey indeMP_EUA25 (NIK), the monetary policy uncertainty index (PM_JP), the fiscal policy uncertainty index (FP_JP), and the trade policy index (T_JP) as well as the Consumer Price Index based on 2015 (NIK) prices were used. For Canada the consumer price index based on 2015 prices. As in the first part, the data were taken from the "Federal Reserve economic data" and "https://www.policyuncertainty.com/"

3.2. Time varying causality

The methodology chosen for this paper about time-varying causality, we following the studies developed by Shi et al., (2018,2020); Fromentin et al., (2022) Baum et al., (2022), among others. The same authors suggested to estimate Augmented VAR model with lags (LA-VAR), so that it was possible to include non-stationary variables in the VAR model. Mathematically the LA-VAR model is presented as follows:

$$y_{1t} = \alpha_{10} + \alpha_{11t} + \sum_{i=1}^{k+d} \beta_{1i} y_{1t-i} + \sum_{i=1}^{k+d} \delta_{1i} y_{2t-i} + \varepsilon_{1t} \tag{1}$$

$$y_{2t} = \alpha_{20} + \alpha_{21t} + \sum_{i=1}^{k+d} \beta_{2i} y_{1t-i} + \sum_{i=1}^{k+d} \delta_{2i} y_{2t-i} + \varepsilon_{2t} \tag{2}$$

where t is the time trend, k is the lag order of the original VAR model and ε_{it} correspond to the error terms. The maximum possible order of integration of the variables is possible through the additional lags (d). Non-causality from y_{2t} to y_{1t} refers to the fact that it is possible that the predictions of y_{1t} constrain its behavior over time and cannot be improved by incorporating the lags of the y_{2t} model (Shi et al., 2018).

The null hypothesis of this system is presented as follows: $H_0: \delta_{11} = \cdots = \delta_{1k} = 0$
In general, for n dimensions of vector yt, the LA-VAR model is presented:

$$y_t = \gamma_0 + \gamma_1 t + \sum_{i=1}^{k} J_i y_{t-1} + \sum_{j=k+1}^{k+d} J_i y_{t-j} + \varepsilon_t \tag{3}$$

In which, $J_{k+1} = \cdots J_{k+d} = 0$ together with d represents the maximum order of integration of the dependent variable (Shi et al., 2020). The null hypothesis of the first mentioned equation of Granger causality can be verified through the test of joint significance, known as Wald Test. In the study developed by Shi et al, (2018,2020), these authors concluded that this real-time variation test based on Wald statistics produces better effects used the recursive evolving procedure. Given this evidence, in our study we therefore decided to use this same recursive procedure. This recursive Granger causality test uses the subsamples of the data to calculate the Wald statistics. The Wald statistic will be calculated using the following equation:

$t_1 = [f_1 T], t_2 = [f_2 T], t_w = [f_w T]$, Where f_1 and f_2 are the starting and ending points of a simple regression f_w=$f_1 - f_2$ the minimum number of observations required for the estimation of the VAR model, and T is the total number of observations (Shi et al., 2018).

In the direction of causality, considering Recursive Evolving the norms is determined by the following function:

(4)

$$\text{Recursive Evolving: } \widehat{f_e} = \inf_{f \in [f_0, 1]} \{f : \mathcal{SW}_f(f_0) > scv\} \text{ and}$$
$$\widehat{f_f} = \inf_{f \in [\widehat{f_e}, 1]} \{f : \mathcal{SW}_f(f_0) < scv\}$$

In which cv and scv are the critical values of $\mathcal{W}_f$ and $\mathcal{SW}_f$, respectively (Raifu, 2022; Shi et al., 2018). The test statistic is defined as the maximum value of the following equation:

(5)

$$\mathcal{SW}_f(f_0) = \sup_{(f_1, f_2) \in \Lambda_0, f_2 = f} \{\mathcal{W}_{f2}(f_1)\}$$

Being, $\Lambda_0 = \{(f_1, f_2) : 0 < f_0 + f_1 \leq f_2 \leq 1, and\ 0 \leq f_1 \leq 1 - f_0\}$, this approach is called the recursive evolving procedure (Shi et al., 2018), this procedure allows changes in the window scope $f_W = f_2 - f_1 \geq f_0$, differently of the rolling window procedure (Shi et al., 2018).

3.3 Markov Switching Regression

The Markov-Switching regression allows the analysis of the behavior of the rate of index returns and the degree of uncertainty of that country measuring simultaneously the influence of economic uncertainty of other countries on that same index.

The Markov-Switching Dynamic regression model is represented by the following equation, according to Hamilton (1988,1989) where the change of state by the stochastic process is represented by the following equation:

(6)

$$y_t = \mu_s + x_t \alpha + z_t \beta_s + e_{t,s}$$

where is y_t the dependent variable, the state-dependent μ_s intercept, is the vector of exogenous variables with state invariant coefficients α; is the vector of exogenous variables with state-dependent coefficients and ~iid N(0, x_t z_t β_s e_(t,s) 〖σ^2〗_(s_t)).

According to Smith (2008), the inherent regime changes over time as a first-order Markov chain with the transition probabilities as follows:

(7)

$$P\{s_t = j | s_{t-1} = i, s_{t-2} = k, \dots\} = P\{s_t = j | s_{t-1} = i\} = p_{ij}$$

Suppose that s_t represents a state variable that follows an ergodic M-State Markov process, characterized by an irreducible transition matrix. We have the condition p_11 + p_MM = 1, indicating that the sum of the probabilities of transitioning from state 1 to itself and from state M to itself is equal to 1. At each stage, the probability vector for the next stage (s_(t+1)) is obtained by multiplying the transition matrix by the conditional probability vector at the current stage (s_t). It is important to note that the process described by s_t follows an ergodic M-State Markov process with an indivisible transition matrix, as explained in the work by Barbosa et al. (2022).

(8)

$$P = \begin{bmatrix} p_{11} & \cdots & p_{1M} \\ \vdots & \ddots & \vdots \\ p_{M1} & \cdots & p_{MM} \end{bmatrix}$$

As per Hamilton (1988, 1989), the probability vector for the subsequent stage (s_(t+1)) is obtained by taking the product of the transition matrix and the conditional probability vector at the present stage (s_t). This implies that the transition matrix governs the probabilities of moving from one state to another, while the conditional probability vector captures the likelihood of being in each state given the current stage.

3.4 Multivariate Autoregressive Conditional Heteroscedasticity Models

Considering the existing literature, the most adequate models to study interdependence relations, market co-movements and risk are the multivariate autoregressive conditional heteroskedasticity models, namely the DCC-MGARCH models.

Considering the stochastic vector process $\{y_t\}_{t=1}^{T}$, of order $(N \times 1)$, taking into account that the conditional values to the information set I_{t-1}, formed by the series of y_t until the period $t-1$. The finite vector of parameters of the conditional mean function is denoted by θ by presenting the following expression:

(9)

$$y_t = \mu_t(\theta) + \varepsilon_t$$

Represented by the vector of the conditional mean function where $\mu_t(\theta)$ and

(10)

$$\varepsilon_t = H_t^{\frac{1}{2}}(\theta) z_t$$

where $H_t^{\frac{1}{2}}(\theta)$ is a positive defined matrix $(N \times N)$. Additionally, we assume that the random vector z has the following two first moments:

$$E(z_t) = 0$$
$$Var(z_t) = I_N \tag{11}$$

where I_N is the identity matrix of order N. The conditional variance matrix of y_t:

$$\begin{aligned} Var(y_t|I_{t-1}) &= Var_{t-1}(y_t) = Var_{t-1}(\varepsilon_t) \\ &= H_t^{\frac{1}{2}} Var_{t-1}(z_t) \left(H_t^{\frac{1}{2}}\right)' = H_t \end{aligned} \tag{12}$$

where $H_t^{\frac{1}{2}}$ is any positive defined matrix $(N \times N)$ such that H_t is the conditional variance matrix de y_t, *i.e.*, $H_t^{\frac{1}{2}}$ can be obtained by factorizing Cholesky de H_t .The unknown parameter θ influences both the behavior of H_t as of μ_t. Usually, a VAR or VECM model is used to specify the function of the prior values in the conditional mean equation of y_t.

3.4.1 Model with Dynamic Conditional Correlation - DCC-MGARCH

It can be stated that the DCC-MGARCH model is a combination of univariate GARCH models. One of the advantages of this model is the ability to separately specify the conditional correlation matrix and the individual conditional variances.

