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How Currency Crises Impact on Stock Markets: A Cointegration Analysis

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Master in Finance

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ISCTE Business School

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ISCTE BUSINESS SCHOOL

Department of Finance

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Dedicated to my family

Acknowledgements

The last year, during which I combined the research and writing of this dissertation with a full-time job at Siemens Healthineers, was a sometimes difficult one. At times I thought it was going to be impossible to balance the two, as well as my family life, but as everything in life, it is only after going through the obstacles that we know the level of difficulty, the cost and how to do it. We also realize that nothing is possible without a purpose, resoluteness, the setting of goals, personal stability and being surrounded by people who support us.

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Resumo

Esta dissertação tem como objetivo estudar o impacto das crises cambiais nas bolsas de valores e concluir sobre a existência de relações de cointegração ao estimar as equações de cointegração usando modelos VECM.

Tendo em conta as crises cambiais do Rublo Russo, Yuan Chinês, Libra Britânica e Lira Turca, foram recolhidas amostras para cada moeda e subsequentemente divididas em três períodos temporais: período antes, durante e depois da depreciação da moeda. A dissertação analisa a conexão entre os resultados diários das moedas e índices de ações escolhidos de cada país onde a crise ocorreu e de cada continente (índices americanos, europeus e asiáticos) de forma a compreender se existe cointegração entre os mercados de ações e as moedas estudadas.

Os resultados sugerem a existência de interdependência entre as crises cambiais e os mercados de ações, concluindo que as crises cambiais fortaleceram e reforçaram os co-movimentos dos mercados. Existe maior proximidade da Rússia aos mercados europeus, o crescimento do mercado americano e britânico levam ao refortalecimento do Yuan Chinês em relação ao Dólar e do Dólar em relação à Libra, respetivamente, o Brexit teve maior impacto no mercado europeu que no britânico, a maioria das moedas tiveram uma recuperação lenta, as crise cambiais tiveram impacto nos mercados globais e finalmente o FTSE100 e Shanghai Composite Index depois da crise cambial apresentaram melhores resultados do que no período antes da crise, saindo refortalecidos.

Palavras-chave: Crises cambiais, Mercados de ações, Séries temporais, Cointegração.

JEL Sistema de Classificação: C32 (Modelos de Séries Temporais), G01 (Crises Financeiras).

Abstract

This dissertation aims to study the impact of currency crises on stock markets and to conclude on the existence of cointegration relationships through the estimation of cointegrating equations using VECM models.

Taking into account the currency crises of the Russian Ruble, Chinese Yuan, British Pound and the Turkish Lira, different samples were collected for each currency and subsequently divided in three time periods: the period before, during and after the currency depreciation. The dissertation analyses the connection between the daily results of the exchange rates and the stock indexes chosen from each country where the crisis occurred and from each continent (American, European and Asian indexes) in order to understand whether there is cointegration between the stock markets and the currencies studied.

The results suggest the existence of interdependence between currency crises and stock markets, concluding that currency crises strengthened and reinforced the markets co-movements. There is a greater proximity of Russia to European markets, the growth of the American and British markets lead to a strengthening of the Chinese Yuan against the Dollar and the Dollar against the Pound, respectively, Brexit had a greater impact on European markets than on British, most currencies had a slow recovery, currency crises had an impact on global markets and finally the FTSE 100 and Shanghai Composite Index after the currency crisis showed better results than in the period before the crisis, coming out stronger.

Key words: Currency crises, Stock markets, Time series, Cointegration.

JEL Classification System: C32 (Time-Series Models), G01 (Financial Crises).

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CHAPTER 1

Introduction

Currency crises occur when a currency faces high volatility that causes a sudden and severe drop in the value of the currency leading to speculation in the forex market. The main reasons for its occurrence are due to central bank policies that slow the economy, economic sanctions, wars, market panic, over-reliance on foreign investment/debt and pure speculation. Currency crises have such an overwhelming impact on the global economy that it is essential to understand what are the main impacts and consequences on the stock markets.

The relationship between stock prices and exchange rates has motivated financial research in recent times and contributed to the expansion of econometric models. Nowadays, investors are more attentive and sensitive to financial news around the world. Thanks to globalization, the world has become a global village due to capital market liberalisation, free trade agreements and technology, that makes information available worldwide at a rate of few seconds. This high interdependence has increased the effects of an economy's shocks as they spread to the rest of the world and economies have developed into a more integrated structure. Consequently, investment decisions must be taken according to the correct information and investors have become more cautious about market cointegration.

Most financial time series are generated by nonstationary processes. In periods of speculative bubbles, the rates of return in financial markets are nonstationary explaining why the instability in currency markets can last longer. Previous studies suggest that currency crises have strengthened and reinforce the interdependence of global markets. The relationship between stock markets has been found to be much less pronounced before currency crises, then increased drastically during the crash and the co-movement begins to decrease after it. However, co-movements generally persist after crises and remain stronger in some economies.

When a currency crisis occurs, it is expected that exchange rates and stock markets that initially followed different paths, after the crisis become cointegrated. Cointegration is a rigorous way of defining a stable long-term relationship between time series over time, which may reflect the equilibrium relationship[1]. In other words, it is expected that the different

[1] For this reason it has become an important statistical property in contemporary time series analysis.

variables become somehow linked to each other, being possible to predict one in terms of the others.

The long-term relationship between exchange rates and stock indices is the basis of the Vector Error Correction Model (VECM). The VECM is a multiple equation model in which we regress the variation of each variable as a function of the variation of the other variables. Our study aims to use the VECM for stock indices to capture their dynamic relations with exchange rates and to compare these relations before, during and after the currency crisis, in order to study the impact of currency crises on stock markets based on cointegrating equations. There are as many equations as the number of variables to include in the model. Opposite to VAR, which only has stationary variables on both sides of the equation, the VECM introduces non-stationary data that allows to capture the long-term relationship between time series variables. This way, the VECM allows to interpret both long-term and short-term equations through the error correction method[2].

Vector error correction modelling is done step by step under the Johansen procedure, that comes in two asymptotically tests: the Trace Test and the Maximum Eigenvalue Test. The Johansen test is a cointegration test for large samples that allows for the possibility of more than one cointegration relationship. Cointegration tests identify scenarios in which two or more non-stationary time series are integrated in such a way that they do not deviate from equilibrium in the long run. If two time series are separately first-order integrated (I(1)) but some cointegrating vector of coefficients can form a stationary linear combination, then the time series are said to be cointegrated. This stationary linear combination is called cointegrating equation and can be interpreted as the long-term equilibrium relationship between the time series variables.

A cointegrating equation can be interpreted as a relationship between the exchange rate and the stock prices in which the current stock prices are a linear combination of historical exchange rates. The cointegrating equation, being a linear relationship between different time series, can lead to the existence of more than one cointegrating equation or linear combination able to describe the relationship between more than two time series. The Trace Test and the Maximum Eigenvalue Test of the Johansen procedure indicate, by the rank r, the number of cointegration relationships present in the model.

[2] By adding error correction terms to a multifactorial VAR model

This dissertation analyses the impact of currency crises on stock markets. Taking into account some of the most important currency crises – the Russian Ruble (2014), Chinese Yuan (2015), British Pound (2016) and Turkish Lira (2018) – different samples were collected for each currency and subsequently divided in three time periods: the period before the currency depreciation, the period during its depreciation and the period after the depreciation (or when it begins to stabilize). This study analyses the connection between the exchange rates' daily results and the stock indexes chosen from each country (where the crisis occurred) and from each continent (American, European and Asian indexes) in order to understand if there are cointegration relationships between the stock markets and the currencies studied.

The dissertation is organized as follows: Chapter 2 presents a short description of the variables included and the respective time period of data collected for each currency crisis. It can be observed the number of observations, the source from which the data was collected and why it was chosen to use exchange rates denominated in USD. A brief overview of currency crises and stock markets is presented in Chapter 3, in which there is a theoretical overview and the main empirical studies already carried out on this topic, as well as the research methods followed and the conclusions reached. The methodology that has been used is introduced in Chapter 4, starting with a brief review of cointegration and followed by topics such as non-stationarity, VECM, cointegration tests and cointegrating equations. The empirical findings are shown in Chapter 5, where additionally, to validate the consistency and adequacy of the model, the residual analysis was carried out taking into consideration diagnostic tests for residual autocorrelation, non-normality and conditional heteroskedasticity. Finally, the conclusions are presented in Chapter 6.

CHAPTER 2

Currencies and stock indexes: variables description

The analysis focuses on some of the most important currency crises: the Russian Ruble (2014), Chinese Yuan (2015), British Pound (2016) and Turkish Lira (2018). Different samples were collected for each currency and subsequently divided in three periods: the period before currency depreciation, the period during depreciation and the period after depreciation (when the currency starts to recover or when it begins to stabilize). This study analyses the connection between the exchange rates daily results and the stock indices chosen from each country (where the crisis occurred) and from each continent (American, European and Asian indices), in order to understand if there is any cointegration relationship between the stock markets and currencies studied. For each currency crisis, it was necessary to focus on different time periods, depending on when the crisis occurred, as per table 2.1.

Currency Exchange rate	**Period before the crisis**	**Period during the crisis**	**Period after the crisis**	**Stock Index (of each country)**	**Stock Index (general)**
Russian Ruble RUB/USD (n = 1267)	9th September 2012 – 5th July 2014 (n = 471)	6th July 2014 – 16th January 2016 (n = 395)	17th January 2016 – 1st August 2017 (n = 401)	RTS Index	S&P Global 1200
Chinese Yuan CNY/USD (n = 1059)	1st April 2014 –31st July 2015 (n = 346)	1st August 2015 – 23rd January 2017 (n = 384)	24th January 2017 – 1st May 2018 (n = 329)	Shanghai Composite Index	S&P 500
British Pound GBP/USD (n = 720)	16th April 2015 – 22nd June 2016 (n = 308)	23rd June 2016– 4th March 2017 (n = 182)	5th March 2017 – 19th January 2018 (n = 230)	FTSE 100	S&P Europe 350
Turkish Lira TRY/USD (n = 850)	20th November 2016 – 2nd September 2017 (n = 204)	3rd September 2017 – 31st August 2018 (n = 259)	1st September 2018 – 1st March 2020 (n = 387)	BIST 100	S&P Asia 50

Table 2.1 – Main variables and respective time period of data collected for each crisis.

The time series sample data was collected from Barchart and comprises daily currency and stock closing prices from each of the periods that have been chosen. As previously indicated, the main variables are the exchange rates (Russian Ruble, Chinese Yuan[3], British Pound and Turkish Lira) denominated in USD, in second place each exchange rate was analysed taking into account each country's main index (RTS Index, Shanghai Composite Index, FTSE 100 and BIST 100) and the worldwide general stock index (S&P 1200). If there is no cointegration with the S&P 1200, the analysis with indexes from each continent will follow (S&P 500, S&P Europe 350 and S&P Asia 50) in order to particularize the study to more specific regions of the world.

Exchange rates have been responsible for the convergence in several markets by presenting an estimated threshold close to zero, while real effective exchange rates have not. Thus, we chose to use exchange rates as they have greater explanatory capacity than real effective exchange rates.

Figure 2.1 shows the currency composition of global reserve holdings:

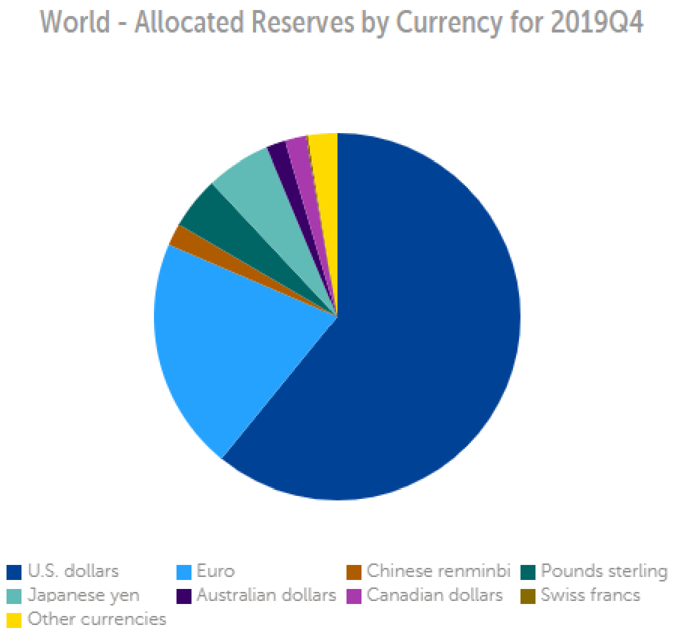

Figure 2.1 – World-Allocated Reserves by Currency for 2019Q4 [4]

As the USD is the major currency in terms of official foreign exchange reserves, responsible for the composition of more than 60% of global reserve holdings, we chose to

[3] The Chinese Yuan is also denominated as Renminbi (RMB).
[4] Source: IMF https://data.imf.org/?sk=E6A5F467-C14B-4AA8-9F6D-5A09EC4E62A4

denominate the exchange rates of this study in USD, in order to reach more reliable and accurate conclusions about the impact of currency crises on stock markets.

Finally, we present a brief description of each stock index mentioned in table 2.1:

- RTS Index: it is the official indicator of the Moscow Stock Exchange based on the prices of the 50 most liquid Russian stocks.
- Shanghai Composite Index: is a stock market index of all stocks traded on the Shanghai Stock Exchange.
- FTSE 100: is a stock index composed of the 100 largest market capitalization companies listed on the London Stock Exchange.
- BIST 100: is an abbreviation of the Borsa Istanbul 100 Index and is composed of companies in the Turkish national market selected under pre-determined criteria, being used as the main indicator of the domestic market.
- S&P Global 1200: is a global stock index of Standard & Poor's that measures the performance of the 1200 largest multinational companies, covering 31 countries and almost 70% of global stock market capitalization. It covers indexes such as the S&P 500, S&P 350 and S&P 50.
- S&P 500: is an American index composed of 500 assets listed on the NASDAQ Stock Exchange and qualified due to their liquidity, market size and representativeness of a particular industrial group.
- S&P Europe 350: is a stock index composed of European stocks selected due to their relevance to the broad market, share liquidity, longevity and industrial sector balance.
- S&P Asia 50: is an Asian stock index composed of companies listed on the Hong Kong, Singapore, South Korea and Taiwan stock exchanges.

CHAPTER 3

Currency crises and stock markets: an overview

In his first speech as president of the European Central Bank, Mario Draghi said that "In today's global economy, advanced economies can face some of the same distress that was earlier associated with emerging economies (...) At the same time, and going forward, the emerging economies will be confronted with the challenges that have long concerned advanced economies". Something that both economies would have to face was currency crises. Currency crises have such an overwhelming impact on the global economy that it is essential to understand what are the main impacts and consequences on the stock markets. Many studies have pointed to the existence of a significant relationship between stocks and currency markets.

3.1 Theoretical Overview

The flow-oriented approach (Dornbusch and Fisher, 1980) states that exchange rate changes have immediate effects on stock markets. In this case, domestic currency appreciation (depreciation) implies a negative (positive) impact on the country's export competitiveness and will decrease (increase) the stock prices, leading to a positive relationship between stock prices and exchange rates depreciation. On the other hand, the portfolio balance theory poses that the rising stock prices tends to increase income (wealth) and it can have a positive effect on interest rates and domestic money demand. By rising the interest rate it encourages capital inflows (investors become attracted to invest their money in the country) and leads to an increase in the demand of domestic currency causing the currency appreciation.

The causes of currency crises to occur are explained through time on the literature by three so-called generation models. The first generation models state that inconsistencies between a fixed exchange rate and government policies lead to speculative attacks that become concentrated on the relationship between the probability of a currency crisis and the fundamental variables (mainly fiscal deficits, measures of economic activity, credit growth and current account). The second generation models highlighted the importance of investors' expectations as a factor that leads to currency crises when the macroeconomic fundamentals significantly determine the range of agents' equilibrium. The third generation models[5] focus on

[5] The third generation models were created to substitute the previous two that failed on explaining the causes of more recent currency crises.

the degree of liquidity of the banking system and the existence of government guarantees in which a substantial amount of short-term external liabilities, weak banking supervision and a high ratio of non-performing loans-to-gross loans are indicated as increasing the risk of a crisis (Grabowski and Welfe, 2019).

The diversification of portfolios, in which as the number of assets increases, leads to an intensification in the search for additional information regarding their status or development and consequently culminates in different accesses to information, that is, asymmetry. As consequence, investors end up relying on information that is not supported by fundamentals. In currency markets, this effect can occur from signs of deteriorating macroeconomic conditions in a country that may trigger investors to a massive capital outflow not only from that country but also from the neighbouring countries. The herd effect states that a sudden depreciation of one country's currency causes the currency of another country in the same region to follow suit.

The existing empirical study provides evidence that most financial time series are generated by nonstationary processes. In periods of speculative bubbles, the rates of return in financial markets are nonstationary explaining why the instability in currency markets can last longer. Previous studies suggest that currency crises have strengthened the interdependent relationship with global stock markets. However, co-movements generally persist after crises and remain stronger in some economies. The relationship between stock markets has been found to be much less pronounced before currency crises, then increased drastically during the crash and the co-movement begins to decrease after it. As the integration of financial markets deepens, the correlations among stock markets become stronger. The higher co-movement in global stock markets during crisis period may reflect that more common shocks were shared between them being it also stimulated by the overall panic among investors. It can be concluded that currency crises reinforce the interdependence of global markets (Jiang *et al.*, 2017).

3.2 Currency crises

Turkey was ranked in 2000's as the leading economic power of Middle East and lived in prosperity and financial stability until 2016. The financial market had a fast growth due to financial liberalization, structural changes, abolition of the currency peg, institutional improvements and trade liberalization that combined with favourable global financial conditions led to the increase of foreign capital inflows.

Unfortunately, in the past few years, Turkey has suffered several problems that have caused negative impacts on markets performance. Political instability, higher volatility of

Turkish Lira, excessive foreign currency debt, deteriorating business climate, excessive current account deficits, terrorism, higher dollarization on Turkish firms liabilities and weak growth combined with the fall of the Turkish Lira (represented by its depreciation against other major currencies such as the USD and the EUR) have negatively affected the inflation, liquidity, interest rates, asset prices and foreign investors' expectations toward Turkish markets (Kassouri and Altintas, 2020).

Turkey went through an economic and financial crisis in 2018. The Turkish currency crash occurred on August 10, 2018 when the lira plunged in value by 18%, the highest single day drop of since the currency devaluation in 2001 (Arbaa and Varon, 2019). Similarly to other developing countries, Turkey's financial reserves became mainly constituted by US dollars, making the Turkish Forex market more sensitive and volatile to external conditions and for that reason the financial market behaviour in emerging countries is better explained by US dollar variations. The Central Bank of the Republic of Turkey reported net foreign reserves stood at $28.1 billion in April 2019 strengthening its foreign currency reserves with $13 billion dollars in short-term loans, which left analysts and investors afraid to invest their money in Turkish markets due to a potential market crisis (Pitel and Samson, 2019).

Mechri *et al.* (2019) proved the very significant impact of the exchange rate on stock market fluctuations in Turkey. According to Kassouri and Altintas (2020) there is an asymmetric threshold long-run relationship (cointegration) between stock and Forex markets in Turkey being possible to predict one from another, violating the efficient market hypothesis and implying that they are asymmetrically interdependent. Asymmetric threshold indicates that stock prices have different reactions to positive or negative shocks in exchange rates. The conclusion is similar between stock prices and the USD/TRY exchange rate but the estimated threshold value decreases from 0.0115 to 0.0041. As the USD/TRY exchange rate presents an estimated threshold close to zero, it has more explanatory ability of asymmetric cointegration between exchange rates and stock prices providing more evidence on the time-varying dependence between both markets. The USD/TRY exchange rate is responsible for the convergence in Turkish markets. On the other hand, the real effective exchange rate is not adjustable to any financial markets disequilibrium, sustaining that financial market behaviour in emerging countries is better explained by US dollar variations.

The study concluded that the "estimated long-run coefficient of exchange rates is negative and statistically significant during [exchange rate] appreciation while the coefficient associated with exchange rate depreciation is no significant", being the asymmetric long-run impact of USD/TRY exchange rate on stock prices statistically significant with exchange rate appreciation while with depreciation is not significant.

The "results suggest that a 1% appreciation of the Turkish Lira against the USD leads to 1.64% decrease in the expected value of the stock prices", i.e. "following Lira appreciation, the long-run pass through to stock prices is estimated to be -1.64". This means that an appreciation of the Lira reduces companies' exports and has a negative impact on stock markets. This finding was expected due to Turkey's economic structure and its major dependency on foreign intermediate inputs and exports of low-value added goods, where a domestic currency appreciation leads to a lower capacity to export them.

This shaping of the Turkish market with the rest of the world together with an underdeveloped national economy has led to greater sensitivity to the impact of exchange rate variations on stock prices in the long run. The long-term exchange rate coefficients indicate that the Turkish stock market is more sensitive to the appreciation of the exchange rate, confirming the asymmetric effect of the Turkish lira on share prices. Positive and negative shocks in the USD/TRY exchange rate have a time-deferred impact on stock markets, with the equilibrium correction being achieved in almost 40 months.

The least expected currency crisis in the past years was caused by Brexit. Britain decided to leave the EU on June 23, 2016 when the UK voted in the referendum to leave the EU with a result of 52% vs. 48%. The EU is one of the most important trading partners for the UK, accounting for half of its goods exports. The free trade agreement with the EU allows the UK to trade freely with more than 60 countries. Now, with the referendum, the future relationship between the UK and the EU is still not entirely clear. The expectations of market participants and investors are reflected in the financial markets. Brexit had an immediate negative impact on exchange rates, indicating that it was a big surprise for the forex market. In the stock market, the referendum had a significant negative effect on the British and European market indices. It was therefore an unexpected event for the financial markets.

Chen *et al.* (2018) performed a comparative analysis of pairwise dynamic integration of US, Eurozone and UK stock markets and concluded that the degree of correlation and cointegration between stock markets increases during periods of high volatility and uncertainty. In contrast, it is possible to observe a weaker correlation and cointegration between stock markets during the recovery periods. Exchange rate fluctuations also influence the integration between stock indexes. Risk diversification on investing in the stock markets is limited during periods of financial and political shocks.

According to Garcia and Rodrigues (2019), there is a cointegration relationship between the STOXX50 Index, FTSE100, USD/EUR and USD/GBP, meaning that each of the variables are predictable based on the past values of the other three and they have a long-run relationship. These findings confirm the belief that there is an association between stock prices and exchange rates and, therefore, investors can use information about currency markets to improve the forecast of stock prices.

Tabeshian (2018) conducted an event study (considering July 23, 2016 as the event day) on the historical volatilities of the UK and EU financial markets that pointed to heteroskedasticity or ARCH effects on the returns of FTSE100. The study states that the volatility after the referendum is lower than the volatility before the referendum. The uncertainty before Brexit brought an increase in volatility. After the referendum, the fact that people realized the result and the interest rate cut by the central bank led investors to ask for a lower risk premium, which consequently reduced the stock market's volatility.

The author proposed several hypothesis tests for the study. Regarding the currency markets, there were two hypothesis tests. The first was that Brexit had (no) negative effects on currency markets on the event day or Brexit was (not) a surprise for the markets; the second was that the effects of Brexit on the pound sterling were less (greater) than on the euro at the event day. For the stock markets, the hypotheses are similar: Brexit had (no) negative effects on stock markets on the event day or Brexit was (not) a surprise for the markets; and the effects of Brexit on British indices were less (greater) than on the European indices at the event day.

Tests concluded that the abnormal returns of -8.37% on that day for the GBP/USD exchange rate, -5.96% for GBP/EUR and -2.42% for EUR/USD point for the fact that "Brexit had a significant negative impact on the currency market at the event day" and "the impact of Brexit on pound sterling was much greater than on the euro". Surprisingly, in the case of stock markets, the FTSE100 and FTSE EUROTOP100 had on that day abnormal returns of -3.16% and -6.58% respectively, pointing to the fact that "Brexit was a surprise for these two indices and (…) the negative abnormal return for the European index is greater than the British one", due to the involvement of British companies in the European index, causing overestimated effects of the event on that index. The post-event window analysis gives information on the existence of positive abnormal returns for FTSE 100 and DAX pointing to a relationship between the currency markets and the stock markets. A weaker pound may have led to higher US dollar income for companies included in the FTSE 100, which helped the market to recover after the referendum.

On the other side of the world, China has been recording a lasting surplus in current and capital accounts over the years. The increase in foreign direct investment associated with a net foreign trade surplus has created the highest value in foreign reserves ever recorded. Despite the increased inflow of foreign currencies with China's accession to the World Trade Organization (WTO), the capital account was still partially under the control of Chinese authorities. In response to international criticism, China has allowed an appreciation of the yuan (or Renminbi - RMB) over time and, to promote the use of the yuan abroad, policymakers have allowed some yuan-denominated transactions abroad by opening the capital account. In 2013, the National Congress of the Communist Party of China reinforced its commitment to a greater concession for the market in setting the exchange rate, aiming at a greater degree of internationalisation of the yuan.

In April 2015, Chinese state media advised domestic investors to invest in the stock market, giving the perception that the government would support a bull market (in which a large portion of security prices are constantly rising) in order to subsequently avoid a sharp fall and consequently a financial crisis. As a result, the SSE Index rose 36% in three months from 3810 points to 5166 points in June. When investors realised the potential for a bubble, the Shanghai Stock Exchange Index dropped 43% from 5166 points on June 12 to 2927 points on August 26. The capital flight from China reached 42.5 billion USD in July 2015 and 93.9 billion USD in August.

Despite China is the world's second major economy, its financial system is less developed and is sensitive to market volatility. The objective to internationalise the renminbi remains in progress. According to Li (2015) the fall of the RMB "seems more a part of the RMB internationalisation process than an arbitrary move to rescue China's economic slowdown" due to low export indices and "After the RMB devaluation on 11 August, the IMF also endorsed it as a step toward market-oriented [currency] reform". For China, international acceptance of the yuan has been a priority over its foreign policy, leading China to offer political benefits and favourable financing conditions for companies and countries that intend to use the yuan. Despite that, CNY assets are limited in both availability and liquidity, with capital controls by China that restrict trade in yuan-denominated assets and a range of legal obstacles.

The Chinese GDP growth slowed from 11% a year in 2010 to 6% a year currently. The slowdown in China's growth is not transitory as it is mainly due to domestic structural factors and is therefore a long-term phenomenon. The increased risk due to soaring indebtedness and the risks of the domestic financial sector combined with pro-democracy protests in Hong Kong and the US-China trade war increase the likelihood of an abrupt slowdown in the Chinese economy. China's market size is almost equal to the euro area with a nominal GDP of 13.9 trillion USD in 2018 and representing almost 19% of global output above that of the US (Nuutilainen and Rautava, 2020).

The same author states that economic relations between China and Russia have developed favourably mainly due to Russia's oil exports to China. In 2015, Russia announced that it was adding the Chinese Yuan to foreign currency reserves. The yuan has become almost 15% of Russian reserves (worth 68 billion USD), which means that Russia currently holds a third of the global yuan reserves. This increase of the yuan in currency reserves has helped China to reach its yuan internationalization aspirations. Although this relation has improved the trade situation in both countries, Russia's dependence on commodity exports has also increased. China's growth slowdown will be particularly challenging for Russia in finding alternatives to Chinese demand, being estimated that in a worst case scenario in which the Chinese GDP falls 9% in a 3-year horizon, oil prices will fall 12% and oil-producing countries as Russia will face a 3%-4% drop in GDP over the same 3-year horizon.

Russia's annexation of Crimea led to a breakdown in the relations with Europe and the US. The growing role of the Russian government in the economy and protectionist policies have reinforced its unbalanced economic structure, forcing Russia's dependence on the energy sector and to increase relations with China. The Russian economy has stagnated in the last years with a nominal GDP of 1.7 trillion USD in 2018 (Nuutilainen and Rautava, 2020) and has been experiencing an economic downturn. One of the causes is undoubtedly the depreciation of the Russian Ruble that began in the second half of 2014. Fluctuations in the Ruble usually reflect changes in oil prices, although the correlation between oil prices and the Ruble's exchange rate appears to have weakened somehow in recent times. Several studies have pointed that a 10% increase (decrease) in crude oil prices lead to a 1%-2% increase (decrease) in the Russian GDP over the long run.

Urbanovsky (2015) wrote an article that aimed to discover and determine the impact of several variables on changes in the RUB/USD exchange rate based on cointegration analysis.

Analysing the cointegrating regressions, the signs of the correlation coefficients correspond to the signs of the regression coefficients. As the correlation signal between RUB/USD and EUR/USD is positive, it means that when the dollar depreciates (appreciation of the EUR and rise of the EUR/USD exchange rate), the RUB/USD exchange rate rises and the Ruble appreciates, representing a negative relationship between the two currencies. When the USD appreciates 1% against the EUR, the Ruble depreciates 0.285%, ceteris paribus. Regarding the impact of stock market development (represented by the MIC Index) on the value of the Ruble, the stock market index has a positive correlation with the exchange rate, proving that "an increase in a stock index value leads to depreciation of the Ruble on the grounds of rising interest in stocks, which leads to formation of money excess on the markets". When the MIC Index increases by 1%, the Ruble depreciates 0.214%, ceteris paribus. The appreciation of the USD and the rise of stock market play a significant role in the depreciation of the Ruble.

3.3 Main Goals

The main goal of this dissertation is to provide a more in-depth analysis, with a special focus on the cointegration between currency crises and stock markets in the pre-crisis, during the crisis and post-crisis periods through the analysis of cointegrating equations. Additionally, this dissertation addresses the following topics: Does one exchange rate's movement significantly affect another stock index movement? How quickly are the price movements of one variable transmitted to others? Does the relationship between currency crises and stock markets differ before, during and/or after currency crises? Are the selected exchange rates long-term cointegrated with the stock indexes? Did cointegration between variables persist over the different periods? Did currency crises intensify cointegration relations? Did any currency crisis have a greater impact on the index of another continent than on the index of its own country or continent (to measure the impact of globalization)? Did any currency overshoot in the long run, i.e. did it recover better than it was before the crisis (to test whether the currency crisis had positive effects in the long run)?

CHAPTER 4

Methodology overview

When a currency crisis occurs, it is expected that exchange rates and stock markets that initially followed different paths, after the crisis become cointegrated. The idea of cointegration is a long-term relationship between time series over time, which may reflect the equilibrium relationship. In other words, it is expected that the different variables become somehow linked to each other, being possible to predict one in terms of the other(s). Multivariate time series models are models with more than one time series that describe the variation of a variable by the variation of the other(s). The long-term relationship between exchange rates and stock indices is the basis of the Vector Error Correction Model (VECM). Our study aims to use the VECM for stock indices to capture their dynamic relations with exchange rates and to compare these relations before, during and after the currency crisis, in order to study the impact of currency crises on stock markets based on cointegrating equations. To reflect the long-term equilibrium relationship between the variables, we estimated the cointegrating equations.

4.1 Cointegration: a brief review

Cointegration is a rigorous way of defining a stable long-term relationship between time series over time, being a statistical property of a collection of time series variables that has become important in contemporary time series analysis.

Engel and Granger (1987) developed the Error Correction Model based on the cointegrating vector approach. The two economists were against using linear regressions[6] to analyse the long run relationship between two or more time series, because detrending them would not solve the spurious correlation problem. The ECM is an extended VAR model composed by an equation with variables in first differences and with an error correction term that shows the long-run relation and the short-run deviations from the equilibrium relationship.

The ECM concept established that two non-stationary time series can be cointegrated if there is a relationship between the variables that cannot deviate from the equilibrium in the long run. This approach has some weaknesses, such as being restricted to just a single equation for

[6] Before introducing the concept of cointegration in the 1980's, investors used linear regressions to analyse the relationship between time series variables.

the parameters, with a dependent variable explained by another weakly exogenous variable and to be based on the stationarity test. The model that allows to overcome these limitations is known as VECM, that is a multiple equation model based on a restricted VAR that allows to include the multivariate part of the model.

Cointegration tests identify scenarios in which two or more non-stationary time series are integrated in such a way that they do not deviate from equilibrium in the long run. If two time series are separately first-order integrated (I(1)) but some cointegrating vector of coefficients can form a stationary linear combination, then the time series are said to be cointegrated. This stationary linear combination is called cointegrating equation and can be interpreted as the long-term equilibrium relationship between the time series variables.

4.2 Spurious Regression

Previous empirical studies provide evidence that most financial time series are generated by nonstationary processes and are integrated of first order. In periods of speculative bubbles, currency crises have strengthened the interdependent relationship with global stock markets. The relationship between stock markets has been found to be much less pronounced before currency crisis, then increased sharply during the crash and the co-movement starts to decrease after it. As the integration of financial markets deepens, the correlations between stock markets become stronger (Jiang *et al.*, 2017).

Before the introduction of cointegration tests, analysts relied on linear regressions in order to find the relationship between time series variables. However, Granger and Newbold (1974) argued that regression analysis can indicate that two time series are associated when, in fact, they are not causally related. This misleading relationship, called spurious regression, can occur if the series have stochastic trends and are not cointegrated. In spurious regressions, the variables are causally related due to a coincidence or an unknown third factor. In order to study the long-run relationship of nonstationary series, we must consider the series measured in levels.