The model is proposed by Engle (2002) as follows:

$$H_t = D_t R_t D_t \tag{13}$$

Where:

$$D_t = diag(h_{11,t}^{\frac{1}{2}} \dots h_{NN,t}^{\frac{1}{2}}) \tag{14}$$

Where $h_{ii,t}$ it can be defined as any univariate GARCH model with

$$R_t = diag\left(q_{11,t}^{-\frac{1}{2}} \dots q_{NN,t}^{-\frac{1}{2}}\right) Q_t diag\left(q_{11,t}^{-\frac{1}{2}} \dots q_{NN,t}^{-\frac{1}{2}}\right) \quad (15)$$

Where the matrix $Q_t = (q_{ij,t})$, is positive definite and symmetric.$(N \times N)$,is given by:

$$Q_t = \left(1 - \sum_{i=1}^{q} \alpha_i - \sum_{j=1}^{p} \beta_j\right)\bar{Q} + \sum_{i=1}^{q} \alpha_i \left(u_{t-i} u'_{t-i}\right) + \sum_{j=1}^{p} \beta_j Q_{t-j} \quad (16)$$

Where $\bar{Q} = (1/T) \sum_{t=1}^{T} (u_t u'_t)$ is the matrix of non-conditional covariances of normalized residuals., $u_t = \varepsilon_t \left[diag(h_{11,t}^{\frac{1}{2}} \dots h_{NN,t}^{\frac{1}{2}})\right]^{-1}$, with $\alpha_i \geq 0$, $\beta_j \geq 0$, $\sum_{i=1}^{q} \alpha_i + \sum_{j=1}^{p} \beta_j < 1$. If the conditional variances are estimated using a GARCH (1,1) model, the matrix Q_t:

$$Q_t = (1 - \alpha - \beta)\bar{Q} + \alpha u_{t-1} u'_{t-1} + \beta Q_{t-1} \quad (17)$$

where α and β are non-negative scalar parameters satisfying α+β<1. In a bivariate model, using the GARCH(1,1).

4.Results

4.1Results for the influence of EPU in the US

4.1.1Unit Root Tests

We first conducted unit root tests using the ADF (Augmented Dickey-Fuller test) and KSS (Kapetanios, Shin & Snell, 2003) methods, presented in the following tables:

Table 1- Unit Root Test without trend results

	ADF Test		KSS Test	
Variables	level	1ª difference	level	1ª difference
SP	-0.134	-4512***	-1.016	0.919
RPI	0.580	-4.621***	-1.977	-7.283***
RM	-3.197***	-6.842***	-3.120***	-1.065
RF	-3.094***	-5.908***	-2.707**	-0.783
RFR	-2.297*	-6.358***	-1.628	-1.758

Legend: SP- Rate of change of the index; RPI- Rate of change of the industrial production index; rm- Rate of change of the monetary policy uncertainty index; RF- Rate of change of the fiscal policy uncertainty index; Rate of change of the financial regulation uncertainty index

Table 2- Unit root test with trend results

	ADF Test		KSS Test	
variables	level	1ª difference	level	1ª difference
SP	-1.867	-4.524***	-1.958	0.990
RPI	-1.830	-4.834***	-5.638***	-7.290***
RM	-3.7***	-6.878***	-3.437***	-1.052
RF	-3.024**	-5.912***	-2.917**	-0.795
RFR	-2.341	-6.355***	-1.647	-1.759

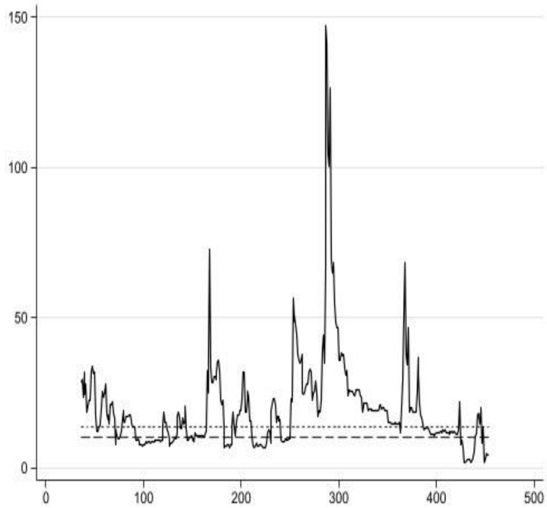
Legend: SP- Rate of change of the index; RPI- Rate of change of the industrial production index; rm- Rate of change of the monetary policy uncertainty index; RF- Rate of change of the fiscal policy uncertainty index; Rate of change of the financial regulation uncertainty index

In the previous table, the results of the ADF and KSS stationarity tests are presented. These tests are widely used in the literature, where the null hypothesis assumes the existence of a unit root, and the alternative hypothesis assumes the stationarity of the series. Analyzing the results, we can conclude that, after taking the first differences of the series, the ADF test shows that all variables are stationary with a confidence level of 99% when we use the variables in the first differences. However, the same results are not obtained with the KSS test.

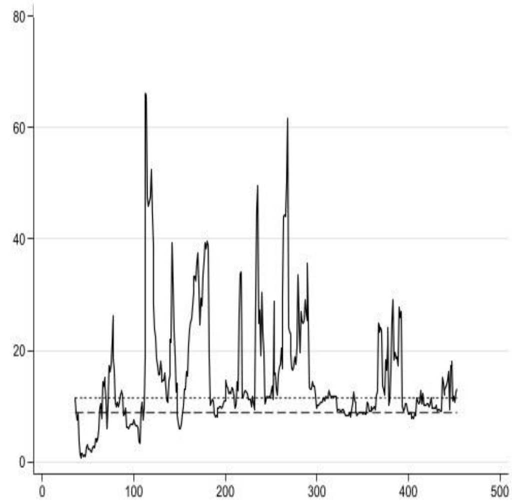
4.1.2 Time-varying LA-VAR Granger causality test including trend

Next, we conducted Time-varying LA-VAR Granger causality tests, including trend, and obtained the following graphs:

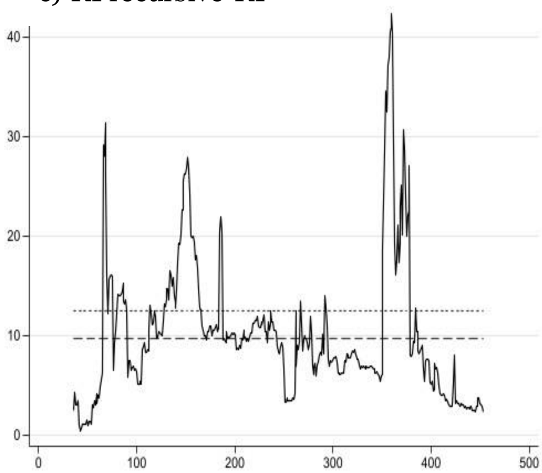
a) RI recursive RPI



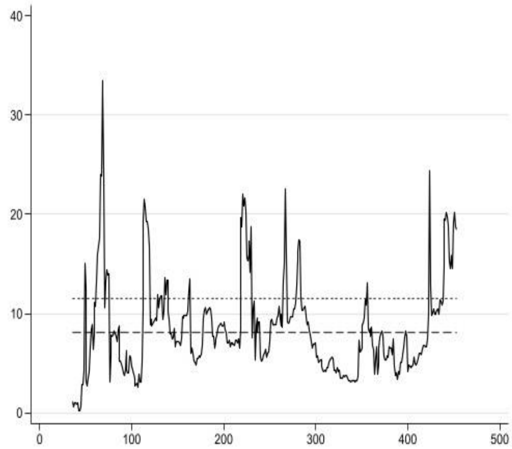
b) RI recursive RM



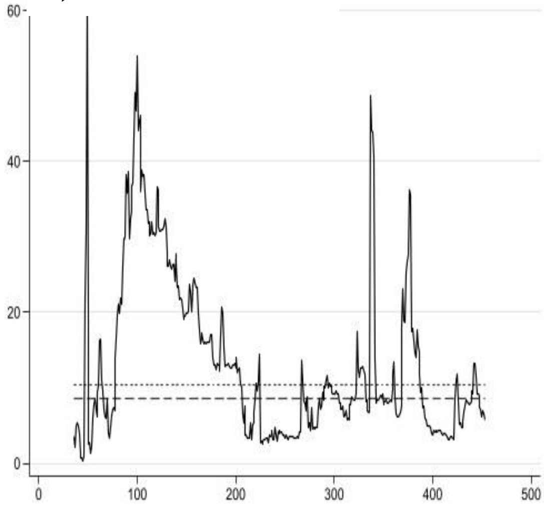
c) RI recursive RF



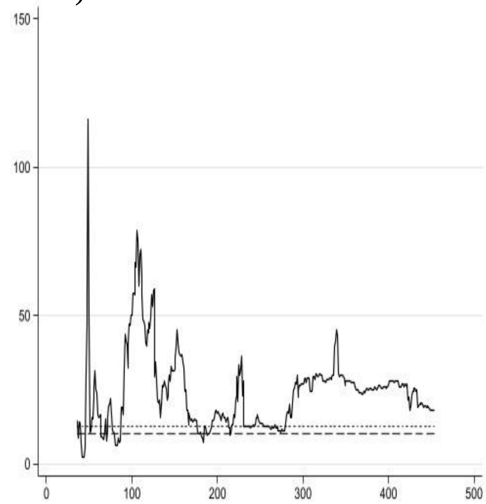
d) RI recursive RFR



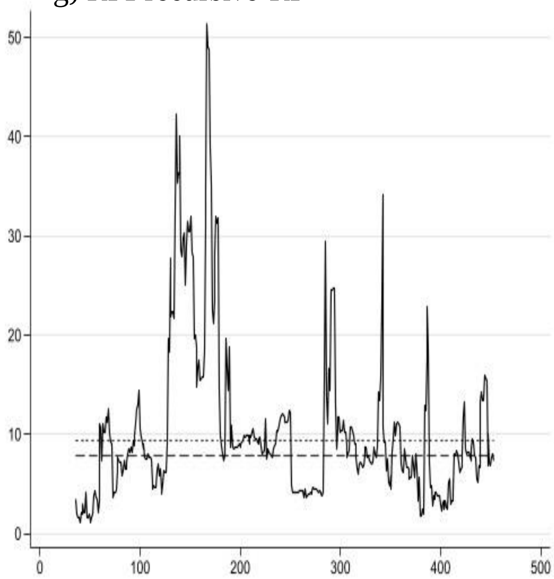
e) RPI recursive RI



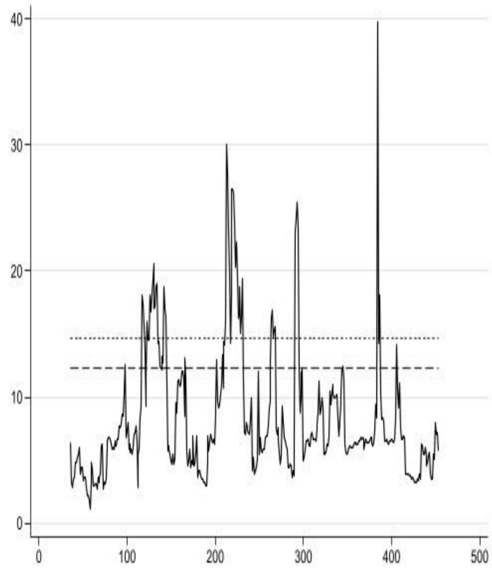
f) RPI recursive RM



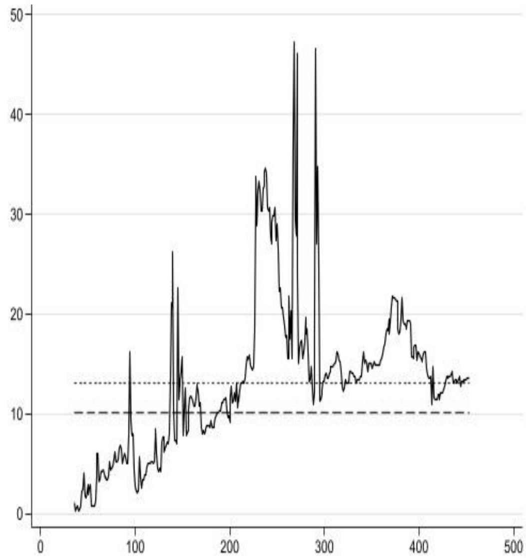
g) RPI recursive RF



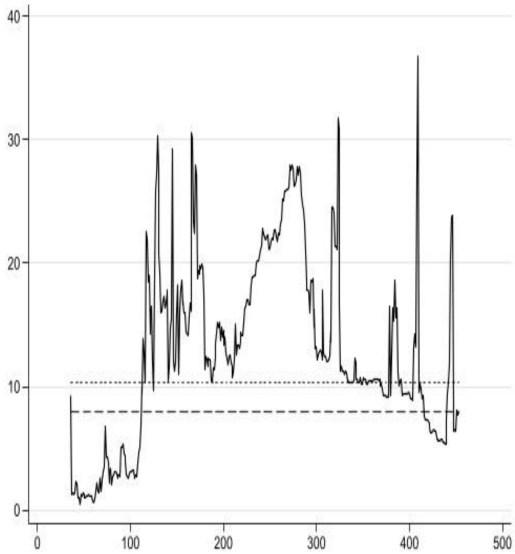
h) RPI recursive RFR



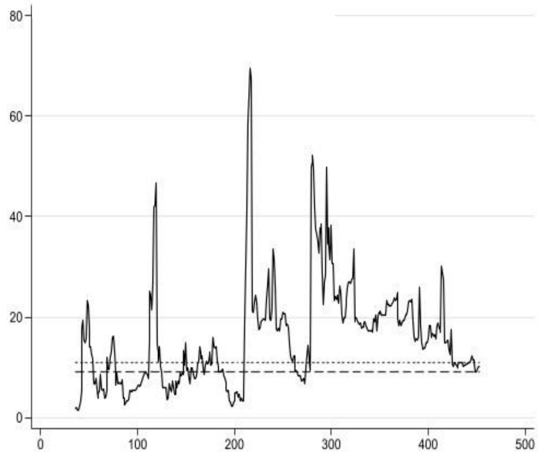
i) RM recursive RI



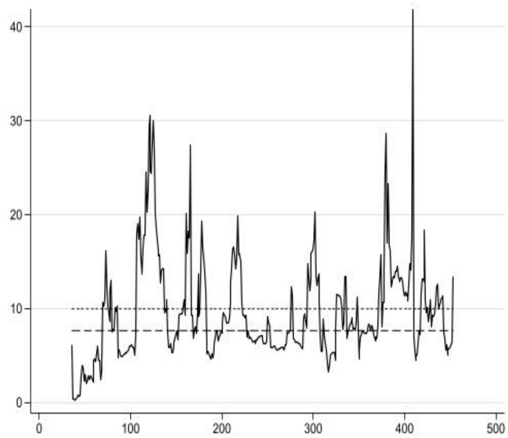
j) RM recursive RPI



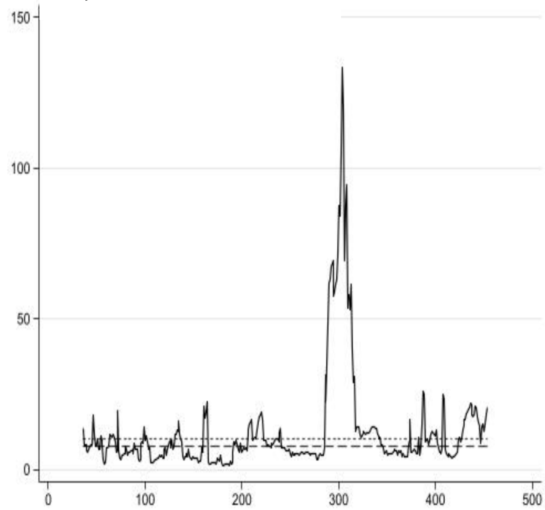
k) RM recursive RF



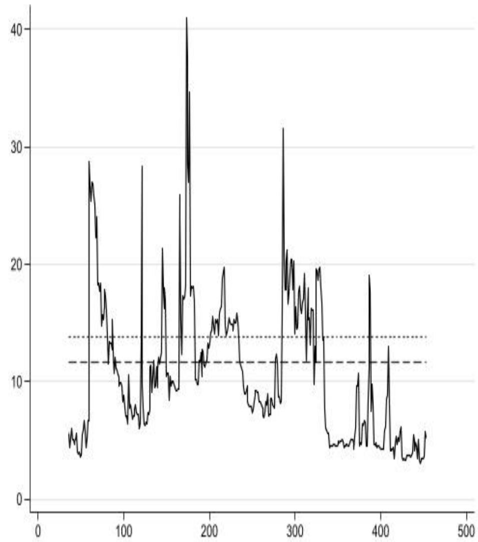
l) RM recursive RFR



m) RF recursive RI



n) RF recursive RPI



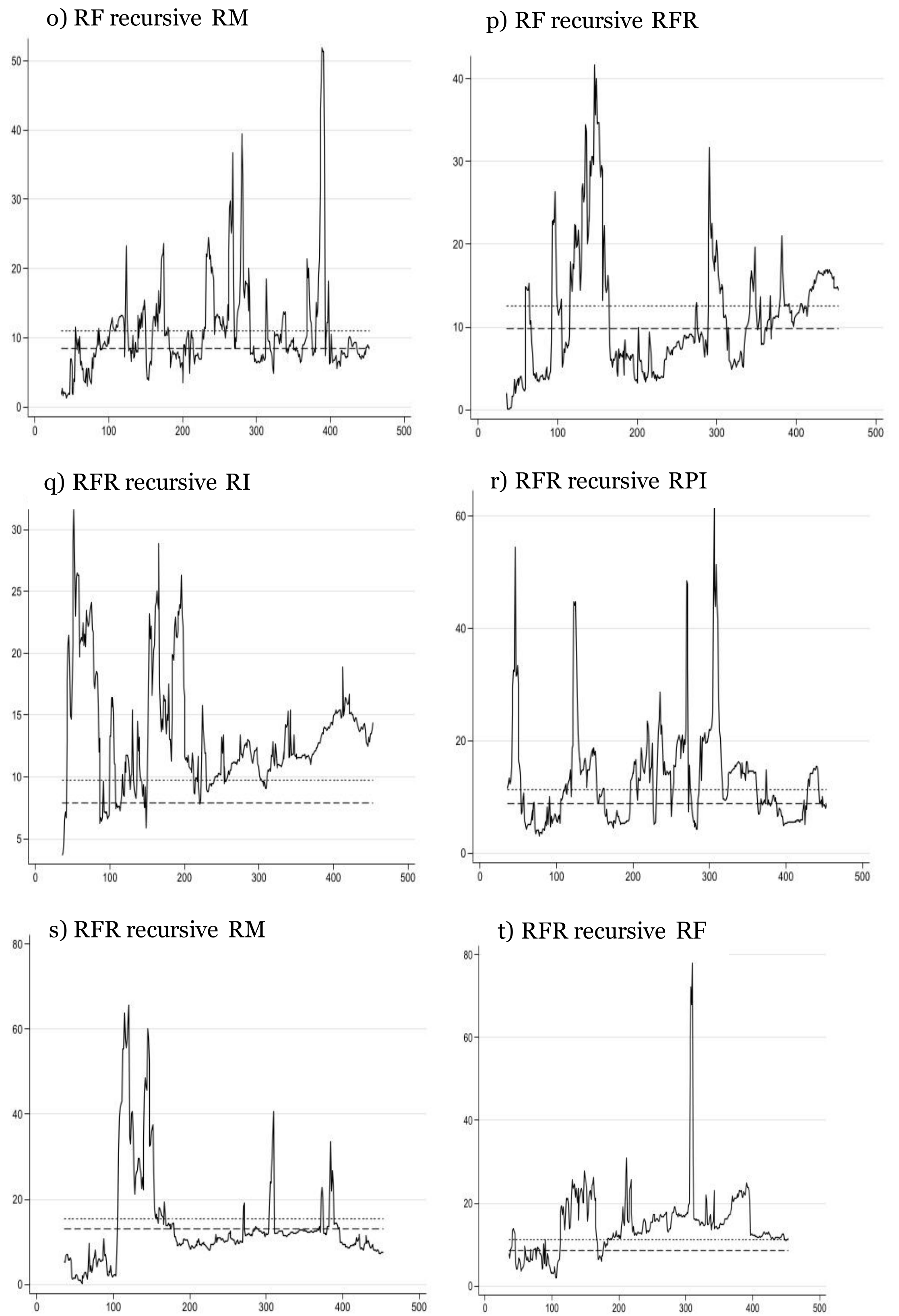


Figure 6- Time varying causality results

From the graphs obtained from the results, we can highlight the following facts:

The rate of change of the index does not have a significant effect on the industrial production index or the monetary policy uncertainty index. However, we can observe that the rate of change of the index shows some asymmetrical causality over time, particularly in relation to the fiscal policy uncertainty index and the economic regulation uncertainty index, especially during the pandemic crisis period.

Regarding the industrial production index, we can conclude that it practically does not have any significant effect on the monetary policy uncertainty index. However, we can conclude that there are periods in which it has a significant effect on the returns of the indices, as well as the fiscal policy uncertainty index. There are few periods in which there is no causality between the index and the economic regulation uncertainty index.

The uncertainty about monetary policy has an interesting behavior, as it is statistically significant in the behavior of the index return in the early sample period, losing its influence for the rest of the period, as well as the industrial production index. With the other chosen uncertainty indices, we can conclude that there are periods of causality and other periods without causality.

The uncertainty about fiscal policy is shown over time as causing the behavior of the indices, except in one period. Regarding the other chosen series, we can conclude that there is an asymmetrical behavior with respect to their causality, existing periods in which there is a cause, and others in which it is not statistically significant.

Finally, financial regulation uncertainty shows little causality with the index returns, as well as with fiscal policy. Regarding the industrial production index and the monetary policy uncertainty index, there are periods of asymmetrical causality, without showing a clear pattern.

4.2 Results the influence of EUA in another countries

4.2.1 Pearson correlations results

In the second part, the first method adopted was the Pearson correction as the following tables show. To measure the correlation between variables we created 4 models to capture the effects of UPR in the different countries. All tables are presented in the appendix.

Model 1 = SP; NIK; TSX; EPU_EUA; EPU_JP; EPU_CAN; IPI_EUA; IPI_JP; IPI_CAN; IPC_EUA; IPC_JP; IPC_CAN

In this case, it appears that the variables are related to varying degrees, as indicated by the correlation values. Some observations from the table are as follows: Variables SP, NIK, and TSX are moderately correlated with each other, with correlation coefficients of 0.5511, 0.7938, and 0.5013, respectively.

Variable IPI_JP is weakly correlated with the other variables, except for a weak positive correlation with IPI_EUA. Variable w1 is moderately correlated with IPI_EUA, IPC_EUA, and IPI_JP. Variable IPC_EUA is weakly correlated with the other variables, except for a moderate positive correlation with IPI_EUA and IPI_CAN. Variable IPC_JP is weakly correlated with the other variables. Variable IPC_CAN is weakly correlated with the other variables, except for a moderate positive correlation with IPC_EUA and a weak negative correlation with IPC_JP.

Model 2 = SP; IPI_EUA; MP_EUA; FP_EUA; RP_EUA; TP_EUA; IPC_EUA; IPI_JP; MP_JP; FP_JP; ;TP_JP; IPC_JP

The analysis of the correlation matrix reveals some relationships between the studied variables. The variable SP shows a moderately positive correlation with IPI_EUA, indicating that these two variables are significantly related. On the other hand, MP_EUA exhibits a weak negative correlation with SP, while FP_EUA has a moderate negative correlation with SP and a weak positive correlation with MP_EUA.

Regarding the variables FR_EUA and TP_EUA, they show a weak negative correlation with SP, but both have weak positive correlations with other variables such as FP_EUA and FR_EUA. The variable IPC_EUA shows a moderate positive correlation with SP and a weak positive correlation with IPI_EUA, suggesting a possible relationship between these variables.

As for the variables IPi_JP, MP_JP, FP_JP, TP_JP, and IPC_JP, their correlation with SP is relatively weak, indicating a less significant relationship. However, some of these variables exhibit weak or moderate positive correlations with other variables. For instance, IPi_JP shows a weak positive correlation with IPI_EUA and a weak negative correlation with MP_EUA. Variables MP_JP and FP_JP also display weak positive correlations with MP_EUA and FP_EUA, respectively.

Model 3 = NIK; IPI_EUA; MP_EUA; FP_EUA; RP_EUA; TP_EUA; IPC_EUA; IPI_JP; MP_JP; FP_JP; TP_JP; IPC_JP

Among these variables, NIK shows a moderate positive correlation with IPI_EUA, indicating a meaningful relationship between them. Conversely, MP_EUA does not exhibit a significant correlation with NIK.

When it comes to the predictor variables, FP_EUA and FR_EUA both display moderate negative correlations with NIK. This suggests that higher values of FP_EUA and FR_EUA tend to be associated with lower values of NIK. On the other hand, TP_EUA does not show a significant correlation with NIK.

The variable IPC_EUA demonstrates a moderate positive correlation with NIK, indicating a meaningful relationship between them.

Turning to the variables IPi_JP, MP_JP, FP_JP, TP_JP, and IPC_JP, none of them exhibit significant correlations with NIK. This means that the relationships between these variables and NIK are not statistically significant.

Model 4 = TSX; IPI_EUA; MP_EUA; FP_EUA; RP_EUA; TP_EUA; IPC_EUA; IPI_JP; MP_JP; FP_JP; TP_JP; IPC_JP

The variable TSX shows a significant positive correlation with w1 and a moderate positive correlation with IPI_EUA and IPC_EUA. However, it exhibits a weak negative correlation with MP_EUA and FP_EUA.

The variables w1 and w2 are moderately correlated with each other. Additionally, w1 has a moderate positive correlation with IPI_EUA, IPC_EUA, and IPi_JP. Meanwhile, w2 shows a weak positive correlation with IPI_EUA and IPC_EUA.

Among the predictor variables, IPI_EUA has moderate positive correlations with TSX, w1, and IPC_EUA. It also exhibits weak positive correlations with FP_EUA and FR_EUA. On the other hand, MP_EUA has a weak negative correlation with TSX, while FP_EUA has a weak negative correlation with TSX, FR_EUA, and TP_EUA.