The linear combination of first order integrated variables tends to generate a residual variable that is also integrated of first order. In such cases, the T and F tests on the Ordinary Least Squares (OLS) estimates do not follow the t and f distributions and are therefore useless (Phillips, 1986). The model is probably capturing a common stochastic trend between the variables in levels and not the necessary causal relationship. A spurious regression can be detected if the residuals of the variables in levels are strongly autocorrelated and the Durbin-

Watson statistic converges to zero (Granger and Newbold, 1973). In addition, the variables may be related in the short term and not related in the long term, as in the case of the relationship between two random walks.

It is also necessary to check for the presence of perfect (or very strong) linear relationships between the explanatory variables. Despite multicollinearity occurs often in cross-section data, when the integration of financial markets deepens, the correlations between stock markets become stronger. If the correlation coefficients are close to -1 and +1, the normal equations tend to infinite numbers of solutions, making the OLS estimates not unique and if two variables are strongly correlated it can suggest that at least one of them is useless. If two variables are perfectly correlated, it means that the rank of matrices X and X'X is lower than the number of parameters k to estimate, i.e. $r(X) = r(X'X) < k$. In consequence, the matrix X'X det=0 and the matrix is singular, has no inverse and makes impossible to compute the OLS and ML methods.

4.3 Stochastic nonstationarity

Stochastic nonstationarity can be examined based on unit root tests as the Augmented Dickey-Fuller (ADF) test. The ADF test (Dickey and Fuller, 1981) is based on an autoregression model testing for ρ=1 in the following equation:

$$\Delta Y_{it} = \alpha_0 + a_{1t} + (\rho - 1)\, Y_{i,t-1} + \gamma_1\, \Delta Y_{i,t-1} + \ldots + \gamma_k\, \Delta Y_{i,t-k} + \varepsilon_t \qquad (1)$$

Where Δ denotes a first difference, α_0 is a constant term, a_{1t} represents the linear deterministic trend, $(\rho - 1)\, Y_{i,t-1}$ represents the stochastic trend, $\gamma_1\, \Delta Y_{i,t-1} + \ldots + \gamma_k\, \Delta Y_{i,t-k}$ is the summation term that captures any autocorrelation of the left-hand side variable and ε_t represents the residuals. Taking $a_1 = \gamma_k = 0$, the ADF equation reduces to an autoregressive model of order one - AR($_1$).

The distribution of the ADF test under the null hypothesis H_0: ρ = 1 is given by Dufrénot and Mignon (2002), who showed that the sample moments of Y_t converge into random functions of Brownian motion:

$$t_{\rho = 1} \xrightarrow{d} \frac{\int_0^1 W(r)\, d\, W(r)}{\sqrt[2]{\int_0^1 W(r)^2 dr}} \qquad (2)$$

Where W(r) denotes a Wiener process (standard Brownian Motion) defined on the unit interval. A Wiener process is a continuously time stochastic process, associating to each r ∈ [0, 1] a scalar random variable W(r).

Under the null hypothesis H_0: ρ = 1 the variable is nonstationary, meaning that it contains a stochastic trend. On the other hand, under the alternative hypothesis H_a: ρ < 1 the variable is stationary.

The Dickey-Fuller test considers that the errors are not autocorrelated and have a constant variance. On the other hand, the Augmented Dickey-Fuller test is an update of the original Dickey-Fuller test, as it considers higher-order autoregressive models - $AR_{(p)}$ - which are more appropriate to deal with time series if the errors are autocorrelated. Despite that, the ADF test suffers from low predictable power when the process is stationary with roots close to one (Blough, 1992). Some unit root processes behave more like a white noise than like a random walk for finite samples.

For this reason and to obtain more accurate conclusions, we must use alternative tests for the stationarity analysis. An alternative is the KPSS test (Kwiatkowski *et al.*, 1992). It is applied to check if the time series is trend stationary (H_0) or if the series contains a stochastic trend (H_1):

$$H_0 : \sigma_u^2 = 0 \text{ or } z_t \text{ is a constant}$$

The KPSS test considers that a time series (y_t) can be decomposed into the sum of a deterministic trend (α_t), a random walk (z_t) and a stationary residual term(ε_t):

$$y_t = \alpha_t + z_t + \varepsilon_t \tag{3}$$

Under the null hypothesis, the equation represents a trend stationary process.

The KPSS test statistic is a Lagrange multiplier:

$$LM = T^{-2} \frac{\sum_{t=1}^{T} S_t^2}{\hat{\sigma}_e^2} \tag{4}$$

Where S_t is the partial sum of ε_t and σ_e is the residual variance of the residual sum of squares divided by T.

Unit root tests (as the ADF test) are for the null hypothesis that a time series is integrated of order one - I(1) - meaning that the series is non-stationary and we need to consider a first difference in order to become stationary. On the other hand, stationarity tests (as the KPSS test) are for the null that the series is already stationary - I(0) - or integrated of order zero. In order to obtain more accurate conclusions, both ADF and KPSS tests should lead to the same conclusion.

The attempt to overcome nonstationarity has led researchers to estimate models that include only variables in differences. A model with exclusively variables in differences raises a problem of no long-run properties (in levels) and ignores the potential long-run equilibrium relationship. If we want to capture a long-term relation between time series, the differences are not enough because they only capture the short run relationship, so we need cointegration by considering the variables in levels.

4.4 Vector Autoregressive (VAR) and Vector Error Correction Model (VECM)

In order to analyse the relationship between currency crises and stock markets, the Johansen test is a cointegration test that allows for more than one cointegration relationship and is subject to asymptotic properties[7].

To perform the Johansen test, a k-dimensional Vector Autoregressive (VAR) system introduced by Sims (1980) is considered. This is a technique that represents the dynamic behaviour of a collection of time series with no restrictions implemented. A k-dimensional VAR model is composed by k variables. Each variable has one equation that expresses the current time t observation as a linear function of lagged-order p values of the variable itself and of the other k-1 variables in the VAR, where $y_t = (y_{1t}, y_{2t}, \ldots, y_{kt})'$ is a k-vector of stationary variables I(0), plus an error term. In order to apply VAR models, the time series must be stationary. Due to this, it can only capture the short-run dependencies among the variables.

The k-variable VAR model of order p (VAR(p)) can be formulated as follows:

$$y_t = \mu + \sum_{i=1}^{p} \Gamma_i \, y_{t-i} + \varepsilon_t = \mu + \Gamma_1 \, y_{t-1} + \cdots + \Gamma_p \, y_{t-p} + \varepsilon_t \tag{5}$$

Where ε_t is a vector of innovations (unpredictable error term), μ is a vector of constants, Γ_i are (N x N) matrices of autoregressive coefficients to be estimated.

As the right side of the equation is only composed by lagged values of the variables, simultaneity is not a problem and OLS yields consistent estimators, being the coefficients of

[7] The Johansen test is a test for large sample size due to the fact that a small sample size could produce unreliable results.

each VAR model equation estimated by OLS. A VAR with k time series contains k equations, one for each variable, where the regressors in the equations are lagged values of all variables.

Another way to represent is:

$$\begin{pmatrix} y_{1t} \\ y_{2t} \\ \cdots \\ y_{kt} \end{pmatrix} = \begin{pmatrix} \mu_1 \\ \mu_2 \\ \cdots \\ \mu_k \end{pmatrix} + \begin{pmatrix} \Gamma_{1(1)} \\ \Gamma_{1(2)} \\ \cdots \\ \Gamma_{1(k)} \end{pmatrix} \begin{pmatrix} y_{t-1} \\ y_{t-1} \\ \cdots \\ y_{t-1} \end{pmatrix} + \cdots + \begin{pmatrix} \Gamma_{p(1)} \\ \Gamma_{p(2)} \\ \cdots \\ \Gamma_{p(k)} \end{pmatrix} \begin{pmatrix} y_{t-p} \\ y_{t-p} \\ \cdots \\ y_{t-p} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \cdots \\ \varepsilon_{kt} \end{pmatrix} \quad (6)$$

In order to choose the optimal lag-order for the VAR(p) model, we determine the Araike Information Criteria (AIC) given by:

$$\text{AIC} = \ln\left(\frac{\text{RSS}}{\text{n}}\right) + \frac{2\text{k}}{\text{n}} \quad (7)$$

The optimal lag-order is the one that minimizes the Information Criteria.

Unfortunately[8], the VAR requires variables to be stationary, but most financial time series are generated by nonstationary processes and are integrated of first order. To overcome this issue, the VECM imposes restrictions due to the existence of cointegrated non-stationary data in its specification (Suharsono *et al.*, 2017). Opposite to (unrestricted) VAR, which only has stationary variables on both sides of the equation, the VECM introduces non-stationary data that allows to capture the long-term relationship between time series variables. This way, the VECM allows to interpret both long-term and short-term equations through the error correction method, i.e. by adding error correction terms to a multifactorial model (VAR). The advantage of VECM over VAR is that the VAR represented in the VECM form has more efficient coefficient estimates.

Subtracting y_{t-1} from both sides of the VAR model equation:

$$y_t - y_{t-1} = \mu + (\Gamma_1 - I)\, y_{t-1} + \cdots + \Gamma_p\, y_{t-p} + \varepsilon_t \quad (8)$$

Adding and subtracting $\Gamma_p\, y_{t-p+1}$ on the right side of the equation:

$$\begin{gathered} \Delta y_t = \mu + (\Gamma_1 - I) y_{t-1} + \cdots + \Gamma_{p-1} y_{t-p+1} + \left(\Gamma_p y_{t-p+1} - \Gamma_p y_{t-p+1}\right) + \Gamma_p y_{t-p} + \varepsilon_t \\ \Delta y_t = \mu + (\Gamma_1 - I) y_{t-1} + \cdots + (\Gamma_{p-1} + \Gamma_p) y_{t-p+1} + \Gamma_p\left(-y_{t-p+1} + y_{t-p}\right) + \varepsilon_t \\ \Delta y_t = \mu + (\Gamma_1 - I) y_{t-1} + \cdots + (\Gamma_{p-1} + \Gamma_p) y_{t-p+1} - \Gamma_p \Delta y_{t-p+1} + \varepsilon_t \end{gathered} \quad (9)$$

[8] McMillin (1988) pointed out that VAR models are particularly useful for analysing the economy's cyclical behaviour.

To convert the y_{t-p+2} term to Δy_{t-p+2}:

$$\Delta y_t = \mu + (\Gamma_1 - I)y_{t-1} + \cdots + \Gamma_{p-2}y_{t-p+2} + (\Gamma_{p-1} + \Gamma_p)y_{t-p+1} - \Gamma_p \Delta y_{t-p+1} + \varepsilon_t \quad (10)$$

Adding and subtracting $(\Gamma_{p-1} + \Gamma_p)y_{t-p+2}$ on the right side of the equation:

$$\Delta y_t = \mu + (\Gamma_1 - I)y_{t-1} + \cdots + (\Gamma_{p-2} + \Gamma_{p-1} + \Gamma_p)y_{t-p+2} + (-\Gamma_{p-1} - \Gamma_p)\Delta y_{t-p+2} + (-\Gamma_p)\Delta y_{t-p+1} + \varepsilon_t \quad (11)$$

Repeating this approach until the term y_{t-1}, the VECM model is then:

$$\Delta y_t = \mu + (\sum_{j=1}^{p} \Gamma_j - I)y_{t-1} + \sum_{i=1}^{p-1} - (\sum_{j=i+1}^{p} \Gamma_j)\Delta y_{t-i} + \varepsilon_t \quad (12)$$

Applying new notation for the coefficient matrices we get:

$$\Delta y_t = \mu + \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \varepsilon_t \quad (13)$$

Where, $\Gamma_i = -\sum_{j=i+1}^{P} \Gamma_j$ and $\Pi = \sum_{j=1}^{P} \Gamma_j - I$

With Δ being the first difference operator, y_t is a vector of non-stationary (I(1)) variables, μ is a vector of constants, Γ represents the shot-run dynamics, Π is the long-run level solution that substitutes the term *aβ'* in the model and represents the cointegrating relationships.

The VECM includes the stationary part of the VAR, represented by the first differences, and the non-stationary part that models the long-term relationship between the variables represented by the error correction term (Magee and Winter, 2013). It is a multiple equation model in which we are regressing the variation of each variable as a function of the variation of the other variables. There are as many equations as the number of variables included in the model.

4.5 Cointegration tests

The Johansen test is used to test for cointegration relationships between non-stationary time series, considering the rank of the Π matrix via its eigenvalues and it is subject to asymptotic properties. The rank of Π - r - gives the number of linear combinations of y_t (eigenvalues or characteristic roots) that are stationary, meaning that either y_t contains a determined number of cointegrating vectors or Π must be a matrix of zeros. If r = 0, it means that there are no stationary linear combinations and the variables are not cointegrated. If r = k, the variables in levels are stationary. When 0 < r < k, it means there exist r stationary linear combinations of y_t or r cointegration vectors and one can factorize Π_p ; - $\Pi_p = a\beta'$, where a and β are (k x r) matrices, α contains the factor loadings and β the cointegration vectors.

The Johansen procedure comes in two asymptotically tests: the Trace Test and the Maximum Eigenvalue Test. They are computed considering the optimal lag-length (obtained by minimizing the Information Criteria) and the eigenvalues from the rank of the Π matrix that are different from zero.

The two test statistics for cointegration under the Johansen approach are formulated as follows:

$$\lambda_{max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1}) \quad (14)$$

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{g} \ln(1 - \hat{\lambda}_i) \quad (15)$$

Where r is the number of cointegrating vectors, $\hat{\lambda}_i$ is the estimated value of the i^{th} order eigenvalue of the Π matrix. The eigenvalues ($\hat{\lambda}_i$) vary from 0 to 1 and are placed in ascending order $\lambda_1 > \lambda_2 > \ldots > \lambda_g$, where λ_1 is the highest (the closest to 1) and λ_k is the smallest (the closest to 0). The higher the $\hat{\lambda}_i$, the higher will be the ln(1- $\hat{\lambda}_i$) and the higher will be the test value.

Each eigenvalue is associated to different cointegrating vectors (eigenvectors), which means that if the eigenvalue is statistically different from zero, the eigenvector is statistically significant. Higher eigenvalues are associated with a cointegrating vector being more correlated with the stationary component of the process.

λ_{trace} is a joint test with the null hypothesis that there are r or less cointegrating vectors against the alternative hypothesis that there are more than r cointegrating vectors. It starts with p eigenvalues, and then successively the highest one is removed. λ_{trace} is equal to 0 when all the λ_i are 0.

λ_{max} conducts separated tests on each eigenvalue and has the null hypothesis that the number of cointegrating vectors is r against an alternative of r + 1.

Johansen and Juselius (1990) provided critical values for both statistics. Due to the presence of unit roots, the limiting distribution of the tests is not chi-square but a function of standard Brownian motions. The distribution of test statistics is not standard, and the critical values depend on the value of k-1. If the test statistic is greater than the critical value provided in the Johansen tables, we reject the null hypothesis that the number of cointegrating vectors is r + 1 (for the Trace Test) or greater than r (for the Maximum Eigenvalue Test). The testing process is conducted under a sequence and the null that r = 0, 1, …, k-1. The testing hypotheses are:

$$H_0 : r = 0 \quad \text{vs.} \quad H_1 : 0 < r \leq k$$

$$H_0 : r = 1 \quad \text{vs.} \quad H_1 : 1 < r \leq k$$

…..

$$H_0 : r = k - 1 \quad \text{vs.} \quad H_1 : r = k$$

The testing process follows sequentially from r = 0 to r = k – 1, where k represents the number of variables in the regression. If the value of the test statistic is greater than any of the critical values in the Johansen tables, we reject the null hypothesis. The first test is for the null that there are no cointegrating vectors (with Π = 0). If the null is not rejected, we conclude that there are no cointegrating vectors and the test is completed. If we reject the null of H_0: r = 0, the null that there is one cointegrating vector (H_0 : r = 1) will also be tested and so on, with a continually increasing value of r, until we do not reject the null.

As r is the rank of Π, it cannot be full rank (k), otherwise it would correspond to the original y_t being stationary. On the other hand, if Π has rank (0), by analogy to the univariate case, Δy_t would only depend on Δy_{t-i} and not on y_{t-1}, meaning that there would not be any long-run relationship between the elements of y_{t-1} and no cointegration. In the case of 0 < rank (Π) < k, it means there are r cointegration vectors and Π is defined as the product of two matrices: matrix a of dimension (k x r) and matrix β of dimension (r x k).

4.6 Cointegrating equations

For the estimated equation based on VECM, we must use the Π matrix, which is defined as the product of the two matrices a and β:

$$\Pi = a\beta' \tag{16}$$

The matrix β provides the cointegrating vectors and the matrix a provides the amount of each cointegrating vector that enters each cointegrating equation, known as adjustment parameters.

After extracting the cointegrating vector (from β) and the error correction term coefficients (from a), we can finally estimate the cointegrating equations, which represent the cointegration relationships or stationary linear combinations and how the variable relates to others, being this the ultimate goal of this study to analyse the impact of currency crises on stock markets.

A cointegrating equation can be interpreted as a relationship between the exchange rate and the stock prices in which the current stock prices are a linear combination of historical exchange rates. The historical prices form a long-run (equilibrium) relationship, where the variables involved co-move over time independently of the existence of stochastic trends in each of them, so that their difference is stable. The long-run residuals measure the difference between the system to the equilibrium at each moment[9], being its difference corresponding to the impossibility of prices to adjust instantaneously to new information or to short-run dynamics present in data. There is a compound adjustment process involving both short-run and long-run dynamics when the variables are cointegrated.

The cointegrating equation, being a linear relationship between different time series, can lead to the existence of more than one cointegrating equation or linear combination able to describe the relationship between more than two time series. The Trace Test and the Maximum Eigenvalue Test of the Johansen procedure indicate, by the rank r, the number of cointegration relationships present in the model.

If the unit-root tests suggest that at least two of the k variables are I(1), then it is possible to have at least one cointegrating relation. If the unit-root tests suggest that one of the variables is I(0), then the variable itself constitutes a cointegration vector. So, if the cointegration tests suggest that we have, per example, two cointegration vectors and from the unit-root tests we know that one of the k variables in the VAR model is I(0), then we should pursue the estimation of only one cointegration relation among the k variables. Of course, it is not necessary that all the k variables must be present in the cointegration relationship. If none of the k variables is I(0), then the cointegration tests actually indicate that it should be identified and estimated two cointegration relations. Following the assumption that the tests of cointegration rank (r) point

9 Cointegration relationship disequilibrium level captured by the error-correction term.

that r = 2 and the unit-root tests point that one of the variables is I(0), it follows that there is only one “levels relationship” (Johansen e Juselius, 1990). In case there is more than one linear combination, we choose the one that minimizes the Akaike Information Criteria (AIC).

4.7 VECM: in-depth analysis

Vector error correction models with a finite number of lagged differences, endogenous variables, specified number of cointegration relations and deterministic terms can be specified, estimated and used for causality and impulse response analysis. VEC modelling is done step by step under the Johansen procedure previously mentioned, as it can be used to estimate VEC models in the form of equation (13). Specifying a model of this form also requires the specification of the cointegration rank and the pre-specification of the optimal lag order p for the variables, which is selected by minimizing the Araike Information Criteria (AIC). Once the model has been estimated, the diagnostic tests, stability analysis and structural analysis are based on the results of the estimate.

The cointegration matrix β' is normalized as follows:

$$\beta' = \begin{bmatrix} I_r \\ \beta'_{(k-r)} \end{bmatrix} \tag{17}$$

Where, $\beta'_{(k-r)}$ is a ((k-r)x r) matrix and for normalization it is necessary that the order of the variables is specified so that the first r variables are involved in the cointegration relationships. Significant cointegration relationships should result with normalization.

The Error Correction Term (ECT) present in the VECM, measures the speed of adjustment[10] of the variables in the model. The signs of the coefficients are reversed in the long-run. If a coefficient has positive (negative) sign, it has a negative (positive) effect on the variable of interest. The r estimated error correction terms can be plot and displayed as the following representation:

$$\beta' \begin{bmatrix} y_{t-1} \\ D^{co}_{t-1} \end{bmatrix} M$$

Where D^{co}_{t-1} represents the deterministic terms and the matrix M is defined as:

[10] The error correction mechanism is asymptotic so it takes infinite time to adjust. The ECT cannot be interpreted as time measure but the speed of adjustment towards long-run equilibrium (Lütkepohl and Krätzig, 2004).

$$M = I_T - X\,(X'X)^{-1}\,X' \tag{18}$$

With $X' = [X_0, \dots, X_{T-1}]$, $X'_{t-1} = (\Delta y'_{t-1}, \dots, \Delta y'_{t-p}, CD'_t, x', x'_{t-1}, \dots, x'_{t-q})$, and CD are the deterministic terms outside the cointegration relations. The product with M eliminates the short-run dynamics, remaining only the long term.

4.8 Residual analysis

After specifying and estimating the model, the residual analysis is splitted into: Diagnostic tests for residual autocorrelation, non-normality and conditional heteroskedasticity; plotting of the residuals to check for the presence of trends and graphical autocorrelation analysis. Plotting the residuals can be useful to detect structural changes, serial correlation or heteroskedasticity problems.

4.8.1 Diagnostic tests

Tests for residual autocorrelation, non-normality and heteroskedasticity are necessary to check the adequacy of the VECM (Pesaran *et al.*, 2000).

The autocorrelation assumption is that the errors ε_i and ε_j, with $i \neq j$, are linearly independent. When autocorrelation[11] occurs, the elements outside the main diagonal of the variance-covariance matrix are non-zero. In this case, the OLS estimators are not the most efficient and the estimated variances are biased.

The Portmanteau test for residual autocorrelation checks the null hypothesis:

$$H_0 : E\,(u_t u'_{t-i}) = 0, \quad i = 1, \dots, h$$

Against the alternative hypothesis that at least one of the autocovariance and consequently its autocorrelation to be different of zero.

The Portmanteau test statistic has the form:

$$Q_h = T \sum_{j=1}^{h} tr\,(\hat{C}'_j\, \hat{C}_0^{-1}\, \hat{C}_j\, \hat{C}_0^{-1}) \tag{19}$$

Where $\hat{C}_i = T^{-1} \sum_{t=i+1}^{T} \hat{u}_t\, \hat{u}'_{t-1}$. The test follows a χ^2 $(K^2 h - n^*)$ distribution with n representing the number of estimated loading (α) and short-run parameters (Γ_i) present in the VECM.

[11] Autocorrelation occurs more frequently in time series data.

The LM test for h-th order residual autocorrelation assumes the following model:

$$u_t = B_1^* u_{t-1} + \cdots + B_h^* u_{t-h} + \varepsilon_t \tag{20}$$

The LM test for h-th order residual autocorrelation checks the hypothesis test:

$$H_0 = B_1^* = \cdots = B_h^* = 0 \text{ vs. } H_0 = \exists\, B_i^* \neq 0$$

The test statistic has the form:

$$LM_h = T\ (K - tr\ (\widetilde{\Sigma}_R^{-1} \widetilde{\Sigma}_e))\ \sim \chi^2\ (\mathrm{h\ K}^2) \tag{21}$$

With the residual covariance matrix estimator $\widetilde{\Sigma}_e = \frac{1}{T} \sum_{t=1}^{T} \hat{e}_t\, \hat{e}_t'$ and the estimation residuals represented by $\hat{e}_t$ $(t = 1, \ldots, T)$.

The idea of non-normality tests is to transform the residual vector so that its components are independent and check the compatibility with the normal distribution. The error term consists of independent factors not captured by the regressors and the Central Limit Theorem suggests that the error term has a normal distribution for large samples. The assumption of error normality is the support for all statistical inferences of linear regressions. Normality is also necessary for the coefficients' confidence intervals.

The first step is to estimate the residual covariance matrix as:

$$\widetilde{\Sigma}\, u = T^{-1} \sum_{t=1}^{T}\ (\hat{u}_t - \bar{\hat{u}})\ (\hat{u}_t - \bar{\hat{u}})' \tag{22}$$

The non-normality tests are based on the skewness and kurtosis of the standardized residuals $\hat{u}_t^s = (\hat{u}_{1t}^s, \ldots, \hat{u}_{Kt}^s)' = \widetilde{\Sigma}_u^{1/2}\ (\hat{u}_t - \bar{\hat{u}})$:

$$b_1 = (\ b_{11}, \ldots, b_{1k})'\ ,\ b_{1k} = T^{-1} \sum_{t=1}^{T}\ (\hat{u}_{kt}^s)^3 \tag{23}$$

$$b_2 = (\ b_{21}, \ldots, b_{2k})'\ ,\ b_{2k} = T^{-1} \sum_{t=1}^{T}\ (\hat{u}_{kt}^s)^4 \tag{24}$$

In order that:

$$s_3^2 = T\ b_1' b_1 / 6 \tag{25}$$

$$s_4^2 = T\ (b_2 - 3_K)'(b_2 - 3_K)/24 \tag{26}$$

With 3_K= (3, …, 3)' being a (K x 1) vector.

Then, the multivariate version of the Lomnicki-Jarque-Bera (LJB) test statistic is:

$$LJB_k = s_3^2 + s_4^2 \sim \chi^2 (K) \tag{27}$$

Another assumption to check is the absence of heteroskedasticity, which occurs when the errors' variance is not constant. In this case, the OLS estimators are still unbiased but they are no longer the most efficient.

A multivariate ARCH-LM test is based on the multivariate regression model:

$$vech\ (\hat{u}_t\, \hat{u}_t') = \beta_0 + B_1 vech\ (\hat{u}_{t-1}\hat{u}_{t-1}') + \cdots + B_q vech\left(\hat{u}_{t-q}\hat{u}_{t-q}'\right) + \varepsilon_t \tag{28}$$

With vech being the column stacking operator for symmetric matrices main diagonal, β_0 is $\frac{1}{2}$ K (K+1)-dimensional and B_j , j = 1, … , q, are coefficient matrices.

The multivariate ARCH-LM test has the following hypothesis test:

$$H_0 = B_1 = \cdots = B_q = 0 \text{ vs. } H_0 = \exists\, B_i \neq 0$$

The LM test statistic has the form:

$$VARCH_{LM}(q) = \frac{1}{2} \text{T K (K+1)}\, R_m^2 \sim \chi^2 (\text{q } K^2(K+1)^2/4)\ ,\ R_m^2 = 1 - \frac{2}{K(K+1)} \text{t r} (\hat{\Omega}\hat{\Omega}_0^{-1}) \tag{29}$$

Where $\hat{\Omega}$ is the residual covariance matrix of the *vech* $(\hat{u}_t\, \hat{u}_t')$ regression and $\hat{\Omega}_0$ is the corresponding matrix with q = 0.

CHAPTER 5

How currency crises impact on stock markets: empirical analysis

This section contains the analysis performed using the EViews econometric software for the different variables selected for this study. It is divided into four parts, each to analyse the cointegration relations between the currency crises and stock markets.

5.1 Russian Ruble

The Russian economy has stagnated in the last years and has been experiencing an economic downturn. The Russian Ruble crisis was glanced with the depreciation of the Russian Ruble that began in the second half of 2014. The number of daily observations collected were 471, 395 and 401 for the periods before, during and after the currency crisis, respectively. The time series were considered in levels and the descriptive statistics are in table 5.1.

Before Crisis	RUB	RTS	SP1200	SP5000	SP350	SP50
Mean	0.030751	1393.668	1688.163	1667.671	1250.290	3496.394
Median	0.030910	1401.890	1680.270	1667.470	1241.780	3518.200
Maximum	0.033830	1634.120	1961.120	1985.440	1430.100	3740.100
Minimum	0.027310	1065.250	1406.270	1353.330	1074.290	3084.280
Std. Dev.	0.001628	116.5779	143.9005	168.2648	94.16229	132.1644
Skewness	-0.398429	-0.353533	-0.053927	-0.052283	0.128499	-0.465570
Kurtosis	2.133401	2.788355	1.846401	1.800430	1.854758	2.514448
Jarque-Bera	27.19982	10.69045	26.34507	28.45436	27.03592	21.64211
Probability	0.000001	0.004771	0.000002	0.000001	0.000001	0.000020
Sum	14.48376	656417.6	795124.6	785473.1	588886.6	1646801.
Sum Sq. Dev.	0.001245	6387495.	9732455.	13307134	4167273.	8209696.
Observations	471	471	471	471	471	471

During Crisis	RUB	RTS	SP1200	SP5000	SP350	SP50
Mean	0.018910	944.2052	1898.462	2036.371	1489.614	3613.500
Median	0.017422	897.5600	1909.800	2052.230	1469.060	3628.610
Maximum	0.029470	1403.720	2007.620	2130.820	1693.810	4173.970
Minimum	0.012854	629.7400	1676.140	1862.490	1273.160	2935.860
Std. Dev.	0.004540	162.4473	65.12837	63.86619	103.5150	262.6488
Skewness	0.935015	0.752139	-0.793411	-0.603463	0.211068	-0.197392
Kurtosis	2.578820	2.754285	3.270602	2.435326	1.777372	2.614320
Jarque-Bera	60.47462	38.23648	42.64728	29.22222	27.53512	5.013262
Probability	0.000000	0.000000	0.000000	0.000000	0.000001	0.081542
Sum	7.469414	372961.1	749892.3	804366.7	588397.5	1427333.

Sum Sq. Dev.	0.008120	10397318	1671232.	1607083.	4221850.	27179854
Observations	395	395	395	395	395	395

After Crisis	RUB	RTS	SP1200	SP5000	SP350	SP50
Mean	0.015881	989.4466	1937.542	2204.692	1434.107	3694.651
Median	0.015719	990.8800	1911.080	2180.380	1395.970	3689.860
Maximum	0.017911	1195.610	2197.100	2477.830	1602.830	4616.860
Minimum	0.012159	628.4100	1626.220	1829.080	1225.180	2828.940
Std. Dev.	0.001299	121.5862	132.6979	158.2273	88.35463	425.0050
Skewness	-0.642388	-0.586351	0.046398	-0.123982	0.306942	0.140304
Kurtosis	3.150912	3.136617	2.308080	2.198783	1.892425	2.318241
Jarque-Bera	27.96010	23.28963	8.143047	11.75321	26.79311	9.081580
Probability	0.000001	0.000009	0.017051	0.002804	0.000002	0.010665
Sum	6.368406	396768.1	776954.4	884081.6	575076.9	1481555.
Sum Sq. Dev.	0.000675	5913278.	7043493.	10014349	3122616.	72251684
Observations	401	401	401	401	401	401

Table 5.1 – Russian Ruble summary descriptive statistics.

From the descriptive statistics we can conclude that all data is asymmetric, by the significant skewness, and present significant kurtosis. The statistical evidence of the sample does not point for the normality of the variables, based on the Jarque-Bera test, but under the central limit distribution, the sampling distribution of the means will become approximately normally distributed for large samples.

The results reveal that before the crisis, the RUB and RTS had a higher mean (0.03 and 1394 respectively) and their mean decreased sharply during the crisis (0,019 and 944 respectively) which represents the impact of the currency depreciation. Surprisingly, although the RUB appreciated against the USD after the crisis, the mean was lower than during the crisis (0.016). This can be explained by the minimum and maximum values registered. Both periods had approximately the same minimum value (0.012) but the maximum value in the period during the crisis (0.029) is much higher than after the crisis (0.018), meaning that the Russian Ruble had a very slow recovery. The other stock indexes had a continuous increase of the mean, except for the SP350 small drop from the during to the after crisis period.

In terms of standard deviation, RUB, RTS and SP350 followed the same pattern, showing an increase during the crisis (representing high volatility in this turbulent period) followed by a decrease after the crisis, i.e. the standard deviation reverted to the level before the crisis. In the case of the RUB, the standard deviation almost tripled during the crisis (from 0.0016 to 0.0045) and then returned to values lower than the period before the crisis (0.0013).

The other indexes showed the opposite pattern, except for the SP50, which more than tripled its standard deviation in this period that matches with the Chinese Yuan currency crisis.

5.1.1 Stationarity

The notion of cointegration is applied to non-stationary time series. Most financial time series are generated by nonstationary processes and are integrated of first order. Table 5.2 shows the results of the ADF unit root test, also confirmed by the KPSS stationarity test.

	Before Crisis		During Crisis		After Crisis	
	ADF	KPSS	ADF	KPSS	ADF	KPSS
RUB	-0.9266	2.2302***	-1.8192	1.6984***	-2.3963	2.0872***
RTS	-1.7966	1.3203***	-2.2113	1.3703***	-2.7546*	1.8174***
SP1200	-0.4501	2.6447***	-1.5297	0.6404**	-0.6157	2.3004***
SP500	-0.1857	2.6624***	-2.6504*	0.5578**	-1.3649	2.3354***
SP350	-0.6502	2.6002***	-1.4091	0.8323***	-1.0068	2.1629***
SP50	-2.6528*	0.4122*	-0.4064	0.8409***	-0.2206	2.2532***

* , ** and *** indicate the null hypothesis rejection for 10%, 5% and 1% significance level

Table 5.2 – Russian Ruble unit root and stationarity tests for the variables in levels.

The optimal lag lengths were based on the Akaike Information Criteria (AIC). All variables have a p-value of 0.000 when considering the first differences (annex B). It is possible to conclude that the variables are first order integrated (I(1)).

5.1.2 Cointegration tests

The Johansen procedure is used to test for cointegration relationships between non-stationary time series and comes in two asymptotically tests: the Trace Test and the Maximum Eigenvalue Test. The tests were computed considering the optimal lag-length (obtained in table 5.3 by minimizing the Information Criteria for the VAR model) and the eigenvalues from the rank of the Π matrix that are different from zero. The optimal lag order selection is important because the application of few lags can generate size distortion in the test results and the application of many autoregressive lags can lose the power to obtain correct estimates.