The variables FR_EUA and TP_EUA show weak correlations with the other variables, except for FR_EUA's weak positive correlation with FP_EUA. The variable TP_EUA does not have any strong correlations with the other variables.

Regarding the variables IPi_JP, MP_JP, FP_JP, TP_JP, and IPC_JP, their correlations with the other variables. correlation with FP_EUA. MP_JP and FP_JP have weak positive correlations with MP_EUA and FP_EUA, respectively. TP_JP has a weak positive correlation with TP_EUA.

4.2.2 Results for Markov Switching Dynamic Regression

Markov Switching Dynamic Regression allows us to analyse the series in two distinct phases, in the economic regression phase or in the expansion phase. This analysis allows us to understand which variables have the greatest influence on the behaviour of the markets, as well as to understand the contagion between countries that maintain some kind of relationship. Thus, the following results of 6 equations are presented.

<u>Equation #1</u> L.SP= α +α_1 L.IPI_EUA+ α_2 IPC_EUA+ α_3 EPU_EUA+ α_4 EPU_JP+ α_5 IPI_JP+ α_6 IPC_JP+ α_7 IPI_CAN+ α_8 IPC_CAN

<u>Equation #2</u> L.NIK= α +α_1 L.IPI_EUA+ α_2 IPC_EUA+ α_3 EPU_EUA+ α_4 EPU_JP+ α_5 IPI_JP+ α_6 IPC_JP+ α_7 IPI_CAN+ α_8 IPC_CAN

<u>Equation #3</u> L.TSX= α +α_1 L.IPI_EUA+ α_2 IPC_EUA+ α_3 EPU_EUA+ α_4 EPU_JP+ α_5 IPI_JP+ α_6 IPC_JP+ α_7 IPI_CAN+ α_8 IPC_CAN + α_9 EPU_CAN

<u>Equation #4</u> L.SP= α + α_1 L.IPI_EUA+ α_2 L.MP_EUA+ α_3 L.FP_EUA+ α_4 L.RP_EUA+ α_5 L.TP_EUA+ α_6 L.IPC_EUA+ α_7 L.IPI_EUA+ α_8 L.MP_JP+ α_9 L.FP_JP+ α_{10} L.TP_JP+ α_{11} IPC_JP

Equation #5 L.NIC= α + α_1 L.IPI_EUA+ α_2 L.MP_EUA+ α_3 L.FP_EUA+ α_4 L.RP_EUA+ α_5 L.TP_EUA+ α_6 L.IPC_EUA+ α_7 L.IPI_EUA+ α_8 L.MP_JP+ α_9 L.FP_JP+ α_{10} L.TP_JP+ α_{11} IPC_JP

Equation#6 L.TSX= α + α_1 L.IPI_EUA+ α_2 L.MP_EUA+ α_3 L.FP_EUA+ α_4 L.RP_EUA+ α_5 L.TP_EUA+ α_6 L.IPC_EUA+ α_7 L.IPI_EUA+ α_8 L.MP_JP+ α_9 L.FP_JP+ α_{10} L.TP_JP+ α_{11} IPC_JP+ α_{12} epu_CAN

Table 2- Markov Switching Results

	Equation # 1	Equation # 2	Equation # 3	Equation #4	Equation #5	Equation #6
			Expansion			
IPI_EUA	1.014***	-0.073	-0.243	1.143***	1.07***	-4.633***
MP_EUA				-0.001	-0.006	0.042
FP_EUA				-0.001	-0.043**	0.041
FR_EUA				-0.002	0.003	-0.009
TP_EUA				-0.056*	0.019	0.074**
IPC_EUA	0.342	-3.105	3.121**	-0.399	-1.226	11.564***
EPU_EUA	-0.014	-0.032**	0.006			
EPU_JP	-0.045***	-0.073***	-0.075***			
EPU_CAN			-0.034***			-0.211***
IPI_JP	-0.243**	-0.115	0.463***	-0.195*	-0.400**	1.313***
MP_JP				-0.07	-0.012	0.076***
FP_JP				-0.286**	-0.031	-0.007
TP_JP				-0.003	-0.016	0.0929**
IPC_JP	-0.021	-4.130***	1.346	-0.136	-3.496**	5.027*
IPI_CAN	0.132	0.988*	-0.237			-0.025
IPC_CAN	-1.22	3.419**	0.062			-10.576***
Constant	0.007**	-0.002	-0.005	0.006**	0.001	-0.041***
Recession						
IPI_EUA	-0.038	0.725	1.484***	-0.351	0.385	1.181***
MP_EUA				-0.021*	0.007	-0.007*
FP_EUA				-0.503**	0.014	-0.003
FR_EUA				-0.0286*	-0.011	0.0001
TP_EUA				-0.003	-0.023***	-0.001
IPC_EUA	7.825***	11.594***	7.059***	7.90***	7.029***	3.366***
EPU_EUA	-0.067***	-0.011	-0.031**			
EPU_JP	0.056	-0.008	-0.0354			
EPU_CAN			0.113			-0.004
IPI_JP	0.054*	0.595**	-0.354***	0.732**	1.323***	-0.1824
MP_JP				0.258	-0.009	-0.012**
FP_JP				0.092***	-0.002	0.001
TP_JP				-0.006	0.012	-0.005
IPC_JP	-1.116	1.987	-2.343**	-2.677	1.074	-0.999**

IPI_CAN	0.728	-0.761	0.0371			0.078
IPC_CAN	0.654	-7.581***	1.176*			-0.376
Constant	-0.045	-0.004	0.004	-0.003	-0.013*	-0.002

Notes: *, **, *** mean statistical significance at 10%, 5%, and 1%, respectively

Equation 1 and equation 4 explain the behaviour of the rates of return of the US index. We can immediately observe that the variables that are repeated in both equations maintain the same statistical significance and sign. In both equations, as expected, the industrial production index is significant for a 99% confidence level in the expansion period while in the recession period they lose their significance. For equation 1 it is important to point out some aspects in the short run, such as the fact that the Japanese IPI contributes negatively to North American returns as well as the Japanese monetary policy uncertainty index. In periods of recession, we notice that the IPI loses its significance, however the CPI contributes positively and the degree of policy uncertainty negatively. The Japanese industrial production index is also negative and statistically significant.

Equation 4 maintains identical statistical results to equation 1 despite the addition of new variables. Thus, it is important to point out that in periods of expansion, the Japanese trade policy and the US fiscal policy variables contribute negatively to the development of the indexes. In periods of recession, we point out the significance of trade policy which has an opposite behaviour to that of expansion periods. We can observe that North American monetary policy, fiscal policy, and financial regulation contribute negatively to the development of the index.

Equation 2 and 5 aim to measure which variables impact the development of the Japanese stock market. In equation 2 we conclude that there is a contagion effect of the U.S. SPE on the Japanese stock market as well as the existence of statistical significance of the Japanese CPI and also the industrial production index and the Canada consumer price index when analysing periods of economic expansion. In periods of recession, note the existence of statistical significance for the U.S. CPI.

Equation 5 shows us that the Japanese index depends statistically on the IPI and on the degree of uncertainty of the US fiscal policy and on the Japanese industrial production and consumer price index itself. In periods of recession, we realize that there continues to be a contagion effect from the U.S. as the CPI and the trade policy uncertainty index influence the performance of the index. Note that the CPI has lost significance in this state.

Equations 3 and 6 analyse the contagion effect on the Canadian stock market. In equation 3 it is observed that the Japanese and Canadian EPU affect the development of the index as well as the US CPI as well as the Japanese IPI. However, the control variables used for Canada are not shown to be significant. In stage 2 the Canadian EPU gains statistical significance as well as its own industrial production index. Externally it is also affected by the US and Japanese CPI and CPI.

The equation shows us that the Canadian index is influenced by several variables outside the country. From the outset we observe the importance of the US CPI, CPI and CPI to influence its performance. Concerning the Japanese variables, only the uncertainty index about fiscal policies does not show significance. In periods of recession, we also observe an identical profile of influence.

4.2.3 Results for the DCC-MGARCH

As mentioned above, the DCC-MGARCH model allows one to model the conditional volatility of each series and the conditional correlation between the series. The difference between ARCH and GARCH models is that Engle's ARCH model assumes that the conditional variance of errors is a linear function of period errors while GARCH model also incorporates the moving average in modelling conditional volatility.

To understand if the UPR of the various countries influences the behaviour of their index and the stock market indexes of the other countries, the following equations were chosen, which contain as dependent variables the stock market indexes and the independent variables the macroeconomic variables and aggregate EPU´s.

<u>Equation #1</u> L.SP= α +α_1 L.IPI_EUA+ α_2 L.IPC_EUA+ α_3 L.EPU_EUA+ α_4 L.EPU_JP+ α_5 L.IPI_JP+ α_6 L.IPC_JP+ α_7 L.SP

<u>Equation #2</u> L.NIK= α +α_1 L.IPI_EUA+ α_2 L.IPC_EUA+ α_3 L.EPU_EUA+ α_4 L.EPU_JP+ α_5 L.IPI_JP+ α_6 L.IPC_JP+ α_7 L.IPI_CAN+ α_8 L.IPC_CAN+ α_9 L.NIK

<u>Equation #3</u> L.TSX= α +α_1 L.IPI_EUA+ α_2 L.IPC_EUA+ α_3 L.EPU_EUA+ α_4 L.EPU_JP+ α_5 L.IPI_JP+ α_6 L.IPC_JP+ α_7 L.IPI_CAN+ α_8 L.IPC_CAN + α_9 L.EPU_CAN+ α_9 L.TSX

Table 3- DCC-MGARCH GARCH Results

	EQ 1	EQ2	EQ3
	S&P500	NIKKEY	XTS
S&P500(-1)	0.810***		
NIKKEY(-1)		0.13**	
XTS(-1)			0.007***
IPI_EUA(-1)	0.187**	0.11	0.531***
IPC_EUA(-1)	0.467***	0.432***	0.453***
IPI_JP(-1)	0.917***	0.04	0.919***
IPC_JP(-1)	-0.0154	0.43***	-0.17*
EPU_EUA(-1)			-0.355
EPU_JP(-1)	0.274	0.289*	0.298
EPU_CAN			0.154
IPI_CAN		0.04	0.146
IPC_CAN		0.428***	0.439***
α	0.003	0.007*	0.009***
β	0.879***	0.7526***	0.989***

The results presented in table 3 refer to 3 equations where we intend to understand which is the degree of influence of the SPE on the various indexes. We could see that the Japanese EPU does not present statistical significance for the behavior of the S&P500 return rates. However, we realize that the macroeconomic variables chosen, except for the Japanese CPI, are statistically significant.

The NIKKEI 225 stock market index is also not very receptive to changes in the S&P 500 but is significant for a 90% confidence level. Otherwise, we can also denote some influence from other macroeconomic variables.

Canada also shows that it does not react to the movements of the EPU of the 3 countries under study, but it shows to be an index that reacts very much to foreign macroeconomic indicators such as the North American and Japanese industrial production index and the consumer price index although with a lower degree of confidence.

Table **4-** DCC-MGARCH ARCH Results

	EQ1	**EQ2**	**EQ3**
	S&P500	NIKKEY	XTS

S&P500(-1)	0.170***		
NIKKEY(-1)		0.13**	
XTS(-1)			0.35***
IPI_EUA(-1)	0.55***	0.498***	0.53***
IPC_EUA(-1)	0.482***	0.442***	0.4366***
IPI_JP(-1)	0.096***	0.095***	0.097***
IPC_JP(-1)	0.18**	0.181**	0.17**
EPU_EUA(-1)			-0.014
EPU_JP(-1)	0.176**	0.195**	0.161**
EPU_CAN			0.100*
IPI_CAN		0.20***	0.194***
IPC_CAN		0.290***	0.002***
α	0.003	0.007*	0.009***
β	0.897***	0.7526***	0.989***

For the ARCH results we obtain similar results to those presented for the GARCH model. It is important to point out that the Canadian and Japanese EPU variables are now statistically significant for a confidence level of at least 90%, something that did not happen before.

For the equation that explains the behavior of the Canadian stock market index the sums of α and β are greater than 0.9 which shows that the dependent variables have a high persistence of their conditional variances. This means that in the long run when there are shocks to the conditional variance the respective expected values will revert to the long run average values.

Overall, we can see that the macroeconomic indicators indicated are statistically significant not only for the countries themselves but also for the countries with which they establish trade relations. On the other hand, and meeting one of our questions, we realize that the aggregate EPU does not prove to be statistically significant contrary to the results we obtain for the Markov-switching models.

5. Discussion of results

In general, we can say that we obtain results in accordance with the existing literature. We prove that the EPU of countries can influence the development of their stock markets and the stock markets of the countries with which they establish relationships.

For the first question the results agree with the existing literature. From the results obtained we can say that there is a relationship between the EPU and the development of the S&P500 Index, as Zeng et al., (2022) stated in his paper published for the states. This result is not exclusive for the United States since as Nong (2021) and Ma et al., (2019) reached similar conclusions for the Chinese market.

As in the mentioned studies, in this study, fiscal policy and monetary policy are the policies that can change the behaviour of stock markets and it is necessary to pay attention to the sense of security that these policies convey to society shows that in China political uncertainty negatively affects stock returns in the following months guaranteed that there is more predictability regarding returns.

Albrecht et al., 2022 also analyzed the EPU effect in 4 countries (Germany, Japan, the United States and the United Kingdom) and come to similar conclusions. There is a short-term effect of EPU on stock markets ranging from 2 to 6 months when analyzing investments longer than 32 months.

The results of the second part also do not differ from what the literature tells us so far. The goal we set ourselves in the second part was also achieved. We show that trade policy and fiscal policy affect the stock market both domestically and in Japan and Canada and we also realize that Canada's EPU also affects the movement of the Japanese market. As proved by Tsai (2017), the U.S EPU affects the behaviour of the other indexes.

The results obtained by ji et al., (2020) are in line with the results obtained in this paper. Ji says that negative shocks in one national market may affect other stock markets and we can see this relationship when we notice that both the disaggregated EPU and the other macroeconomic indicators register a statistically significant influence with the rates of return of the indexes.

Bensaida and Litimi (2020) also found manifestations of contagion among the G10 countries, and the same results were found, since the USA, Japan, and Canada are three of the 13 countries that make up the G10. In other words, we can consider that the results are in line with those already presented in the literature, differing only in the number of countries studied in this article.

Another important component of the Stock Index is the companies that make up the index. Taking this aspect into consideration together with the study of Azimili (2022), where he shows that destabilizing events in a border market in the EU can trigger a liquidity crisis, once again it is evident that the fiscal policy that affects taxpayers and companies can influence their behavior and consequently the stock index of the country itself when this uncertainty takes on greater proportions.

Not being the main objective, we also realize the economic influence of the United States when the industrial production index also affects the stock market of the other countries under analysis.

We can then state that there is a relationship between the UBS and the development of the US stock market and there is also a contagion effect from the US stock market to the Japanese and Canadian markets. These are the answers to the two questions we initially asked and which we now see answered.

General, we can consider that the population's insecurity about the economy reflects the behavior that exists in the market. The higher the degree of uncertainty and insecurity, the lower the rate of return on the indices.

6.Conclusion

For the first goal we focused on studying to what extent the uncertainty that a population has regarding economic policies impacts the behavior of the stock index. For this analysis, the United States of America was chosen as a country given the availability of data for the desired time horizon, from January 2010 to August 2022.

As econometric methodology, the stationarity of the series was used to understand how the statistics of the series behave over time and the Time-varying LA-VAR Granger causality test to understand if the past values of a series influence the present values of another series.

The first part meets the intended goal. It is possible to prove that in the USA and similarly to the articles mentioned in the literature review there is a link between URP and the stock market. This work distinguishes itself for also being able to disaggregate the UPR in several economic areas to indicate which sectors impact the stock market the most.

With the second question we tried to understand the contagion effect of political uncertainty between three countries, namely the United States, Japan, and Canada. For this research we use a time horizon ranging from 1987 to 2022 to encompass periods of recession and economic expansion with monthly data. We used the aggregate EPU of the 3 countries as well as several strands of the EPU to filter which type of policies influenced society the most with respect to its confidence in stock markets.

Using Pearson's correlation allows us to see how the variables influence each other but does not allow us to draw strong statistical conclusions. To be able to draw strong statistical conclusions we used the Markov-Switching dynamic regression that allows us to divide the time horizon into two states, in this case of economic expansion and recession.

Regarding correlation, we can see that the independent variables of each country establish a relationship with the dependent variable of their country. On the other hand, we can see that there is also a correlation between the financial indicators of the United States and the stock markets analysed for Japan and Canada. However, and as already mentioned, the use of Pearson's correlation is insufficient for us to draw robust conclusions about the results.

To obtain more robust data and conclusions we use the Markov-Switching dynamic regression, this regression allows us to divide the time horizon into two states, namely the state of economic expansion and the state of economic recession.

The results obtained show us that in most of the equations tested we see that the EPU influences the behaviour of the indexes, especially the U.S. index which influences the Japanese and the U.S. indexes.

The DCC-MGARCH models show us that the aggregate EPU is not as statistically significant as expected, but there are still models where it is significant, as in the case of Canada.

We also notice that the EPU on trade and financial regulation are more often statistically significant than the EPU on monetary and fiscal policy. We too highlight the fact that the EPU of Canada also influences the behaviour of the chosen Japanese stock market.