Lag Order Selection by the Akaike Information Criteria			
Lag	Before Crisis AIC	During Crisis AIC	After Crisis AIC
0	12.36897	26.56723	13.07463

1	1.897484	13.36575	2.645943
2	1.754824	13.22797	2.517521*
3	1.747624*	13.16786	2.544818
4	1.772907	13.13812*	2.543387
5	1.779921	13.26843	2.520527
6	1.802060	13.33198	2.551592
7	1.820430	13.36983	2.580222
8	1.833890	13.36690	2.609900
* indicates lag order selected by the criterion AIC: Akaike information criterion			

Table 5.3 - Russian Ruble lag order selection by the Akaike Information Criteria

Due to the fact that the objective of the study is to analyse the impact of currency crises on stock markets using cointegrating equations, cointegration tests were initially performed for the global market (Currency, Country Index and S&P Global 1200 or Currency and S&P 1200). When global cointegration was rejected, a more detailed sequential analysis was made based on the hypothesis of cointegration of continental regions (Currency, Country Index, S&P500, S&P350 and S&P50), where variables were removed in order to test possible cointegrations reduced in terms of number of variables.

Before the crisis: RUB-SP350-SP50

During the crisis: RUB – SP500 – SP350 – SP50

After the crisis: RUB – SP350 – SP50

Unrestricted Cointegration Rank Test (Trace)						
No. of CE(s)	Before Crisis Trace Stat.	Prob.*	During Crisis Trace Stat.	Prob.*	After Crisis Trace Stat.	Prob.*
None*	33.40550	0.0184*	51.55058	0.0216*	30.11854	0.0459*
At most 1	7.732528	0.4944	21.85759	0.3065	7.214321	0.5529
At most 2	0.030519	0.8613	8.153915	0.4491	0.063282	0.8014
At most 3	-	-	0.603564	0.4372	-	-
Trace test indicates 1 cointegrating eqn(s) at the 0.05 level * denotes rejection of the hypothesis at the 0.05 level						

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)						
No. of CE(s)	Before Crisis Max-E Stat.	Prob.*	During Crisis Max-E Stat.	Prob.*	After Crisis Max-E Stat.	Prob.*
None*	25.67297	0.0107*	29.69300	0.0264*	22.90422	0.0279*
At most 1	7.702009	0.4098	13.70367	0.3898	7.151039	0.4714
At most 2	0.030519	0.8613	7.550350	0.4263	0.063282	0.8014
At most 3	-	-	0.603564	0.4372	-	-
Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level * denotes rejection of the hypothesis at the 0.05 level						

Table 5.4 – Russian Ruble cointegration tests.

As per table 5.4, both Trace and Maximum Eigenvalue tests are in accordance and point for the presence of one cointegrating equation (r = 1), since the hypothesis for “None” cointegrating equations is rejected for the 5% significance level and the hypothesis for “At most 1” cointegrating equations is not rejected.

5.1.3 VECM and Cointegrating Equations

The VECM is a multiple equation model in which there are as many equations as the number of endogenous variables included. VECM modelling is done step by step under the Johansen procedure. It requires the specification of the cointegration rank, resulting from the cointegration test (table 5.4), and the pre-specification of the optimal lag order p for the variables, which was selected by minimizing the Akaike Information Criteria (table 5.3).

An unrestricted VECM was estimated for each period, with the inclusion of the variables present in the cointegration relations in section 5.1.2. The first part of the model explains the breakdown of the ECT, with the first variable being the variable of interest (in this case the exchange rate). The signs of the coefficients are reversed in the long-run. If a coefficient has positive (negative) sign, it has a negative (positive) effect on the variable of interest. It represents the cointegrating equation and long-run relationship among the variables. The second part of the model represents the short-run coefficients, starting with the error correction sum and then the adjustment coefficients. The adjustment coefficients mean that: previous periods deviation from the long-run equilibrium is corrected, in the current period, with an adjustment speed of the respective percentage. The percentage variation of the variable (related to the adjustment coefficient) is associated to an increase/decrease (depending on the sign) of the respective percentage in relation to the variable of interest, on average, ceteris paribus, in the short-run.

From the VECM (annex E), we can finally present the cointegrating equations, which represent the cointegration relationships between the variables. The cointegrating equations in table 5.5 were based on equation (13).

BEFORE THE CRISIS
$\mathbf{\Delta RUB_t}$ = – 0.059097 [1.000 RUB_{t-1} + 0.00002 $SP350_{t-1}$ – 0.00000771 $SP50_{t-1}$ – 0.028797] – 0.019706 ΔRUB_{t-1} + 0.008992 ΔRUB_{t-2} + 0.004203 ΔRUB_{t-3} – 0.0000000474 $\Delta SP350_{t-1}$ + 0.00000317 $\Delta SP350_{t-2}$ + 0.000000368 $\Delta SP350_{t-3}$ – 0.00000102 $\Delta SP50_{t-1}$ – 0.0000007 $\Delta SP50_{t-2}$ – 0.000000232 $\Delta SP50_{t-3}$ – 0.00000649
$\mathbf{\Delta SP350_t}$ = – 1135.199 [1.000 RUB_{t-1} + 0.00002 $SP350_{t-1}$ – 0.00000771 $SP50_{t-1}$ – 0.028797] + 8738.748 ΔRUB_{t-1} + 2569.164 ΔRUB_{t-2} + 1215.411 ΔRUB_{t-3} – 0.010587 $\Delta SP350_{t-1}$ + 0.072047 $\Delta SP350_{t-2}$ + 0.029056 $\Delta SP350_{t-3}$ – 0.032587 $\Delta SP50_{t-1}$ + 0.012217 $\Delta SP50_{t-2}$ – 0.033371 $\Delta SP50_{t-3}$ + 0.738010
$\mathbf{\Delta SP50_t}$ = 1866.333 [1.000 RUB_{t-1} + 0.00002 $SP350_{t-1}$ – 0.00000771 $SP50_{t-1}$ – 0.028797] + 33694.58 ΔRUB_{t-1} + 13338.87 ΔRUB_{t-2} + 9833.769 ΔRUB_{t-3} + 0.693984 $\Delta SP350_{t-1}$ + 0.012022 $\Delta SP350_{t-2}$ + 0.035113 $\Delta SP350_{t-3}$ – 0.052991 $\Delta SP50_{t-1}$ + 0.016460 $\Delta SP50_{t-2}$ – 0.024829 $\Delta SP50_{t-3}$ + 0.905278
DURING THE CRISIS
$\mathbf{\Delta RUB_t}$ = – 0.023096 [1.000 RUB_{t-1} + 0.000119 $SP500_{t-1}$ – 0.0000285 $SP350_{t-1}$ – 0.000016 $SP50_{t-1}$ – 0.161051] – 0.053941 ΔRUB_{t-1} – 0.030644 ΔRUB_{t-2} – 0.018098 ΔRUB_{t-3} – 0.039927 ΔRUB_{t-4} + 0.0000023 $\Delta SP500_{t-1}$ + 0.00000193 $\Delta SP500_{t-2}$ + 0.0000022 $\Delta SP500_{t-3}$ + 0.00000171 $\Delta SP500_{t-4}$ + 0.00000153 $\Delta SP350_{t-1}$ – 0.0000000563 $\Delta SP350_{t-2}$ – 0.000000815 $\Delta SP350_{t-3}$ + 0.000000906 $\Delta SP350_{t-4}$ – 0.0000000818 $\Delta SP50_{t-1}$ – 0.000000655 $\Delta SP50_{t-2}$ – 0.000000378 $\Delta SP50_{t-3}$ – 0.00000114 $\Delta SP50_{t-4}$ – 0.0000509
$\mathbf{\Delta SP500_t}$ = – 842.5166 [1.000 RUB_{t-1} + 0.000119 $SP500_{t-1}$ – 0.0000285 $SP350_{t-1}$ – 0.000016 $SP50_{t-1}$ – 0.161051] + 2151.229 ΔRUB_{t-1} + 875.5808 ΔRUB_{t-2} – 4703.841 ΔRUB_{t-3} – 922.7726 ΔRUB_{t-4} + 0.049911 $\Delta SP500_{t-1}$ – 0.031159 $\Delta SP500_{t-2}$ + 0.059156 $\Delta SP500_{t-3}$ – 0.023754 $\Delta SP500_{t-4}$ + 0.046446 $\Delta SP350_{t-1}$ – 0.003636 $\Delta SP350_{t-2}$ + 0.000117 $\Delta SP350_{t-3}$ +

$0.092434\ \Delta SP350_{t-4} + 0.049789\ \Delta SP50_{t-1} - 0.038377\ \Delta SP50_{t-2} + 0.00182\ \Delta SP50_{t-3} - 0.025498\ \Delta SP50_{t-4} - 0.336101$
$\mathbf{\Delta SP350_t} = -308.3498\ [1.000\ RUB_{t-1} + 0.000119\ SP500_{t-1} - 0.0000285\ SP350_{t-1} - 0.000016\ SP50_{t-1} - 0.161051] + 3195.73\ \Delta RUB_{t-1} - 682.3962\ \Delta RUB_{t-2} - 3821.523\ \Delta RUB_{t-3} + 1551.739\ \Delta RUB_{t-4} + 0.374724\ \Delta SP500_{t-1} + 0.047422\ \Delta SP500_{t-2} + 0.039375\ \Delta SP500_{t-3} - 0.05567\ \Delta SP500_{t-4} - 0.187764\ \Delta SP350_{t-1} - 0.066051\ \Delta SP350_{t-2} + 0.052622\ \Delta SP350_{t-3} + 0.120253\ \Delta SP350_{t-4} + 0.014762\ \Delta SP50_{t-1} - 0.045599\ \Delta SP50_{t-2} + 0.016612\ \Delta SP50_{t-3} - 0.055708\ \Delta SP50_{t-4} - 0.200331$
$\mathbf{\Delta SP50_t} = -668.8977\ [1.000\ RUB_{t-1} + 0.000119\ SP500_{t-1} - 0.0000285\ SP350_{t-1} - 0.000016\ SP50_{t-1} - 0.161051] + 11536.35\ \Delta RUB_{t-1} + 4380.066\ \Delta RUB_{t-2} + 1971.489\ \Delta RUB_{t-3} + 337.6639\ \Delta RUB_{t-4} + 0.667262\ \Delta SP500_{t-1} + 0.171514\ \Delta SP500_{t-2} + 0.096298\ \Delta SP500_{t-3} - 0.104304\ \Delta SP500_{t-4} + 0.248304\ \Delta SP350_{t-1} + 0.044040\ \Delta SP350_{t-2} - 0.000487\ \Delta SP350_{t-3} + 0.195934\ \Delta SP350_{t-4} - 0.152705\ \Delta SP50_{t-1} - 0.028055\ \Delta SP50_{t-2} + 0.022493\ \Delta SP50_{t-3} - 0.060729\ \Delta SP50_{t-4} - 1.477368$
AFTER THE CRISIS
$\mathbf{\Delta RUB_t} = -0.023909\ [1.000\ RUB_{t-1} - 0.0000182\ SP350_{t-1} + 0.0000012\ SP50_{t-1} + 0.005817] - 0.104903\ \Delta RUB_{t-1} - 0.074732\ \Delta RUB_{t-2} - 0.000000612\ \Delta SP350_{t-1} - 0.000000314\ \Delta SP350_{t-2} + 0.000000171\ \Delta SP50_{t-1} - 0.000000248\ \Delta SP50_{t-2} + 0.0000138$
$\mathbf{\Delta SP350_t} = 1561.529\ [1.000\ RUB_{t-1} - 0.0000182\ SP350_{t-1} + 0.0000012\ SP50_{t-1} + 0.005817] + 2179.628\ \Delta RUB_{t-1} + 3366.928\ \Delta RUB_{t-2} + 0.084719\ \Delta SP350_{t-1} - 0.059416\ \Delta SP350_{t-2} - 0.005855\ \Delta SP50_{t-1} - 0.010063\ \Delta SP50_{t-2} + 0.515946$
$\mathbf{\Delta SP50_t} = -2652.993\ [1.000\ RUB_{t-1} - 0.0000182\ SP350_{t-1} + 0.0000012\ SP50_{t-1} + 0.005817] + 65294.24\ \Delta RUB_{t-1} + 10424.25\ \Delta RUB_{t-2} + 0.426068\ \Delta SP350_{t-1} - 0.044546\ \Delta SP350_{t-2} - 0.106804\ \Delta SP50_{t-1} - 0.058911\ \Delta SP50_{t-2} + 4.114176$

Table 5.5 – Russian Ruble cointegrating estimated equations using VECM.

Cointegrating equations represent the long-run (cointegration) relationships, which means that it is possible to predict one variable from the others. The signs of the coefficients are reversed in the long run. For example, before the crisis, in the long-run, the SP350 has a negative impact on RUB and the SP50 has a positive impact on RUB, on average, ceteris paribus. During the crisis, in the long-run, the SP500 has a negative impact on RUB, the SP350 has a positive impact on RUB and the SP50 has a positive impact on RUB, on average, ceteris paribus. After the crisis, in the long-run, the SP350 has a positive impact on RUB and the SP50 has a negative impact on RUB, on average, ceteris paribus.

The negative impact of the S&P 500 on Russian Ruble was expected, which means that, on average, when American markets rise, the RUB depreciates against the USD, meaning that a growing US market produces a more powerful USD against the Ruble. The same for the positive impact of the S&P Europe 350 on Ruble, that is, on average, when European markets rise, the RUB appreciates against the USD. Surprisingly, the S&P Asia 50 had a reversed impact on RUB, becoming from positive to negative. This may mean a new perception of market dependence and an even closer approach between Russia and Europe.

Before the crisis, a certain degree of interdependence existed between the RUB, SP350 and SP50. A substantial amount of interdependence existed between the RUB, SP500, SP350 and SP50 during the currency crisis. The co-movements were then extended to the SP500, but after the crisis the cointegration decreased. Despite this, the cointegration between RUB-SP350-SP50 still remained. The results confirm the increase in relations with Asian markets (mainly with China due to Russia currently holding one third of the global yuan reserves) but reject the idea of a collapse in the relations with Europe due to the annexation of Crimea, being this just a political collapse.

5.1.4 Residual analysis

After specifying and estimating the model, the residual analysis is divided into diagnostic tests for residual autocorrelation, conditional heteroskedasticity and non-normality (already done in section 5.1). These tests are necessary to conclude the adequacy of the VECM.

5.1.4.1 Autocorrelation diagnostic tests

The autocorrelation assumption is that the errors ε_i and ε_j, with $i \neq j$, are linearly independent. When (strong) autocorrelation occurs, the elements outside the main diagonal of the variance-covariance matrix are non-zero, which can be a sign of model misspecification. For this purpose, the Portmanteau and LM tests for residual autocorrelation are shown in table 5.6.

VEC Residual Portmanteau Tests for Autocorrelations						
Lags	Before Crisis Q - Stat.	Prob.*	During Crisis Q - Stat.	Prob.*	After Crisis Q - Stat.	Prob.*
1	0.470192	-	0.031531	-	0.468699	-

2	1.109875	-	0.190926	-	0.891526	-
3	2.424545	-	0.710598	-	17.25294	0.3040
4	11.90929	0.6859	1.733468	-	42.85136	0.0103
5	19.19255	0.7416	9.851995	0.9994	49.77671	0.0306
6	25.76107	0.8112	23.39921	0.9954	54.53976	0.0929
7	38.24405	0.6366	46.72469	0.8949	60.40277	0.1725
8	43.25254	0.7712	60.69333	0.8999	73.10599	0.1192
9	56.74984	0.5952	69.64119	0.9603	82.61409	0.1258
10	67.05083	0.5440	85.19247	0.9485	86.31632	0.2431
*Test is valid only for lags larger than the VAR lag order.						

VEC Residual Serial Correlation LM Tests						
Lags	Before Crisis LRE*- Stat.	Prob.	During Crisis LRE*- Stat.	Prob.	After Crisis LRE*- Stat.	Prob.
1	32.47131	0.0002	4.052912	0.9988	19.27321	0.0230
2	26.30952	0.0018	11.24622	0.7940	6.743255	0.6638
3	19.36327	0.0223	21.06015	0.1762	17.18777	0.0459
4	11.64938	0.2338	14.30411	0.5761	26.90124	0.0015
5	7.764939	0.5580	8.759227	0.9230	7.184564	0.6179
6	6.767456	0.6613	13.86624	0.6087	4.872637	0.8453
7	12.97376	0.1638	23.84477	0.0930	5.943512	0.7456
8	5.418207	0.7964	14.40642	0.5685	13.01268	0.1620
9	14.33939	0.1108	9.220515	0.9041	9.752177	0.3709
10	10.80513	0.2893	16.19817	0.4392	3.749574	0.9271
*Edgeworth expansion corrected likelihood ratio statistic.						

Table 5.6 – Russian Ruble Portmanteau and LM tests for residual autocorrelation.

Table 5.6 shows the Portmanteau and LM tests for residual autocorrelation. Due to the fact that the optimal lag-length obtained by minimizing the Information Criteria is 3, 4 and 2 for the period before, during and after the crisis (table 5.3), the analysis is done considering lag 4, 5 and 3 upwards, respectively. The non-rejection of the null hypothesis of "No residual autocorrelation" allows to conclude that there are no residual autocorrelation problems in the model before and during the crisis. For the period after the crisis, both tests reject the null of "No residual autocorrelation" for two lags: lags 3 and 4 in the Portmanteau test and lags 4 and

5 in the LM test. When the residuals are strongly autocorrelated, it can cause problems in conventional analyses. In this case, as the null is rejected only for two lags, the non-rejection of the null hypothesis of “No residual autocorrelation” for the vast majority of lags allows to conclude that there are no residuals’ autocorrelation problems in the model.

5.1.4.2 Heteroskedasticity diagnostic tests

Heteroskedasticity problems occur when the variance of the errors is not constant. In such case, the estimators are still unbiased, but they are no longer the most efficient. The ARCH-LM multivariate test was run to check for heteroskedasticity problems in each model.

ARCH-LM test	Before Crisis	During Crisis	After Crisis
Chi-square	582.6176	2288.54	460.3089
Prob.	0.0000	0.0000	0.0000

Table 5.7 – Russian Ruble multivariate ARCH-LM test.

Table 5.7 shows the multivariate ARCH-LM test for residual heteroskedasticity, in which we reject the null hypothesis of residual homoskedasticity, meaning that the estimators are no longer the most efficient but they are still unbiased. Heteroskedasticity has impact on standard errors, i.e. it has impact on the statistical significance of the parameters estimation but it does not affect the cointegrating equations (which are the final objective of this analysis).

5.2 Chinese Yuan

In April 2015, Chinese state media advised domestic investors to invest in the stock market, giving the perception that the government would support a bull market in order to avoid a financial crisis. The Shanghai Stock Exchange Index rose 36% in three months, but when investors realised the potential for a bubble, the SSE Index dropped 43% from June 12 to August 26, leading the Chinese economy into a currency crisis. The number of daily observations collected were 346, 384 and 329 for the periods before, during and after the currency crisis, respectively. The time series were considered in levels and the descriptive statistics are in table 5.8.

Before Crisis	CNY	SCI	SP1200	SP5000	SP350	SP50
Mean	0.161347	2987.769	1919.244	2015.283	1472.997	3723.929
Median	0.161120	2655.321	1927.070	2024.735	1416.540	3694.840
Maximum	0.163600	5166.350	2007.620	2130.820	1693.810	4173.970
Minimum	0.159320	2003.487	1773.700	1815.690	1273.160	3442.240
Std. Dev.	0.001071	918.9004	44.96835	80.48715	111.9123	162.5286
Skewness	0.449729	0.663756	-0.422667	-0.444540	0.491036	0.827230
Kurtosis	2.309169	2.196381	2.927342	2.069330	1.700318	3.075985

Jarque-Bera	18.54374	34.71665	10.37809	23.88279	38.25661	39.54511
Probability	0.000094	0.000000	0.005577	0.000007	0.000000	0.000000
Sum	55.82607	1033768.	664058.3	697287.8	509657.1	1288479.
Sum Sq. Dev.	0.000396	2.91E+08	697642.5	2234973.	4320907.	9113367.
Observations	346	346	346	346	346	346

During Crisis	CNY	SCI	SP1200	SP5000	SP350	SP50
Mean	0.151644	3124.016	1849.952	2082.395	1410.203	3403.259
Median	0.152260	3076.397	1860.400	2085.745	1388.395	3383.395
Maximum	0.161100	3993.668	1989.780	2276.980	1643.700	3857.640
Minimum	0.139190	2655.661	1626.220	1829.080	1225.180	2828.940
Std. Dev.	0.005076	256.5314	75.51985	102.4826	70.97288	249.8303
Skewness	-1.009585	1.052828	-0.651828	-0.213479	0.713473	-0.113790
Kurtosis	3.756264	3.844623	3.071360	2.547979	3.515831	2.085461
Jarque-Bera	74.38366	82.35482	27.27380	6.185843	36.83612	14.21081
Probability	0.000000	0.000000	0.000001	0.045369	0.000000	0.000821
Sum	58.23127	1199622.	710381.4	799639.7	541518.0	1306852.
Sum Sq. Dev.	0.009868	25204607	2184344.	4022526.	1929228.	23905020
Observations	384	384	384	384	384	384

After Crisis	CNY	SCI	SP1200	SP5000	SP350	SP50
Mean	0.150555	3262.311	2219.554	2525.406	1547.322	4657.866
Median	0.150510	3261.219	2212.050	2488.110	1546.110	4638.760
Maximum	0.159510	3559.465	2518.110	2872.870	1626.610	5572.770
Minimum	0.139190	3052.785	1990.420	2278.870	1463.120	3783.180
Std. Dev.	0.005000	108.9768	129.2890	146.7406	36.29007	486.0011
Skewness	0.313262	0.242088	0.130977	0.339520	-0.082690	-0.084029
Kurtosis	2.047334	2.479557	2.040711	2.013043	2.298394	1.832144
Jarque-Bera	17.82227	6.926649	13.55555	19.67391	7.122872	19.08379
Probability	0.000135	0.031325	0.001139	0.000053	0.028398	0.000072
Sum	49.53256	1073300.	730233.3	830858.5	509069.0	1532438.
Sum Sq. Dev.	0.008199	3895308.	5482734.	7062755.	431965.9	77472645
Observations	329	329	329	329	329	329

Table 5.8 – Chinese Yuan summary descriptive statistics

From the descriptive statistics we can conclude that all data is asymmetric, by the significant skewness, and present significant kurtosis. The statistical evidence of the sample does not point for the normality of the variables, based on the Jarque-Bera test, but under the central limit distribution, the sampling distribution of the means will become approximately normally distributed for large samples.

The results reveal that before the crisis, the CNY had a higher mean (0.16) and the mean decreased during the crisis (0.152), which represents the impact of the currency depreciation.

Despite the low values, when representing the USD as function of the CNY, it represents an increase from 6.2 to 6.6. Surprisingly, although the CNY appreciated against the USD after the crisis, the mean was lower than during the crisis (0.151). This can be explained by the recorded minimum and maximum values. Both periods had approximately the same minimum value (0.139) but the maximum value in the period during the crisis (0.161) is greater than after the crisis (0.0159), meaning that the Chinese Yuan had a slow recovery.

The Shanghai Composite Index (SCI) did not follow the same pattern in terms of mean, but when analysing the maximum and minimum values, two different scenarios can be observed. Before the crisis, the SCI registered a minimum value of 2003 and a maximum value of 5166, which represents the period when the state media advised domestic investors to invest in the stock market and consequently the formation of a speculative bubble. During and after the crisis, the range was more stable with maximum values of 3993 and 3559 and minimum values of 2655 and 3052, respectively. The minimum values are very important because they are a sign that despite the crash that occurred, the index never registered values lower than the pre-crisis period. The SP1200 and SP500 had a decrease of the mean from the period before to during the crisis and then an increase from during to after the crisis. The remaining three indexes show a continuous increase of the mean.

In terms of standard deviation, the CNY almost quintupled during the crisis (from 0.0011 to 0.0051), representing high volatility in this turbulent period, followed by a constant level after the crisis, i.e. the standard deviation remained almost the same (0.005). As for the indexes, the most notable values are from SCI and SP50. The SP50 shows a continuous increase that tripled from 162 (before the crisis) to 486 (after the crisis) and the SCI had a standard deviation of 919 before the crisis, being the highest standard deviation from all variables and represents the speculative bubble and corresponding volatile period.

5.2.1 Stationarity

The notion of cointegration is applied to non-stationary time series. Most financial time series are generated by nonstationary processes and are integrated of first order. Table 5.9 shows the results of the ADF unit root test, also confirmed by the KPSS stationarity test.

	Before Crisis		During Crisis		After Crisis	
	ADF	KPSS	ADF	KPSS	ADF	KPSS
CNY	-1.5104	0.3235	-0.1087	1.9375***	-0.9409	2.022***
SCI	-1.1119	2.0127***	-2.9199**	0.6666**	-1.8230	0.6095**

SP1200	-2.9634**	0.8284***	-1.832	1.0637***	-1.4947	2.0165***
SP500	-1.8786	2.0007***	-1.3163	1.5978***	-1.4401	1.9944***
SP350	-1.0828	1.7312***	-3.4075**	0.7318**	-2.8441*	0.3608*
SP50	-1.8383	0.6975**	-1.1295	1.3672***	-1.4799	2.0883***

* , ** and *** indicate the null hypothesis rejection for 10%, 5% and 1% significance level

Table 5.9 – Chinese Yuan unit root and stationarity tests for the variables in levels.

The optimal lag lengths were based on the Akaike Information Criteria (AIC). Variables rejected for 5% significance level on the ADF test were not taken into account, as in the case of the SP1200 (before the crisis), SCI and SP350 (during the crisis). All variables have a p-value of 0.00 when considering the first differences (annex B). It is possible to conclude that the variables are first order integrated (I(1)).

5.2.2 Cointegration tests

The Johansen procedure is used to test for cointegration relationships between non-stationary time series and comes in two asymptotically tests: the Trace Test and the Maximum Eigenvalue Test. The tests were computed considering the optimal lag-length (obtained in table 5.10 by minimizing the Information Criteria for the VAR model) and the eigenvalues from the rank of the Π matrix that are different from zero. The optimal lag order selection is important because the application of few lags can generate size distortion in the test results and the application of many autoregressive lags can lose the power to obtain correct estimates.

Lag Order Selection by the Akaike Information Criteria	
Lag	After Crisis AIC
0	12.56949
1	2.527317
2	2.362697
3	2.334518
4	2.276131*
5	2.313726
6	2.315021
7	2.344017
8	2.377839

* indicates lag order selected by the criterion AIC: Akaike information criterion

Table 5.10- Chinese Yuan lag order selection by the Akaike Information Criteria.

Due to the fact that the objective of the study is to analyse the impact of currency crises on stock markets using cointegrating equations, cointegration tests were initially performed for the global market (Currency, Country Index and S&P Global 1200 or Currency and S&P 1200). When global cointegration was rejected, a more detailed sequential analysis was made based on the hypothesis of cointegration of continental regions (Currency, Country Index, S&P500, S&P350 and S&P50), where variables were removed in order to test possible cointegrations reduced in terms of number of variables.

Before the crisis: No cointegration found

During the crisis: No cointegration found

After the crisis: CNY – SP500 – SP350

Unrestricted Cointegration Rank Test (Trace)			Unrestricted Cointegration Rank Test (Maximum Eigenvalue)		
No. of CE(s)	After Crisis Trace Stat.	Prob.*	No. of CE(s)	After Crisis Max-E Stat.	Prob.*
None*	30.60665	0.0403*	None	17.53714	0.1481
At most 1	13.06951	0.1123	At most 1	12.04305	0.1090
At most 2	1.026463	0.3110	At most 2	1.026463	0.3110
Trace test indicates 1 cointegrating eqn(s) * denotes rejection of the hypothesis at the 0.05 level			Max-eigenvalue test indicates 0 cointegrating eqn(s) * denotes rejection of the hypothesis at the 0.05 level		

Table 5.11 – Chinese Yuan cointegration tests.

As per table 5.11, the Trace and Maximum Eigenvalue tests show different results. The Trace test points for the presence of one cointegrating equation (r = 1), since the hypothesis for “None” cointegrating equations is rejected for the 5% significance level and the hypothesis for “At most 1” cointegrating equation is not rejected, but the Maximum Eigenvalue does not point to the same conclusion. We will take into consideration the Trace test as it considers all of the small eigenvalues, it holds more statistical power than the Maximum Eigenvalue statistic and

Johansen and Juselius (1990) recommended the use of Trace statistic when the two statistics provide contradictory results.

5.2.3 VECM and Cointegrating Equations

The VECM is a multiple equation model in which there are as many equations as the number of endogenous variables included. VECM modelling is done step by step under the Johansen procedure. It requires the specification of the cointegration rank, resulting from the cointegration test (table 5.11), and the pre-specification of the optimal lag order p for the variables, which was selected by minimizing the Akaike Information Criteria (table 5.10).

An unrestricted VECM was estimated for the period after the crisis (as it is the only period with cointegration tests pointing to the existence of cointegration relationships), with the inclusion of the variables present in the cointegration relations in section 5.2.2. From the VECM (annex E), we can finally present the cointegrating equations, which represent the cointegration relationships between the variables. The cointegrating equations in table 5.12 were based on equation (13).

AFTER THE CRISIS
$\mathbf{\Delta CNY_t} = -0.042372\,[1.000\ CNY_{t-1} - 0.0000362\ SP500_{t-1} + 0.0000279\ SP350_{t-1} - 0.10249] + 0.222117\ \Delta CNY_{t-1} - 0.109058\ \Delta CNY_{t-2} + 0.058196\ \Delta CNY_{t-3} + 0.125619\ \Delta CNY_{t-4} - 0.00000126\ \Delta SP500_{t-1} - 0.00000226\ \Delta SP500_{t-2} + 0.00000209\ \Delta SP500_{t-3} - 0.00000372\ \Delta SP500_{t-4} - 0.000000636\ \Delta SP350_{t-1} + 0.00000117\ \Delta SP350_{t-2} + 0.000000825\ \Delta SP350_{t-3} + 0.00000908\ \Delta SP350_{t-4} + 0.0000347$
$\mathbf{\Delta SP500_t} = 932.2961\,[1.000\ CNY_{t-1} - 0.0000362\ SP500_{t-1} + 0.0000279\ SP350_{t-1} - 0.10249] - 487.3981\ \Delta CNY_{t-1} - 2247.095\ \Delta CNY_{t-2} + 355.8958\ \Delta CNY_{t-3} + 396.0661\ \Delta CNY_{t-4} + 0.105578\ \Delta SP500_{t-1} - 0.198348\ \Delta SP500_{t-2} + 0.284095\ \Delta SP500_{t-3} + 0.020495\ \Delta SP500_{t-4} - 0.135581\ \Delta SP350_{t-1} + 0.023965\ \Delta SP350_{t-2} - 0.231919\ \Delta SP350_{t-3} + 0.165895\ \Delta SP350_{t-4} + 1.107647$
$\mathbf{\Delta SP350_t} = 625.2458\,[1.000\ CNY_{t-1} - 0.0000362\ SP500_{t-1} + 0.0000279\ SP350_{t-1} - 0.10249] - 571.5183\ \Delta CNY_{t-1} - 302.6653\ \Delta CNY_{t-2} + 1188.512\ \Delta CNY_{t-3} - 2384.947\ \Delta CNY_{t-4} + 0.281357\ \Delta SP500_{t-1} + 0.017569\ \Delta SP500_{t-2} + 0.095002\ \Delta SP500_{t-3} - 0.026477\ \Delta SP500_{t-4} - 0.22879\ \Delta SP350_{t-1} - 0.026113\ \Delta SP350_{t-2} - 0.034111\ \Delta SP350_{t-3} - 0.075956\ \Delta SP350_{t-4} + 0.028792$

Table 5.12 – Chinese Yuan cointegrating estimated equations using VECM.

Cointegrating equations represent the long-run (cointegration) relationship, which means that it is possible to predict one variable from the others. The signs of the coefficients are reversed in the long run. After the crisis, in the long-run, the SP500 has a positive impact on CNY and the SP350 has a negative impact on CNY, on average, ceteris paribus. The negative impact of the SP350 on Chinese Yuan was expected due to the evolution of the cracks in China-Europe relations since the 1990’s and a closer approach to the USA, which means that, on average, when the S&P Europe 350 index rises, the Chinese Yuan depreciates against the USD.

Surprisingly, the S&P 500 has a positive impact on CNY. This can be explained by the evolution of China’s role as the largest US creditor, leading to that, on average, a growing US market produces a more powerful CNY against the USD. It can be a very dangerous sign for the US.

In the CNY study, we excluded some stationary variables (see table 5.9), such as the SP1200 (before the crisis), SCI and SP350 (during the crisis). After the crisis, a substantial amount of interdependence exists between the CNY, SP500 and SP350. We cannot conclude whether the co-movement started to decrease after the crisis, as we excluded the SP350 from during the crisis period, but we can conclude that the currency crisis increased the co-movements between stock markets. The fact that the CNY went from no cointegration relations before the crisis to a sharp increase after the crisis, contributes to the theory of Li (2015) that the fall of the RMB “seems more a part of the RMB internationalisation process than an arbitrary move to rescue China’s economic slowdown”. The bubble created by Chinese state entities suggests that the Yuan devaluation was part of Chinese reforms to move towards a market-oriented economy, which had substantial worldwide repercussions and impact on global markets, with the emergence of cointegration relationships between the Chinese Yuan and European and American markets.

5.2.4 Residual analysis

After specifying and estimating the model, the residual analysis is divided into diagnostic tests for residual autocorrelation, conditional heteroskedasticity and non-normality (already done in section 5.2). These tests are necessary to conclude the adequacy of the VECM.

5.2.4.1 Autocorrelation diagnostic tests

The autocorrelation assumption is that the errors ε_i and ε_j, with $i \neq j$, are linearly independent. When (strong) autocorrelation occurs, the elements outside the main diagonal of the variance-covariance matrix are non-zero, which can be a sign of model misspecification. For this purpose, the Portmanteau and LM tests for residual autocorrelation are shown in table 5.13.

VEC Residual Portmanteau Tests for Autocorrelations			VEC Residual Serial Correlation LM Tests		
Lags	After Crisis Q - Stat.	Prob.*	Lags	After Crisis LRE* - Stat.	Prob.*
1	7.107901	---	1	45.74663	0.0000
2	8.691888	---	2	11.46918	0.2449
3	9.878872	---	3	8.194294	0.5147
4	12.19681	---	4	10.90765	0.2821
5	18.79852	0.2230	5	6.769580	0.6611
6	24.23120	0.4484	6	5.970414	0.7429
7	34.23806	0.4081	7	10.66272	0.2995
8	53.46671	0.1105	8	21.49802	0.1106
9	60.41948	0.1721	9	7.911510	0.5431
10	67.00343	0.2494	10	7.218496	0.6144
*Test is valid only for lags larger than the VAR lag order.			*Edgeworth expansion corrected likelihood ratio statistic.		

Table 5.13 – Chinese Yuan Portmanteau and LM tests for residual autocorrelation.

Table 5.13 shows the Portmanteau and LM tests for residual autocorrelation. Due to the fact that the optimal lag-length obtained by minimizing the Information Criteria is 4 (table 5.10), the analysis is done considering lag 5 upwards. The non-rejection of the null hypothesis of "No residual autocorrelation" allows to conclude that there are no residuals' autocorrelation problems in the model.

5.2.4.2 Heteroskedasticity diagnostic tests

Heteroskedasticity problems occur when the variance of the errors is not constant. In such case, the estimators are still unbiased, but they are no longer the most efficient. The ARCH-LM multivariate test was run to check for heteroskedasticity problems in the model.

ARCH-LM test	After Crisis
Chi-square	1223.117
Prob.	0.0000

Table 5.14 – Chinese Yuan multivariate ARCH-LM test.

Table 5.14 shows the multivariate ARCH-LM test for residual heteroskedasticity, in which we reject the null hypothesis of residual homoskedasticity, meaning that the estimators are no longer the most efficient but they are still unbiased. Heteroskedasticity has impact on standard errors, i.e. it has impact on the statistical significance of the parameters estimation but it does not affect the cointegrating equations (which are the final objective of this analysis).

5.3 British Pound

Britain decided to leave the EU on June 23, 2016 when the UK voted in the referendum to leave the EU. Brexit had an immediate negative impact on exchange rates. In the stock market, the referendum had a significant negative effect on the British and European market indices. It was therefore an unexpected event for the financial markets. The number of daily observations collected were 308, 182 and 230 for the periods before, during and after the crisis, respectively. The time series were considered in levels and the descriptive statistics are in table 5.15.

Before Crisis	GBP	FTSE100	SP1200	SP5000	SP350	SP50
Mean	1.496195	6338.341	1850.292	2039.755	1468.234	3407.397
Median	1.512005	6261.050	1849.640	2066.010	1454.100	3323.090
Maximum	1.587740	7104.000	2007.620	2130.820	1686.240	4173.970
Minimum	1.386430	5537.000	1626.220	1829.080	1225.180	2828.940
Std. Dev.	0.053953	346.6587	90.19787	73.32452	112.1727	333.2245
Skewness	-0.205732	0.531396	-0.180486	-0.986129	0.219419	0.734771
Kurtosis	1.634469	2.480191	2.401680	2.854806	1.836362	2.639945
Jarque-Bera	26.10272	17.96319	6.266356	50.18962	19.84842	29.37794
Probability	0.000002	0.000126	0.043579	0.000000	0.000049	0.000000
Sum	460.8280	1952209.	569890.0	628244.6	452216.2	1049478.
Sum Sq. Dev.	0.893653	36892876	2497646.	1650581.	3862895.	34088835
Observations	308	308	308	308	308	308

During Crisis	GBP	FTSE100	SP1200	SP5000	SP350	SP50
Mean	1.271187	6922.513	1927.075	2202.966	1411.573	3686.799
Median	1.255765	6900.750	1912.925	2181.095	1389.420	3691.635
Maximum	1.485110	7382.900	2065.280	2395.960	1524.440	3977.400
Minimum	1.204290	5982.200	1743.890	2000.540	1252.870	3261.420
Std. Dev.	0.042329	245.3487	58.56841	76.12947	55.35960	144.8999
Skewness	0.907907	-0.502301	0.272458	0.461556	0.247974	-0.546120
Kurtosis	4.874719	3.957215	3.311929	2.847818	2.376313	3.465809
Jarque-Bera	51.65580	14.60160	2.989598	6.637652	4.815026	10.69225
Probability	0.000000	0.000675	0.224294	0.036195	0.090039	0.004767
Sum	231.3560	1259897.	350727.7	400939.8	256906.2	670997.5
Sum Sq. Dev.	0.324304	10895475	620876.8	1049021.	554708.1	3800274.
Observations	182	182	182	182	182	182

After Crisis	GBP	FTSE100	SP1200	SP5000	SP350	SP50
Mean	1.302879	7430.303	2198.917	2495.869	1559.551	4575.195
Median	1.302050	7415.600	2185.180	2466.520	1563.695	4587.840
Maximum	1.389200	7778.600	2470.000	2810.300	1619.710	5428.850
Minimum	1.215080	7114.400	2039.320	2328.950	1489.900	3887.370
Std. Dev.	0.035547	124.6051	104.4106	116.3476	28.24907	375.9624
Skewness	-0.248981	0.460602	0.466319	0.766584	-0.129744	0.110748
Kurtosis	2.894988	3.537732	2.537626	2.759758	2.240033	2.135125
Jarque-Bera	2.482016	10.90364	10.38452	23.07975	6.180140	7.638574
Probability	0.289093	0.004288	0.005559	0.000010	0.045499	0.021943
Sum	299.6621	1708970.	505750.9	574049.9	358696.6	1052295.
Sum Sq. Dev.	0.289355	3555553.	2496459.	3099918.	182744.2	32368622
Observations	230	230	230	230	230	230

Table 5.15 – British Pound summary descriptive statistics

From the descriptive statistics, we can conclude that all data is asymmetric, by the significant skewness, and present significant kurtosis. The statistical evidence of the sample does not point for the normality of the variables (except for the SP1200 during the crisis), based on the Jarque-Bera test, but under the central limit distribution, the sampling distribution of the means will become approximately normally distributed for large samples.

The results reveal that GBP and SP350 followed the same pattern: before the crisis they had a higher mean (1.5 and 1468 respectively) which decreased sharply during the crisis (1.27 and 1411 respectively), representing the impact of the currency depreciation, and then increased. In the case of GBP, the mean after the crisis was 1.3, not recovering up to the values before the crisis, which is also represented by the maximum and lower values, both below the minimum registered before the crisis.

Surprisingly, the FTSE100 followed the same pattern as the other indexes (SP1200, SP500 and SP50) in which the mean was continuously increasing. Comparing the FTSE100 with SP350, we can conclude that the Brexit had a greater (negative) impact on European markets than on British markets, with FTSE100 registering a continuously upward tendence, going from a mean of 6338 to 7430 and a maximum-minimum range that passed from 7104-5537 to 7415-7114. The announcement of the cut in relations with Europe and the understanding of possible easier and less bureaucratic deals with other markets may have triggered this growing trend in the British market, although it was not followed by the GBP, with greater penalties in the rest of European market.

In terms of standard deviation, GBP, FTSE100 and SP350 followed the same pattern, showing a decrease between the three periods, going from 0.05 to 0.03, 347 to 125 and 112 to

28 respectively. It proves the conclusions of Tabeshian (2018) that volatility after the referendum was lower than before the referendum because the uncertainty before Brexit brought an increase in volatility. After the referendum, the fact that people realized the result and the interest rate cut by the central bank led investors to ask for a lower risk premium, which consequently reduced the stock market's volatility.

5.3.1 Stationarity

The notion of cointegration is applied to non-stationary time series. Most financial time series are generated by nonstationary processes and are integrated of first order. Table 5.16 shows the results of the ADF unit root test, also confirmed by the KPSS stationarity test.

	Before Crisis		During Crisis		After Crisis	
	ADF	KPSS	ADF	KPSS	ADF	KPSS
GBP	-1.287689	1.7758***	-2.325454	1.3144***	-1.3325	1.71099***
FTSE 100	-2.411373	1.42109***	-1.863863	1.3631***	-1.667	0.76645***
SP1200	-2.053721	1.12275***	-0.651758	1.2683***	1.6814	1.94317***
SP500	-2.359723	0.373592*	-1.43152	1.3725***	2.2441	1.86805***
SP350	-2.028071	1.76043***	-0.960618	1.3872***	-1.9143	0.50087**
SP50	-2.072367	1.33493***	-1.962021	0.7621***	0.010131	1.98296***

* , ** and *** indicate the null hypothesis rejection for 10%, 5% and 1% significance level

Table 5.16 – British Pound unit root and stationarity tests for the variables in levels

The optimal lag lengths were based on the Akaike Information Criteria (AIC). All variables have a p-value of 0.000 when considering the first differences (annex B). It is possible to conclude that all variables are first order integrated (I(1)).

5.3.2 Cointegration tests

The Johansen procedure is used to test for cointegration relationships between non-stationary time series and comes in two asymptotically tests: the Trace Test and the Maximum Eigenvalue Test. The tests were computed considering the optimal lag-length (obtained in table 5.17 by minimizing the Information Criteria for the VAR model) and the eigenvalues from the rank of the Π matrix that are different from zero. The optimal lag order selection is important because the application of few lags can generate size distortion in the test results and the application of many autoregressive lags can lose the power to obtain correct estimates.

Lag Order Selection by the Akaike Information Criteria			
Lag	Before Crisis AIC	During Crisis AIC	After Crisis AIC
0	21.06248	18.18491	28.09383
1	11.91063	10.28823*	16.60674
2	11.77896*	10.29402	16.51230*
3	11.80967	10.32542	16.57611
4	11.80118	10.35838	16.63813
5	11.80736	10.35470	16.68128
6	11.85271	10.40492	16.76852
7	11.88827	10.42673	16.83461
8	11.91623	10.45047	16.88732
* indicates lag order selected by the criterion AIC: Akaike information criterion			

Table 5.17- British Pound lag order selection by the Akaike Information Criteria

Due to the fact that the objective of the study is to analyse the impact of currency crises on stock markets using cointegrating equations, cointegration tests were initially performed for the global market (Currency, Country Index and S&P Global 1200 or Currency and S&P 1200). When global cointegration was rejected, a more detailed sequential analysis was made based on the hypothesis of cointegration of continental regions (Currency, Country Index, S&P500, S&P350 and S&P50), where variables were removed in order to test possible cointegrations reduced in terms of number of variables.

Before the crisis: GBP – SP350 – SP50

During the crisis: GBP – FTSE100 – SP1200

After the crisis: GBP – SP500 – SP350 – SP50

Unrestricted Cointegration Rank Test (Trace)

No. of CE(s)	Before Crisis Trace Stat.	Prob.*	During Crisis Trace Stat.	Prob.*	After Crisis Trace Stat.	Prob.*
None*	31.61623	0.0305*	30.73373	0.0389*	53.07637	0.0149*
At most 1	13.06729	0.1124	7.434491	0.5277	25.99360	0.1289
At most 2	5.408147	0.02*	0.682170	0.4088	11.04207	0.2089
At most 3	-	-	-	-	4.588784	0.0322*
Trace test indicates 1 cointegrating eqn(s) at the 0.05 level * denotes rejection of the hypothesis at the 0.05 level						
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)						
No. of CE(s)	Before Crisis Max-E Stat.	Prob.*	During Crisis Max-E Stat.	Prob.*	After Crisis Max-E Stat.	Prob.*
None*	18.54894	0.1107	23.29924	0.0244*	27.08277	0.0579
At most 1	7.659146	0.4144	6.752321	0.5188	14.95153	0.2923
At most 2	5.408147	0.02*	0.682170	0.4088	6.453286	0.5557
At most 3	-	-	-	-	4.588784	0.0322*
Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level * denotes rejection of the hypothesis at the 0.05 level						

Table 5.18 – British Pound cointegration tests.

As per table 5.18, both Trace and Maximum Eigenvalue tests are in accordance for during the crisis and point for the presence of one cointegrating equation (r = 1), since the hypothesis for "None" cointegrating equations is rejected for the 5% significance level and the hypothesis for "At most 1" cointegrating equations is not rejected. On the other hand, before and after the crisis, the Trace and Maximum Eigenvalue tests show different results. The Trace test points for the presence of one cointegrating equation (r = 1), but the Maximum Eigenvalue does not. We will take into consideration the Trace test as it considers all of the small eigenvalues, it holds more statistical power than the Maximum Eigenvalue statistic and Johansen and Juselius (1990) recommended the use of Trace statistic when the two statistics provide contradictory results.

5.3.3 VECM and Cointegrating Equations

The VECM is a multiple equation model in which there are as many equations as the number of endogenous variables included. VECM modelling is done step by step under the Johansen procedure. It requires the specification of the cointegration rank, resulting from the cointegration test (table 5.18), and the pre-specification of the optimal lag order p for the variables, which was selected by minimizing the Akaike Information Criteria (table 5.17).

An unrestricted VECM was estimated for each period, with the inclusion of the variables present in the cointegration relations in section 5.3.2. From the VECM (annex E), we can finally present the cointegrating equations, which represent the cointegration relationships between the variables. The cointegrating equations in table 5.19 were based on equation (13).

BEFORE THE CRISIS
$\Delta \mathbf{GBP_t} = -\,0.040415\,[1.000\ GBP_{t-1} - 0.00071\ SP350_{t-1} + 0.0000708\ SP50_{t-1} - 0.695509] + 0.101468\ \Delta GBP_{t-1} + 0.048949\ \Delta GBP_{t-2} - 0.00000103\ \Delta SP350_{t-1} + 0.0000479\ \Delta SP350_{t-2} - 0.00000426\ \Delta SP50_{t-1} - 0.000022\ \Delta SP50_{t-2} - 0.0000678$
$\Delta \mathbf{SP350_t} = 103.2003\,[1.000\ GBP_{t-1} - 0.00071\ SP350_{t-1} + 0.0000708\ SP50_{t-1} - 0.695509] + 209.1256\ \Delta GBP_{t-1} - 18.25935\ \Delta GBP_{t-2} + 0.088587\ \Delta SP350_{t-1} + 0.048296\ \Delta SP350_{t-2} - 0.027697\ \Delta SP50_{t-1} - 0.03968\ \Delta SP50_{t-2} - 0.946393$
$\Delta \mathbf{SP50_t} = 99.05071\,[1.000\ GBP_{t-1} - 0.00071\ SP350_{t-1} + 0.0000708\ SP50_{t-1} - 0.695509] + 923.8272\ \Delta GBP_{t-1} - 10.78479\ \Delta GBP_{t-2} + 0.716973\ \Delta SP350_{t-1} + 0.099881\ \Delta SP350_{t-2} - 0.146978\ \Delta SP50_{t-1} + 0.002643\ \Delta SP50_{t-2} - 1.620095$
DURING THE CRISIS
$\Delta \mathbf{GBP_t} = -\,0.013968\,[1.000\ GBP_{t-1} + 0.000409\ FTSE100_{t-1} - 0.000953\ SP1200_{t-1} - 2.262803] + 0.151299\ \Delta GBP_{t-1} + 0.0000267\ \Delta FTSE100_{t-1} - 0.000124\ \Delta SP1200_{t-1} - 0.000578$
$\Delta \mathbf{FTSE100_t} = -\,512.9385\,[1.000\ GBP_{t-1} + 0.000409\ FTSE100_{t-1} - 0.000953\ SP1200_{t-1} - 2.262803] - 100.1501\ \Delta GBP_{t-1} + 0.017262\ \Delta FTSE100_{t-1} + 1.335562\ \Delta SP1200_{t-1} + 5.28799$
$\Delta \mathbf{SP1200_t} = -\,83.76391\,[1.000\ GBP_{t-1} + 0.000409\ FTSE100_{t-1} - 0.000953\ SP1200_{t-1} - 2.262803] + 124.3323\ \Delta GBP_{t-1} + 0.036839\ \Delta FTSE100_{t-1} + 0.008143\ \Delta SP1200_{t-1} + 1.50452$
AFTER THE CRISIS
$\Delta \mathbf{GBP_t} = -\,0.020031\,[1.000\ GBP_{t-1} + 0.000296\ SP500_{t-1} - 0.000743\ SP350_{t-1} - 0.000165\ SP50_{t-1} - 0.12584] - 0.024999\ \Delta GBP_{t-1} - 0.04082\ \Delta GBP_{t-2} + 0.0000915\ \Delta SP500_{t-1} - 0.0000226\ \Delta SP500_{t-2} - 0.00011\ \Delta SP350_{t-1} + 0.0000746\ \Delta SP350_{t-2} - 0.0000123\ \Delta SP50_{t-1} + 0.00000206\ \Delta SP50_{t-2} + 0.000739$

ΔSP500$_t$ = $41.02594\ [1.000\ GBP_{t-1} + 0.000296\ SP500_{t-1} - 0.000743\ SP350_{t-1} - 0.000165\ SP50_{t-1} - 0.12584] - 81.84934\ \Delta GBP_{t-1} + 122.7394\ \Delta GBP_{t-2} - 0.076775\ \Delta SP500_{t-1} - 0.001333\ \Delta SP500_{t-2} - 0.007901\ \Delta SP350_{t-1} - 0.17152\ \Delta SP350_{t-2} - 0.015533\ \Delta SP50_{t-1} + 0.032243\ \Delta SP50_{t-2} + 2.059427$
ΔSP350$_t$ = $112.5586\ [1.000\ GBP_{t-1} + 0.000296\ SP500_{t-1} - 0.000743\ SP350_{t-1} - 0.000165\ SP50_{t-1} - 0.12584] - 160.5856\ \Delta GBP_{t-1} - 78.05086\ \Delta GBP_{t-2} + 0.146538\ \Delta SP500_{t-1} + 0.028242\ \Delta SP500_{t-2} - 0.139603\ \Delta SP350_{t-1} - 0.102695\ \Delta SP350_{t-2} + 0.018192\ \Delta SP50_{t-1} + 0.022457\ \Delta SP50_{t-2} + 0.160886$
ΔSP50$_t$ = $73.77008\ [1.000\ GBP_{t-1} + 0.000296\ SP500_{t-1} - 0.000743\ SP350_{t-1} - 0.000165\ SP50_{t-1} - 0.12584] + 736.161\ \Delta GBP_{t-1} + 427.6883\ \Delta GBP_{t-2} + 1.193268\ \Delta SP500_{t-1} - 0.245869\ \Delta SP500_{t-2} + 0.089805\ \Delta SP350_{t-1} + 0.057263\ \Delta SP350_{t-2} - 0.016857\ \Delta SP50_{t-1} + 0.05546\ \Delta SP50_{t-2} + 3.605117$

Table 5.19 – British Pound cointegrating estimated equations using VECM.

Cointegrating equations represent the long-run (cointegration) relationships, which means that it is possible to predict one variable from the others. The signs of the coefficients are reversed in the long run. For example, before the crisis, in the long-run, the SP350 has a positive impact on GBP and the SP50 has a negative impact on GBP, on average, ceteris paribus. During the crisis, in the long-run, the FTSE100 has a negative impact on GBP and the SP1200 has a positive impact on GBP. After the crisis, in the long-run, the SP500 has a negative impact on GBP, the SP350 has a positive impact on GBP and the SP50 has a positive impact on GBP, on average, ceteris paribus.

The negative impact of the SP500 on British Pound was expected, which means that, on average, when American markets rise, the GBP depreciates against the USD, i.e. a growing US market produces a more powerful USD against the GBP. The same for the positive impact of the SP350 on GBP, that is, on average, when European markets rise, the GBP appreciates against the USD. Surprisingly, the SP1200 has a positive impact on GBP, which means that, on average, when global markets rise, the GBP appreciates against the USD. This result was not expected because 500 of the 1200 companies that constitute the index are American and only 350 are European, which means that most other companies (Australian, Asian, etc) also have a positive impact on GBP. Other surprise is that the SP50 has a reversed impact on GBP, becoming from negative to positive. It reinforces the theory that the announcement of the cut in relations with Europe and the understanding of possible easier and less bureaucratic deals with other markets may have triggered this positive relation between the British Pound and Asian markets.

Surprisingly, the FTSE 100 has a negative impact on GBP. From the descriptive statistics in table 5.15, this is justified by the fact that FTSE 100 followed a total different pattern from the GBP/USD exchange rate, which before the crisis had a higher mean of 1.5 that decreased sharply during the crisis to 1.27, representing the impact of the currency depreciation, and then increased to 1.3, not recovering up to the values before the crisis. On the other hand, the FTSE100 followed a continuous upward tendence, going from a mean of 6338 to 7430 and a maximum-minimum range that passed from 7104-5537 to 7415-7114. This means that a growing FTSE100 produces a more powerful USD against the GBP.

The relationship between stock markets was less pronounced before the currency crisis, with a certain degree of interdependence between the GBP, SP350 and SP50. A substantial amount of interdependence increased sharply during the crisis, with the cointegration relationship between the GBP, FTSE100 and SP1200. The co-movements were extended to the FTSE100 and worldwide with the inclusion of the SP1200, but started to decrease after the crisis. Despite this, the cointegration between the GBP, SP500, SP350 and SP50 still remained.

5.3.4 Residual analysis

After specifying and estimating the model, the residual analysis is divided into diagnostic tests for residual autocorrelation, conditional heteroskedasticity and non-normality (already done in section 5.3). These tests are necessary to conclude the adequacy of the VECM.

5.3.4.1 Autocorrelation diagnostic tests

The autocorrelation assumption is that the errors ε_i and ε_j, with $i \neq j$, are linearly independent. When (strong) autocorrelation occurs, the elements outside the main diagonal of the variance-covariance matrix are non-zero, which can be a sign of model misspecification. For this purpose, the Portmanteau and LM tests for residual autocorrelation are shown in table 5.20.

VEC Residual Portmanteau Tests for Autocorrelations						
Lags	Before Crisis Q - Stat.	Prob.*	During Crisis Q - Stat.	Prob.*	After Crisis Q - Stat.	Prob.*

1	0.094667	---	18.86711	---	0.246104	---
2	0.567100	---	28.76276	0.0173	1.311689	---
3	14.67120	0.4754	36.35805	0.0506	13.58568	0.9899
4	25.96511	0.3549	44.64210	0.0850	30.39713	0.9407
5	34.36668	0.4021	56.44861	0.0673	47.96131	0.8688
6	38.71779	0.6158	61.16748	0.1558	62.68181	0.8634
7	49.78074	0.5221	72.80913	0.1240	75.21097	0.8984
8	56.02613	0.6217	83.78638	0.1085	88.21385	0.9181
9	61.98242	0.7128	97.30334	0.0686	94.97303	0.9754
10	67.11864	0.8055	108.3704	0.0602	116.7765	0.9240
*Test is valid only for lags larger than the VAR lag order.						
VEC Residual Serial Correlation LM Tests						
Lags	Before Crisis LRE*- Stat.	Prob.	During Crisis LRE*- Stat.	Prob.	After Crisis LRE*- Stat.	Prob.
1	14.93398	0.0928	53.88063	0.0000	12.91059	0.6793
2	6.673398	0.6711	11.52267	0.2416	13.61366	0.6275
3	16.17473	0.0633	7.764459	0.5580	13.68596	0.6221
4	12.28097	0.1979	8.843029	0.4519	18.35843	0.3033
5	8.783393	0.4575	12.41291	0.1910	18.39305	0.3014
6	4.559843	0.8709	4.882204	0.8445	16.27390	0.4340
7	11.35814	0.2520	12.27244	0.1984	13.68259	0.6223
8	6.660605	0.6724	11.55477	0.2396	13.77550	0.6154
9	6.329255	0.7066	14.21083	0.1150	7.411029	0.9645
10	5.304677	0.8070	11.76794	0.2267	22.58413	0.1253
*Edgeworth expansion corrected likelihood ratio statistic.						

Table 5.20 – British Pound Portmanteau and LM tests for residual autocorrelation.

Table 5.20 shows the Portmanteau and LM tests for residual autocorrelation. Due to the fact that the optimal lag-length obtained by minimizing the Information Criteria is 2, 1 and 2 for the period before, during and after the crisis (table 5.17), the analysis is done considering lag 3, 2 and 3 upwards, respectively. The non-rejection of the null hypothesis of "No residual autocorrelation" allows to conclude that there are no residual autocorrelation problems in the model before and after the crisis. For the period during the crisis, it can be observed that the

Portmanteau and LM tests are not in agreement. In this case, we will consider the LM test, as it is used to test for any correlation order at any significance level and has better size properties compared to the Portmanteau test (Hatemi-J, 2002). The non-rejection of the null hypothesis of “No residual autocorrelation” in the LM test allows to conclude that there are no residuals’ autocorrelation problems in the model.

5.3.4.2 Heteroskedasticity diagnostic tests

Heteroskedasticity problems occur when the variance of the errors is not constant. In such case, the estimators are still unbiased, but they are no longer the most efficient. The ARCH-LM multivariate test was run to check for heteroskedasticity problems in each model.

ARCH-LM test	Before Crisis	During Crisis	After Crisis
Chi-square	232.5732	215.8271	571.66
Prob.	0.1364	0.0000	0.1672

Table 5.21 – British Pound multivariate ARCH-LM test.

Table 5.21 shows the multivariate ARCH-LM test for residual heteroskedasticity. We do not reject the null hypothesis of residual homoskedasticity for the periods before and after the crisis. On the other hand, we reject the null hypothesis of residual homoskedasticity for the period during the crisis, meaning that the estimators are no longer the most efficient but they are still unbiased. Heteroskedasticity has impact on standard errors, i.e. it has impact on the statistical significance of the parameters estimation but it does not affect the cointegrating equations (which are the final objective of this analysis).

5.4 Turkish Lira

Turkey has suffered several problems that have caused negative impacts on markets performance, leading to an economic and financial crisis in 2018. The Turkish currency crash occurred on August 10, 2018 when the lira plunged in value by 18%, the highest single day drop of since the currency devaluation in 2001. The number of daily observations collected were 204, 259 and 387 for the periods before, during and after the currency crisis, respectively. The time series were considered in levels and the descriptive statistics are in table 5.22.

Before Crisis	TRY	BIST100	SP1200	SP5000	SP350	SP50
Mean	0.278607	92132.85	2069.434	2362.725	1517.921	4096.684
Median	0.280475	90857.86	2064.385	2371.175	1524.605	4071.240
Maximum	0.297290	110423.1	2202.080	2480.910	1602.830	4649.960
Minimum	0.258100	72519.85	1899.820	2191.080	1378.030	3542.800
Std. Dev.	0.007806	10529.80	84.48475	79.00885	52.20057	329.8282
Skewness	-0.437416	-0.041317	-0.284862	-0.412910	-0.795781	0.021400

Kurtosis	2.779289	2.055563	2.004257	2.102797	3.431808	1.764029
Jarque-Bera	6.919384	7.639714	11.18677	12.63907	23.11601	13.00038
Probability	0.031439	0.021931	0.003722	0.001801	0.000010	0.001503
Sum	56.83589	18795101	422164.5	481995.9	309656.0	835723.5
Sum Sq. Dev.	0.012369	2.25E+10	1448948.	1267207.	553154.7	22083686
Observations	204	204	204	204	204	204

During Crisis	TRY	BIST100	SP1200	SP5000	SP350	SP50
Mean	0.243283	106247.4	2341.699	2691.272	1556.748	5012.583
Median	0.255740	107015.1	2347.660	2698.630	1558.230	5020.500
Maximum	0.293590	120845.3	2518.110	2914.040	1626.610	5572.770
Minimum	0.145160	87143.21	2182.780	2457.850	1463.410	4558.040
Std. Dev.	0.032364	8564.739	63.99864	105.3193	32.20682	239.8251
Skewness	-1.025166	-0.276003	-0.019092	-0.142736	-0.325726	0.109954
Kurtosis	3.538009	1.972858	3.058839	2.269727	2.869157	2.097414
Jarque-Bera	48.49036	14.67377	0.053096	6.634636	4.764617	9.313423
Probability	0.000000	0.000651	0.973801	0.036250	0.092337	0.009498
Sum	63.01025	27518081	606500.1	697039.4	403197.8	1298259.
Sum Sq. Dev.	0.270237	1.89E+10	1056723.	2861779.	267618.1	14839152
Observations	259	259	259	259	259	259

After Crisis	TRY	BIST100	SP1200	SP5000	SP350	SP50
Mean	0.175326	100195.1	2396.259	2915.571	1545.190	4618.002
Median	0.174230	98695.44	2391.210	2905.970	1542.640	4617.480
Maximum	0.193560	123556.1	2706.840	3386.150	1741.950	5292.050
Minimum	0.149860	83675.33	2014.900	2351.100	1334.670	4103.400
Std. Dev.	0.008727	8601.385	142.9355	205.1969	87.00560	264.2837
Skewness	0.056814	0.933076	0.153830	0.200878	0.104272	0.403952
Kurtosis	2.518658	3.438179	2.882931	2.909681	2.632777	2.648256
Jarque-Bera	3.944194	59.25171	1.747305	2.734249	2.875783	12.51997
Probability	0.139165	0.000000	0.417424	0.254839	0.237428	0.001911
Sum	67.85132	38775515	927352.1	1128326.	597988.7	1787167.
Sum Sq. Dev.	0.029401	2.86E+10	7886198.	16252819	2922010.	26960512
Observations	387	387	387	387	387	387

Table 5.22 – Turkish Lira summary descriptive statistics

From the descriptive statistics we can conclude that all data is asymmetric, by the significant skewness, and present significant kurtosis. The statistical evidence of the sample does not point for the normality of the variables, based on the Jarque-Bera test, but under the central limit distribution, the sampling distribution of the means will become approximately normally distributed for large samples.

The results reveal that before the crisis, the TRY had a higher mean (0.279) which decreased sharply during the crisis (0,243) which represents the impact of the currency depreciation. Surprisingly, although the TRY appreciated against the USD after the crisis, the mean was lower than during the crisis (0.175). This can be explained by the minimum and maximum values registered. Both periods had approximately the same minimum value (0.15) but the maximum value in the period during the crisis (0.294) is much higher than after the crisis (0.19), meaning that the Turkish Lira had a very slow recovery. The other stock indexes had a continuous increase of the mean, except for the SP350 small drop from the during to the after crisis period. Note that the BIST100 followed the same pattern as the other indexes, in which the mean was continuously upward, going from a mean of 92.133 to 100.195 and a maximum-minimum range that passed from 110.423-72.510 to 123.556-83675.

In terms of standard deviation, the TRY almost quadrupled during the crisis (from 0.008 to 0.032), which represents high volatility in this turbulent period, followed by a fall after the crisis, in which the standard deviation reverted to approximately the level before the crisis (0.009). The stock indexes in general followed an opposite pattern, showing a decline from before to during the crisis and then an increase from during to after the crisis, showing greater market volatility in the period after the Turkish Lira crisis (mainly due to the Coronavirus).

5.4.1 Stationarity

The notion of cointegration is applied to non-stationary time series. Most financial time series are generated by nonstationary processes and are integrated of first order. Table 5.23 shows the results of the ADF unit root test, also confirmed by the KPSS stationarity test.

	Before Crisis		During Crisis		After Crisis	
	ADF	KPSS	ADF	KPSS	ADF	KPSS
GBP	-2.59727*	0.418231*	1.527919	1.7733***	-2.16355	0.5573**
FTSE 100	-0.436532	1.740542***	-0.831907	1.0211***	-1.92614	1.291***
SP1200	-1.417325	1.747976***	-2.9369**	0.873***	-1.92170	1.648***
SP500	-1.599835	1.686048***	-1.802104	1.418***	-1.41187	1.777***
SP350	-2.890**	1.201727***	-3.0378**	0.2603	-1.63674	1.7096***
SP50	-0.600841	1.767613***	-2.161478	0.45577*	-2.07251	0.952***

* , ** and *** indicate the null hypothesis rejection for 10%, 5% and 1% significance level

Table 5.23 – Turkish Lira unit root and stationarity tests for the variables in levels.

The optimal lag lengths were based on the Akaike Information Criteria (AIC). Variables rejected for 5% significance level on the ADF test will not be taken into account, as in the case of the SP350 (before the crisis), SP1200 and SP350 (during the crisis). All variables have a p-value of 0.000 when considering the first differences (annex B). It is possible to conclude that the variables are first order integrated (I(1)).