After reviewing the results, it is important for policymakers to be able to communicate clearly so that there is no fear among the general population. Economic policy decisions can influence the masses and potentially cause significant damage to financial markets through the behavior of the population.

As future lines of thought it would be interesting to understand if events that accentuate the degree of uncertainty of the population accentuate or attenuate the influence of uncertainty in economic policies. Also, and given the connections between the United States and Europe, it would be interesting to understand which countries are more interconnected to the United States in what concerns financial markets.

One of another possibility is to limit the time horizon to a period of crisis such as the subprime crisis or the COVID 19 and to understand which variables significantly influence the performance of a stock index.

7. Bibliography

Azimli, A. (2022). The impact of policy, political and economic uncertainty on corporate capital investment in the emerging markets of Eastern Europe and Turkey. Economic Systems, 46(2). https://doi.org/10.1016/j.ecosys.2022.100974

Baker, S. R., Bloom, N., Davis, S. J., Jorring, A., Kost, K., Al-Kuwari, A., Biffar, S., Boehnke, J., Dashkeyev, V., Deriy, O., Dinh, E., Ezure, Y., Gong, R., Jindal, S., Kim, R., Klosin, S., Koh, J., Lajewski, P., Nebiyu, D., ... Katz, L. (2016). Measuring Economic Policy Uncertainty. www.policyuncertainty.com

Bai, L., Zhang, X., Liu, Y., & Wang, Q. (2019). Economic risk contagion among major economies: New evidence from EPU spillover analysis in time and frequency domains. Physica A: Statistical Mechanics and Its Applications, 535. https://doi.org/10.1016/j.physa.2019.122431

Baum, C. F., Hurn, S., & Otero, J. (2022). Testing for time-varying Granger causality. Stata Journal, 22(2), 355–378. https://doi.org/10.1177/1536867MP_EUA21106403

BenMim, I., & BenSaïda, A. (2019). Financial contagion across major stock markets: A study during crisis episodes. North American Journal of Economics and Finance, 48, 187–201. https://doi.org/10.1016/j.najef.2019.02.005

Bekaert, G., Harvey, C. R., & Ng, A. (2005). Market Integration and Contagion. https://doi.org/0021-9398/2205/7801-0001

Chang, K. L. (2022). Do economic policy uncertainty indices matter in joint volatility cycles between U.S. and Japanese stock markets? *Finance Research Letters*, *47*. https://doi.org/10.1016/j.frl.2021.102579

Chiang, T. C. (2019). Economic policy uncertainty, risk and stock returns: Evidence from G7 stock markets. *Finance Research Letters*, *29*, 41–49. https://doi.org/10.1016/j.frl.2019.03.018

Chiang, T. C. (2022). Evidence of Economic Policy Uncertainty and COVID-19 Pandemic on Global Stock Returns. *Journal of Risk and Financial Management*, *15*(1). https://doi.org/10.3390/jrfm15010028

Cui, J., Goh, M., Li, B., & Zou, H. (2021). Dynamic dependence and risk connectedness among oil and stock markets: New evidence from time-frequency domain perspectives. Energy, 216. https://doi.org/10.1016/j.energy.2020.119302

Dai, P. F., Xiong, X., Liu, Z., Huynh, T. L. D., & Sun, J. (2021b). Preventing crash in stock market: The role of economic policy uncertainty during COVID-19. Financial Innovation, 7(1). https://doi.org/10.1186/s40854-021-00248-y

Forbes, K., & Rigobon, R. (2000). Contagion in Latin America: Definitions, measurement, and policy implications. Conference "Internacional Financial Contagion: How It Spreads and How It Can Be Stopped." NBER Working Papers 7885, National Bureau of Economic Research, Inc.

Fromentin, V., Lorraine, M. S. H., ARIANE, C. P. E. R., & Alshammari, T. (2022). Time-varying causality between stock prices and macroeconomic fundamentals: Connection or disconnection? *Finance Research Letters*, *49*. https://doi.org/10.1016/j.frl.2022.103073

Ghani, M., Guo, Q., Ma, F., & Li, T. (2022). Forecasting Pakistan stock market volatility: Evidence from economic variables and the uncertainty index. *International Review of Economics and Finance*, *80*, 1180–1189. https://doi.org/10.1016/j.iref.2022.04.003

Gong, Y., He, Z., & Xue, W. (2022). EPU spillovers and stock return predictability: A cross-country study. Journal of International Financial Markets, Institutions and Money, 78. https://doi.org/10.1016/j.intfin.2022.101556

Hamilton, J.D., 1989. A new approach to the economic analysis of nonstationary time series and the business cycle. Econometrica, 357–384

Hu, Z., Kutan, A. M., & Sun, P. W. (2018). Is U.S. economic policy uncertainty priced in China's A-shares market? Evidence from market, industry, and individual stocks. International Review of Financial Analysis, 57, 207–220. https://doi.org/10.1016/j.irfa.2018.03.015

Jeon, J. H. (2018). The impact of Asian economic policy uncertainty: Evidence from Korean housing market. *Journal of Asian Finance, Economics and Business*, *5*(2), 43–51. https://doi.org/10.13106/jafeb.2018.vol5.no2.43

Ji, Q., Liu, B. Y., Cunado, J., & Gupta, R. (2020). Risk spillover between the US and the remaining G7 stock markets using time-varying copulas with Markov switching: Evidence from over a century of data. North American Journal of Economics and Finance, 51. https://doi.org/10.1016/j.najef.2018.09.004

Kho, B. C., Stulz, R. M., & Warnock, F. E. (2009). Financial globalization, governance, and the evolution of the home bias. Journal of Accounting Research, 47(2), 597–635. https://doi.org/10.1111/j.1475-679X.2009.00323.x

Liu, L., & Zhang, T. (2015). Economic policy uncertainty and stock market volatility. *Finance Research Letters*, *15*, 99–105. https://doi.org/10.1016/j.frl.2015.08.009

Li, S., Li, J., Lu, X., & Sun, Y. (2022). Exploring the dynamic nonlinear relationship between crude oil price and implied volatility indices: A new perspective from MMV-MFDFA. Physica A: Statistical Mechanics and Its Applications, 603. https://doi.org/10.1016/j.physa.2022.127684

Li, X., & Wei, Y. (2018). The dependence and risk spillover between crude oil market and China stock market: New evidence from a variational mode decomposition-based copula method. Energy Economics, 74, 565–581. https://doi.org/10.1016/j.eneco.2018.07.011

Manuel De Sousa Gabriel, V., Ramos, J., & Manso, P. (2015). Análise do contágio entre os mercados bolsistas internacionais no âmbito da crise financeira global. https://10.1590/0103-6351/2055

Ma, X., Zhang, Z., Ma, X., & Shen, Y. (2019). Measuring cross-category spillovers of policy-specific uncertainty in China. *Economics Letters*, *183*. https://doi.org/10.1016/j.econlet.2019.108611

Ng, A. (2000). Volatility spillover effects from Japan and the US to the Pacific-Basin. In Journal of International Money and Finance (Vol. 19). www.elsevier.nl/locate/econbase

Nong, H. (2021). Have cross-category spillovers of economic policy uncertainty changed during the US–China trade war? *Journal of Asian Economics*, *74*. https://doi.org/10.1016/j.asieco.2021.101312

Plachý, R., & Rašovec, T. (2015). Impact of economic indicators on development of capital market. *E a M: Ekonomie a Management*, *18*(3), 101–112. https://doi.org/10.15240/tul/001/2015-3-010

Raifu, I. A. (2022). Examining the Time-Varying Causality Between Oil Returns and Stock Returns in Norway. *Energy* Researcuh letters,, *3*(Early View), 1–9. https://doi.org/10.46557/001c.37693

Raifu, I. A. (2022). Examining the Time-Varying Causality Between Oil Returns and Stock Returns in Norway. Energy Researcuh letters, 3(Early View), 1–9. https://doi.org/10.46557/001c.37693

Rehman, M. U., Asghar, N., & Hussain, J. (2019). Are disaggregate industrial returns sensitive to economic policy uncertainty. *Physica A: Statistical Mechanics and Its Applications*, *527*. https://doi.org/10.1016/j.physa.2019.121301

Sharif, A., Aloui, C., & Yarovaya, L. (2020). COVID-19 pandemic, oil prices, stock market, geopolitical risk and policy uncertainty nexus in the US economy: Fresh evidence from the wavelet-based approach. International Review of Financial Analysis, 70. https://doi.org/10.1016/j.irfa.2020.101496

Shi, S., Hurn, S., & Phillips, P. C. B. (2020). Causal change detection in possibly integrated systems: Revisiting the money-income relationship. *Journal of Financial Econometrics*, *18*(1), 158–180. https://doi.org/10.1093/JJFINEC/NBZ004