5.4.2 Cointegration tests

The Johansen procedure is used to test for cointegration relationships between non-stationary time series and comes in two asymptotically tests: the Trace Test and the Maximum Eigenvalue Test. The tests were computed considering the optimal lag-length (obtained in table 5.24 by minimizing the Information Criteria for the VAR model) and the eigenvalues from the rank of the Π matrix that are different from zero. The optimal lag order selection is important because the application of few lags can generate size distortion in the test results and the application of many autoregressive lags can lose the power to obtain correct estimates.

Lag Order Selection by the Akaike Information Criteria	
Lag	After Crisis AIC
0	24.98400
1	15.49583
2	15.43570
3	15.41152*
4	15.43153
5	15.44770
6	15.47026
7	15.48389
8	15.51568
* indicates lag order selected by the criterion AIC: Akaike information criterion	

Table 5.24- Turkish Lira lag order selection by the Akaike Information Criteria.

Due to the fact that the objective of the study is to analyse the impact of currency crises on stock markets using cointegrating equations, cointegration tests were initially performed for the global market (Currency, Country Index and S&P Global 1200 or Currency and S&P 1200). When global cointegration was rejected, a more detailed sequential analysis was made based on the hypothesis of cointegration of continental regions (Currency, Country Index, S&P500, S&P350 and S&P50), where variables were removed in order to test possible cointegrations reduced in terms of number of variables.

Before the crisis: No cointegration found

During the crisis: No cointegration found

After the crisis: TRY – BIST100 – SP1200

Unrestricted Cointegration Rank Test (Trace)			Unrestricted Cointegration Rank Test (Maximum Eigenvalue)		
No. of CE(s)	After Crisis Trace Stat.	Prob.*	No. of CE(s)	After Crisis Max-E Stat.	Prob.*
None*	33.72752	0.0168*	None*	21.70828	0.0415*
At most 1	12.01924	0.156	At most 1	9.877133	0.2201
At most 2	2.142109	0.1433	At most 2	2.142109	0.1433
Trace test indicates 1 cointegrating eqn(s) * denotes rejection of the hypothesis at the 0.05 level			Max-eigenvalue test indicates 1 cointegrating eqn(s) * denotes rejection of the hypothesis at the 0.05 level		

Table 5.25 – Turkish Lira cointegration tests.

As per table 5.25, both Trace and Maximum Eigenvalue tests are in accordance and point for the presence of one cointegrating equation (r = 1), since the hypothesis for “None” cointegrating equations is rejected for the 5% significance level and the hypothesis for “At most 1” cointegrating equation is not rejected.

5.4.3 VECM and Cointegrating Equations

The VECM is a multiple equation model in which there are as many equations as the number of endogenous variables included. VECM modelling is done step by step under the Johansen procedure. It requires the specification of the cointegration rank, resulting from the cointegration test (table 5.25), and the pre-specification of the optimal lag order p for the variables, which was selected by minimizing the Akaike Information Criteria (table 5.24).

An unrestricted VECM was estimated for the period after the crisis (as it is the only period with cointegration tests pointing to the existence of cointegration relationships), with the inclusion of the variables present in the cointegration relations in section 5.4.2. From the VECM (annex E), we can finally present the cointegrating equations, which represent the cointegration relationships between the variables. The cointegrating equations in table 5.26 were based on equation (13).

AFTER THE CRISIS
$\Delta \mathbf{TRY_t} = -0.065876\ [1.000\ TRY_{t-1} - 0.000000628\ BIST100_{t-1} + 0.0000843\ SP1200_{t-1} - 0.314531] - 0.025828\ \Delta TRY_{t-1} - 0.236824\ \Delta TRY_{t-2} - 0.078035\ \Delta TRY_{t-3} + 0.000000156\ \Delta BIST100_{t-1} + 0.000000125\ \Delta BIST100_{t-2} + 0.00000011\ \Delta BIST100_{t-3} - 0.0000124\ \Delta SP1200_{t-1} - 0.00000239\ \Delta SP1200_{t-2} - 0.00000157\ \Delta SP1200_{t-3} + 0.00000219$
$\Delta \mathbf{BIST100_t} = 3543.066\ [1.000\ TRY_{t-1} - 0.000000628\ BIST100_{t-1} + 0.0000843\ SP1200_{t-1} - 0.314531] - 25412.75\ \Delta TRY_{t-1} - 12098.44\ \Delta TRY_{t-2} - 3621.503\ \Delta TRY_{t-3} + 0.077655\ \Delta BIST100_{t-1} + 0.031317\ \Delta BIST100_{t-2} + 0.063545\ \Delta BIST100_{t-3} + 3.15293\ \Delta SP1200_{t-1} + 3.103077\ \Delta SP1200_{t-2} + 3.483254\ \Delta SP1200_{t-3} + 22.94967$
$\Delta \mathbf{SP1200_t} = -185.5976\ [1.000\ TRY_{t-1} - 0.000000628\ BIST100_{t-1} + 0.0000843\ SP1200_{t-1} - 0.314531] + 484.364\ \Delta TRY_{t-1} - 199.6057\ \Delta TRY_{t-2} + 239.2744\ \Delta TRY_{t-3} + 0.000234\ \Delta BIST100_{t-1} + 0.000619\ \Delta BIST100_{t-2} - 0.000181\ \Delta BIST100_{t-3} + 0.227678\ \Delta SP1200_{t-1} + 0.023349\ \Delta SP1200_{t-2} + 0.080803\ \Delta SP1200_{t-3} - 0.078078$

Table 5.26 – Turkish Lira cointegrating estimated equations using VECM

Cointegrating equations represent the long-run (cointegration) relationship, which means that it is possible to predict one variable from the others. The signs of the coefficients are reversed in the long run. After the crisis, in the long-run, the BIST100 has a positive impact on TRY and the SP1200 has a negative impact on TRY, on average, ceteris paribus. The positive impact of the BIST 100 on Turkish Lira was expected, which means that, on average, when the Turkish index rises, the Turkish Lira appreciates against the USD. Despite the Turkish Lira's cointegration with global markets, the S&P Global 1200 has a negative impact on the Lira, which means that, on average, when global markets rise, the TRY depreciates against the USD, making sense due to the greater importance of the USD worldwide, rather than Turkish Lira.

In the TRY study, we excluded some stationary variables (see table 5.23), such as the SP1200 (during the crisis) and SP350 (before and during the crisis). After the crisis, a substantial amount of interdependence exists between the TRY, BIST100 and SP1200. We cannot conclude whether the co-movement started to decrease after the crisis, as we excluded the SP1200 from during the crisis period, but we can conclude that the currency crisis increased the co-movements between stock markets. Similarly to other countries, during the currency crisis, Turkey's financial reserves became mainly constituted by US dollars, with the Central Bank of the Republic of Turkey reporting net foreign currency reserves strengthened in April 2019 with $13 billion dollars in short-term loans. The fact that the TRY went from no cointegration relations before the crisis to a sharp increase worldwide after the crisis, proves that the Turkish Lira Forex market has become more sensitive and volatile to external conditions and that the devaluation of the Lira had an impact on the markets in general.

5.4.4 Residual analysis

After specifying and estimating the model, the residual analysis is divided into diagnostic tests for residual autocorrelation, conditional heteroskedasticity and non-normality (already done in section 5.4). These tests are necessary to conclude the adequacy of the VECM.

5.4.4.1 Autocorrelation diagnostic tests

The autocorrelation assumption is that the errors ε_i and ε_j, with $i \neq j$, are linearly independent. When (strong) autocorrelation occurs, the elements outside the main diagonal of the variance-covariance matrix are non-zero, which can be a sign of model misspecification. For this purpose, the Portmanteau and LM tests for residual autocorrelation are shown in table 5.27.

VEC Residual Portmanteau Tests for Autocorrelations			VEC Residual Serial Correlation LM Tests		
Lags	After Crisis Q - Stat.	Prob.*	Lags	After Crisis LRE* - Stat.	Prob.*
1	0.257473	---	1	17.00126	0.0487
2	0.671835	---	2	9.386330	0.4024
3	1.191359	---	3	10.61214	0.3032
4	12.14982	0.6677	4	12.14455	0.2053
5	20.90948	0.6441	5	9.414460	0.3999
6	34.02357	0.4181	6	14.39324	0.1090
7	41.51544	0.4921	7	8.396249	0.4948
8	44.50586	0.7277	8	3.192752	0.9562

9	51.23592	0.7826	9	7.143639	0.6222
10	59.09815	0.7966	10	8.420604	0.4924
*Test is valid only for lags larger than the VAR lag order.			*Edgeworth expansion corrected likelihood ratio statistic.		

Table 5.27 – Turkish Lira Portmanteau and LM tests for residual autocorrelation.

Table 5.27 shows the Portmanteau and LM tests for residual autocorrelation. Due to the fact that the optimal lag-length obtained by minimizing the Information Criteria is 3 (table 5.24), the analysis is done considering lag 4 upwards. The non-rejection of the null hypothesis of "No residual autocorrelation" allows to conclude that there are no residuals' autocorrelation problems in the model.

5.4.4.2 Heteroskedasticity diagnostic tests

Heteroskedasticity problems occur when the variance of the errors is not constant. In such case, the estimators are still unbiased, but they are no longer the most efficient. The ARCH-LM multivariate test was run to check for heteroskedasticity problems in the model.

ARCH-LM test	After Crisis
Chi-square	691.1901
Prob.	0.0000

Table 5.28 – Turkish Lira multivariate ARCH-LM test.

Table 5.28 shows the multivariate ARCH-LM test for residual heteroskedasticity, in which we reject the null hypothesis of residual homoskedasticity, meaning that the estimators are no longer the most efficient but they are still unbiased. Heteroskedasticity has impact on standard errors, i.e. it has impact on the statistical significance of the parameters estimation but it does not affect the cointegrating equations (which are the final objective of this analysis).

CHAPTER 6

Conclusions

A substantial amount of interdependence exists between currency crises and stock markets. This dissertation therefore concludes that the currency crises studied had an impact on markets in general. Currency crises have strengthened and reinforce the interdependence of global markets. The relationship between stock markets was less pronounced before the currency crises, then increased drastically during the crash and co-movements persisted after the crises, despite their decrease. The higher overall co-movement in global stock markets than before the crisis period may reflect that common shocks were shared by these markets during the crisis, such as panic. In general, it can be concluded that currency crises have reinforced the interdependence of global markets. The long-run (cointegration) relationship between stock markets and exchange rates, indicating the possibility of predicting one market from another, which violates the efficient market hypothesis, can be used to predict and anticipate exchange rate dynamics more efficiently.

First, in the case of the Russian Ruble, the results reveal that the RUB had a very slow recovery. The currency depreciation had a huge impact represented by the mean that decreased sharply during the crisis and by the standard deviation that almost tripled, representing high volatility in this turbulent period.

The negative impact of the S&P 500 on Russian Ruble was expected, which means that, on average, when American markets rise, the RUB depreciates against the USD, meaning that a growing US market produces a more powerful USD against the Ruble. The same for the positive impact of the S&P Europe 350 on Ruble, that is, on average, when European markets rise, the RUB appreciates against the USD. Surprisingly, the S&P Asia 50 had a reversed impact on RUB, becoming from positive to negative. This may mean a new perception of market dependence and an even closer approach between Russia and Europe.

Before the crisis, a certain degree of interdependence existed between the Russian Ruble, S&P Europe 350 and S&P Asia 50. Afterwards, a substantial amount of interdependence existed between the Russian Ruble, S&P 500, S&P Europe 350 and S&P Asia 50 during the currency crisis. The cointegration relationship was then extended to the S&P 500, but after the crisis the co-movements decreased. Despite this, cointegration between the Russian Ruble, S&P Europe 350 and S&P Asia 50 still remained. The results confirm the increased relations with Asian markets[12], but reject the idea of a collapse in the relations with Europe due to the annexation of Crimea, which was in retrospect a political rather than a financial collapse. In fact, the results show an even closer approach between Russia and European markets.

Second, in the case of the Chinese Yuan, the results reveal that the Chinese Yuan had a very slow recovery. The currency depreciation had a huge impact represented by the mean that decreased sharply during the crisis and by the standard deviation that almost quintupled, representing high volatility in this turbulent period.

The Shanghai Composite Index did not follow the same pattern. Despite the crash, the index never registered values lower than the pre-crisis period. The SCI had the highest standard deviation from all variables, which represents the time when the state media advised domestic investors to invest in the stock market and consequently the formation of a speculative bubble and corresponding volatile period.

The negative impact of the S&P Europe 350 on the Chinese Yuan was expected due to the evolution of the cracks in China-Europe relations since the 1990's and a closer approach to the US, which means that, on average, when the S&P Europe 350 index rises, the Chinese Yuan depreciates against the USD. Surprisingly, the S&P 500 has a positive impact on CNY. This can be explained by the evolution of China's role as the largest US creditor, leading to that, on average, a growing US market produces a more powerful CNY against the USD, which can be a very dangerous sign for the US.

After the crisis, a substantial amount of interdependence exists between the Chinese Yuan, S&P 500 and S&P Europe 350. We cannot conclude whether the co-movement started to decrease after the crisis, as we excluded the S&P Europe 350 from during the crisis period, but we can conclude that the currency crisis increased the co-movements between stock markets. The fact that the CNY went from no cointegration relations before the crisis to a sharp increase after the crisis, contributes to the theory of Li (2015) that the fall of the RMB "seems more a part of the RMB internationalisation process than an arbitrary move to rescue China's economic slowdown". The bubble created by Chinese state entities suggests that the Yuan devaluation was part of Chinese reforms to move towards a market-oriented economy, which

[12] Increased relations with China as Russia currently holds a third of the global yuan reserves.

had substantial worldwide repercussions and impact on global markets, with the emergence of cointegration relationships between the Chinese Yuan and European and American markets.

Third, in the case of the British Pound, the results reveal that the GBP and S&P Europe 350 followed the same downward pattern. Surprisingly, the FTSE100 has a negative impact on the British Pound, which is justified by the fact that FTSE 100 followed a total different path of continuous upward tendency. This means that a growing FTSE100 produces a more powerful USD against the GBP, which can be a very dangerous sign for the UK. Comparing the FTSE100 with S&P Europe 350, we can conclude that the Brexit had a greater (negative) impact on European markets than on British markets, with FTSE100 registering a continuously upward tendency, going from a mean of 6338 to 7430 and a maximum-minimum range that passed from 7104-5537 to 7415-7114. The announcement of the cut in relations with Europe and the understanding of possible easier and less bureaucratic deals with other markets, may have triggered this growing trend in the British market, although it was not followed by the GBP, with greater penalties in the rest of the European market.

In terms of standard deviation, the GBP, FTSE100 and S&P Europe 350 followed the same downward pattern, showing a decrease between the three periods, confirming the conclusions of Tabeshian (2018) that after the referendum, the fact that people realized the result and the interest rate cut by the central bank led investors to ask for a lower risk premium, which consequently reduced the stock market's volatility.

The negative impact of the S&P 500 on the British Pound was expected, which means that, on average, when American markets rise, the GBP depreciates against the USD, i.e. a growing US market produces a more powerful USD against the GBP. The same for the positive impact of the S&P Europe 350 on British Pound, that is, on average, when European markets rise, the GBP appreciates against the USD. Surprisingly, the S&P 1200 has a positive impact on British Pound, which means that, on average, when global markets rise, the GBP appreciates against the USD. This result was not expected because 500 of the 1200 companies that constitute the index are American and only 350 are European, which means that most other companies (Australian, Asian, etc) also have a positive impact on GBP. Other surprise is that the S&P Asia 50 has a reversed impact on GBP, becoming from negative to positive. It reinforces the theory that the announcement of the cut in relations with Europe and the understanding of possible easier and less bureaucratic deals with other markets may have triggered this positive relation between the British Pound and Asian markets.

The relationship between stock markets was less pronounced before the currency crisis, with a certain degree of interdependence between the British Pound, S&P Europe 350 and S&P Asia 50. A substantial amount of interdependence increased sharply during the crisis, with the co-movements extended to the FTSE100 and the impact of Brexit on the markets in general, with the inclusion of the S&P Global 1200. Despite the decrease after the crisis, the cointegration between the British Pound, S&P 500, S&P Europe 350 and S&P Asia 50 still remained.

Fourth, in the case of Turkish Lira, the results reveal that the Turkish Lira had a very slow recovery. The currency depreciation had a huge impact represented by the mean that decreased sharply during the crisis and by the standard deviation that almost quadrupled, representing high volatility in this turbulent period. Note that the BIST100 followed the opposite pattern (upwards), in which the mean was continuously increasing, going from 92.133 to 100.195 and a maximum-minimum range that passed from 110.423-72.510 to 123.556-83675.

The stock indexes in general followed the pattern opposite to that of the Lira, showing a drop in the standard deviation from before to during the crisis and then an increase from during to after the crisis, showing greater market volatility in the period after[13] the Lira crisis.

The positive impact of the BIST 100 on Turkish Lira was expected, which means that, on average, when the Turkish index rises, the Turkish Lira appreciates against the USD. Despite the Turkish Lira's cointegration with global markets, the S&P Global 1200 has a negative impact on the Lira, which means that, on average, when global markets rise, the TRY depreciates against the USD, making sense due to the greater importance of the USD worldwide, rather than Turkish Lira. After the crisis, a substantial amount of interdependence exists between the Turkish Lira, BIST 100 and S&P Global 1200. We cannot conclude whether the co-movement started to decrease after the crisis, as we excluded the S&P Global 1200 from during the crisis period, but we can conclude that the currency crisis increased the co-movements between stock markets. Similarly to other countries, during the currency crisis, Turkey's financial reserves became mainly constituted by US dollars, with the Central Bank of the Republic of Turkey reporting net foreign currency reserves strengthened in April 2019 with $13 billion dollars in short-term loans. The fact that the Lira went from no cointegration relationships before the crisis to a sharp increase worldwide after the crisis, proves that the

[13] This period corresponds to the start of the Coronavirus pandemic, which may explain the volatility.

Turkish Lira Forex market has become more sensitive and volatile to external conditions and that the devaluation of the Lira had an impact on the markets in general.

The main limitation of this dissertation is in the analysis of the Chinese Yuan and Turkish Lira, in which the exclusion of important variables such as the S&P Global 1200 in certain time periods, does not allow a 100% reliable conclusion on the real impact of the currency crisis on stock markets. For future researches, there is a range of options yet to be explored, such as an in-depth study on the recent market liberalization taken by the Chinese state entities and possible repercussions or impacts worldwide, as well as the changes in the economic and financial framework that currency crises (and referendums) can trigger through the rupture of relations and approximation between certain countries.

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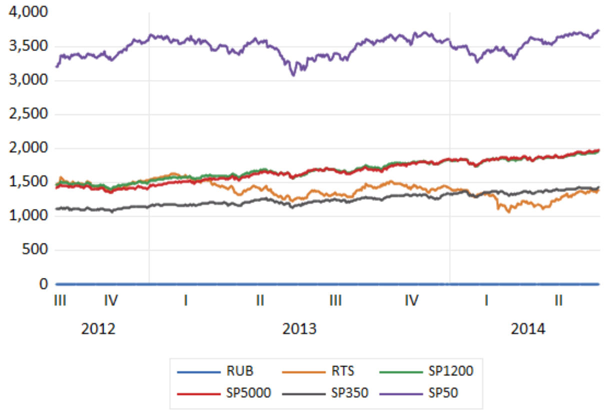
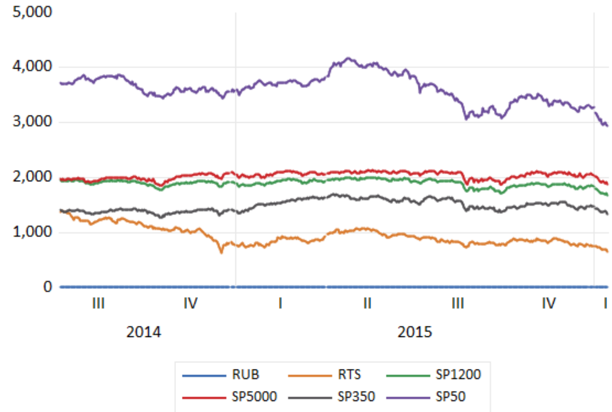
ANNEX

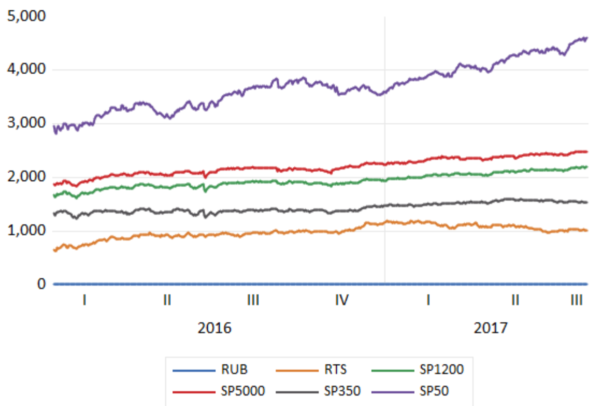
ANNEX A – Time Series graphical representation



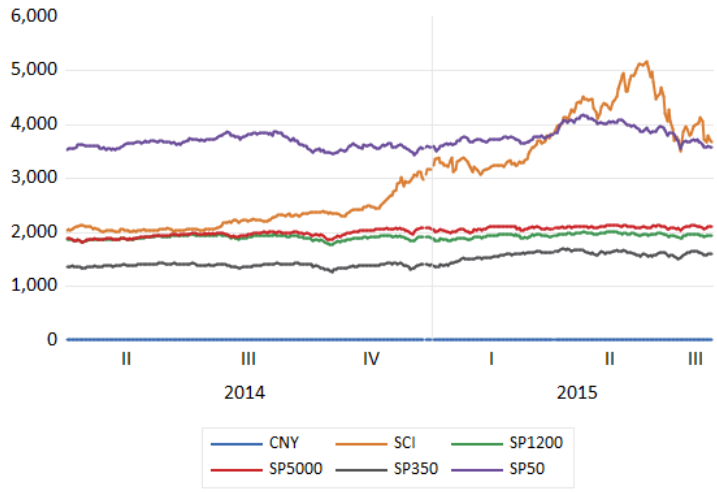
Russian Ruble before the crisis



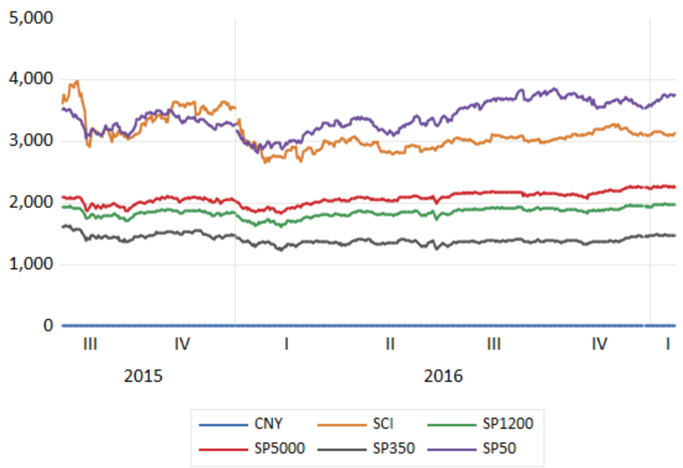
Russian Ruble during the crisis



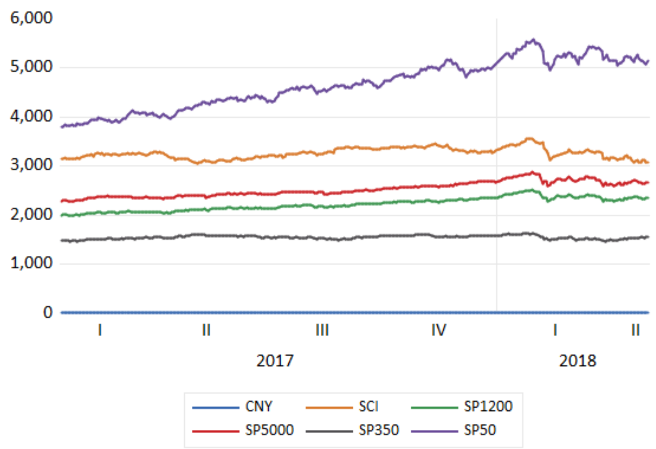
Russian Ruble after the crisis



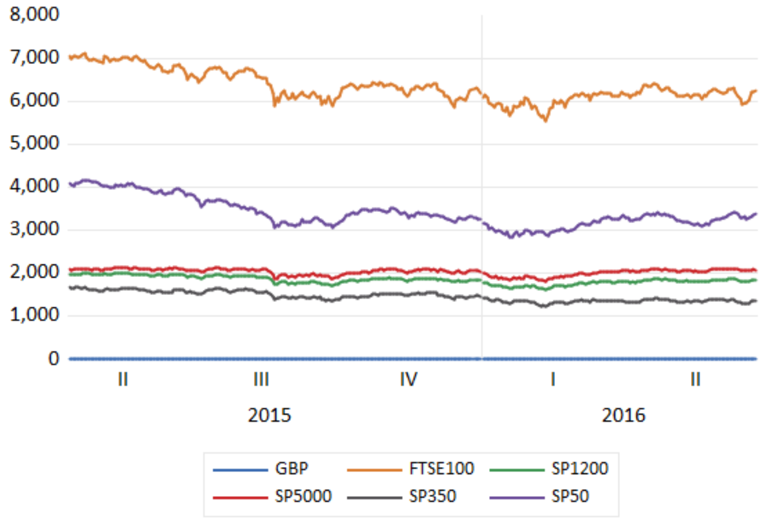
Chinese Yuan before the crisis



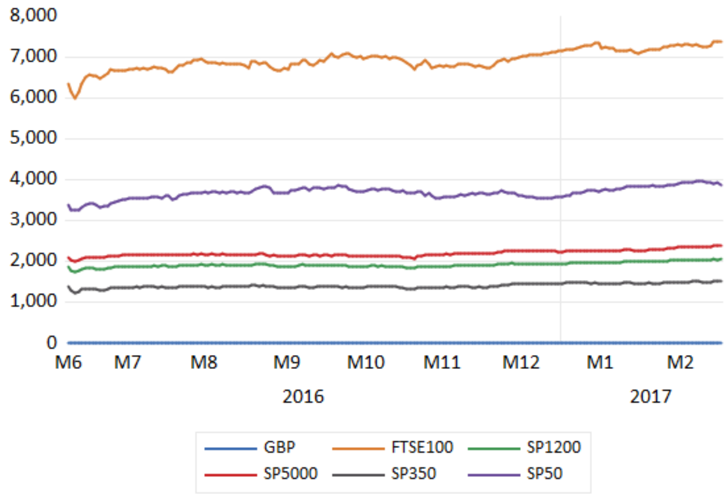
Chinese Yuan during the crisis



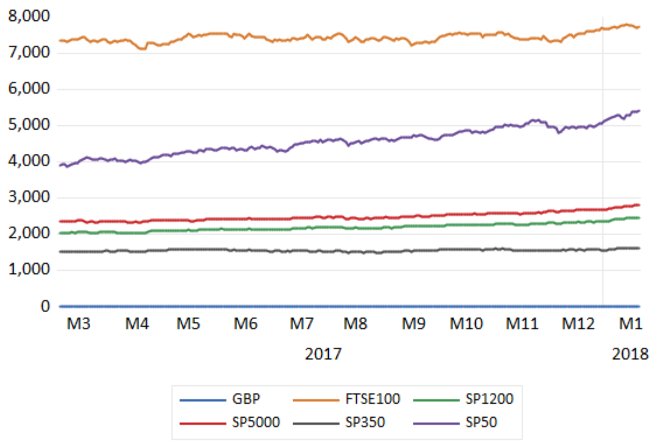
Chinese Yuan after the crisis



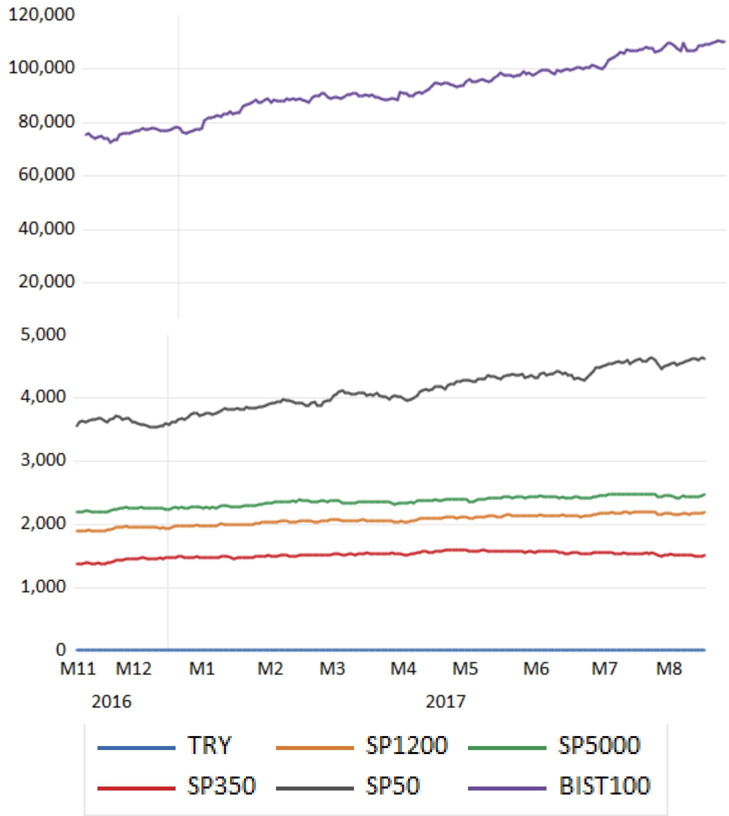
British Pound before the crisis



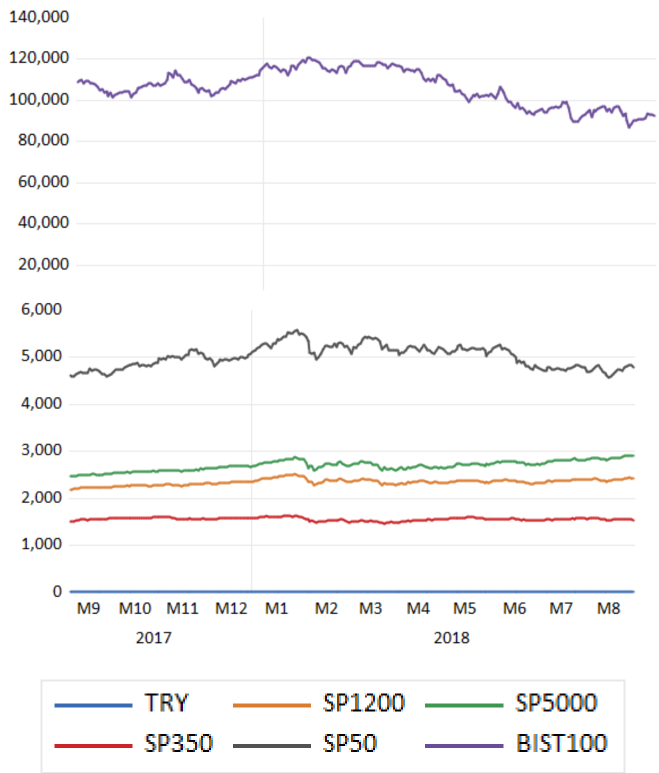
British Pound during the crisis



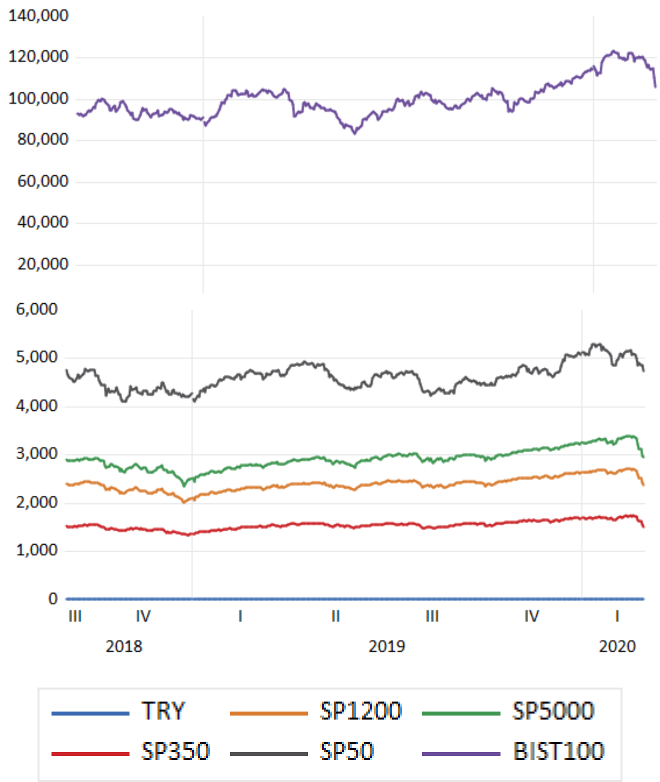
British Pound after the crisis



Turkish Lira before the crisis



Turkish Lira during the crisis



Turkish Lira after the crisis

ANNEX B – Stationarity and Unit Root tests

Null Hypothesis: RUB has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.926559	0.7795
Test critical values:	1% level	-3.444068	
	5% level	-2.867483	
	10% level	-2.569998	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: RTS has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.796572	0.3822
Test critical values:	1% level	-3.444039	
	5% level	-2.867470	
	10% level	-2.569991	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP1200 has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.450146	0.8976
Test critical values:	1% level	-3.444068	
	5% level	-2.867483	
	10% level	-2.569998	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP5000 has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.185715	0.9374
Test critical values:	1% level	-3.444039	
	5% level	-2.867470	
	10% level	-2.569991	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP350 has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.650159	0.8562
Test critical values:	1% level	-3.444039	
	5% level	-2.867470	
	10% level	-2.569991	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP50 has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.652834	0.0832
Test critical values:	1% level	-3.444068	
	5% level	-2.867483	
	10% level	-2.569998	

*MacKinnon (1996) one-sided p-values.

Russian Ruble before the crisis ADF test

Null Hypothesis: D(RUB) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-23.14297	0.0000
Test critical values:	1% level	-3.444068	
	5% level	-2.867483	
	10% level	-2.569998	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(RTS) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-21.45462	0.0000
Test critical values:	1% level	-3.444068	
	5% level	-2.867483	
	10% level	-2.569998	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP1200) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-18.93570	0.0000
Test critical values:	1% level	-3.444068	
	5% level	-2.867483	
	10% level	-2.569998	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP5000) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-21.86197	0.0000
Test critical values:	1% level	-3.444068	
	5% level	-2.867483	
	10% level	-2.569998	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP350) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-21.82742	0.0000
Test critical values:	1% level	-3.444068	
	5% level	-2.867483	
	10% level	-2.569998	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP50) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-19.71880	0.0000
Test critical values:	1% level	-3.444068	
	5% level	-2.867483	
	10% level	-2.569998	

*MacKinnon (1996) one-sided p-values.

Russian Ruble before the crisis ADF test (1st differences)

Null Hypothesis: RUB is stationary
Exogenous: Constant
Bandwidth: 17 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		2.230188
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: RTS is stationary
Exogenous: Constant
Bandwidth: 17 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.320338
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP1200 is stationary
Exogenous: Constant
Bandwidth: 17 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		2.644696
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP5000 is stationary
Exogenous: Constant
Bandwidth: 17 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		2.662440
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP350 is stationary
Exogenous: Constant
Bandwidth: 17 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		2.600165
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP50 is stationary
Exogenous: Constant
Bandwidth: 17 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.412162
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Russian Ruble before the crisis KPSS test

Null Hypothesis: RUB has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.819190	0.3710
Test critical values:	1% level	-3.446734	
	5% level	-2.868657	
	10% level	-2.570627	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: RTS has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.211303	0.2027
Test critical values:	1% level	-3.446777	
	5% level	-2.868676	
	10% level	-2.570637	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP1200 has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.529708	0.5176
Test critical values:	1% level	-3.446777	
	5% level	-2.868676	
	10% level	-2.570637	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP5000 has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.650420	0.0838
Test critical values:	1% level	-3.446777	
	5% level	-2.868676	
	10% level	-2.570637	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP350 has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.409132	0.5783
Test critical values:	1% level	-3.446734	
	5% level	-2.868657	
	10% level	-2.570627	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP50 has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.406412	0.9051
Test critical values:	1% level	-3.446819	
	5% level	-2.868694	
	10% level	-2.570647	

*MacKinnon (1996) one-sided p-values.

Russian Ruble during the crisis ADF test

Null Hypothesis: D(RUB) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-19.81805	0.0000
Test critical values:	1% level	-3.446777	
	5% level	-2.868676	
	10% level	-2.570637	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(RTS) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-17.39141	0.0000
Test critical values:	1% level	-3.446777	
	5% level	-2.868676	
	10% level	-2.570637	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP1200) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-16.42220	0.0000
Test critical values:	1% level	-3.446777	
	5% level	-2.868676	
	10% level	-2.570637	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP5000) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-18.80368	0.0000
Test critical values:	1% level	-3.446777	
	5% level	-2.868676	
	10% level	-2.570637	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP350) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-18.91659	0.0000
Test critical values:	1% level	-3.446777	
	5% level	-2.868676	
	10% level	-2.570637	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP50) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-18.29477	0.0000
Test critical values:	1% level	-3.446777	
	5% level	-2.868676	
	10% level	-2.570637	

*MacKinnon (1996) one-sided p-values.

Russian Ruble during the crisis ADF test (1st differences)

Null Hypothesis: RUB is stationary
Exogenous: Constant
Bandwidth: 16 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.698356
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: RTS is stationary
Exogenous: Constant
Bandwidth: 16 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.370337
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP1200 is stationary
Exogenous: Constant
Bandwidth: 15 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.640397
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP5000 is stationary
Exogenous: Constant
Bandwidth: 15 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.557811
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP350 is stationary
Exogenous: Constant
Bandwidth: 16 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.832337
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP50 is stationary
Exogenous: Constant
Bandwidth: 16 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.840924
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Russian Ruble during the crisis KPSS test

Null Hypothesis: RUB has a unit root
Exogenous: Constant
Lag Length: 8 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.396307	0.1434
Test critical values:	1% level	-3.446819	
	5% level	-2.868694	
	10% level	-2.570647	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: RTS has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.754575	0.0659
Test critical values:	1% level	-3.446484	
	5% level	-2.868547	
	10% level	-2.570568	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP1200 has a unit root
Exogenous: Constant
Lag Length: 5 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.615700	0.8640
Test critical values:	1% level	-3.446692	
	5% level	-2.868638	
	10% level	-2.570617	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP5000 has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.364890	0.6000
Test critical values:	1% level	-3.446525	
	5% level	-2.868565	
	10% level	-2.570578	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP350 has a unit root
Exogenous: Constant
Lag Length: 5 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.006826	0.7520
Test critical values:	1% level	-3.446692	
	5% level	-2.868638	
	10% level	-2.570617	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP50 has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.220594	0.9330
Test critical values:	1% level	-3.446484	
	5% level	-2.868547	
	10% level	-2.570568	

*MacKinnon (1996) one-sided p-values.

Russian Ruble after the crisis ADF test

Null Hypothesis: D(RUB) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-22.31377	0.0000
Test critical values:	1% level	-3.446525	
	5% level	-2.868565	
	10% level	-2.570578	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(RTS) has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.47109	0.0000
Test critical values:	1% level	-3.446650	
	5% level	-2.868620	
	10% level	-2.570607	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP1200) has a unit root
Exogenous: Constant
Lag Length: 4 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.67363	0.0000
Test critical values:	1% level	-3.446692	
	5% level	-2.868638	
	10% level	-2.570617	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP5000) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-22.31718	0.0000
Test critical values:	1% level	-3.446525	
	5% level	-2.868565	
	10% level	-2.570578	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP350) has a unit root
Exogenous: Constant
Lag Length: 4 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.58866	0.0000
Test critical values:	1% level	-3.446692	
	5% level	-2.868638	
	10% level	-2.570617	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP50) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-19.79240	0.0000
Test critical values:	1% level	-3.446525	
	5% level	-2.868565	
	10% level	-2.570578	

*MacKinnon (1996) one-sided p-values.

Russian Ruble after the crisis ADF test (1st differences)

Null Hypothesis: RUB is stationary
Exogenous: Constant
Bandwidth: 16 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		2.087155
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: RTS is stationary
Exogenous: Constant
Bandwidth: 16 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.817405
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP1200 is stationary
Exogenous: Constant
Bandwidth: 16 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		2.300433
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP5000 is stationary
Exogenous: Constant
Bandwidth: 16 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		2.335435
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP350 is stationary
Exogenous: Constant
Bandwidth: 16 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		2.162883
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP50 is stationary
Exogenous: Constant
Bandwidth: 16 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		2.253156
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Russian Ruble after the crisis KPSS test

Null Hypothesis: CNY has a unit root
Exogenous: Constant
Lag Length: 5 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.510382	0.5273
Test critical values:	1% level	-3.449389	
	5% level	-2.869825	
	10% level	-2.571253	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SCI has a unit root
Exogenous: Constant
Lag Length: 8 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.111876	0.7121
Test critical values:	1% level	-3.449562	
	5% level	-2.869901	
	10% level	-2.571293	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP1200 has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.963385	0.0395
Test critical values:	1% level	-3.449220	
	5% level	-2.869750	
	10% level	-2.571213	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP5000 has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.878638	0.3423
Test critical values:	1% level	-3.449108	
	5% level	-2.869701	
	10% level	-2.571187	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP350 has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.082834	0.7235
Test critical values:	1% level	-3.449276	
	5% level	-2.869775	
	10% level	-2.571226	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP50 has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.838273	0.3616
Test critical values:	1% level	-3.449164	
	5% level	-2.869726	
	10% level	-2.571200	

*MacKinnon (1996) one-sided p-values.

Chinese Yuan before the crisis ADF test

Null Hypothesis: D(CNY) has a unit root
Exogenous: Constant
Lag Length: 4 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-8.143799	0.0000
Test critical values:	1% level	-3.449389	
	5% level	-2.869825	
	10% level	-2.571253	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SCI) has a unit root
Exogenous: Constant
Lag Length: 7 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.827201	0.0001
Test critical values:	1% level	-3.449562	
	5% level	-2.869901	
	10% level	-2.571293	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP1200) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-16.80900	0.0000
Test critical values:	1% level	-3.449164	
	5% level	-2.869726	
	10% level	-2.571200	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP5000) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-19.05764	0.0000
Test critical values:	1% level	-3.449164	
	5% level	-2.869726	
	10% level	-2.571200	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP350) has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.900366	0.0000
Test critical values:	1% level	-3.449276	
	5% level	-2.869775	
	10% level	-2.571226	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP50) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-17.14424	0.0000
Test critical values:	1% level	-3.449164	
	5% level	-2.869726	
	10% level	-2.571200	

*MacKinnon (1996) one-sided p-values.

Chinese Yuan before the crisis ADF test (1st differences)

Null Hypothesis: CNY is stationary
Exogenous: Constant
Bandwidth: 15 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.323506
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SCI is stationary
Exogenous: Constant
Bandwidth: 15 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		2.012672
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP1200 is stationary
Exogenous: Constant
Bandwidth: 15 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.828367
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP5000 is stationary
Exogenous: Constant
Bandwidth: 15 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		2.000690
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP350 is stationary
Exogenous: Constant
Bandwidth: 15 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.731205
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP50 is stationary
Exogenous: Constant
Bandwidth: 15 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.697488
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Chinese Yuan before the crisis KPSS test

Null Hypothesis: CNY has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.108665	0.9463
Test critical values:	1% level	-3.447304	
	5% level	-2.868908	
	10% level	-2.570761	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SCI has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.919960	0.0440
Test critical values:	1% level	-3.447304	
	5% level	-2.868908	
	10% level	-2.570761	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP1200 has a unit root
Exogenous: Constant
Lag Length: 6 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.831985	0.3647
Test critical values:	1% level	-3.447487	
	5% level	-2.868988	
	10% level	-2.570805	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP5000 has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.316257	0.6231
Test critical values:	1% level	-3.447214	
	5% level	-2.868868	
	10% level	-2.570740	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP350 has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.407535	0.0113
Test critical values:	1% level	-3.447214	
	5% level	-2.868868	
	10% level	-2.570740	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP50 has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.129465	0.7052
Test critical values:	1% level	-3.447214	
	5% level	-2.868868	
	10% level	-2.570740	

*MacKinnon (1996) one-sided p-values.

Chinese Yuan during the crisis ADF test

Null Hypothesis: D(CNY) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-14.68494	0.0000
Test critical values:	1% level	-3.447304	
	5% level	-2.868908	
	10% level	-2.570761	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SCI) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-12.49254	0.0000
Test critical values:	1% level	-3.447304	
	5% level	-2.868908	
	10% level	-2.570761	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP1200) has a unit root
Exogenous: Constant
Lag Length: 5 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-8.091590	0.0000
Test critical values:	1% level	-3.447487	
	5% level	-2.868988	
	10% level	-2.570805	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP5000) has a unit root
Exogenous: Constant
Lag Length: 6 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.959313	0.0000
Test critical values:	1% level	-3.447534	
	5% level	-2.869009	
	10% level	-2.570816	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP350) has a unit root
Exogenous: Constant
Lag Length: 4 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-10.60055	0.0000
Test critical values:	1% level	-3.447441	
	5% level	-2.868968	
	10% level	-2.570794	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP50) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-18.53928	0.0000
Test critical values:	1% level	-3.447259	
	5% level	-2.868888	
	10% level	-2.570751	

*MacKinnon (1996) one-sided p-values.

Chinese Yuan during the crisis ADF test (1st differences)

Null Hypothesis: CNY is stationary
Exogenous: Constant
Bandwidth: 16 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.937493
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SCI is stationary
Exogenous: Constant
Bandwidth: 15 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.666597
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP1200 is stationary
Exogenous: Constant
Bandwidth: 15 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.063672
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP5000 is stationary
Exogenous: Constant
Bandwidth: 16 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.597749
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP350 is stationary
Exogenous: Constant
Bandwidth: 15 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.731782
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP50 is stationary
Exogenous: Constant
Bandwidth: 16 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.367156
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Chinese Yuan during the crisis KPSS test

Null Hypothesis: CNY has a unit root
Exogenous: Constant
Lag Length: 4 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.940874	0.7744
Test critical values:	1% level	-3.450348	
	5% level	-2.870247	
	10% level	-2.571478	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SCI has a unit root
Exogenous: Constant
Lag Length: 4 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.823019	0.3690
Test critical values:	1% level	-3.450348	
	5% level	-2.870247	
	10% level	-2.571478	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP1200 has a unit root
Exogenous: Constant
Lag Length: 9 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.494736	0.5352
Test critical values:	1% level	-3.450682	
	5% level	-2.870387	
	10% level	-2.571554	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP5000 has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.440050	0.5628
Test critical values:	1% level	-3.450285	
	5% level	-2.870219	
	10% level	-2.571464	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP350 has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.844078	0.0533
Test critical values:	1% level	-3.450099	
	5% level	-2.870137	
	10% level	-2.571420	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP50 has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.479889	0.5427
Test critical values:	1% level	-3.450285	
	5% level	-2.870219	
	10% level	-2.571464	

*MacKinnon (1996) one-sided p-values.

Chinese Yuan after the crisis ADF test

Null Hypothesis: D(CNY) has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-8.555586	0.0000
Test critical values:	1% level	-3.450348	
	5% level	-2.870247	
	10% level	-2.571478	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SCI) has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.070186	0.0000
Test critical values:	1% level	-3.450348	
	5% level	-2.870247	
	10% level	-2.571478	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP1200) has a unit root
Exogenous: Constant
Lag Length: 10 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.746748	0.0000
Test critical values:	1% level	-3.450812	
	5% level	-2.870444	
	10% level	-2.571584	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP5000) has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.658678	0.0000
Test critical values:	1% level	-3.450285	
	5% level	-2.870219	
	10% level	-2.571464	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP350) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-17.99035	0.0000
Test critical values:	1% level	-3.450161	
	5% level	-2.870164	
	10% level	-2.571434	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP50) has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-8.839799	0.0000
Test critical values:	1% level	-3.450285	
	5% level	-2.870219	
	10% level	-2.571464	

*MacKinnon (1996) one-sided p-values.

Chinese Yuan after the crisis ADF test (1st differences)

Null Hypothesis: CNY is stationary
Exogenous: Constant
Bandwidth: 15 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		2.021998
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SCI is stationary
Exogenous: Constant
Bandwidth: 15 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.609493
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP1200 is stationary
Exogenous: Constant
Bandwidth: 15 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		2.016519
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP5000 is stationary
Exogenous: Constant
Bandwidth: 15 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.994424
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP350 is stationary
Exogenous: Constant
Bandwidth: 15 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.360777
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP50 is stationary
Exogenous: Constant
Bandwidth: 15 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		2.088252
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Chinese Yuan after the crisis KPSS test

Null Hypothesis: GBP has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.287693	0.6361
Test critical values:	1% level	-3.451703	
	5% level	-2.870836	
	10% level	-2.571794	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: FTSE100 has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.411373	0.1394
Test critical values:	1% level	-3.451491	
	5% level	-2.870743	
	10% level	-2.571744	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP1200 has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.053721	0.2639
Test critical values:	1% level	-3.451561	
	5% level	-2.870774	
	10% level	-2.571761	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP5000 has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.359723	0.1542
Test critical values:	1% level	-3.451491	
	5% level	-2.870743	
	10% level	-2.571744	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP350 has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.028071	0.2748
Test critical values:	1% level	-3.451491	
	5% level	-2.870743	
	10% level	-2.571744	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP50 has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.072367	0.2562
Test critical values:	1% level	-3.451491	
	5% level	-2.870743	
	10% level	-2.571744	

*MacKinnon (1996) one-sided p-values.

British Pound before the crisis ADF test

Null Hypothesis: D(GBP) has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-10.77754	0.0000
Test critical values:	1% level	-3.451703	
	5% level	-2.870836	
	10% level	-2.571794	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(FTSE100) has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.362043	0.0000
Test critical values:	1% level	-3.451775	
	5% level	-2.870868	
	10% level	-2.571811	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP1200) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-14.36103	0.0000
Test critical values:	1% level	-3.451561	
	5% level	-2.870774	
	10% level	-2.571761	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP5000) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-13.27744	0.0000
Test critical values:	1% level	-3.451632	
	5% level	-2.870805	
	10% level	-2.571777	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP350) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-16.93648	0.0000
Test critical values:	1% level	-3.451561	
	5% level	-2.870774	
	10% level	-2.571761	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP50) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-16.33016	0.0000
Test critical values:	1% level	-3.451561	
	5% level	-2.870774	
	10% level	-2.571761	

*MacKinnon (1996) one-sided p-values.

British Pound before the crisis ADF test (1st differences)

Null Hypothesis: GBP is stationary
Exogenous: Constant
Bandwidth: 14 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.775800
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: FTSE100 is stationary
Exogenous: Constant
Bandwidth: 14 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.421089
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP1200 is stationary
Exogenous: Constant
Bandwidth: 14 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.122749
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP5000 is stationary
Exogenous: Constant
Bandwidth: 14 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.373592
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP350 is stationary
Exogenous: Constant
Bandwidth: 14 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.760431
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP50 is stationary
Exogenous: Constant
Bandwidth: 14 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.334925
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

British Pound before the crisis KPSS test

Null Hypothesis: GBP has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.325454	0.1651
Test critical values:	1% level	-3.466786	
	5% level	-2.877453	
	10% level	-2.575332	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: FTSE100 has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.863863	0.3488
Test critical values:	1% level	-3.466580	
	5% level	-2.877363	
	10% level	-2.575284	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP1200 has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.651758	0.8546
Test critical values:	1% level	-3.466580	
	5% level	-2.877363	
	10% level	-2.575284	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP5000 has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.431520	0.5659
Test critical values:	1% level	-3.466994	
	5% level	-2.877544	
	10% level	-2.575381	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP350 has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.960618	0.7667
Test critical values:	1% level	-3.466580	
	5% level	-2.877363	
	10% level	-2.575284	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP50 has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.962021	0.3035
Test critical values:	1% level	-3.466580	
	5% level	-2.877363	
	10% level	-2.575284	

*MacKinnon (1996) one-sided p-values.

British Pound during the crisis ADF test

Null Hypothesis: D(GBP) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-16.74412	0.0000
Test critical values:	1% level	-3.466786	
	5% level	-2.877453	
	10% level	-2.575332	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(FTSE100) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.76001	0.0000
Test critical values:	1% level	-3.466786	
	5% level	-2.877453	
	10% level	-2.575332	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP1200) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.95186	0.0000
Test critical values:	1% level	-3.466994	
	5% level	-2.877544	
	10% level	-2.575381	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP5000) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.07867	0.0000
Test critical values:	1% level	-3.466994	
	5% level	-2.877544	
	10% level	-2.575381	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP350) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-12.57610	0.0000
Test critical values:	1% level	-3.466994	
	5% level	-2.877544	
	10% level	-2.575381	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP50) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-13.83288	0.0000
Test critical values:	1% level	-3.466786	
	5% level	-2.877453	
	10% level	-2.575332	

*MacKinnon (1996) one-sided p-values.

British Pound during the crisis ADF test (1st differences)

Null Hypothesis: GBP is stationary
Exogenous: Constant
Bandwidth: 10 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.314364
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: FTSE100 is stationary
Exogenous: Constant
Bandwidth: 10 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.363115
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP1200 is stationary
Exogenous: Constant
Bandwidth: 10 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.268329
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP5000 is stationary
Exogenous: Constant
Bandwidth: 10 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.372458
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP350 is stationary
Exogenous: Constant
Bandwidth: 10 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.387145
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP50 is stationary
Exogenous: Constant
Bandwidth: 10 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.762130
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

British Pound during the crisis KPSS test

Null Hypothesis: GBP has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.332523	0.6146
Test critical values:	1% level	-3.458845	
	5% level	-2.873974	
	10% level	-2.573472	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: FTSE100 has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.666770	0.4468
Test critical values:	1% level	-3.459101	
	5% level	-2.874086	
	10% level	-2.573533	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP1200 has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		1.681447	0.9996
Test critical values:	1% level	-3.459101	
	5% level	-2.874086	
	10% level	-2.573533	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP5000 has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		2.244137	1.0000
Test critical values:	1% level	-3.459101	
	5% level	-2.874086	
	10% level	-2.573533	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP350 has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.914325	0.3253
Test critical values:	1% level	-3.458845	
	5% level	-2.873974	
	10% level	-2.573472	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP50 has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		0.010131	0.9577
Test critical values:	1% level	-3.458845	
	5% level	-2.873974	
	10% level	-2.573472	

*MacKinnon (1996) one-sided p-values.

British Pound after the crisis ADF test

Null Hypothesis: D(GBP) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-15.80048	0.0000
Test critical values:	1% level	-3.458973	
	5% level	-2.874029	
	10% level	-2.573502	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(FTSE100) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.49684	0.0000
Test critical values:	1% level	-3.459101	
	5% level	-2.874086	
	10% level	-2.573533	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP1200) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-12.05958	0.0000
Test critical values:	1% level	-3.459101	
	5% level	-2.874086	
	10% level	-2.573533	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP5000) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-12.18624	0.0000
Test critical values:	1% level	-3.459101	
	5% level	-2.874086	
	10% level	-2.573533	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP350) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-14.95261	0.0000
Test critical values:	1% level	-3.458973	
	5% level	-2.874029	
	10% level	-2.573502	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP50) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-14.82753	0.0000
Test critical values:	1% level	-3.458973	
	5% level	-2.874029	
	10% level	-2.573502	

*MacKinnon (1996) one-sided p-values.

British Pound after the crisis ADF test (1st differences)

Null Hypothesis: GBP is stationary
Exogenous: Constant
Bandwidth: 11 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.710988
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: FTSE100 is stationary
Exogenous: Constant
Bandwidth: 11 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.766452
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP1200 is stationary
Exogenous: Constant
Bandwidth: 11 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.943169
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP5000 is stationary
Exogenous: Constant
Bandwidth: 11 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.868047
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP350 is stationary
Exogenous: Constant
Bandwidth: 11 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.500872
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP50 is stationary
Exogenous: Constant
Bandwidth: 11 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.982956
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

British Pound after the crisis KPSS test

Null Hypothesis: TRY has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.597268	0.0952
Test critical values:	1% level	-3.462574	
	5% level	-2.875608	
	10% level	-2.574346	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: BIST100 has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.436532	0.8991
Test critical values:	1% level	-3.463067	
	5% level	-2.875825	
	10% level	-2.574462	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP1200 has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.417325	0.5732
Test critical values:	1% level	-3.462574	
	5% level	-2.875608	
	10% level	-2.574346	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP5000 has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.599835	0.4808
Test critical values:	1% level	-3.462574	
	5% level	-2.875608	
	10% level	-2.574346	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP350 has a unit root
Exogenous: Constant
Lag Length: 4 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.889993	0.0483
Test critical values:	1% level	-3.463235	
	5% level	-2.875898	
	10% level	-2.574501	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP50 has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.600841	0.8664
Test critical values:	1% level	-3.462574	
	5% level	-2.875608	
	10% level	-2.574346	

*MacKinnon (1996) one-sided p-values.

Turkish Lira before the crisis ADF test

Null Hypothesis: D(TRY) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.19774	0.0000
Test critical values:	1% level	-3.462901	
	5% level	-2.875752	
	10% level	-2.574423	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(BIST100) has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.847684	0.0000
Test critical values:	1% level	-3.463067	
	5% level	-2.875825	
	10% level	-2.574462	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP1200) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-13.88926	0.0000
Test critical values:	1% level	-3.462737	
	5% level	-2.875680	
	10% level	-2.574385	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP5000) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-15.48889	0.0000
Test critical values:	1% level	-3.462737	
	5% level	-2.875680	
	10% level	-2.574385	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP350) has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-8.627201	0.0000
Test critical values:	1% level	-3.463235	
	5% level	-2.875898	
	10% level	-2.574501	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP50) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-14.64815	0.0000
Test critical values:	1% level	-3.462737	
	5% level	-2.875680	
	10% level	-2.574385	

*MacKinnon (1996) one-sided p-values.

Turkish Lira before the crisis ADF test (1st differences)

Null Hypothesis: TRY is stationary
Exogenous: Constant
Bandwidth: 11 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.418231
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: BIST100 is stationary
Exogenous: Constant
Bandwidth: 11 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.740542
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP1200 is stationary
Exogenous: Constant
Bandwidth: 11 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.747976
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP5000 is stationary
Exogenous: Constant
Bandwidth: 11 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.686048
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP350 is stationary
Exogenous: Constant
Bandwidth: 11 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.201727
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP50 is stationary
Exogenous: Constant
Bandwidth: 11 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.767613
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Turkish Lira before the crisis KPSS test

Null Hypothesis: TRY has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		1.527919	0.9994
Test critical values:	1% level	-3.455887	
	5% level	-2.872675	
	10% level	-2.572778	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: BIST100 has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.831907	0.8080
Test critical values:	1% level	-3.455585	
	5% level	-2.872542	
	10% level	-2.572707	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP1200 has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.936935	0.0426
Test critical values:	1% level	-3.455887	
	5% level	-2.872675	
	10% level	-2.572778	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP5000 has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.802104	0.3790
Test critical values:	1% level	-3.455887	
	5% level	-2.872675	
	10% level	-2.572778	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP350 has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.037800	0.0328
Test critical values:	1% level	-3.455887	
	5% level	-2.872675	
	10% level	-2.572778	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP50 has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.161478	0.2211
Test critical values:	1% level	-3.455685	
	5% level	-2.872586	
	10% level	-2.572730	

*MacKinnon (1996) one-sided p-values.

Turkish Lira during the crisis ADF test

Null Hypothesis: D(TRY) has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.59913	0.0000
Test critical values:	1% level	-3.455887	
	5% level	-2.872675	
	10% level	-2.572778	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(BIST100) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-16.63922	0.0000
Test critical values:	1% level	-3.455685	
	5% level	-2.872586	
	10% level	-2.572730	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP1200) has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.310114	0.0000
Test critical values:	1% level	-3.455887	
	5% level	-2.872675	
	10% level	-2.572778	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP5000) has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-8.290591	0.0000
Test critical values:	1% level	-3.455887	
	5% level	-2.872675	
	10% level	-2.572778	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP350) has a unit root
Exogenous: Constant
Lag Length: 10 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.039415	0.0000
Test critical values:	1% level	-3.456730	
	5% level	-2.873045	
	10% level	-2.572976	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP50) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-14.55161	0.0000
Test critical values:	1% level	-3.455685	
	5% level	-2.872586	
	10% level	-2.572730	

*MacKinnon (1996) one-sided p-values.

Turkish Lira during the crisis ADF test (1st differences)

Null Hypothesis: TRY is stationary
Exogenous: Constant
Bandwidth: 12 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.773256
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: BIST100 is stationary
Exogenous: Constant
Bandwidth: 12 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.021052
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP1200 is stationary
Exogenous: Constant
Bandwidth: 12 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.873399
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP5000 is stationary
Exogenous: Constant
Bandwidth: 12 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.417897
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP350 is stationary
Exogenous: Constant
Bandwidth: 12 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.260311
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP50 is stationary
Exogenous: Constant
Bandwidth: 12 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.455766
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Turkish Lira during the crisis KPSS test

Null Hypothesis: TRY has a unit root
Exogenous: Constant
Lag Length: 4 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.163552	0.2202
Test critical values:	1% level	-3.447259	
	5% level	-2.868888	
	10% level	-2.570751	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: BIST100 has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.926141	0.3201
Test critical values:	1% level	-3.447214	
	5% level	-2.868868	
	10% level	-2.570740	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP1200 has a unit root
Exogenous: Constant
Lag Length: 7 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.921701	0.3222
Test critical values:	1% level	-3.447395	
	5% level	-2.868948	
	10% level	-2.570783	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP5000 has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.411869	0.5770
Test critical values:	1% level	-3.447125	
	5% level	-2.868829	
	10% level	-2.570719	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP350 has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.636743	0.4628
Test critical values:	1% level	-3.447125	
	5% level	-2.868829	
	10% level	-2.570719	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: SP50 has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.072507	0.2561
Test critical values:	1% level	-3.447169	
	5% level	-2.868848	
	10% level	-2.570730	

*MacKinnon (1996) one-sided p-values.

Turkish Lira after the crisis ADF test

Null Hypothesis: D(TRY) has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.424931	0.0000
Test critical values:	1% level	-3.447259	
	5% level	-2.868888	
	10% level	-2.570751	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(BIST100) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-17.52931	0.0000
Test critical values:	1% level	-3.447125	
	5% level	-2.868829	
	10% level	-2.570719	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP1200) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-15.26495	0.0000
Test critical values:	1% level	-3.447125	
	5% level	-2.868829	
	10% level	-2.570719	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP5000) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-17.85350	0.0000
Test critical values:	1% level	-3.447125	
	5% level	-2.868829	
	10% level	-2.570719	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP350) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-16.49956	0.0000
Test critical values:	1% level	-3.447125	
	5% level	-2.868829	
	10% level	-2.570719	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(SP50) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-12.48297	0.0000
Test critical values:	1% level	-3.447169	
	5% level	-2.868848	
	10% level	-2.570730	

*MacKinnon (1996) one-sided p-values.