Shi, S., Phillips, P. C. B., & Hurn, S. (2018). Change Detection and the Causal Impact of the Yield Curve. *Journal of Time Series Analysis*, *39*(6), 966–987. https://doi.org/10.1111/jtsa.12427

Shi, S., Hurn, S., & Phillips, P. C. B. (2020). Causal change detection in possibly integrated systems: Revisiting the money-income relationship. Journal of

Financial Econometrics, 18(1), 158–180. https://doi.org/10.1093/JJFINEC/NBZ004

Tsai, I. C. (2017). The source of global stock market risk: A viewpoint of economic policy uncertainty. Economic Modelling, 60, 122–131. https://doi.org/10.1016/j.econmod.2016.09.002

Zeng, Q., Lu, X., Dong, D., & Li, P. (2022). Category-specific EPU indices, macroeconomic variables and stock market return predictability. *International Review of Financial Analysis*, *84*. https://doi.org/10.1016/j.irfa.2022.102353

Xu, Y., Wang, J., Chen, Z., & Liang, C. (2021). Economic policy uncertainty and stock market returns: New evidence. The North American Journal of Economics and Finance, 58, 101525. https://doi.org/10.1016/j.najef.2021.101525

8. Attachments

Table 5-Time-varying LA-VAR Granger causality test including trend (99th percentile of test statistics)

	Max Wald Recursive		**Max wald recursive**
	Ho: SP is GC		Ho: IPI is GC
IPI	18.28	**SP**	20.15
PM	19.06	**PM**	18.7
FP	16.58	**FP**	16.14
RP	14.80	**RP**	15.51
	Ho: PM is GC		Ho: FP is GC
SP	14.93	**SP**	16.01
IPI	13.29	**IPI**	15.01
FP	20.74	**PM**	25.24
RP	21.72	**RP**	18.2
	Ho: RP is GC		
SP	15.41		
IPI	16.27		
PM	20.64		
FP	16.54		

Legend: IPI- Industrial Production index; SP- S&P500; PM- Monetary policy; FP- Fiscal policy; RP-Financial regulation policy

Table 6- Equation 1

	SP	**NIK**	**TSX**	**EPU_EUA**	**EPU_JP**	**EPU_CAN**	**IPI_EUA**
SP	1						
NIK	0.5511***	1					
TSX	0.7938***	0.5013***	1				
EPU_EUA	-0.1977*	-0.1133	0.1333*	1			
EPU_JP	-0.1314*	-0.1550*	0.1899***	???	1		
EPU_CAN	-0.1289*	-0.0750	-0.1401*	0.4210*	0.2004*	1	
IPI_EUA	0.2392*	0.1451*	0.2865*	-0.1173	-0.0017	-0.0354	1
IPI_JP	0.0964	0.1083	0.1089	-0.0454	0.0074	-0.0167	0.3121*
EPU_EUA	0.1954*	0.1643*	0.223*	-0.0631	-0.0328	-0.0001	0.6728*
IPC_EUA	0.1766*	0.1784*	0.3281*	0.0453	-0.0052	-0.0171	0.2140***
IPC_JP	0.0106	-0.0399	0.3281***	0.0453	-0.0269	0.1366***	0.0154

EPU_JP	0.0776	0.0679	0.1481***	-0.0263	-0.046	0.0092	0.1255**

	IPI_JP	**IPI_CAN**	**IPC_EUA**	**IPC_JP**	**IPC_CAN**
IPI_JP	1				
w1	0.2105***	1			
IPC_EUA	0.1673***	0.1899***	1		
IPC_JP	-0.0299	0.0326	0.0639	1	
IPC_CAN	0.0279	0.1413***	0.5143***	-0.0026	1

Table 7- Equation 2

	SP	**IPI_EUA**	**MP_EUA**	**FP_EUA**	**FR_EUA**	**TP_EUA**	**IPC_EUA**
SP	1						
IPI_EUA	0.2392***	1					
MP_EUA	- 0.1301***	-0.0140	1				
FP_EUA	- 0.1477***	-0.0741	0.5020**	1			
FR_EUA	-0.0876	-0.855	0.2521***	0.1836***	1		
TP_EUA	-0.1505**	0.03384	0.1685***	0.1813***	0.0493	1	
IPC_EUA	0.1766***	0.2140***	0.0623	0.0149	0.0482	-0.0017	1
IPI_JP	0.0964	0.3121***	0.0224	-0.0381	0.0008	0.0410	8.1673***
MP_JP	-0.0943*	0.0712	0.2026***	0.1875***	0.0484	0.0019	-0.0325
FP_JP	-0.1109**	-0.0175	0.1803***	0.2040***	0.0876*	0.0447	-0.0054
TP_JP	-0.0795	0.0210	-0.0168	0.129***	0.0302	0.1362***	-0.0285
IPC_JP	0.0106	0.0154	0.0007	0.0235	-0.0574	0.0611	0.0639

	IPi_JP	**MP_JP**	**FP_JP**	**TP_JP**	**IPC_JP**
IPi_JP	1				
MP_JP	0.0432	1			
FP_JP	0.0134	0.4833***	1		
TP_JP	-0.099	0.1836***	0.3361***	1	
IPC_JP	-0.0299	-0.0050	0.0098	-0.0118	1

Table 8- Equation 3

	TSX	**IPI_CAN**	**IPC_CAN**	**IPI_EUA**	**MP_EUA**	**FR_EUA**	**FR_EUA**
NIK	1						
IPI_EUA	0.1451***	1					
MP_EUA	-0.0556	-0.0140	1				
FP_EUA	-0.1175	-0.741	0.5020***	1			
FR_EUA	-0.0569	-0.0855	0.5251***	0.1836***	1		
TP_EUA	-0.0402	0.0384	0.1685***	0.1813***	0.0493	1	

IPC_EUA	0.1784***	0.2140***	0.0623	0.0149	0.0482	-0.0017	1
IPi_JP	0.1083	0.3121***	0.0224	-0.0381	0.008	0.0410	0.1673
MP_JP	-0.0978	0.0712	0.2026	0.1875	0.0484	0.0019	-0.0325
FP_JP	-0.1051	-0.0175	0.1803***	0.2040***	0.0876	0.0047	-0.0054
TP_JP	-0.0806	0.0210	-0.0168	0.129***	0.0302	0.1362***	-0.0285
IPC_JP	-0.0399	0.0154	0.0007	0.0235	-0.0574	0.0611	0.0639

	IPi_JP	**MP_JP**	**FP_JP**	**TP_JP**	**IPC_JP**
IPi_JP	1				
MP_JP	**0.0432**	1			
FP_JP	**0.0134**	**0.4833*** **	1		
TP_JP	**-0.099**	**0.1836*** **	**0.3361*** **	1	
IPC_JP	**-0.0299**	**-0.0050**	**0.0098**	-0.0118	1

Table 9-Equation 4

	TSX	**w1**	**w2**	**IPI_EUA**	**MP_EUA**	**FR_EUA**	**FR_EUA**
TSX	1						
IPI_CAN	0.223***	1					
IPC_CAN	0.2865***	0.1413***	1				
IPI_EUA	0.2865***	0.6728***	0.1255***	1			
MP_EUA	-0.1054**	0.0038	0.0022	-0.0140	1		
FP_EUA	-0.1127	-0.0413	-0.0543	-0.0741	0.5020	1	
FR_EUA	-0.0421	-0.0466	0.0235	-0.0855	0.2521***	0.1836***	1
TP_EUA	-0.0303	-0.0259	0.0005	0.0384	0.1685***	0.1813***	0.0493
IPC_EUA	0.3281***	0.1899***	0.5143***	0.2140***	0.0623	0.0149	0.0482
IPI_JP	0.1089	0.2105***	0.0279	0.3121***	0.0224	-0.0381	0.0008
MP_JP	- 0.1274***	0.0581	-0.0436	0.0712	0.2026***	0.1875***	0.0876
FP_JP	-0.1235	-0.0341	-0.0293	-0.0175	-0.1803	0.2040***	0.0876
TP_JP	-0.0890	0.0300	-0.0302	0.021	-0.0168	0.129***	0.0302
IPC_JP	-0.0116	0.0326	-0.0026	0.0154	0.0007	0.0235	-0.0574

	TP_EUA	**IPC_EUA**	**IPi_JP**	**MP_JP**	**FP_JP**	**TP_JP**	**IPC_JP**
TP_EUA	1						
IPC_EUA	-0.0017	1					
IPi_JP	0.0410	0.1673***	1				
MP_JP	0.0019	-0.0325	0.0432	1			
FP_JP	0.0047	-0.0054	0.0134	0.4833***	1		
TP_JP	0.1362***	0.0285	-0.099**	0.1836***	0.3361***	1	
IPC_JP	0.0611	0.0639	-0.0299	-0.005	0.0098	-0.0118	1