Turkish Lira after the crisis ADF test (1st differences)

Null Hypothesis: TRY is stationary
Exogenous: Constant
Bandwidth: 16 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.557302
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: BIST100 is stationary
Exogenous: Constant
Bandwidth: 16 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.291032
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP1200 is stationary
Exogenous: Constant
Bandwidth: 16 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.647574
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP5000 is stationary
Exogenous: Constant
Bandwidth: 16 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.777451
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP350 is stationary
Exogenous: Constant
Bandwidth: 16 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.709566
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Null Hypothesis: SP50 is stationary
Exogenous: Constant
Bandwidth: 16 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.951699
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Turkish Lira after the crisis KPSS test

ANNEX C – Lag Order Selection

VAR Lag Order Selection Criteria
Endogenous variables: RUB SP350 SP50
Exogenous variables: C
Date: 10/19/20 Time: 22:10
Sample: 9/10/2012 7/03/2014
Included observations: 463

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-2860.417	NA	47.24480	12.36897	12.39578	12.37953
1	-427.2676	4824.258	0.001339	1.897484	2.004726	1.939702
2	-385.2418	82.78080	0.001161	1.754824	1.942497*	1.828706*
3	-374.5748	20.87317*	0.001152*	1.747624*	2.015727	1.853168
4	-371.4279	6.117199	0.001182	1.772907	2.121441	1.910115
5	-364.0518	14.24237	0.001190	1.779921	2.208887	1.948793
6	-360.1768	7.431957	0.001217	1.802060	2.311456	2.002595
7	-355.4296	9.043251	0.001240	1.820430	2.410257	2.052629
8	-349.5456	11.13262	0.001256	1.833890	2.504148	2.097752

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

VAR Lag Order Selection Criteria
Endogenous variables: RUB SP5000 SP350 SP50
Exogenous variables: C
Date: 10/20/20 Time: 11:33
Sample: 7/07/2014 1/15/2016
Included observations: 387

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-5136.760	NA	4056069.	26.56723	26.60815	26.58346
1	-2566.272	5074.554	7.495061	13.36575	13.57032	13.44686
2	-2506.227	117.2981	5.969403*	13.22797	13.50635*	13.28413*
3	-2495.981	19.80217	6.150017	13.16786	13.69974	13.37877
4	-2491.611	8.355871	6.531809	13.13812*	13.92350	13.50376
5	-2483.440	15.45542	6.802865	13.26843	14.12762	13.60912
6	-2479.739	6.924341	7.251418	13.33198	14.35483	13.73757
7	-2471.062	16.05358	7.534158	13.36983	14.55633	13.84031
8	-2454.496	30.30739*	7.516158	13.36690	14.71706	13.90227

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

VAR Lag Order Selection Criteria
Endogenous variables: RUB SP350 SP50
Exogenous variables: C
Date: 10/20/20 Time: 13:23
Sample: 1/19/2016 8/01/2017
Included observations: 393

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-2566.164	NA	95.67879	13.07463	13.10496	13.08665
1	-507.9278	4074.575	0.002829	2.645943	2.767281	2.694028
2	-473.6929	67.25024	0.002488*	2.517521*	2.729862*	2.601669*
3	-470.0567	7.087491	0.002557	2.544818	2.848162	2.665029
4	-460.7756	17.94807	0.002554	2.543387	2.937735	2.699662
5	-447.2836	25.88550*	0.002496	2.520527	3.005878	2.712865
6	-444.3878	5.511552	0.002575	2.551592	3.127946	2.779994
7	-441.0136	6.370659	0.002650	2.580222	3.247579	2.844687
8	-437.8454	5.933269	0.002731	2.609900	3.368261	2.910429

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

VAR Lag Order Selection Criteria
Endogenous variables: CNY SP5000 SP350
Exogenous variables: C
Date: 10/20/20 Time: 18:44
Sample: 1/24/2017 4/27/2018
Included observations: 321

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-2014.403	NA	57.73468	12.56949	12.60474	12.58356
1	-393.6343	3201.144	0.002513	2.527317	2.668305	2.583610
2	-358.2128	69.29812	0.002132	2.362697	2.609427*	2.461210*
3	-344.6902	26.20273	0.002072	2.334518	2.686990	2.475251
4	-332.3530	23.67510	0.002030	2.276131*	2.771938	2.496679
5	-317.3191	28.56917*	0.001955*	2.313726	2.840085	2.501304
6	-314.5608	5.189958	0.002033	2.315021	2.984716	2.582414
7	-310.2148	8.096352	0.002093	2.344017	3.119454	2.653630
8	-306.6431	6.587068	0.002166	2.377839	3.259016	2.729671

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

VAR Lag Order Selection Criteria
Endogenous variables: GBP SP350 SP50
Exogenous variables: C
Date: 10/20/20 Time: 19:45
Sample: 4/16/2015 6/22/2016
Included observations: 300

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-3156.372	NA	281769.8	21.06248	21.09951	21.07730
1	-1774.595	2726.706	29.87449	11.91063	12.05878	11.96992
2	-1745.843	56.16082	26.18929*	11.77896*	12.03822*	11.88271*
3	-1741.451	8.491726	27.00758	11.80967	12.18005	11.95790
4	-1731.177	19.65845*	26.78146	11.80118	12.28267	11.99387
5	-1723.104	15.28520	26.95125	11.80736	12.39996	12.04452
6	-1720.906	4.115936	28.20749	11.85271	12.55643	12.13434
7	-1717.240	6.795397	29.23673	11.88827	12.70310	12.21436
8	-1712.435	8.809320	30.07706	11.91623	12.84218	12.28680

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

VAR Lag Order Selection Criteria
Endogenous variables: GBP FTSE100 SP1200
Exogenous variables: C
Date: 10/20/20 Time: 20:57
Sample: 6/23/2016 3/03/2017
Included observations: 174

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1579.087	NA	15855.66	18.18491	18.23938	18.20701
1	-883.0758	1360.023	5.898046*	10.28823*	10.50609*	10.37661*
2	-874.5801	16.30794	5.932960	10.29402	10.67529	10.44869
3	-868.3117	11.81632	6.123726	10.32542	10.87009	10.54637
4	-862.1791	11.34884	6.331808	10.35838	11.06644	10.64561
5	-852.8585	16.92694*	6.313105	10.35470	11.22616	10.70822
6	-848.2278	8.250111	6.645296	10.40492	11.43978	10.82472
7	-841.1259	12.40798	6.801785	10.42673	11.62500	10.91282
8	-834.1911	11.87684	6.978597	10.45047	11.81213	11.00285

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

VAR Lag Order Selection Criteria
Endogenous variables: GBP SP5000 SP350 SP50
Exogenous variables: C
Date: 10/20/20 Time: 21:44
Sample: 3/06/2017 1/19/2018
Included observations: 222

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-3114.415	NA	18667958	28.09383	28.15514	28.11858
1	-1823.348	2523.977	191.5716	16.60674	16.91329*	16.73050*
2	-1796.865	50.81809*	174.3336*	16.51230*	17.06409	16.73508
3	-1787.948	16.79061	185.8864	16.57611	17.37313	16.89790
4	-1778.832	16.83540	197.9117	16.63813	17.68039	17.05893
5	-1767.622	20.30018	206.8589	16.68128	17.96878	17.20109
6	-1761.306	11.20935	226.0710	16.76852	18.30126	17.38734
7	-1752.642	15.06464	242.0408	16.83461	18.61258	17.55244
8	-1742.493	17.28071	255.8750	16.88732	18.91053	17.70417

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

VAR Lag Order Selection Criteria
Endogenous variables: TRY BIST100 SP1200
Exogenous variables: C
Date: 10/21/20 Time: 00:47
Sample: 9/04/2018 2/28/2020
Included observations: 379

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-4731.468	NA	14222957	24.98400	25.01517	24.99637
1	-2924.460	3575.874	1077.286	15.49583	15.62050*	15.54530
2	-2904.065	40.03627	1014.427	15.43570	15.65387	15.52228*
3	-2890.483	26.44611*	990.2204*	15.41152*	15.72320	15.53521
4	-2885.275	10.05860	1010.280	15.43153	15.83671	15.59233
5	-2879.339	11.37171	1026.817	15.44770	15.94638	15.64560
6	-2874.614	8.976037	1050.352	15.47026	16.06245	15.70527
7	-2868.197	12.08994	1064.913	15.48389	16.16958	15.75600
8	-2865.221	5.559151	1099.511	15.51568	16.29487	15.82490

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

ANNEX D – Cointegration tests

Date: 10/20/20 Time: 00:04
Sample (adjusted): 9/14/2012 7/03/2014
Included observations: 467 after adjustments
Trend assumption: Linear deterministic trend
Series: RUB SP350 SP50
Lags interval (in first differences): 1 to 3

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.053490	33.40550	29.79707	0.0184
At most 1	0.016357	7.732528	15.49471	0.4944
At most 2	6.53E-05	0.030519	3.841465	0.8613

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.053490	25.67297	21.13162	0.0107
At most 1	0.016357	7.702009	14.26460	0.4098
At most 2	6.53E-05	0.030519	3.841465	0.8613

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Date: 10/20/20 Time: 11:38
Sample (adjusted): 7/14/2014 1/15/2016
Included observations: 390 after adjustments
Trend assumption: Linear deterministic trend
Series: RUB SP5000 SP350 SP50
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.073310	51.55058	47.85613	0.0216
At most 1	0.034527	21.85759	29.79707	0.3065
At most 2	0.019174	8.153915	15.49471	0.4491
At most 3	0.001546	0.603564	3.841465	0.4372

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.073310	29.69300	27.58434	0.0264
At most 1	0.034527	13.70367	21.13162	0.3898
At most 2	0.019174	7.550350	14.26460	0.4263
At most 3	0.001546	0.603564	3.841465	0.4372

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Date: 10/20/20 Time: 13:25
Sample (adjusted): 1/22/2016 8/01/2017
Included observations: 398 after adjustments
Trend assumption: Linear deterministic trend
Series: RUB SP350 SP50
Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.055924	30.11854	29.79707	0.0459
At most 1	0.017807	7.214321	15.49471	0.5529
At most 2	0.000159	0.063282	3.841465	0.8014

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.055924	22.90422	21.13162	0.0279
At most 1	0.017807	7.151039	14.26460	0.4714
At most 2	0.000159	0.063282	3.841465	0.8014

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Date: 10/20/20 Time: 19:46
Sample (adjusted): 4/21/2015 6/22/2016
Included observations: 305 after adjustments
Trend assumption: Linear deterministic trend
Series: GBP SP350 SP50
Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.059004	31.61623	29.79707	0.0305
At most 1	0.024799	13.06729	15.49471	0.1124
At most 2 *	0.017575	5.408147	3.841465	0.0200

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.059004	18.54894	21.13162	0.1107
At most 1	0.024799	7.659146	14.26460	0.4144
At most 2 *	0.017575	5.408147	3.841465	0.0200

Max-eigenvalue test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Date: 10/20/20 Time: 21:50
Sample (adjusted): 3/09/2017 1/19/2018
Included observations: 227 after adjustments
Trend assumption: Linear deterministic trend
Series: GBP SP5000 SP350 SP50
Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.112465	53.07637	47.85613	0.0149
At most 1	0.063743	25.99360	29.79707	0.1289
At most 2	0.028028	11.04207	15.49471	0.2089
At most 3 *	0.020012	4.588784	3.841465	0.0322

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.112465	27.08277	27.58434	0.0579
At most 1	0.063743	14.95153	21.13162	0.2923
At most 2	0.028028	6.453286	14.26460	0.5557
At most 3 *	0.020012	4.588784	3.841465	0.0322

Max-eigenvalue test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Date: 10/20/20 Time: 18:47
Sample (adjusted): 1/31/2017 4/27/2018
Included observations: 324 after adjustments
Trend assumption: Linear deterministic trend
Series: CNY SP5000 SP350
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.052688	30.60665	29.79707	0.0403
At most 1	0.036488	13.06951	15.49471	0.1123
At most 2	0.003163	1.026463	3.841465	0.3110

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.052688	17.53714	21.13162	0.1481
At most 1	0.036488	12.04305	14.26460	0.1090
At most 2	0.003163	1.026463	3.841465	0.3110

Max-eigenvalue test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Date: 10/20/20 Time: 20:58
Sample (adjusted): 6/27/2016 3/03/2017
Included observations: 180 after adjustments
Trend assumption: Linear deterministic trend
Series: GBP FTSE100 SP1200
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.121413	30.73373	29.79707	0.0389
At most 1	0.036818	7.434491	15.49471	0.5277
At most 2	0.003783	0.682170	3.841465	0.4088

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.121413	23.29924	21.13162	0.0244
At most 1	0.036818	6.752321	14.26460	0.5188
At most 2	0.003783	0.682170	3.841465	0.4088

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Date: 10/21/20 Time: 01:00
Sample (adjusted): 9/10/2018 2/28/2020
Included observations: 383 after adjustments
Trend assumption: Linear deterministic trend
Series: TRY BIST100 SP1200
Lags interval (in first differences): 1 to 3

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.055103	33.72752	29.79707	0.0168
At most 1	0.025459	12.01924	15.49471	0.1560
At most 2	0.005577	2.142109	3.841465	0.1433

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.055103	21.70828	21.13162	0.0415
At most 1	0.025459	9.877133	14.26460	0.2201
At most 2	0.005577	2.142109	3.841465	0.1433

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

ANNEX E – Vector Error Correction Models

Vector Error Correction Estimates
Date: 10/20/20 Time: 00:05
Sample (adjusted): 9/14/2012 7/03/2014
Included observations: 467 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
RUB(-1)	1.000000		
SP350(-1)	2.00E-05		
	(1.5E-06)		
	[13.7409]		
SP50(-1)	-7.71E-06		
	(1.1E-06)		
	[-7.30297]		
C	-0.028797		
Error Correction:	**D(RUB)**	**D(SP350)**	**D(SP50)**
CointEq1	-0.059097	-1135.199	1866.333
	(0.01301)	(667.155)	(1941.59)
	[-4.54161]	[-1.70155]	[0.96124]
D(RUB(-1))	-0.019706	8738.748	33694.58
	(0.04793)	(2457.47)	(7151.84)
	[-0.41114]	[3.55600]	[4.71132]
D(RUB(-2))	0.008992	2569.164	13338.87
	(0.04924)	(2524.70)	(7347.51)
	[0.18260]	[1.01761]	[1.81543]
D(RUB(-3))	0.004203	1215.411	9833.769
	(0.04879)	(2501.64)	(7280.41)
	[0.08613]	[0.48584]	[1.35072]
D(SP350(-1))	-4.74E-08	-0.010587	0.693984
	(1.0E-06)	(0.05288)	(0.15390)
	[-0.04600]	[-0.20020]	[4.50944]
D(SP350(-2))	3.17E-06	0.072047	0.012022
	(1.1E-06)	(0.05401)	(0.15717)
	[3.00732]	[1.33406]	[0.07649]
D(SP350(-3))	3.68E-07	0.029056	0.035113
	(1.1E-06)	(0.05421)	(0.15778)
	[0.34778]	[0.53594]	[0.22255]
D(SP50(-1))	-1.02E-06	-0.032587	-0.052991
	(3.4E-07)	(0.01761)	(0.05124)
	[-2.97826]	[-1.85071]	[-1.03412]
D(SP50(-2))	-7.00E-07	0.012217	0.016460
	(3.5E-07)	(0.01771)	(0.05155)
	[-2.02710]	[0.68969]	[0.31930]
D(SP50(-3))	-2.32E-07	-0.033371	-0.024829
	(3.2E-07)	(0.01642)	(0.04778)
	[-0.72513]	[-2.03260]	[-0.51964]
C	-6.49E-06	0.738010	0.905278
	(8.0E-06)	(0.41058)	(1.19489)
	[-0.81018]	[1.79748]	[0.75763]
R-squared	0.073697	0.048728	0.140054
Adj. R-squared	0.053384	0.027867	0.121195
Sum sq. resids	1.33E-05	34978.21	296249.7
S.E. equation	0.000171	8.758230	25.48863
F-statistic	3.627973	2.335821	7.426563
Log likelihood	3394.096	-1670.466	-2169.333
Akaike AIC	-14.48863	7.201138	9.337615
Schwarz SC	-14.39097	7.298803	9.435280
Mean dependent	-6.27E-06	0.672784	1.021049
S.D. dependent	0.000176	8.882874	27.18944
Determinant resid covariance (dof adj.)		0.001135	
Determinant resid covariance		0.001057	
Log likelihood		-387.9442	
Akaike information criterion		1.815607	
Schwarz criterion		2.135238	
Number of coefficients		36	

Vector Error Correction Estimates
Date: 10/20/20 Time: 11:39
Sample (adjusted): 7/14/2014 1/15/2016
Included observations: 390 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1			
RUB(-1)	1.000000			
SP5000(-1)	0.000119			
	(2.1E-05)			
	[5.79507]			
SP350(-1)	-2.85E-05			
	(1.2E-05)			
	[-2.29645]			
SP50(-1)	-1.60E-05			
	(3.0E-06)			
	[-5.27594]			
C	-0.161051			
Error Correction:	**D(RUB)**	**D(SP5000)**	**D(SP350)**	**D(SP50)**
CointEq1	-0.023096	-842.5166	-308.3498	-668.8977
	(0.00473)	(255.734)	(235.291)	(443.004)
	[-4.88061]	[-3.29451]	[-1.31050]	[-1.50991]
D(RUB(-1))	-0.053941	2151.229	3195.730	11536.35
	(0.05249)	(2836.55)	(2609.80)	(4913.71)
	[-1.02766]	[0.75840]	[1.22451]	[2.34779]
D(RUB(-2))	-0.030644	875.5808	-682.3962	4380.066
	(0.05296)	(2861.76)	(2633.00)	(4957.39)
	[-0.57867]	[0.30596]	[-0.25917]	[0.88354]
D(RUB(-3))	-0.018098	-4703.841	-3821.523	1971.489
	(0.05297)	(2862.66)	(2633.83)	(4958.94)
	[-0.34164]	[-1.64317]	[-1.45094]	[0.39756]
D(RUB(-4))	-0.039927	-922.7726	1551.739	337.6639
	(0.05303)	(2865.73)	(2636.65)	(4964.26)
	[-0.75293]	[-0.32200]	[0.58853]	[0.06802]
D(SP5000(-1))	2.30E-06	0.049911	0.374724	0.667262
	(1.3E-06)	(0.06819)	(0.06274)	(0.11813)
	[1.82356]	[0.73190]	[5.97244]	[5.64852]
D(SP5000(-2))	1.93E-06	-0.031159	0.047422	0.171514
	(1.4E-06)	(0.07398)	(0.06806)	(0.12815)
	[1.40716]	[-0.42120]	[0.69673]	[1.33839]
D(SP5000(-3))	2.20E-06	0.059156	0.039375	0.096298
	(1.4E-06)	(0.07329)	(0.06743)	(0.12696)
	[1.62353]	[0.80713]	[0.58391]	[0.75847]
D(SP5000(-4))	1.71E-06	-0.023754	-0.055670	-0.104304
	(1.3E-06)	(0.07104)	(0.06536)	(0.12306)
	[1.29877]	[-0.33438]	[-0.85174]	[-0.84759]
D(SP350(-1))	1.53E-06	0.046446	-0.187764	0.248304
	(1.4E-06)	(0.07301)	(0.06717)	(0.12647)
	[1.13130]	[0.63619]	[-2.79531]	[1.96336]
D(SP350(-2))	-5.63E-08	-0.003636	-0.066051	0.044040
	(1.4E-06)	(0.07539)	(0.06936)	(0.13060)
	[-0.04033]	[-0.04823]	[-0.95225]	[0.33722]
D(SP350(-3))	-8.15E-07	0.000170	0.052622	-0.000487
	(1.4E-06)	(0.07531)	(0.06929)	(0.13045)
	[-0.58482]	[0.00226]	[0.75949]	[-0.00373]
D(SP350(-4))	9.06E-07	0.092434	0.120253	0.195934
	(1.3E-06)	(0.07195)	(0.06620)	(0.12465)
	[0.68015]	[1.28462]	[1.81644]	[1.57192]
D(SP50(-1))	-8.18E-08	0.049789	0.014762	-0.152705
	(6.2E-07)	(0.03355)	(0.03087)	(0.05812)
	[-0.13168]	[1.48387]	[0.47818]	[-2.62723]
D(SP50(-2))	-6.55E-07	-0.038377	-0.045599	-0.028055
	(6.3E-07)	(0.03397)	(0.03125)	(0.05884)
	[-1.04230]	[-1.12981]	[-1.45905]	[-0.47678]
D(SP50(-3))	-3.78E-07	0.001820	0.016612	0.022493
	(6.2E-07)	(0.03355)	(0.03086)	(0.05811)
	[-0.60908]	[0.05427]	[0.53824]	[0.38707]
D(SP50(-4))	-1.14E-06	-0.025498	-0.055708	-0.060729
	(5.7E-07)	(0.03071)	(0.02826)	(0.05320)
	[-2.00067]	[-0.83019]	[-1.97140]	[-1.14143]
C	-5.09E-05	-0.336101	-0.200331	-1.477368
	(1.8E-05)	(0.96028)	(0.88352)	(1.66348)
	[-2.86172]	[-0.35000]	[-0.22674]	[-0.88812]
R-squared	0.083949	0.067765	0.131795	0.204794
Adj. R-squared	0.042086	0.025163	0.092119	0.168454
Sum sq. resids	4.25E-05	124122.5	105071.6	372468.4
S.E. equation	0.000338	18.26644	16.80627	31.64268
F-statistic	2.005342	1.590644	3.321774	5.635491
Log likelihood	2572.873	-1677.147	-1644.655	-1891.429
Akaike AIC	-13.10191	8.693062	8.526436	9.791946
Schwarz SC	-12.91886	8.876115	8.709489	9.974998
Mean dependent	-4.19E-05	-0.223692	-0.138026	-1.956846
S.D. dependent	0.000345	18.50068	17.63830	34.70005

Vector Error Correction Estimates
Date: 10/20/20 Time: 13:26
Sample (adjusted): 1/22/2016 8/01/2017
Included observations: 398 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
RUB(-1)	1.000000		
SP350(-1)	-1.82E-05 (4.0E-06) [-4.51777]		
SP50(-1)	1.20E-06 (8.4E-07) [1.42319]		
C	0.005817		
Error Correction:	**D(RUB)**	**D(SP350)**	**D(SP50)**
CointEq1	-0.023909 (0.00943) [-2.53465]	1561.529 (853.915) [1.82867]	-2652.993 (1884.30) [-1.40795]
D(RUB(-1))	-0.104903 (0.05454) [-1.92349]	2179.628 (4937.08) [0.44148]	65294.24 (10894.4) [5.99335]
D(RUB(-2))	-0.074732 (0.05686) [-1.31439]	3336.928 (5146.98) [0.64833]	10424.25 (11357.6) [0.91782]
D(SP350(-1))	-6.12E-07 (6.5E-07) [-0.93523]	0.084719 (0.05922) [1.43055]	0.426068 (0.13068) [3.26036]
D(SP350(-2))	-3.14E-07 (6.6E-07) [-0.47505]	-0.059416 (0.05985) [-0.99283]	-0.044546 (0.13206) [-0.33732]
D(SP50(-1))	1.71E-07 (2.8E-07) [0.61625]	-0.005855 (0.02506) [-0.23361]	-0.106804 (0.05530) [-1.93127]
D(SP50(-2))	-2.48E-07 (2.5E-07) [-0.97973]	-0.010063 (0.02290) [-0.43951]	-0.058911 (0.05053) [-1.16596]
C	1.38E-05 (7.7E-06) [1.79723]	0.515946 (0.69445) [0.74296]	4.114176 (1.53240) [2.68478]
R-squared	0.038555	0.021751	0.165563
Adj. R-squared	0.021299	0.004193	0.150586
Sum sq. resids	8.77E-06	71857.57	349898.0
S.E. equation	0.000150	13.57388	29.95287
F-statistic	2.234223	1.238792	11.05441
Log likelihood	2943.788	-1598.739	-1913.748
Akaike AIC	-14.75270	8.074067	9.657023
Schwarz SC	-14.67258	8.154197	9.737153
Mean dependent	1.11E-05	0.530101	4.484874
S.D. dependent	0.000152	13.60242	32.49965
Determinant resid covariance (dof adj.)		0.002528	
Determinant resid covariance		0.002378	
Log likelihood		-491.9820	
Akaike information criterion		2.607950	
Schwarz criterion		2.878388	
Number of coefficients		27	

Vector Error Correction Estimates
Date: 10/20/20 Time: 18:48
Sample (adjusted): 1/31/2017 4/27/2018
Included observations: 324 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
CNY(-1)	1.000000		
SP5000(-1)	-3.62E-05 (2.9E-06) [-12.2840]		
SP350(-1)	2.79E-05 (1.2E-05) [2.25436]		
C	-0.102490		
Error Correction:	**D(CNY)**	**D(SP5000)**	**D(SP350)**
CointEq1	-0.042372 (0.01151) [-3.68027]	932.2961 (578.063) [1.61279]	625.2458 (282.576) [2.21267]
D(CNY(-1))	0.222117 (0.05075) [4.37682]	-487.3981 (2548.02) [-0.19128]	-571.5183 (1245.56) [-0.45885]
D(CNY(-2))	-0.109058 (0.05117) [-2.13131]	-2247.095 (2569.15) [-0.87465]	-302.6653 (1255.88) [-0.24100]
D(CNY(-3))	0.058196 (0.05134) [1.13350]	355.8958 (2577.84) [0.13806]	1188.512 (1260.13) [0.94316]
D(CNY(-4))	0.125619 (0.04998) [2.51334]	396.0661 (2509.48) [0.15783]	-2384.947 (1226.71) [-1.94418]
D(SP5000(-1))	-1.26E-06 (1.3E-06) [-0.96110]	0.105578 (0.06608) [1.59785]	0.281357 (0.03230) [8.71080]
D(SP5000(-2))	-2.26E-06 (1.5E-06) [-1.52901]	-0.198348 (0.07418) [-2.67374]	0.017569 (0.03626) [0.48450]
D(SP5000(-3))	2.09E-06 (1.4E-06) [1.45882]	0.284095 (0.07202) [3.94443]	0.095002 (0.03521) [2.69833]
D(SP5000(-4))	-3.72E-06 (1.4E-06) [-2.57510]	0.020495 (0.07246) [0.28284]	-0.026477 (0.03542) [-0.74751]
D(SP350(-1))	-6.36E-07 (2.7E-06) [-0.23916]	-0.135581 (0.13346) [-1.01585]	-0.228790 (0.06524) [-3.50679]
D(SP350(-2))	1.17E-06 (2.7E-06) [0.43492]	0.023965 (0.13538) [0.17702]	-0.026113 (0.06618) [-0.39458]
D(SP350(-3))	8.25E-07 (2.7E-06) [0.31033]	-0.231919 (0.13355) [-1.73660]	-0.034111 (0.06528) [-0.52252]
D(SP350(-4))	9.08E-06 (2.4E-06) [3.75039]	0.165895 (0.12154) [1.36494]	-0.075956 (0.05941) [-1.27845]
C	3.47E-05 (2.0E-05) [1.72518]	1.107647 (1.01118) [1.09540]	0.028792 (0.49430) [0.05825]
R-squared	0.171010	0.121751	0.219179
Adj. R-squared	0.136246	0.084921	0.186435
Sum sq. resids	3.73E-05	93987.56	22458.97
S.E. equation	0.000347	17.41223	8.511657
F-statistic	4.919149	3.305777	6.693712
Log likelihood	2128.655	-1378.304	-1146.406
Akaike AIC	-13.05342	8.594471	7.162999
Schwarz SC	-12.89006	8.757836	7.326364
Mean dependent	4.82E-05	1.200648	0.247870
S.D. dependent	0.000373	18.20225	9.436655
Determinant resid covariance (dof adj.)		0.001998	
Determinant resid covariance		0.001750	
Log likelihood		-350.7962	
Akaike information criterion		2.443187	
Schwarz criterion		2.968290	
Number of coefficients		45	

Vector Error Correction Estimates
Date: 10/20/20 Time: 19:52
Sample (adjusted): 4/21/2015 6/22/2016
Included observations: 305 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
GBP(-1)	1.000000		
SP350(-1)	-0.000710		
	(0.00014)		
	[-5.16899]		
SP50(-1)	7.08E-05		
	(4.6E-05)		
	[1.54049]		
C	-0.695509		
Error Correction:	**D(GBP)**	**D(SP350)**	**D(SP50)**
CointEq1	-0.040415	103.2003	99.05071
	(0.01453)	(34.7804)	(63.7088)
	[-2.78130]	[2.96720]	[1.55474]
D(GBP(-1))	0.101468	209.1256	923.8272
	(0.05717)	(136.830)	(250.638)
	[1.77495]	[1.52836]	[3.68591]
D(GBP(-2))	0.048949	-18.25935	-10.78479
	(0.05849)	(140.001)	(256.445)
	[0.83686]	[-0.13042]	[-0.04205]
D(SP350(-1))	-1.03E-06	0.088587	0.716973
	(2.9E-05)	(0.06911)	(0.12660)
	[-0.03572]	[1.28175]	[5.66329]
D(SP350(-2))	4.79E-05	0.048296	0.099881
	(3.0E-05)	(0.07157)	(0.13109)
	[1.60046]	[0.67483]	[0.76192]
D(SP50(-1))	-4.26E-06	-0.027697	-0.146978
	(1.6E-05)	(0.03731)	(0.06834)
	[-0.27356]	[-0.74235]	[-2.15063]
D(SP50(-2))	-2.20E-05	-0.039680	0.002643
	(1.4E-05)	(0.03451)	(0.06321)
	[-1.52539]	[-1.14982]	[0.04181]
C	-6.78E-05	-0.946393	-1.620095
	(0.00047)	(1.13644)	(2.08167)
	[-0.14284]	[-0.83277]	[-0.77827]
R-squared	0.051771	0.044783	0.149097
Adj. R-squared	0.029422	0.022269	0.129042
Sum sq. resids	0.020259	116064.7	389430.8
S.E. equation	0.008259	19.76841	36.21070
F-statistic	2.316506	1.989139	7.434433
Log likelihood	1034.190	-1338.869	-1523.476
Akaike AIC	-6.729115	8.831927	10.04247
Schwarz SC	-6.631533	8.929509	10.14005
Mean dependent	-6.60E-05	-0.932721	-2.126918
S.D. dependent	0.008383	19.99227	38.80059
Determinant resid covariance (dof adj.)		24.64884	
Determinant resid covariance		22.75969	
Log likelihood		-1774.890	
Akaike information criterion		11.81567	
Schwarz criterion		12.14501	
Number of coefficients		27	

Vector Error Correction Estimates
Date: 10/20/20 Time: 21:06
Sample (adjusted): 6/27/2016 3/03/2017
Included observations: 180 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
GBP(-1)	1.000000		
FTSE100(-1)	0.000409		
	(5.8E-05)		
	[7.06715]		
SP1200(-1)	-0.000953		
	(0.00024)		
	[-3.98378]		
C	-2.262803		
Error Correction:	**D(GBP)**	**D(FTSE100)**	**D(SP1200)**
CointEq1	-0.013968	-512.9385	-83.76391
	(0.02301)	(110.406)	(23.5180)
	[-0.60691]	[-4.64592]	[-3.56169]
D(GBP(-1))	0.151299	-100.1501	124.3323
	(0.08482)	(406.889)	(86.6728)
	[1.78380]	[-0.24614]	[1.43450]
D(FTSE100(-1))	2.67E-05	0.017262	0.036839
	(2.2E-05)	(0.10346)	(0.02204)
	[1.23786]	[0.16684]	[1.67156]
D(SP1200(-1))	-0.000124	1.335562	0.008143
	(0.00011)	(0.54645)	(0.11640)
	[-1.08820]	[2.44406]	[0.06996]
C	-0.000578	5.287990	1.504520
	(0.00073)	(3.50461)	(0.74653)
	[-0.79080]	[1.50887]	[2.01536]
R-squared	0.021355	0.193835	0.108797
Adj. R-squared	-0.001014	0.175408	0.088426
Sum sq. resids	0.016015	368562.5	16723.36
S.E. equation	0.009566	45.89195	9.775584
F-statistic	0.954676	10.51925	5.340939
Log likelihood	584.0358	-941.6057	-663.2534
Akaike AIC	-6.433731	10.51784	7.425037
Schwarz SC	-6.345038	10.60653	7.513731
Mean dependent	-0.000764	6.864442	1.547778
S.D. dependent	0.009562	50.53787	10.23875
Determinant resid covariance (dof adj.)		7.606864	
Determinant resid covariance		6.990404	
Log likelihood		-941.2353	
Akaike information criterion		10.65817	
Schwarz criterion		10.97747	
Number of coefficients		18	

Vector Error Correction Estimates
Date: 10/20/20 Time: 21:51
Sample (adjusted): 3/09/2017 1/19/2018
Included observations: 227 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
GBP(-1)	1.000000
SP5000(-1)	0.000296 (0.00013) [2.30098]
SP350(-1)	-0.000743 (0.00019) [-3.98687]
SP50(-1)	-0.000165 (3.8E-05) [-4.38058]
C	-0.125840

Error Correction:	D(GBP)	D(SP5000)	D(SP350)	D(SP50)
CointEq1	-0.020031 (0.01969) [-1.01737]	41.02594 (31.5144) [1.30182]	112.5586 (23.4268) [4.80469]	73.77008 (97.3702) [0.75763]
D(GBP(-1))	-0.024999 (0.06917) [-0.36139]	-81.84934 (110.723) [-0.73923]	-160.5856 (82.3077) [-1.95104]	736.1610 (342.100) [2.15189]
D(GBP(-2))	-0.040820 (0.06957) [-0.58673]	122.7394 (111.360) [1.10219]	-78.05086 (82.7814) [-0.94286]	427.6883 (344.069) [1.24303]
D(SP5000(-1))	9.15E-05 (5.1E-05) [1.79846]	-0.076775 (0.08142) [-0.94290]	0.146538 (0.06053) [2.42100]	1.193268 (0.25158) [4.74317]
D(SP5000(-2))	-2.26E-05 (5.4E-05) [-0.42090]	-0.001333 (0.08612) [-0.01547]	0.028242 (0.06402) [0.44114]	-0.245869 (0.26610) [-0.92399]
D(SP350(-1))	-0.000110 (6.8E-05) [-1.61993]	-0.007901 (0.10899) [-0.07249]	-0.139603 (0.08102) [-1.72304]	0.089805 (0.33675) [0.26668]
D(SP350(-2))	7.46E-05 (6.8E-05) [1.10345]	-0.171520 (0.10827) [-1.58418]	-0.102695 (0.08049) [-1.27595]	0.057263 (0.33453) [0.17118]
D(SP50(-1))	-1.23E-05 (1.5E-05) [-0.84250]	-0.015533 (0.02332) [-0.66623]	0.018192 (0.01733) [1.04961]	-0.016857 (0.07204) [-0.23401]
D(SP50(-2))	2.06E-06 (1.4E-05) [0.15152]	0.032243 (0.02173) [1.48355]	0.022457 (0.01616) [1.38999]	0.055460 (0.06715) [0.82590]
C	0.000739 (0.00046) [1.59696]	2.059427 (0.74058) [2.78084]	0.160886 (0.55052) [0.29224]	3.605117 (2.28817) [1.57555]
R-squared	0.040370	0.050652	0.125862	0.165784
Adj. R-squared	0.000570	0.011279	0.089608	0.131185
Sum sq. resids	0.008946	22920.05	12665.56	218801.1
S.E. equation	0.006421	10.27727	7.639806	31.75374
F-statistic	1.014326	1.286448	3.471630	4.791595
Log likelihood	828.9613	-845.8808	-778.5611	-1101.954
Akaike AIC	-7.215518	7.540800	6.947675	9.796951
Schwarz SC	-7.064639	7.691679	7.098554	9.947830
Mean dependent	0.000738	1.970573	0.476123	6.563965
S.D. dependent	0.006423	10.33573	8.006968	34.06678

Determinant resid covariance (dof adj.)	156.4670
Determinant resid covariance	130.6647
Log likelihood	-1841.440
Akaike information criterion	16.61181
Schwarz criterion	17.27567
Number of coefficients	44

Vector Error Correction Estimates
Date: 10/21/20 Time: 01:18
Sample (adjusted): 9/10/2018 2/28/2020
Included observations: 383 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
TRY(-1)	1.000000
BIST100(-1)	-6.28E-07 (2.2E-07) [-2.91335]
SP1200(-1)	8.43E-05 (1.3E-05) [6.56882]
C	-0.314531

Error Correction:	D(TRY)	D(BIST100)	D(SP1200)
CointEq1	-0.065876 (0.01584) [-4.15991]	3543.066 (12883.0) [0.27502]	-185.5976 (176.109) [-1.05388]
D(TRY(-1))	-0.025828 (0.05431) [-0.47554]	-25412.75 (44185.3) [-0.57514]	484.3640 (604.009) [0.80191]
D(TRY(-2))	-0.236824 (0.05279) [-4.48638]	-12098.44 (42943.9) [-0.28173]	-199.6057 (587.039) [-0.34002]
D(TRY(-3))	-0.078035 (0.05233) [-1.49121]	-3621.503 (42571.8) [-0.08507]	239.2744 (581.952) [0.41116]
D(BIST100(-1))	1.56E-07 (7.2E-08) [2.18138]	0.077655 (0.05833) [1.33137]	0.000234 (0.00080) [0.29355]
D(BIST100(-2))	1.25E-07 (7.2E-08) [1.72981]	0.031317 (0.05879) [0.53272]	0.000619 (0.00080) [0.76985]
D(BIST100(-3))	1.10E-07 (7.3E-08) [1.51432]	0.063545 (0.05902) [1.07667]	-0.000181 (0.00081) [-0.22448]
D(SP1200(-1))	-1.24E-05 (5.1E-06) [-2.41669]	3.152930 (4.18263) [0.75381]	0.227678 (0.05718) [3.98205]
D(SP1200(-2))	-2.39E-06 (5.4E-06) [-0.44309]	3.103077 (4.39372) [0.70625]	0.023349 (0.06006) [0.38874]
D(SP1200(-3))	-1.57E-06 (5.4E-06) [-0.29381]	3.483254 (4.35288) [0.80022]	0.080803 (0.05950) [1.35795]
C	2.19E-06 (8.1E-05) [0.02703]	22.94967 (65.9428) [0.34802]	-0.078078 (0.90143) [-0.08662]
R-squared	0.145519	0.027220	0.067752
Adj. R-squared	0.122549	0.001070	0.042692
Sum sq. resids	0.000931	6.16E+08	115171.6
S.E. equation	0.001582	1287.170	17.59548
F-statistic	6.335195	1.040900	2.703551
Log likelihood	1932.068	-3280.230	-1636.180
Akaike AIC	-10.03169	17.18658	8.601462
Schwarz SC	-9.918297	17.29997	8.714852
Mean dependent	1.02E-05	33.21018	0.030470
S.D. dependent	0.001689	1287.858	17.98355

Determinant resid covariance (dof adj.)	951.3745
Determinant resid covariance	871.7340
Log likelihood	-2926.908
Akaike information criterion	15.47211
Schwarz criterion	15.84320
Number of coefficients	36

ANNEX F – Portmanteau Residual Autocorrelation Test

VEC Residual Portmanteau Tests for Autocorrelations
Null Hypothesis: No residual autocorrelations up to lag h
Date: 10/20/20 Time: 00:07
Sample: 9/10/2012 7/03/2014
Included observations: 467

Lags	Q-Stat	Prob.*	Adj Q-Stat	Prob.*	df
1	0.470192	---	0.471201	---	---
2	1.109875	---	1.113636	---	---
3	2.424545	---	2.436806	---	---
4	11.90929	0.6859	12.00349	0.6788	15
5	19.19255	0.7416	19.36558	0.7322	24
6	25.76107	0.8112	26.01959	0.8009	33
7	38.24405	0.6366	38.69253	0.6170	42
8	43.25254	0.7712	43.78831	0.7530	51
9	56.74984	0.5952	57.55084	0.5658	60
10	67.05083	0.5440	68.07724	0.5088	69

*Test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for (approximate) chi-square distribution after adjustment for VEC estimation (Bruggemann, et al. 2005)

VEC Residual Portmanteau Tests for Autocorrelations
Null Hypothesis: No residual autocorrelations up to lag h
Date: 10/20/20 Time: 11:57
Sample: 7/07/2014 1/15/2016
Included observations: 390

Lags	Q-Stat	Prob.*	Adj Q-Stat	Prob.*	df
1	0.031531	---	0.031613	---	---
2	0.190926	---	0.191828	---	---
3	0.710598	---	0.715529	---	---
4	1.733468	---	1.748999	---	---
5	9.851995	0.9994	9.972962	0.9993	28
6	23.39921	0.9954	23.73185	0.9946	44
7	46.72469	0.8949	47.48364	0.8793	60
8	60.69333	0.8999	61.74483	0.8815	76
9	69.64119	0.9603	70.90405	0.9498	92
10	85.19247	0.9485	86.86457	0.9330	108

*Test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for (approximate) chi-square distribution after adjustment for VEC estimation (Bruggemann, et al. 2005)

VEC Residual Portmanteau Tests for Autocorrelations
Null Hypothesis: No residual autocorrelations up to lag h
Date: 10/20/20 Time: 13:29
Sample: 1/19/2016 8/01/2017
Included observations: 398

Lags	Q-Stat	Prob.*	Adj Q-Stat	Prob.*	df
1	0.468699	---	0.469879	---	---
2	0.891526	---	0.894842	---	---
3	17.25294	0.3040	17.38052	0.2966	15
4	42.85136	0.0103	43.23883	0.0093	24
5	49.77671	0.0306	50.25228	0.0277	33
6	54.53976	0.0929	55.08824	0.0849	42
7	60.40277	0.1725	61.05621	0.1582	51
8	73.10599	0.1192	74.02000	0.1053	60
9	82.61409	0.1258	83.74809	0.1091	69
10	86.31632	0.2431	87.54574	0.2153	78

*Test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for (approximate) chi-square distribution after adjustment for VEC estimation (Bruggemann, et al. 2005)

VEC Residual Portmanteau Tests for Autocorrelations
Null Hypothesis: No residual autocorrelations up to lag h
Date: 10/20/20 Time: 19:11
Sample: 1/24/2017 4/27/2018
Included observations: 324

Lags	Q-Stat	Prob.*	Adj Q-Stat	Prob.*	df
1	7.107901	---	7.129906	---	---
2	8.691888	---	8.723733	---	---
3	9.878872	---	9.921809	---	---
4	12.19681	---	12.26872	---	---
5	18.79852	0.2230	18.97391	0.2149	15
6	24.23120	0.4484	24.50909	0.4328	24
7	34.23806	0.4081	34.73693	0.3851	33
8	53.46671	0.1105	54.45237	0.0943	42
9	60.41948	0.1721	61.60379	0.1469	51
10	67.00343	0.2494	68.39743	0.2137	60

*Test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for (approximate) chi-square distribution after adjustment for VEC estimation (Bruggemann, et al. 2005)

VEC Residual Portmanteau Tests for Autocorrelations
Null Hypothesis: No residual autocorrelations up to lag h
Date: 10/20/20 Time: 19:54
Sample: 4/16/2015 6/22/2016
Included observations: 305

Lags	Q-Stat	Prob.*	Adj Q-Stat	Prob.*	df
1	0.094667	---	0.094979	---	---
2	0.567100	---	0.570530	---	---
3	14.67120	0.4754	14.81473	0.4648	15
4	25.96511	0.3549	26.25873	0.3402	24
5	34.36668	0.4021	34.80033	0.3823	33
6	38.71779	0.6158	39.23875	0.5929	42
7	49.78074	0.5221	50.56157	0.4910	51
8	56.02613	0.6217	56.97518	0.5870	60
9	61.98242	0.7128	63.11258	0.6769	69
10	67.11864	0.8055	68.42291	0.7724	78

*Test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for (approximate) chi-square distribution after adjustment for VEC estimation (Bruggemann, et al. 2005)

VEC Residual Portmanteau Tests for Autocorrelations
Null Hypothesis: No residual autocorrelations up to lag h
Date: 10/20/20 Time: 21:09
Sample: 6/23/2016 3/03/2017
Included observations: 180

Lags	Q-Stat	Prob.*	Adj Q-Stat	Prob.*	df
1	18.86711	---	18.97251	---	---
2	28.76276	0.0173	28.97935	0.0162	15
3	36.35805	0.0506	36.70337	0.0468	24
4	44.64210	0.0850	45.17570	0.0769	33
5	56.44861	0.0673	57.31953	0.0578	42
6	61.16748	0.1558	62.20113	0.1353	51
7	72.80913	0.1240	74.31382	0.1012	60
8	83.78638	0.1085	85.80164	0.0832	69
9	97.30334	0.0686	100.0300	0.0472	78
10	108.3704	0.0602	111.7480	0.0382	87

*Test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for (approximate) chi-square distribution after adjustment for VEC estimation (Bruggemann, et al. 2005)

VEC Residual Portmanteau Tests for Autocorrelations
Null Hypothesis: No residual autocorrelations up to lag h
Date: 10/20/20 Time: 21:55
Sample: 3/06/2017 1/19/2018
Included observations: 227

Lags	Q-Stat	Prob.*	Adj Q-Stat	Prob.*	df
1	0.246104	---	0.247193	---	---
2	1.311689	---	1.322250	---	---
3	13.58568	0.9899	13.76062	0.9888	28
4	30.39713	0.9407	30.87362	0.9327	44
5	47.96131	0.8688	48.83340	0.8482	60
6	62.68181	0.8634	63.95355	0.8363	76
7	75.21097	0.8984	76.88136	0.8713	92
8	88.21385	0.9181	90.35923	0.8900	108
9	94.97303	0.9754	97.39747	0.9628	124
10	116.7765	0.9240	120.2057	0.8856	140

*Test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for (approximate) chi-square distribution after adjustment for VEC estimation (Bruggemann, et al. 2005)

VEC Residual Portmanteau Tests for Autocorrelations
Null Hypothesis: No residual autocorrelations up to lag h
Date: 10/21/20 Time: 01:32
Sample: 9/04/2018 2/28/2020
Included observations: 383

Lags	Q-Stat	Prob.*	Adj Q-Stat	Prob.*	df
1	0.257473	---	0.258147	---	---
2	0.671835	---	0.674685	---	---
3	1.191359	---	1.198309	---	---
4	12.14982	0.6677	12.27243	0.6583	15
5	20.90948	0.6441	21.14796	0.6300	24
6	34.02357	0.4181	34.47076	0.3973	33
7	41.51544	0.4921	42.10210	0.4666	42
8	44.50586	0.7277	45.15632	0.7039	51
9	51.23592	0.7826	52.04833	0.7577	60
10	59.09815	0.7966	60.12135	0.7684	69

*Test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for (approximate) chi-square distribution after adjustment for VEC estimation (Bruggemann, et al. 2005)

ANNEX G – Residual Autocorrelation LM Test

VEC Residual Serial Correlation LM Tests
Date: 10/20/20 Time: 00:08
Sample: 9/10/2012 7/03/2014
Included observations: 467

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	32.47131	9	0.0002	3.650004	(9, 1097.8)	0.0002
2	26.30952	9	0.0018	2.949076	(9, 1097.8)	0.0018
3	19.36327	9	0.0223	2.163602	(9, 1097.8)	0.0223
4	11.64938	9	0.2338	1.297111	(9, 1097.8)	0.2338
5	7.764939	9	0.5580	0.863068	(9, 1097.8)	0.5580
6	6.767456	9	0.6613	0.751858	(9, 1097.8)	0.6613
7	12.97376	9	0.1638	1.445445	(9, 1097.8)	0.1638
8	5.418207	9	0.7964	0.601588	(9, 1097.8)	0.7964
9	14.33939	9	0.1108	1.598587	(9, 1097.8)	0.1108
10	10.80513	9	0.2893	1.202644	(9, 1097.8)	0.2893

VEC Residual Serial Correlation LM Tests
Date: 10/20/20 Time: 11:58
Sample: 7/07/2014 1/15/2016
Included observations: 390

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	4.052912	16	0.9988	0.252183	(16, 1115.7)	0.9988
2	11.24622	16	0.7940	0.702016	(16, 1115.7)	0.7940
3	21.06015	16	0.1762	1.320398	(16, 1115.7)	0.1762
4	14.30411	16	0.5761	0.894116	(16, 1115.7)	0.5761
5	8.759227	16	0.9230	0.546166	(16, 1115.7)	0.9230
6	13.86624	16	0.6087	0.866577	(16, 1115.7)	0.6087
7	23.84477	16	0.0930	1.496845	(16, 1115.7)	0.0930
8	14.40642	16	0.5685	0.900553	(16, 1115.7)	0.5685
9	9.220515	16	0.9041	0.575047	(16, 1115.7)	0.9041
10	16.19817	16	0.4392	1.013366	(16, 1115.7)	0.4392

VEC Residual Serial Correlation LM Tests
Date: 10/20/20 Time: 13:30
Sample: 1/19/2016 8/01/2017
Included observations: 398

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	19.27321	9	0.0230	2.155507	(9, 937.1)	0.0230
2	6.743255	9	0.6638	0.749145	(9, 937.1)	0.6638
3	17.18777	9	0.0459	1.920136	(9, 937.1)	0.0459
4	26.90124	9	0.0015	3.020896	(9, 937.1)	0.0015
5	7.184564	9	0.6179	0.798360	(9, 937.1)	0.6179
6	4.872637	9	0.8453	0.540789	(9, 937.1)	0.8453
7	5.943512	9	0.7456	0.660016	(9, 937.1)	0.7456
8	13.01268	9	0.1620	1.450484	(9, 937.1)	0.1620
9	9.752177	9	0.3709	1.085159	(9, 937.1)	0.3709
10	3.749574	9	0.9271	0.415897	(9, 937.1)	0.9271

VEC Residual Serial Correlation LM Tests
Date: 10/20/20 Time: 19:12
Sample: 1/24/2017 4/27/2018
Included observations: 324

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	45.74663	9	0.0000	5.217461	(9, 742.4)	0.0000
2	11.46918	9	0.2449	1.278175	(9, 742.4)	0.2449
3	8.194294	9	0.5147	0.911201	(9, 742.4)	0.5147
4	10.90765	9	0.2821	1.215137	(9, 742.4)	0.2821
5	6.769580	9	0.6611	0.752054	(9, 742.4)	0.6611
6	5.970414	9	0.7429	0.662916	(9, 742.4)	0.7429
7	10.66272	9	0.2995	1.187656	(9, 742.4)	0.2995
8	21.49802	9	0.0106	2.412052	(9, 742.4)	0.1106
9	7.911510	9	0.5431	0.879588	(9, 742.4)	0.5431
10	7.218496	9	0.6144	0.802167	(9, 742.4)	0.6144

VEC Residual Serial Correlation LM Tests
Date: 10/20/20 Time: 19:55
Sample: 4/16/2015 6/22/2016
Included observations: 305

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	14.93398	9	0.0928	1.668582	(9, 710.8)	0.0928
2	6.673398	9	0.6711	0.741313	(9, 710.8)	0.6711
3	16.17473	9	0.0633	1.808789	(9, 710.8)	0.0633
4	12.28097	9	0.1979	1.369606	(9, 710.8)	0.1979
5	8.783393	9	0.4575	0.977146	(9, 710.8)	0.4575
6	4.559843	9	0.8709	0.505779	(9, 710.8)	0.8709
7	11.35814	9	0.2520	1.265870	(9, 710.8)	0.2520
8	6.660605	9	0.6724	0.739885	(9, 710.8)	0.6724
9	6.329255	9	0.7066	0.702914	(9, 710.8)	0.7066
10	5.304677	9	0.8070	0.588704	(9, 710.8)	0.8070

VEC Residual Serial Correlation LM Tests
Date: 10/20/20 Time: 21:10
Sample: 6/23/2016 3/03/2017
Included observations: 180

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	53.88063	9	0.0000	6.336745	(9, 413.9)	0.0000
2	11.52267	9	0.2416	1.287248	(9, 413.9)	0.2416
3	7.764459	9	0.5580	0.863490	(9, 413.9)	0.5581
4	8.843029	9	0.4519	0.984714	(9, 413.9)	0.4519
5	12.41291	9	0.1910	1.388186	(9, 413.9)	0.1910
6	4.882204	9	0.8445	0.541077	(9, 413.9)	0.8445
7	12.27244	9	0.1984	1.372245	(9, 413.9)	0.1984
8	11.55477	9	0.2396	1.290883	(9, 413.9)	0.2396
9	14.21083	9	0.1150	1.592700	(9, 413.9)	0.1150
10	11.76794	9	0.2267	1.315036	(9, 413.9)	0.2267

VEC Residual Serial Correlation LM Tests
Date: 10/20/20 Time: 21:57
Sample: 3/06/2017 1/19/2018
Included observations: 227

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	12.91059	16	0.6793	0.806201	(16, 642.2)	0.6793
2	13.61366	16	0.6275	0.850567	(16, 642.2)	0.6275
3	13.68596	16	0.6221	0.855131	(16, 642.2)	0.6221
4	18.35843	16	0.3033	1.151231	(16, 642.2)	0.3034
5	18.39305	16	0.3014	1.153433	(16, 642.2)	0.3014
6	16.27390	16	0.4340	1.018869	(16, 642.2)	0.4341
7	13.68259	16	0.6223	0.854919	(16, 642.2)	0.6224
8	13.77550	16	0.6154	0.860786	(16, 642.2)	0.6155
9	7.411029	16	0.9645	0.460820	(16, 642.2)	0.9645
10	22.58413	16	0.1253	1.420859	(16, 642.2)	0.1253

VEC Residual Serial Correlation LM Tests
Date: 10/21/20 Time: 01:33
Sample: 9/04/2018 2/28/2020
Included observations: 383

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	17.00126	9	0.0487	1.899605	(9, 893.3)	0.0487
2	9.386330	9	0.4024	1.044311	(9, 893.3)	0.4024
3	10.61214	9	0.3032	1.181502	(9, 893.3)	0.3032
4	12.14455	9	0.2053	1.353270	(9, 893.3)	0.2053
5	9.414460	9	0.3999	1.047457	(9, 893.3)	0.3999
6	14.39324	9	0.1090	1.605860	(9, 893.3)	0.1090
7	8.396249	9	0.4948	0.933639	(9, 893.3)	0.4948
8	3.192752	9	0.9562	0.353996	(9, 893.3)	0.9562
9	7.143639	9	0.6222	0.793797	(9, 893.3)	0.6222
10	8.420604	9	0.4924	0.936360	(9, 893.3)	0.4924

ANNEX H – Multivariate ARCH-LM Test

VEC Residual Heteroskedasticity Tests (Includes Cross Terms)
Date: 10/20/20 Time: 21:59
Sample: 3/06/2017 1/19/2018
Included observations: 227

Joint test:

Chi-sq	df	Prob.
571.6600	540	0.1672

Individual components:

Dependent	R-squared	F(54,172)	Prob.	Chi-sq(54)	Prob.
res1*res1	0.213557	0.864930	0.7288	48.47743	0.6865
res2*res2	0.135951	0.501164	0.9981	30.86093	0.9952
res3*res3	0.312366	1.446911	0.0392	70.90717	0.0611
res4*res4	0.251420	1.069786	0.3650	57.07239	0.3616
res2*res1	0.224224	0.920620	0.6304	50.89883	0.5948
res3*res1	0.264175	1.143539	0.2572	59.96764	0.2683
res3*res2	0.246772	1.043526	0.4083	56.01718	0.3991
res4*res1	0.217957	0.887720	0.6895	49.47635	0.6493
res4*res2	0.303621	1.388742	0.0589	68.92205	0.0831
res4*res3	0.268405	1.168569	0.2260	60.92790	0.2408

VEC Residual Heteroskedasticity Tests (Includes Cross Terms)
Date: 10/20/20 Time: 00:08
Sample: 9/10/2012 7/03/2014
Included observations: 467

Joint test:

Chi-sq	df	Prob.
582.6176	390	0.0000

Individual components:

Dependent	R-squared	F(65,401)	Prob.	Chi-sq(65)	Prob.
res1*res1	0.427597	4.608549	0.0000	199.6879	0.0000
res2*res2	0.131104	0.930849	0.6292	61.22556	0.6098
res3*res3	0.157972	1.157401	0.2030	73.77283	0.2133
res2*res1	0.131336	0.932748	0.6251	61.33409	0.6060
res3*res1	0.177806	1.334145	0.0525	83.03541	0.0652
res3*res2	0.134557	0.959177	0.5689	62.83810	0.5529

VEC Residual Heteroskedasticity Tests (Includes Cross Terms)
Date: 10/20/20 Time: 11:59
Sample: 7/07/2014 1/15/2016
Included observations: 390

Joint test:

Chi-sq	df	Prob.
2288.540	1700	0.0000

Individual components:

Dependent	R-squared	F(170,219)	Prob.	Chi-sq(170)	Prob.
res1*res1	0.827379	6.174562	0.0000	322.6778	0.0000
res2*res2	0.670514	2.621601	0.0000	261.5006	0.0000
res3*res3	0.629302	2.186926	0.0000	245.4278	0.0001
res4*res4	0.553839	1.599144	0.0005	215.9973	0.0098
res2*res1	0.777643	4.505319	0.0000	303.2809	0.0000
res3*res1	0.643997	2.330377	0.0000	251.1590	0.0001
res3*res2	0.543709	1.535043	0.0014	212.0467	0.0157
res4*res1	0.504420	1.311213	0.0297	196.7237	0.0785
res4*res2	0.486973	1.222812	0.0807	189.9195	0.1408
res4*res3	0.672483	2.645105	0.0000	262.2684	0.0000

VEC Residual Heteroskedasticity Tests (Includes Cross Terms)
Date: 10/20/20 Time: 13:30
Sample: 1/19/2016 8/01/2017
Included observations: 398

Joint test:

Chi-sq	df	Prob.
460.3089	210	0.0000

Individual components:

Dependent	R-squared	F(35,362)	Prob.	Chi-sq(35)	Prob.
res1*res1	0.341216	5.357071	0.0000	135.8041	0.0000
res2*res2	0.144577	1.748075	0.0067	57.54180	0.0095
res3*res3	0.074029	0.826882	0.7483	29.46343	0.7322
res2*res1	0.249030	3.429815	0.0000	99.11412	0.0000
res3*res1	0.176748	2.220559	0.0001	70.34572	0.0004
res3*res2	0.093288	1.064136	0.3750	37.12864	0.3711

VEC Residual Heteroskedasticity Tests (Includes Cross Terms)
Date: 10/20/20 Time: 19:16
Sample: 1/24/2017 4/27/2018
Included observations: 324

Joint test:

Chi-sq	df	Prob.
1223.117	624	0.0000

Individual components:

Dependent	R-squared	F(104,219)	Prob.	Chi-sq(104)	Prob.
res1*res1	0.806120	8.755453	0.0000	261.1830	0.0000
res2*res2	0.730654	5.712300	0.0000	236.7317	0.0000
res3*res3	0.278422	0.812516	0.8839	90.20886	0.8303
res2*res1	0.778580	7.404521	0.0000	252.2599	0.0000
res3*res1	0.542242	2.494410	0.0000	175.6864	0.0000
res3*res2	0.491277	2.033554	0.0000	159.1737	0.0004

VEC Residual Heteroskedasticity Tests (Includes Cross Terms)
Date: 10/20/20 Time: 19:56
Sample: 4/16/2015 6/22/2016
Included observations: 305

Joint test:

Chi-sq	df	Prob.
232.5732	210	0.1364

Individual components:

Dependent	R-squared	F(35,269)	Prob.	Chi-sq(35)	Prob.
res1*res1	0.100676	0.860386	0.6962	30.70612	0.6755
res2*res2	0.216853	2.128176	0.0004	66.14030	0.0011
res3*res3	0.150628	1.362991	0.0918	45.94162	0.1021
res2*res1	0.122349	1.071424	0.3675	37.31634	0.3630
res3*res1	0.108161	0.932113	0.5824	32.98913	0.5655
res3*res2	0.172958	1.607299	0.0205	52.75213	0.0275

VEC Residual Heteroskedasticity Tests (Includes Cross Terms)
Date: 10/20/20 Time: 21:11
Sample: 6/23/2016 3/03/2017
Included observations: 180

Joint test:

Chi-sq	df	Prob.
215.8271	84	0.0000

Individual components:

Dependent	R-squared	F(14,165)	Prob.	Chi-sq(14)	Prob.
res1*res1	0.257722	4.092047	0.0000	46.38994	0.0000
res2*res2	0.196323	2.879023	0.0007	35.33811	0.0013
res3*res3	0.147862	2.045045	0.0174	26.61518	0.0216
res2*res1	0.341922	6.123577	0.0000	61.54592	0.0000
res3*res1	0.373847	7.036700	0.0000	67.29243	0.0000
res3*res2	0.289928	4.812197	0.0000	52.18702	0.0000

VEC Residual Heteroskedasticity Tests (Includes Cross Terms)
Date: 10/21/20 Time: 01:38
Sample: 9/04/2018 2/28/2020
Included observations: 383

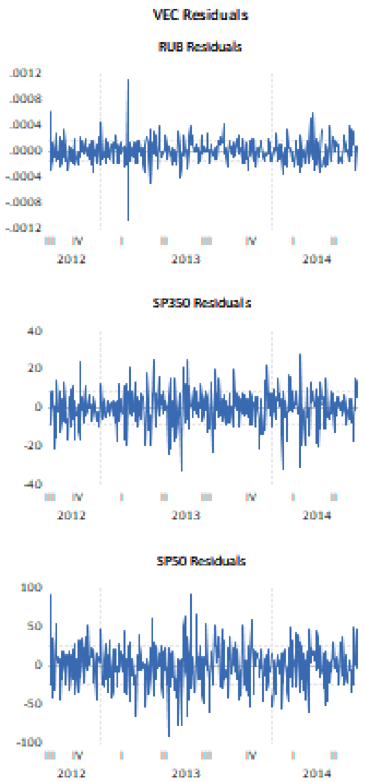
Joint test:

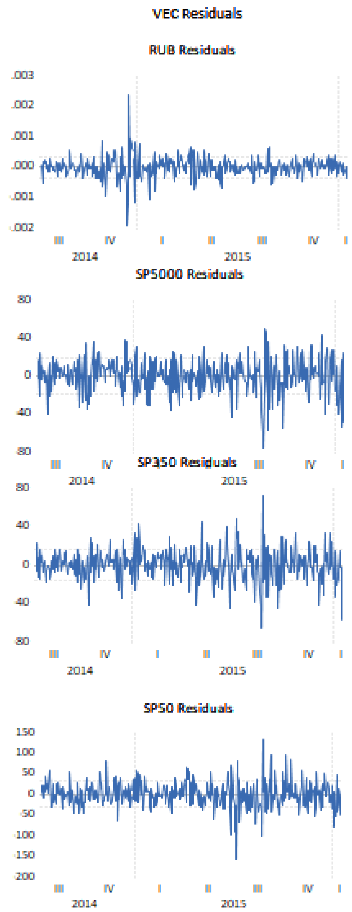
Chi-sq	df	Prob.
691.1901	390	0.0000

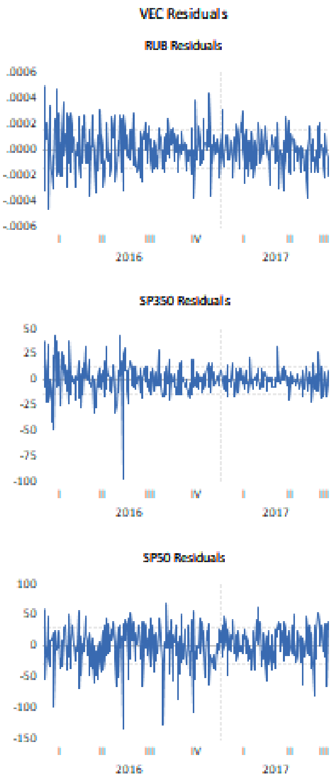
Individual components:

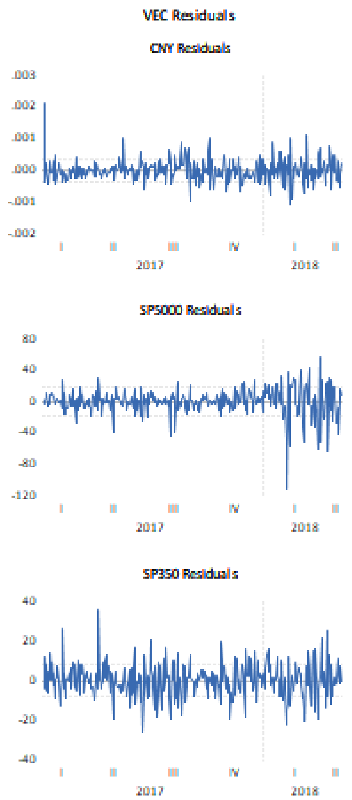
Dependent	R-squared	F(65,317)	Prob.	Chi-sq(65)	Prob.
res1*res1	0.281007	1.906064	0.0001	107.6255	0.0007
res2*res2	0.319354	2.288220	0.0000	122.3127	0.0000
res3*res3	0.323894	2.336325	0.0000	124.0512	0.0000
res2*res1	0.229976	1.456546	0.0191	88.08081	0.0299
res3*res1	0.217550	1.355965	0.0471	83.32167	0.0625
res3*res2	0.313074	2.222708	0.0000	119.9072	0.0000

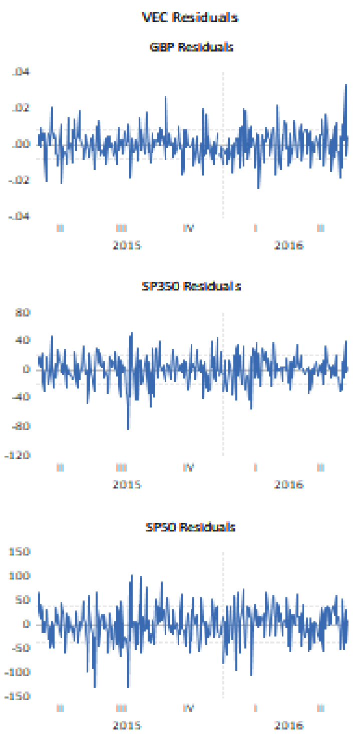
ANNEX I – Residual Graphical Representation

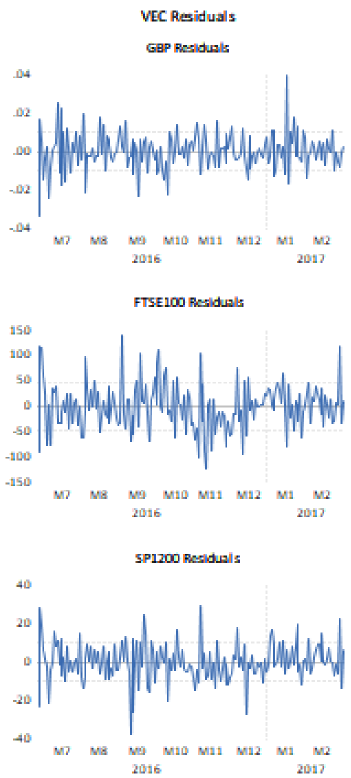


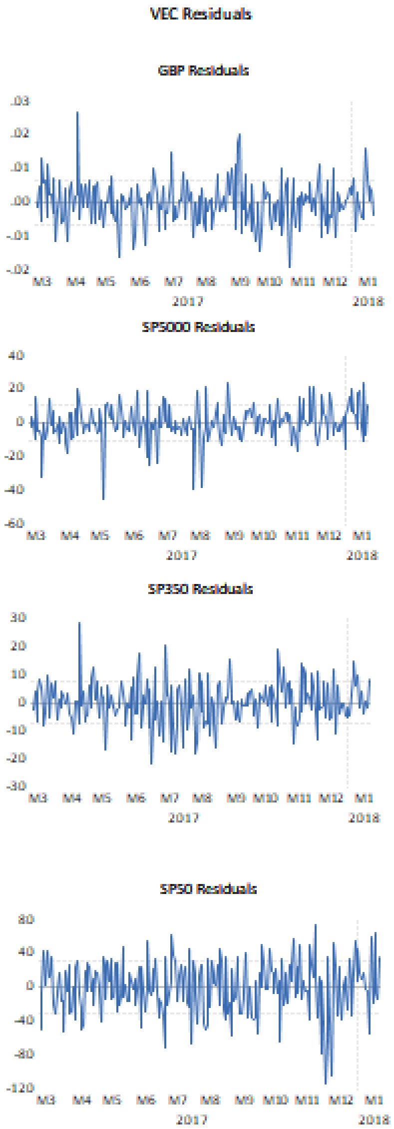


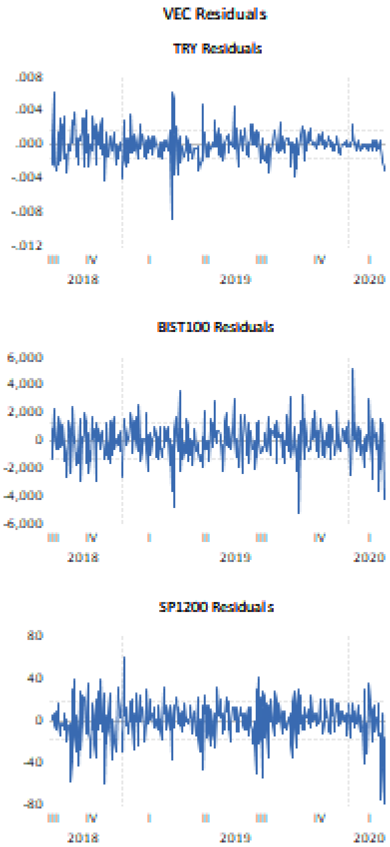









VEC Residuals
GBP Residuals
SP5000 Residuals
SP350 Residuals
SP50 Residuals
M3 M4 M5 M6 M7 M8 M9 M10 M11 M12 M1
2017
2018


VEC Residuals
TRY Residuals
BIST100 Residuals
SP1200 Residuals
III IV I II III IV I
2018
2019
2020